# Pension Fund Investment

## Implications for the Real Economy

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**ISSN 0906-6934**

**Print ISBN: 978-87-7568-185-3**
**Online ISBN: 978-87-7568-186-0**

**DOI: https://doi.org/10.22439/phd.21.2023**

PENSION FUND INVESTMENT: IMPLICATIONS FOR THE REAL ECONOMY

PhD Series 21.2023

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# PENSION FUND INVESTMENT: IMPLICATIONS FOR THE REAL ECONOMY

Department of Economics

**PhD Series 21.2023**

CBS COPENHAGEN BUSINESS SCHOOL
HANDELSHØJSKOLEN

Doctor of Philosophy

Doctoral Thesis in Economics

**Copenhagen Business School**

Department of Economics

# Pension Fund Investment: Implications for the Real Economy

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Supervisors: Svend E. Hougaard Jensen, Roel Beetsma, Dario Pozzoli

Copenhagen, March 2023

CBS

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*Pension Fund Investment: Implications for the Real Economy*

First edition 2023
Ph.D. Series 21.2023



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*To my father, whose resilience is a constant source of inspiration.*

# Acknowledgements

This doctoral thesis marks the culmination of my time as a PhD student at Copenhagen Business School. I moved to Copenhagen knowing that I would spend a lot of time researching pension systems (yes, this was a choice!). This is more or less the only thing that went as expected over these, let's say, eventful, three years. I would like to thank a few people without whom you would not be reading these pages.

First and foremost, I am immensely grateful to my three doctoral supervisors. Svend has been constantly supportive throughout this project, encouraging me to pursue my own ideas and offering guidance on how to implement them. Above all, he kept surprising me with amazing opportunities, the most important one being the team he put together to accompany my PhD project. Working with Roel taught me a lot about academic rigour and refining research ideas. Dario was continually approachable with helpful suggestions and managed to make extended discussions on methodological intricacies both interesting and instructive. Collaborating with all three was a true pleasure and I am grateful for everything I have learned from them. I count myself very lucky to have had such an outstanding group of supervisors during my doctoral studies.

A truly formative experience during my PhD was my two-month research stay at the National Bureau of Economic Research in Cambridge, Massachusetts. I am indebted to Jim Poterba for hosting me during this time and am thankful to many other researchers in the Boston area for interesting and fruitful discussions. Over the course of my research project, I also had the chance to interact with many colleagues from the Danish pension fund industry. I am grateful to them for their participation in this research project. This collaboration was not only essential in collecting data for this thesis but was also very helpful in framing my ideas.

I am also grateful to the whole Department of Economics at Copenhagen Business

School. Whenever I needed advice or feedback, I found an open door. Understanding Danish register data without speaking a word of Danish was a challenge I would not have managed without the help of many colleagues. The co-authorship of one chapter of this thesis with Cédric Schneider came out of this quest (and it was definitely a quest!). I am grateful to Cédric and my other co-authors for the opportunity to work together.

I was lucky to start my time at the Department together with a group of fellow PhD students that are almost as fun as they are excellent economists. A special mention goes to Tim and Freddy. On a professional level, the brainstorming and feedback sessions we had were very important in completing this thesis. On a personal level, the close friendship we have developed is one of the main things I take with me from my time in Copenhagen. Speaking about close friendships, I am also thankful to my flatmates Franz and Aru without whom I cannot imagine the time in Copenhagen.

My family and friends outside Denmark have been instrumental in supporting me throughout my PhD, and I cannot thank them enough. I am particularly grateful to my parents for their enduring love and support, and for consistently placing their children first. I cannot imagine having completed this thesis without Isabel's constant support. Not only did you have to deal with multiple lockdowns, but also the added burden of constant screentime with a face that was barely recognisable under wild hair and a long beard (quite the academic look). Thank you for your invaluable emotional and moral support over these three years. E ti ringrazio per avermi incoraggiato a mettere da parte ogni tanto le pensioni e viaggiare insieme in Italia.

Last but not least, I am grateful to Jeremy Coller for many out-of-the-box conversations about pensions. I could have started these acknowledgements with Jeremy for two reasons. First, he is the person that started my passion for pension systems all the way back in 2013. Second, our conversations convinced me to start a PhD. So, if you, the reader, do not enjoy the many pages that follow, you know who to thank.

- David  
Copenhagen, March 2023

# Thesis Abstract

Given the increasing importance of funded pension systems around the world, it is crucial to understand the impacts of such systems on the real economy. This thesis examines the economic effects of pension funds from various perspectives. The three chapters of this thesis produce new empirical evidence on that issue by applying advanced micro-econometric methods to novel data on pension fund asset allocation.

In summary, this thesis finds that domestic pension funds exhibit unique trading behaviours, including a longer investment horizon, compared to other institutional investors, justifying their recognition as long-term investors in policy discussions on funded pension systems. Moreover, this thesis shows that pension fund investment positively affects the productivity of domestic firms. Lastly, this thesis finds a positive relationship between pension fund investment and increased patenting activities at the firm level.

These results are important evidence that domestic pension funds support the domestic economy highlighting the wider economic benefits of funded pension systems. The findings of this thesis are relevant for policy makers, researchers and financial sector stakeholders interested in understanding the broader economic implications of funded pension systems.

**Chapter I**, entitled *Are Pension Funds Different from Other Institutional Investors? Investment Horizon, Activity and Performance*, is motivated by the fact that, although pension funds are often presented as long-term investors in policy discussions on funded pension systems, the empirical evidence to justify this claim remains limited. I contribute to the literature by providing evidence explicitly comparing domestic pension funds to other investors along four key dimensions: investment horizon, stock picking, performance, as well as trading behaviour and performance during times of financial market turmoil. The last point is motivated by the fact that although long-term in-

vestors should, in theory, have a stabilising influence on financial markets in times of distress, the empirical evidence on the stabilizing effects of pension funds in this context remains mixed. An important innovation of this Chapter is the use of novel and detailed panel data on the domestic investment portfolios of six large Danish pension funds. This data was directly collected from these funds. I find that domestic pension funds exhibit a longer investment horizon than other institutional investors holding Danish listed equity. Domestic pension funds also engage less in stock picking than other institutional investors, domestic or foreign. Finally, the trading activity of domestic pension funds increases less than that of other domestic institutional investors during periods of financial market distress.

**Chapter II**, entitled *Do Pension Fund Investments Make a Difference? Effects on Firm Productivity* and co-authored with Roel Beetsma, Svend E. Hougaard Jensen, and Dario Pozzoli, investigates the impact of pension fund investment on firm productivity in Denmark. Pension funds can affect firm productivity by providing long-term capital, thus allowing firms to invest in projects that will result in productivity gains in the long run. This chapter contributes to the wider literature on sources of firm productivity, as well as a smaller literature on the effects of a firm's ownership structure on its productivity. Contrary to most prior work on the impact of shareholders on firm productivity, the novel dataset used in this chapter allows for the inclusion of privately held firms in addition to publicly listed firms. It is the first paper to investigate the effect of pension funds specifically on firm productivity. To rule out that pension funds simply select more productive firms, we estimate firm productivity via a structural estimation method that explicitly accounts for past productivity. Our results show that firms receiving pension fund investment become more productive after the investment. We also find evidence that the effect on productivity increases with the size of the investment, and the longer pension funds stay invested. Lastly, the impact of pension fund investment is more pronounced for privately held firms than for publicly listed ones.

**Chapter III** is entitled *Pension Fund Investment and Firm Innovation* and is joint work with Dario Pozzoli and Cédric Schneider. This chapter studies the relationship between pension fund investment and firm innovation using patenting data of Danish firms. Given the long-term nature of innovation, investors such as pension funds can be an important source of financing for these activities. Considering the increasing im-

portance of green investment among institutional investors, we extended the analysis to examine the impact of pension fund investment on green patenting in particular. Prior literature on the effects of institutional investors on firm innovation mostly studies publicly listed firms in the United States, while we study Danish firms and are able to include privately held firms. This chapter also contributes to an emerging literature on the role of pension funds in firm sustainability. We find a positive relationship between pension fund investment and firm innovation. This conclusion holds for three different measures of innovation: the propensity to apply for a patent, the number of weighted patent applications, and the share of total employees working in R&D. Furthermore, high product competition weakens the relationship. Our findings also show a positive relationship between pension fund investment and the production of green patents. We present extensive robustness checks and use different estimation methods to test identification and address concerns about endogeneity.

# Resumé

I betragtning af den stigende betydning, som opsparingsbaserede pensionssystemer også internationalt, er det afgørende at forstå virkningerne af sådanne pensionssystemer på realøkonomien. Denne afhandling analyserer økonomiske effekter af investeringer foretaget af danske pensionsselskaber. Ved at udnytte nye og detaljerede data om pensionsselskabers investeringer i kombination med avancerede mikroøkonometriske metoder frembringer afhandlingen ny empirisk evidens for, hvordan pensionsselskaber påvirker realøkonomien.

Et af de vigtigste resultater i afhandlingen er, at danske pensionsselskaber adskiller sig fra andre institutionelle investorer med hensyn til investorhorisont og aktievalg. Dette bidrager til at forklare, hvorfor pensionsselskaber ofte tiltrækker sig særlig opmærksomhed i debatten om langsigtede investeringer. Et andet hovedresultat er, at danske pensionsselskabers investeringer har en positiv effekt på danske virksomheders produktivitet. Endelig viser afhandlingen en positiv sammenhæng mellem investeringer foretaget af pensionsselskaber og patenteringsaktiviteter på virksomhedsniveau.

Disse resultater udgør en afgørende evidens for, at pensionsselskaber kan understøtte makroøkonomien gennem eksterne effekter af deres investeringsaktiviteter. Resultaterne er således relevante for politiske beslutningstagere, forskere og interessenter i den finansielle sektor, som er optaget af de bredere samfundsøkonomiske effekter af opsparingsbaserede pensionssystemer.

**Kapitel I** er motiveret af det faktum, at selvom pensionsselskaber ofte præsenteres som langsigtede investorer, så er den empiriske dokumentation for denne påstand ret begrænset. Kapitlet bidrager til litteraturen med evidens, der eksplicit sammenligner indenlandske pensionsselskaber med andre investorer med hensyn til fire centrale dimen-

sioner: investeringshorisont, aktieudvælgelse, performance og adfærd under markedsuro. Det sidste punkt er motiveret af, at selvom langsigtede investorer i teorien burde have en stabiliserende indflydelse på de finansielle markeder i tider med markedsturbulens, er den empiriske evidens for pensionsselskabers stabiliserende effekter i denne sammenhæng stadig uklar. En vigtig nyskabelse i dette kapitel er indsamlingen og brugen af detaljerede paneldata for seks store danske pensionsselskabers indenlandske investeringsporteføljer. Kapitlet dokumenterer, at danske pensionsselskaber har en længere investeringshorisont end andre institutionelle investorer i danske børsnoterede aktier. Danske pensionsselskaber engagerer sig også mindre i "stock picking" end andre institutionelle investorer, uanset om de er indenlandske eller udenlandske. Endelig omsætter danske pensionsselskaber mindre af deres indenlandske portefølje end andre indenlandske institutionelle investorer i perioder med krise på de finansielle markeder.

**Kapitel II**, skrevet sammen med Roel Beetsma, Svend E. Hougaard Jensen og Dario Pozzoli, undersøger effekten af investeringer foretaget af danske pensionsselskaber på danske virksomheders produktivitet i Danmark. Pensionsselskaber kan påvirke virksomhedernes produktivitet ved at stille langsigtet kapital til rådighed og dermed give virksomhederne mulighed for at investere i projekter, der vil skabe produktivitetsgevinster i det lange løb. Dette kapitel bidrager dels til litteraturen om kilder til virksomheders produktivitet, dels til litteraturen om virkningerne af en virksomheds ejerskabsstruktur på dens produktivitet. I modsætning til tidligere arbejde om aktionærkredsens betydning for virksomhedernes produktivitet, giver det nye datasæt, der bruges i dette kapitel, mulighed for at inkludere både noterede og unoterede virksomheder. For at udelukke, at pensionsselskaber blot vælger mere produktive virksomheder, estimeres virksomhedernes produktivitet via en strukturel estimeringsmetode, der eksplicit tager højde for tidligere produktivitet. Resultater viser, at virksomheder, der modtager finansiering fra pensionsselskaber, bliver mere produktive efter investeringen. Vi finder også dokumentation for, at effekten på produktiviteten stiger med investeringens størrelse, og jo længere pensionsmidlerne bliver investeret. Endelig er effekten stærkere for unoterede end for noterede virksomheder.

**Kapitel III**, skrevet sammen med Dario Pozzoli og Cédric Schneider, undersøger forholdet mellem investeringer foretaget af pensionsselskaber og virksomhedsinnovation ved hjælp af danske virksomheders patenteringsdata. Innovation er typisk en aktivitet

med en lang tidshorisont, og derfor kan investorer såsom pensionsselskaber potentielt være en vigtig finansieringskilde for disse aktiviteter. Analysen omfatter også grøn patentering, da grønne investeringer er af stigende betydning blandt institutionelle investorer. Tidligere litteratur om virkningerne af institutionelle investorer på virksomhedernes innovation studerer for det meste børsnoterede virksomheder i USA, mens kapitlet studerer danske virksomheder og er i stand til at inkludere unoterede virksomheder. Dette kapitel bidrager også til en ny litteratur om pensionsselskabers rolle for virksomhedernes bæredygtighed. Kapitlet finder en positiv sammenhæng mellem investeringer foretaget af pensionsselskaber og virksomhedsinnovation. Denne konklusion gælder for tre forskellige mål for innovation: tilbøjeligheden til at ansøge om et patent, antallet af vægtede patentansøgninger og andelen af det samlede antal ansatte, der arbejder med F&U. Ydermere svækker høj produktkonkurrence forholdet. Vores resultater viser også en positiv sammenhæng mellem pensionsfondsinvesteringer og produktion af grønne patenter. Vi præsenterer omfattende robusthedstjek og bruger forskellige estimeringsmetoder til at teste identifikation og adressere bekymringer om endogenitet.

# Contents

# Introduction

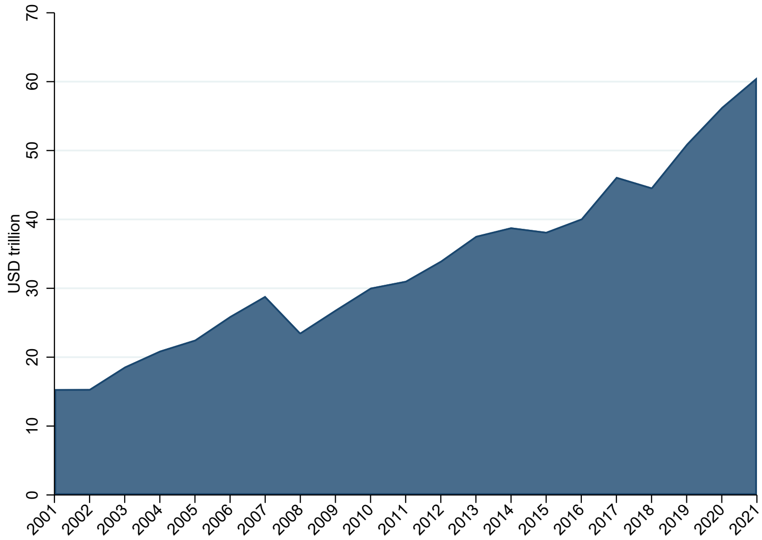
## Setting the Scene

One of the key challenges facing the societies of most developed countries is population ageing. The combination of a longer life expectancy and declining fertility rates creates a perfect storm for one of the key pillars of modern welfare states: the pension system. Most industrialised countries mainly rely on pay-as-you-go (PAYG) pension systems. In such a system, the pensions of currently retired citizens are financed by the contributions of the population currently working. The demographic change, resulting in a larger ratio of retirees to workers, naturally puts strain on the finances of PAYG pension schemes.

In light of this challenge, policy makers in numerous countries have undertaken reforms to increase the role of funded pension schemes. In such schemes, citizens contribute parts of their earnings to the system during their working life. These contributions are invested in financial markets by asset managers, in most cases pension funds. Therefore, funded pension systems create investors that pool the pension savings of a country's population. Over time, these investors accumulate a considerable amount of assets under their management.

This point is illustrated by Figure 1, which shows that the value of assets in funded and private pension plans exceeded 60 trillion USD at the end of 2021 (OECD, 2023). Most of these assets are managed by pension funds, making them one of the most important investor groups in global financial markets. In addition, their significance is poised to rise even further in the future owing to the global trend towards greater pension funding.

**Figure 1.** Assets in Funded and Private Pension Systems, 2001-2021




*Notes:* This figure presents the aggregate nominal value of assets in funded and private pension systems in OECD and non-OECD jurisdictions.
*Source:* OECD Global Pension Statistics as published in OECD (2023).

The large amount of savings in funded pension systems naturally has led policy makers and researchers to ask about the impact of such schemes on the wider economy. In particular, the assets in funded pension systems are often seen as a potential source of long-term capital for long-term projects that support economic growth, such as infrastructure (OECD, 2022). Institutional investors, generally defined as investors that are not individual investors, feature prominently in these discussions. For example, in 2013 the OECD published the *G20/OECD High-Level Principles of Long-Term Investment Financing by Institutional Investors* (OECD, 2013), a set of policy recommendations to promote long-term investment by this group of investors. While in principle all institutional investors can engage in long-term investment, those managing retirement assets, such as pension funds and insurance companies, are often described as long-term investors par excellence.

# This Thesis

Given the increasing importance of funded pension systems around the world, it is crucial to understand the effects of such systems on the real economy. This thesis comprises three empirical chapters that investigate the economic impact of pension funds from various perspectives, in the context of Denmark. The project is motivated by two main factors.

The first motivation is the attention given to pension funds in the policy discourse on long-term investment. Why would pension funds be different from other investors? The answer is a longer investment horizon. Pension funds have longer liabilities than most other investors since workers typically start contributing to their pension fund at a young age and only access these savings when they retire (Çelik & Isaksson, 2014; Derrien et al., 2013). This, theoretically, should entice them to adopt a long-term view in their investment activities (Della Croce et al., 2011; Harford et al., 2018).

And indeed, investment horizon matters for the real economy. Prior research has predominantly identified a positive relationship between the investment horizon of a company's shareholder base and various corporate performance measures such as stock price and return (Cella et al., 2013; Yan & Zhang, 2009), earnings management and fraud (Harford et al., 2018), R&D spending (Bushee, 1998), patenting (Aghion et al., 2013) and credit ratings (Driss et al., 2021). Other papers have shown that firms with a higher share of short-horizon investors adapt better to shocks increasing competition in their industry (Giannetti & Yu, 2021) and foreign short-term investors have been found to drive firm value (Döring et al., 2021). In a survey of institutional investors, McCahery et al. (2016) find that long-term investors engage more intensively with their portfolio firms. Evaluating if pension funds really are different from other institutional investors is the aim of the first chapter of this thesis.

The underexplored role of asset allocation in the connection between funded pensions and economic growth serves as the second motivation for this thesis. Despite the increasing importance of pension funds described above, detailed data on their actual *asset allocation* is very scarce. The literature interested in the relationship between economic growth and funded pensions has instead mostly focused on the domestic *level of pension savings* and its impact on growth, coming to mixed conclusions (Altiparmakov & Nedeljkovic, 2018; Bijlsma et al., 2018; Zandberg & Spierdijk, 2013). Theory, however, tells us that the way pension savings are invested can impact economic growth (Barr & Diamond, 2008). For example, the relationship between the level of domestic pension assets and domestic economic growth becomes less straightforward when the majority of pension assets is invested abroad, as is the case in the Netherlands. The types of assets that these savings are channelled into are also important (Barr & Diamond, 2008; OECD, 2022). In fact, Altiparmakov and Nedeljkovic (2018) find a positive effect of pension funding on economic growth when pension funds invest less in government bonds, suggesting the relevance of asset allocation. Chapters II and III of this thesis take a different approach than previous literature on the subject. Instead of focusing on pension savings and GDP growth at the aggregate level, they investigate the effect of domestic pension fund investment on two key drivers of economic growth at the firm level: productivity and innovation.

Two novel datasets on the domestic investments of Danish pension funds enable these analyses of pension fund investment at the firm level. As detailed data on pension fund asset allocation is generally unavailable, the construction of these datasets represents an essential part of the PhD project. The first dataset, presented in detail in Chapter I, is the result of a data collection exercise directly from six large Danish pension funds. The participating funds managed approximately 70% of total assets under management in the Danish pension fund sector at the end of 2019. The second dataset is described in Appendix D (Data Appendix) and is based on business register data of all limited liability companies in Denmark. Thus, the second dataset enables the analysis of not only publicly listed firms, as is the case in most prior literature on the effects of investors on target firms, but also privately held firms. Chapters II and III of this thesis further use high-quality Danish administrative data.

# Outline of the Chapters

**Chapter I** is motivated by the fact that, although pension funds are often presented as long-term investors in policy discussions on funded pension systems, the empirical evidence to justify this claim remains limited. Prior literature has indeed identified pension funds as one of the investor groups with the longest investment horizon (Cella et al., 2013; Cremers & Pareek, 2016; Döring et al., 2021; Harford et al., 2018). While the investors analysed in these studies include pension funds, the latter are generally not contrasted with other institutional investors. This chapter contributes to the literature by providing evidence explicitly comparing domestic pension funds to other investors across four key dimensions: investment horizon, stock picking, performance, as well as trading behaviour and performance during times of financial market turmoil. The last point is motivated by the fact that although long-term investors should, in theory, have a stabilising influence on financial markets in times of distress, the empirical evidence on the stabilizing effects of pension funds in this context remains mixed (Ben-David et al., 2021; Blake et al., 2017; Broeders et al., 2021; Duijm & Steins Bisschop, 2018; Thomas et al., 2014). An important innovation of this Chapter is the use of novel and detailed panel data on the domestic listed equity portfolios of six large Danish pension funds. This data was directly collected from these funds. I find that domestic pension funds exhibit a longer investment horizon than other institutional investors holding Danish listed equity. Furthermore, the analysis shows that domestic pension funds engage less in stock picking than other institutional investors, domestic or foreign. Finally, the trading activity of domestic pension funds increases less than that of other domestic institutional investors during periods of financial market distress.

**Chapter II**, co-authored with Roel Beetsma, Svend Erik Hougaard Jensen, and Dario Pozzoli, investigates the impact of pension fund investment on firm productivity in Denmark. Pension funds can affect firm productivity by providing long-term capital, thus allowing firms to invest in projects that will result in productivity gains in the long run. This chapter contributes to the wider literature on sources of firm productivity (Caggese, 2019; De Loecker, 2013; Doraszelski & Jaumandreu, 2013; Levine & Warusawitharana, 2021), as well as a smaller literature on the effects of a firm's ownership structure on its productivity (Bircan, 2019; Braguinsky et al., 2015; Davis et al., 2014; Fons-Rosen et al., 2021). Contrary to most prior work on the subject, the novel dataset used in this chapter allows for the inclusion of privately held firms in addition to publicly listed firms. To the best of our knowledge, this Chapter is the first academic study to investigate the effect of pension funds specifically on firm productivity. To rule out that pension funds simply select more productive firms, we estimate firm productivity via a structural estimation method that explicitly accounts for past productivity. Our results show that firms receiving pension fund investment become more productive after the investment. We also find evidence that the effect on productivity increases with the size of the investment, and the longer pension funds stay invested. Lastly, the impact of pension fund investment is more pronounced for privately held firms than for publicly listed ones.

**Chapter III**, co-authored with Dario Pozzoli and Cédric Schneider, studies the relationship between pension fund investment and firm innovation using patenting data of Danish firms. Given the long-term nature of innovation, investors such as pension funds can prove an important source of financing for these activities. Considering the increasing importance of green investment among institutional investors, we extended the analysis to examine the impact of pension fund investment on green patenting in particular. Prior literature on the effects of institutional investors on firm innovation (Aghion et al., 2013; Bena et al., 2017; Bushee, 1998; Schain & Stiebale, 2021) mostly studies publicly listed firms in the United States, while we study Danish firms and are able to include privately held firms. This chapter also contributes to an emerging literature on the role of pension funds in firm sustainability (Alda, 2019; Dyck et al., 2019). We find a positive relationship between pension fund investment and firm innovation. This conclusion holds for three different measures of innovation: the propensity to apply for a patent, the number of quality-weighted patent applications, and the share of total employees working in R&D. Furthermore, high product competition weakens the relationship between pension fund investment and innovation. Our findings also show a positive relationship between pension fund investment and the production of green patents. We present extensive robustness checks and use different estimation methods to test identification and address concerns about endogeneity.

In summary, this thesis finds that domestic pension funds exhibit unique trading behaviours, including a longer investment horizon, compared to other institutional investors, justifying their recognition as long-term investors in policy discussions on funded pension systems. Moreover, this thesis shows that pension fund investment positively affects the productivity of domestic firms. Lastly, this thesis finds a positive relationship between pension fund investment and increased patenting activities at the firm level. These results are important evidence that domestic pension funds support the domestic economy highlighting the wider economic benefits of funded pension systems. The findings of this thesis are relevant for policy makers, researchers and financial sector stakeholders interested in understanding the broader economic implications of funded pension systems.

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# Chapter I

David Pinkus

# Are Pension Funds Different from Other Institutional Investors?

## Investment Horizon, Activity and Performance

CHAPTER

# Are Pension Funds Different from Other Institutional Investors? Investment Horizon, Activity and Performance


## Abstract

This paper first presents a new dataset on the domestic investments of Danish pension funds from 2005 to 2019 collected directly from six large Danish pension funds. The second part of this paper uses this novel data and other data sources to compare Danish pension funds to other institutional investors across four key dimensions: investment horizon, activity in terms of stock picking, performance, as well as portfolio turnover and performance during times of financial market turmoil. The results show that Danish pension funds exhibit a longer investment horizon and engage less in stock picking than other institutional investors, while no clear differences emerge regarding performance. Furthermore, this study finds that domestic pension funds react less strongly to financial market turmoil than other domestic institutional investors. Understanding the investment behaviour of pension funds is important for policy makers interested in the wider effects of funded pension systems.



I am grateful to professionals at the Danish pension funds that provided data used in this paper. I also thank Roger Bandick, Andreas Gerckens, Natalia Khorunzhina and Tim Maurer for useful comments and suggestions on an earlier version of this paper.

## I.1 Introduction

Policy makers often urge financial investors to adopt a long-term perspective. Institutional investors, in particular, have been a focus of this discussion. For example, long-term investment by institutional investors is seen as a crucial source of capital to support the transition towards a more sustainable future, including investment in green energy infrastructure and other technologies (OECD, 2013, 2020). To illustrate this point further, in 2022 the European Union envisaged facilitating institutional investors' investment in green and innovative projects as part of a review of its fund and insurance regulation (European Central Bank, 2022). Traditionally, pension funds and life insurance companies are viewed as having the longest investment horizon among institutional investors, given their long-term liabilities.

The aim of this paper is to compare domestic pension funds to other types of institutional investors across four key dimensions: i) investment horizon, ii) activity in the sense of active stock picking, iii) performance, and finally iv) trading behaviour and performance during times of financial market turmoil. The analysis uses a novel and proprietary dataset on Danish listed equity holdings collected directly from six large Danish pension funds. These funds managed approximately 70% of total assets under management in the Danish pension sector at the end of 2019. This novel data is combined with third-party data on the shareholdings of other investors in Danish listed equity shares to undertake the analysis. Danish pension funds are compared to three other types of institutional investors: i) other domestic investors ii) other foreign investors, and iii) foreign pension funds. I distinguish between domestic and foreign investors since recent literature has identified this differentiation to be important for performance and effects on firm outcomes (Bena et al., 2017; Ferreira et al., 2017).

The results show that Danish pension funds have a longer investment horizon in their domestic listed equity portfolios than non-pension fund investors, domestic or foreign. Furthermore, domestic pension funds engage less in stock picking than other institutional investors. However, I do not find clear evidence for differences in average performance between domestic pension funds and other investors. Last but not least, the analysis shows that domestic pension funds increase their trading activity, measured as quarterly portfolio turnover, less than other investors during times of market turmoil. This result is important because heightened activity by large investors can amplify market shocks, raising concerns for policy makers (Antolin & Stewart, 2009; Bank of England, 2014). If large asset managers buy or sell simultaneously, for example in times of market turmoil, this could have an important effect on market volatility (Broeders et al., 2021). Large swings in investor activity are especially important in the context of institutional investors since prior research has identified their tendency to “herd”, meaning that they trade in the same direction (Koch et al., 2016; Sias, 2004). This phenomenon has also been found among pension funds specifically (Blake et al., 2017; Broeders et al., 2021). Overall, the empirical evidence on the stabilising effects of pension funds for the financial system remains mixed (Ben-David et al., 2021; Blake et al., 2017; Broeders et al., 2021; Duijm & Steins Bisschop, 2018; Thomas et al., 2014). My results suggest that domestic pension funds do not increase their trading activity in the domestic listed equity space during times of financial market turmoil, contrary to other domestic investors. Pension funds could therefore provide stability in times of financial market distress. This paper, however, presents descriptive evidence comparing Danish pension funds to other investors and does not investigate the wider effects on financial markets.

The assumption that pension funds are long-term investors stems from their long-term liabilities (Della Croce et al., 2011; Harford et al., 2018). Indeed, savers typically start contributing to their pension fund at a young age and only access these savings when they retire (Çelik & Isaksson, 2014; Derrien et al., 2013). A number of empirical studies support the notion that pension funds have a long investment horizon relative to other types of investors. In their analysis of shareholders of stocks listed in the US, Cella et al. (2013) find that pension funds, insurance companies, university and foundation endowments, as well as unclassified investors have a longer investment horizon than mutual funds, hedge funds, independent investment advisors, and bank trusts. Harford et al. (2018) also find that the majority of pension funds are long-term investors in the public equity of US firms. Cremers and Pareek (2016) conclude that corporate and public pension funds, as well as insurance companies, engage less in stock picking and have a longer investment horizon than other institutional investors. Döring et al. (2021) study institutional shareholdings of publicly listed non-US firms and report that pension funds have the largest proportion of long-term investors among institutional investors.

Investment horizon, in turn, matters for the real economy. Prior research has generally found a positive effect of longer shareholder horizon on corporate outcomes such as equity returns (Cella et al., 2013; Yan & Zhang, 2009), earnings management and fraud (Harford et al., 2018), R&D spending (Bushee, 1998), patenting (Aghion et al., 2013) and credit ratings (Driss et al., 2021).

The primary innovation of this paper is the use of novel and precise data on the asset allocation of Danish pension funds, which are key actors in Danish financial markets. In fact, I show that this data gives a significantly more accurate picture of the domestic holdings of Danish pension funds than a widely-used financial database. Detailed data on the portfolios of pension funds is typically not widely available, which constrains research on pension funds.

This paper contributes to several strands of literature. First, it contributes to the literature on institutional investor heterogeneity by comparing pension funds to other investors on several important dimensions. Only a small number of studies explicitly compare pension funds to other investors. Duijm and Steins Bisschop (2018), for example, analyse differences in the trading behaviour of pension funds and insurance companies in the Netherlands.

Second, this study is related to the literature about the trading behaviour of institutional investors during financial crises. Cella et al. (2013) find that investors with a shorter investment horizon sell more equities during periods of financial market stress. They also show that stocks with higher ownership by short-term investors experience larger price drops during times of market turmoil, followed by higher price reversals. Ben-David et al. (2018) find that stocks with more concentrated ownership by large institutional investors yield lower returns during times of market turmoil.

Third, the present analysis adds to the limited literature on the trading behaviour of pension funds specifically during times of financial market distress. Previous studies have reached mixed conclusions depending on the time period and geographical location. For example, Papaioannou et al. (2013) show that pension funds in Turkey, Italy, Norway and Poland bought equities during 2008–2009, while those in Spain, Finland, Portugal and the United States were net sellers of equity. Duijm and Steins Bisschop (2018) find that Dutch pension funds invest countercyclically only outside of periods of financial market turmoil.

This paper also contributes to the policy discussions about pension funds and long-term investment (Della Croce et al., 2011; OECD, 2022) by empirically investigating if they behave differently than other institutional investors. Instead of classifying investors according to a characteristic, for example investment horizon, as is common in the literature (see e.g. Bushee, 1998; Cella et al., 2013; Harford et al., 2018; Yan & Zhang, 2009), I investigate whether the assumption that pension funds have a longer investment horizon than other institutional investors holds.

In contrast to most prior literature, I study a market other than the United States. Non-US markets are mostly included in cross-country studies (see e.g. Ferreira et al., 2017) but are not analysed in depth. However, Denmark's highly developed pension fund sector and its large pool of domestic retirement savings assets, which represented over 230% of GDP at the end of 2021 (OECD, 2023), make it an important market to study. While this paper studies the Danish setting, the findings are relevant for policy makers in other countries interested in the design of funded pension systems. In fact, the Danish pension system is consistently ranked as one of the best-performing in the world (Mercer, 2021) and policy makers could therefore look to the Danish experience for insights on the long-term effects of pension reform. This paper presents novel empirical evidence on the investment behaviour of pension funds and can therefore inform discussions on funded pensions.

The remainder of this paper is structured as follows. Section I.2 describes the new dataset on the domestic holdings of Danish pension funds and investigates its scientific value through a comparison to shareholder data from a well-known financial database. Section I.3 describes the variables used in the empirical analysis and presents descriptive statistics. Section I.4 presents the empirical methodology and the results as well as some robustness exercises. Finally, Section I.5 concludes the paper.

## I.2 A New Dataset on Pension Fund Investment in Denmark

Detailed data on pension fund investment is scarce. This section describes an original data collection exercise to gather information on the domestic holdings of a subset of Danish pension funds.

### I.2.1 Data Collection and Verification

Over the spring of 2020, I contacted the 16 major Danish pension funds asking for asset-level data on their *domestic* asset holdings since 2005, across all asset classes, at a monthly frequency. Six funds agreed to participate.[1] These pension funds accounted for approximately 70% of total assets under management in the entire Danish pension industry at the end of 2019.[2] Therefore, a significant part of the industry is covered by the data.

Participants submitted information on over 2,500 different financial instruments across listed and private equity, listed and unlisted fixed income, infrastructure and other asset classes. Not all participating funds provided data going back to 2005, with more funds sharing data for later years.[3] Financial instruments are identified by their International Securities Identification Number (ISIN). In this data, a holding (or position) is identified by the name of the investor, the ISIN of the instrument, the date and the size of the holding.

After receiving the data, I carefully inspected it. First, I identified large month-to-month movements in holdings or value at three different levels: i) total portfolio level, ii) asset class level and iii) ISIN level. Second, I noted instances where an ISIN was missing for a short period while the size of the holding was identical before and after the data gap. Lastly, I identified potential typos in the ISIN. I asked the data provider to verify the consistency of the data and to provide additional information in all such cases. I excluded positions if no additional verification was undertaken.

Due to the significant efforts necessary to prepare the obtained data for analysis, the remainder of this paper only focuses on the portfolios of domestic listed equity shares collected from the participating funds. Henceforth, I refer to this data as the "Collected Data" and use the term "listed equity" to denote listed equity shares only.

### I.2.2 Merger with Financial Market Data

After verifying the data, the next step was to augment the holdings data with time-series financial data such as stock prices and total shares outstanding from Refinitiv Datastream and Eikon. I matched stocks in the Collected Data to Eikon using their ISINs.

[1] Confidentiality agreements prevent the identification of the participating funds. A domestic holding is defined as an instrument emitted by a company headquartered in Denmark.

[2] Own calculations based on annual reports.

[3] The fact that not all pension funds submitted data naturally introduces some response bias in the dataset. In particular, the set of respondents is skewed towards the larger funds. Larger funds are more likely to manage portfolios in-house, particularly domestic portfolios that are the subject of this paper. Therefore, respondents are more likely than non-respondents to manage the portfolios under study in-house. While the reasons for declining participation differed, some pension funds stated an increased organisational burden due to the Covid-19 pandemic.

However, Eikon and Datastream store the historical data only under the stock's most recent ISIN, while the ISINs in the Collected Data included outdated ISINs. A stock's ISIN might change due to corporate actions, such as stock splits. To accurately match the data to Datastream and Eikon, I first mapped each ISIN in the Collected Data to its most recent ISIN using a combination of Refinitiv Eikon, manual inspection and online research. If an ISIN could not be matched to Eikon through these efforts, I excluded it from the dataset.[4] Furthermore, the data provided by participating funds includes the number of shares and the value of each position, but not how much of a stock's total shares outstanding this position represents. I calculated the latter using the number of total shares outstanding of the stock sourced from Refinitiv Eikon and recalculated the value of each position using the prices from Eikon adjusted for subsequent corporate action.[5]

The resulting dataset includes the domestic listed equity holdings of a subset of Danish pension funds over the period 2005–2019 at a monthly frequency and at the stock level, combined with historical financial data of the instrument.

### I.2.3 Alternative Source of Ownership Data

The Collected Data described above has two limitations. First, it only contains the stocks included in the data shared by the participating pension funds. Second, all participants in the data collection exercise are Danish pension funds, so the Collected Data includes no information on the holdings of other types of investors. To address the first point, I query Refinitiv Eikon for all stocks ever listed on the Nasdaq Copenhagen stock exchange (formerly Copenhagen Stock Exchange, hereafter Nasdaq Copenhagen) and add these to the dataset.[6] To address the second limitation, I use Refinitiv Eikon's shareholder history module to download the complete list of shareholders of these stocks over the period 2005–2019 at a quarterly frequency. I subsequently refer to the shareholder data from Eikon as "Eikon Data". To be clear, the Collected Data was directly collected from

[4]This is the case for approximately 5% of stocks.

[5]This ensures that holding size and prices are comparable across the Collected Data and the data downloaded from Eikon. Adjusting for corporate actions is necessary to make numbers comparable across time. For example, if an issuer executed a 1-to-2 stock split in December 2010, the number of shares held before that date needs to be multiplied by two to make it comparable to holdings after that date. This ensures that the holding size does not mechanically double due to the stock split.

[6]Defining the universe of stocks via the exchange instead of the location of the emitting firm allowed for a cleaner definition. While this excludes Danish companies only listed on a foreign stock exchange from the search, this number is very small in the Eikon database.

six large pension funds and contains the Danish listed equity portfolios of these six funds. The Eikon Data was downloaded from Refinitiv Eikon and contains the Danish listed equity portfolios of a much larger set of domestic and foreign investors.

The next subsection describes the merger of the Collected Data and the Eikon Data, as well as the steps taken to construct the sample for analysis used in the rest of this paper. Merging the Collected Data and the Eikon Data enables the two analyses conducted in this paper. The first analysis assesses the scientific value of the Collected Data by comparing it to the portfolios of Danish pension funds comprised in the Eikon Data (Section I.2.5). The second analysis compares Danish pension funds and other investors using a combination of both datasets (Section I.4).

### I.2.4 Sample Construction

After converting the Collected Data from monthly to quarterly frequency, I merge it with the data from Eikon's shareholder history module.[7]. In the resulting dataset, one observation is an investor-ISIN-quarter combination that gives the stake of a particular investor in a specific stock at the end of a specific quarter. I now describe the steps taken to clean the data and to construct the sample for analysis.[8]

First, I only keep financial instruments defined as "ordinary shares" or "preference shares" in Eikon.[9] Since the data collection exercise described in Section I.2.1 only covers investments in Danish companies, I exclude the stocks emitted by companies not headquartered in Denmark.[10] I also drop observations without valid price or return information.[11] To address potential reporting errors in the Eikon Data, I exclude cases

[7]This operation naturally created some overlapping observations when a holding by the same pension fund was recorded in both the Collected Data and the Eikon Data. These overlaps are analysed in Section I.2.5 and subsequently excluded from further analyses.

[8]Since the combined ownership data from Eikon and the Collected Data is the basis for the empirical analysis of this paper, these steps also apply to the sample used further in sections I.3 and I.4.

[9]The excluded instruments are one American depository receipt and one open-end fund. For the Collected Data, I additionally verify cases of discrepancies between the instrument type listed in Eikon and the type specified by the fund providing the data. If these cannot be reconciled, I exclude the instrument from the dataset.

[10]These instruments were originally included in the data downloaded from Eikon and are shares listed on the Nasdaq Copenhagen by companies that are not domiciled in Denmark and have their primary listing on another stock exchange. The excluded instruments correspond to approximately 4% of all stocks in the data.

[11]The closing price at the end of the quarter is defined as the closing price on the latest date in the quarter with valid price information. This step also ensures that the sample only contains financial instruments that are active during the period.

where the investor only holds a single stock while holding more than five different stocks in the preceding and subsequent quarters.

In the next step, I drop any observations that do not contain information on the size of the holding. Next, I impute the percentage of shares held for missing periods with information from the previous quarter if i) information on the investor-stock combination is missing for less than four quarters and ii) the sizes of the holdings are equivalent before and after the missing periods (rounded to the nearest percentage point).[12] Furthermore, I only keep stocks and investors that are in the dataset for at least four consecutive quarters. To ensure the internal consistency of the data, I also drop ISIN-period combinations if the sum of the stakes held by all investors in the dataset exceeds 100% (accounting for duplicates). Lastly, I exclude observations with missing values for any variable used in the baseline analysis of Section I.4.2.

I now turn to the set of investors that will be compared to Danish pension funds in the analysis. The Eikon Data includes two kinds of investors: 1) investors that engage in trading in the sense of traditional investment managers, and 2) strategic investors that hold stakes in specific companies without the intent to trade them, for example, a holding company that solely manages the shareholdings of the heirs of a company's founders. The latter type of investor tends to hold large stakes in a very small number of companies. Comparing pension funds to institutions that do not trade frequently could distort the analysis. For example, if a holding company merely exists to hold shares of one specific firm on behalf of that firm's founder, then it would be natural for the holding company to exhibit a very long investment horizon. This observation, however, would simply be due to the fact that the holding company does not trade. Comparing such a company to other investors that actively trade shares would distort the analysis. To address this issue, any investor classified by Refinitiv Eikon as a "strategic entity" is excluded from the analysis.[13] This step reduces the set of investors in the data by 23.8%. The dataset at this point contains 271,335 investor-ISIN-quarter observations, including 208 different stocks and 1,983 investors.

After cleaning the data, I briefly explore the coverage of the shareholder information

[12] Imputations are only made for the Eikon Data. For the Collected Data, I verify short gaps in series with the participating data providers as described in Section I.2.1.

[13] Refinitiv Eikon defines strategic entities as "entities (including individuals) that do not invest for "investment management" purposes, but rather invest for strategic stakes in companies." (Refinitiv, 2020, p.2). The excluded investors are of the types Bank and Trust, Corporation, Government Agency, Holding Company, Individual Investor, or Other Insider Investor.

in the Eikon Data. Ideally, the database would identify the owners of 100% of shares outstanding of all stocks. However, this is not the case. On average, the Eikon Data identifies owners of 41.2% of total shares outstanding of a given stock in a given period before excluding strategic investors and 16.1% after excluding them. Therefore, one clear limitation of this study is the lack of complete information on stock ownership.

To analyse the potential differences between pension funds and other investors, I classify all investors in the sample into five types: 1) *Pension Fund – Collected Data*, containing the holding information directly collected from Danish pension funds described in Section I.2.1; 2) *Pension Fund – Eikon*, the holding data of Danish pension funds downloaded from Refinitiv Eikon; 3) *Other – Domestic*, containing investors headquartered in Denmark that are not pension funds; 4) *Other – Foreign*, consisting of foreign investors that are not pension funds; and 5) *Pension Fund – Foreign*, reflecting information on the Danish holdings of foreign pension funds. To clarify, the source for the holdings of all investor types except *Pension Fund – Collected Data* is Refinitiv Eikon.

Table I.1 provides details on the number of observations for each investor type and some statistics describing the investors.[14] The dataset is dominated by foreign investors other than pension funds. Refinitiv Eikon being a global database and Denmark being a comparably small market, it is unsurprising that the database contains mostly the holdings of foreign investors.

Column 4 of Table I.1 gives the average number of stocks per period that an investor of each type invests in. Based on the Collected Data, a Danish pension fund on average holds over 36 different stocks per quarter. This number is significantly higher than for the other investor types, meaning that the portfolios of domestic pension funds are much more diversified. Column 5 gives the average number of periods in which an investor of each type is present in the dataset. Using the Collected Data, the average pension fund is in the dataset for 41.7 quarters, compared to a sample average of 20.8 for all investors. The combination of higher numbers of periods and instruments per investor, on average, means the Collected Data contains a significantly higher number of data points per investor than the Eikon Data.

Furthermore, a Danish pension fund on average holds 2.17% of a stock, conditional on

[14]The quantitative analysis in Section I.4 is carried out with observations at the investor-period level. The total observations in column 2 of Table I.1 less the observations for the investor type *Pension Fund – Eikon* yields $41,214 - 243 = 40,971$ observations, corresponding to the largest sample used in the quantitative analysis (see e.g. Table I.4).

investing in that instrument (column 6). While this number may seem small in absolute terms, particularly in comparison to the average holding size of 9.75% for domestic pension funds in the Eikon Data, column 7 provides some insight into the holding size relative to the other investors in the same Stock. With an average rank of 8.18, it can be inferred that, on average, a domestic pension fund is in the top 20 percent largest institutional shareholders of an instrument that it holds. This is evidence that Danish pension funds are usually an important part of the shareholder base of a stock that they hold.

Column 8 of Table I.1 shows the average size of an investor of each type, defined as the total value of the investor's Danish listed equity portfolio captured in the data.[15] A Danish pension fund in the Collected Data on average holds 7.74 billion DKK of Danish public equity per quarter. This value is much higher than for all other investor types. While the category *Other – Foreign* includes by far the most investors in the dataset, the average portfolio size of an individual investor is relatively small at 460 million DKK. This indicates that foreign investors, at an individual level and on average, do not invest heavily in Danish listed equity.

**Table I.1.** Number of Observations and Investor-Level Characteristics

| | (1) Investors | (2) Investor-quarter observations | (3) Investor-ISIN-quarter observations | (4) $\overline{\text{Stocks}_i}$ | (5) $\overline{\text{T}_i}$ | (6) $\overline{\text{Stake}_{i,z,t}}$ | (7) $\overline{\text{Rank}_{i,z,t}}$ | (8) $\overline{\text{Size}_{i,t}}$ |
|---|---|---|---|---|---|---|---|---|
| Other - Domestic | 58 | 1,642 | 30,121 | 18.3 | 28.3 | 1.69 | 6.24 | 2,282 |
| Other - Foreign | 1,887 | 38,601 | 223,207 | 5.78 | 20.5 | .212 | 5.1 | 460 |
| Pension Fund - Collected Data | 6 | 250 | 9,046 | 36.2 | 41.7 | 2.17 | 8.18 | 7,657 |
| Pension Fund - EIKON | 8 | 243 | 1,462 | 6.02 | 30.4 | 9.75 | 7.74 | 2,065 |
| Pension Fund - Foreign | 24 | 478 | 7,499 | 15.7 | 19.9 | .21 | 6.68 | 1,512 |
| Total | 1,983 | 41,214 | 271,335 | 6.58 | 20.8 | 0.493 | 5.39 | 598 |

*Notes:* This table presents the number of observations in the dataset and descriptive statistics at the investor level. All numbers are conditional on a positive number of shares held, meaning that positions of zero shares held are excluded. Column 1 shows the number of investors of each type. Column 2 describes the number of investor-quarter combinations. Column 3 shows the number of investor-ISIN-quarter combinations. Column 4 gives the average number of stocks that a single investor of each type holds per quarter. Column 5 shows the average number of quarters in which an investor of each type is present in the dataset. Column 6 depicts the mean holding size of an investor of each type, defined as the percentage of total shares outstanding of a single stock that an investor holds. Column 7 gives the average decile of the stake size distribution for each type. This number reflects how large on average the stake of an investor is, relative to all investors investing in the same stock at the same time. Lastly, column 8 gives the average portfolio size of a single investor of each type.

Overall, compared to other investors in the dataset, the Collected Data shows that

[15]To be clear, in the remainder of this paper investor size always refers to the size of the investor's Danish listed equity portfolio only.

Danish pension funds are important and diversified investors in the domestic listed equity space. Relying on the Eikon Data on Danish pension funds leads to different conclusions. The next subsection further investigates the scientific value of the Collected Data by comparing the information on the portfolios of Danish pension funds contained in the two sources. When making these comparisons, it is important to keep in mind that the data comes from two different sources. In particular, the Collected Data should include the complete portfolios of the pension funds that provided data and has been extensively verified as described in Section I.2.1. The Eikon Data, on the other hand, does not necessarily capture all investment positions of Danish pension funds, and the company publishing the data does not claim to do so. As described above, Eikon only contains ownership information for significantly less than 100% of the shares outstanding of each stock. Nevertheless, and keeping these limitations in mind, it is useful to compare the Collected Data to an existing source of information on the portfolios of pension funds.

### I.2.5 Comparison of the Two Data Sources and Scientific Value

Although the Collected Data "only" covers the holdings of six pension funds, these funds held Danish listed equity worth 56.4 billion DKK at the end of 2019. This represents 69.7% of all Danish listed equity assets held directly by the sector based on national statistics published by the Danish Central Bank (Danmarks Nationalbank, 2022).[16] The portfolios covered by the Collected Data, therefore, represent a significant part of the total domestic listed equity holdings of Danish pension funds.

As becomes apparent from Table I.1, the Collected Data covers significantly more instruments and periods than the investment records of Danish pension funds in Eikon. The Collected Data includes 9,046 investor-ISIN-quarter observations compared to 1,462 in the Eikon Data. Therefore, the Collected Data captures significantly more shareholdings than the Eikon Data. In fact, according to the Collected Data, a single pension fund on average invests in 36.2 different stocks per quarter and is present in the dataset

[16] Own calculations based on Danmarks Nationalbank (2022) before fund look-through. After fund look-through, the value of the holdings covered in the Collected Data represents 50.1% of Danish pension funds' total investment in domestic listed equity at the end of 2019. As it is not possible to evaluate the exact degree of fund look-through performed by the pension funds covered in the Collected Data, the true coverage of the Collected Data lies between 50.1% and 69.7%. However, I argue that it is sensible to compare the Collected Data to the statistics on direct holdings since most participating funds indicated to have performed a partial fund look-through. Furthermore, the statistics published by the Danish Central Bank include pension funds as well as insurance companies, while the data collection exercise only targets pension funds.

for 41.7 quarters, compared to 6.02 instruments and 30.4 quarters, respectively, in the Eikon Data. Therefore, the Collected Data gives a much more diversified picture of Danish pension funds' domestic listed equity portfolios than the alternative data source. Furthermore, the size of the average stake that a pension fund holds is 2.17% of total shares outstanding in the Collected Data and 9.75% in the Eikon Data. One explanation for the smaller number of holdings but the higher average size of each holding could be that the Eikon Data focuses on larger positions. This fact should be kept in mind by the reader for the remainder of this paper.

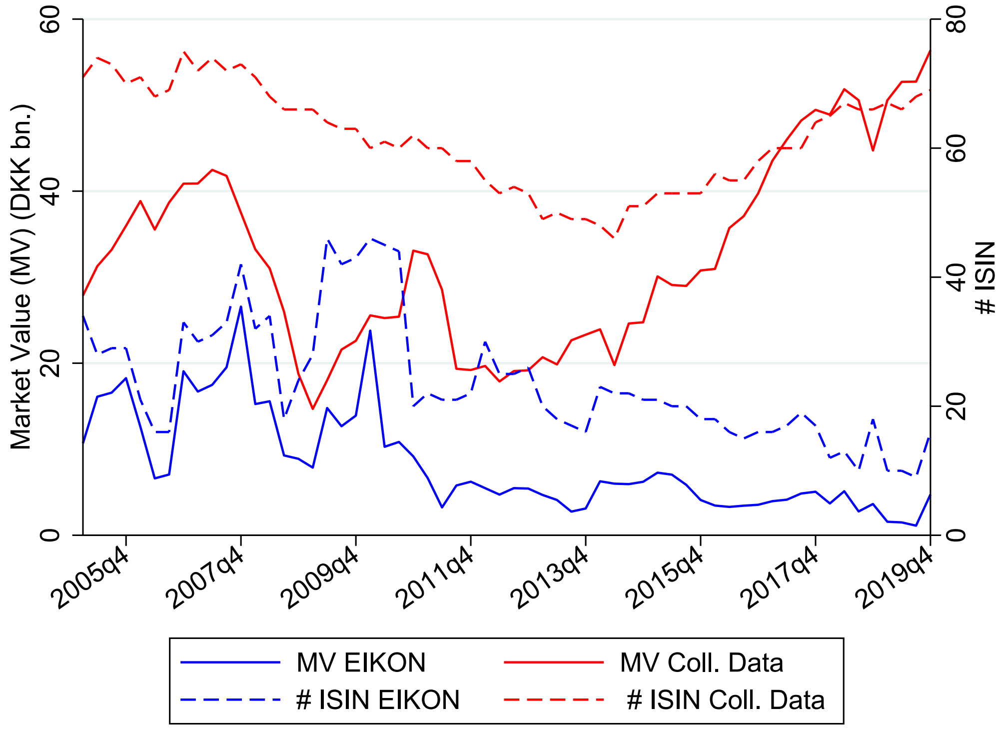
To further compare the Collected Data and Eikon Data, Figure I.1 shows the total number of unique instruments held by domestic pension funds and the respective value of these holdings in the two data sources. Across the sample period, the Collected Data gives a much more comprehensive picture of Danish pension fund investment in Danish equities than Refinitiv Eikon. The six Danish funds included in the Collected Data together on average invest in 62 different stocks per quarter, amounting to almost 33.5 billion DKK. The Eikon Data on the other hand only shows close to 24 different instruments with a value of approximately 8.4 billion DKK. Therefore, the Collected Data gives a much more diverse picture of Danish pension funds' portfolios than the Eikon Data. It is important to note that the number of investors included in the Collected Data increases over time, partly explaining the increase in portfolio value and stocks in later years.[17]

Finally, I inspect the 1,146 overlapping observations in the Collected Data and Eikon. "Overlapping" means that the same pension fund holds the same stock at the same period in both datasets. Looking at these instances, Danish pension funds in the Eikon Data together on average hold 9.65% of the stock per period, with a median value of 8.99%. These values stand at 9.15% and 8.08%, respectively, when considering the Collected Data. Thus, the information given in both datasets is very similar for overlapping observations. The Collected Data, however, contains over 6 times more pension fund positions than Eikon. These observations, combined with the fact that the Collected data was obtained from, and verified by, the investor directly, yield the conclusion that the main advantage of the Collected Data is that it covers the entirety of a pension fund's portfolio, or at least significantly more than one readily available database. While data on the portfolios of Danish pension funds from sources other than Eikon is not available

[17] I intentionally refrain from showing the number of pension funds in the Collected Data over time for reasons of data confidentiality.

for this study, it is very likely that the Collected Data also outperforms other third-party sources of data.

**Figure I.1.** Coverage of Pension Fund Investment in the Collected Data and Eikon Data




*Notes:* This figure presents the aggregate number of different stocks held by Danish pension funds over the sample period, as well as the total market value (MV) of these holdings, in the Collected Data and the Eikon Data.

To summarise, the Collected Data covers a significant part of the Danish listed equity investment of Danish pension funds based on national statistics. It also contains much more complete information on these portfolios than a widely-used financial database. Therefore, the Collected Data represents a meaningful addition to the data universe about pension fund investment in Denmark.

Given that the Collected Data is similar to the Eikon Data on domestic pension funds when the two datasets overlap, but contains a significantly higher number of financial positions, I exclude the data on Danish pension funds in the Eikon Data from all subsequent analyses. In the remainder of this paper, investors are therefore classified into four different investor types: i) *Other – Domestic*, containing investors headquartered in Denmark that are not pension funds; ii) *Other – Foreign*, consisting of foreign investors that are not pension funds; iii) *Pension Fund – Foreign*, reflecting information on the

Danish holdings of foreign pension funds; and iv) *Pension Fund – Domestic*, containing the holding information directly collected from Danish pension funds described in Section I.2.1.[18] To clarify, the source of information for all investor types except *Pension Fund – Domestic* is Refinitiv Eikon.

# I.3 Combined Dataset for Empirical Analysis

This section describes the sample used in the empirical analysis of Section I.4. Section I.3.1 details the construction of the variables and Section I.3.2 presents descriptive statistics. The sample at the investor-ISIN-quarter level resulting from the cleaning procedure described in Section I.2.4 is used to construct all variables. Eventually, the data is aggregated to the investor-quarter level for the empirical analysis of Section I.4.

## I.3.1 Variable Construction

*Investor Activity*

To measure investor activity, I construct the active share measure developed by Cremers and Petajisto (2009). This variable measures how much an investor engages in stock picking relative to a benchmark index. Formally, let $Z_{i,t}$ be the set of stocks that investor $i$ holds at time $t$ and let stock $z$ be an element of this set. Then:

$$Active\ Share_{i,t} = \frac{1}{2} \sum_{z \in Z_{i,t}} |w_{i,z,t} - w_{index,z,t}| \tag{I.1}$$

Where $w_{i,z,t}$ is the weight of stock $z$ in investor $i$'s portfolio in quarter $t$, measured as the value of the shares of stock $z$ divided by the total value of the investor's portfolio, and $w_{index,z,t}$ is the weight of stock $z$ in a benchmark index. I choose the OMX Copenhagen All Share Index (hereafter OMX CPH Index) published by Eikon as the benchmark and set $w_{index,z,t}$ as the share of the market capitalization of stock $z$ in the total market capitalization of all stocks in the index at time $t$. $Active\ Share_{i,t}$ measures how much the portfolio composition of investor $i$ differs from the composition of the benchmark index using as weights the total market capitalisation of each stock. A value of $Active\ Share_{i,t}$ equal to zero means that the investor has a portfolio structure equal to

[18]Appendix Table A.1 shows statistics on the investors included in the types *Other – Domestic* and *Other – Foreign*.

simply weighting individual stocks by their share in the benchmark index. A high value of $Active\ Share_{i,t}$, on the other hand, signals that the investor engages significantly in stock picking in quarter $t$.

*Investment Horizon*

Investment horizon is a key issue in policy discussions about institutional investors in general and pension funds specifically (Della Croce et al., 2011; OECD, 2022). The intuition is that pension funds' long-term liabilities should allow them to adopt a longer investment horizon than other investors. The longer investment horizon of pension funds has been documented in parts of the literature on institutional investors (e.g. Cella et al., 2013; Cremers & Pareek, 2016; Döring et al., 2021). To test if Danish pension funds exhibit a longer investment horizon than other institutional investors in Danish listed equity assets, I construct two measures of investment horizon.

As a first measure of investment horizon, I compute the non-zero-points duration (Bøhren et al., 2005; Elyasiani & Jia, 2010). The stock-level non-zero-points duration $NZD_{i,z,t}$ measures how many quarters a stock $z$ is in investor $i$'s portfolio from $t-7$ to $t$. It is therefore calculated over a rolling window of 8 quarters (2 years). $NZD_{i,z,t}$ is only computed for stocks that are present in the investor's portfolio in quarter $t$. To obtain a measure at the investor-quarter level, I calculate the value-weighted average of the non-zero-points durations of all stocks $z$ that investor $i$ holds in a given period:

$$NZDW_{i,t} = \sum_{z \in Z_{i,t}} w_{i,z,t} \times NZD_{i,z,t} \tag{I.2}$$

$NZDW_{i,t}$ is a proxy for investment horizon reflecting how stable an investor's portfolio is on average. A value of 5, for example, means that investor $i$ has held the stocks present in its portfolio in quarter $t$ for an average of 5 out of the 8 most recent quarters, weighted by the value of each stock in its portfolio at time $t$. Weighting the non-zero-points duration of each stock by value ensures that larger positions are more important when calculating the measure.

My second measure of investment horizon is based on the portfolio churn rate proposed by Gaspar et al. (2005). The churn rate is a measure of portfolio turnover, meaning how much of its portfolio the investor modifies per quarter, relative to the size of the portfolio. In the first step, the quarterly churn rate of investor $i$ is calculated as:

$$CR_{i,t} = \frac{\sum\limits_{z \in Z_{i,t}} |N_{i,z,t}P_{z,t} - N_{i,z,t-1}P_{z,t-1} - N_{i,z,t-1}\Delta P_{z,t}|}{\sum\limits_{z \in Z_{i,t}} \frac{N_{i,z,t}P_{z,t} + N_{i,z,t-1}P_{z,t-1}}{2}} \tag{I.3}$$

where $N_{i,z,t}$ and $P_{z,t}$ are the number of shares of stock $z$ held by investor $i$ and the stock price, respectively. $\Delta P_{z,t}$ is the change in the price of stock $z$ from $t-1$ to $t$.

In the second step, I follow the literature and measure the investment horizon of an investor by calculating its average quarterly churn rate over several quarters:

$$AvgCR_{i,t} = \sum_{r=1}^{M} \frac{CR_{i,t-r+1}}{M} \tag{I.4}$$

where I choose $M = 8$. $AvgCR_{i,t}$ reflects the average quarterly churn rate of investor $i$ over the most recent 8 quarters including the current quarter. The average churn rate is widely used in the literature to measure investment horizon (see e.g. Artiga González et al., 2020; Cella et al., 2013; Gaspar et al., 2005; Harford et al., 2018).[19] To give an example of interpretation for this measure, $AvgCR_{i,t}$=0.2 means that investor $i$ turns over 10% of its portfolio per quarter on average over the most recent 8 quarters (Gaspar et al., 2005). It is important to note that $AvgCR_{i,t}$ likely underestimates an investor's actual portfolio turnover since it is computed from end-of-quarter snapshots and does not take into account intra-quarter trading (Gaspar et al., 2005).

I compute two different measures of investment horizon because they reflect different dimensions of an investor's portfolio (Garel, 2017). $NZDW_{i,t}$ measures the stability of the portfolio. On the other hand, $AvgCR_{i,t}$ is a measure of portfolio turnover over several time periods and therefore reflects how much an investor trades over a defined time horizon. A second difference between the two measures is that the non-zero-points duration does not take into account the size of holdings in past quarters, while the average churn rate does so.

*Performance*

To measure investor performance, I first compute the raw quarterly portfolio return of the investor as:

[19] While most of the literature computes the average churn rate over four quarters, I choose eight quarters since eight quarters are used to calculate the non-zero-points duration. The main results of the empirical analysis are qualitatively similar using $AvgCR_{i,t}$ calculated over 4 quarters. These results are available on request.

$$R_{i,t} = \sum_{z \in Z_{i,t-1}} w_{i,z,t-1} R_{z,t} \tag{I.5}$$

Where $w_{i,z,t-1}$ is the weight of stock $z$ in the portfolio of investor $i$ at the end of quarter t-1 and $R_{z,t}$ is the total return of stock $z$ in quarter $t$.[20] Further, I also compute the quarterly value-weighted excess return of each investor's portfolio over a risk-free asset:

$$Excess\ Return_{i,t}^{rf} = R_{i,t} - R_{rf,t} \tag{I.6}$$

Where $R_{rf,t}$ is the rate of return on a risk-free asset. Since the sample only includes stocks listed in Denmark, I choose the interest rate on a 3-month Danish government bond as the risk-free rate. As a measure of risk-adjusted returns, I also compute investor-specific alphas from the CAPM model:

$$R_{i,t} - R_{rf,t} = \alpha_i + \beta\left(R_{M,t} - R_{rf,t}\right) + \epsilon_{i,t} \tag{I.7}$$

where $R_{M,t}$ is the return of a market portfolio, defined as the total return of the OMX CPH Index. The returns of the risk-free asset and the market portfolio are sourced from Refinitiv Eikon.

## I.3.2 Descriptive Statistics

Table I.2 presents descriptive statistics of the sample used in the quantitative analysis of Section I.4.2. Looking at the two measures of investment horizon, an investor on average holds a stock that is in its portfolio in period $t$ for 5.61 of the most recent 8 quarters, weighted by value. The average churn rate has a mean of 0.34, meaning that over the previous 2 years an investor on average turns over approximately 17% of its portfolio per quarter. Importantly, there is a large dispersion in the measure. Investors with a churn ratio below the 5th percentile on average do not modify their portfolios, while investors with a churn ratio above the 95th percentile turn over nearly 44% of their portfolios

[20] I collect stock return data from Refinitiv Eikon, defined as total return including dividend payments. Equation (I.5) implicitly makes the assumption that the stock holdings observed at the end of quarter $t-1$ are maintained until the end of the last day of quarter $t$. Therefore, the investor earns the full return $R_{z,t}$ on its holding of stock $z$ as recorded by $w_{i,z,t-1}$. Such an assumption is necessary since I do not observe the exact date of each trade, but only the portfolio composition at the end of each quarter.

on average per quarter. The average active share stands at over 78%. This high value is in line with the literature, for example Cremers and Pareek (2016). Turning to the performance measures, on average an investor achieves a raw quarterly return of 3.15% on its Danish listed equity portfolio, while the average excess return over the risk-free rate stands at 2.55%. On average, investors outperform the OMX CPH Index by 0.15% per quarter. The mean alpha is 0.07%. Lastly, the average portfolio is valued at 589.46 million DKK. This rather small value is driven by the many foreign investors that hold a small portfolio of Danish stocks (see Table I.1).

**Table I.2.** Descriptive Statistics

| | N | Mean | SD | P05 | Median | P95 |
|---|---|---|---|---|---|---|
| Non-Zero Points Duration (weighted) | 40,971 | 5.61 | 2.17 | 2.00 | 6.00 | 8.00 |
| Avgerage Churn Rate | 40,971 | 0.34 | 0.28 | 0.00 | 0.29 | 0.87 |
| Active Share | 40,971 | 78.42 | 17.39 | 44.15 | 79.41 | 99.53 |
| Raw return (%) | 40,971 | 3.15 | 12.77 | -16.68 | 3.47 | 21.86 |
| Excess Return over Risk-Free Rate (%) | 40,971 | 2.55 | 13.15 | -18.56 | 3.14 | 21.40 |
| Excess Return over CPH OMX Index (%) | 40,971 | 0.15 | 9.46 | -14.92 | 0.20 | 13.61 |
| Alpha (CAPM, %) | 1,975 | 0.07 | 6.18 | -7.90 | 0.21 | 6.38 |
| Portfolio Size (Million DKK) | 40,971 | 589.46 | 2,708.76 | 0.77 | 33.35 | 2,221.34 |

*Notes:* This table presents descriptive statistics on the sample used in the empirical analysis of Section I.4. The sample consists of the Collected Data combined with the data from Refinitiv Eikon's shareholder history module, excluding the portfolios of Danish pension funds included in the data from Eikon.

# I.4 Empirical Analysis

This section presents the empirical methodology used to compare domestic pension funds and other institutional investors, as well as the results of the analysis.

## I.4.1 Methodology

To remind the reader, the 1,975 investors in the sample are classified into the following investor types for the analysis: i) *Other – Domestic*, containing investors headquartered in Denmark that are not pension funds (58 investors); ii) *Other – Foreign*, consisting of foreign investors that are not pension funds (1,887 investors); iii) *Pension Fund – Foreign*, reflecting information on the Danish holdings of foreign pension funds (24 investors); and iv) *Pension Fund – Domestic*, containing the holding information directly collected from

Danish pension funds described in Section I.2.1 (6 investors).[21] To clarify, the source of information for all investor types except *Pension Fund – Domestic* is Refinitiv Eikon.

To investigate differences between domestic pension funds and other investors, I estimate the following specification:

$$Y_{i,t} = \alpha_0 + \beta_{OD} Type_i^{OD} + \beta_{OF} Type_i^{OF} + \beta_{PFF} Type_i^{PFF} + \delta_t + \epsilon_{i,t} \tag{I.8}$$

$$\text{with} \begin{cases} Type_i^{OD} = 1, & \text{if } Investor\ Type_i = Other - Domestic, \text{ 0 otherwise} \\ Type_i^{OF} = 1, & \text{if } Investor\ Type_i = Other - Foreign, \text{ 0 otherwise} \\ Type_i^{PFF} = 1, & \text{if } Investor\ Type_i = Pension\ Fund - Foreign, \text{ 0 otherwise} \end{cases}$$

where $Y_{i,t}$ is the outcome of interest (investment horizon, activity or performance) of investor $i$ in period $t$ and $\alpha_0$ is a constant. The investor types are included as a series of indicator variables as described above. Lastly, $\delta_t$ are quarter fixed effects and $\epsilon_{i,t}$ is an idiosyncratic error term. Since the goal of this paper is to compare domestic pension funds to other investors, the focus is primarily on the coefficients of the investor type indicators. In all specifications, the omitted investor type is *Pension Fund – Domestic*. Therefore, the coefficients of the type indicators should be interpreted as differences between a specific investor type and domestic pension funds. All specifications are estimated using OLS.

## I.4.2 Investment Horizon, Activity and Performance

I start by comparing domestic pension funds and other investors regarding their investment horizon. Since the weighted non-zero-points duration is computed over 8 quarters, investors that have been in the dataset for less than 8 quarters have, by definition, a shorter non-zero-points duration. To make sure that results are not distorted by the amount of time an investor is in the sample, I condition that an investor must have been in the sample for 8 quarters from $t-7$ to $t$ in order to be included in the analysis. This excludes all observations before 2006Q4, the 8th quarter of the sample period.

[21] Appendix Table A.1 shows statistics on the investors included in the types *Other – Domestic* and *Other – Foreign*.

Table I.3 presents the results from estimating equation (I.8) using the two measures of investment horizon as dependent variables. Higher values of $NZDW_{i,t}$ mean a longer investment horizon, while higher values of $AvgCR_{i,t}$ reflect higher average portfolio turnover and consequently a shorter investment horizon. Therefore, a *negative* coefficient in columns 1–4 of Table I.3 means that the specific investor type has a shorter investment horizon than domestic pension funds, on average. The same interpretation holds for a *positive* coefficient in columns 5–8.

Column 1 of Table I.3 shows results from the estimation of equation (I.8) without any additional controls. The first coefficient in column 1 shows that, on average, other domestic investors hold a stock for 0.484 quarters less than domestic pension funds over 8 quarters (column 1). While this difference may appear small, it represents over 8% of the sample average, so it is not negligible. The coefficient of 0.077 in the first row of column 5 means that other domestic investors have a 7.7 percentage points higher quarterly churn rate, averaged over two years, than domestic pension funds. This means that other domestic investors on average turn over approximately 3.7% more of their portfolio on a quarterly basis compared to domestic pension funds, measured over two years. Again, while the coefficient equal to 0.077 may appear small, it represents over 22% of the mean average churn rate in the sample equal to 0.34.

These results show that domestic pension funds have a longer investment horizon than other domestic investors. Furthermore, non-pension fund foreign investors also display a significantly shorter investment horizon than domestic pension funds. Depending on the specification, the coefficient of the investor type *Other – Foreign* can reach twice the magnitude of the coefficient of the type *Other – Domestic*, meaning that the difference to domestic pension funds is much larger for foreign non-pension fund investors than domestic ones. However, I do not find clear evidence that foreign pension funds display a different investment horizon than domestic pension funds, as the coefficients have the according sign but are mostly not statistically significant.

To control for investor heterogeneity beyond investor type, as suggested by Garel (2017), columns 2–4 and 6–8 of Table I.3 show results of specifications including investor size and active share to proxy for indexing strategies. $Size_{i,t}$ is the (log) value of the investor's portfolio at the end of quarter $t$ and $HighAS_{i,t}$ is a dummy variable equal to one if the investor's active share value is in the highest tercile of its quarter-specific distribution.[22] The conclusions remain unchanged when controlling for these factors.

[22] I model active share as a dummy in these specifications to avoid multicollinearity issues with the

Overall, the results show that domestic pension funds have a longer investment horizon than non-pension funds, domestic or foreign.

**Table I.3.** Investment Horizon

| Dependent Var.: | $NZDW_{i,t}$ | | | | $AvgCR_{i,t}$ | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| $Other - Domestic$ | -0.484*** | -0.246** | -0.359*** | -0.202* | 0.077** | 0.055** | 0.081*** | 0.062** |
| | (0.129) | (0.107) | (0.134) | (0.111) | (0.030) | (0.027) | (0.030) | (0.026) |
| $Other - Foreign$ | -0.947*** | -0.467*** | -0.868*** | -0.464*** | 0.189*** | 0.144*** | 0.191*** | 0.144*** |
| | (0.094) | (0.074) | (0.096) | (0.075) | (0.026) | (0.023) | (0.026) | (0.023) |
| $Pension\ Fund - Foreign$ | -0.281 | -0.103 | -0.253 | -0.102 | 0.068* | 0.051 | 0.069* | 0.051 |
| | (0.182) | (0.161) | (0.178) | (0.160) | (0.036) | (0.034) | (0.036) | (0.034) |
| $Size_{i,t}$ | | 0.115*** | | 0.106*** | | -0.011*** | | -0.012*** |
| | | (0.012) | | (0.013) | | (0.002) | | (0.002) |
| $HighAS_{i,t}$ | | | -0.320*** | -0.159** | | | -0.009 | -0.028** |
| | | | (0.068) | (0.068) | | | (0.012) | (0.012) |
| Time FE | Quarter | Quarter | Quarter | Quarter | Quarter | Quarter | Quarter | Quarter |
| N | 25,914 | 25,914 | 25,914 | 25,914 | 25,914 | 25,914 | 25,914 | 25,914 |
| Adjusted $R^2$ | 0.027 | 0.053 | 0.034 | 0.054 | 0.037 | 0.048 | 0.037 | 0.051 |

*Notes:* This table presents the main results on investment horizon. All specifications are estimated using OLS. $NZDW_{i,t}$ is the weighted non-zero-points duration of investor $i$ computed over the most recent 2 years including quarter $t$. $AvgCR_{i,t}$ is the average churn rate computed over the same period. $Size_{i,t}$ is the (log) value of the investor's portfolio at the end of quarter $t$. $HighAS_{i,t}$ is a binary variable equal to one if the value of $Active\ Share_{i,t}$ is in the top tercile of its quarter-specific distribution. All models include a constant that is not reported and quarter fixed effects. The omitted investor type are domestic pension funds in all specifications. White heteroskedasticity-robust standard errors are clustered at the quarter and investor levels and are reported in parentheses. Finally, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Moving on to investor activity, Table I.4 shows results from estimating equation (I.8) using $Active\ Share_{i,t}$ as the dependent variable. As explained above, $Active\ Share_{i,t}$ measures how much the investor's portfolio weights differ from the composition of the OMX CPH Index. Therefore, it measures the degree of stock picking that the investor engages in relative to the index. Column 1 of Table I.4 shows that, without controlling for other investor characteristics, other domestic investors have, on average, a 30 percentage points higher active share than domestic pension funds. To contextualise, this difference represents more than 38% of the mean active share value in the sample and is therefore meaningful. Foreign investors that are not pension funds have on average a 34 percentage points higher active share value, while foreign pension funds display a much smaller, but still significant difference of 18 percentage points to domestic pension funds. Since Cremers and Petajisto (2009) show a significant relationship between active share and portfolio size, I control for the total value of the investor's portfolio in column 2. While the differences between domestic pension funds and other investors decrease,

investor type indicators.

they still remain significant. To summarise, I find evidence that Danish pension funds engage significantly less in stock picking than other institutional investors in Danish listed equity.

**Table I.4.** Investor Activity

| Dependent Var.: | $Active\ Share_{i,t}$ | |
|---|---|---|
| | (1) | (2) |
| $Other - Domestic$ | 30.377*** | 23.780*** |
| | (3.886) | (3.787) |
| $Other - Foreign$ | 34.731*** | 21.417*** |
| | (1.797) | (1.951) |
| $Pension\ Fund - Foreign$ | 18.038*** | 12.274*** |
| | (3.912) | (3.251) |
| $Size_{i,t}$ | | -2.864*** |
| | | (0.161) |
| Time FE | Quarter | Quarter |
| N | 40,971 | 40,971 |
| Adjusted $R^2$ | 0.067 | 0.218 |

*Notes:* This table presents the main results on investor activity. The dependent variable in all columns is $Active\ Share_{i,t}$ as proposed by Cremers and Petajisto (2009). It measures how much the investor's portfolio composition differs from that of the benchmark index. $Size_{i,t}$ is the (log) value of the investor's portfolio at the end of quarter $t$. All models include a constant that is not reported and quarter fixed effects. The omitted investor type are domestic pension funds in all specifications. White heteroskedasticity-robust standard errors are clustered at the quarter and investor levels and are reported in parentheses. Finally, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Turning to the question of whether domestic pension funds outperform other institutional investors, Table I.5 presents results on the relationship between investor type and portfolio return. In columns 1–4, the dependent variable used in the estimation of equation (I.8) is the quarterly return of the investor portfolio in excess of the risk-free rate. I control for investor heterogeneity by including in the specification the investor size (column 2) as is common in the literature, and also a dummy equal to one if the investor has an *Active Share* value in the top tercile of its quarter-specific distribution (column 3) (as in Artiga González et al., 2020). While columns 1–3 suggest that domestic pension funds on average achieve a 0.5–0.9 percentage point higher excess return on their Danish listed equity portfolio than other domestic investors, the difference loses statistical significance when controlling for both investor size and active share in column 4. Moving on to risk-adjusted returns, Column 5 shows the results of a cross-sectional regression of the alpha from equation (I.7) on the investor type indicators.[23] None of the coefficients are statistically significant, suggesting no meaningful differences between domestic pension funds and other investors in terms of average risk-adjusted returns. To summarise, the analysis does not yield clear evidence that domestic pension funds on average perform differently than other institutional investors.

**Table I.5.** Investor Performance

| Dependent Var.: | $Excess\ Return^{rf}_{i,t}$ | | | | $\alpha_i$ |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| $Other - Domestic$ | -0.933*** | -0.510* | -0.668** | -0.398 | -0.831 |
| | (0.278) | (0.299) | (0.313) | (0.303) | (1.030) |
| $Other - Foreign$ | -0.162 | 0.693* | 0.036 | 0.710* | -0.106 |
| | (0.326) | (0.375) | (0.504) | (0.398) | (0.239) |
| $Pension\ Fund - Foreign$ | -0.566 | -0.196 | -0.455 | -0.173 | -0.487 |
| | (0.771) | (0.756) | (0.822) | (0.775) | (0.966) |
| $Size_{i,t}$ | | 0.184*** | | 0.161*** | |
| | | (0.038) | | (0.052) | |
| $HighAS_{i,t}$ | | | -0.632 | -0.390 | |
| | | | (0.622) | (0.670) | |
| Time FE | Quarter | Quarter | Quarter | Quarter | No |
| N | 40,971 | 40,971 | 40,971 | 40,971 | 1,975 |
| Adjusted $R^2$ | 0.504 | 0.505 | 0.504 | 0.505 | -0.001 |
| $R^2$ | 0.505 | 0.506 | 0.505 | 0.506 | 0.000 |

*Notes:* This table presents the main results on investor performance. All specifications are estimated using OLS. $Excess\ Return^{rf}_{i,t}$ is the excess return of the investor over the risk-free rate in quarter $t$. $\alpha_i$ is the alpha from the CAPM model as described by equation (I.7). $Size_{i,t}$ is the (log) value of the investor's portfolio at the end of quarter $t$. $HighAS_{i,t}$ is a binary variable equal to one if the value of $Active\ Share_{i,t}$ is in the top tercile of its quarter-specific distribution. All models include a constant that is not reported and quarter fixed effects. The omitted investor type are domestic pension funds in all specifications. White heteroskedasticity-robust standard errors are clustered at the quarter and investor levels and are reported in parentheses. Finally, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

## I.4.3 Turnover and Performance During Market Turmoil

The previous subsection investigates if domestic pension funds, on average, exhibit a different investment horizon, are more active, and achieve a higher return in the domestic listed equity space than other institutional investors. I now specifically address the

[23]The estimated equation is: $\alpha_i = \beta_0 + \beta_{OD}Type^{OD}_i + \beta_{OF}Type^{OF}_i + \beta_{PFF}Type^{PFF}_i + \epsilon_i$ where $\alpha_i$ is estimated via equation (I.7) and $\beta_0$ is a constant.

question of whether the trading intensity and performance of domestic pension funds differ from those of other investors during periods of financial market turmoil. The performance of pension funds is important since it ultimately has a significant impact on the level of retirement savings in the population. Their trading behaviour during market crises is relevant because large investors can amplify financial market shocks if they trade in the same direction (Ben-David et al., 2021; Cella et al., 2013; Thomas et al., 2014). In fact, column 7 of Table I.1 shows that if a Danish pension fund holds a stock, it is on average in the top quintile of largest shareholders of the stock. Therefore, these investors often hold large stakes compared to other investors.

For this analysis, I adopt an empirical methodology similar to Cella et al. (2013) and interact the variable of interest, in this case indicators reflecting the investor type, with a dummy taking value 1 in quarters of market turmoil. The resulting specification is:

$$\begin{aligned} CR_{i,t} = &\alpha_0 + \beta_1 Turmoil_t \\ &+ \beta_{OD} Type_i^{OD} + \gamma_{OD} Type_i^{OD} \times Turmoil_t \\ &+ \beta_{OF} Type_i^{OF} + \gamma_{OF} Type_i^{OF} \times Turmoil_t \\ &+ \beta_{PFF} Type_i^{PFF} + \gamma_{PFF} Type_i^{PFF} \times Turmoil_t \\ &+ \delta_t + \epsilon_{i,t} \end{aligned} \tag{I.9}$$

where $CR_{i,t}$ is the quarterly churn rate measuring portfolio turnover defined by equation (I.3), $Turmoil_t$ is a binary variable taking value 1 if quarter $t$ is a quarter of market turmoil, and $\delta_t$ are year fixed effects. All specifications are estimated via OLS. The main coefficients of interest are the $\gamma$ coefficients of the interaction terms between the investor type dummies and the Turmoil dummy. A positive and significant coefficient indicates that investors of a specific type increase portfolio turnover more than domestic pension funds, the reference category, during times of market turmoil. In other terms, a significant coefficient indicates that the investor type reacts more strongly to market turmoil than domestic pension funds. I exclude investors that are not in the sample during any quarter of market turmoil from the analyses in this subsection.[24]

Quarters of market turmoil are defined as quarters that contain a month in which two factors occur simultaneously: i) the monthly return of the OMX CPH Index is in the

[24]The main conclusions, however, also hold when including all investors in the analysis. See Table A.2 in the Appendix.

bottom 5th percentile of returns over the period 2005–2019, and ii) the monthly volatility of the index returns, defined as the standard deviation of daily returns, is above the 95th percentile of the distribution.[25] Using this definition, the quarters of market turmoil in the sample are 2008Q3 and 2008Q4, coinciding with the market shocks surrounding the Lehman Brothers bankruptcy on 15th September 2008, as well as 2011Q3, the quarter of the stock market crash known as Black Monday 2011.

Table I.6 shows the main results on portfolio turnover and market turmoil obtained from the estimation of equation (I.9). The negative coefficient of $Turmoil_t$ in column 1 indicates that portfolio turnover is on average lower during periods of financial market turmoil. Column 2 shows that when omitting the Turmoil dummy, non-pension funds, domestic or foreign, on average turn over more of their portfolio on a quarterly basis than domestic pension funds, while there are no significant differences between foreign pension funds and the latter. Column 3 shows results from the model including the interaction terms. The coefficient of the interaction term is only statistically significant for the investor type *Other – Domestic*. The positive sign of it means that domestic investors other than pension funds increase portfolio turnover more than domestic pension funds during times of market turmoil. This is evidence that other domestic investors react more strongly to periods of market turmoil by increasing their trading activity than domestic pension funds. On the other hand, I do not find evidence that episodes of financial market distress affect foreign pension funds differently than domestic pension funds regarding portfolio turnover.

These results are confirmed when additionally controlling for investor size at the end of the previous quarter, as is common in the literature, and also by the inclusion of a full set of investor fixed effects to control for time-invariant investor heterogeneity (columns 5–7).[26] The main conclusion from this analysis is that domestic pension funds increase their trading activity less than other domestic institutional investors during periods of

[25] This approach is inspired by Cella et al. (2013) who use changes of the VIX index and returns of the S&P 500 index to identify periods of market turmoil. Since the stock sample I use is restricted to the Nasdaq Copenhagen, I define market turmoil based on the Danish stock market. My conclusions are however robust to using the same definition of market turmoil as Cella et al. (2013) and alternative definitions, see Section I.4.4.

[26] Table A.3 in the Appendix shows results only using the sample of investors headquartered in Denmark. In these specifications, the investors in the group *Other – Domestic* are classified based on the more specific investor types given by Refinitiv Eikon. The results suggest that the differences between domestic pension funds and other domestic investors are driven by investment advisors and especially hedge funds. Furthermore, unreported results show that the interaction terms are not statistically significant when replacing the Turmoil dummy with its one-period lag. Therefore, domestic pension funds do not simply react to market turmoil later than other investors.

market turmoil.

**Table I.6.** Turnover and Market Turmoil

| Dependent Var.: | $CR_{i,t}$ | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| $Turmoil_t$ | -0.084* | | -0.086* | -0.079 | -0.082* | -0.095** | -0.087* |
| | (0.046) | | (0.047) | (0.049) | (0.045) | (0.047) | (0.050) |
| $Other-Domestic$ | | 0.098*** | 0.087** | 0.056* | | | |
| | | (0.036) | (0.037) | (0.029) | | | |
| $Other-Foreign$ | | 0.199*** | 0.199*** | 0.118*** | | | |
| | | (0.029) | (0.031) | (0.025) | | | |
| $Pension\ Fund-Foreign$ | | 0.042 | 0.042 | 0.006 | | | |
| | | (0.039) | (0.042) | (0.038) | | | |
| $Turmoil_t \times Other-Domestic$ | | | 0.213*** | 0.206*** | | 0.232*** | 0.221*** |
| | | | (0.067) | (0.067) | | (0.075) | (0.078) |
| $Turmoil_t \times Other-\ Foreign$ | | | -0.007 | -0.018 | | 0.004 | -0.009 |
| | | | (0.041) | (0.043) | | (0.041) | (0.045) |
| $Turmoil_t \times Pension\ Fund-Foreign$ | | | -0.002 | -0.006 | | 0.014 | 0.010 |
| | | | (0.070) | (0.071) | | (0.069) | (0.078) |
| $Size_{i,t-1}$ | | | | -0.020*** | | | -0.053*** |
| | | | | (0.003) | | | (0.005) |
| Time FE | Year | Year | Year | Year | Year | Year | Year |
| Investor FE | No | No | No | No | Yes | Yes | Yes |
| N | 26,627 | 26,627 | 26,627 | 26,627 | 26,627 | 26,627 | 26,627 |
| Adjusted $R^2$ | 0.009 | 0.012 | 0.014 | 0.024 | 0.119 | 0.120 | 0.136 |

*Notes:* This table presents the main results on portfolio turnover and market turmoil. All specifications are estimated using OLS. The dependent variable is the quarterly churn rate $CR_{i,t}$ as defined by equation (I.3). $Turmoil_t$ is a dummy taking value 1 if quarter $t$ contains a month in which the monthly return of the OMX CPH Index was in the bottom 5th percentile of its distribution while the volatility of daily returns was above the 95th percentile. $Size_{i,t-1}$ is the (log) value of the investor's portfolio in the previous quarter. Time and investor fixed effects are included as specified. All models include a constant that is not reported. The omitted investor type are domestic pension funds in all specifications. White heteroskedasticity-robust standard errors are clustered at the quarter and investor levels and are reported in parentheses. Finally, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

I next turn to the analysis of investor performance and market stress. Table I.7 shows the results from the estimation of equation (I.9) using the quarterly excess portfolio return over the risk-free rate as the dependent variable. The negative coefficients of the type indicators in columns 3 and 4 suggest that domestic pension funds outperform the other investor types outside of periods of financial market stress, although the difference to foreign non-pension funds is not statistically significant. The large negative coefficients of the Turmoil dummy in all models suggest that, unsurprisingly, all investors, including domestic pension funds, perform significantly worse during periods of financial market distress. Nevertheless, the positive and significant coefficients of the interaction terms between the Turmoil dummy and the investor type indicators point to a less pronounced impact of market turmoil on the performance of investors other than domestic pension funds. However, when measuring performance as the excess return over the OMX CPH Index (Table I.8), the coefficients of the interaction terms remain positive but are not statistically significant anymore. The only coefficient that maintains statistical significance across both measures of performance is the negative coefficient of the type *Other – Domestic*, indicating that domestic pension funds on average outperform other domestic institutional investors outside of periods of financial market turmoil. Overall, the results on performance and market turmoil tentatively suggest that domestic pension funds outperform other domestic investors outside of episodes of financial market turmoil. The evidence regarding different impacts of market turmoil on performance across investor types, however, is inconclusive.

**Table I.7.** Performance and Market Turmoil, Excess Return over Risk-Free Rate

| Dependent Var.: | $Excess\ Return^{rf}_{i,t}$ | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| $Turmoil_t$ | -17.734*** | | -20.100*** | -20.099*** | -17.699*** | -20.096*** | -20.033*** |
| | (3.382) | | (3.143) | (3.145) | (3.370) | (3.164) | (3.150) |
| $Other - Domestic$ | | -0.983*** | -1.131*** | -1.134*** | | | |
| | | (0.343) | (0.372) | (0.314) | | | |
| $Other - Foreign$ | | -0.171 | -0.246 | -0.254 | | | |
| | | (0.243) | (0.239) | (0.331) | | | |
| $Pension\ Fund - Foreign$ | | -0.934*** | -1.112** | -1.115*** | | | |
| | | (0.347) | (0.429) | (0.410) | | | |
| $Turmoil_t \times Other - Domestic$ | | | 2.434** | 2.433** | | 2.544** | 2.461** |
| | | | (1.053) | (1.090) | | (1.189) | (1.159) |
| $Turmoil_t \times Other - Foreign$ | | | 2.353*** | 2.352*** | | 2.390*** | 2.285*** |
| | | | (0.437) | (0.529) | | (0.386) | (0.445) |
| $Turmoil_t \times Pension\ Fund - Foreign$ | | | 4.330 | 4.330* | | 3.984* | 3.954* |
| | | | (2.626) | (2.554) | | (2.042) | (2.020) |
| $Size_{i,t-1}$ | | | | -0.002 | | | -0.409*** |
| | | | | (0.057) | | | (0.131) |
| Time FE | Year | Year | Year | Year | Year | Year | Year |
| Investor FE | No | No | No | No | Yes | Yes | Yes |
| N | 26,627 | 26,627 | 26,627 | 26,627 | 26,627 | 26,627 | 26,627 |
| Adjusted $R^2$ | 0.353 | 0.294 | 0.353 | 0.353 | 0.352 | 0.352 | 0.353 |

*Notes:* This table presents results on performance and market turmoil. All specifications are estimated using OLS. The dependent variable $Excess\ Return^{rf}_{i,t}$ is the investor's excess return over the risk-free rate in quarter $t$. $Turmoil_t$ is a dummy taking value 1 if quarter $t$ contains a month in which the monthly return of the OMX CPH Index was in the bottom 5th percentile of its distribution while the volatility of daily returns was above the 95th percentile. $Size_{i,t-1}$ is the (log) value of the investor's portfolio in the previous quarter. Time and investor fixed effects are included as specified. All models include a constant that is not reported. The omitted investor type are domestic pension funds in all specifications. White heteroskedasticity-robust standard errors are clustered at the quarter and investor levels and are reported in parentheses. Finally, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

**Table I.8.** Performance and Market Turmoil, Excess Return over Index

| Dependent Var.: | $Excess\ Return^{index}_{i,t}$ | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| $Turmoil_t$ | 1.433 | | -0.777 | -0.792 | 1.445 | -0.735 | -0.708 |
| | (2.100) | | (1.283) | (1.283) | (2.107) | (1.309) | (1.303) |
| $Other - Domestic$ | | -1.010*** | -1.113*** | -1.042*** | | | |
| | | (0.326) | (0.365) | (0.379) | | | |
| $Other - Foreign$ | | -0.128 | -0.232 | -0.042 | | | |
| | | (0.332) | (0.342) | (0.459) | | | |
| $Pension\ Fund - Foreign$ | | -0.724 | -0.926 | -0.840 | | | |
| | | (0.620) | (0.645) | (0.643) | | | |
| $Turmoil_t \times Other - Domestic$ | | | 2.289 | 2.304 | | 2.410 | 2.375 |
| | | | (1.719) | (1.728) | | (1.737) | (1.722) |
| $Turmoil_t \times Other - Foreign$ | | | 2.201 | 2.226 | | 2.173 | 2.128 |
| | | | (1.522) | (1.532) | | (1.553) | (1.558) |
| $Turmoil_t \times Pension\ Fund - Foreign$ | | | 3.735 | 3.746 | | 3.408 | 3.395 |
| | | | (3.541) | (3.456) | | (3.056) | (3.075) |
| $Size_{i,t-1}$ | | | | 0.047 | | | -0.174* |
| | | | | (0.047) | | | (0.093) |
| Time FE | Year | Year | Year | Year | Year | Year | Year |
| Investor FE | No | No | No | No | Yes | Yes | Yes |
| N | 26,627 | 26,627 | 26,627 | 26,627 | 26,627 | 26,627 | 26,627 |
| Adjusted $R^2$ | 0.012 | 0.012 | 0.012 | 0.013 | 0.022 | 0.022 | 0.023 |

*Notes:* This table presents results on performance and market turmoil. All specifications are estimated using OLS. The dependent variable $Excess\ Return^{index}_{i,t}$ is the investor's excess return over the OMX CPH Index in quarter $t$. $Turmoil_t$ is a dummy taking value 1 if quarter $t$ contains a month in which the monthly return of the OMX CPH Index was in the bottom 5th percentile of its distribution while the volatility of daily returns was above the 95th percentile. $Size_{i,t-1}$ is the (log) value of the investor's portfolio in the previous quarter. Time and investor fixed effects are included as specified. All models include a constant that is not reported. The omitted investor type are domestic pension funds in all specifications. White heteroskedasticity-robust standard errors are clustered at the quarter and investor levels and are reported in parentheses. Finally, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

## I.4.4 Robustness Analysis

This subsection describes a series of exercises to test the robustness of the main findings. The results of these exercises are available in the tables in Appendix A.

I first test the sensitivity of the results on investment horizon, activity and performance described in Section I.4.2. Since the number of pension funds covered by the Collected Data increases over time, as a first exercise I modify the sample period. Tables A.4 and A.5 in the Appendix show results on investment horizon over the periods 2010–2019 and 2015–2019, respectively. Although statistical significance levels are lower than in the main analysis, notably when only using the much shorter period 2015–2019, the coefficients of the investor type indicators almost always remain negative, and, if positive, are not statistically significant. This robustness check, therefore, confirms the main conclusions based on Table I.3. As a second exercise, I extend the period over which the two measures of investment horizon are calculated from two to five years. To be included in these estimations, an investor must be in the sample for the most recent 20 quarters, compared to 8 quarters in the baseline analysis. This results in a much smaller sample size than in the baseline analysis. Appendix Table A.6 shows the results of this exercise. While precision is reduced for some coefficients, the coefficients of the investor types *Other – Domestic* and *Other – Foreign* have the same sign and are statistically significant, therefore confirming the main conclusion of the baseline analysis (see Table I.3).

Moving on to the analysis of investor activity, Table A.7 shows the main investor activity results over the two alternative sample periods 2010–2019 and 2015–2019. These models confirm that domestic pension funds engage much less in stock picking than other institutional investors. Continuing with the analysis of Active Share, an investor holding only a small number of stocks will by definition have a high Active Share value since the benchmark index is composed of a large number of ISIN. To address this issue, I repeat the empirical analysis for the subsamples of portfolios containing at least 5, 10, or 15 different stocks. These results are presented in Appendix Table A.8 and show that all other investor types engage more in stock picking than domestic pension funds, although the coefficients are smaller than in the baseline results of Table I.4. Finally, Tables A.9 and A.10 show results for investor performance over the sample periods 2010–2019 and 2015–2019, respectively. As in the baseline results included in Table I.5, no clear differences in performance between domestic pension funds and other investor types emerge.

Turning to the testing of results about portfolio turnover and financial market turmoil in Section I.4.3, I first modify the definition of market turmoil by using the definition of Cella et al. (2013). According to this definition, a month is defined as a month of market turmoil if the monthly change of the VIX index is above the 95th percentile and the monthly return of the S&P 500 is simultaneously in the bottom 5th percentile. Any quarter containing a month fitting these criteria is defined as a quarter of market turmoil. This alternative definition results in the third and fourth quarters of 2008 being identified as periods of financial market stress. Table A.11 presents results from equation (I.9) using this alternative definition of market turmoil. As in the baseline analysis, other domestic investors increase their portfolio turnover or trading activity significantly more than domestic pension funds during times of financial market turmoil.

To further challenge my results, I use two additional definitions of market turmoil that focus solely on market volatility, instead of market volatility and market return as in the baseline analysis. Table A.12 presents these results. For ease of reading, only the models without investor fixed effects are presented since results are qualitatively similar if these fixed effects are included. In columns 1–4, a quarter of market turmoil is defined as a quarter when the quarterly price volatility of the OMX CPH Index is above the 95th percentile of the distribution. In columns 5–8, a quarter of market turmoil is defined as a quarter when the quarterly return volatility of the index is above the 90th percentile. The specific quarters that are categorised as periods of market turmoil are specified in the notes to Table A.12. These results also confirm the main conclusion that domestic pension funds increase their trading activity less than other domestic institutional investors during times of market turmoil.

Having confirmed the main finding using several definitions of market turmoil, I now use an alternative definition of portfolio turnover. Specifically, I compute the portfolio churn rate following Giannetti and Yu (2021) as the minimum of the absolute values of buys and sells by investor $i$ in a given quarter $t$, divided by the total value of its holdings at the end of quarter $t-1$. The stock prices at the end of quarter $t-1$ are used for all calculations. Table A.13 presents the results of equation (I.9) using this alternative definition of portfolio turnover. While at a lower significance level than in the baseline analysis, the coefficients of the interaction term remain positive and statistically significant for the investor type *Other – Domestic*, confirming the conclusion of the baseline analysis.

The baseline results could also be noisy because the sample includes the years 2005–2019, but market turmoil as defined in the baseline analysis only occurs in the years 2008 and 2011. I estimate the main specifications again excluding the years after 2012 to ensure that my conclusions do not depend on the time window without periods of financial market distress. Table A.14 depicts the results using the sample period 2005–2012. Although the precision is generally lower than in the baseline results, the difference in reaction to market turmoil between domestic pension funds and other domestic investors remains.

Table A.15 shows the results of two further exercises accounting for investor heterogeneity in diversification and size. The sample is restricted to investors that invest in more than 3 different stocks per quarter on average (columns 1–3) or to investors that have an average portfolio size above the 75th percentile. These results also confirm the main takeaways of the baseline analysis.[27]

Next, I include two alternative controls for investor heterogeneity in the models: the number of stocks that the investor holds in quarter $t-1$ and the difference in the number of stocks held between $t$ and $t-1$. The outcomes of this exercise are presented in Table A.16 and confirm the main conclusions since the coefficients of the interaction term of the investor type indicator with the Turmoil dummy remain positive and statistically significant.

Finally, I briefly discuss some robustness checks regarding the analysis of investor performance and market turmoil. Table A.17 shows results of specifications using the definition of Cella et al. (2013) to define periods of market turmoil. In columns 1–4, the dependent variable is the investor's quarterly excess return over the risk-free rate, while in columns 5–8 it is the quarterly return over the OMX CPH Index. Using this alternative definition of market turmoil, domestic pension funds outperform other domestic investors outside episodes of financial market distress. This is consistent with the results from the baseline analysis. Furthermore, the coefficients of most interaction terms become statistically insignificant when measuring performance as the excess return over the index. These results are broadly in line with the main results on performance and market turmoil in Tables I.7 and I.8. A similar pattern emerges from Table A.18 that shows the outcome of models using the same definition of market turmoil as the baseline analysis but restricting the sample to 2005-2012.

## I.5 Conclusion

This paper first presents a novel dataset about the domestic listed equity portfolios of Danish pension funds which has been directly collected from six large Danish pension funds. I combine this data with shareholder history data of Danish listed shares from Refinitiv Eikon to investigate whether domestic pension funds differ from other institutional investors across four important dimensions: i) investment horizon, ii) activity, iii) performance, and iv) trading behaviour and performance during times of market turmoil.

The first takeaway of this paper is that the novel data gives a much more comprehensive picture of the domestic listed equity portfolios of Danish pension funds than the

[27] Alternative thresholds yield qualitatively similar results.

data on these portfolios in Refinitiv Eikon. Therefore, the new dataset is a valuable new resource for research relying on data about the asset allocation of pension funds.

Further, the empirical analysis in this paper shows that Danish pension funds display a longer investment horizon than domestic and foreign institutional investors other than pension funds. On the other hand, I do not find that performance differs significantly between investor types on average. Furthermore, the results suggest that the trading activity of domestic pension funds increases less than that of other domestic institutional investors during times of market turmoil. Lastly, I do not find conclusive evidence that periods of market turmoil impact performance differently across investor types.

These results are relevant for policy makers since large institutional investors can raise concerns regarding the amplification of market shocks and more broadly for financial stability if they engage in significant pro-cyclical activities during market distress (Antolin & Stewart, 2009; Blake et al., 2017; Broeders et al., 2021; Duijm & Steins Bisschop, 2018). Furthermore, the findings on the trading behaviour of domestic pension funds relative to other investors are pertinent to the policy discussions about how pension funds can support the broader economy (OECD, 2022).

I contribute to the literature by investigating differences in investment horizon, activity and performance between different types of institutional investors in a small non-US economy, whereas most of the literature to date focuses on the US market. Furthermore, the novel source of information on pension fund investment gives a much more precise picture of the holdings of Danish pension funds than any other source currently available to the best of my knowledge. The data presented in this paper shows significantly better coverage of Danish pension funds' domestic listed equity investments than information from a widely used financial database. The unprecedented degree of detail and accuracy of the data will enable new avenues for research on the activities of the Danish pension sector and their effects on the wider economy.

While my results are robust to a number of refinements, one limitation of this study is that the shareholder data for domestic pension funds is directly collected from a subset of Danish pension funds, whereas the data for all other investors is sourced from a third-party financial database. This difference in sources needs to be kept in mind. Furthermore, the data on the portfolios of Danish pension funds does not cover all pension funds active in the country.

An interesting venture for future research would be to deepen the analysis of this paper by complementing the novel data presented in this paper with data containing more information on investor characteristics. While the present paper provides a descriptive analysis of differences between investor types, more research is needed to establish causal relationships explaining these differences and exploring their effects on financial market stability and corporate outcomes. Recent policy discussions about long-term investment will benefit from novel empirical evidence on the investment activities of pension funds, in particular since such funds are set to grow in the future.

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# Appendix A: Appendix to Chapter I

## Additional Statistics

**Table A.1.** Disaggregated Investor Types

| Investor location: | Domestic | | | Foreign | | |
|---|---|---|---|---|---|---|
| | (1) Investors | (2) Investor-period observations | (3) Investor-period - ISIN observations | (4) Investors | (5) Investor-period observations | (6) Investor-period - ISIN observations |
| Bank and Trust | 6 | 189 | 4,799 | 115 | 1,710 | 5,978 |
| Investment Advisor | 40 | 1,156 | 20,335 | 1,256 | 24,682 | 125,457 |
| Investment Advisor/Hedge Fund | 4 | 182 | 4,775 | 441 | 11,186 | 86,961 |
| Private Equity | 4 | 25 | 25 | 8 | 93 | 106 |
| Venture Capital | 4 | 90 | 187 | 10 | 180 | 195 |
| Foundation | | | | 2 | 19 | 257 |
| Hedge Fund | | | | 33 | 337 | 640 |
| Independent Research Firm | | | | 1 | 24 | 44 |
| Insurance Company | | | | 14 | 197 | 1,348 |
| Research Firm | | | | 3 | 51 | 266 |
| Sovereign Wealth Fund | | | | 4 | 122 | 1,955 |
| Total | 58 | 1,642 | 30,121 | 1,887 | 38,601 | 223,207 |

*Notes:* This table presents information on the disaggregated investor types in the data. In the quantitative analysis, the domestic investors shown in this table (columns 1–3) are collapsed into the investor type *Other – Domestic*. The foreign investors (columns 4–6) are collapsed into the type *Other – Foreign*. The full sample used in the empirical analysis of Section I.4 is composed of the 1,945 investors shown in this table, 6 domestic pension funds and 24 foreign pension funds.

# Additional Results

**Table A.2.** Turnover during Market Turmoil, All Investors

| Dependent Var.: | $CR_{i,t}$ | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| $Turmoil_t$ | -0.076 | | -0.084* | -0.087* | -0.076 | -0.088* | -0.080 |
| | (0.047) | | (0.048) | (0.049) | (0.046) | (0.047) | (0.051) |
| $Other - Domestic$ | | 0.095*** | 0.086** | 0.051* | | | |
| | | (0.033) | (0.034) | (0.029) | | | |
| $Other - Foreign$ | | 0.193*** | 0.193*** | 0.122*** | | | |
| | | (0.028) | (0.030) | (0.025) | | | |
| $Pension\ Fund - Foreign$ | | 0.046 | 0.047 | 0.016 | | | |
| | | (0.035) | (0.037) | (0.033) | | | |
| $Turmoil_t \times Other - Domestic$ | | | 0.214*** | 0.221*** | | 0.231*** | 0.221*** |
| | | | (0.065) | (0.066) | | (0.075) | (0.078) |
| $Turmoil_t \times Other - Foreign$ | | | -0.001 | 0.001 | | 0.004 | -0.010 |
| | | | (0.040) | (0.042) | | (0.041) | (0.045) |
| $Turmoil_t \times Pension\ Fund - Foreign$ | | | -0.005 | -0.006 | | 0.013 | 0.010 |
| | | | (0.068) | (0.069) | | (0.069) | (0.077) |
| $Size_{i,t-1}$ | | | | -0.015*** | | | -0.053*** |
| | | | | (0.002) | | | (0.004) |
| Time FE | Year | Year | Year | Year | Year | Year | Year |
| Investor FE | No | No | No | No | Yes | Yes | Yes |
| N | 40,971 | 40,971 | 40,971 | 40,971 | 40,971 | 40,971 | 40,971 |
| Adjusted $R^2$ | 0.006 | 0.009 | 0.010 | 0.016 | 0.129 | 0.129 | 0.144 |

*Notes:* This table presents results on portfolio turnover and market turmoil using all investors in the sample. As a reminder to the reader, the baseline models only include investors present in the sample during at least one period of market turmoil. All specifications are estimated using OLS. The dependent variable is the quarterly churn rate $CR_{i,t}$ as defined in equation (I.3). $Turmoil_t$ is a dummy taking value 1 if quarter $t$ contains a month in which the monthly return of the OMX CPH Index was in the bottom 5th percentile of its distribution while the volatility of daily returns was above the 95th percentile. $Size_{i,t-1}$ is the (log) value of the investor's portfolio in the previous quarter. Time and investor fixed effects are included as specified. All models include a constant that is not reported. The omitted investor type are domestic pension funds in all specifications. White heteroskedasticity-robust standard errors are clustered at the quarter and investor levels and are reported in parentheses. Finally, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

**Table A.3.** Turnover and Market Turmoil, Domestic Investors

| Dependent Var.: | $CR_{i,t}$ | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| $Turmoil_t$ | 0.074* | | -0.101** | -0.096** | 0.084* | -0.104** | -0.107* |
| | (0.037) | | (0.044) | (0.045) | (0.043) | (0.049) | (0.054) |
| *Bank and Trust* | | 0.084* | 0.086* | 0.005 | | | |
| | | (0.043) | (0.046) | (0.042) | | | |
| *Investment Advisor* | | 0.083** | 0.075* | 0.017 | | | |
| | | (0.039) | (0.042) | (0.030) | | | |
| *Investment Advisor/Hedge Fund* | | 0.184* | 0.156 | 0.082 | | | |
| | | (0.093) | (0.094) | (0.060) | | | |
| *Private Equity* | | -0.210*** | -0.206*** | -0.352*** | | | |
| | | (0.037) | (0.042) | (0.036) | | | |
| *Venture Capital* | | 0.053 | 0.048 | 0.006 | | | |
| | | (0.050) | (0.050) | (0.033) | | | |
| $Turmoil_t \times$ *Bank and Trust* | | | 0.016 | 0.020 | | 0.015 | 0.021 |
| | | | (0.084) | (0.071) | | (0.060) | (0.050) |
| $Turmoil_t \times$ *Investment Advisor* | | | 0.188* | 0.182* | | 0.198* | 0.196* |
| | | | (0.109) | (0.100) | | (0.113) | (0.109) |
| $Turmoil_t \times$ *Investment Advisor/Hedge Fund* | | | 0.632*** | 0.626*** | | 0.675*** | 0.632*** |
| | | | (0.060) | (0.099) | | (0.074) | (0.075) |
| $Turmoil_t \times$ *Private Equity* | | | 0.087 | 0.090 | | 0.089 | 0.092 |
| | | | (0.074) | (0.066) | | (0.073) | (0.071) |
| $Turmoil_t \times$ *Venture Capital* | | | 0.049 | -0.033 | | 0.051 | -0.056 |
| | | | (0.065) | (0.065) | | (0.066) | (0.079) |
| $Size_{i,t-1}$ | | | | -0.040*** | | | -0.059*** |
| | | | | (0.007) | | | (0.014) |
| Time FE | Year | Year | Year | Year | Year | Year | Year |
| Investor FE | No | No | No | No | Yes | Yes | Yes |
| N | 1,412 | 1,412 | 1,412 | 1,412 | 1,412 | 1,412 | 1,412 |
| Adjusted $R^2$ | 0.025 | 0.048 | 0.057 | 0.102 | 0.101 | 0.111 | 0.140 |

*Notes:* This table presents results on portfolio turnover and market turmoil for investors headquartered in Denmark and disaggregated by investor type. The investor type is sourced from Refinitiv Eikon. All investors included in the sample used for this analysis are aggregated into the investor type *Other – Domestic* in the baseline analysis. All specifications are estimated using OLS. The dependent variable is the quarterly churn rate $CR_{i,t}$ as defined in equation (I.3). $Turmoil_t$ is a dummy taking value 1 if quarter $t$ contains a month in which the monthly return of the OMX CPH Index was in the bottom 5th percentile of its distribution while the volatility of daily returns was above the 95th percentile. $Size_{i,t-1}$ is the (log) value of the investor's portfolio in the previous quarter. Time and investor fixed effects are included as specified. All models include a constant that is not reported. The omitted investor type are domestic pension funds in all specifications. White heteroskedasticity-robust standard errors are clustered at the quarter and investor levels and are reported in parentheses. Finally, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

# Results of Robustness Checks

**Table A.4.** Investment Horizon 2010–2019

| Dependent Var.: | $NZDW_{i,t}$ | | | | $AvgCR_{i,t}$ | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| $Other - Domestic$ | -0.440*** | -0.187* | -0.316** | -0.153 | 0.072*** | 0.046** | 0.077*** | 0.057** |
| | (0.116) | (0.108) | (0.124) | (0.113) | (0.024) | (0.022) | (0.024) | (0.021) |
| $Other - Foreign$ | -0.901*** | -0.417*** | -0.830*** | -0.415*** | 0.194*** | 0.146*** | 0.198*** | 0.147*** |
| | (0.073) | (0.075) | (0.076) | (0.076) | (0.018) | (0.017) | (0.018) | (0.017) |
| $Pension\ Fund - Foreign$ | -0.312* | -0.147 | -0.284 | -0.144 | 0.069** | 0.052 | 0.070** | 0.053 |
| | (0.177) | (0.171) | (0.174) | (0.170) | (0.032) | (0.031) | (0.032) | (0.032) |
| $Size_{i,t}$ | | 0.117*** | | 0.111*** | | -0.012*** | | -0.014*** |
| | | (0.013) | | (0.013) | | (0.002) | | (0.002) |
| $HighAS_{i,t}$ | | | -0.286*** | -0.110 | | | -0.013 | -0.035** |
| | | | (0.071) | (0.069) | | | (0.013) | (0.013) |
| Time FE | Quarter | Quarter | Quarter | Quarter | Quarter | Quarter | Quarter | Quarter |
| N | 22,195 | 22,195 | 22,195 | 22,195 | 22,195 | 22,195 | 22,195 | 22,195 |
| Adjusted $R^2$ | 0.019 | 0.048 | 0.025 | 0.049 | 0.033 | 0.047 | 0.034 | 0.051 |

*Notes:* This table presents results on investment horizon over the period 2010–2019. All specifications are estimated using OLS. $NZDW_{i,t}$ is the weighted non-zero-points duration of investor $i$ computed over the most recent 2 years including quarter $t$. $AvgCR_{i,t}$ is the average churn rate computed over the same period. $Size_{i,t}$ is the (log) value of the investor's portfolio at the end of quarter $t$. $HighAS_{i,t}$ is a binary variable equal to one if the value of $Active\ Share_{i,t}$ is in the top tercile of its quarter-specific distribution. All models include a constant that is not reported and quarter fixed effects. The omitted investor type are domestic pension funds in all specifications. White heteroskedasticity-robust standard errors are clustered at the quarter and investor levels and are reported in parentheses. Finally, $^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$.

**Table A.5.** Investment Horizon 2015–2019

| Dependent Var.: | $NZDW_{i,t}$ | | | | $AvgCR_{i,t}$ | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| $Other - Domestic$ | -0.264** | 0.071 | -0.125 | 0.111 | 0.067** | 0.033 | 0.065** | 0.038 |
| | (0.124) | (0.116) | (0.131) | (0.120) | (0.024) | (0.023) | (0.024) | (0.022) |
| $Other - Foreign$ | -0.792*** | -0.221** | -0.701*** | -0.216** | 0.190*** | 0.132*** | 0.189*** | 0.133*** |
| | (0.074) | (0.081) | (0.075) | (0.081) | (0.018) | (0.018) | (0.018) | (0.018) |
| $Pension\ Fund - Foreign$ | -0.326 | -0.112 | -0.277 | -0.104 | 0.074** | 0.053 | 0.073** | 0.053 |
| | (0.206) | (0.206) | (0.204) | (0.205) | (0.033) | (0.032) | (0.033) | (0.032) |
| $Size_{i,t}$ | | 0.131*** | | 0.123*** | | -0.013*** | | -0.014*** |
| | | (0.013) | | (0.013) | | (0.002) | | (0.002) |
| $HighAS_{i,t}$ | | | -0.343*** | -0.151** | | | 0.006 | -0.016 |
| | | | (0.071) | (0.070) | | | (0.014) | (0.014) |
| Time FE | Quarter | Quarter | Quarter | Quarter | Quarter | Quarter | Quarter | Quarter |
| N | 14,032 | 14,032 | 14,032 | 14,032 | 14,032 | 14,032 | 14,032 | 14,032 |
| Adjusted $R^2$ | 0.009 | 0.049 | 0.018 | 0.050 | 0.022 | 0.041 | 0.022 | 0.042 |

*Notes:* This table presents results on investment horizon over the period 2015–2019. All specifications are estimated using OLS. $NZDW_{i,t}$ is the weighted non-zero-points duration of investor $i$ computed over the most recent 2 years including quarter $t$. $AvgCR_{i,t}$ is the average churn rate computed over the same period. $Size_{i,t}$ is the (log) value of the investor's portfolio at the end of quarter $t$. $HighAS_{i,t}$ is a binary variable equal to one if the value of $Active\ Share_{i,t}$ is in the top tercile of its quarter-specific distribution. All models include a constant that is not reported and quarter fixed effects. The omitted investor type are domestic pension funds in all specifications. White heteroskedasticity-robust standard errors are clustered at the quarter and investor levels and are reported in parentheses. Finally, $^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$.

**Table A.6.** Investment Horizon, 5 Years

| Dependent Var.: | $NZDW_{i,t}$ | | | | $AvgCR_{i,t}$ | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| $Other - Domestic$ | -1.607** | -0.941 | -1.045 | -0.658 | 0.075** | 0.055** | 0.084*** | 0.068*** |
| | (0.671) | (0.565) | (0.707) | (0.601) | (0.029) | (0.026) | (0.029) | (0.025) |
| $Other - Foreign$ | -2.991*** | -1.640*** | -2.729*** | -1.643*** | 0.184*** | 0.144*** | 0.188*** | 0.144*** |
| | (0.490) | (0.383) | (0.495) | (0.403) | (0.022) | (0.020) | (0.022) | (0.019) |
| $Pension\ Fund - Foreign$ | -0.170 | 0.179 | -0.160 | 0.140 | 0.063 | 0.053 | 0.064 | 0.051 |
| | (0.645) | (0.529) | (0.649) | (0.542) | (0.041) | (0.042) | (0.041) | (0.043) |
| $Size_{i,t}$ | | 0.379*** | | 0.329*** | | -0.011*** | | -0.013*** |
| | | (0.064) | | (0.066) | | (0.003) | | (0.003) |
| $HighAS_{i,t}$ | | | -1.523*** | -1.001** | | | -0.023 | -0.044*** |
| | | | (0.380) | (0.391) | | | (0.014) | (0.015) |
| Time FE | Quarter | Quarter | Quarter | Quarter | Quarter | Quarter | Quarter | Quarter |
| N | 12,278 | 12,278 | 12,278 | 12,278 | 12,278 | 12,278 | 12,278 | 12,278 |
| Adjusted $R^2$ | 0.019 | 0.052 | 0.035 | 0.058 | 0.046 | 0.064 | 0.049 | 0.072 |

*Notes:* This table results on investment horizon measured over a rolling window of five years. All specifications are estimated using OLS. $NZDW_{i,t}$ is the weighted non-zero-points duration of investor $i$ computed over the most recent 5 years including quarter $t$. $AvgCR_{i,t}$ is the average churn rate computed over the same period. $Size_{i,t}$ is the (log) value of the investor's portfolio at the end of quarter $t$. $HighAS_{i,t}$ is a binary variable equal to one if the value of $Active\ Share_{i,t}$ is in the top tercile of its quarter-specific distribution. All models include a constant that is not reported and quarter fixed effects. The omitted investor type are domestic pension funds in all specifications. White heteroskedasticity-robust standard errors are clustered at the quarter and investor levels and are reported in parentheses. Finally, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

**Table A.7.** Investor Activity, Alternative Sample Periods

| Dependent Var.: $Active\ Share_{i,t}$ | 2010-2019 | | 2015-2019 | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| $Other - Domestic$ | 34.405*** | 26.978*** | 33.841*** | 25.063*** |
| | (4.059) | (4.182) | (4.354) | (4.337) |
| $Other - Foreign$ | 35.804*** | 21.875*** | 36.773*** | 21.680*** |
| | (2.070) | (2.507) | (2.648) | (2.828) |
| $Pension\ Fund - Foreign$ | 19.273*** | 13.578*** | 22.358*** | 15.733*** |
| | (4.661) | (4.055) | (5.423) | (4.550) |
| $Size_{i,t}$ | | -2.973*** | | -3.083*** |
| | | (0.170) | | (0.173) |
| Time FE | Quarter | Quarter | Quarter | Quarter |
| N | 32,382 | 32,382 | 19,658 | 19,658 |
| Adjusted $R^2$ | 0.042 | 0.201 | 0.040 | 0.213 |

*Notes:* This table presents results on investor activity over alternative sample periods. Columns 1–3 include the period 2010–2019, while columns 3–4 include the period 2015–2019. The dependent variable in all columns is $Active\ Share_{i,t}$ as proposed by Cremers and Petajisto (2009). It measures how much the investor's portfolio composition differs from that of the benchmark index. $Size_{i,t}$ is the (log) value of the investor's portfolio at the end of quarter $t$. All models include a constant that is not reported and quarter fixed effects. The omitted investor type are domestic pension funds in all specifications. White heteroskedasticity-robust standard errors are clustered at the quarter and investor levels and are reported in parentheses. Finally, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

**Table A.8.** Investor Activity, Diversification Subsamples

| Dependent Var.: *Active Share*$_{i,t}$ | #Stocks $\geq$ 5 | | #Stocks $\geq$ 10 | | #Stocks $\geq$ 15 | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $Other - Domestic$ | 15.989*** | 14.319*** | 11.627*** | 11.562*** | 10.742*** | 10.559*** |
| | (3.808) | (3.725) | (3.284) | (3.289) | (3.516) | (3.432) |
| $Other - Foreign$ | 20.127*** | 16.669*** | 14.051*** | 13.936*** | 11.708*** | 11.403*** |
| | (1.834) | (1.951) | (1.817) | (2.210) | (1.942) | (2.384) |
| $Pension\ Fund - Foreign$ | 7.699*** | 6.177*** | 7.726*** | 7.667*** | 6.361*** | 6.219** |
| | (2.379) | (2.133) | (2.206) | (2.266) | (2.292) | (2.339) |
| $Size_{i,t}$ | | -1.134*** | | -0.044 | | -0.143 |
| | | (0.311) | | (0.407) | | (0.511) |
| Time FE | Quarter | Quarter | Quarter | Quarter | Quarter | Quarter |
| N | 14,885 | 14,885 | 8,781 | 8,781 | 5,591 | 5,591 |
| Adjusted $R^2$ | 0.087 | 0.104 | 0.095 | 0.095 | 0.088 | 0.088 |

*Notes:* This table presents results on investor activity using different subsamples based on portfolio diversification. Columns 1–2, 3–4 and 5–6 only include observations where the investor holds at least 5, 10, or 15 different stocks, respectively. The dependent variable in all columns is $Active\ Share_{i,t}$ as proposed by Cremers and Petajisto (2009). It measures how much the investor's portfolio composition differs from that of the benchmark index. $Size_{i,t}$ is the (log) value of the investor's portfolio at the end of quarter $t$. All models include a constant that is not reported and quarter fixed effects. The omitted investor type are domestic pension funds in all specifications. White heteroskedasticity-robust standard errors are clustered at the quarter and investor levels and are reported in parentheses. Finally, $^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$.

**Table A.9.** Investor Performance, 2010–2019

| Dependent Var.: | $Excess\ Return^{rf}_{i,t}$ | | | | $\alpha_i$ |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| $Other - Domestic$ | -0.836** | -0.390 | -0.472 | -0.215 | -0.027 |
| | (0.354) | (0.340) | (0.307) | (0.273) | (1.227) |
| $Other - Foreign$ | -0.063 | 0.773** | 0.188 | 0.794** | -0.013 |
| | (0.344) | (0.316) | (0.546) | (0.349) | (0.436) |
| $Pension\ Fund - Foreign$ | -0.476 | -0.134 | -0.314 | -0.083 | 0.081 |
| | (0.947) | (0.915) | (1.004) | (0.945) | (1.763) |
| $Size_{i,t}$ | | 0.179*** | | 0.145** | |
| | | (0.040) | | (0.062) | |
| $HighAS_{i,t}$ | | | -0.800 | -0.572 | |
| | | | (0.713) | (0.784) | |
| Time FE | Quarter | Quarter | Quarter | Quarter | No |
| N | 32,382 | 32,382 | 32,382 | 32,382 | 1,075 |
| Adjusted $R^2$ | 0.458 | 0.459 | 0.459 | 0.459 | -0.003 |
| $R^2$ | 0.458 | 0.460 | 0.459 | 0.460 | |

*Notes:* This table presents results on investor performance using the sample period 2010–2019. All specifications are estimated using OLS. $Excess\ Return^{rf}_{i,t}$ is the excess return of the investor over the risk-free rate in quarter $t$. $\alpha_i$ is the alpha from the CAPM model as described by equation (I.7). $Size_{i,t}$ is the (log) value of the investor's portfolio at the end of quarter $t$. $HighAS_{i,t}$ is a binary variable equal to one if the value of $Active\ Share_{i,t}$ is in the top tercile of its quarter-specific distribution. All models include a constant that is not reported and quarter fixed effects. The omitted investor type are domestic pension funds in all specifications. White heteroskedasticity-robust standard errors are clustered at the quarter and investor levels and are reported in parentheses. Finally, $^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$.

**Table A.10.** Investor Performance, 2015–2019

| Dependent Var.: | $Excess\ Return^{rf}_{i,t}$ | | | | $\alpha_i$ |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| $Other - Domestic$ | -0.398 | 0.098 | -0.280 | 0.101 | -1.418 |
| | (0.331) | (0.336) | (0.315) | (0.256) | (2.187) |
| $Other - Foreign$ | -0.352 | 0.501 | -0.260 | 0.501 | 0.673*** |
| | (0.537) | (0.437) | (0.818) | (0.490) | (0.211) |
| $Pension\ Fund - Foreign$ | 0.141 | 0.515 | 0.211 | 0.516 | 1.758 |
| | (1.194) | (1.155) | (1.309) | (1.215) | (2.218) |
| $Size_{i,t}$ | | 0.174*** | | 0.174* | |
| | | (0.050) | | (0.087) | |
| $HighAS_{i,t}$ | | | -0.290 | -0.012 | |
| | | | (0.953) | (1.062) | |
| Time FE | Quarter | Quarter | Quarter | Quarter | No |
| N | 19,658 | 19,658 | 19,658 | 19,658 | 578 |
| Adjusted $R^2$ | 0.474 | 0.475 | 0.474 | 0.475 | -0.002 |
| $R^2$ | 0.475 | 0.476 | 0.475 | 0.476 | 0.004 |

*Notes:* This table presents results on investor performance using the sample period 2015–2019. All specifications are estimated using OLS. $Excess\ Return^{rf}_{i,t}$ is the excess return of the investor over the risk-free rate in quarter $t$. $\alpha_i$ is the alpha from the CAPM model as described by equation (I.7). $Size_{i,t}$ is the (log) value of the investor's portfolio at the end of quarter $t$. $HighAS_{i,t}$ is a binary variable equal to one if the value of $Active\ Share_{i,t}$ is in the top tercile of its quarter-specific distribution. All models include a constant that is not reported and quarter fixed effects. The omitted investor type are domestic pension funds in all specifications. White heteroskedasticity-robust standard errors are clustered at the quarter and investor levels and are reported in parentheses. Finally, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

**Table A.11.** Turnover and Market Turmoil, Definition Based on VIX

| Dependent Var.: | $CR_{i,t}$ | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| $Turmoil_t$ | -0.068 | | -0.076 | -0.071 | -0.068 | -0.088 | -0.090 |
| | (0.080) | | (0.074) | (0.074) | (0.080) | (0.072) | (0.071) |
| $Other - Domestic$ | | 0.098*** | 0.089** | 0.058* | | | |
| | | (0.036) | (0.037) | (0.029) | | | |
| $Other - Foreign$ | | 0.199*** | 0.199*** | 0.118*** | | | |
| | | (0.029) | (0.030) | (0.024) | | | |
| $Pension\ Fund - Foreign$ | | 0.042 | 0.040 | 0.004 | | | |
| | | (0.039) | (0.041) | (0.038) | | | |
| $Turmoil_t \times Other - Domestic$ | | | 0.252*** | 0.244*** | | 0.285*** | 0.277*** |
| | | | (0.076) | (0.077) | | (0.074) | (0.078) |
| $Turmoil_t \times Other - Foreign$ | | | -0.004 | -0.015 | | 0.007 | -0.005 |
| | | | (0.048) | (0.050) | | (0.047) | (0.051) |
| $Turmoil_t \times Pension\ Fund - Foreign$ | | | 0.042 | 0.031 | | 0.054 | 0.046 |
| | | | (0.093) | (0.094) | | (0.089) | (0.100) |
| $Size_{i,t-1}$ | | | | -0.020*** | | | -0.053*** |
| | | | | (0.003) | | | (0.005) |
| Time FE | Year | Year | Year | Year | Year | Year | Year |
| Investor FE | No | No | No | No | Yes | Yes | Yes |
| N | 26,627 | 26,627 | 26,627 | 26,627 | 26,627 | 26,627 | 26,627 |
| Adjusted $R^2$ | 0.008 | 0.012 | 0.013 | 0.023 | 0.119 | 0.119 | 0.136 |

*Notes:* This table presents results on portfolio turnover and market turmoil. All specifications are estimated using OLS. The dependent variable is the quarterly churn rate $CR_{i,t}$ as defined in equation (I.3). $Turmoil_t$ is a dummy taking value 1 if quarter $t$ contains a month in which the monthly return of the S&P500 index was in the bottom 5th percentile of its distribution while the month-on-month change in the VIX index was above the 95th percentile. $Size_{i,t-1}$ is the (log) value of the investor's portfolio in the previous quarter. Time and investor fixed effects are included as specified. All models include a constant that is not reported. The omitted investor type are domestic pension funds in all specifications. White heteroskedasticity-robust standard errors are clustered at the quarter and investor levels and are reported in parentheses. Finally, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

**Table A.12.** Turnover and Market Turmoil, Definitions Based on Volatility

| Dependent Var.: $CR_{i,t}$ | Index Price Volatility > p95 | | | | Index Return Volatilty > p90 | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| $Turmoil_t$ | -0.023 | | -0.018 | -0.020 | -0.049 | | -0.066* | -0.064* |
| | (0.031) | | (0.026) | (0.021) | (0.039) | | (0.037) | (0.038) |
| $Other - Domestic$ | | 0.098*** | 0.092** | 0.061** | | 0.098*** | 0.085** | 0.055* |
| | | (0.036) | (0.036) | (0.029) | | (0.036) | (0.038) | (0.030) |
| $Other - Foreign$ | | 0.199*** | 0.199*** | 0.118*** | | 0.199*** | 0.198*** | 0.117*** |
| | | (0.029) | (0.030) | (0.024) | | (0.029) | (0.032) | (0.026) |
| $Pension\ Fund - Foreign$ | | 0.042 | 0.043 | 0.006 | | 0.042 | 0.042 | 0.005 |
| | | (0.039) | (0.042) | (0.038) | | (0.039) | (0.042) | (0.039) |
| $Turmoil_t \times Other - Domestic$ | | | 0.135** | 0.129** | | | 0.123* | 0.120* |
| | | | (0.066) | (0.060) | | | (0.072) | (0.072) |
| $Turmoil_t \times Other - Foreign$ | | | -0.011 | -0.010 | | | 0.011 | 0.006 |
| | | | (0.017) | (0.015) | | | (0.041) | (0.043) |
| $Turmoil_t \times Pension\ Fund - Foreign$ | | | -0.016 | -0.013 | | | 0.004 | 0.004 |
| | | | (0.064) | (0.056) | | | (0.050) | (0.051) |
| $Size_{i,t-1}$ | | | | -0.020*** | | | | -0.020*** |
| | | | | (0.003) | | | | (0.003) |
| Time FE | Year | Year | Year | Year | Year | Year | Year | Year |
| Investor FE | No | No | No | No | No | No | No | No |
| N | 26,627 | 26,627 | 26,627 | 26,627 | 26,627 | 26,627 | 26,627 | 26,627 |
| Adjusted $R^2$ | 0.008 | 0.012 | 0.012 | 0.022 | 0.008 | 0.012 | 0.013 | 0.023 |

*Notes:* This table presents results on portfolio turnover and market turmoil. All specifications are estimated using OLS. The dependent variable is the quarterly churn rate $CR_{i,t}$ as defined in equation (I.3). $Turmoil_t$ is a dummy taking value 1 if quarter $t$ is a quarter of market turmoil defined as follows. In columns 1–4, periods of market turmoil are defined as quarters when the quarterly price volatility of the OMX CPH Index is above the 95th percentile. These are 2011Q3, 2015Q1, and 2019Q4. In columns 5–8, periods of market turmoil are defined as quarters where the quarterly return volatility of the OMX CPH Index is above the 90th percentile. These are 2008Q3, 2008Q4, 2009Q1, 2009Q2m 2011Q3, and 2016Q1. $Size_{i,t-1}$ is the (log) value of the investor's portfolio in the previous quarter. Time and investor fixed effects are included as specified. All models include a constant that is not reported. The omitted investor type are domestic pension funds in all specifications. White heteroskedasticity-robust standard errors are clustered at the quarter and investor levels and are reported in parentheses. Finally, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

**Table A.13.** Turnover and Market Turmoil, Alternative Definition of Turnover

| Dependent Var.: | $CR_{i,t}$ (Giannetti & Yu, 2021) | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| $Turmoil_t$ | -0.005 | | -0.048*** | -0.034** | -0.006 | -0.051*** | -0.034 |
| | (0.028) | | (0.018) | (0.017) | (0.025) | (0.015) | (0.022) |
| $Other - Domestic$ | | 0.065*** | 0.056*** | -0.022 | | | |
| | | (0.021) | (0.021) | (0.033) | | | |
| $Other - Foreign$ | | 0.162*** | 0.161*** | -0.049* | | | |
| | | (0.011) | (0.011) | (0.029) | | | |
| $Pension\ Fund - Foreign$ | | 0.042** | 0.041* | -0.050 | | | |
| | | (0.020) | (0.021) | (0.036) | | | |
| $Turmoil_t \times Other - Domestic$ | | | 0.184** | 0.163** | | 0.196** | 0.181** |
| | | | (0.075) | (0.065) | | (0.079) | (0.075) |
| $Turmoil_t \times Other - Foreign$ | | | 0.037 | 0.018 | | 0.039* | 0.012 |
| | | | (0.024) | (0.018) | | (0.022) | (0.026) |
| $Turmoil_t \times Pension\ Fund - Foreign$ | | | 0.013 | 0.008 | | 0.011 | 0.037 |
| | | | (0.031) | (0.021) | | (0.037) | (0.043) |
| $Size_{i,t-1}$ | | | | -0.057*** | | | -0.103*** |
| | | | | (0.003) | | | (0.006) |
| Time FE | Year | Year | Year | Year | Year | Year | Year |
| Investor FE | No | No | No | No | Yes | Yes | Yes |
| N | 22,317 | 22,317 | 22,317 | 22,317 | 22,298 | 22,298 | 22,298 |
| Adjusted $R^2$ | 0.012 | 0.019 | 0.019 | 0.134 | 0.132 | 0.132 | 0.225 |

*Notes:* This table presents results on portfolio turnover and market turmoil. All specifications are estimated using OLS. The dependent variable is the quarterly churn rate $CR_{i,t}$ as defined by Giannetti and Yu (2021). $Turmoil_t$ is a dummy taking value 1 if quarter $t$ contains a month in which the monthly return of the OMX CPH Index was in the bottom 5th percentile of its distribution while the volatility of daily returns was above the 95th percentile. $Size_{i,t-1}$ is the (log) value of the investor's portfolio in the previous quarter. Time and investor fixed effects are included as specified. All models include a constant that is not reported. The omitted investor type are domestic pension funds in all specifications. White heteroskedasticity-robust standard errors are clustered at the quarter and investor levels and are reported in parentheses. Finally, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

**Table A.14.** Turnover and Market Turmoil, 2005-2012

| Dependent Var.: | $CR_{i,t}$ | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| $Turmoil_t$ | -0.084* | | -0.085 | -0.083 | -0.081* | -0.089 | -0.081 |
| | (0.046) | | (0.069) | (0.067) | (0.045) | (0.061) | (0.056) |
| $Other - Domestic$ | | 0.106* | 0.084 | 0.064 | | | |
| | | (0.055) | (0.060) | (0.051) | | | |
| $Other - Foreign$ | | 0.199*** | 0.200*** | 0.147*** | | | |
| | | (0.049) | (0.056) | (0.046) | | | |
| $Pension\ Fund - Foreign$ | | 0.045 | 0.046 | 0.022 | | | |
| | | (0.058) | (0.064) | (0.059) | | | |
| $Turmoil_t \times Other - Domestic$ | | | 0.216** | 0.212** | | 0.228** | 0.203** |
| | | | (0.082) | (0.079) | | (0.084) | (0.081) |
| $Turmoil_t \times Other - \ Foreign$ | | | -0.009 | -0.012 | | -0.000 | -0.015 |
| | | | (0.069) | (0.066) | | (0.061) | (0.055) |
| $Turmoil_t \times Pension\ Fund - Foreign$ | | | -0.006 | -0.007 | | 0.016 | 0.007 |
| | | | (0.088) | (0.084) | | (0.082) | (0.079) |
| $Size_{i,t-1}$ | | | | -0.013*** | | | -0.056*** |
| | | | | (0.004) | | | (0.008) |
| Time FE | Year | Year | Year | Year | Year | Year | Year |
| Investor FE | No | No | No | No | Yes | Yes | Yes |
| N | 13,426 | 13,426 | 13,426 | 13,426 | 13,422 | 13,422 | 13,422 |
| Adjusted $R^2$ | 0.010 | 0.012 | 0.014 | 0.017 | 0.111 | 0.112 | 0.124 |

*Notes:* This table presents results on portfolio turnover and market turmoil restricting the sample period to 2005-2012. All specifications are estimated using OLS. The dependent variable is the quarterly churn rate $CR_{i,t}$ as defined by equation (I.3). $Turmoil_t$ is a dummy taking value 1 if quarter $t$ contains a month in which the monthly return of the OMX CPH Index was in the bottom 5th percentile of its distribution while the volatility of daily returns was above the 95th percentile. $Size_{i,t-1}$ is the (log) value of the investor's portfolio in the previous quarter. Time and investor fixed effects are included as specified. All models include a constant that is not reported. The omitted investor type are domestic pension funds in all specifications. White heteroskedasticity-robust standard errors are clustered at the quarter and investor levels and are reported in parentheses. Finally, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

**Table A.15.** Turnover and Market Turmoil, Diversification and Size

| Dependent Var.: $CR_{i,t}$ | $\overline{Stocks_i} > 3$ | | | | $\overline{Size_i} >$ p75 | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| $Turmoil_t$ | -0.074* | | -0.091* | -0.080 | -0.076* | | -0.103** | -0.087** |
| | (0.043) | | (0.046) | (0.048) | (0.040) | | (0.043) | (0.043) |
| $Other - Domestic$ | | 0.103*** | 0.092** | 0.043 | | 0.100*** | 0.088** | 0.009 |
| | | (0.035) | (0.036) | (0.028) | | (0.036) | (0.037) | (0.030) |
| $Other - Foreign$ | | 0.211*** | 0.211*** | 0.097*** | | 0.196*** | 0.195*** | 0.060** |
| | | (0.030) | (0.031) | (0.023) | | (0.030) | (0.031) | (0.025) |
| $Pension\ Fund - Foreign$ | | 0.044 | 0.045 | -0.019 | | 0.039 | 0.040 | -0.060 |
| | | (0.039) | (0.042) | (0.040) | | (0.040) | (0.042) | (0.047) |
| $Turmoil_t \times Other - Domestic$ | | | 0.188*** | 0.178*** | | | 0.234*** | 0.230*** |
| | | | (0.061) | (0.062) | | | (0.079) | (0.079) |
| $Turmoil_t \times Other -\ Foreign$ | | | 0.007 | -0.009 | | | 0.010 | -0.011 |
| | | | (0.042) | (0.043) | | | (0.042) | (0.042) |
| $Turmoil_t \times Pension\ Fund - Foreign$ | | | -0.002 | -0.007 | | | 0.000 | -0.012 |
| | | | (0.072) | (0.074) | | | (0.072) | (0.073) |
| $Size_{i,t-1}$ | | | | -0.036*** | | | | -0.055*** |
| | | | | (0.004) | | | | (0.005) |
| Time FE | Year | Year | Year | Year | Year | Year | Year | Year |
| Investor FE | No | No | No | No | No | No | No | No |
| N | 16,752 | 16,752 | 16,752 | 16,752 | 13,904 | 13,904 | 13,904 | 13,904 |
| Adjusted $R^2$ | 0.012 | 0.020 | 0.021 | 0.050 | 0.014 | 0.022 | 0.024 | 0.081 |

*Notes:* This table presents results on portfolio turnover and market turmoil using subsamples of investors conditional on portfolio diversification and size. In columns 1–4, only investors that on average invest in more than three different stocks per quarter are included. The models in columns 5–8 only include investors that have an average portfolio value above the 75th percentile of the distribution. The dependent variable is the quarterly churn rate $CR_{i,t}$ as defined by equation (I.3). $Turmoil_t$ is a dummy taking value 1 if quarter $t$ contains a month in which the monthly return of the OMX CPH Index was in the bottom 5th percentile of its distribution while the volatility of daily returns was above the 95th percentile. $Size_{i,t-1}$ is the (log) value of the investor's portfolio in the previous quarter. Time and investor fixed effects are included as specified. All models include a constant that is not reported. The omitted investor type are domestic pension funds in all specifications. White heteroskedasticity-robust standard errors are clustered at the quarter and investor levels and are reported in parentheses. Finally, $^{*}\ p < 0.1$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$.

**Table A.16.** Turnover and Market Turmoil, Alternative Controls

| Dependent Var.: | $CR_{i,t}$ | | | | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $Turmoil_t$ | -0.078 | -0.080* | -0.074 | -0.082 | -0.089* | -0.080 |
| | (0.054) | (0.048) | (0.054) | (0.058) | (0.047) | (0.057) |
| $Other - Domestic$ | 0.046 | 0.087** | 0.049 | | | |
| | (0.033) | (0.036) | (0.032) | | | |
| $Other - Foreign$ | 0.113*** | 0.200*** | 0.117*** | | | |
| | (0.026) | (0.030) | (0.026) | | | |
| $Pension\ Fund - Foreign$ | -0.017 | 0.042 | -0.015 | | | |
| | (0.045) | (0.041) | (0.045) | | | |
| $Turmoil_t \times Other - Domestic$ | 0.205*** | 0.213*** | 0.205** | 0.211** | 0.232*** | 0.213** |
| | (0.075) | (0.073) | (0.080) | (0.085) | (0.081) | (0.088) |
| $Turmoil_t \times Other - Foreign$ | -0.016 | -0.013 | -0.020 | -0.010 | -0.001 | -0.012 |
| | (0.049) | (0.042) | (0.050) | (0.055) | (0.042) | (0.054) |
| $Turmoil_t \times Pension\ Fund - Foreign$ | 0.001 | 0.001 | 0.002 | 0.024 | 0.016 | 0.024 |
| | (0.076) | (0.079) | (0.080) | (0.086) | (0.075) | (0.088) |
| $\#Stocks_{t-1}$ | -0.003*** | | -0.003*** | -0.005*** | | -0.004*** |
| | (0.000) | | (0.001) | (0.001) | | (0.001) |
| $\Delta\#Stocks_t$ | | 0.006*** | 0.005*** | | 0.006*** | 0.004*** |
| | | (0.002) | (0.002) | | (0.001) | (0.002) |
| Time FE | Year | Year | Year | Year | Year | Year |
| Investor FE | No | No | No | Yes | Yes | Yes |
| N | 26,627 | 26,627 | 26,627 | 26,627 | 26,627 | 26,627 |
| Adjusted $R^2$ | 0.017 | 0.015 | 0.018 | 0.122 | 0.121 | 0.123 |

*Notes:* This table presents results on portfolio turnover and market turmoil using alternative control variables for investor heterogeneity. All specifications are estimated using OLS. The dependent variable is the quarterly churn rate $CR_{i,t}$ as defined in equation (I.3). $Turmoil_t$ is a dummy taking value 1 if quarter $t$ contains a month in which the monthly return of the OMX CPH Index was in the bottom 5th percentile of its distribution while the volatility of daily returns was above the 95th percentile. $\#Stocks_{i,t-1}$ is the number of stocks that the investor holds in the previous period. $\Delta\#Stocks$ is the change in the number of stocks that the investor holds from period $t-1$ to $t$. Time and investor fixed effects are included as specified. All models include a constant that is not reported. The omitted investor type are domestic pension funds in all specifications. White heteroskedasticity-robust standard errors are clustered at the quarter and investor levels and are reported in parentheses. Finally, $^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$.

**Table A.17.** Performance and Market Turmoil, Definition Based on VIX

| Dependent Var.: | $Excess\ Return^{rf}_{i,t}$ | | | | $Excess\ Return^{index}_{i,t}$ | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| $Turmoil_t$ | -13.077*** | | -16.517*** | -16.517*** | 5.404*** | | 2.096** | 2.085** |
| | (3.344) | | (4.448) | (4.451) | (1.373) | | (0.949) | (0.928) |
| $Other - Domestic$ | | -0.983*** | -1.059*** | -1.052*** | | -1.010*** | -1.050*** | -0.970** |
| | | (0.343) | (0.383) | (0.293) | | (0.326) | (0.364) | (0.374) |
| $Other - Foreign$ | | -0.171 | -0.249 | -0.232 | | -0.128 | -0.216 | -0.006 |
| | | (0.243) | (0.263) | (0.306) | | (0.332) | (0.336) | (0.457) |
| $Pension\ Fund - Foreign$ | | -0.934*** | -1.122** | -1.115*** | | -0.724 | -0.910 | -0.816 |
| | | (0.347) | (0.425) | (0.365) | | (0.620) | (0.621) | (0.623) |
| $Turmoil_t \times Other - Domestic$ | | | 2.450** | 2.452* | | | 2.441 | 2.462 |
| | | | (1.184) | (1.256) | | | (2.452) | (2.455) |
| $Turmoil_t \times Other - Foreign$ | | | 3.464*** | 3.466*** | | | 3.333* | 3.363* |
| | | | (0.180) | (0.395) | | | (1.723) | (1.736) |
| $Turmoil_t \times Pension\ Fund - Foreign$ | | | 6.197** | 6.200** | | | 5.557 | 5.585 |
| | | | (3.018) | (3.033) | | | (5.211) | (5.115) |
| $Size_{i,t-1}$ | | | | 0.004 | | | | 0.052 |
| | | | | (0.056) | | | | (0.048) |
| Time FE | Year | Year | Year | Year | Year | Year | Year | Year |
| Investor FE | No | No | No | No | No | No | No | No |
| N | 26,627 | 26,627 | 26,627 | 26,627 | 26,627 | 26,627 | 26,627 | 26,627 |
| Adjusted $R^2$ | 0.311 | 0.294 | 0.311 | 0.311 | 0.018 | 0.012 | 0.018 | 0.018 |

*Notes:* This table presents results on performance and market turmoil. All specifications are estimated using OLS. The dependent variable $Excess\ Return^{rf}_{i,t}$ in columns 1–4 is the investor's excess return over the risk-free rate in quarter $t$. The dependent variable $Excess\ Return^{index}_{i,t}$ in columns 5–8 is the investor's excess return over the OMX CPH Index in quarter $t$. $Turmoil_t$ is a dummy taking value 1 if quarter $t$ contains a month in which the monthly return of the S&P500 index was in the bottom 5th percentile of its distribution while the month-on-month change in the VIX index was above the 95th percentile. $Size_{i,t-1}$ is the (log) value of the investor's portfolio in the previous quarter. Time and investor fixed effects are included as specified. All models include a constant that is not reported. The omitted investor type are domestic pension funds in all specifications. White heteroskedasticity-robust standard errors are clustered at the quarter and investor levels and are reported in parentheses. Finally, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

**Table A.18.** Performance and Market Turmoil, 2005-2012

| Dependent Var.: | $Excess\ Return^{rf}_{i,t}$ | | | | $Excess\ Return^{index}_{i,t}$ | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| $Turmoil_t$ | -17.734*** | | -19.841*** | -19.838*** | 1.433 | | -0.511 | -0.511 |
| | (3.408) | | (3.089) | (3.087) | (2.116) | | (1.452) | (1.446) |
| $Other - Domestic$ | | -1.619** | -2.024*** | -2.066*** | | -1.736*** | -2.077*** | -2.070*** |
| | | (0.626) | (0.651) | (0.518) | | (0.506) | (0.621) | (0.662) |
| $Other - Foreign$ | | 0.209 | 0.064 | -0.052 | | 0.300 | 0.088 | 0.108 |
| | | (0.370) | (0.343) | (0.734) | | (0.546) | (0.611) | (0.930) |
| $Pension\ Fund - Foreign$ | | -0.277 | -0.603 | -0.655 | | 0.015 | -0.363 | -0.353 |
| | | (0.343) | (0.470) | (0.620) | | (0.715) | (0.716) | (0.840) |
| $Turmoil_t \times Other - Domestic$ | | | 3.326** | 3.318** | | | 3.252 | 3.253 |
| | | | (1.323) | (1.364) | | | (1.952) | (1.945) |
| $Turmoil_t \times Other - Foreign$ | | | 2.043*** | 2.035*** | | | 1.880 | 1.882 |
| | | | (0.538) | (0.552) | | | (1.667) | (1.669) |
| $Turmoil_t \times Pension\ Fund - Foreign$ | | | 3.820 | 3.817 | | | 3.171 | 3.171 |
| | | | (2.590) | (2.495) | | | (3.737) | (3.435) |
| $Size_{i,t-1}$ | | | | -0.027 | | | | 0.005 |
| | | | | (0.102) | | | | (0.086) |
| Time FE | Year | Year | Year | Year | Year | Year | Year | Year |
| Investor FE | No | No | No | No | No | No | No | No |
| N | 13,426 | 13,426 | 13,426 | 13,426 | 13,426 | 13,426 | 13,426 | 13,426 |
| Adjusted $R^2$ | 0.418 | 0.331 | 0.418 | 0.418 | 0.009 | 0.010 | 0.011 | 0.011 |

*Notes:* This table presents results on performance and market turmoil restricting the sample period to 2005–2012. All specifications are estimated using OLS. The dependent variable $Excess\ Return^{rf}_{i,t}$ in columns 1–4 is the investor's excess return over the risk-free rate in quarter $t$. The dependent variable $Excess\ Return^{index}_{i,t}$ in columns 5–8 is the investor's excess return over the OMX CPH Index in quarter $t$. $Turmoil_t$ is a dummy taking value 1 if quarter $t$ contains a month in which the monthly return of the OMX CPH Index was in the bottom 5th percentile of its distribution while the volatility of daily returns was above the 95th percentile. $Size_{i,t-1}$ is the (log) value of the investor's portfolio in the previous quarter. Time and investor fixed effects are included as specified. All models include a constant that is not reported. The omitted investor type are domestic pension funds in all specifications. White heteroskedasticity-robust standard errors are clustered at the quarter and investor levels and are reported in parentheses. Finally, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

# Chapter II

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# Do Pension Fund Investments Make a Difference?

## Effects on Firm Productivity

*Also available as CEPR Discussion Paper No. 17639.*

# CHAPTER II

# Do Pension Fund Investments Make a Difference? Effects on Firm Productivity


## Abstract

We construct a comprehensive ownership dataset merged with the Danish registers to explore firms' productivity responses to a pension fund investment. Our analysis demonstrates that pension funds raise firms' productivity by investing in their equity. This result is robust to the consideration of selection issues and a large set of refinements, which show that the effect is larger for unlisted firms. We also find evidence to suggest that the increase in productivity tends to be larger the longer the duration and the larger the equity investment by pension funds.



I gratefully acknowledge comments by participants at conferences and seminars at the University of Amsterdam, Bruegel, Copenhagen Business School as well as faculty members at the NBER and the Boston College Center for Retirement Research. In particular, I thank Roger Bandick, Victoria Ivashina, Jordi Jaumandreu, Natalia Khorunzhina, Josh Lerner, Jim Poterba, Joshua Rauh, Mikkel Svenstrup, Stephen Terry and Frederic Warzynski for helpful suggestions and discussions. Furthermore, I am grateful to professionals at Danish pension funds who shared some of the investment data used in parts of this paper. Lastly, I acknowledge support from the Pension Scholarship Trust in partly funding this research.

# II.1 Introduction

Global assets in retirement savings plans amounted to over 60 trillion USD for the first time at the end of 2021 (OECD, 2023). A large part of these savings is accumulated in pension funds, making them key investors in global financial markets. Given their rising importance, it is not surprising that funded pensions have attracted the attention of policy makers and researchers alike. For example, the G20 has identified pension funds as a key source of long-term capital to finance growth and development (OECD, 2019).[1]

Against this backdrop, a natural question that arises is whether and how pension funds affect the economy at large. However, the understanding of the economic implications of pension funds is still rather limited. This study aims to reduce this gap by providing empirical evidence on the effects of pension funds' investments on firms' productivity with high-quality data, which offer three main advantages. First, they are based on a large and comprehensive sample of firms drawn from Danish administrative registers. Second, they include detailed information on the ownership structure of the firms involved in the analysis and cover both publicly listed and unlisted companies. Third, they carefully identify Danish pension funds' investments in domestic firms. Armed with these data, we find that firms experience a productivity increase after they receive a pension fund investment.[2] We also provide suggestive evidence that the effect on productivity tends to be larger the larger the investment in the firm and the longer its duration. Finally, we find that unlisted firms benefit more from pension fund investment than do listed firms. These results suggest two main economic channels through which pension funds help firms improve their productivity: long-term investment commitment and capital provision.

We use the Danish matched employer–employee dataset for the period 2003–2019, combined with a comprehensive ownership dataset. Denmark is a fitting setting for this type of analysis for two main reasons. First, the unique features of the Danish data allow us to link pension funds' investments to both listed and unlisted firms' characteristics. To the best of our knowledge, most previous studies analysing similar research questions focus mainly on listed firms. Second, Danish pension funds play an important role in the domestic economy. At the end of 2021, assets in retirement savings plans in Denmark

[1] See also, for example, Andonov et al. (2021).

[2] In this paper, "pension fund investment" always refers to equity investment by Danish pension funds, unless explicitly noted otherwise.

were the largest as a share of GDP among OECD countries, standing at over 230% (OECD, 2023). Furthermore, the Danish pension system is frequently described as one of the best in the world (Mercer, 2021) and serves as an example of a well-functioning system largely reliant on a funded pension pillar. Since an increasing number of countries are shifting from pay-as-you-go pension schemes towards funded pension arrangements, our findings are relevant beyond the Danish context.

It is important to note that while our data do not include information on debt financing, focusing on equity investments should not be a major limitation, because equity is by and large the most important source of financing for Danish non-financial companies.[3] Whereas the previous literature has suggested that both equity and debt financing affect productivity, equity seems to be a more relevant driver of productivity increases, because it is more likely to finance risky projects such as R&D intensive investments that are crucial for productivity growth.[4]

A major challenge in investigating the effect of investors on the firms that they invest in is that investors may carefully select the latter. The issue of selection is relevant in our case if pension funds choose to invest in firms that are already relatively more productive to start with, because this selection effect would confound with the observed productivity increases implied by the pension fund investment itself. While controlling for selection is empirically difficult without any exogenous variation, we adopt the following strategies to isolate the causal effect of pension funds' investment net of selection. First, we show with an event study that "treated" (through a pension fund's investment) and control firms share almost identical pre-trends in productivity. The same analysis provides suggestive evidence of a positive relationship between a pension fund's investment and firm productivity in the period after the investment event. We argue that this positive trend is consistent with a whole host of benefits that pension funds bring to the table, such as an increase in capital availability and long-term financing commitment.

Second, we estimate the impact of a pension fund investment directly in a structural production function framework that allows us to control for past productivity and therefore selection. Similarly to the event study, in the structural estimations, we find that a pension fund investment positively affects firm productivity. Furthermore, the concern that the estimated effects are merely driven by selection is also dismissed by our

[3]National accounts data show that at the end of 2019 equity and loans were the main liabilities of Danish non-financial companies, with equity accounting for 59.5% of total liabilities and loans 30.1% (Danmarks Nationalbank, 2022).

[4]See Heil (2018) for an overview of the literature on finance and productivity.

refinement analyses. For example, we find suggestive evidence that investments of long duration tend to provide even larger benefits in terms of productivity. These results are instead consistent with the hypothesis that pension funds offer a stable and long-term financing commitment that allows firms to invest in projects that are less liquid but yield a higher long-term return. Indeed, other studies have shown that pension funds tend to commit their investments for longer periods than other investors (Artiga González et al., 2020; Cella et al., 2013; Cremers & Pareek, 2016). Our findings resonate with previous evidence that investors' time horizon matters for corporate outcomes, such as the quality of corporate governance (Garel, 2017).

This paper contributes to several strands of the literature. First, we contribute to the work done on funded pensions and economic growth by investigating the hypothesis that pension investments promote productivity growth at the firm level. The literature has, to date, focused mostly on the relationship between the amount of pension savings in an economy and its economic growth, largely disregarding how these savings are invested. The conclusions have been mixed so far. Bijlsma et al. (2018) find evidence of higher output growth in sectors that strongly rely on external financing in countries with a larger pension asset pool. Altiparmakov and Nedeljkovic (2018) find no significant impact on economic growth of pension reform toward a funded system.[5] Zandberg and Spierdijk (2013) fail to find short-term effects of pension funding on economic growth when controlling for capital market returns and demographic changes, while the evidence for long-term effects is more mixed and tends to confirm only a small positive effect of pension funding.

Second, we add to the growing literature on the effects of ownership composition on corporate outcomes by explicitly investigating the role of pension funds. Our study is one of the few relating ownership to firm productivity (Bircan, 2019; Braguinsky et al., 2015; Chemmanur et al., 2011; Davis et al., 2014; Fons-Rosen et al., 2021) and the first to focus on pension funds in this regard.

Third, our new ownership data allow us to include both listed and unlisted firms in the analysis. Most of the literature on ownership and firm outcomes, particularly on ownership by institutional investors, such as pension funds, focuses only on listed firms. We provide a comprehensive set of results by looking at a sample of both publicly

[5] However, they identify a positive relationship between economic growth and pension reform in countries where pension funds invest less than 50% of assets in domestic government bonds. This finding suggests that the asset allocation of pension funds matters with regard to their macroeconomic effects, an aspect that we further explore in the present paper.

listed and privately held firms, and by investigating whether the effects of a pension fund investment are heterogeneous across the two groups. We also validate the analysis based on listed firms by deploying an alternative database constructed by exploiting direct information on ownership kindly provided by major Danish pension funds.

Finally, our paper adds to the extensive literature on the determinants of firm productivity. Existing work has singled out, among other factors, the importance of financial frictions (Caggese, 2019; Coricelli et al., 2012; Levine & Warusawitharana, 2021), leverage (Coricelli et al., 2012), firm size, book-to-market ratio and hiring practices (İmrohoroğlu & Tüzel, 2014; Parrotta & Pozzoli, 2012). Other studies have suggested that the threat of foreign competition (Bao & Chen, 2018), export experience (De Loecker, 2013) and workforce composition characteristics (Parrotta et al., 2014) also play an important role. We contribute by highlighting pension funds' investments as a novel and unexplored driver of productivity at the firm level.

The remainder of this paper is structured as follows. Section II.2 describes the economic channels through which pension funds can affect firm productivity. Data and summary statistics are then discussed in section II.3 and followed by the presentation of our empirical strategy in section II.4. We present our empirical results in section II.5, along with a series of robustness checks and heterogeneity analyses. Finally, section II.6 offers concluding remarks.

## II.2 Channels from Pension Investment to Firm Productivity

Once we control for selection, pension fund investments may directly affect firm-level productivity through a number of channels. First, as suggested by the existing literature on institutional investors, pension funds could actively engage with firms that they invest in, with the aim of improving their productivity. For example, Chemmanur et al. (2011) find that investments by venture capital (VC) funds lead to higher productivity through increased sales and lower production costs of the firms that they take a stake in. Davis et al. (2014) suggest that private equity buyouts affect firm productivity by accelerating the closure of less productive plants and the opening of more productive ones.

Second, pension funds may increase the supply of financial capital to the firm. This implies a reduction in the required rate of return on the firm's investment in (physical) capital, leading the firm to expand its investment until its demand for financing again equals the supply of financing. The additional investment could be directed towards items that raise productivity, such as advanced equipment or innovation-related items. Alvarez et al. (2018) evaluate a sample of publicly traded firms from several emerging economies. They conclude that the relationship between investment and institutional blockholding follows an inverse U-shape. Hence, when institutional blockholders own a large share of controlling rights, investment rates decline. The authors interpret this as evidence that large holdings by institutional investors translate into increased monitoring of managers and lead the firm to take a long-term view regarding investment instead of short-term capital spending, reflected in a reduction of overinvestment.

Third, beyond the direct effect of raising the supply of capital just discussed, pension fund investment in a firm can provide a positive signal about the firm to the market, thereby reducing the cost of capital, which in turn would stimulate productivity-improving investment. In particular, the presence of important institutional investors could signal well-functioning corporate governance mechanisms. Jara et al. (2019), for example, find evidence that Chilean firms that receive pension fund investments are more likely to issue bonds and pay a lower interest rate on these bonds, crowding out bank lending. The authors attribute this effect to better corporate governance and improved information disclosure. Alvarez et al. (2018) conclude that the presence of institutional investors in a firm's shareholder mix reduces the firm's reliance on internal operating cash flow to fund capital expenditure. They interpret this as institutional investors signalling better corporate governance, leading to easier credit access.

Fourth, it is important to keep in mind that pension funds and other types of investors, such as private equity/venture capital (PE/VC) funds, differ considerably in their business model. Therefore, the channels through which these investors affect firm productivity may differ. For example, PE/VC funds are more likely to seek direct influence over the operational structure of target firms and to invest in younger firms or start-ups than pension funds. The potential effects of pension funds' investment in firms may stem instead from the fact that pension funds tend to be long-term investors and, hence, their involvement raises the security over the long-term financing of the firm. This might lead firms to invest in projects that favour long-term objectives, such as productivity enhancement, over short-term dividend payouts. The long investment horizon of pension funds is also at the centre of policy discussions on their role in terms of economic growth.

While other investors such as PE/VC funds might strive to increase firm productivity through, for example, changes in management, pension funds appear generally less inclined to interfere with the organisation of a firm. Therefore, we interpret any effects on productivity as a byproduct or an externality rather than a reflection of the direct objective of pension funds. Nonetheless, we cannot exclude instances in which pension funds invest in a firm with the intent of making it more productive. However, the available data do not allow us to identify these cases, which we deem rare in any case.

The channels outlined above are likely to be more salient in our context in which we focus on pension funds, which tend to be large stakeholders relative to other investors. We also expect these channels to be more relevant for privately held than for publicly listed firms. Since listed firms have, by definition, easier access to external capital and a broader investor base than non-listed firms, we expect any productivity effect induced by pension funds to be smaller for listed firms.

# II.3 Data

## II.3.1 Ownership Data from Experian

We construct information on pension funds' investment in a firm based on shareholder data of all incorporated Danish firms from the data provider Experian. The original dataset reflects only direct ownership relationships between pairs of firms. To address this limitation, we proceed as follows.[6] First, we construct a panel dataset where the unit of observation is a single firm. Second, we iterate through the ownership levels to identify the ultimate owner of each firm. The following example illustrates the main features and the salience of this procedure. Suppose that firm A owns 100% of firm B and firm B owns 100% of firm C. Here, firm A is the "ultimate owner" of firm C, meaning that firm A is not owned by any other firm. The original dataset shows only the bilateral relationships between firms A and B and firms B and C but not that firm A owns 100% of firm C through firm B. However, the relationship between firms A and C is the one that we are actually interested in for our empirical purposes. This is especially relevant if firm B is merely a legal entity with the sole purpose of owning firm C. Therefore, we

[6]For a detailed description of the data construction process please see Appendix D (Data Appendix).

iterate through the ownership levels until the ultimate owners (i.e., less than 80% of their own equity should be owned by other firms) of all firms in the dataset are identified.

The final result is a panel dataset where one observation identifies a relationship between two firms in a given year, or equivalently an owner–owned firm–year combination. To determine ownership by pension funds, we manually search the main CVR number (the Danish business registration number) of each domestic pension fund using public sources, notably the Danish Business Register (Virk, 2022). Finally, we consider a firm to have received a pension fund investment if any of these CVR numbers are among the shareholders of the firm.

The Experian ownership data cover all incorporated Danish firms. Therefore, we are able to identify a pension fund investment in both listed and unlisted firms. The majority of the literature on the firm-level effects of pension funds and of institutional investors more generally covers only listed firms (e.g., Aghion et al., 2013; Alvarez et al., 2018; Jara et al., 2019). Therefore, we see our inclusion of unlisted firms as a relevant contribution to the literature.

## II.3.2 Danish Registers

Once we have obtained the ownership data we merge its anonymised version to two Danish registers, FIRE and FIRM, which provide detailed information about a firm's balance sheet, its number of employees and the sector it operates in. We now describe how we process the firm accounting data. In the remainder of this section, we define a firm's sector as the NACE Rev.2 1-digit sector based on the Danish Industry Classification (DB07).[7] The sample period covers the years 2003–2019, for which we have matching accounting and pension fund investment data. First, we exclude all firms with imputed values or missing sector information. To estimate firm productivity as described in Subsection II.4.2, we exclude all observations with zero or missing values for capital, labour (number of employees), output, value added or intermediate inputs. We deflate output, value added, intermediate inputs and capital with sector-specific deflators.[8] To improve balance sheet consistency, we drop observations with negative equity values. Next, we drop sectors with very few firms receiving pension fund investments and firms that we

[7]Table B.1 in the Appendix shows the sectors included in the analysis and the number of firms in each sector in the sample.

[8]Deflators are compiled at the DB07 10-industry grouping level and sourced from Statistics Denmark.

observe only in a single year. Afterwards, we winsorise capital, labour, intermediate inputs and output at the 1st and 99th percentiles. Finally, Denmark has many small firms, while pension funds invest mostly in large firms. To improve comparability across firms in the treated and control groups, we restrict our analysis sample to firms that have at least 10 employees in all periods.[9]

### II.3.3 Measures of Pension Fund Investment

In our empirical analysis, we use three different measures of pension fund investment in a firm: (i) a dummy for whether the firm received a pension fund investment in the previous year, (ii) investment intensity, which is equal to the aggregate share of a firm owned by all domestic pension funds together, and (iii) investment length, captured by the number of consecutive years (up to and including the previous year) of pension fund investment in the firm. We expect the latter variable to be relevant for the following reason. Productivity-enhancing investments are typically of a long-term nature (frequently involving new technology) because they take time to be planned, implemented and bear fruit. Hence, for a firm to be willing to make such investments, it needs to be confident that financing will remain available for a sufficiently long period. In view of their long-term liabilities, pension funds can be long-term financiers. Precisely because the effects of pension fund investment on productivity materialise only gradually over time, we expect the length of the pension fund investment history to be relevant for current productivity.[10]

### II.3.4 Descriptive Statistics

Our final sample consists of firms for which we can successfully compute productivity as described below.[11] This includes 102,443 firm–year observations, representing 14,968

[9] This restriction is common in the literature working with Danish register data (see, e.g., Fan et al., 2022; Parrotta et al., 2014).

[10] One main limitation of our data is that they only cover equity investments and not debt or loans. However, national accounts data (Danmarks Nationalbank, 2022) show that at the end of 2019 domestic pension funds and insurance companies held 254.6 bn DKK in equity and only 38.6bn DKK in debt and loans of Danish non-financial companies. Furthermore, Danish pension funds and insurance companies held 15.7% of the total equity of non-financial companies held by domestic financial corporations and only 2.1% of debt and loans. Therefore, they are much more active as equity rather than debt investors.

[11] The descriptive statistics and sample sizes discussed in this section refer to the final sample that we use to estimate equation (II.10) below and its variations. Since this estimation uses one-period lags

different firms. Of these, 574 (3.8%) are treated in at least one year. Following our methodology described below in Section II.4, we define treatment as a firm receiving a pension fund investment in the previous year. Descriptive statistics and definitions of all variables used in the analysis can be found in Table II.1. We show statistics for four different sub-samples: (i) all firm-year observations, (ii) firm-year observations with treatment, equivalent to receiving a pension fund investment in the previous year (year $t-1$), (iii) firm-year observation without treatment, and (iv) firm-year observations without treatment in the matched sample only (the matching procedure is part of our robustness analysis and is explained in the next section). Focusing on the second sub-sample, we observe that domestic pension funds invest on average for over 4 consecutive years and hold an aggregate stake of approximately 10.4% in a firm, conditional on investing in the firm in period $t$.

The second panel of Table II.1 reports some interesting facts about the firms that pension funds invest in. If we look at two standard measures of labour productivity, output per worker and value added per worker, firms with a pension fund investment are relatively more productive than untreated firms in the year following treatment. These firms, on average, also produce higher output (value added) with higher consumption of inputs (labour, capital and intermediary inputs). This is in line with the observation highlighted by the previous literature that institutional investors, including pension funds, tend to invest in larger firms (Ferreira & Matos, 2008). Pension funds also tend to invest in older firms: the average age of a firm one year after treatment exceeds that of untreated firms in the sample by more than three years. On average, pension funds start to invest in a firm in its 21st year of existence.

Furthermore, 48% of the firms that receive a pension fund investment do so in 2003, the first year for which we have pension fund data. Therefore, the variable that measures the length of the investment is left-censored by construction, given that we do not observe ownership data before 2003. For 62% of the firms that pension funds invest in, the first investment coincides with the first year that the firm is in the sample. This is again the result of the left-censoring of the investment tenure variable. Furthermore, we record 347 instances of pension funds fully divesting from a firm, meaning that at least one pension fund invests in the firm in some year $t-1$ but none invests in it in year $t$. Table B.1 in the Appendix shows the number of firms in the sample per NACE Rev.2 1-digit sector. Pension fund investment is clearly concentrated within the manufacturing sector,

of several variables, the final estimation period starts in 2004 and ends in 2019.

with 49% of all firms receiving a pension fund investment being in this sector.

Our hypothesis that pension funds can affect firm productivity through long-term investments is inspired by the assumptions that pension funds seek to match their long-term liabilities with long-term assets (Beyer et al., 2014; Della Croce et al., 2011). Empirical evidence supports the notion that pension funds typically have a longer investment horizon than other institutional investors (Cella et al., 2013; Cremers & Pareek, 2016; Döring et al., 2021; Harford et al., 2018). Our data confirms this trend. In the Appendix, Table B.2 compares the length of the investment period of domestic pension funds with that of other investors in the domestic financial industry. We classify other investors based on their 6-digit industry code (and 3-digit code for insurance companies). Panel A of Table B.2 reports the mean investment horizon of each investor group, conditional on investing in firm $i$ at time $t-1$, as well as the difference from the average investment horizon of pension funds for that firm and the p-value of a simple difference-in-means t-test. On average, pension funds invest in a firm for 0.89 years longer than banks. While this difference may seem small, it represents more than 20% of the mean investment horizon of pension funds, making it relatively important.[12] Our data show that, among domestic investors, pension funds feature a longer investment horizon than investors from all other sectors except for non-financial holding companies.[13] Moreover, the differences in the mean investment horizon between pension funds and other investor types are statistically significant for all sectors except investment companies. Panel B of Table B.2 shows that, prior to divestment, pension funds invested in firms for a larger number of consecutive years than any other investor type.[14] These differences are mostly statistically significant at the 1% level and always at least at the 10% level. To conclude, our data show that domestic pension funds exhibit a longer investment horizon than other domestic investors.

[12] Small absolute differences are also consistent with the empirical finance literature on investor horizon (see e.g. Cella et al., 2013).

[13] Non-financial holding companies correspond to DB07 sector 642020. According to Statistics Denmark, this sector includes holding companies whose main activity is to hold controlling stakes in other non-financial companies. Therefore, this sector does not include outside investors in the sense of asset managers, and therefore it is not surprising that they have a long investment horizon.

[14] In Panel B, the length variable is the number of consecutive years of investment in firm $i$ by at least one investor of each type in year $t-1$, conditional on no investor of that specific type investing in the firm in period $t$. This condition addresses the concern that the length variable is right-truncated, as investment by an investor type might continue after 2019 or the firm exits the sample due to our sampling conditions.

**Table II.1.** Descriptive Statistics

| Variable | Definition | All Mean | | Treatment Mean | | No Treatment Mean | | No Treatment (matched sample) Mean | |
|---|---|---|---|---|---|---|---|---|---|
| **Pension Fund Investment Variables** | | | | | | | | | |
| $DPFI_{it-1}$ | dummy = 1 if a pension fund invests in the firm | 0.022 | (0.148) | 1.000 | (0.000) | | | | |
| $Length_{it-1}$ | duration of the current episode of pension fund investment (years) | 0.093 | (0.788) | 4.156 | (3.294) | | | | |
| $Intensity_{it-1}$ | total ownership by domestic pension funds (%) | 0.233 | (2.391) | 10.393 | (12.250) | | | | |
| **Firm Variables** | | | | | | | | | |
| Output/Worker | output per worker (DKK, log) | 7.375 | (0.717) | 7.589 | (0.794) | 7.370 | (0.715) | 7.491 | (0.752) |
| VA/Worker | value added per worker (DKK, log) | 6.306 | (0.414) | 6.435 | (0.486) | 6.303 | (0.411) | 6.360 | (0.408) |
| Value Added | (DKK,log) | 10.035 | (1.141) | 11.411 | (1.207) | 10.003 | (1.119) | 10.550 | (1.050) |
| Labour | number of full-time employees (log) | 3.729 | (0.999) | 4.976 | (1.113) | 3.701 | (0.978) | 4.191 | (0.955) |
| Capital | fixed capital (DKK, log) | 8.995 | (1.747) | 10.697 | (1.727) | 8.956 | (1.728) | 9.609 | (1.638) |
| Intermediary Inputs | (DKK, log) | 10.540 | (1.474) | 12.043 | (1.477) | 10.506 | (1.456) | 11.142 | (1.435) |
| Age | firm age (years) | 24.463 | (18.888) | 28.135 | (21.080) | 24.377 | (18.824) | 25.779 | (18.591) |
| Capital Intensity | capital stock per worker (DKK, log) | 5.265 | (1.310) | 5.721 | (1.255) | 5.255 | (1.310) | 5.418 | (1.249) |
| **Observations** | | 102,443 | | 2,292 | | 100,151 | | 46,262 | |

*Notes:* All descriptive statistics are calculated as averages over the 2004–2019 period. Variables in DKK are in real Danish kroner (using 2010 as the base year). Since pension fund investment enters our estimations lagged by one year, we choose to report lagged pension fund investment variables. The table presents means and standard deviations in parentheses for four different subsamples: (i) all firm-year observations, (ii) firm-year observations with treatment, equivalent to receiving a pension fund investment in the previous year (year $t-1$), (iii) firm-year observations without treatment, and (iv) firm-year observations without treatment in the matched sample only. Values for subsample (ii) are reported conditional on the firm receiving a pension fund investment in the previous year $t-1$.

# II.4 Methodology

In this section, we describe the methods used to address selection and the identification of the impact of a pension fund investment on firms' productivity.

## II.4.1 Addressing Selection

Selection may confound the causal impact of a pension fund investment on productivity, as pension funds may actively select firms with certain characteristics that make them more productive to begin with. Selection is a very pervasive issue in the literature looking at the effects of investors on target firms (see, e.g., Aghion et al., 2013; Fons-Rosen et al., 2021; Garel, 2017; Lerner et al., 2011; Levine & Warusawitharana, 2021). A common approach is to use the inclusion of a firm in a large index as an exogenous event (Aghion et al., 2013), which exposes the firm to investment by certain institutional investors. For our case, this is not a suitable approach since (i) the indices on Danish listed equity instruments include only a small number of firms and (ii) the composition of the indices does not vary much over time, resulting in very low exogenous variation that can be exploited to tease out causality in our analysis. Furthermore, to the best of our knowledge, there are no other events in our sample period, such as a regulatory change, that would clearly affect the propensity of Danish pension funds to invest in domestic equity. We, therefore, adopt two strategies to account for selection effects.

First, we take an event study approach that allows us to check for differential pre-trends, i.e., to assess whether, before the treatment occurs, firms eventually treated with a pension fund investment differ in terms of productivity from their counterparts that do not receive a pension fund investment. A number of recent studies have highlighted concerns with the traditional event study design when units, in our case firms, receive treatment at different points in time (see, e.g., de Chaisemartin & D'Haultfoeuille, 2022; Goodman-Bacon, 2021). This issue is important in our context since pension funds start investing in firms in different years. Therefore, we use the estimator suggested by Sun and Abraham (2021) that is robust to treatment heterogeneity with respect to the timing of the treatment. For this event study, we use two different measures of labour productivity — i) value added per worker and ii) output per worker — and control for year-by-NACE Rev. 2 1-digit sector fixed effects. We also include the following control variables: firm age, firm size, a dummy for whether the firm is listed in the base year (the first year that it is in the sample), and capital intensity, defined as the capital-to-labour ratio.

Second, we implement a structural estimation approach developed by Bøler et al. (2015) and Doraszelski and Jaumandreu (2013) that allows us to explicitly attenuate the issue of selection by controlling for past productivity and thus firm-level heterogeneity. The next subsection describes this procedure in detail.

## II.4.2 Structural Productivity Estimation

Firm productivity is often defined as total factor productivity (TFP), the residual from a regression of firm output on input factors, usually formed by capital and labour. The main advantage of TFP over labour productivity measures such as output per employee is that it captures productivity changes after variation in input factors is accounted for (Chemmanur et al., 2011). This is particularly important in our case, since pension fund investments in a company may imply an injection of new capital and thus an increase in one of the inputs of the production function. We are interested in the productivity changes in response to pension fund investments that are not explained by changes in the amounts of inputs used in the production process.

A key concern in estimating TFP relates to potential simultaneity bias: changes in productivity may affect not only output (the dependent variable) but also the input mix that the firm chooses (the explanatory variables). Based on Ackerberg et al. (2015), we illustrate this problem using a Cobb–Douglas production function in logs:

$$y_{it} = \beta_k k_{it} + \beta_l l_{it} + \omega_{it} + \varepsilon_{it} \tag{II.1}$$

where lower case letters denote logs and $y_{it}$ is the value added of firm $i$ at time $t$, $k_{it}$ is its capital stock and $l_{it}$ is its labour input.[15] Furthermore, $\varepsilon_{it}$ is an i.i.d. unobservable shock to production (or a measurement error), while $\omega_{it}$ is a shock to production that cannot be observed by the econometrician but that can be anticipated by the firm and

[15] Industry subscripts are omitted for ease of reading. We define capital as the total value of tangible fixed assets (including real estate), calculated with the perpetual inventory method. Labour is the total number of employees, whereas intermediate inputs equal the sum of the following items: raw materials, consumables, goods for resale, finished goods and packaging (excluding purchases of energy), energy purchases, the value of subcontracts, rental and leasing costs. All monetary variables are deflated with sector-specific deflators published by Statistics Denmark.

is a source of potential endogeneity problems.[16] Simultaneity bias can arise because the firm may choose its capital and labour inputs as a function of its prediction of the future productivity shock that is unobservable to the econometrician. Hence, the choice of the inputs $(l_{it}, k_{it})$ and $\omega_{it}$ may be correlated, resulting in biased OLS estimates of the coefficients on the inputs (Ackerberg et al., 2015).

The use of proxy variables has recently become a popular approach to address this endogeneity issue. The approach uses available information to proxy for the unobservable $\omega_{it}$.[17] Popular estimation techniques include Olley and Pakes (1996), Levinsohn and Petrin (2003), Wooldridge (2009) and Ackerberg et al. (2015) (henceforth OP, LP, Wooldridge and ACF, respectively). OP uses an inverted demand function for investment as a proxy variable, while LP, ACF and Wooldridge use an inverted demand function for intermediate inputs since investment is often zero for a large share of observations. We follow Bøler et al. (2015), Doraszelski and Jaumandreu (2013), and Fan et al. (2022) and estimate the impact of a pension fund investment by using a control function approach in two steps. This structural estimation attenuates the selection issue discussed above. Furthermore, this approach addresses the concern that a firm receiving a pension fund investment may alter the use of inputs in a way that may bias the estimation of productivity. De Loecker (2013) finds that controlling for endogeneity is important for the correct estimation of firm productivity. While factors impacting productivity can be the result of firm decisions such as export or R&D expenditure choices (Bøler et al., 2015; De Loecker, 2013; Doraszelski & Jaumandreu, 2013; Fan et al., 2022), changes in the ownership structure have also been found to be important for firm productivity (Bircan, 2019; Braguinsky et al., 2015).

Productivity is obtained from a Cobb–Douglas production function containing value added, labour and capital. Following ACF in a setup described by equation (II.1), we assume that:

$$E\left(\varepsilon_{it} \mid l_{it}, k_{it}, m_{it}, l_{it-1}, k_{it-1,}, m_{it-1}, ..., l_{i1}, k_{i1}, m_{i1}\right) = 0 \tag{II.2}$$

where $m$ refers to our proxy variable (materials). Because past values of $\varepsilon_{it}$ are not included in the conditioning set, we allow for serial dependence in the pure shock term. However, we need to restrict the dynamics of the productivity process:

[16]More precisely, the firm does not observe $\omega_{it}$ until time $t$ and has information $p(\omega_{it+1}|\omega_{it})$ about the conditional distribution of the future shock.

[17]For an overview and discussion on the identification assumptions, see Ackerberg et al. (2015).

$$E\left(\omega_{it} \mid \omega_{it-1}, \omega_{it-2}, ..., \omega_{i1}\right) = E\left(\omega_{it} \mid \omega_{it-1}\right) = g\left(\omega_{it-1}\right) \tag{II.3}$$

for a given function $g(\cdot)$. As in ACF, for the timing of the choice of the inputs, we assume the following: i) $k_t$ is a function of $k_{t-1}$ and new investment at $t-1$, so it is fully determined by choices made at $t-1$ or earlier; ii) $l_t$ is chosen between $t-1$ and $t$; and iii) $m_t$ is chosen at time $t$. As a result, material demand is a function not only of capital and productivity but also of labour:

$$m_{it} = f(k_{it}, l_{it}, \omega_{it}) \tag{II.4}$$

Moreover, following the standard assumption in the literature that the material demand function is strictly monotonic in the productivity shock $\omega_{it}$ , we can invert the function in (II.4) to obtain $\omega_{it}$ as a function of $k_{it}, l_{it}$ and $m_{it}$:

$$\omega_{it} = \tilde{h}(k_{it}, m_{it}, l_{it}) \tag{II.5}$$

Plugging $\tilde{h}\,(.)$ into production function (II.1), we obtain:

$$y_{it} = h\left(k_{it}, m_{it}, l_{it}\right) + \varepsilon_{it} \tag{II.6}$$

where the linear terms in capital and labour in the production function have been subsumed in the new function $h(.)$. The goal of this (first-stage) equation is solely to predict output net of measurement error or unanticipated shocks, hence to separate $\omega_{it}$ from $\varepsilon_{it}$. We operationalise the first stage by approximating $h(.)$ using a second-degree polynomial of capital, labour and intermediate inputs with full interaction terms.[18] We then estimate the following equation separately by each NACE 1-digit sector $s$ via OLS:

$$y_{ist} = \delta_s + \kappa_t + h\left(k_{it}, m_{it}, l_{it}\right) + \varepsilon_{it} \tag{II.7}$$

where $\delta_s$ and $\kappa_t$ capture sector and year fixed effects, respectively. We then define $\widehat{h}_{it}$ as the predicted output net of sector and year fixed effects. The predicted output from the first stage $\widehat{h}_{it}$ is then used to identify the input elasticities in the second stage.

To obtain the second-stage estimation equation, it is important to note that productivity $\omega_{it}$ follows a first-order Markov process. In the standard ACF approach, this

[18]The results are unaffected when we use an alternative specification of the first stage – see the discussion of robustness in Section II.6 below.

Markov process is exogenous to the firm, meaning that the firm cannot affect it. Therefore, the firm can only react to changes in productivity but cannot influence how it evolves. Following Bøler et al. (2015), De Loecker (2013), and Doraszelski and Jaumandreu (2013), we relax this exogeneity assumption by augmenting the Markov process with our endogenous variable of interest, pension fund investment at time $t-1$. In other terms, pension fund investment enters as a shifter in the evolution of productivity $\omega_{it}$ over time. We prefer this approach to the inclusion of pension fund investment directly as an input in the production function (II.1) since pension fund investments in a given firm are not only determined by the firm in question, as it is the case for capital and labour. They are in fact the outcome of a complex decision-making process that involves both the investor and the firm. Formally, we assume that productivity $\omega_{it}$ depends on firm $i$ receiving a pension fund investment through the following law of motion:

$$\omega_{it} = \rho\omega_{it-1} + \gamma PFI_{it-1} + \xi_{it} \tag{II.8}$$

where $PFI_{it-1}$ denotes a pension fund investment in firm $i$ at time $t-1$. Furthermore, $\xi_{it}$ is an idiosyncratic error term uncorrelated with the other right-hand-side variables.[19]

Rewriting productivity in terms of predicted output $\widehat{h}_{it}$ from the first stage yields:

$$\widehat{\omega}_{it} = \widehat{h}_{it} - \beta_k k_{it} - \beta_l l_{it} \tag{II.9}$$

Integrating the law of motion (II.8) into (II.9) yields the estimating equation for the second stage:

$$\widehat{h}_{it} = \alpha + \beta_k k_{it} + \beta_l l_{it} + \rho\left(\widehat{h}_{it-1} - \beta_k k_{it-1} - \beta_l l_{it-1}\right) + \gamma PFI_{it-1} + \xi_{it} \tag{II.10}$$

where we have added the constant $\alpha$ to arrive at the empirical specification. We estimate (II.10) by the generalised method of moments (GMM).[20] Following the standard ACF approach, we use $k_{it}$ and $l_{it-1}$ as instruments. Since $\widehat{h}_{it-1}$, $k_{it-1}$, $k_{it}$ and $PFI_{it-1}$

[19] $PFI_{t-1}$ and earlier pension fund investment therefore indirectly enter the production function (II.1) through $\omega_{it}$. Relating this to our timing assumptions, input choices at time $t$ can depend on pension fund investment since it is in the information set at time $t$.

[20] For the identification of the production function elasticities, our approach requires variation in these inputs conditionally on $\omega_{it}$. Put differently, our approach requires either exogenous input price differences across firms or differences in input dynamics across firms. However, we obtain similar results (available upon request from the authors) when we include average wages at the firm level in the $\tilde{h}(.)$ function and we rule out variation in the price of the quasi-flexible inputs across firms.

are determined at time $t-1$ or earlier, they are orthogonal to the error term $\xi_{it}$ and can be used to form the necessary moment conditions. Labour $l_{it}$, however, is chosen after $t-1$, given our timing assumptions, so we instrument it with $l_{it-1}$. Finally, we allow the constant $\alpha$ to vary by industry by including sector dummies in the estimation, using these dummies as their own instruments. The instrument set thus contains $l_{it-1}$, $\widehat{h}_{it-1}$, $k_{it}$, $PFI_{it-1}$ and the industry dummies. The error term $\xi_{it}$ is uncorrelated with the instrument set since it is uncorrelated with all the information at time $t-1$ and, hence also, current capital $k_{it}$.

The coefficient $\gamma$ in equation (II.10) captures the effect of a past pension fund investment on firm productivity. We identify this effect in the second stage by exploiting variation in past pension fund investment $PFI_{it-1}$ conditional on lagged productivity $\omega_{it-1}$. The literature on the effect of ownership on productivity (see, e.g., Bircan, 2019; Braguinsky et al., 2015; Fons-Rosen et al., 2021) mostly uses a three-stage approach that consists of first estimating the elasticities of capital and labour in two steps to produce TFP estimates and then regressing the latter on the variables of interest and firm control variables. However, retrieving the effect of interest directly from the law of motion of productivity as we do allows us to control for past productivity and to address more explicitly the issue of selection.

### II.4.3 Matching

To address the fact that the firms in the control group tend to differ on average in terms of observable characteristics (such as size and industry) from treated firms, we construct a matched sample using a propensity score approach. First, we estimate the probability of a firm receiving a pension fund investment with a logit regression of the dummy variable $DPFI_{it}$ on valued added, labour, capital and an indicator for whether firm $i$ is listed (all at time $t-1$).[21] We calculate propensity scores using this method by sector-year and then drop firms from the matched control sample that have a propensity score below the sector-year-specific 25th percentile in at least one year.[22] We therefore proceed very conservatively and keep only firms in the matched control group that are

[21] The results from estimating our main specifications using a sample matched on base year values instead of one-period lags are very similar to our baseline results.

[22] Sectors are here defined as the standard DB07 36-industry grouping. The 25th percentile is calculated only among firms that do not receive a pension fund investment in any year. We keep firms for which a propensity score could be computed in at least one year. Including firms with missing propensity scores in all years from the matched control group does not change our results.

likely to receive a pension fund investment over the sample period. Furthermore, while the specification for the propensity score is very parsimonious, estimating it separately for each sector–year alleviates concerns over misspecification.

# II.5 Empirical Analysis

## II.5.1 Event Study

Figure II.1 presents the effect of a pension fund investment on two measures of firm productivity, output per worker and value added per worker, using the methodology described in Subsection II.4.1. We show the impact on these two straightforward measures of firm productivity instead of deriving the latter from structural estimation for two reasons: (i) we explore the selection hypothesis by testing for the presence of differential pre-trends, and this can be feasibly done only with standard measures of productivity, and (ii) the justification for extrapolating the productivity term outside the production function and using it as a dependent variable in a separate regression is not theoretically obvious (Ackerberg et al., 2015).[23] Figures II.1(b) and II.1(a) indicate that there are no significant pre-existing differences in productivity trends between treated and non-treated firms prior to the first pension fund investment in the firm (which we refer to as the "event" date).[24] However, we do observe a positive effect on productivity in the first few years following the event date, as shown in Figure II.1. To further explore this effect, we use a structural estimation approach in the next section.

We find that our event study results are robust to alternative specifications and sample restrictions. Specifically, we obtain qualitatively similar results in the event study analysis when we: (i) use a matched sample, ii) use an alternative measure of output[25], (iii) include the share of R&D workers among the control variables, or (iv) omit all control variables from the event study regressions. These results are available in Appendix Figures B.1–B.4, respectively. Moreover, our findings remain consistent

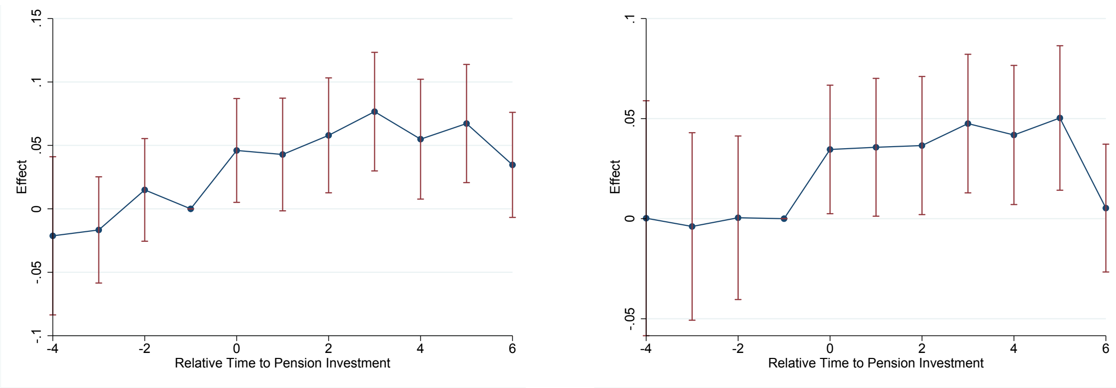
[23] In fact, the possibility of computing the effect of a pension fund investment directly in the productivity estimation is one of the main reasons that we choose this approach rather than the more traditional three-stage analysis used in the literature (e.g., Bircan, 2019; Braguinsky et al., 2015).

[24] We also do not find any evidence of differences in pre-trends using the estimator proposed by de Chaisemartin and D'Haultfoeuille (2022).

[25] Instead of using sales to measure output, the alternative measure is the sum of sales, work carried out at own expense and listed under assets, other operating income, and inventory changes.

when we focus on events where only one pension fund invests in a given firm over the sample period or when we exclude pension fund investments that last for fewer than five consecutive years. These results are reported in Appendix Figures B.5 and B.6.

**Figure II.1.** Event Study Results




**(a)** Value Added per Worker **(b)** Output per Worker

*Notes:* The outcome variable is (log) value added per worker in panel (a) and (log) output per worker in panel (b). The effect is shown in %. This figure presents point estimates and 95% confidence intervals of an event study specification using the estimator proposed by Sun and Abraham (2021). The following controls enter the specification: firm age, a dummy for the firm being listed in the base year, firm size (number of employees), and capital intensity. We also include year-by-NACE Rev.2 1-digit sector fixed effects.

## II.5.2 Main Results

All results reported in this section are obtained from the estimation of equation (II.10) using the log of the firm's value added as a measure of output $y_{it}$. We report the results for the baseline sample and the sample resulting from the matching procedure described in Subsection II.4.3. For convenience, we report the coefficient estimates of the pension fund investment variable and the related standard errors multiplied by 100.

Table II.2 presents the results for the model in which the pension fund investment is included through a dummy variable. Columns 1 and 5 show estimates for the case in which the law of motion of the productivity process is specified without the pension fund investment variable. Columns 2 and 6 introduce the pension fund dummy in the law of motion. Columns 3 and 7 restrict the pension fund investment dummy to take a value of 1 only if the aggregate holding by all Danish pension funds in firm $i$ is at least 5%. This allows us to abstract from those cases in which investment by pension funds constitutes only a negligible source of capital for the firm. Moreover, there are good reasons to assume that a non-negligible equity stake provides a stronger signal of commitment and a stronger signal to the rest of the financial market. Previous literature found that export status is important in the estimation of productivity (De Loecker, 2013). Columns 4 and 8 therefore report results including a dummy in equation (II.10) taking a value of 1 if firm $i$ is an exporter at $t-1$.

We observe a positive and significant effect of a pension fund investment in all specifications. Receiving a pension fund investment in the previous year is associated with an increase in productivity ranging from 3.0% to 4.6%, depending on the specification. As expected, the effect is slightly stronger when we restrict the pension fund investment dummy to take a value of 1 only when aggregate ownership of pension funds in the company is at least 5%. We also find a stronger effect when we select the matched sample. Interestingly, including the export dummy hardly affects the estimate of the pension investment dummy, suggesting that the effects of exporting and receiving a pension investment on productivity are independent.

Although we do not control for a large number of firm characteristics, the structural approach that we employ has the advantage of controlling for past productivity. In this way, we control for selection effects driven by heterogeneity, particularly for pension funds selecting firms based on their productivity. Hence, even controlling for such a potential selection effect, we find robust positive and significant effects of a pension fund investment on firm productivity.

**Table II.2.** Productivity Estimates: Pension Fund Dummy

| | Whole sample | | | | Matched sample | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| $\beta_l$ | 0.954*** | 0.953*** | 0.953*** | 0.950*** | 0.912*** | 0.910*** | 0.910*** | 0.908*** |
| | (0.005) | (0.005) | (0.005) | (0.005) | (0.008) | (0.008) | (0.008) | (0.008) |
| $\beta_k$ | 0.085*** | 0.085*** | 0.085*** | 0.084*** | 0.092*** | 0.092*** | 0.092*** | 0.091*** |
| | (0.003) | (0.003) | (0.003) | (0.003) | (0.005) | (0.005) | (0.006) | (0.005) |
| $DPFI_{it-1}$ | | 3.361*** | 3.460*** | 2.969*** | | 4.401*** | 4.638*** | 3.981*** |
| | | (0.992) | (1.129) | (0.989) | | (0.975) | (1.067) | (0.979) |
| Industry FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $PFI_{it-1} \geq 5\%$ | No | No | Yes | No | No | No | Yes | No |
| Export$_{it-1}$ | No | No | No | Yes | No | No | No | Yes |
| Obs. | 102,443 | 102,443 | 102,443 | 102,443 | 48,554 | 48,554 | 48,554 | 48,554 |
| Obs. PF | 2,292 | 2,292 | 1,730 | 2,292 | 2,292 | 2,292 | 1,730 | 2,292 |
| # Firms | 14,968 | 14,968 | 14,968 | 14,968 | 7,468 | 7,468 | 7,468 | 7,468 |
| # Firms PF | 574 | 574 | 429 | 574 | 574 | 574 | 429 | 574 |

*Notes:* This table presents the results from the estimation of equation (II.10). $DPFI_{it-1}$ is a dummy taking a value of 1 if at least one domestic pension fund invests in firm $i$ in year $t-1$. Coefficient estimates and standard errors for $DPFI_{it-1}$ are multiplied by 100. The estimated coefficient of $DPFI_{it-1}$ measures its effect on productivity. All specifications include industry fixed effects at the NACE Rev.2 1-digit level. Bootstrapped standard errors, clustered by firm, with 200 replications in parentheses. In columns 3 and 8, $DPFI_{it-1}$ equals 1 if the aggregate holding of all pension funds in firm $i$ in year $t-1$ was at least equal to 5%. In columns 4 and 8, we include a dummy equal to 1 if firm $i$ is an exporter in year $t-1$. The line "Obs. PF" ("# Firms PF") gives the number of observations (number of firms) with a pension fund investment in year $t-1$. Finally, $^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, and $^{***}$ $p < 0.01$.

Next, we investigate whether the size of the pension fund investment matters by defining pension fund investment in equation (II.10) as the total share of the equity of firm $i$ (in percent) held by all domestic pension funds. Table II.3 presents the results of this specification. On average, an increase of 1 percentage point in pension fund investment is associated with a TFP increase of approximately 0.2%. Note that the estimated coefficient on $Intensity_{it-1}$ combines the effect due to the extensive margin (i.e., receiving a pension fund investment at all) with the one induced by the intensive margin (i.e., the size of the investment).[26]

[26]Unfortunately, we lack the statistical power to distinguish between these two effects due to a limited number of treated observations.

**Table II.3.** Productivity Estimates: Pension Fund Investment Intensity

| | Whole sample | | | Matched sample | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\beta_l$ | 0.953*** | 0.953*** | 0.950*** | 0.911*** | 0.911*** | 0.909*** |
| | (0.005) | (0.005) | (0.005) | (0.008) | (0.008) | (0.008) |
| $\beta_k$ | 0.085*** | 0.085*** | 0.084*** | 0.092*** | 0.092*** | 0.091*** |
| | (0.003) | (0.003) | (0.003) | (0.006) | (0.006) | (0.005) |
| $Intensity_{it-1}$ | 0.220*** | 0.219*** | 0.208** | 0.243*** | 0.242*** | 0.230*** |
| | (0.084) | (0.084) | (0.081) | (0.086) | (0.086) | (0.083) |
| Industry FE | Yes | Yes | Yes | Yes | Yes | Yes |
| $PFI_{it-1} \geq 5\%$ | No | Yes | No | No | Yes | No |
| Export$_{it-1}$ | No | No | Yes | No | No | Yes |
| Obs. | 102,443 | 102,443 | 102,443 | 48,554 | 48,554 | 48,554 |
| Obs. PF | 2,292 | 1,730 | 2,292 | 2,292 | 1,730 | 2,292 |
| # Firms | 14,968 | 14,968 | 14,968 | 7,468 | 7,468 | 7,468 |
| # Firms PF | 574 | 429 | 574 | 574 | 429 | 574 |

*Notes:* This table presents results from the estimation of equation (II.10). $Intensity_{it-1}$ is the aggregate share of equity of firm $i$ (in percent) held by domestic pension funds in year $t-1$. Coefficient estimates and standard errors for $Intensity_{it-1}$ are multiplied by 100. The estimated coefficient of $Intensity_{it-1}$ measures its effect on productivity. All specifications include industry fixed effects at the NACE Rev.2 1-digit level. Bootstrapped standard errors, clustered by firm, with 200 replications in parentheses. In columns 2 and 5, $Intensity_{it-1}$ is equal to 0 if the aggregate holding of all domestic pension funds in firm $i$ at time $t-1$ is less than 5%. In columns 3 and 6, we include a dummy taking value 1 if firm $i$ is an exporter at time $t-1$. The line "Obs. PF" ("# Firms PF") gives the number of observations (number of firms) with a pension fund investment at time $t-1$ in the sample. Finally, $^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, and $^{***}$ $p < 0.01$.

One of the main differences between pension funds and most other types of investors is their long investment horizon. Therefore, pension funds can provide long-term financing security and stimulate firms to make productivity-enhancing investments (often using new technology). Hence, we now investigate whether the holding period of a pension fund investment makes a difference by capturing the pension fund investment in equation (II.10) with the variable $Length_{it-1}$, which measures the number of consecutive years that firm $i$ has received pension fund investment up to year $t-1$. Table II.4 shows that an additional year of a pension fund investment is associated with a highly significant increase in productivity in the range of 0.4%–0.6%, depending on the specification. Hence, this finding lends support to the hypothesised mechanism.

These results on duration should be interpreted with caution due to the following two caveats. First, like in the intensity results, the coefficients estimated on the variable $Length_{it-1}$ capture the impact of both the extensive and intensive margins. Although we do not have enough power to separate the two effects, we are confident that the duration of the investment matters for productivity. The event study provides in fact suggestive evidence for a positive effect on productivity not only in the first year of the investment but also some years after the investment starts. Furthermore, regression results based on equation (II.10) including $Length_{it-1}$ and its square, as reported in Table B.7 of the Appendix, suggest a non-linear relationship between productivity and our length variable. This supports the hypothesis that not all of the estimated effects in Table II.4 are driven by the extensive margin. Second, the length variable may be a downward-biased estimate of the actual length of the investment history in the firm, because our sample starts only in 2003. However, because of this truncation at the start of the sample period and the associated measurement error, we are likely to underestimate the effect of investment tenure, and the estimates reported in Table II.4 likely represent a lower bound on the true effect of investment tenure.

**Table II.4.** Productivity Estimates: Pension Fund Investment Length

| | Whole sample | | | Matched sample | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\beta_l$ | 0.953*** | 0.953*** | 0.950*** | 0.911*** | 0.911*** | 0.909*** |
| | (0.005) | (0.005) | (0.005) | (0.008) | (0.008) | (0.008) |
| $\beta_k$ | 0.085*** | 0.085*** | 0.084*** | 0.092*** | 0.092*** | 0.091*** |
| | (0.003) | (0.003) | (0.003) | (0.006) | (0.006) | (0.005) |
| $Length_{it-1}$ | 0.469** | 0.486** | 0.414** | 0.589*** | 0.639*** | 0.527*** |
| | (0.203) | (0.242) | (0.203) | (0.188) | (0.213) | (0.188) |
| Industry FE | Yes | Yes | Yes | Yes | Yes | Yes |
| $PFI_{it-1} \geq 5\%$ | No | Yes | No | No | Yes | No |
| Export$_{it-1}$ | No | No | Yes | No | No | Yes |
| Obs. | 102,443 | 102,443 | 102,443 | 48,554 | 48,554 | 48,554 |
| Obs. PF | 2,292 | 1,730 | 2,292 | 2,292 | 1,730 | 2,292 |
| # Firms | 14,968 | 14,968 | 14,968 | 7,468 | 7,468 | 7,468 |
| # Firms PF | 574 | 429 | 574 | 574 | 429 | 574 |

*Notes:* This table presents the results from the estimation of equation (II.10). $Length_{it-1}$ is the number of consecutive years that firm $i$ receives investment from any domestic pension fund up to year $t-1$ included. Coefficient estimates and standard errors for $Length_{it-1}$ are multiplied by 100. The estimated coefficient of $Length_{it-1}$ measures its effect on productivity. All specifications include industry fixed effects at the NACE Rev.2 1-digit level. Bootstrapped standard errors, clustered by firm, with 200 replications in parentheses. In columns 2 and 5, $Length_{it-1}$ includes only the years when aggregate investment by domestic pension funds in the firm is at least 5%. In columns 3 and 6, we include a dummy taking value 1 if firm $i$ is an exporter at time $t-1$. The line "Obs. PF" ("# Firms PF") gives the number of observations (number of firms) with a pension fund investment at time $t-1$ in the sample. Finally, * $p < 0.1$, ** $p < 0.05$, and *** $p < 0.01$.

### II.5.3 Robustness Checks

In this section, we discuss the robustness of our main results. First, we explore the robustness of our results to different levels of sectoral classification. In the baseline analysis, we estimate our production function separately by NACE 1-digit industry, which is a rather aggregated classification. Our baseline results could be affected by the fact that we estimate the first stage across very broadly defined industries that could mask substantial variation at a more granular industry level. As a first robustness check, we re-estimate the productivity effect of a pension investment at a more granular level, i.e. at the DB07 36-industry group level instead of the NACE 1-digit level). This classification can be seen as an intermediary level between the NACE 1-digit and 2-digit levels. The second robustness check addresses data limitations regarding firm ownership. Our baseline estimations use a control group based on all firms in Denmark. However, we have ownership data only for firms that are at least partly owned by one other firm or more. Therefore, the set of firms that receive a pension fund investment is a subset of the latter. To verify that our results are not driven by the inclusion of firms for which ownership data are unavailable, we repeat our baseline exercise excluding these firms.

Table II.5 presents the results of both of these checks. The left-hand part of the table includes sector fixed effects at the DB07 36-industry level, while the right-hand part excludes firms without ownership information from the sample.[27] When we use a more granular sector classification, the magnitudes of the coefficients on all pension fund investment variables slightly decrease, while they slightly increase when we include only firms with ownership data. Notwithstanding these small changes, our baseline results are confirmed for both checks.

As a third robustness check, we explore whether including co-investments by other parties from the financial sector in our regressions affects our coefficients of interest. There is in fact a concern that if pension funds invest in a firm always in conjunction with other investors (such as private equity or insurance companies), then it would be misleading to interpret the estimated positive coefficients reported in the previous tables as the effects on productivity exclusively attributable to the presence of pension funds in the shareholder base of a firm. We, therefore, augment our baseline specification from column 2 of Table II.2 by adding a dummy that captures investments by firms

[27]The specifications of the models estimated for each variant in Table II.5 correspond to those in column 2 in Table II.2 and column 1 in Tables II.3 and II.4.

from different sub-sectors of the domestic financial sector and report the results in Table II.6.[28] These additional results allow us to dismiss the concern that the estimated effects reported in the baseline analysis are confounded by the presence of other investors. Table II.6 shows in fact that no matter how we measure the other investor dummy, our central variable capturing pension fund investments remains positive and significant, with a coefficient estimate ranging from 2.1 to 3.4 percent.

**Table II.5.** Productivity Estimates: Robustness Checks

| | 36-industry grouping | | | Excl. firms without ownership data | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\beta_l$ | 0.949*** | 0.949*** | 0.949*** | 0.933*** | 0.933*** | 0.933*** |
| | (0.520) | (0.515) | (0.518) | (0.562) | (0.562) | (0.560) |
| $\beta_k$ | 0.087*** | 0.087*** | 0.087*** | 0.093*** | 0.093*** | 0.093*** |
| | (0.350) | (0.350) | (0.350) | (0.395) | (0.396) | (0.396) |
| $DPFI_{it-1}$ | 3.289*** | | | 4.472*** | | |
| | (1.131) | | | (0.992) | | |
| $Intensity_{it-1}$ | | 0.228*** | | | 0.269*** | |
| | | (0.081) | | | (0.079) | |
| $Length_{it-1}$ | | | 0.450** | | | 0.639*** |
| | | | (0.229) | | | (0.200) |
| Industry FE | Yes | Yes | Yes | Yes | Yes | Yes |
| $PFI_{it-1} \geq 5\%$ | No | No | No | No | No | No |
| Export$_{it-1}$ | No | No | No | No | No | No |
| Obs. | 102,443 | 102,443 | 102,443 | 73,309 | 73,309 | 73,309 |
| Obs. PF | 2,292 | 2,292 | 2,292 | 2,236 | 2,236 | 2,236 |
| # Firms | 14,968 | 14,968 | 14,968 | 10,803 | 10,803 | 10,803 |
| # Firms PF | 574 | 574 | 574 | 564 | 564 | 564 |

*Notes:* This table presents the results from the estimation of equation (II.10). $DPFI_{it-1}$ is a dummy taking a value of 1 if at least one domestic pension fund invests in firm $i$ in period $t-1$. $Intensity_{it-1}$ is the aggregate share of the equity of firm $i$ (in percent) held by domestic pension funds in year $t-1$. $Length_{it-1}$ is the number of consecutive years that firm $i$ receives investment from any domestic pension fund up to year $t-1$ included. Coefficient estimates and standard errors for $DPFI_{it-1}$, $Length_{it-1}$ and $Intensity_{it-1}$ are multiplied by 100. The coefficient estimates measure the effect of these variables on productivity. Columns 1–3 include industry fixed effects at the DB07 36-industry level. Bootstrapped standard errors, clustered by firm, with 200 replications in parentheses. Columns 4–6 include industry fixed effects at the NACE Rev. 2 1-digit level. Bootstrapped standard errors, clustered by firm, with 200 replications in parentheses. The line "Obs. PF" ("# Firms PF") gives the number of observations (number of firms) with a pension fund investment at time $t-1$. Finally, $^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, and $^{***}$ $p < 0.01$.

We now conclude this robustness checks section by briefly discussing additional results that can be found in Appendix B. First, Tables B.3–B.5 show that our results

[28] We construct this additional variable on the basis of the investor's main sector of activity.

**Table II.6.** Productivity Estimates: Including Other Investors

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $\beta_l$ | 0.953*** | 0.953*** | 0.953*** | 0.953*** | 0.953*** | 0.953*** | 0.953*** | 0.953*** | 0.953*** | 0.953*** | 0.953*** | 0.953*** | 0.953*** |
| | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) |
| $\beta_k$ | 0.085*** | 0.085*** | 0.085*** | 0.085*** | 0.085*** | 0.085*** | 0.085*** | 0.085*** | 0.085*** | 0.085*** | 0.085*** | 0.085*** | 0.085*** |
| | (0.003) | (0.003) | (0.003) | (0.003) | (0.003) | (0.003) | (0.003) | (0.003) | (0.003) | (0.003) | (0.003) | (0.003) | (0.003) |
| $DPFI_{it-1}$ | 3.283*** | 3.277*** | 3.000*** | 3.363*** | 3.272*** | 3.362*** | 2.815*** | 3.252*** | 3.041*** | 3.352*** | 2.079* | 3.349*** | 3.356*** |
| | (0.989) | (0.989) | (1.086) | (0.994) | (1.006) | (0.994) | (1.020) | (1.053) | (0.990) | (1.214) | (1.115) | (1.038) | (0.990) |
| $Other_{it-1}$ | 0.176 | 0.192 | 1.260 | -0.005 | 0.301 | -0.003 | 1.422** | 1.346 | 1.406** | 0.030 | 2.545*** | 0.151 | 0.663 |
| | (0.287) | (0.286) | (1.548) | (0.282) | (0.710) | (0.287) | (0.658) | (1.932) | (0.693) | (1.408) | (0.903) | (1.699) | (1.865) |
| Obs. | 102,443 | 102,443 | 102,443 | 102,443 | 102,443 | 102,443 | 102,443 | 102,443 | 102,443 | 102,443 | 102,443 | 102,443 | 102,443 |
| Obs. PF | 2,292 | 2,292 | 2,292 | 2,292 | 2,292 | 2,292 | 2,292 | 2,292 | 2,292 | 2,292 | 2,292 | 2,292 | 2,292 |
| # Firms | 14,968 | 14,968 | 14,968 | 14,968 | 14,968 | 14,968 | 14,968 | 14,968 | 14,968 | 14,968 | 14,968 | 14,968 | 14,968 |
| # Firms PF | 574 | 574 | 574 | 574 | 574 | 574 | 574 | 574 | 574 | 574 | 574 | 574 | 574 |
| Obs. other | 40,994 | 40,852 | 959 | 37,207 | 3,478 | 35,156 | 4,219 | 290 | 3,622 | 919 | 3,441 | 229 | 81 |
| # Firms other | 7,384 | 7,367 | 315 | 6,893 | 973 | 6,582 | 1,050 | 136 | 909 | 279 | 923 | 88 | 32 |
| Obs. both | 2,020 | 2,008 | 664 | 1,659 | 738 | 1,524 | 990 | 190 | 627 | 706 | 1,234 | 180 | 18 |
| # Firms both | 540 | 539 | 234 | 478 | 258 | 450 | 312 | 100 | 219 | 216 | 358 | 72 | 7 |

*Notes:* This table presents the results from the estimation of equation (II.10), the baseline variant in column 2 of Table 2, adding a dummy for domestic investors that are not pension funds. $DPFI_{it-1}$ is a dummy equal to 1 if at least one domestic pension fund invests in firm $i$ in year $t-1$. $Other_{it-1}$ is a dummy equal to 1 if at least one non-pension fund investor from a specific part (as indicated in the following) of the domestic financial industry, according to the 6-digit DB07 sector classification, invested in firm $i$ in year $t-1$. This dummy takes value 1 as follows. Column 1: any investor from the domestic financial industry, except for pension funds (the *other* investors in all subsequent columns are subsets of this group). Column 2: banking and financing activities, except insurance and pensions. Column 3: banks, savings banks and cooperative banks. Column 4: holding company. Column 5: financial holding company. Column 6: non-financial holding company. Column 7: investment associations, investment companies etc. Column 8: money market associations. Column 9: investment companies. Column 10: venture companies and capital funds. Column 11: other financial intermediaries except for insurance and pension insurance. Column 12: insurance companies. Column 13: asset management. Coefficient estimates and standard errors for $DPFI_{it-1}$ and $Other_{it-1}$ are multiplied by 100. The coefficient estimate of $DPFI_{it-1}$ measures its effect on productivity. All specifications include industry fixed effects at the NACE Rev.2 1-digit level. Bootstrapped standard errors, clustered by firm, with 200 replications in parentheses. The line "Obs. PF" ("# Firms PF") gives the number of observations (number of firms) with a pension fund investment at time $t-1$. The line "Obs. other" ("# Firms other") gives the number of observations (number of firms) with an investment from the indicated part of the financial sector at time $t-1$. The line "Obs. both" ("# Firms both") gives the number of observations (number of firms) with a simultaneous investment by a pension fund and a firm from the indicated part of the financial sector at time $t-1$. Finally, $^{*}$ $p<0.1$, $^{**}$ $p<0.05$, and $^{***}$ $p<0.01$.

and interpretations are largely robust to the use of a gross output-based instead of a value added-based production function. Even though the coefficients estimated on our pension fund investment variables are generally not precisely estimated, they remain positive and far from zero. Further details of the estimation procedure can be found in the Appendix.

Second, jointly including the investment intensity and its square yields positive coefficients on the linear term that remain significant for the matched sample, but lose significance for the full sample, although their magnitude is not far from their original magnitude (Table B.6). We attribute this loss of significance to the low number of treatment observations. Jointly including the holding period and its square yields a highly significant positive coefficient on the former and a significant negative coefficient on the latter (Table B.7), providing an indication of a potential non-linear relationship between productivity and holding period.

Third, limiting the definition of pension fund investment to include only direct pension fund investments in a firm reduces precision because the number of firms with a pension fund investment falls substantially.[29] Nevertheless, the coefficients of the pension fund dummy and intensity remain positive (Tables B.8 and B.9). It is noteworthy that the aggregate direct stake that domestic pension funds hold is always at least 5% in the sample.

Fourth, we exclude from the sample firms whose paid-in share capital increased in any sample year. Firms that increase capital may experience a productivity increase regardless of whether a pension fund invests, which would complicate our interpretation of the effect of a pension fund investment. However, excluding these firms confirms our baseline results for the investment dummy and intensity, with positive and highly significant coefficients in all models (Tables B.10 and B.11). The coefficient on investment length remains positive in all models (Table B.12). Fifth, we replace the pension fund investment dummy with the number of pension funds investing in a firm and obtain a positive and highly significant coefficient (Table B.13). However, as mentioned in the previous section discussing the results on the intensity and length variables, the positive effect estimated on the number of pension funds is due to changes at both the extensive

[29] Direct pension fund investments are defined as cases where the direct owner is a pension fund. In the baseline analysis, we use a broader definition of pension fund investment along the following lines. Let firm C be a pension fund and let it invest in firm B. Let firm B in turn own firm A. In the baseline analysis, Firm A is defined as receiving pension fund investment since firm C is a pension fund that invests in it through firm B (this can be seen as indirect investment).

and the intensive margin of investment. The limited number of treated observations does not allow for separating the two effects. Sixth, our main findings are robust to defining capital as the book value of fixed assets instead of the value obtained via the perpetual inventory method as in our baseline results (Tables B.14–B.16). Finally, our results remain unaffected if we approximate the function $h(.)$ in the first-stage equation (II.7) by a third-degree polynomial in labour, capital, intermediary inputs, average wage and investment rate (following Fan et al., 2022). The results of this exercise are presented in Tables B.17–B.19.

## II.5.4 Heterogeneity Analysis

In this subsection, we explore if the impact of a pension fund investment is heterogeneous across firms.

### II.5.4.1 Listed and Unlisted Firms

One of the strengths of our dataset is that it includes information on pension fund investments for both listed and unlisted firms. In this subsection, we explore whether the effect of a pension fund investment differs between these two categories of firms. We define a firm as listed if it issued an equity instrument listed on the Copenhagen Stock Exchange over the sample period. Furthermore, we apply business group mapping to expand the group of listed firms as follows. Using the KONC register published by Statistics Denmark, we map firms that belong to the same business group. If one firm in a business group is listed in a given year, we define all firms in the business group as listed in that year. We apply the same logic to our pension fund investment measures. Therefore, if one company in a business group receives a pension fund investment in a given year, we assume that all companies in the business group receive a pension fund investment in that year.[30]

This mapping addresses two issues: (i) the number of individual listed firms in Denmark is very low, and therefore, the mapping allows us to increase the sample size

[30]To illustrate the mapping with an example, let firms A and B belong to the same business group. Firm A receives a pension fund investment at time $t-1$, while firm B does not. Furthermore, firm B is publicly listed, while firm A is not. In Tables II.7 and II.8, both firms A and B are defined as treated and publicly listed, since they belong to the same business group. In our baseline results, only firm A is defined as treated, because we do not use business group mapping. However, the baseline results are robust to using the mapping and defining both A and B as treated.

to allow a meaningful analysis; and (ii) the actual equity instrument is often issued by a headquarters company, for example, a holding company, that has only administrative tasks in the business group. However, this type of firm is not the ideal object for productivity analysis. The drawback of the approach proposed here would be that any analysis of investment intensity would necessitate the additional stronger assumption that the amount invested in one firm in the business group is equivalent for all firms in the business group. A similar argument holds for the investment length. We refrain from making these assumptions and therefore restrict the analysis in this subsection to the pension fund investment dummy variable.

As a first exercise, we modify equation (II.10) as follows:

$$\begin{aligned}\widehat{h}_{it} =& \alpha + \beta_k k_{it} + \beta_l l_{it} + \rho\left(\widehat{h}_{it-1} - \beta_k k_{it-1} - \beta_l l_{it-1}\right) + \gamma_1 PFI_{it-1} \\ &+ \gamma_2 List_i + \gamma_3 PFI_{it-1} \times List_i + \xi_{it}\end{aligned} \tag{II.11}$$

where $List_i$ is a dummy equal to 1 if firm $i$ is part of a business group that includes at least one firm listed on the Copenhagen Stock Exchange in at least one year from 2003–2019. The coefficient $\gamma_3$ indicates whether the effect of a pension fund investment is different for listed and unlisted firms. Table II.7 reports the results of this specification. While listed firms overall seem to be more productive, as indicated by the positive sign of the coefficient $\gamma_2$, the coefficient $\gamma_3$ reveals that the pension fund investment effect is stronger for unlisted firms by 6–7 percentage points. Therefore, we find that unlisted firms indeed benefit more from pension fund investment than do listed firms. This finding is consistent with the hypothesis that pension fund investment raises productivity through the capital provision channel. Listed firms typically have easier access to third-party capital compared to unlisted firms. As a result, an investment from a particular investor, such as a pension fund, may have a greater impact on unlisted firms.

**Table II.7.** Productivity Estimates: Listed vs. Unlisted Firms

| | (1) | (2) |
|---|---|---|
| $\beta_l$ | 0.951*** | 0.947*** |
| | (0.005) | (0.005) |
| $\beta_k$ | 0.084*** | 0.083*** |
| | (0.003) | (0.003) |
| $DPFI_{it-1}$ | 3.869*** | 3.474*** |
| | (1.151) | (1.140) |
| $List_i$ | 7.921*** | 7.842*** |
| | (1.761) | (1.741) |
| $DPFI_{it-1} \times List_i$ | -6.822*** | -6.568*** |
| | (2.224) | (2.214) |
| Industry FE | Yes | Yes |
| $PFI_{it-1} \geq 5\%$ | No | No |
| Export$_{it-1}$ | No | Yes |
| Obs. | 102,443 | 102,443 |
| Obs. PF | 2,753 | 2,753 |
| # Firms | 14,968 | 14,968 |
| # Firms PF | 712 | 712 |

*Notes:* This table presents the results from the estimation of equation (II.11). $DPFI_{it-1}$ is a dummy equal to 1 if at least one domestic pension fund invests in firm $i$ in year $t-1$. $List_i$ is a dummy equal to 1 if firm $i$ is part of a business group including at least one firm listed on the Copenhagen Stock Exchange in at least one sample year. Coefficient estimates and standard errors for $DPFI_{it-1}$, $List_i$ and their interaction term are multiplied by 100. The coefficient estimates on these regressors measure their effect on productivity. All specifications include industry fixed effects at the NACE Rev.2 1-digit level. Bootstrapped standard errors, clustered by firm, with 200 replications in parentheses. In column 2, we include a dummy equal to 1 if firm $i$ was an exporter in year $t-1$. The line "Obs. PF" ("# Firms PF") gives the number of observations (number of firms) with a pension fund investment in year $t-1$. Finally, $^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, and $^{***}$ $p < 0.01$.

For the set of listed firms, we have the possibility of verifying our findings using another dataset. This second dataset, which we henceforth refer to as "Collected Data", is the result of an original data collection effort in which we obtain investment data directly from six large Danish pension funds, which at the end of 2019 together managed approximately 70% of assets in the Danish pension sector. We use only data on listed equity holdings of these funds during the period from 2005 through 2019 due to data availability constraints.[31]

Table II.8 shows the results using this alternative source of pension fund investment data. Since the Collected Data only includes pension fund investment information for

[31]Please see Section I.2 of Chapter I for a detailed description of this dataset.

publicly listed firms, we exclude privately held firms from this exercise. The positive coefficient on the pension fund investment variable supports our main conclusions, and its magnitude is even larger than that from our baseline specifications. However, the results obtained from this additional refinement have to be interpreted with some caution due to the small sample size.

**Table II.8.** Productivity Estimates: Listed Firms from Collected Data

| | (1) | (2) | (3) |
|---|---|---|---|
| $\beta_l$ | 0.785*** | 0.775*** | 0.771*** |
| | (0.037) | (0.038) | (0.039) |
| $\beta_k$ | 0.145*** | 0.144*** | 0.144*** |
| | (0.025) | (0.025) | (0.025) |
| $DPFI_{it-1}$ | | 8.165** | 8.017** |
| | | (3.274) | (3.245) |
| Industry FE | Yes | Yes | Yes |
| $PFI_{it-1} \geq 5\%$ | No | No | No |
| Export$_{it-1}$ | No | No | Yes |
| Obs. | 2,802 | 2,802 | 2,802 |
| Obs. PF | 1,330 | 1,330 | 1,330 |
| # Firms | 348 | 348 | 348 |
| # Firms PF | 222 | 222 | 222 |

*Notes:* This table presents the results from the estimation of equation (II.10) using data on domestic listed equity holdings collected directly from a subset of Danish pension funds. $DPFI_{it-1}$ is a dummy equal to 1 if at least one domestic pension fund invests in firm $i$ in year $t-1$. Coefficient estimates and standard errors for $DPFI_{it-1}$ are multiplied by 100. The coefficient estimate of $DPFI_{it-1}$ measures its effect on productivity. All specifications include industry fixed effects at the NACE Rev.2 1-digit level. Bootstrapped standard errors, clustered by firm, with 200 replications in parentheses. In column 3, we include a dummy equal to 1 if firm $i$ is an exporter in year $t-1$. The line "Obs. PF" ("# Firms PF") gives the number of observations (number of firms) with a pension fund investment at time $t-1$. Finally, $^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, and $^{***}$ $p < 0.01$.

### II.5.4.2 Further Heterogeneity Analysis

We further explore heterogeneity along the following dimensions: firm size, age and labour productivity. For each of those variables, we construct a dummy indicator. Specifically, the dummy $small_i$ equals 1 if firm $i$'s employment, defined as the number of employees, in its base year is below the sample median employment.[32] Furthermore, the dummy $young_i$ is equal to 1 if the number of years since firm $i$ was established is below

[32]The base year is defined as the first year in which we observe a firm in our sample.

the sample median. Finally, $hlprod_i$ equals 1 if firm $i$'s base year output per worker is above the sample median.[33] We interact each of these dummies with the pension fund investment dummy analogous to equation (II.11).

Table II.9 presents the results. Whereas the age of the firm does not matter for the effect of a pension fund investment, we find evidence that smaller firms benefit more from a pension fund investment. This larger effect for small firms is in line with the notion that pension fund investment is relatively more important as a source of funding for small firms, which are more likely to be non-listed firms and therefore companies with fewer possibilities of turning to alternative financing sources. Finally, base year output per worker does not matter for the effect of a pension fund investment. However, it is noteworthy that the coefficient on the pension fund investment variable is still significant after we control for high base year labour productivity, supporting the notion that the pension fund investment effect that we estimate is not specifically due to the selection of highly-productive firms by pension funds when they start their investment.

# II.6 Discussion and Conclusion

Among a multitude of potential initiatives to raise productivity, this paper has focused on the role of pension funds. In recent decades, funded pension savings have increased significantly across the globe, and countries with high levels of pension savings relative to GDP typically top the international ranking of pension systems. For example, Mercer (2021) ranks pension systems in terms of adequacy, sustainability and integrity. The three countries with the best-rated pension systems, Iceland, the Netherlands and Denmark, also have the highest pension assets to GDP ratios among OECD countries (OECD, 2023). However, while pension funds are potential financiers of firms, it is largely an unresolved question whether and to what extent pension fund investments affect firms' productivity.

In this paper, we have highlighted several possible channels for a positive effect of a pension fund investment on firms' productivity. For example, by channelling savings toward firms, pension funds can raise the supply of capital, thereby reducing its cost and hence stimulating investment by firms. Additionally, pension funds are long-term investors in the sense that they try to match their long-term liabilities with long-term

[33]When we calculate these dummies on the basis of year-specific medians, we obtain similar results.

**Table II.9.** Productivity Estimates: Heterogeneity Analysis

| | Age | | | Size | | | $\frac{output}{worker}$ | | |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| $\beta_l$ | 0.953*** | 0.953*** | 0.950*** | 0.950*** | 0.950*** | 0.948*** | 0.950*** | 0.950*** | 0.948*** |
| | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) |
| $\beta_k$ | 0.085*** | 0.085*** | 0.084*** | 0.085*** | 0.085*** | 0.084*** | 0.076*** | 0.076*** | 0.075*** |
| | (0.003) | (0.003) | (0.003) | (0.003) | (0.003) | (0.003) | (0.003) | (0.003) | (0.003) |
| $DPFI_{it-1}$ | 5.238*** | 4.582*** | 4.610*** | 2.083** | 2.590** | 1.718* | 3.145*** | 3.372*** | 2.822*** |
| | (1.632) | (1.634) | (1.596) | (0.961) | (1.138) | (0.966) | (0.980) | (1.128) | (0.961) |
| $young_i$ | -0.050 | -0.084 | -0.425 | | | | | | |
| | (0.398) | (0.397) | (0.390) | | | | | | |
| $DPFI_{it-1} \times young_i$ | -2.996 | -1.765 | -2.622 | | | | | | |
| | (1.826) | (1.893) | (1.804) | | | | | | |
| $small_i$ | | | | -0.945 | -0.914 | -0.637 | | | |
| | | | | (0.576) | (0.576) | (0.577) | | | |
| $DPFI_{it-1} \times small_i$ | | | | 10.052** | 8.681** | 9.731** | | | |
| | | | | (4.085) | (4.310) | (4.101) | | | |
| $hlprod_i$ | | | | | | | 17.980*** | 17.980*** | 17.650*** |
| | | | | | | | (0.665) | (0.664) | (0.657) |
| $DPFI_{it-1} \times hlprod_i$ | | | | | | | -1.886 | -2.388 | -1.673 |
| | | | | | | | (1.904) | (2.058) | (1.893) |
| Industry FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $PFI_{it-1} \geq 5\%$ | No | Yes | No | No | Yes | No | No | Yes | No |
| Export$_{it-1}$ | No | No | Yes | No | No | Yes | No | No | Yes |
| Obs. | 102,443 | 102,443 | 102,443 | 102,443 | 102,443 | 102,443 | 102,443 | 102,443 | 102,443 |
| Obs. PF | 2,292 | 1,730 | 2,292 | 2,292 | 1,730 | 2,292 | 2,292 | 1,730 | 2,292 |
| # Firms | 14,968 | 14,968 | 14,968 | 14,968 | 14,968 | 14,968 | 14,968 | 14,968 | 14,968 |
| # Firms PF | 574 | 429 | 574 | 574 | 429 | 574 | 574 | 429 | 574 |

*Notes:* This table presents the results from estimations of a specification analogous to that in (II.11) using dummies for young firms ($young_i$=1 if firm age in the base year is below the sample median), small firms ($small_i$=1 if firm size in the base year is below the sample median), and labour productivity ($hlprod_i$=1 if labour productivity in the base year is above the sample median). $DPFI_{it-1}$ is a dummy taking a value of 1 if at least one domestic pension fund invests in firm $i$ in year $t-1$. Coefficient estimates and standard errors for all variables except $\beta_k$ and $\beta_l$ are multiplied by 100. The coefficient estimates on the other regressors measure their effect on productivity. All specifications include industry fixed effects at the NACE Rev.2 1-digit level. Bootstrapped standard errors, clustered by firm, with 200 replications in parentheses. In columns 2, 5 and 8, $DPFI_{it-1}$ equals 1 if the aggregate holding of all domestic pension funds in firm $i$ in year $t-1$ was at least equal to 5%. In columns 3, 6 and 9, we include a dummy equal to 1 if firm $i$ is an exporter in year $t-1$. The line "Obs. PF" ("# Firms PF") gives the number of observations (number of firms) with a pension fund investment at time $t-1$. Finally, * $p < 0.1$, ** $p < 0.05$, and *** $p < 0.01$.

assets. Investment by a pension fund may thus be taken as a long-term financing commitment. Presumably, such "long-termism" could give firms the assurance they need when undertaking investments that raise productivity in the long run rather than focusing on short-term gains. Furthermore, pension funds could play a role in monitoring firm management, although they tend to be less engaged than some types of activist shareholders, such as private equity firms.

Since which firms receive a pension fund investment may not be a random group, it is important to control for selection when estimating the impact of these investments on productivity. We dealt with this issue as follows. First, we conducted an event study that made us confident that there were no differential pre-trends. We then proceeded by implementing a structural estimation approach in which we explicitly controlled for selection. An added advantage of the structural estimation was that it addressed omitted variable bias issues by fully controlling for firms' heterogeneity in terms of past productivity.

We deployed three main sources of Danish data. The first was firm register data. In particular, we constructed a dataset at the individual firm level for Denmark with information on inputs, output, and other individual firm-level characteristics. The second was a dataset that we constructed covering pension fund investment in listed and unlisted Danish firms. The third source was data on domestic listed equity holdings that we collected directly from six large Danish pension funds.

We found that pension fund investment has a highly significant and quantitatively substantial positive effect on firms' productivity. This finding was highly robust. It was robust to, for example, controlling for whether a firm exports, suggesting that the effects of pension fund investment and exporting are additive. We also found suggestive evidence that the productivity effect was stronger the larger the pension funds' stake in a firm and the longer the pension fund had been investing in a firm. Although these results combine the impact of the extensive margin with the one of the intensive margin of a pension fund investment, we believe that the long-term financing commitment is an important mechanism behind our main results. Finally, the effects of pension fund investment are larger for non-listed than for publicly listed firms, in line with the notion that listed firms have more alternative sources of financing.

Our findings may provide leads for policies aimed at increasing firms' productivity. On the one hand, this is important in an era where potential GDP growth has gradually fallen over several decades in the industrialised world. This naturally raises the question of how to reverse this development. On the other hand, many emerging and developing countries are facing the dual challenge of fostering economic development while designing sustainable pension systems for a growing population. The challenge of boosting productivity growth becomes even more important in view of the prospect of ageing populations and other contemporary challenges. At the same time, there is a global trend towards more pension funding, increasing the importance of pension funds for the global economy. Against this backdrop, our results at the micro level have the potential to inform policy makers on the macroeconomic implications of funded pension systems and the potential of pension funds to support the real economy.

Specifically, a positive effect of a pension fund investment on productivity could support the introduction, or enlargement, of funded pension schemes, or even making participation in a funded pension scheme mandatory.[34] To the extent that the productivity effect is driven by pension funds' long-term financing commitment, this is an argument for restricting early withdrawal of accumulated pension savings to avoid the danger of premature liquidation of pension investment in firms.[35] Other policies aimed at increasing pension savings and investment could also support domestic productivity. Such policies could rely on tax incentives by, for example, allowing pension contributions to be deducted from taxable income or increasing the maximum deduction limit. Another measure would make the tax rate on capital gain a declining function of the length of the holding period of equities. Although our paper focuses on the impact of pension fund investments, larger equity holdings held by other long-term institutional investors, such as insurance companies, may also have a positive effect on firms' productivity. Investigating the impact of these institutional investors on productivity, and how it varies across different types of investors, would be an interesting area for future research.

Our findings may also have consequences for the supervision of institutional investors, particularly pension funds, as well as other investors with long-term liabilities, such as insurance companies. Typically, supervision focuses on the protection of savings held by individual institutions. However, an "excessive" quest for safety at the level of individual institutions may have adverse macroeconomic implications, as it could undermine the availability of long-term financing for firms and the real economy more broadly. On a related point, our conclusion that the effect of pension fund investment is more pronounced for unlisted than listed firms could be understood as an argument to support more investment by pension funds into unlisted assets and potentially more broadly alternative asset classes. While we do find a positive effect of pension fund investment on productivity, it is important to stress that regulation needs to strike a careful balance between the benefits and the risks for pension savers. Investigation of this trade-off between the risks at the level of individual pension fund participants through

[34]For example, in the Netherlands most employees are obliged to participate in the pension fund of their sector or company.

[35]See Beetsma et al. (2012) on the sustainability of non-mandatory funded pensions and Brown et al. (2022) on take-up trends of retirement income in the U.S.

fund ownership of firms and the macroeconomic benefits in terms of higher productivity constitutes interesting opportunities for future research.

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# Appendix B: Appendix to Chapter II

## Additional Statistics

**Table B.1.** Number of Firms per NACE Rev.2 1-Digit Sector

| **Sector** | **Firms with PFI** | **Firms without PFI** |
|---|---|---|
| Manufacturing | 283 | 3,391 |
| Construction | 37 | 2,383 |
| Wholesale and retail trade; repair of motor vehicles and motorcycles | 87 | 4,374 |
| Transportation and storage | 28 | 1,154 |
| Information and communication | 73 | 707 |
| Real estate activities | 12 | 219 |
| Professional, scientific and technical activities | 34 | 1,345 |
| Administrative and support service activities | 20 | 821 |
| **Total** | **574** | **14,394** |

*Notes:* This table illustrates the sector distribution among firms in the sample. Since a firm is "treated" if it received a pension fund investment in the previous year, this table splits the sample into firms that are treated at least once over the sample period (left column) and firms that are never treated (right column). "PFI" denotes "pension fund investment".

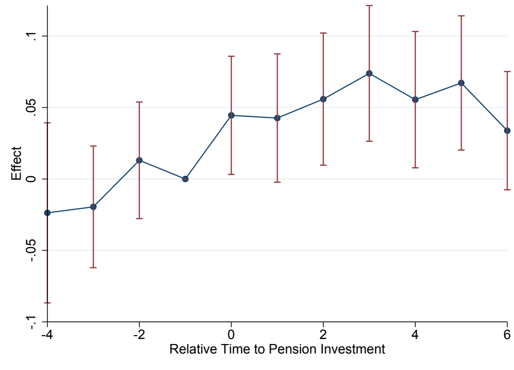
**Table B.2.** Investment Length: Pension Funds and Other Investors

| **Investor sector** | **N** | **Mean** $\boldsymbol{Length_{it-1}}$ | **Difference** | **Difference p-value** |
|---|---|---|---|---|
| *Panel A* | | | | |
| Pension funds | 2,292 | 4.16 | . | . |
| Banks, savings banks and cooperative banks | 959 | 3.26 | 0.89 | 0.00 |
| Financial holding companies | 3,478 | 3.53 | 0.63 | 0.00 |
| Non-financial holding companies | 35,156 | 4.82 | -0.67 | 0.00 |
| Investment associations | 290 | 1.91 | 2.25 | 0.00 |
| Investment companies | 3,622 | 4.10 | 0.05 | 0.54 |
| Venture companies and capital funds | 919 | 3.27 | 0.88 | 0.00 |
| Other financial intermediation except insurance and pension insurance | 3,441 | 3.73 | 0.43 | 0.00 |
| Asset management | 81 | 3.22 | 0.93 | 0.01 |
| Insurance companies | 229 | 2.76 | 1.39 | 0.00 |
| *Panel B* | | | | |
| Pension funds | 347 | 4.41 | . | . |
| Banks, savings banks and cooperative banks | 219 | 3.36 | 1.06 | 0.00 |
| Financial holding companies | 527 | 2.94 | 1.47 | 0.00 |
| Non-financial holding companies | 2,098 | 3.99 | 0.42 | 0.03 |
| Investment associations | 103 | 2.26 | 2.15 | 0.00 |
| Investment companies | 521 | 3.54 | 0.87 | 0.00 |
| Venture companies and capital funds | 164 | 3.85 | 0.56 | 0.06 |
| Other financial intermediation except insurance and pension insurance | 529 | 3.32 | 1.09 | 0.00 |
| Asset management | 13 | 1.92 | 2.49 | 0.01 |
| Insurance companies | 79 | 2.32 | 2.10 | 0.00 |

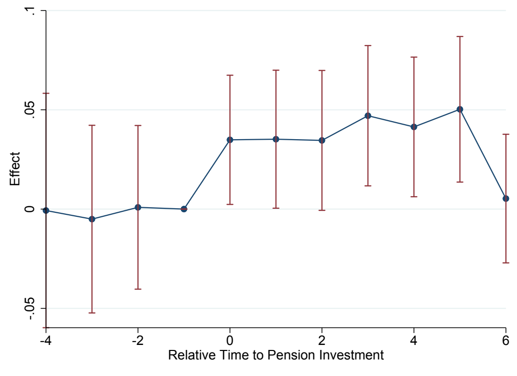
*Notes:* This table shows the average value of our treatment variable measuring investment length, $Length_{it-1}$, for the six-digit investor sectors included in table II.6 and insurance companies (three-digit sector), as well as pension funds. The table also includes the differences in means of the length variable between each investor sector and pension funds and the p-values of t-tests for the equality of these means. All results are conditional on at least one investor of the sector investing in firm $i$ at time $t-1$. In panel A, all such observations are considered. In panel B, we additionally condition on observing active divestment of the sector, so on at least one investor of the sector investing in firm $i$ at time $t-1$ and no investment by the investor sector in company $i$ in period $t$.

# Additional Figures

**Figure B.1.** Event Study Results, Matched Sample



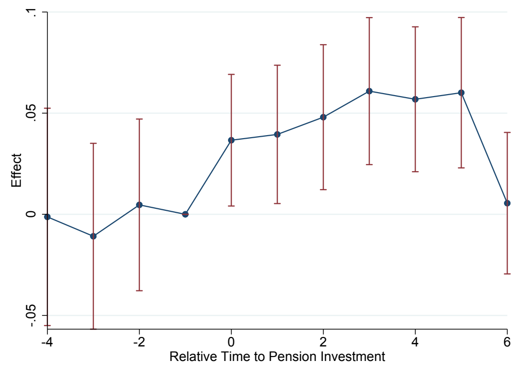

**(a)** Value Added per Worker



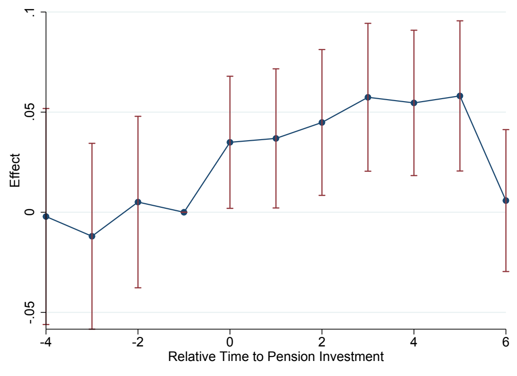

**(b)** Output per Worker

*Notes:* The outcome variable is value added per worker in panel (a) and output per worker in panel (b). Results are obtained with the matched sample. This figure presents point estimates and 95% confidence intervals of an event study specification using the estimator proposed by Sun and Abraham (2021). The following controls enter the specification: firm age, a dummy for the firm being listed in the base year, firm size (number of employees), and capital intensity. We also include year-by-industry (NACE Rev.2 1-digit) fixed effects.

**Figure B.2.** Event Study Results, Alternative Measure of Output



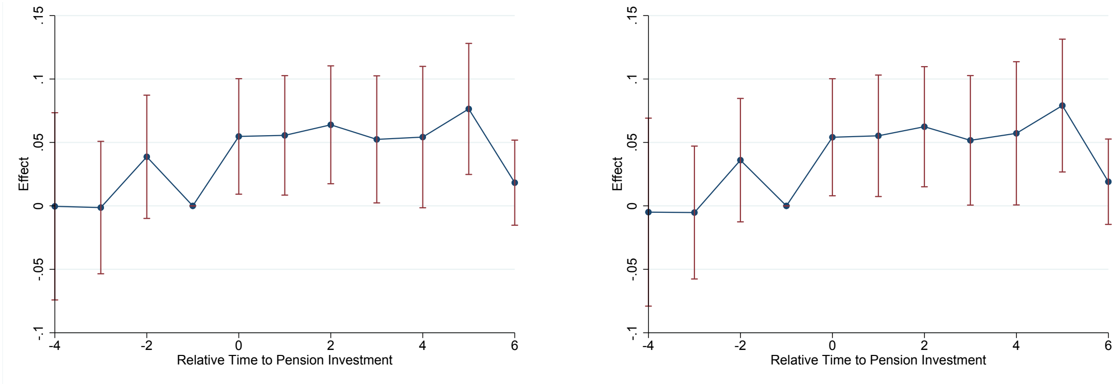

**(a)** Output per Worker (Alt. Def.)




**(b)** Output per Worker (Alt. Def.) and Matched Sample

*Notes:* The outcome variable is output per worker where output is defined as the sum of sales, work carried out at own expense and listed under assets, other operating income, and inventory changes. Results in the second panel are obtained with the matched sample. This figure presents point estimates and 95% confidence intervals of an event study specification using the estimator proposed by Sun and Abraham (2021). The following controls enter the specification: firm age, a dummy for the firm being listed in the base year, firm size (number of employees), and capital intensity. We also include year-by-industry (NACE Rev.2 1-digit) fixed effects.

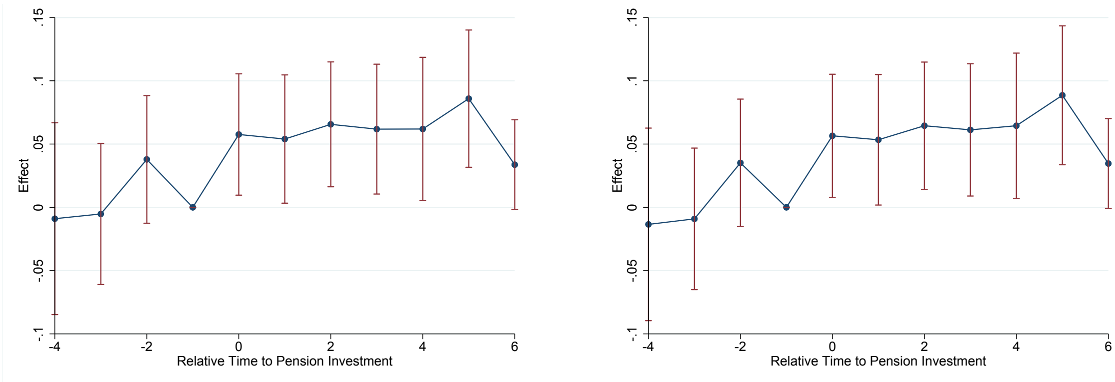
**Figure B.3.** Event Study Results, Controlling for the Share of R&D Workers




**(a)** Value Added per Worker **(b)** Value Added per Worker and Matched Sample

*Notes:* The outcome variable is value added per worker. Results in the second panel are obtained with the matched sample. This figure presents point estimates and 95% confidence intervals of an event study specification using the estimator proposed by Sun and Abraham (2021). The following controls enter the specification: firm age, a dummy for the firm being listed in the base year, firm size (number of employees), capital intensity, and share of R&D workers. We also include year-by-industry (NACE Rev.2 1-digit) fixed effects.

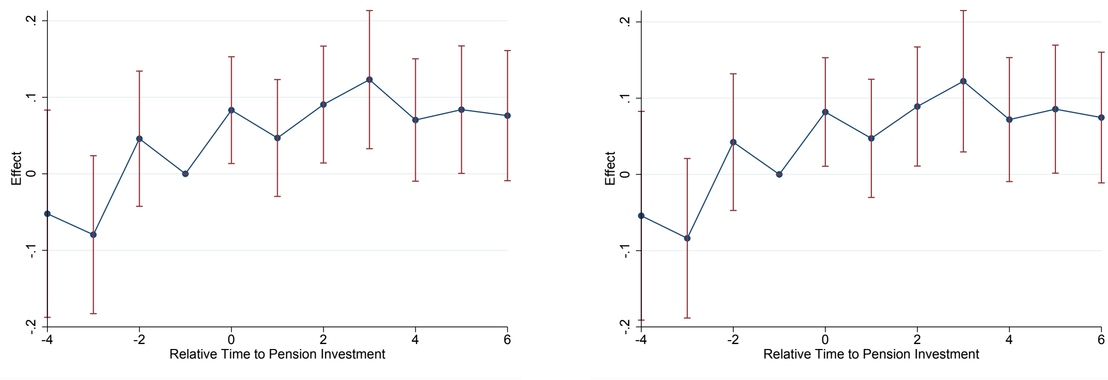
**Figure B.4.** Event Study Results, Specification without Control Variables




**(a)** Value Added per Worker **(b)** Value Added per Worker and Matched Sample

*Notes:* The outcome variable is value added per worker. Results in the second panel are obtained with the matched sample. This figure presents point estimates and 95% confidence intervals of an event study specification using the estimator proposed by Sun and Abraham (2021). We only include year-by-industry (NACE Rev.2 1-digit) fixed effects.

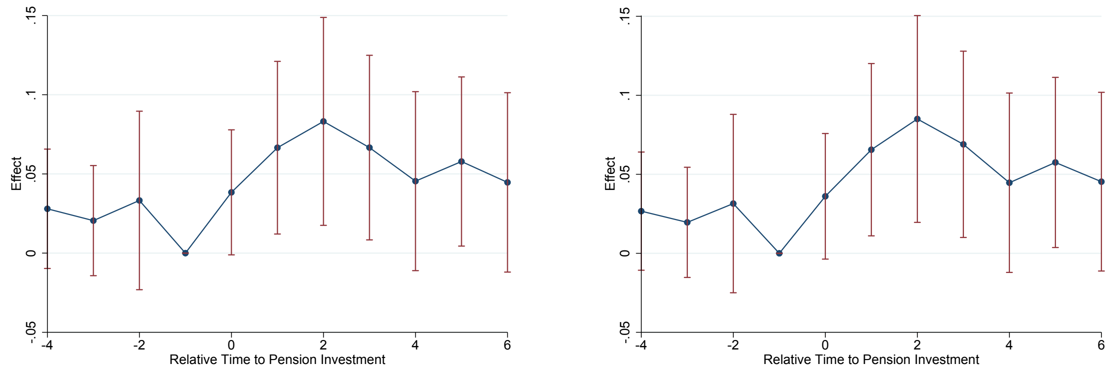
**Figure B.5.** Event Study Results, Excl. Multiple Investments




**(a)** Value Added per Worker **(b)** Value Added per Worker and Matched Sample

*Notes:* The outcome variable is value added per worker. Results in the second panel are obtained with the matched sample. This figure presents point estimates and 95% confidence intervals of an event study specification using the estimator proposed by Sun and Abraham (2021). We focus on events in which only one pension fund invests in a given firm over the sample period. The following controls enter the specification: firm age, a dummy for the firm being listed in the base year, firm size (number of employees), and capital intensity. We also include year-by-industry (NACE Rev.2 1-digit) fixed effects.

**Figure B.6.** Event Study Results, Excl. Short Investments




**(a)** Value Added per Worker **(b)** Value Added per Worker and Matched Sample

*Notes:* The outcome variable is value added per worker. Results in the second panel are obtained with the matched sample. This figure presents point estimates and 95% confidence intervals of an event study specification using the estimator proposed by Sun and Abraham (2021). We exclude pension fund investments that last for fewer than 5 consecutive years. The following controls enter the specification: firm age, a dummy for the firm being listed in the base year, firm size (number of employees), and capital intensity. We also include year-by-industry (NACE Rev.2 1-digit) fixed effects.

## Gross Output Production Function

In our main specifications, we use a value added production function. An alternative approach is to model the production function with a gross output production function. The main difference is that in a gross output production function, intermediate inputs enter the right-hand side of the production function. Formally, the production function in logs is:

$$y_{it} = \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + \omega_{it} + \varepsilon_{it} \tag{II.12}$$

and the second-stage equation, analogous to equation (II.10), is:

$$\begin{aligned} \widehat{h}_{it} =& \alpha + \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} \\ &+ \rho\left(\widehat{h}_{it-1} - \beta_k k_{it-1} - \beta_l l_{it-1} - \beta_m m_{it-1}\right) + \gamma PFI_{it-1} + \xi_{it} \end{aligned} \tag{II.13}$$

where all variables are defined as in the main text. Ackerberg et al. (2015) conclude that the lagged value of intermediate inputs $m_{it-1}$ is not a suitable instrument for the input $m_{it}$ in the context of gross output production functions; therefore, the parameter $\beta_m$ cannot be estimated as in our main approach. To address this, we exploit the firms' first-order condition for intermediate inputs following (Gandhi et al., 2020) and Fan et al. (2022). In particular, Fan et al. (2022) show that the following condition holds:

$$\frac{P_{mt} \times \exp\left(m_{it}\right)}{\exp\left(y_{it}\right)} \times \exp\left(\tilde{\varepsilon}_{it}\right) = \widehat{\beta}_m \tag{II.14}$$

where $P_{mt}$ is the price of material inputs and $\tilde{\varepsilon}_{it}$ is the estimated residual from the first stage of the estimation procedure. The first term on the left-hand side of equation (II.14) is the share of intermediate inputs in revenue (output) of the firm. With that share readable from the data and $\tilde{\varepsilon}_{it}$ in hand from the first-stage estimation, we follow Fan et al. (2022) and estimate $\widehat{\beta_m}$ through equation (II.14) by the method of moments, assuming that $\exp\left(\tilde{\varepsilon}_{it}\right)$ has a mean of 1. We then plug $\widehat{\beta_m}$ into equation (II.13) and estimate all other parameters via GMM as in our baseline approach. Tables B.3–B.5 are the counterparts to Tables II.2–II.4, which display the main results using a gross output production function. Although coefficients are generally less precisely estimated than in the baseline specifications, they remain positive and far from zero.

**Table B.3.** Productivity Estimates: Pension Fund Dummy, Gross Output Production Function

| | Whole sample | | | | Matched sample | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| $\beta_l$ | 0.414*** | 0.414*** | 0.413*** | 0.413*** | 0.400*** | 0.399*** | 0.399*** | 0.399*** |
| | (0.005) | (0.005) | (0.005) | (0.005) | (0.007) | (0.008) | (0.008) | (0.008) |
| $\beta_k$ | 0.030*** | 0.030*** | 0.030*** | 0.030*** | 0.033*** | 0.032*** | 0.032*** | 0.032*** |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.003) | (0.003) | (0.003) | (0.003) |
| $\beta_m$ | 0.605*** | 0.605*** | 0.605*** | 0.605*** | 0.618*** | 0.618*** | 0.618*** | 0.618*** |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) |
| $DPFI_{it-1}$ | | 2.111* | 3.490** | 1.990 | | 2.054 | 3.493** | 1.966 |
| | | (1.226) | (1.493) | (1.225) | | (1.307) | (1.622) | (1.305) |
| Industry FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $PFI_{it-1} \geq 5\%$ | No | No | Yes | No | No | No | Yes | No |
| Export$_{it-1}$ | No | No | No | Yes | No | No | No | Yes |
| Obs. | 102,443 | 102,443 | 102,443 | 102,443 | 48,554 | 48,554 | 48,554 | 48,554 |
| Obs. PF | 2,203 | 2,292 | 1,730 | 2,292 | 2,203 | 2,292 | 1,730 | 2,292 |
| # Firms | 14,968 | 14,968 | 14,968 | 14,968 | 7,468 | 7,468 | 7,468 | 7,468 |
| # Firms PF | 570 | 574 | 429 | 574 | 570 | 574 | 429 | 574 |

*Notes:* This table presents the results from the estimation of equation (II.13). $DPFI_{it-1}$ is a dummy equal to 1 if at least one domestic pension fund invests in firm $i$ in year $t-1$. Coefficient estimates and standard errors for $DPFI_{it-1}$ are multiplied by 100. The estimated coefficient of $DPFI_{it-1}$ measures its effect on productivity. All specifications include industry fixed effects at the NACE Rev.2 1-digit level. Bootstrapped standard errors, clustered by firm, with 200 replications in parentheses. In columns 3 and 7, $DPFI_{it-1}$ equals 1 if the aggregate holding of all domestic pension funds in firm $i$ in year $t-1$ was at least equal to 5%. In columns 4 and 8, we include a dummy equal to 1 if firm $i$ is exporter in year $t-1$. The line "Obs. PF" ("# Firms PF") gives the number of observations (number of firms) with a pension fund investment at time $t-1$. Finally, $^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, and $^{***}$ $p < 0.01$.

**Table B.4.** Productivity Estimates: Pension Fund Investment Intensity, Gross Output Production Function

| | Whole sample | | | Matched sample | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\beta_l$ | 0.414*** | 0.414*** | 0.413*** | 0.400*** | 0.400*** | 0.399*** |
| | (0.005) | (0.005) | (0.005) | (0.008) | (0.008) | (0.008) |
| $\beta_k$ | 0.030*** | 0.030*** | 0.030*** | 0.033*** | 0.033*** | 0.032*** |
| | (0.002) | (0.002) | (0.002) | (0.003) | (0.003) | (0.003) |
| $\beta_m$ | 0.605*** | 0.605*** | 0.605*** | 0.618*** | 0.618*** | 0.618*** |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) |
| $Intensity_{it-1}$ | 0.061 | 0.064 | 0.057 | 0.052 | 0.056 | 0.049 |
| | (0.084) | (0.084) | (0.082) | (0.099) | (0.099) | (0.098) |
| Industry FE | Yes | Yes | Yes | Yes | Yes | Yes |
| $PFI_{it-1} \geq 5\%$ | No | Yes | No | No | Yes | No |
| Export$_{it-1}$ | No | No | Yes | No | No | Yes |
| Obs. | 102,443 | 102,443 | 102,443 | 48,554 | 48,554 | 48,554 |
| Obs. PF | 2,292 | 1,730 | 2,292 | 2,292 | 1,730 | 2,292 |
| # Firms | 14,968 | 14,968 | 14,968 | 7,468 | 7,468 | 7,468 |
| # Firms PF | 574 | 429 | 574 | 574 | 429 | 574 |

*Notes:* This table presents the results from the estimation of equation (II.13). $Intensity_{it-1}$ is the aggregate share of the equity of firm $i$ (in percent) held by domestic pension funds in year $t-1$. Coefficient estimates and standard errors for $Intensity_{it-1}$ are multiplied by 100. The estimated coefficient of $Intensity_{it-1}$ measures its effect on productivity. All specifications include industry fixed effects at the NACE Rev.2 1-digit level. Bootstrapped standard errors, clustered by firm, with 200 replications in parentheses. In columns 2 and 5, $Intensity_{it-1}$ equals 0 if the aggregate holding of all domestic pension funds in firm $i$ at time $t-1$ is less than 5%. In columns 3 and 6, we include a dummy equal to 1 if firm $i$ is an exporter in year $t-1$. The line “Obs. PF” (“# Firms PF”) gives the number of observations (number of firms) with a pension fund investment at time $t-1$. Finally, $^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, and $^{***}$ $p < 0.01$.

**Table B.5.** Productivity Estimates: Pension Fund Investment Length, Gross Output Production Function

| | Whole sample | | | Matched sample | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\beta_l$ | 0.414*** | 0.414*** | 0.413*** | 0.400*** | 0.399*** | 0.399*** |
| | (0.005) | (0.005) | (0.005) | (0.008) | (0.008) | (0.008) |
| $\beta_k$ | 0.030*** | 0.030*** | 0.030*** | 0.032*** | 0.032*** | 0.032*** |
| | (0.002) | (0.002) | (0.002) | (0.003) | (0.003) | (0.003) |
| $\beta_m$ | 0.605*** | 0.605*** | 0.605*** | 0.618*** | 0.618*** | 0.618*** |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) |
| $Length_{it-1}$ | 0.326 | 0.522* | 0.309 | 0.264 | 0.467 | 0.250 |
| | (0.248) | (0.305) | (0.248) | (0.252) | (0.335) | (0.252) |
| Industry FE | Yes | Yes | Yes | Yes | Yes | Yes |
| $PFI_{it-1} \geq 5\%$ | No | Yes | No | No | Yes | No |
| Export$_{it-1}$ | No | No | Yes | No | No | Yes |
| Obs. | 102,443 | 102,443 | 102,443 | 48,554 | 48,554 | 48,554 |
| Obs. PF | 2,292 | 1,730 | 2,292 | 2,292 | 1,730 | 2,292 |
| # Firms | 14,968 | 14,968 | 14,968 | 7,468 | 7,468 | 7,468 |
| # Firms PF | 574 | 429 | 574 | 574 | 429 | 574 |

*Notes:* This table presents results from the estimation of equation (II.13). $Length_{it-1}$ is the number of consecutive years that firm $i$ receives investment from any domestic pension fund up to year $t-1$ included. Coefficient estimates and standard errors for $Length_{it-1}$ are multiplied by 100. The estimated coefficient of $Length_{it-1}$ measures its effect on productivity. All specifications include industry fixed effects at the NACE Rev.2 1-digit level. Bootstrapped standard errors, clustered by firm, with 200 replications in parentheses. In columns 2 and 5, $Length_{it-1}$ includes only the years when aggregate investment by domestic pension funds in the firm is at least 5%. In columns 3 and 6, we include a dummy taking value 1 if firm $i$ is an exporter in year $t-1$. The line "Obs. PF" ("# Firms PF") gives the number of observations (number of firms) with a pension fund investment in year $t-1$ in the sample. Finally, $^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, and $^{***}$ $p < 0.01$.

# Results from Additional Robustness Checks

**Table B.6.** Productivity Estimates: Investment Intensity and Intensity Squared

| | Whole sample | | | Matched sample | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\beta_l$ | 0.953*** | 0.953*** | 0.950*** | 0.911*** | 0.911*** | 0.909*** |
| | (0.005) | (0.005) | (0.005) | (0.008) | (0.008) | (0.008) |
| $\beta_k$ | 0.085*** | 0.085*** | 0.084*** | 0.092*** | 0.092*** | 0.091*** |
| | (0.003) | (0.003) | (0.003) | (0.006) | (0.006) | (0.005) |
| $Intensity_{it-1}$ | 0.190 | 0.188 | 0.144 | 0.278** | 0.276** | 0.231* |
| | (0.143) | (0.144) | (0.142) | (0.131) | (0.131) | (0.130) |
| $Intensity^2_{it-1}$ | 0.001 | 0.001 | 0.001 | -0.001 | -0.001 | -0.000 |
| | (0.004) | (0.004) | (0.004) | (0.004) | (0.004) | (0.004) |
| Industry FE | Yes | Yes | Yes | Yes | Yes | Yes |
| $PFI_{it-1} \geq 5\%$ | No | Yes | No | No | Yes | No |
| Export$_{it-1}$ | No | No | Yes | No | No | Yes |
| Obs. | 102,443 | 102,443 | 102,443 | 48,554 | 48,554 | 48,554 |
| Obs. PF | 2,292 | 1,730 | 2,292 | 2,292 | 1,730 | 2,292 |
| # Firms | 14,968 | 14,968 | 14,968 | 7,468 | 7,468 | 7,468 |
| # Firms PF | 574 | 429 | 574 | 574 | 429 | 574 |

*Notes:* This table presents results from the estimation of equation (II.10) including $Intensity_{it-1}$ and $Intensity^2_{it-1}$. $Intensity_{it-1}$ is the aggregate share of the equity of firm $i$ (in percentage points) held by domestic pension funds in year $t-1$. Coefficient estimates and standard errors for $Intensity_{it-1}$ and $Intensity^2_{it-1}$ are multiplied by 100. All specifications include industry fixed effects at the NACE Rev.2 1-digit level. Bootstrapped standard errors, clustered by firm, with 200 replications in parentheses. In columns 2 and 5, $Intensity_{it-1}$ is equal to 0 if the aggregate holding of all domestic pension funds in firm $i$ at time $t-1$ is less than 5%. In columns 3 and 6, we include a dummy taking value 1 if firm $i$ is an exporter at time $t-1$. The line "Obs. PF" ("# Firms PF") gives the number of observations (number of firms) with pension fund investment at time $t-1$. Finally, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Finally, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

**Table B.7.** Productivity Estimates: Investment Length and Length Squared

| | Whole sample | | | Matched sample | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\beta_l$ | 0.953*** | 0.953*** | 0.950*** | 0.911*** | 0.911*** | 0.909*** |
| | (0.005) | (0.005) | (0.005) | (0.008) | (0.008) | (0.008) |
| $\beta_k$ | 0.085*** | 0.085*** | 0.084*** | 0.092*** | 0.092*** | 0.091*** |
| | (0.003) | (0.003) | (0.003) | (0.006) | (0.006) | (0.005) |
| $Length_{it-1}$ | 1.197*** | 1.199*** | 1.018** | 1.583*** | 1.666*** | 1.398*** |
| | (0.399) | (0.452) | (0.396) | (0.396) | (0.426) | (0.398) |
| $Length^2_{it-1}$ | -0.081** | -0.079* | -0.067* | -0.109*** | -0.114*** | -0.096*** |
| | (0.035) | (0.041) | (0.035) | (0.036) | (0.039) | (0.036) |
| Industry FE | Yes | Yes | Yes | Yes | Yes | Yes |
| $PFI_{it-1} \geq 5\%$ | No | Yes | No | No | Yes | No |
| Export$_{it-1}$ | No | No | Yes | No | No | Yes |
| Obs. | 102,443 | 102,443 | 102,443 | 48,554 | 48,554 | 48,554 |
| Obs. PF | 2,292 | 1,730 | 2,292 | 2,292 | 1,730 | 2,292 |
| # Firms | 14,968 | 14,968 | 14,968 | 7,468 | 7,468 | 7,468 |
| # Firms PF | 574 | 429 | 574 | 574 | 429 | 574 |

*Notes:* This table presents results from the estimation of equation (II.10) including $Length_{it-1}$ and $Length^2_{it-1}$. $Length_{it-1}$ is the number of consecutive years that firm $i$ receives investment from any domestic pension fund up to year $t-1$ included. Coefficient estimates and standard errors for $Length_{it-1}$ and $Length^2_{it-1}$ are multiplied by 100. All specifications include industry fixed effects at the NACE Rev.2 1-digit level. Bootstrapped standard errors, clustered by firm, with 200 replications in parentheses. In columns 2 and 5, $Length_{it-1}$ only includes the years when aggregate investment by domestic pension funds in the firm is at least 5%. In columns 3 and 6, we include a dummy taking value 1 if firm $i$ is an exporter at time $t-1$. The line "Obs. PF" ("# Firms PF") gives the number of observations (number of firms) with pension fund investment at time $t-1$ in the sample. Finally, $^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$.

**Table B.8.** Productivity Estimates: Investment Dummy, Direct Investments Only

| | Whole sample | | | Matched sample | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\beta_l$ | 0.954*** | 0.954*** | 0.950*** | 0.911*** | 0.911*** | 0.909*** |
| | (0.005) | (0.005) | (0.005) | (0.008) | (0.008) | (0.008) |
| $\beta_k$ | 0.085*** | 0.085*** | 0.084*** | 0.092*** | 0.092*** | 0.091*** |
| | (0.003) | (0.003) | (0.003) | (0.006) | (0.006) | (0.005) |
| $DPFI_{it-1}$ | 1.565 | 1.565 | 1.411 | 3.356 | 3.356 | 3.080 |
| | (2.785) | (2.785) | (2.823) | (2.438) | (2.438) | (2.481) |
| Industry FE | Yes | Yes | Yes | Yes | Yes | Yes |
| $PFI_{it-1} \geq 5\%$ | No | Yes | No | No | Yes | No |
| Export$_{it-1}$ | No | No | Yes | No | No | Yes |
| Obs. | 102,443 | 102,443 | 102,443 | 48,554 | 48,554 | 48,554 |
| Obs. PF | 311 | 311 | 311 | 311 | 311 | 311 |
| # Firms | 14,968 | 14,968 | 14,968 | 7,468 | 7,468 | 7,468 |
| # Firms PF | 52 | 52 | 52 | 52 | 52 | 52 |

*Notes:* This table presents results from the estimation of equation (II.10). $DPFI_{it-1}$ is a dummy taking a value of 1 if at least one domestic pension fund directly invests, meaning not through other firms or subsidiaries, in firm $i$ in year $t-1$. Coefficient estimates and standard errors for $DPFI_{it-1}$ are multiplied by 100. All specifications include industry fixed effects at the NACE Rev.2 1-digit level. Bootstrapped standard errors, clustered by firm, with 200 repetitions in parentheses. In columns 2 and 5, $DPFI_{it-1}$ takes value 1 if the aggregate holding of all domestic pension funds in firm $i$ at time $t-1$ is at least equal to 5%. In columns 3 and 6, we include a dummy taking value 1 if firm $i$ is an exporter in year $t-1$. The line "Obs. PF" ("# Firms PF") gives the number of observations (number of firms) with pension fund investment at time $t-1$. Finally, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

**Table B.9.** Productivity Estimates: Investment Intensity, Direct Investments Only

| | Whole sample | | | Matched sample | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\beta_l$ | 0.954*** | 0.954*** | 0.950*** | 0.911*** | 0.911*** | 0.909*** |
| | (0.005) | (0.005) | (0.005) | (0.008) | (0.008) | (0.008) |
| $\beta_k$ | 0.085*** | 0.085*** | 0.084*** | 0.092*** | 0.092*** | 0.091*** |
| | (0.003) | (0.003) | (0.003) | (0.006) | (0.006) | (0.005) |
| $Intensity_{it-1}$ | 0.148 | 0.148 | 0.156 | 0.157 | 0.157 | 0.162 |
| | (0.163) | (0.163) | (0.160) | (0.185) | (0.185) | (0.179) |
| Industry FE | Yes | Yes | Yes | Yes | Yes | Yes |
| $PFI_{it-1} \geq 5\%$ | No | Yes | No | No | Yes | No |
| Export$_{it-1}$ | No | No | Yes | No | No | Yes |
| Obs. | 102,443 | 102,443 | 102,443 | 48,554 | 48,554 | 48,554 |
| Obs. PF | 311 | 311 | 311 | 311 | 311 | 311 |
| # Firms | 14,968 | 14,968 | 14,968 | 7,468 | 7,468 | 7,468 |
| # Firms PF | 52 | 52 | 52 | 52 | 52 | 52 |

*Notes:* This table presents results from the estimation of equation (II.10). $Intensity_{it-1}$ is the aggregate share of the equity of firm $i$ (in percentage points) held directly, meaning not through other firms or subsidiaries, by domestic pension funds in year $t-1$. Coefficient estimates and standard errors for $Intensity_{it-1}$ are multiplied by 100. All specifications include industry fixed effects at the NACE Rev.2 1-digit level. Bootstrapped standard errors, clustered by firm, with 200 repetitions in parentheses. In columns 2 and 5, $Intensity_{it-1}$ is equal to 0 if the aggregate holding of all domestic pension funds in firm $i$ in year $t-1$ is less than 5%. In columns 3 and 6, we include a dummy taking value 1 if firm $i$ is an exporter in year $t-1$. The line "Obs. PF" ("# Firms PF") gives the number of observations (number of firms) with pension fund investment at time $t-1$. Finally, $^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$. Finally, $^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$.

**Table B.10.** Productivity Estimates: Investment Dummy, Excluding Firms with Capital Increases

| | Whole sample | | | | Matched sample | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| $\beta_l$ | 0.966*** | 0.965*** | 0.965*** | 0.962*** | 0.907*** | 0.906*** | 0.906*** | 0.904*** |
| | (0.006) | (0.006) | (0.006) | (0.006) | (0.010) | (0.010) | (0.010) | (0.010) |
| $\beta_k$ | 0.081*** | 0.081*** | 0.081*** | 0.080*** | 0.095*** | 0.095*** | 0.095*** | 0.093*** |
| | (0.004) | (0.004) | (0.004) | (0.004) | (0.007) | (0.007) | (0.007) | (0.007) |
| $DPFI_{it-1}$ | | 4.157*** | 3.834*** | 3.855*** | | 4.775*** | 4.602*** | 4.478*** |
| | | (1.434) | (1.472) | (1.423) | | (1.426) | (1.466) | (1.414) |
| Industry FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $PFI_{it-1} \geq 5\%$ | No | No | Yes | No | No | No | Yes | No |
| Export$_{it-1}$ | No | No | No | Yes | No | No | No | Yes |
| Obs. | 73,375 | 73,375 | 73,375 | 73,375 | 32,495 | 32,495 | 32,495 | 32,495 |
| Obs. PF | 1,185 | 1,185 | 903 | 1,185 | 1,185 | 1,185 | 903 | 1,185 |
| # Firms | 11,752 | 11,752 | 11,752 | 11,752 | 5,662 | 5,662 | 5,662 | 5,662 |
| # Firms PF | 336 | 336 | 250 | 336 | 336 | 336 | 250 | 336 |

*Notes:* This table presents results from the estimation of equation (II.10). We exclude firms that increase their share capital ("Selbskabskapital") in any year of the sample period. $DPFI_{it-1}$ is a dummy taking a value of 1 if at least one domestic pension fund invests in firm $i$ in year $t-1$. Coefficient estimates and standard errors for $DPFI_{it-1}$ are multiplied by 100. All specifications include industry fixed effects at the NACE Rev.2 1-digit level. Bootstrapped standard errors, clustered by firm, with 200 repetitions in parentheses. In columns 3 and 7, $DPFI_{it-1}$ takes value 1 if the aggregate holding of all domestic pension funds in firm $i$ in year $t-1$ is at least equal to 5%. In columns 4 and 8, we include a dummy taking value 1 if firm $i$ is an exporter in year $t-1$. The line "Obs. PF" ("# Firms PF") gives the number of observations (number of firms) with pension fund investment at time $t-1$. Finally, $^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$.

**Table B.11.** Productivity Estimates: Investment Intensity, Excluding Firms with Capital Increases

| | Whole sample | | | Matched sample | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\beta_l$ | 0.965*** | 0.965*** | 0.962*** | 0.906*** | 0.906*** | 0.904*** |
| | (0.006) | (0.006) | (0.006) | (0.010) | (0.010) | (0.010) |
| $\beta_k$ | 0.081*** | 0.081*** | 0.080*** | 0.095*** | 0.095*** | 0.093*** |
| | (0.004) | (0.004) | (0.004) | (0.007) | (0.007) | (0.007) |
| $Intensity_{it-1}$ | 0.296** | 0.295** | 0.294** | 0.303** | 0.301** | 0.301** |
| | (0.127) | (0.127) | (0.121) | (0.141) | (0.140) | (0.134) |
| Industry FE | Yes | Yes | Yes | Yes | Yes | Yes |
| $PFI_{it-1} \geq 5\%$ | No | Yes | No | No | Yes | No |
| Export$_{it-1}$ | No | No | Yes | No | No | Yes |
| Obs. | 73,375 | 73,375 | 73,375 | 32,495 | 32,495 | 32,495 |
| Obs. PF | 1,185 | 903 | 1,185 | 1,185 | 903 | 1,185 |
| # Firms | 11,752 | 11,752 | 11,752 | 5,662 | 5,662 | 5,662 |
| # Firms PF | 336 | 250 | 336 | 336 | 250 | 336 |

*Notes:* This table presents results from the estimation of equation (II.10). We exclude firms that increase their share capital ("Selbskabskapital") in any year of the sample period. $Intensity_{it-1}$ is the aggregate share of the equity of firm $i$ (in percentage points) held by domestic pension funds in year $t-1$. Coefficient estimates and standard errors for $Intensity_{it-1}$ are multiplied by 100. All specifications include industry fixed effects at the NACE Rev.2 1-digit level. Bootstrapped standard errors, clustered by firm, with 200 repetitions in parentheses. In columns 2 and 5, $Intensity_{it-1}$ is equal to 0 if the aggregate holding of all domestic pension funds in firm $i$ at time $t-1$ is less than 5%. In columns 3 and 6, we include a dummy taking value 1 if firm $i$ is an exporter in year $t-1$. The line "Obs. PF" ("# Firms PF") gives the number of observations (number of firms) with pension fund investment at time $t-1$. Finally, $^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$. Finally, $^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$.

**Table B.12.** Productivity Estimates: Investment Length, Excluding Firms with Capital Increases

| | Whole sample | | | Matched sample | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\beta_l$ | 0.966*** | 0.966*** | 0.962*** | 0.907*** | 0.907*** | 0.904*** |
| | (0.006) | (0.006) | (0.006) | (0.010) | (0.010) | (0.010) |
| $\beta_k$ | 0.081*** | 0.081*** | 0.080*** | 0.095*** | 0.095*** | 0.093*** |
| | (0.004) | (0.004) | (0.004) | (0.007) | (0.007) | (0.007) |
| $Length_{it-1}$ | 0.385 | 0.285 | 0.347 | 0.421 | 0.355 | 0.382 |
| | (0.291) | (0.302) | (0.288) | (0.300) | (0.317) | (0.301) |
| Industry FE | Yes | Yes | Yes | Yes | Yes | Yes |
| $PFI_{it-1} \geq 5\%$ | No | Yes | No | No | Yes | No |
| Export$_{it-1}$ | No | No | Yes | No | No | Yes |
| Obs. | 73,375 | 73,375 | 73,375 | 32,495 | 32,495 | 32,495 |
| Obs. PF | 1,185 | 903 | 1,185 | 1,185 | 903 | 1,185 |
| # Firms | 11,752 | 11,752 | 11,752 | 5,662 | 5,662 | 5,662 |
| # Firms PF | 336 | 250 | 336 | 336 | 250 | 336 |

*Notes:* This table presents results from the estimation of equation (II.10). We exclude firms that increase their share capital ("Selbskabskapital") in any year of the sample period. $Length_{it-1}$ is the number of consecutive years that firm $i$ receives investment from any domestic pension fund up to year $t-1$ included. Coefficient estimates and standard errors for $Length_{it-1}$ are multiplied by 100. All specifications include industry fixed effects at the NACE Rev.2 1-digit level. Bootstrapped standard errors, clustered by firm, with 200 repetitions in parentheses. In columns 2 and 5, $Length_{it-1}$ only includes the years when aggregate investment by domestic pension funds in the firm is at least 5%. In columns 3 and 6, we include a dummy taking value 1 if firm $i$ is an exporter in year $t-1$. The line "Obs. PF" ("# Firms PF") gives the number of observations (number of firms) with pension fund investment at time $t-1$ in the sample. Finally, $^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$.

**Table B.13.** Productivity Estimates: Number of Pension Funds

| | Whole sample | | Matched sample | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| $\beta_l$ | 0.953*** | 0.950*** | 0.911*** | 0.909*** |
| | (0.005) | (0.005) | (0.008) | (0.008) |
| $\beta_k$ | 0.085*** | 0.084*** | 0.092*** | 0.091*** |
| | (0.003) | (0.003) | (0.005) | (0.005) |
| $NPF_{it-1}$ | 1.505*** | 1.307*** | 1.712*** | 1.511*** |
| | (0.443) | (0.440) | (0.409) | (0.409) |
| Industry FE | Yes | Yes | Yes | Yes |
| $PFI_{it-1} \geq 5\%$ | No | No | No | No |
| Export$_{it-1}$ | No | Yes | No | Yes |
| Obs. | 102,443 | 102,443 | 48,554 | 48,554 |
| Obs. PF | 2,292 | 2,292 | 2,292 | 2,292 |
| # Firms | 14,968 | 14,968 | 7,468 | 7,468 |
| # Firms PF | 574 | 574 | 574 | 574 |

*Notes:* This table presents results from the estimation of equation (II.10). $NPF_{it-1}$ is the number of domestic pension funds that invest in firm $i$ at time $t-1$. Coefficient estimates and standard errors for $NPF_{it-1}$ are multiplied by 100. All specifications include industry fixed effects at the NACE Rev.2 1-digit level. Bootstrapped standard errors, clustered by firm, with 200 repetitions in parentheses. In columns 2 and 4, we include a dummy taking value 1 if firm $i$ is an exporter in year $t-1$. The line "Obs. PF" ("# Firms PF") gives the number of observations (number of firms) with pension fund investment at time $t-1$. Finally, $^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$.

**Table B.14.** Productivity Estimates: Investment Dummy, Alternative Definition of Capital

| | Whole sample | | | | Matched sample | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| $\beta_l$ | 0.990*** | 0.989*** | 0.989*** | 0.985*** | 0.952*** | 0.951*** | 0.951*** | 0.948*** |
| | (0.004) | (0.004) | (0.004) | (0.004) | (0.007) | (0.007) | (0.007) | (0.007) |
| $\beta_k$ | 0.053*** | 0.053*** | 0.053*** | 0.053*** | 0.054*** | 0.054*** | 0.054*** | 0.054*** |
| | (0.003) | (0.003) | (0.003) | (0.003) | (0.004) | (0.004) | (0.004) | (0.004) |
| $DPFI_{it-1}$ | | 3.749*** | 3.999*** | 3.327*** | | 5.065*** | 5.488*** | 4.564*** |
| | | (0.988) | (1.144) | (0.990) | | (1.117) | (1.255) | (1.112) |
| Industry FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $PFI_{it-1} \geq 5\%$ | No | No | Yes | No | No | No | Yes | No |
| $\text{Export}_{it-1}$ | No | No | No | Yes | No | No | No | Yes |
| Obs. | 101,034 | 101,034 | 101,034 | 101,034 | 48,090 | 48,090 | 48,090 | 48,090 |
| Obs. PF | 2,278 | 2,278 | 1,720 | 2,278 | 2,278 | 2,278 | 1,720 | 2,278 |
| # Firms | 14,833 | 14,833 | 14,833 | 14,833 | 7,404 | 7,404 | 7,404 | 7,404 |
| # Firms PF | 568 | 568 | 427 | 568 | 568 | 568 | 427 | 568 |

*Notes:* This table presents results from the estimation of equation (II.10) with $k_{it}$ defined as the log book value of fixed assets (instead of calculated through the perpetual inventory method as in the main results). $DPFI_{it-1}$ is a dummy taking a value of 1 if at least one domestic pension fund invests in firm $i$ at time $t-1$. Coefficient estimates and standard errors for $DPFI_{it-1}$ are multiplied by 100. All specifications include industry fixed effects at the NACE Rev.2 1-digit level. Bootstrapped standard errors, clustered by firm, with 200 repetitions in parentheses. In columns 3 and 7 $DPFI_{it-1}$ takes value 1 if the aggregate holding of all domestic pension funds in firm $i$ at time $t-1$ is at least equal to 5%. In columns 4 and 8 we include a dummy taking value 1 if firm $i$ is an exporter in year $t-1$. The line "Obs. PF" ("# Firms PF") gives the number of observations (number of firms) with pension fund investment at time $t-1$ in the sample. Finally, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

**Table B.15.** Productivity Estimates: Investment Intensity Results, Alternative Definition of Capital

| | Whole sample | | | Matched sample | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\beta_l$ | 0.989*** | 0.990*** | 0.985*** | 0.951*** | 0.951*** | 0.948*** |
| | (0.004) | (0.004) | (0.004) | (0.007) | (0.007) | (0.007) |
| $\beta_k$ | 0.053*** | 0.053*** | 0.053*** | 0.054*** | 0.054*** | 0.054*** |
| | (0.003) | (0.003) | (0.003) | (0.004) | (0.004) | (0.004) |
| $Intensity_{it-1}$ | 0.232*** | 0.232*** | 0.220*** | 0.260*** | 0.259*** | 0.244*** |
| | (0.085) | (0.085) | (0.081) | (0.097) | (0.098) | (0.092) |
| Industry FE | Yes | Yes | Yes | Yes | Yes | Yes |
| $PFI_{it-1} \geq 5\%$ | No | Yes | No | No | Yes | No |
| Export$_{it-1}$ | No | No | Yes | No | No | Yes |
| Obs. | 101,034 | 101,034 | 101,034 | 48,090 | 48,090 | 48,090 |
| Obs. PF | 2,278 | 1,720 | 2,278 | 2,278 | 1,720 | 2,278 |
| # Firms | 14,833 | 14,833 | 14,833 | 7,404 | 7,404 | 7,404 |
| # Firms PF | 568 | 427 | 568 | 568 | 427 | 568 |

*Notes:* This table presents results from the estimation of equation (II.10) with $k_{it}$ defined as the log book value of fixed assets (instead of calculated through the perpetual inventory method as in the main results). $Intensity_{it-1}$ is the aggregate share of the equity of firm $i$ (in percentage points) held by domestic pension funds in year $t-1$. Coefficient estimates and standard errors for $Intensity_{it-1}$ are multiplied by 100. All specifications include industry fixed effects at the NACE Rev.2 1-digit level. Bootstrapped standard errors, clustered by firm, with 200 repetitions in parentheses. In columns 2 and 5, $Intensity_{it-1}$ is equal to 0 if the aggregate holding of all domestic pension funds in firm $i$ at time $t-1$ is less than 5%. In columns 3 and 6, we include a dummy taking value 1 if firm $i$ is an exporter in year $t-1$. The line "Obs. PF" ("# Firms PF") gives the number of observations (number of firms) with pension fund investment at time $t-1$ in the sample. Finally, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

**Table B.16.** Productivity Estimates: Investment Length, Alternative Definition of Capital

| | Whole sample | | | Matched sample | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\beta_l$ | 0.989*** | 0.989*** | 0.985*** | 0.951*** | 0.951*** | 0.948*** |
| | (0.004) | (0.004) | (0.004) | (0.007) | (0.007) | (0.007) |
| $\beta_k$ | 0.053*** | 0.053*** | 0.053*** | 0.054*** | 0.054*** | 0.054*** |
| | (0.003) | (0.003) | (0.003) | (0.004) | (0.004) | (0.004) |
| $Length_{it-1}$ | 0.573*** | 0.614** | 0.511*** | 0.755*** | 0.832*** | 0.679*** |
| | (0.196) | (0.239) | (0.196) | (0.220) | (0.258) | (0.219) |
| Industry FE | Yes | Yes | Yes | Yes | Yes | Yes |
| $PFI_{it-1} \geq 5\%$ | No | Yes | No | No | Yes | No |
| Export$_{it-1}$ | No | No | Yes | No | No | Yes |
| Obs. | 101,034 | 101,034 | 101,034 | 48,090 | 48,090 | 48,090 |
| Obs. PF | 2,278 | 1,720 | 2,278 | 2,278 | 1,720 | 2,278 |
| # Firms | 14,833 | 14,833 | 14,833 | 7,404 | 7,404 | 7,404 |
| # Firms PF | 568 | 427 | 568 | 568 | 427 | 568 |

*Notes:* This table presents results from the estimation of equation (II.10) with $k_{it}$ defined as the log book value of fixed assets (instead of calculated through the perpetual inventory method as in the main results). $Length_{it-1}$ is the number of consecutive years that firm $i$ receives investment from any domestic pension fund up to year $t-1$ included. Coefficient estimates and standard errors for $Length_{it-1}$ are multiplied by 100. All specifications include industry fixed effects at the NACE Rev.2 1-digit level. Bootstrapped standard errors, clustered by firm, with 200 repetitions in parentheses. In columns 2 and 5, $Length_{it-1}$ only includes the years when aggregate investment by domestic pension funds in the firm is at least 5%. In columns 3 and 6, we include a dummy taking value 1 if firm $i$ is an exporter in year $t-1$. The line "Obs. PF" ("# Firms PF") gives the number of observations (number of firms) with pension fund investment at time $t-1$ in the sample. Finally, $^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$.

**Table B.17.** Productivity Estimates: Investment Dummy, Alternative First Stage Polynomial

| | Whole sample | | | | Matched sample | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| $\beta_l$ | 0.957*** | 0.955*** | 0.955*** | 0.949*** | 0.920*** | 0.918*** | 0.918*** | 0.914*** |
| | (0.005) | (0.005) | (0.005) | (0.005) | (0.008) | (0.008) | (0.008) | (0.008) |
| $\beta_k$ | 0.088*** | 0.088*** | 0.088*** | 0.085*** | 0.093*** | 0.093*** | 0.093*** | 0.091*** |
| | (0.003) | (0.003) | (0.003) | (0.003) | (0.006) | (0.006) | (0.006) | (0.006) |
| $DPFI_{it-1}$ | | 6.082*** | 6.761*** | 5.231*** | | 7.627*** | 8.508*** | 6.759*** |
| | | (1.532) | (1.764) | (1.536) | | (1.412) | (1.691) | (1.419) |
| Industry FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $PFI_{it-1} \geq 5\%$ | No | No | Yes | No | No | No | Yes | No |
| Export$_{it-1}$ | No | No | No | Yes | No | No | No | Yes |
| Obs. | 101,034 | 101,034 | 101,034 | 101,034 | 48,090 | 48,090 | 48,090 | 48,090 |
| Obs. PF | 2,278 | 2,278 | 1,720 | 2,278 | 2,278 | 2,278 | 1,720 | 2,278 |
| # Firms | 14,833 | 14,833 | 14,833 | 14,833 | 7,404 | 7,404 | 7,404 | 7,404 |
| # Firms PF | 568 | 568 | 427 | 568 | 568 | 568 | 427 | 568 |

*Notes:* This table presents results from the estimation of equation (II.10) after approximating the function $h(.)$ in the first stage equation (II.7) by a third-degree polynomial in labour, capital, intermediary inputs, average wage and the investment rate (following Fan et al. (2022)). $DPFI_{it-1}$ is a dummy taking a value of 1 if at least one domestic pension fund invests in firm $i$ at time $t-1$. Coefficient estimates and standard errors for $DPFI_{it-1}$ are multiplied by 100. All specifications include industry fixed effects at the NACE Rev.2 1-digit level. Bootstrapped standard errors, clustered by firm, with 200 repetitions in parentheses. In columns 3-4 and 7-8 $DPFI_{it-1}$ takes value 1 if the aggregate holding of all domestic pension funds in firm $i$ at time $t-1$ was at least equal to 5%. In columns 4 and 8 we include a dummy taking value 1 if firm $i$ is an exporter in year $t-1$. The line "Obs. PF" ("# Firms PF") gives the number of observations (number of firms) with pension fund investment at time $t-1$ in the sample. Finally, $^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$.

**Table B.18.** Productivity Estimates: Investment Intensity, Alternative First Stage Polynomial

| | Whole sample | | | Matched sample | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\beta_l$ | 0.955*** | 0.955*** | 0.949*** | 0.918*** | 0.918*** | 0.914*** |
| | (0.005) | (0.005) | (0.005) | (0.008) | (0.008) | (0.008) |
| $\beta_k$ | 0.088*** | 0.088*** | 0.086*** | 0.093*** | 0.093*** | 0.091*** |
| | (0.003) | (0.003) | (0.003) | (0.006) | (0.006) | (0.006) |
| $Intensity_{it-1}$ | 0.504*** | 0.501*** | 0.478*** | 0.540*** | 0.537*** | 0.513*** |
| | (0.097) | (0.098) | (0.103) | (0.099) | (0.099) | (0.103) |
| Industry FE | Yes | Yes | Yes | Yes | Yes | Yes |
| $PFI_{it-1} \geq 5\%$ | No | Yes | No | No | Yes | No |
| Export$_{it-1}$ | No | No | Yes | No | No | Yes |
| Obs. | 101,034 | 101,034 | 101,034 | 48,090 | 48,090 | 48,090 |
| Obs. PF | 2,278 | 1,720 | 2,278 | 2,278 | 1,720 | 2,278 |
| # Firms | 14,833 | 14,833 | 14,833 | 7,404 | 7,404 | 7,404 |
| # Firms PF | 568 | 427 | 568 | 568 | 427 | 568 |

*Notes:* This table presents results from the estimation of equation (II.10) after approximating the function $h(.)$ in the first stage equation (II.7) by a third-degree polynomial in labour, capital, intermediary inputs, average wage and the investment rate (following Fan et al. (2022)). $Intensity_{it-1}$ is the aggregate share of the equity of firm $i$ (in percentage points) held by domestic pension funds in year $t-1$. Coefficient estimates and standard errors for $Intensity_{it-1}$ are multiplied by 100. All specifications include industry fixed effects at the NACE Rev.2 1-digit level. Bootstrapped standard errors, clustered by firm, with 200 repetitions in parentheses. In columns 2 and 5, $Intensity_{it-1}$ is equal to 0 if the aggregate holding of all domestic pension funds in firm $i$ at time $t-1$ is less than 5%. In columns 3 and 6, we include a dummy taking value 1 if firm $i$ is an exporter in year $t-1$. The line "Obs. PF" ("# Firms PF") gives the number of observations (number of firms) with pension fund investment at time $t-1$ in the sample. Finally, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

**Table B.19.** Productivity Estimates: Investment Length, Alternative First Stage Polynomial

| | Whole sample | | | Matched sample | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\beta_l$ | 0.955*** | 0.955*** | 0.949*** | 0.918*** | 0.918*** | 0.914*** |
| | (0.005) | (0.005) | (0.005) | (0.008) | (0.008) | (0.008) |
| $\beta_k$ | 0.088*** | 0.088*** | 0.085*** | 0.093*** | 0.093*** | 0.091*** |
| | (0.003) | (0.003) | (0.003) | (0.006) | (0.006) | (0.006) |
| $Length_{it-1}$ | 1.273*** | 1.412*** | 1.155*** | 1.515*** | 1.703*** | 1.389*** |
| | (0.319) | (0.389) | (0.320) | (0.315) | (0.388) | (0.315) |
| Industry FE | Yes | Yes | Yes | Yes | Yes | Yes |
| $PFI_{it-1} \geq 5\%$ | No | Yes | No | No | Yes | No |
| Export$_{it-1}$ | No | No | Yes | No | No | Yes |
| Obs. | 101,034 | 101,034 | 101,034 | 48,090 | 48,090 | 48,090 |
| Obs. PF | 2,278 | 1,720 | 2,278 | 2,278 | 1,720 | 2,278 |
| # Firms | 14,833 | 14,833 | 14,833 | 7,404 | 7,404 | 7,404 |
| # Firms PF | 568 | 427 | 568 | 568 | 427 | 568 |

*Notes:* This table presents results from the estimation of equation (II.10) after approximating the function $h(.)$ in the first stage equation (II.7) by a third-degree polynomial in labour, capital, intermediary inputs, average wage and the investment rate (following Fan et al. (2022)). $Length_{it-1}$ is the number of consecutive years that firm $i$ receives investment from any domestic pension fund up to year $t-1$ included. Coefficient estimates and standard errors for $Length_{it-1}$ are multiplied by 100. All specifications include industry fixed effects at the NACE Rev.2 1-digit level. Bootstrapped standard errors, clustered by firm, with 200 repetitions in parentheses. In columns 2 and 5, $Length_{it-1}$ only includes the years when aggregate investment by domestic pension funds in the firm is at least 5%. In columns 3 and 6, we include a dummy taking value 1 if firm $i$ is an exporter in year $t-1$. The line "Obs. PF" ("# Firms PF") gives the number of observations (number of firms) with pension fund investment at time $t-1$ in the sample. Finally, $^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$.

# Chapter III

David Pinkus, Dario Pozzoli and Cédric Schneider

# Pension Fund Investment and Firm Innovation

# CHAPTER III

# Pension Fund Investment and Firm Innovation


## Abstract

We use a novel database on domestic pension fund investment to analyse the relationship between pension fund investment and innovation among Danish firms. We find a significant positive correlation between pension fund investment and various measures of innovation, including in the area of climate change mitigation (green) technologies. Interestingly, we find that this correlation is weaker in highly competitive industries, which suggests that pension funds may increase innovation by disciplining "lazy" managers. Our analysis also suggests that pension funds foster investment in innovation by providing long-term capital security. In fact, we find a positive relationship between investment duration and innovation activities, supporting this idea. Overall, our study highlights the important role that pension funds can play in driving innovation among firms, particularly by providing stable, long-term capital.



I am grateful to Roger Bandik, Marek Giebel and Natalia Khorunzhina for their comments and suggestions. I acknowledge support from the Pension Scholarship Trust in partly funding this research.

# III.1 Introduction

The seminal works of Solow (1956), further supported by Romer (1994), have established that innovation is critical for sustainable economic growth and development. However, financing innovative projects presents a significant challenge due to the need for long-term and stable commitments from financiers. Moreover, managers may pursue inefficient "empire building" strategies that discourage risk-taking activities, such as innovation (Baumol, 1959). Additionally, innovation is highly uncertain, has long lead times, and requires cumulative efforts (Arrow, 1962; Mazzucato & Semieniuk, 2017). These uncertainties require investors to be willing to take significant risks, while the long-term nature of innovation and its cumulative effects necessitate stable, long-term capital provision.

Pension funds can play a crucial role in helping firms overcome the challenges associated with financing innovation. Pension funds can help in two primary ways. Firstly, pension funds typically have a longer investment horizon compared to other investors who often have short-term return objectives and frequently move in and out of stocks. Research has shown that pension funds (as well as insurance companies) tend to adopt a particularly long investment horizon compared to other institutional investors (Cella et al., 2013; Cremers & Pareek, 2016; Döring et al., 2021; Harford et al., 2018). This longer-term investment approach allows pension funds to stay invested for a longer period instead of reacting to short-term shocks, providing stable and patient capital to firms pursuing innovative projects.

Secondly, pension funds can represent an effective instrument to combat managers' tendency to support short-sighted and inefficient strategies. By concentrating ownership, pension funds can exercise greater influence on firms' management and governance, promoting more long-term and sustainable strategies, including innovation. This concentrated ownership can help to align the interests of the investors and the management of the firm and provide the necessary incentives to pursue innovative projects with a long time horizon. In summary, pension funds can offer a critical source of stable, long-term capital to firms pursuing innovation while also providing governance mechanisms to promote long-term and sustainable strategies.

This study provides the first analysis of the role of pension funds' investments in Danish firms' innovation in general and in the area of green technologies specifically. In recent decades, pension funds have emerged as major owners of public and private companies in capital markets worldwide, and Denmark is no exception to this trend. At the end of 2021 global assets in funded and private pension plans reached 60 trillion USD for the first time (OECD, 2023). In Denmark, these assets amounted to over 230 percent of GDP, the highest ratio among all countries included in comparable OECD statistics (OECD, 2023). Most of these assets were managed by pension funds. The amount of equity of Danish non-financial corporations held by the domestic pension fund and insurance sectors increased from 213.6 to 316.8 billion DKK from 2017 to 2021, an increase of over 48%.[1] This trend highlights the growing importance of pension funds as significant investors in the Danish economy, underscoring the potential role that they can play in promoting innovation and sustainable growth. In particular, environmental, social, and governance (ESG) investing has emerged as a key issue for pension funds, and Danish funds are leading the way in this regard. For example, Denmark's largest pension fund, ATP, announced an increase in its climate investment targets in October 2021 (ATP, 2021). Against this backdrop, this study contributes to the ongoing discussions about pension funds and the climate transition by examining the extent to which pension fund investments specifically support innovation in green technologies.

The identification and estimation of the relationship between pension fund investment and firms' innovation have been plagued by a lack of sufficiently rich data at both the investor and firm levels. In this study, we address this challenge by merging the Danish matched employer-employee dataset with newly collected data on pension funds' investments spanning the period 2003–2019. Unlike previous studies in this field (see, e.g., Aghion et al., 2013), we are able to include both publicly listed and unlisted companies in our analysis and we study three different measures of innovation. First, we rely on patent applications and their citations recorded for Danish firms at the European Patent Office (PATSTAT) to proxy for innovation (Bloom et al., 2016). Second, we define a patent application as "green" if it involves climate change mitigation technologies, using either the Cooperative Patent Classification (CPC) or the International Patent Classification (ICP) (Li et al., 2021). Third, we examine the share of R&D workers within a firm as an additional proxy for the intensive margin of innovation. We identify R&D workers using individual occupational codes and the classification of knowledge-intensive jobs suggested by Bernard et al. (2017). Consistent with previous research on innovation (Blundell et al., 1999), we focus our analysis on the sample of firms that op-

[1]Authors' calculations based on National Accounts Statistics published by the Danish Central Bank (Danmarks Nationalbank, 2022).

erate in the manufacturing sector only. Nevertheless, we conduct a refinement analysis that encompasses all industries.

Our results show that pension funds' investments relate positively with firms' innovation in a static specification, in which we control for a number of observed confounding factors and unobserved heterogeneity with the method developed by Blundell et al. (1999). Specifically, firms, where pension funds invest at time $t$, have a 7 percentage points higher probability of having at least one patent application and a nearly twice as large number of patent applications (weighted by citations) relative to the other companies, controlling for unobserved heterogeneity and a whole host of observed characteristics, such as firms' productivity and capital intensity. Interestingly, pension funds' investments are shown to be correlated with firms' innovation in green technologies, with firms, where pension funds invest at time $t$, featuring on average a 1 percentage point larger probability of having at least one green patent application compared to other firms in the sample. Finally, we also show that firms with a pension fund investment have on average a 5 percentage points larger share of R&D workers than otherwise similar firms. Our refinements and robustness checks confirm these main results in the static framework. We also show that product market competition weakens the association between pension funds and firms' innovation, suggesting that pension fund investment is more beneficial for firms' innovation when competition is weak. This result is consistent with the hypothesis that institutional investors (such as pension funds) exert greater discipline on a "lazy manager" to put in more effort given that when competition is strong, such lazy managers tend to disappear rapidly from the market without additional disciplining. Our findings contrast with those of Aghion et al. (2013), who find that competition strengthens the impact of ownership by institutional investors, of which pension funds are one category, on innovation. This difference in results may be partly explained by three key differences between our study and theirs. Firstly, we examine a large and representative sample of publicly listed and unlisted manufacturing firms, while Aghion et al. (2013) only analyse publicly listed firms. Secondly, we study a more recent sample period and a European country, whereas their study focused on the US. Thirdly, we focus solely on pension fund ownership, while their study analyses the ownership of the broader institutional investor space. Additionally, other studies have revisited the findings of Aghion et al. (2013). For instance, using the same dataset, Schain and Stiebale (2021) find that the relationship between competition and institutional investment does not hold when they account for heterogeneity in external finance dependency and financial constraints at the firm level. Similarly, Samila et al. (2021) find no effect of institutional ownership on corporate patenting and even a negative effect on corporate scientific publications, particularly from short-term institutional investors. Furthermore, their findings suggest that high levels of competition do not promote innovation through institutional ownership in contrast with Aghion et al. (2013).

To complement our static analysis, we employ a dynamic event study approach based on the method proposed by Sun and Abraham (2021), which adds two valuable insights. First, the event study analysis demonstrates that before first pension fund investment, there are no discernible differences in trends regarding innovation between firms that pension funds invest in and other firms. This finding refutes the possibility that pension funds selectively invest in more innovative firms, which could bias the results of the static models (see, e.g., Aghion et al., 2013; Fons-Rosen et al., 2021; Garel, 2017; Lerner et al., 2011; Levine & Warusawitharana, 2021). In other words, we observe no significant differences in innovation outcomes between firms that receive pension fund investment and those that do not prior to the investment. Second, the event study analysis reveals a positive trend effect on our measures of innovation in the first 5–6 years after the first pension fund investment.

This study makes several contributions to the existing literature. First, due to a lack of detailed data on pension fund asset allocation, we know relatively little about how they affect the companies they invest in. A few studies have analysed only the effect of other investor types, notably private equity (PE) and venture capital (VC) funds (see, e.g., Chemmanur et al., 2011; Davis et al., 2014). These studies suggest that PE and VC funds have a positive impact on the performance of the firms, in which they invest. They also show that this positive effect goes beyond the mere provision of capital. The mechanisms highlighted are among others: the hiring of better managers, improved company oversight, and easier access to third-party financing for the firm as a consequence of being associated with a given investor (Chemmanur et al., 2011). Our study is the first one to undertake a similar analysis for pension funds. There are critical differences between pension funds and VC and PE funds. PE and VC funds are more likely to take an active part in the functioning of the target firm to raise its value, while pension funds tend to invest in mature companies with a longer investment horizon. Although pension funds may not take an active role in improving the value of the firm, their long-term investment horizon could enable firms to invest in innovative projects with long-term objectives. However, large pension funds have recently increasingly made use of their voting power as shareholders, particularly regarding environmental, social and governance (ESG) issues. They also exert pressure on their external asset managers to take ESG into account.

Second, despite the growing importance of institutional investors in financial markets, there have been relatively few studies that specifically examine their impact on firm-level innovation (Aghion et al., 2013; Bena et al., 2017; Samila et al., 2021; Schain & Stiebale, 2021). These studies offer mixed results. For example, Aghion et al. (2013) find that publicly listed US firms with a higher share of institutional ownership tend to apply for more patents. However, more recent studies using similar datasets arrive at more ambiguous conclusions (Samila et al., 2021; Schain & Stiebale, 2021). Analysing a dataset of publicly listed firms in 30 countries, Bena et al. (2017) find that only foreign institutional investors have a positive effect on corporate innovation. On the related topic of R&D spending, Bushee (1998) finds that firms with a higher share of institutional ownership reduce R&D investment less after a decline in earnings, with this effect stemming from ownership by investors with a long investment horizon. Our paper differs from previous studies by focusing on a sample that includes both listed and unlisted companies, with a specific focus on the effect of pension funds on firm-level innovation. We also contribute to the understanding of whether pension funds induce firms to invest in "green" innovation, specifically patent applications within climate change mitigation technologies. The role of institutional investors in the ESG investment area has received increased attention in recent years, with Dyck et al. (2019) finding that ownership by institutional investors has a positive impact on the environmental and social performance of their portfolio firms. Interestingly, Dyck et al. (2019) also find a positive effect of pension funds specifically when separating the institutional investors by investor type. Additionally, institutional investors are increasingly incorporating climate risk in their investment process (Krueger et al., 2020). However, very few studies have focused on the impact of pension funds (e.g. Alda, 2019). Overall, this study aims to fill a gap in the literature by examining the impact of pension funds on firm-level innovation, with a particular focus on the potential for these investors to promote green innovation. In doing so, we contribute to a better understanding of the role of institutional investors in driving innovation and promoting sustainable growth.

The paper is organised as follows. Section III.2 describes the data. Section III.3 lays out the empirical strategy whereas section III.4 presents its main results and some refinements and robustness exercises. Section III.5 concludes.

# III.2 Data

This study draws on data from multiple sources, including two registers at Statistics Denmark — the Integrated Database for Labour Market Research (IDA) and the Firm Statistics Register (FIRM). In addition, we integrate these registers with a newly collected database on Danish pension funds' domestic investments from Experian, as well as a register of patent applications by Danish firms (PATSTAT). To ensure the quality of our analysis, we limit our sample to private firms operating in the manufacturing industry and included in the first two registers between 2003 and 2019. In the following sections, we describe in more detail the data processing procedures for each database.

The Integrated Database for Labour Market Research (IDA) is a register maintained by Statistics Denmark. It is a longitudinal employer-employee database that contains information on gender, place of work, education, labour market status, and occupation of individuals aged 15–74 from 1980 to 2019. The information is updated once a year in week 48. We only use information on individuals' main occupations from 2003 to 2019. This information is used to measure various workforce characteristics at the firm level, such as the share of R&D workers and of workers with tertiary education.

Our second database is the Firm Statistics Register (FIRM), which provides comprehensive data on a sample of private-sector firms from 2003 to 2019. FIRM contains information on firms' annual sales and capital stock[2] and the 4-digit level classification of the Danish Industrial Activities. To ensure the accuracy of our analysis, we exclude observations with missing values for any of the financial items used as control variables, as well as those with negative equity values.

The third data source we use is a novel database about Danish pension funds' domestic investments. We construct information on pension fund investment in a firm based on shareholder data of all limited liability Danish firms from the data provider Experian. Our panel dataset has ownership relationships between two domestic firms in a given year as the unit of observation.[3] We identify the ultimate owner of each firm by keeping track of all ownership levels. To illustrate, if firm A owns 100% of firm B, and firm B owns 100% of firm C, then firm A is the ultimate owner of firm C since it controls firm B, which in turn controls firm C. We differentiate between ultimate owners and

[2]We calculate the real version of all monetary values by using industry-specific deflators at the DB07 36-industry grouping level based on national accounts data.

[3]The data does not encompass ownership by foreign firms or individuals.

intermediary owners like firm B, which could be a legal entity established to own firm C. We iterate through all ownership layers until all owners in the dataset are ultimate owners or firms owned to less than 80% by other firms.[4] This results in a panel dataset where each observation identifies a relationship between two firms in a given year, or an owner-owned-year combination. To identify pension fund ownership, we manually check the main CVR number (Danish business registration number) of each domestic pension fund group using the Danish Business Register (Virk, 2022). We consider a firm as receiving pension fund investment if any of these CVR numbers are among the ultimate owners of the firm. Importantly, the Experian ownership data covers all incorporated Danish firms, allowing us to analyse both publicly quoted and private firms. This is an important contribution to the literature as previous studies have mainly covered listed firms (Aghion et al., 2013; Alvarez et al., 2018; Jara et al., 2019; Samila et al., 2021; Schain & Stiebale, 2021, e.g.). Although our data does not include information on debt financing, it is unlikely to significantly limit our analysis since equity is the primary source of funding for Danish non-financial companies. In fact, national accounts data from 2019 shows that equity accounts for 59.5% of total liabilities, while loans account for 30.1%.

We obtain measures of innovation from patent applications filed by Danish firms with the European Patent Office (PATSTAT). We count the number of patent applications and their citations owned by Danish firms. To combine the firm-level data with PATSTAT, we match on the name and address of the headquarters using the Danish Business Register (Virk, 2022), as in Bloom et al. (2016). Matching names and addresses presents many challenges, including the lack of harmonised names, partial or missing information, and multiple entries for the same entity. To increase match accuracy, we use four matching criteria: perfect match, alphanumeric match, Jaro–Winkler distance, and Levenshtein distance. The Jaro–Winkler distance measures the similarity between two strings based on common tokens, while the Levenshtein distance is an edit distance that counts the number of changes needed to transform one name into another. Only matches above a threshold value are considered valid. For a detailed description of our methodology, please refer to Tarasconi and Menon (2017).

After constructing the ownership and patent data using Experian, PATSTAT and the Danish Business Register, we proceed to merge their anonymised versions with the other two registers (IDA and FIRM) on a server managed by Statistics Denmark.

[4] A detailed description of this dataset can be found in Section D.2 of the Data Appendix.

## III.2.1 Descriptive Statistics

The first panel of Table III.1 displays descriptive statistics of the main outcome variables used in the empirical analysis. We measure the extensive and intensive margins of innovation respectively as the probability of having at least one patent application and the number of patent applications. The intensive measure is weighted by the number of citations, which ensures that only patent applications of higher quality are considered as innovations. In a refinement, we also use the negative hyperbolic sine function of the number of patent applications, weighted by citations. In addition, we extend the analysis to patent applications related to climate change mitigation technologies using either the ICP or the CPC classifications. Specifically, a patent application is defined as "green" if its Cooperative Patent Classification (CPC) is Y02 or Y04S, or if its International Patent Classification (ICP) is 6, 6A, 6B, 6C, 6D, 6E, 6F, 6G, 6H, 6I, 6Z, ZB, ZC. The averages for the extensive and intensive margins (green) are approximately 1 (0.2) percent and 0.084 (0.013), respectively. This means that on average, we record patenting in 1% of firm-year observations. The averages for the extensive margin are low because a large number of firm-year observations have no patent applications. However, conditionally on the extensive margin being equal to 1, the average number of patent applications weighted by future citations is 6.48 (1.02 for green applications). We also refer to the number of patent applications weighted by future citations as the quality-adjusted number of patent applications. In our final sample, around 1000 (200) firms record at least one patent (green) application over the sample period.

Using patents as a measure of innovation, like any other innovation indicator, has advantages and disadvantages. On the positive side, patent applications (i) are a direct outcome of the innovation process and (ii) can be documented. However, it is important to note that not all inventions are patentable, and firms may have different propensities to apply for patents, which may lead to some limitations in relying solely on patent applications. Nevertheless, we consider patent applications a relatively objective and conservative measure of innovation, making them a plausible and suitable proxy for our purposes. To enhance the reliability of our analysis, we also use the share of R&D workers within a firm as an additional proxy for the intensive margin of innovation. To identify workers involved in R&D activities, we use the classification of knowledge-intensive occupations suggested by Bernard et al. (2017). By using multiple indicators of innovation, we aim to strengthen the robustness of our findings and provide a more comprehensive picture of the relationship between pension fund investments and innovation.

In the following panel of Table III.1, we present the descriptive statistics for the main explanatory variables used in our empirical analysis. The first variable, $PFI_{it}$, is measured as a dummy variable indicating whether a pension fund invests in firm $i$ at time $t$. We find that only around 1 percent of observations feature a pension fund investment. Our sample comprises around 30,000 firms, of which approximately 500 receive pension fund investments. The duration ($Duration_{it}$) and intensity ($Intensity_{it}$) of the investment in a given firm are integrated into our analysis, with an average duration of 4 years and an average intensity of 5 percent for the firms receiving pension fund investments. These figures suggest that pension funds' investments are of a long-term nature.

The remaining sections of Table III.1 present the descriptive statistics for the control variables used in our regression models, which include measures of firms' productivity and capital intensity, among other factors.

**Table III.1.** Descriptive Statistics

| Variables | Definition | Mean | SD |
|---|---|---|---|
| **Outcome variables** | | | |
| Extensive Margin of Inno | 1 if the firm applies for a patent | 0.013 | 0.113 |
| Intensive Margin of Inno | number of firms' patent citations | 0.084 | 3.040 |
| Extensive Margin of Inno2 | 1 if the firm applies for a green patent | 0.011 | 0.104 |
| Intensive Margin of Inno2 | number of firms' green patent citations | 0.013 | 0.922 |
| R&D workers | Share of R&D workers in total employment | 0.011 | 0.064 |
| **Pension investment variables** | | | |
| $PFI_{it}$ | 1 if a pension fund invests in firm $i$ at time $t$ | 0.011 | 0.104 |
| $Intensity_{it}$ | percentage of shares outstanding held by pension funds in firm $i$ at time $t$ | $4.345^{a}$ | 8.019 |
| $Duration_{it}$ | duration of the pension fund investment in firm $i$ at time $t$ | $3.737^{a}$ | 3.004 |
| **Firm variables** | | | |
| Size | log of total number of workers | 1.827 | 1.528 |
| Productivity | log of sales per employee | 13.682 | 0.809 |
| Capital Intensity | log of capital stock per employee | 12.079 | 1.372 |
| Female | share of female workers | 0.258 | 0.288 |
| Tertiary | share of workers with tertiary education | 0.033 | 0.103 |
| **N** | | | 179,301 |
| **Number of firms** | | | 30,802 |

*Notes:* All descriptive statistics are calculated as averages over the 2003–2019 period. Firm variables are in real Danish Kroner (using 2010 as the base year). $^{a}$: the descriptive statistics for this variable are calculated only conditional on receiving any pension fund investment.

# III.3 Empirical Strategy

## III.3.1 Event Study and Pre-trends

To test for pre-trends between firms that receive investments from pension funds and those that do not, we first start the empirical analysis with an event study approach. This method offers the added benefit of examining dynamic effects. However, an issue we encounter is that the impact of pension fund investments varies not only across firms but also with regard to the timing of the investment, as not all firms receive investments simultaneously. The econometric literature has highlighted that the standard event study specification may be biased towards zero in cases of treatment heterogeneity.[5] We estimate the following dynamic two-way fixed effects model developed by Sun and Abraham (2021), which is robust to heterogeneous treatment effects and which uses never-treated units as controls (C):

$$Outcome_{it} = \alpha + \sum_{l=-K, l\neq -1}^{L} \beta_l \mathbb{1}\{F_i = t - l\} + X_{it}^{'}\Gamma + \lambda_t + \theta_i + \epsilon_{it} \tag{III.1}$$

where $F_i$ is the first period at which firm $i$ is treated, i.e. it receives a pension fund investment. The $Outcome_{it}$ variable is one of the innovation outcomes described in the previous section and is regressed on firm and period fixed effects, and relative time indicators $\mathbb{1}\{F_i = t - l\}$ equal to 1 if firm $i$ started receiving a pension fund investment $l$ periods ago. For $l \geq 0$, $\beta_l$ is the estimate of the cumulative effect of $l + 1$ treatment periods. For $l \leq -2$, $\beta_l$ represents the vector of placebo coefficients testing the parallel trends assumption, which unbiased estimation of post-event treatment effects relies on. In the absence of treatment, it is assumed that treated and control firms would have maintained similar differences as in the baseline period. We test this assumption by comparing the outcome trends of firms that will and will not start receiving a pension fund treatment in $|l|$ periods. Put differently, the regression (III.1) interacts relative time dummies with the treatment event, excluding indicators for the comparison group, C. Furthermore, a single lag or lead variable is omitted to capture the baseline difference between firms where the event does and does not occur. In our specification, this baseline omitted case is the period before the first pension fund investment occurs, where $l$ =-

[5] For a comprehensive overview of this discussion, please refer to de Chaisemartin and D'Haultfoeuille (2022b).

1. We augment the specification with control variables $X_{it}$ measured at year $t$, which include a set of firm characteristics that could influence our firm-level outcomes, such as productivity (Bao & Chen, 2018) and the share of tertiary-educated workers (Kaiser et al., 2015).

## III.3.2 Static Models

We then proceed with the analysis by using the following static specification in order to examine the association between pension funds' investments and the extensive and intensive margins of innovation:

$$Outcome_{it} = \beta_1 Pension_{it} + X'_{it}\gamma_1 + \delta_i + \delta_t + \epsilon_{it} \tag{III.2}$$

where the dependent variable, $Outcome_{it}$, is one of the innovation outcomes of firm $i$ in year $t$. Our main independent variable is a dummy variable $Pension_{it}$ taking value 1 if at least one domestic pension fund is a shareholder in firm $i$ in year $t$, and is equal to 0 otherwise. We also present the results obtained using the investment intensity and duration instead of the dummy variable in additional refinements. Furthermore, we incorporate firms' unobserved time-invariant characteristics that influence the ability to innovate ($\delta_i$). Following Blundell et al. (1999) and Lach and Schankerman (2008), we proxy for these time-invariant firm effects in two ways. First, we use the firm's number of patent applications in the pre-sample period (1978–2002) normalised by the total number of patent applications in the same period. Second, we proxy unobserved time-invariant heterogeneity with a dummy for having any patent applications in the pre-sample period. All patent applications in these calculations are weighted by citations. This "pre-sample mean scaling" relaxes the strict exogeneity assumption underlying the fixed-effect models.[6] We finally complete the specification with a vector of explanatory variables ($X_{it}$) and year fixed effects ($\delta_t$). All of these additional control variables allow us to focus more carefully on the effects of pension funds' investments. We cluster the standard errors at the firm level.

[6] Since we are limited by the low variation in patenting activity and pension fund investment occurrences, we primarily rely on the pre-sample mean scaling to account for firm-specific unobserved heterogeneity in the linear specifications. However, we estimate fixed-effect Poisson models with the intensive margin of patenting as the dependent variable.

The linear specification may be problematic when we use the quality-adjusted number of patent applications because our dependent variable only takes on positive values, contains a large number of zeros and its distribution is right-skewed, in which case outliers may influence the results. To address these issues, we use the following approaches. First, we estimate linear models using the inverse hyperbolic sine (IHS) transformation of citation-weighted patents to account for the large number of zeros and reduce the influence of outliers in the dependent variable. Second, we report Poisson Quasi-Maximum Likelihood (QML) estimates using the following log-link formulation of the conditional mean of our dependent variable:

$$E\left[Outcome_{it}|Pension_{it}, X'_{it}, \delta_i, \delta_t\right] = exp(\beta_2 Pension_{it} + X'_{it}\gamma_2 + \delta_i + \delta_t) \qquad \text{(III.3)}$$

Because the Poisson distribution is in the linear exponential family, Poisson QML estimates have the advantage of being consistent, provided the mean is correctly specified, independently of the true underlying distribution (Gourieroux et al., 1984). To account for unobserved heterogeneity, we first use the pre-sample mean scaling suggested by Blundell et al. (1999) estimated by Poisson QML. Additionally, we report the QML estimates (Wooldridge, 1999) of the fixed-effect Poisson model developed by Hausman et al. (1984).

## III.3.3 Matching Approach

Estimating the relationship between pension fund investment and innovation using either dynamic or static approaches poses a significant challenge due to pension funds only investing in a limited subset of firms. This may introduce bias in our findings as we compare this subset of firms with the rest of the sample. Furthermore, the “treated” firms, i.e., those that receive pension fund investment, may differ fundamentally from the control group in ways that cannot be captured by the available controls.

To address this challenge, we use propensity score estimation to create a matched control group for our analysis. To calculate the probability of a firm receiving pension fund investment, we begin by estimating a logit regression of the dummy variable $PFI_{it}$ on the following firm variables lagged by one period: sales, fixed assets, number of employees, total assets, total liabilities, net income, sales growth, ratio of fixed to total assets, firm age, a dummy denoting if the firm belongs to a publicly listed business group, and share of workers with tertiary education. Propensity scores are calculated sector-year wise, and any firm with a propensity score below the 25th percentile of its respective sector-year cell in any year is dropped from the matched control sample.[7] While the specification for the propensity score is simple, estimating it separately for each sector-year cell reduces the risk of misspecification.

In the following section, we present our results for both static and dynamic approaches for the entire sample, as well as the conservative approach where we only keep firms in the matched control group with a high probability of receiving pension fund investment over the sample period.

# III.4 Results

## III.4.1 Results from the Event Study

To assess the evolution of the relationship between pension fund investment and firm innovation over time, we first use the event study approach described in Section III.3.1. This allows us to visually inspect the pre-trends. However, traditional event study methods may not yield accurate estimates when firms exhibit heterogeneity in their response to treatment. To address this issue, we implement the method developed by Sun and Abraham (2021). Figure III.1 presents the results obtained from the dynamic specification (III.1) using the firm's log number of patent applications weighted by citations (intensive margin) in year $t$ as the dependent variable.[8] We find no evidence of differences in pre-trends between treatment and control firms, as the 95% confidence intervals for all of the placebo (pre-treatment) coefficients include zero. This indicates that pension funds do not selectively invest in more innovative firms.[9] Our results also provide suggestive evidence of differences in innovation outcomes between treatment and con-

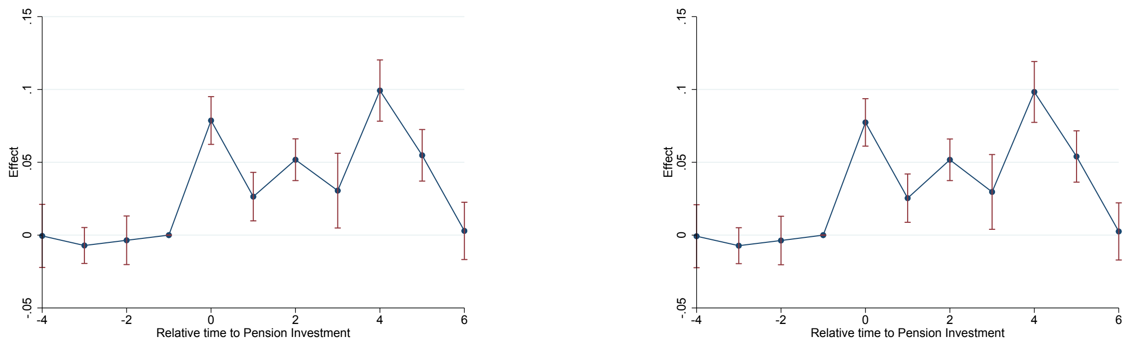
[7]Sectors are defined based on NACE Rev.2 2-digit grouping. The 25th percentile is only calculated among firms that do not receive pension fund investment in any year. Only firms for which a propensity score can be computed in at least one year are kept. The inclusion of firms with missing propensity scores in all years in the matched control group does not alter our results.

[8]We use the natural logarithm of the intensive margin to make the interpretation of coefficients similar in spirit to those of the Poisson models in the main results. Results using the plain intensive margin are available in Appendix Figure C.1.

[9]Qualitatively similar results, which are available on request from the authors, are obtained by using the approach suggested by de Chaisemartin and D'Haultfoeuille (2022a).

trol firms in the first five years following a pension fund investment. We obtain almost identical results when using the matched sample. Furthermore, results are very similar when excluding cases of short-term investments by pension funds, defined as investments lasting only one year (see Appendix Figure C.2). In the next section, we present more rigorous empirical specifications that account for the large number of zero intensive margins and control for the unobserved propensity to patent using the approach suggested in Blundell et al. (1999).

**Figure III.1.** Pension Fund Investments and Innovation Outcomes, Dynamic Specification




**(a)** Intensive Margin of Innovation (Whole Sample)

**(b)** Intensive Margin of Innovation (Matched Sample)

**Note:** This figure shows event time coefficients and 95% confidence intervals estimated using the algorithm developed in Sun and Abraham (2021). The dependent variable is the firm's (log) number of patent applications weighted by citations (intensive margin) in year $t$. Control variables include the firms' productivity, capital intensity, share of female workers and share of tertiary-educated workers.

## III.4.2 Results from the Static Models

Once we have ruled out pre-trends and selection issues, we proceed with the analysis by using the static approach described in equation (III.2). In all tables of this sub-section, the explanatory variable capturing pension fund investment $PFI_{it}$ is a dummy taking value 1 if at least one domestic pension fund is among the shareholders of firm $i$ at time $t$, and 0 otherwise. First, we explore whether pension funds' investments in a firm affect its propensity to apply for a patent (extensive margin of innovation) in a linear probability model. Column 1 of Table III.2 shows a positive association between pension funds' investments at time $t$ and the probability to file for a patent application in the same year after controlling for firm characteristics, firms' unobserved propensity to innovate and year fixed effects. Specifically, the presence of pension funds' investments at time $t$ associates on average with a 7 percentage points increase in the firm's extensive margin of innovation. In column 2, we examine the quality-adjusted intensive margin of innovation, which is the number of patent applications weighted by the number of citations. Pension funds' investments in a firm at time $t$ are associated with a positive increase in the quality-adjusted measure of innovation, after controlling for firms' characteristics (including firms' unobserved heterogeneity in terms of innovation) and year fixed effects. Using the negative hyperbolic sine transformation (IHS) of the dependent variable (column 3 of Table III.2), the Poisson model with standard firm fixed effects (column 4 of Table III.2) and the Poisson model following la Blundell et al. (1999) confirm the positive association between pension funds' investments and the firm's intensive margin of innovation. For example, when we estimate the two Poisson models we obtain a coefficient for pension fund investment of respectively 0.908 (in column 4) and 0.803 (in column 5). On average, these coefficients suggest that, all else being equal, companies receiving pension fund investments have roughly twice as many (quality-adjusted) patents as other companies.

**Table III.2.** Pension Fund Investments and Innovation: Main Results

| Dep. var: | Ext. Margin | Int. Margin | | | | Ext. Margin2 | R&D Workers |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| | OLS | OLS | IHS | FE Poisson QML | Poisson QML | OLS | OLS |
| $PFI_{it}$ | 0.068*** | 1.041* | 0.098*** | 0.908** | 0.803** | 0.012** | 0.051*** |
| | (0.013) | (0.589) | (0.035) | (0.370) | (0.350) | (0.005) | (0.008) |
| Mean Y | 0.013 | 0.084 | 0.013 | 2.670 | 0.084 | 0.002 | 0.011 |
| N | 179,301 | 179,301 | 179,301 | 5,601 | 179,301 | 179,301 | 179,301 |
| N PF | 1,967 | 1,967 | 1,967 | 496 | 1,967 | 1,967 | 1,967 |
| # Firms | 30,802 | 30,802 | 30,802 | 425 | 30,802 | 30,802 | 30,802 |
| # Firms PF | 509 | 509 | 509 | 91 | 509 | 509 | 509 |
| Adj. $R^2$ | 0.130 | 0.107 | 0.128 | | | 0.013 | 0.152 |
| $\chi^2$ | | | | 283.7 | 5,627.9 | | |

*Notes:* In column 1, the dependent variable is a dummy equal to 1, if the firm has at least one patent application in year $t$. In columns 2, 4 and 5 the dependent variable is the number of patent applications (weighted by citations) in year $t$. In column 3 the dependent variable is the inverse hyperbolic sine (IHS) transformation of the number of patent applications (weighted by citations) in year $t$. In column 6, the dependent variable is a dummy equal to 1, if the firm has at least one green patent application in year $t$. In column 7, the dependent variable is the share of R&D workers. The dummy variable $PFI_{it}$ takes value one if at least one domestic pension fund is among the shareholders of firm $i$ in period $t$. In all columns, we include the following control variables: firms' productivity, capital intensity, share of female workers and share of tertiary-educated workers, as well as year fixed effects. In addition in columns 1, 2, 3, 5, 6 and 7, we also include the firms' number of patent applications (weighted by citations) in the pre-sample period (1978–2002) normalised by the total number of patent applications (weighted by citations) in the pre-sample period and a dummy for firms that do not have a patent application (weighted by citations) in the pre-sample period, following the approach developed by Blundell et al. (1999). Standard errors clustered at the firm level are in parentheses. The row "Mean Y" gives the mean of the dependent variable. The rows "N" and "N PF" show the number of observations and the number of observations with pension fund investment, respectively. The rows "# Firms" and "# Firms PF" detail the number of firms and the number of firms receiving pension fund investment in the sample, respectively. Significance levels: ***1%, **5%, *10%.

We proceed to examine whether pension fund investments encourage firms to engage in green technology innovation using a linear probability model that controls for firms' characteristics, unobserved heterogeneity, and year fixed effects (column 6 of Table III.2). The results indicate that firms that receive investments from pension funds are more likely to apply for a green patent by approximately 1 percentage point. The lower adjusted $R^2$ in comparison to the one reported in column 1 for the propensity to apply for a patent can be attributed to the relatively lower variation in green patenting within our sample. In the last column of Table III.2, we investigate the share of R&D workers as an outcome variable. The estimated coefficient on our variable of interest is positive and significant, indicating that pension fund investments are associated with a 5 percentage point increase in the share of R&D workers in the firm.

To ensure our main results are not influenced by selection issues, we conduct static regressions on a matched sample, as outlined in Section III.3.3. The results from the matched sample, presented in Table III.3, are consistent with those from the full sample, indicating a positive correlation between pension fund investments and firm-level innovation, regardless of the measurement method.

**Table III.3.** Pension Fund Investments and Innovation: Main Results (Matched Sample)

| Dep. var: | Ext. Margin | Int. Margin | | | | Ext. Margin2 | R&D Workers |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| | | | | FE Poisson | Poisson | | |
| | OLS | OLS | IHS | QML | QML | OLS | OLS |
| $PFI_{it}$ | 0.065*** | 1.017* | 0.095*** | 0.892** | 0.780** | 0.011** | 0.050*** |
| | (0.013) | (0.590) | (0.034) | (0.354) | (0.367) | (0.005) | (0.008) |
| Mean Y | 0.016 | 0.116 | 0.017 | 3.032 | 0.116 | 0.003 | 0.014 |
| N | 117,209 | 117,209 | 117,209 | 4,451 | 117,209 | 117,209 | 117,209 |
| N PF | 1,967 | 1,967 | 1,967 | 496 | 1,967 | 1,967 | 1,967 |
| # Firms | 24,718 | 24,718 | 24,718 | 346 | 24,718 | 24,718 | 24,718 |
| # Firms PF | 509 | 509 | 509 | 91 | 509 | 509 | 509 |
| Adj. $R^2$ | 0.144 | 0.112 | 0.136 | | | 0.015 | 0.165 |
| $\chi^2$ | | | | 420.4 | 4,872.3 | | |

*Notes:* The sample only includes "matched" firms in the control group as described in section III.3.3. The dummy variable $PFI_{it}$ takes value one if at least one domestic pension fund is among the shareholders of firm $i$ in period $t$. Dependent variables and control variables as specified in the notes to Table III.2. Standard errors clustered at the firm level are in parentheses. Significance levels: ***1%, **5%, *10%.

### III.4.2.1 The Role of Competition

Overall, our findings suggest that pension funds' investments are positively associated with firms' innovation outcomes. However, the main mechanism behind this relationship remains unclear. The theoretical framework developed in Aghion et al. (2013) provides two possible hypotheses.

One hypothesis suggests that by reducing the informational gap between managers and shareholders, pension funds can encourage managers to undertake innovative projects and investments. Under normal circumstances, managers may be hesitant to commit to risky activities because if they are not successful, the market could view them as bad managers, and their careers may suffer. In extreme cases, they may even be fired. However, because pension funds typically have a large stake in the company, they have a greater incentive to gather information about the company's managers. Thus, they may be less likely to fire a manager who is merely unlucky and provide "insurance" to those who innovate by alleviating their career concerns. This hypothesis is referred to as the "career concern" hypothesis in Aghion et al. (2013).

In addition to the "career concern" hypothesis, the theoretical framework developed in Aghion et al. (2013) suggests the "lazy manager" hypothesis as another potential mechanism behind the positive relationship between pension fund investments and firm-level innovation outcomes.

Under this hypothesis, managers may have a preference for stable and routine practices, and pension funds can induce them to put in more effort and engage in innovative activities. However, according to Aghion et al. (2013), if product market competition is high, there may be no need for pension funds to monitor managers as the threat of bankruptcy or takeover, which comes with tough competition, already induces them to work hard and engage in innovation. Therefore, if the "career concern" hypothesis is true, then intense competition should reinforce the positive effect of pension funds on managers' incentives to engage in innovation.

To investigate the relationship between pension fund investments and innovation under high levels of product market competition, we estimate a regression model using specification (III.2) and introduce an interaction term between the variable $Pension_{it}$ and a dummy capturing high levels of competition in the NACE Rev.2 2-digit industry of firm $i$.[10] To measure competition, we adopt two approaches: the inverse Herfindahl index based on firms' sales at the 2-digit industry level and the inverse Lerner index based on gross margins. In the first approach, we define a dummy variable $High\ Competition$ as

[10]We omit the non-interacted dummy variable $High\ Competition$ from the specification given three facts: i) we define competition as a time-invariant characteristic of the sector, (ii) firms rarely change sector and (iii) we control for time-invariant firm characteristics using the approach developed by Blundell et al. (1999).

1 if the firm operates in a sector where the inverse of the Herfindahl index based on sales is above the 75th percentile of the sector-specific distribution. In the second approach, the dummy variable *High Competition* is defined as 1 if the firm operates in a sector where the inverse of the Lerner index is above the 75th percentile of the sector-specific distribution.

Tables III.4 and III.5 report the results of these specifications, including interaction terms. We find a generally negative interaction between high levels of product market competition and pension funds investing in a given firm for both the extensive and intensive margins of innovation, using both definitions of high levels of product market competition. While the coefficients estimated on pension fund investment remain positive and significant, they are generally smaller than the negative coefficients on the interaction term. Furthermore, the joint significance tests at the bottom of Tables III.4 and III.5 indicate that the null hypothesis of the sum of both coefficients being zero cannot be rejected for most specifications. This finding supports the hypothesis that pension funds are not effective in promoting innovation in companies that operate under high competition. We obtain almost identical results when estimating the interaction specifications on the matched sample, as reported in the Appendix (Tables C.3 and C.4).

**Table III.4.** Pension Fund Investments and Innovation: Competition Results (Herfindahl Index)

| Dep. var: | Ext. Margin | Int. Margin | | | | Ext. Margin2 | R&D Workers |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| | OLS | OLS | IHS | FE Poisson QML | Poisson QML | OLS | OLS |
| $PFI_{it}$ | 0.074*** | 1.176* | 0.109*** | 0.917** | 0.812** | 0.012** | 0.058*** |
| | (0.014) | (0.661) | (0.039) | (0.371) | (0.350) | (0.005) | (0.009) |
| $PFI_{it} \times High\ Competition_i$ | -0.056*** | -1.231* | -0.106** | -1.117 | -1.863*** | 0.000 | -0.059*** |
| | (0.020) | (0.659) | (0.041) | (1.220) | (0.699) | (0.011) | (0.010) |
| P-value, Joint Significance | 0.193 | 0.149 | 0.765 | 0.865 | 0.115 | 0.262 | 0.816 |
| Mean Y | 0.013 | 0.084 | 0.013 | 2.670 | 0.084 | 0.002 | 0.011 |
| N | 179,301 | 179,301 | 179,301 | 5,601 | 179,301 | 179,301 | 179,301 |
| N PF | 1,967 | 1,967 | 1,967 | 496 | 1,967 | 1,967 | 1,967 |
| # Firms | 30,802 | 30,802 | 30,802 | 425 | 30,802 | 30,802 | 30,802 |
| # Firms PF | 509 | 509 | 509 | 91 | 509 | 509 | 509 |
| Adj. $R^2$ | 0.131 | 0.107 | 0.128 | | | 0.013 | 0.153 |
| $\chi^2$ | | | | 284.1 | 5,658.0 | | |

*Notes:* The variable $High\ Competition_i$ is a dummy equal to 1 if the firm operates in a sector in which the inverse of the Herfindahl index based on firms' sales is above the 75th percentile of the sector distribution. The dummy variable $PFI_{it}$ takes value one if at least one domestic pension fund is among the shareholders of firm $i$ in period $t$. The row "P-value, Joint Significance" shows the p-value of a joint significance test with null hypothesis $H_0 : PFI_{it} + PFI_{it} \times High\ Competition_i = 0$. Standard errors clustered at the firm level are in parentheses. Dependent variables and control variables as specified in the notes to Table III.2. Significance levels: ***1%, **5%, *10%.

**Table III.5.** Pension Fund Investments and Innovation: Competition Results (Lerner Index)

| Dep. var: | Ext. Margin | Int. Margin | | | | Ext. Margin2 | R&D Workers |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| | OLS | OLS | IHS | FE Poisson QML | Poisson QML | OLS | OLS |
| $PFI_{it}$ | 0.076*** | 1.330* | 0.113*** | 0.878** | 0.878** | 0.013** | 0.067*** |
| | (0.015) | (0.740) | (0.043) | (0.388) | (0.350) | (0.006) | (0.010) |
| $PFI_{it} \times High\ Competition_i$ | -0.039 | -1.394* | -0.074 | -0.961* | -1.176* | -0.004 | -0.075*** |
| | (0.026) | (0.762) | (0.061) | (0.556) | (0.632) | (0.008) | (0.011) |
| P-value, Joint Significance | 0.080 | 0.743 | 0.342 | 0.000 | 0.633 | 0.181 | 0.134 |
| Mean Y | 0.013 | 0.084 | 0.013 | 2.670 | 0.084 | 0.002 | 0.011 |
| N | 179,301 | 179,301 | 179,301 | 5,601 | 179,301 | 179,301 | 179,301 |
| N PF | 1,967 | 1,967 | 1,967 | 496 | 1,967 | 1,967 | 1,967 |
| # Firms | 30,802 | 30,802 | 30,802 | 425 | 30,802 | 30,802 | 30,802 |
| # Firms PF | 509 | 509 | 509 | 91 | 509 | 509 | 509 |
| Adj. $R^2$ | 0.130 | 0.107 | 0.128 | | | 0.013 | 0.155 |
| $\chi^2$ | | | | 290.8 | 5,942.4 | | |

*Notes:* The variable $High\ Competition_i$ is a dummy equal to 1 if the firm operates in a sector in which the inverse of the Lerner index based on gross margins is above the 75th percentile of the sector distribution. The dummy variable $PFI_{it}$ takes value one if at least one domestic pension fund is among the shareholders of firm $i$ in period $t$. The row "P-value, Joint Significance" shows the p-value of a joint significance test with null hypothesis $H_0 : PFI_{it} + PFI_{it} \times High\ Competition_i = 0$. Standard errors clustered at the firm level are in parentheses. Dependent variables and control variables as specified in the notes to Table III.2. Significance levels: ***1%, **5%, *10%.

Our findings suggest that the "lazy manager" hypothesis is more supported than the alternative "career concern" theory, as we observe that product market competition does not strengthen the impact of pension funds on fostering firms' innovation. This contrasts with the evidence provided by Aghion et al. (2013), where competition strengthens the impact of institutional ownership on innovation. However, these inconsistent results may be partially explained by differences between the two studies. First, we use a large and representative sample of manufacturing firms, including both listed and unlisted firms, while Aghion et al. (2013) only focuses on publicly listed firms, which are typically larger and more selected. Second, we examine a European country and a more recent sample period than Aghion et al. (2013), which may result in opposite signs of interaction effects between competition and pension funds on firms' innovation. Given the theoretical ambiguity in the relationships examined, it is possible that other studies may also reach different conclusions than Aghion et al. (2013) (see, e.g., Samila et al., 2021; Schain & Stiebale, 2021).

### III.4.2.2 Robustness Checks

We will now present a series of robustness checks to test the validity of our results. Firstly, we exclude publicly listed companies from our analysis. It is possible that the relationship between pension funds and innovation is only present among listed firms, as they may have more established management structures and practices that facilitate the involvement of pension funds in governance and innovation. By excluding listed companies, we aim to test whether our findings are driven by this subset of firms (which has been the focus of previous studies) or are more broadly applicable across the Danish economy. Publicly listed companies often belong to large business groups but only one of the firms in these groups is actually publicly quoted. To address this issue, we define a firm as publicly listed if in any year of the sample period it belongs to a business group including a firm listed on the Nasdaq Copenhagen Stock Exchange.[11] Table III.6 demonstrates that the positive association between pension funds and firms' innovation persists even when we examine the sample of non-listed companies, thereby refuting the hypothesis that the beneficial effects are mainly confined to listed firms.

**Table III.6.** Pension Fund Investments and Innovation: Excluding Listed Firms

| Dep. var: | Ext. Margin | Int. Margin | | | | Ext. Margin2 | R&D Workers |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| | OLS | OLS | IHS | FE Poisson QML | Poisson QML | OLS | OLS |
| $PFI_{it}$ | 0.076*** | 0.426** | 0.052*** | 0.505 | 1.042*** | 0.013** | 0.067*** |
| | (0.012) | (0.190) | (0.014) | (0.329) | (0.365) | (0.005) | (0.010) |
| Mean Y | 0.011 | 0.041 | 0.009 | 1.440 | 0.041 | 0.002 | 0.010 |
| N | 177,231 | 177,231 | 177,231 | 4,957 | 177,231 | 177,231 | 177,231 |
| N PF | 1,392 | 1,392 | 1,392 | 281 | 1,392 | 1,392 | 1,392 |
| # Firms | 30,595 | 30,595 | 30,595 | 380 | 30,595 | 30,595 | 30,595 |
| # Firms PF | 401 | 401 | 401 | 59 | 401 | 401 | 401 |
| Adj. $R^2$ | 0.011 | 0.001 | 0.004 | | | 0.002 | 0.020 |
| $\chi^2$ | | | | 345.2 | 2,093.8 | | |

*Notes:* The sample excludes firms that belong to a business group including a publicly listed company in any year. The dummy variable $PFI_{it}$ takes value one if at least one domestic pension fund is among the shareholders of firm $i$ in period $t$. Standard errors clustered at the firm level are in parentheses. Dependent variables and control variables as specified in the notes to Table III.2. Significance levels: ***1%, **5%, *10%.

Next, we check whether our main results change by excluding firms with imputed accounting data.[12] The results, presented in Table III.7, confirm the robustness of our main findings. Even after excluding these firms, we find that the coefficients remain positive and precisely estimated, indicating that our results are not driven by the presence of imputed data.

[11] Business group composition is sourced from Statistic Denmark and information about listing status is obtained from Refinitiv Eikon.

[12] Statistics Denmark imputes some accounting values in different scenarios. This imputed information could be less reliable and impact our results.

**Table III.7.** Pension Fund Investments and Innovation: Excluding Imputed Values

| Dep. var: | Ext. Margin | Int. Margin | | | | Ext. Margin2 | R&D Workers |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| | OLS | OLS | IHS | FE Poisson QML | Poisson QML | OLS | OLS |
| $PFI_{it}$ | 0.069*** | 1.251* | 0.117*** | 0.936** | 0.757** | 0.013** | 0.045*** |
| | (0.015) | (0.703) | (0.041) | (0.372) | (0.338) | (0.006) | (0.008) |
| Mean Y | 0.016 | 0.121 | 0.018 | 3.047 | 0.121 | 0.003 | 0.012 |
| N | 118,688 | 118,688 | 118,688 | 4,699 | 118,688 | 118,688 | 118,688 |
| N PF | 1,592 | 1,592 | 1,592 | 462 | 1,592 | 1,592 | 1,592 |
| # Firms | 19,289 | 19,289 | 19,289 | 357 | 19,289 | 19,289 | 19,289 |
| # Firms PF | 422 | 422 | 422 | 85 | 422 | 422 | 422 |
| Adj. $R^2$ | 0.162 | 0.109 | 0.141 | | | 0.017 | 0.234 |
| $\chi^2$ | | | | 303.3 | 4,403.6 | | |

*Notes:* The sample excludes observations with imputed firm accounting values. The dummy variable $PFI_{it}$ takes value one if at least one domestic pension fund is among the shareholders of firm $i$ in period $t$. Dependent variables and control variables as specified in the notes to Table III.2. Standard errors clustered at the firm level are in parentheses. Significance levels: ***1%, **5%, *10%.

To further validate our findings, we conduct additional analyses on two distinct samples. First, we exclude firms with fewer than 10 employees from the sample of manufacturing firms used in the main analysis. Second, we expand our analysis to include all industries. The results, presented in Tables III.8 and III.9, show that the main coefficients of interest remain positive and significant. The magnitudes involved are surprisingly very similar to the ones discussed in the baseline analysis. Specifically, the presence of pension funds' investments at time $t$ is associated with a 5.7 and 5.9 percentage point increase in the firm's extensive margin of innovation, respectively, in the samples that exclude firms with fewer than 10 employees (Table III.8) and include all industries (Table III.9). Furthermore, a pension fund investment is on average associated with a 75-78% increase in the number of weighted patent applications, other things being equal. We also find that firms that receive investments from pension funds are more likely to file a green patent by approximately 1 percentage point and that they increase their share of R&D workers by 4-4.5 percentage points. The evidence reported in Tables III.8 and III.9 suggests that our findings are robust and not driven by the selection of the main sample.

**Table III.8.** Pension Fund Investments and Innovation: Excluding Small Firms

| Dep. var: | Ext. Margin | Int. Margin | | | | Ext. Margin2 | R&D Workers |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| | | | | FE Poisson | Poisson | | |
| | OLS | OLS | IHS | QML | QML | OLS | OLS |
| $PFI_{it}$ | 0.057*** | 1.088* | 0.096** | 0.913** | 0.778** | 0.010** | 0.040*** |
| | (0.014) | (0.649) | (0.038) | (0.371) | (0.340) | (0.005) | (0.008) |
| Mean Y | 0.029 | 0.219 | 0.032 | 2.997 | 0.219 | 0.005 | 0.023 |
| N | 66,888 | 66,888 | 66,888 | 4,884 | 66,888 | 66,888 | 66,888 |
| N PF | 1,782 | 1,782 | 1,782 | 475 | 1,782 | 1,782 | 1,782 |
| # Firms | 9,509 | 9,509 | 9,509 | 362 | 9,509 | 9,509 | 9,509 |
| # Firms PF | 443 | 443 | 443 | 88 | 443 | 443 | 443 |
| Adj. $R^2$ | 0.152 | 0.108 | 0.136 | | | 0.016 | 0.238 |
| $\chi^2$ | | | | 305.0 | 3,702.3 | | |

*Notes:* The sample includes manufacturing firms with at least 10 employees. The dummy variable $PFI_{it}$ takes value one if at least one domestic pension fund is among the shareholders of firm $i$ in period $t$. Dependent variables and control variables as specified in the notes to Table III.2. Standard errors clustered at the firm level are in parentheses. Significance levels: ***1%, **5%, *10%.

**Table III.9.** Pension Fund Investments and Innovation: Including All Industries

| Dep. var: | Ext. Margin | Int. Margin | | | | Ext. Margin2 | R&D Workers |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| | | | | FE Poisson | Poisson | | |
| | OLS | OLS | IHS | QML | QML | OLS | OLS |
| $PFI_{it}$ | 0.059*** | 0.546** | 0.072*** | 0.316 | 0.750** | 0.011*** | 0.053*** |
| | (0.007) | (0.243) | (0.016) | (0.463) | (0.311) | (0.003) | (0.005) |
| Mean Y | 0.003 | 0.018 | 0.003 | 2.786 | 0.018 | 0.000 | 0.003 |
| N | 1,512,767 | 1,512,767 | 1,512,767 | 9,544 | 1,512,767 | 1,512,767 | 1,512,767 |
| N PF | 5,533 | 5,533 | 5,533 | 935 | 5,533 | 5,533 | 5,533 |
| # Firms | 302,261 | 302,261 | 302,261 | 747 | 302,261 | 302,261 | 302,261 |
| # Firms PF | 1,489 | 1,489 | 1,489 | 172 | 1,489 | 1,489 | 1,489 |
| Adj. $R^2$ | 0.107 | 0.071 | 0.105 | | | 0.013 | 0.131 |
| $\chi^2$ | | | | 324.4 | 7,302.1 | | |

*Notes:* The sample includes firms from all industries, while the sample used for the main estimations only includes firms in the manufacturing sector. The dummy variable $PFI_{it}$ takes value one if at least one domestic pension fund is among the shareholders of firm $i$ in period $t$. Dependent variables and control variables as specified in the notes to Table III.2. Standard errors clustered at the firm level are in parentheses. Significance levels: ***1%, **5%, *10%.

In the next step, we investigate whether our results are dependent on the definition of the variable that measures pension fund investment in a firm. Specifically, we redefine the variable $Pension_{it}$ in equation (III.2) as the aggregate percentage of equity held by all domestic pension funds, instead of the dummy used previously. Additionally, we include its square to account for a possible non-linear relationship between pension fund investments and firm innovation. The refined results are reported in Table III.10, which confirm that pension funds appear to increase firm-level innovation at both the extensive and intensive margins, as well as in terms of green technologies, although the coefficient for the latter is not precisely estimated. Furthermore, there is suggestive evidence for a positive and concave relationship between firm innovation and the intensity variable.

**Table III.10.** Pension Fund Investments and Innovation: Intensity Results

| Dep. var: | Ext. Margin | Int. Margin | | | | Ext. Margin2 | R&D Workers |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| | OLS | OLS | IHS | FE Poisson QML | Poisson QML | OLS | OLS |
| $Intensity_{it}$ | 0.020*** | 0.284* | 0.028*** | 0.162** | 0.290** | 0.003 | 0.014*** |
| | (0.004) | (0.157) | (0.010) | (0.076) | (0.148) | (0.002) | (0.002) |
| $Intensity^2_{it}$ | -0.000*** | -0.007* | -0.001*** | -0.005 | -0.019 | -0.000 | -0.000*** |
| | (0.000) | (0.004) | (0.000) | (0.004) | (0.013) | (0.000) | (0.000) |
| Mean Y | 0.013 | 0.084 | 0.013 | 2.670 | 0.084 | 0.002 | 0.011 |
| N | 179,301 | 179,301 | 179,301 | 5,601 | 179,301 | 179,301 | 179,301 |
| N PF | 1,967 | 1,967 | 1,967 | 496 | 1,967 | 1,967 | 1,967 |
| # Firms | 30,802 | 30,802 | 30,802 | 425 | 30,802 | 30,802 | 30,802 |
| # Firms PF | 509 | 509 | 509 | 91 | 509 | 509 | 509 |
| Adj. $R^2$ | 0.133 | 0.108 | 0.130 | | | 0.014 | 0.156 |
| $\chi^2$ | | | | 326.3 | 6,613.0 | | |

*Notes:* The variable $Intensity_{it}$ is the aggregate share of firm $i$ held by domestic pension funds at time $t$. The dummy variable $PFI_{it}$ takes value one if at least one domestic pension fund is among the shareholders of firm $i$ in period $t$. Dependent variables and control variables as specified in the notes to Table III.2. Standard errors clustered at the firm level are in parentheses. Significance levels: ***1%, **5%, *10%.

Next, we investigate the impact of the duration of pension funds' investments on firms' innovation outcomes. We define a duration variable as the number of consecutive years that at least one pension fund has invested in the firm, and examine its relationship with innovation outcomes. We observe a positive relationship between investment duration and innovation activities. In line with the mechanism highlighted in the introduction, the duration variable matters for innovation. This finding is therefore consistent with the idea that pension funds foster investment in innovation not only by disciplining managers (as highlighted in section III.4.2.1) but also by providing long-term capital security. Results in Table III.7 also suggest evidence of a concave relationship, as the positive association between duration and both extensive and intensive margins decreases for each additional year of investment.[13]

[13] We obtain very similar results, available upon request, when defining the duration variable based on investments for which the percentage of shares outstanding held by pension funds is at least 5 percent.

**Table III.11.** Pension Fund Investments and Innovation: Duration Results

| Dep. var: | Ext. Margin | Int. Margin | | | | Ext. Margin2 | R&D Workers |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| | OLS | OLS | IHS | FE Poisson QML | Poisson QML | OLS | OLS |
| $Duration_{it}$ | 0.028*** | 0.277* | 0.040*** | 0.114 | 0.197** | 0.005** | 0.019*** |
| | (0.006) | (0.151) | (0.013) | (0.129) | (0.096) | (0.002) | (0.004) |
| $Duration_{it}^2$ | -0.002*** | -0.009 | -0.002* | -0.002 | -0.009 | -0.000* | -0.001*** |
| | (0.001) | (0.022) | (0.001) | (0.011) | (0.010) | (0.000) | (0.000) |
| Mean Y | 0.013 | 0.084 | 0.013 | 2.670 | 0.084 | 0.002 | 0.011 |
| N | 179,301 | 179,301 | 179,301 | 5,601 | 179,301 | 179,301 | 179,301 |
| N PF | 1,967 | 1,967 | 1,967 | 496 | 1,967 | 1,967 | 1,967 |
| # Firms | 30,802 | 30,802 | 30,802 | 425 | 30,802 | 30,802 | 30,802 |
| # Firms PF | 509 | 509 | 509 | 91 | 509 | 509 | 509 |
| Adj. $R^2$ | 0.130 | 0.107 | 0.128 | | | 0.013 | 0.151 |
| $\chi^2$ | | | | 335.4 | 5,845.6 | | |

*Notes:* The variable $Duration_{it}$ is the number of years of consecutive investment by at least one domestic pension fund in firm $i$. The dummy variable $PFI_{it}$ takes value one if at least one domestic pension fund is among the shareholders of firm $i$ in period $t$. Dependent variables and control variables as specified in the notes to Table III.2. Standard errors clustered at the firm level are in parentheses. Significance levels: ***1%, **5%, *10%.

As an additional check, we investigate the relationship between pension fund investment and firm innovation when the pension fund investment is considered significant. Specifically, in Table III.12, we define a dummy variable as equal to 1 if the aggregate holding by all Danish pension funds in a given firm is at least 5% of its total equity. This allows us to eliminate cases where the investment by pension funds represents a negligible source of capital for the firm. Additionally, a non-negligible equity stake is considered to provide a stronger signal of commitment. Notably, the positive and statistically significant coefficients of the pension fund investment variable persist even when we limit the pension fund investment dummy to take a value of 1 only when the aggregate ownership of domestic pension funds in the company is at least 5%.

**Table III.12.** Pension Fund Investments and Innovation: Alternate Definition of Investment Dummy Results

| Dep. var: | Ext. Margin | Int. Margin | | | | Ext. Margin2 | R&D Workers |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| | OLS | OLS | IHS | FE Poisson QML | Poisson QML | OLS | OLS |
| $PFI_{it}$ | 0.067*** | 1.516* | 0.124** | 0.873** | - | 0.012** | 0.042*** |
| | (0.017) | (0.841) | (0.050) | (0.388) | - | (0.006) | (0.009) |
| Mean Y | 0.013 | 0.084 | 0.013 | 2.670 | - | 0.002 | 0.011 |
| N | 179,301 | 179,301 | 179,301 | 5,601 | - | 179,301 | 179,301 |
| N PF | 1,371 | 1,371 | 1,371 | 358 | - | 1,371 | 1,371 |
| # Firms | 30,802 | 30,802 | 30,802 | 425 | - | 30,802 | 30,802 |
| # Firms PF | 354 | 354 | 354 | 75 | - | 354 | 354 |
| Adj. $R^2$ | 0.129 | 0.107 | 0.128 | | | 0.013 | 0.149 |
| $\chi^2$ | | | | 264.9 | - | | |

*Notes:* The dummy variable $PFI_{it}$ equals 1 if the aggregate holding of all pension funds in firm $i$ in year $t$ is at least equal to 5%. In Column 5, the maximum likelihood estimation does not converge. The dummy variable $PFI_{it}$ takes value one if at least one domestic pension fund is among the shareholders of firm $i$ in period $t$. Dependent variables and control variables as specified in the notes to Table III.2. Standard errors clustered at the firm level are in parentheses. Significance levels: ***1%, **5%, *10%.

We then explore whether the inclusion of a variable measuring investments by other parties from the domesticfinancial sector affects the coefficient estimated on our pension fund investment variable. Since pension funds may invest in a firm alongside, or independently but at the same time as, other investors, such as private equity or insurance companies, the positive estimated coefficients reported in the main results may not be solely attributable to pension fund investments. To address this concern, we re-estimate our baseline models from Table III.2 adding a dummy variable that captures investments by any other party from the domestic financial sector.[14] Results reported in Table III.13 suggest that the estimated coefficients reported in the baseline analysis are not confounded by the presence of other investors. Specifically, Table III.13 shows that when we include the other investor dummy, our main variable of interest on pension fund investments remains positive and significant, and the magnitudes involved are similar to those provided in the baseline analysis.

[14]We identify financial sector firms based on their 2-digit industry code.

**Table III.13.** Pension Fund Investments and Innovation: Adding Other Investor Dummy

| Dep. var: | Ext. Margin | Int. Margin | | | | Ext. Margin2 | R&D Workers |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| | OLS | OLS | IHS | FE Poisson QML | Poisson QML | OLS | OLS |
| $PFI_{it}$ | 0.067*** | 1.046* | 0.097*** | 0.909** | 0.785** | 0.012** | 0.050*** |
| | (0.013) | (0.595) | (0.035) | (0.369) | (0.326) | (0.005) | (0.008) |
| $Other\_Investor_{it}$ | 0.005*** | -0.031 | 0.003 | 0.003 | -0.125 | 0.001 | 0.004*** |
| | (0.001) | (0.043) | (0.003) | (0.164) | (0.302) | (0.000) | (0.001) |
| Mean Y | 0.013 | 0.084 | 0.013 | 2.670 | 0.084 | 0.002 | 0.011 |
| N | 179,301 | 179,301 | 179,301 | 5,601 | 179,301 | 179,301 | 179,301 |
| N PF | 1,967 | 1,967 | 1,967 | 496 | 1,967 | 1,967 | 1,967 |
| # Firms | 30,802 | 30,802 | 30,802 | 425 | 30,802 | 30,802 | 30,802 |
| # Firms PF | 509 | 509 | 509 | 91 | 509 | 509 | 509 |
| Adj. $R^2$ | 0.131 | 0.107 | 0.128 | | | 0.013 | 0.153 |
| $\chi^2$ | | | | 283.8 | 5,696.3 | | |

*Notes:* The dummy variable $Other\_Investor_{it}$ takes value 1 if at least one firm from the domestic financial sector which is not a pension fund is among the shareholders of firm $i$ in period $t$. The dummy variable $PFI_{it}$ takes value one if at least one domestic pension fund is among the shareholders of firm $i$ in period $t$. Dependent variables and control variables as specified in the notes to Table III.2. Standard errors clustered at the firm level are in parentheses. Significance levels: ***1%, **5%, *10%.

We finally conclude this section of robustness checks as follows. First, we define the extensive margin as a dummy equal to 1 if the firm has at least one patent application in year $t$ that receives at least one future citation, therefore also adjusting the extensive margin for the quality of the patent. Column 1 of Table III.14 shows that the coefficient estimated on our pension investment variable remains positive and significant even when we use this alternate measure of extensive margin. Second, we re-run all our main regressions with a pension fund investment dummy lagged by one period. Columns 2–8 of Table III.14 confirm the baseline analysis in that they show that pension funds' investments in year $t-1$ are positively correlated with innovation outcomes at the extensive and intensive margins in year $t$. Third, our main results are confirmed if we use alternate thresholds for the matching procedure used to construct the matched sample (see Appendix Tables C.1 and C.2).

**Table III.14.** Pension Fund Investments and Innovation: Alternate Definition of Extensive Margin and Lagged Specification

| Dep. var: | Ext. Margin | | Int. Margin | | | | Ext. Margin2 | R&D Workers |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | | | | | FE Poisson | Poisson | | |
| | OLS | OLS | OLS | IHS | QML | QML | OLS | OLS |
| $PFI_{it}$ | 0.035*** | | | | | | | |
| | (0.010) | | | | | | | |
| $PFI_{it-1}$ | | 0.066*** | 0.805* | 0.106*** | 0.588** | 0.629** | 0.012** | 0.050*** |
| | | (0.014) | (0.431) | (0.039) | (0.235) | (0.307) | (0.005) | (0.008) |
| Mean Y | 0.006 | 0.014 | 0.088 | 0.014 | 2.739 | 0.088 | 0.002 | 0.012 |
| N | 179,301 | 148,499 | 148,499 | 148,499 | 4,742 | 148,499 | 148,499 | 148,499 |
| N PF | 1,967 | 1,713 | 1,713 | 1,713 | 418 | 1,713 | 1,713 | 1,713 |
| # Firms | 30,802 | 23,863 | 23,863 | 23,863 | 366 | 23,863 | 23,863 | 23,863 |
| # Firms PF | 509 | 445 | 445 | 445 | 77 | 445 | 445 | 445 |
| Adj. $R^2$ | 0.101 | 0.135 | 0.071 | 0.126 | | | 0.014 | 0.169 |
| $\chi^2$ | | | | | 331.7 | 4,831.0 | | |

*Notes:*The dummy variable $PFI_{it}$ takes value one if at least one domestic pension fund is among the shareholders of firm $i$ in period $t$.The dummy variable $PFI_{it-1}$ takes value one if at least one domestic pension fund is among the shareholders of firm $i$ in period $t-1$. In column 1, the dependent variable is a dummy equal to 1 if the firm has at least one patent application in year $t$ that receives at least one future citation. In column 2, the dependent variable is a dummy equal to 1, if the firm has at least one patent application in year $t$. In columns 3, 5 and 6 the dependent variable is the number of patent applications (weighted by citations) in year $t$. In column 4 the dependent variable is the inverse hyperbolic sine (IHS) transformation of the number of patent applications (weighted by citations) in year $t$. In column 7, the dependent variable is a dummy equal to 1, if the firm has at least one green patent application in year $t$. In column 8, the dependent variable is the share of R&D workers. In all columns, we include the following control variables: firms' productivity, capital intensity, share of female workers and share of tertiary-educated workers, as well as year fixed effects. In addition in columns 1, 2, 3, 4, 6, 7 and 8, we also include the firms' number of patent applications (weighted by citations) in the pre-sample period (1978–2002) normalised by the total number of patent applications (weighted by citations) in the pre-sample period and a dummy for firms that do not have a patent application (weighted by citations) in the pre-sample period, following the approach developed by Blundell et al. (1999). Standard errors clustered at the firm level are in parentheses. The row "Mean Y" gives the mean of the dependent variable. The rows "N" and "N PF" show the number of observations and the number of observations with pension fund investment, respectively. The rows "# Firms" and "# Firms PF" detail the number of firms and the number of firms receiving pension fund investment in the sample, respectively. Significance levels: ***1%, **5%, *10%.

# III.5 Conclusion

Innovation is widely recognised as a key driver of economic growth, making the promotion and financing of innovation a topic of great interest for research, policy, and industry. The role of institutional investors in financing innovation has been explored in previous literature, with mixed conclusions (Aghion et al., 2013; Samila et al., 2021; Schain & Stiebale, 2021).

This study investigates specifically the relationship between corporate innovation in Denmark and domestic pension funds as institutional investors. Pension funds are well-suited to the financing of innovation due to their large assets under management and long investment horizon.

Using a novel panel dataset on ownership of all Danish limited liability companies, this study departs from previous research in two important ways. Firstly, it focuses on pension funds instead of a broader institutional investor category. Secondly, it examines public and private manufacturing firms rather than just publicly listed firms. The analysis explores the potential endogeneity of ownership by examining differences in innovation between firms that receive pension fund investment and those that do not before the investment occurs, finding no evidence that pension funds select firms based on prior patenting activity.

This paper finds a positive and statistically significant relationship between pension fund investment and innovation both generally and specifically in the area of climate mitigation technologies. Our findings are robust across various estimation models and exercises. Competition weakens this relationship, which can be explained through the "lazy manager" hypothesis (Aghion et al., 2013). Institutional investors can increase corporate innovation by inducing managers to engage in innovative activities, but this effect is weaker in highly competitive sectors, where managers need to be more proactive to begin with even in absence of pension fund investments. The results indeed support a weaker relationship between pension fund investments and corporate innovation in industries with higher competition, suggesting the relevance of the "lazy manager" hypothesis. The study also finds a positive relationship between the duration of pension fund investment and innovation, suggesting that pension funds provide the patient capital needed to invest in risky, long-term projects.

This study highlights the potential contribution of pension funds to economic growth through their longer investment horizon and patient capital. As funded pension systems become more prominent, understanding how pension funds can contribute to economic growth is becoming increasingly important. Future research could therefore further investigate the channels from pension fund investment to corporate innovation.

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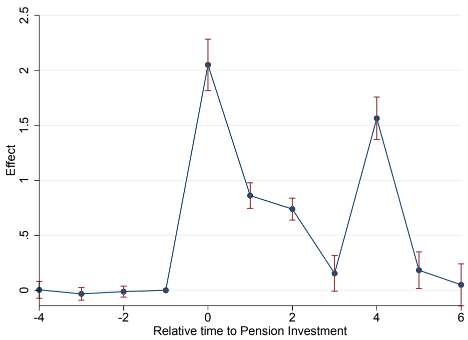
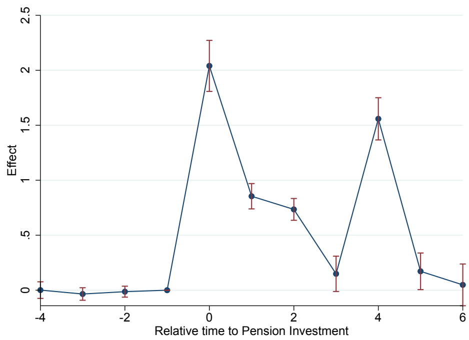
# Appendix C: Appendix to Chapter III

## Additional Figures

**Figure C.1.** Pension Fund Investments and Innovation Outcomes, Alternative Intensive Margin



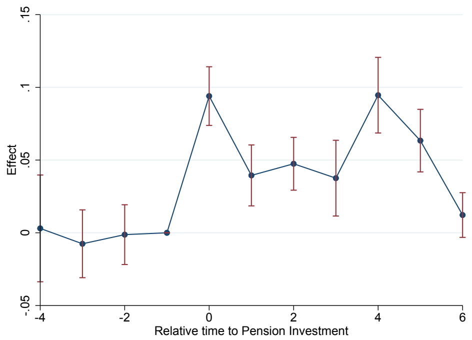

**(a)** Intensive Margin of Innovation (Whole Sample)



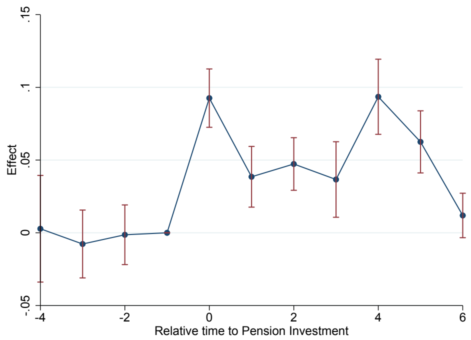

**(b)** Intensive Margin of Innovation (Matched Sample)

**Note:** The figure shows event time coefficients and 95% confidence intervals estimated using the algorithm developed in Sun and Abraham (2021). The dependent variable is the number of patent applications weighted by citations (intensive margin) in year $t$. The sample excludes cases of pension funds investing in a firm only for one year. Control variables include the firms' productivity, capital intensity, share of female workers and share of tertiary-educated workers.

**Figure C.2.** Pension Fund Investments and Innovation Outcomes, Excl. Short-Term Investments




**(a)** Intensive Margin of Innovation (Whole Sample)




**(b)** Intensive Margin of Innovation (Matched Sample)

**Note:** The figure shows event time coefficients and 95% confidence intervals estimated using the algorithm developed in Sun and Abraham (2021). The dependent variable is the firm's (log) number of patent applications weighted by citations (intensive margin) in year *t*. The sample excludes cases of pension funds investing in a firm only for one year. Control variables include the firms' productivity, capital intensity, share of female workers and share tertiary-educated workers.

# Additional Tables

**Table C.1.** Pension Fund Investments and Innovation: Main results (Matched Sample with 50th Percentile as Threshold)

| Dep. var: | Ext. Margin | Int. Margin | | | | Ext. Margin2 | R&D Workers |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| | OLS | OLS | IHS | FE Poisson QML | Poisson QML | OLS | OLS |
| $PFI_{it}$ | 0.062*** | 0.897 | 0.082** | 0.998*** | 0.700* | 0.011** | 0.049*** |
| | (0.013) | (0.598) | (0.034) | (0.350) | (0.390) | (0.005) | (0.008) |
| Mean Y | 0.019 | 0.153 | 0.021 | 3.720 | 0.153 | 0.003 | 0.015 |
| N | 80,893 | 80,893 | 80,893 | 3,323 | 80,893 | 80,893 | 80,893 |
| N PF | 1,967 | 1,967 | 1,967 | 496 | 1,967 | 1,967 | 1,967 |
| # Firms | 21,028 | 21,028 | 21,028 | 267 | 21,028 | 21,028 | 21,028 |
| # Firms PF | 509 | 509 | 509 | 91 | 509 | 509 | 509 |
| Adj. $R^2$ | 0.162 | 0.117 | 0.154 | | | 0.018 | 0.191 |
| $\chi^2$ | | | | 700.6 | 3,714.3 | | |

*Notes:* The sample only includes "matched" firms in the control group. Any firm with a propensity score below the 50th percentile of its respective sector-year cell in any year is dropped. In column 1, the dependent variable is a dummy equal to 1 if the firm has at least one patent application in year $t$. In columns 2, 4 and 5 the dependent variable is the number of patent applications (weighted by citations) in year $t$. In column 3 the dependent variable is the inverse hyperbolic sine (IHS) transformation of the number of patent applications (weighted by citations) in year $t$. In column 6, the dependent variable is a dummy equal to 1, if the firm has at least one green patent application in year $t$. In column 7, the dependent variable is the share of R&D workers. The dummy variable $PFI_{it}$ takes value one if at least one domestic pension fund is among the shareholders of firm $i$ in period $t$. In all columns, we include the following control variables: firms' productivity, capital intensity, share of female workers and share tertiary-educated workers, as well as year fixed effects. In addition in columns 1, 2, 3, 5, 6 and 7, we also include the firms' number of patent applications (weighted by citations) in the pre-sample period (1978–2002) normalised by the total number of patent applications (weighted by citations) in the pre-sample period and a dummy for firms that do not have a patent application (weighted by citations) in the pre-sample period, following the approach developed by Blundell et al. (1999). Standard errors clustered at the firm level are in parentheses. The row "Mean Y" gives the mean of the dependent variable. The rows "N" and "N PF" show the number of observations and the number of observations with pension fund investment, respectively. The rows "# Firms" and "# Firms PF" detail the number of firms and the number of firms receiving pension fund investment in the sample, respectively. Significance levels: ***1%, **5%, *10%.

**Table C.2.** Pension Fund Investments and Innovation: Main results (Matched Sample with 75th Percentile as Threshold)

| Dep. var: | Ext. Margin | Int. Margin | | | | Ext. Margin2 | R&D Workers |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| | | | | FE Poisson | Poisson | | |
| | OLS | OLS | IHS | QML | QML | OLS | OLS |
| $PFI_{it}$ | 0.059*** | 0.900 | 0.082** | 0.886*** | 0.880* | 0.012*** | 0.045*** |
| | (0.012) | (0.617) | (0.032) | (0.329) | (0.491) | (0.005) | (0.008) |
| Mean Y | 0.020 | 0.168 | 0.023 | 4.077 | 0.168 | 0.003 | 0.016 |
| N | 57,402 | 57,402 | 57,402 | 2,352 | 57,402 | 57,402 | 57,402 |
| N PF | 1,967 | 1,967 | 1,967 | 496 | 1,967 | 1,967 | 1,967 |
| # Firms | 18,521 | 18,521 | 18,521 | 202 | 18,521 | 18,521 | 18,521 |
| # Firms PF | 509 | 509 | 509 | 91 | 509 | 509 | 509 |
| Adj. $R^2$ | 0.175 | 0.124 | 0.167 | | | 0.016 | 0.199 |
| $\chi^2$ | | | | 2,464.5 | 3,908.1 | | |

*Notes:* The sample only includes "matched" firms in the control group. any firm with a propensity score below the 75th percentile of its respective sector-year is dropped. In column 1, the dependent variable is a dummy equal to 1 if the firm has at least one patent application in year $t$. In columns 2, 4 and 5 the dependent variable is the number of patent applications (weighted by citations) in year $t$. In column 3 the dependent variable is the inverse hyperbolic sine (IHS) transformation of the number of patent applications (weighted by citations) in year $t$. In column 6, the dependent variable is a dummy equal to 1, if the firm has at least one green patent application in year $t$. In column 7, the dependent variable is the share of R&D workers. The dummy variable $PFI_{it}$ takes value one if at least one domestic pension fund is among the shareholders of firm $i$ in period $t$. In all columns, we include the following control variables: firms' productivity, capital intensity, share of female workers and share tertiary-educated workers, as well as year fixed effects. In addition in columns 1, 2, 3, 5, 6 and 7, we also include the firms' number of patent applications (weighted by citations) in the pre-sample period (1978–2002) normalised by the total number of patent applications (weighted by citations) in the pre-sample period and a dummy for firms that do not have a patent application (weighted by citations) in the pre-sample period, following the approach developed by Blundell et al. (1999). Standard errors clustered at the firm level are in parentheses. The row "Mean Y" gives the mean of the dependent variable. The rows "N" and "N PF" show the number of observations and the number of observations with pension fund investment, respectively. The rows "# Firms" and "# Firms PF" detail the number of firms and the number of firms receiving pension fund investment in the sample, respectively. Significance levels: ***1%, **5%, *10%.

**Table C.3.** Pension Fund Investments and Innovation: Competition Results (Herfindahl Index), Matched Sample

| Dep. var: | Ext. Margin | Int. Margin | | | | Ext. Margin2 | R&D Workers |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| | OLS | OLS | IHS | FE Poisson QML | Poisson QML | OLS | OLS |
| $PFI_{it}$ | 0.073*** | 1.169* | 0.108*** | 0.902** | 0.790** | 0.011** | 0.057*** |
| | (0.014) | (0.671) | (0.039) | (0.355) | (0.367) | (0.005) | (0.009) |
| $PFI_{it} \times High\ Competition_i$ | -0.059*** | -1.231* | -0.107*** | -1.148 | -1.953*** | -0.001 | -0.061*** |
| | (0.019) | (0.669) | (0.041) | (1.197) | (0.705) | (0.010) | (0.010) |
| P-value, Joint Significance | 0.272 | 0.091 | 0.976 | 0.833 | 0.085 | 0.286 | 0.461 |
| Mean Y | 0.016 | 0.116 | 0.017 | 3.032 | 0.116 | 0.003 | 0.014 |
| N | 117,209 | 117,209 | 117,209 | 4,451 | 117,209 | 117,209 | 117,209 |
| N PF | 1,967 | 1,967 | 1,967 | 496 | 1,967 | 1,967 | 1,967 |
| # Firms | 24,718 | 24,718 | 24,718 | 346 | 24,718 | 24,718 | 24,718 |
| # Firms PF | 509 | 509 | 509 | 91 | 509 | 509 | 509 |
| Adj. $R^2$ | 0.144 | 0.112 | 0.136 | | | 0.015 | 0.166 |
| $\chi^2$ | | | | 420.8 | 4,915.4 | | |

*Notes:* The variable $High\ Competition_i$ is a dummy equal to 1 if the firm operates in a sector in which the inverse of the Herfindahl index based on firms' sales is above the 75th percentile of the sector distribution. The row "P-value, Joint Significance" shows the p-value of a joint significance test with null hypothesis $H_0 : PFI_{it} + PFI_{it} \times High\ Competition_i = 0$. In column 1, the dependent variable is a dummy equal to 1, if the firm has at least one patent application in year $t$. In columns 2, 4 and 5 the dependent variable is the number of patent applications (weighted by citations) in year $t$. In column 3 the dependent variable is the inverse hyperbolic sine (IHS) transformation of the number of patent applications (weighted by citations) in year $t$. In column 6, the dependent variable is a dummy equal to 1, if the firm has at least one green patent application in year $t$. In column 7, the dependent variable is the share of R&D workers. The dummy variable $PFI_{it}$ takes value one if at least one domestic pension fund is among the shareholders of firm $i$ in period $t$. In all columns, we include the following control variables: firms' productivity, capital intensity, share of female workers and share tertiary-educated workers, as well as year fixed effects. In addition in columns 1, 2, 3, 5, 6 and 7, we also include the firms' number of patent applications (weighted by citations) in the pre-sample period (1978–2002) normalised by the total number of patent applications (weighted by citations) in the pre-sample period and a dummy for firms that do not have a patent application (weighted by citations) in the pre-sample period, following the approach developed by Blundell et al. (1999). Standard errors clustered at the firm level are in parentheses. The row "Mean Y" gives the mean of the dependent variable. The rows "N" and "N PF" show the number of observations and the number of observations with pension fund investment, respectively. The rows "# Firms" and "# Firms PF" detail the number of firms and the number of firms receiving pension fund investment in the sample, respectively. Significance levels: ***1%, **5%, *10%.

**Table C.4.** Pension Fund Investments and Innovation: Competition Results (Lerner Index), Matched Sample

| Dep. var: | Ext. Margin | Int. Margin | | | | Ext. Margin2 | R&D Workers |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| | OLS | OLS | IHS | FE Poisson QML | Poisson QML | OLS | OLS |
| $PFI_{it}$ | 0.072*** | 1.406* | 0.113** | 0.945*** | 0.921** | 0.013** | 0.062*** |
| | (0.015) | (0.782) | (0.045) | (0.360) | (0.362) | (0.006) | (0.009) |
| $PFI_{it} \times High\ Competition_i$ | -0.027 | -1.538* | -0.074 | -0.747 | -1.268** | -0.007 | -0.050*** |
| | (0.028) | (0.813) | (0.064) | (0.639) | (0.508) | (0.008) | (0.015) |
| P-value, Joint Significance | 0.052 | 0.588 | 0.352 | 0.569 | 0.509 | 0.330 | 0.278 |
| Mean Y | 0.016 | 0.116 | 0.017 | 3.032 | 0.116 | 0.003 | 0.014 |
| N | 117,209 | 117,209 | 117,209 | 4,451 | 117,209 | 117,209 | 117,209 |
| N PF | 1,967 | 1,967 | 1,967 | 496 | 1,967 | 1,967 | 1,967 |
| # Firms | 24,718 | 24,718 | 24,718 | 346 | 24,718 | 24,718 | 24,718 |
| # Firms PF | 509 | 509 | 509 | 91 | 509 | 509 | 509 |
| Adj. $R^2$ | 0.144 | 0.113 | 0.136 | | | 0.015 | 0.167 |
| $\chi^2$ | | | | 443.8 | 5,056.9 | | |

*Notes:* The variable $High\ Competition_i$ is a dummy equal to 1 if the firm operates in a sector in which the inverse of the Lerner index based on gross margins is above the 75th percentile of the sector distribution. The row "P-value, Joint Significance" shows the p-value of a joint significance test with null hypothesis $H_0 : PFI_{it} + PFI_{it} \times High\ Competition_i = 0$. In column 1, the dependent variable is a dummy equal to 1, if the firm has at least one patent application in year $t$. In columns 2, 4 and 5 the dependent variable is the number of patent applications (weighted by citations) in year $t$. In column 3 the dependent variable is the inverse hyperbolic sine (IHS) transformation of the number of patent applications (weighted by citations) in year $t$. In column 6, the dependent variable is a dummy equal to 1, if the firm has at least one green patent application in year $t$. In column 7, the dependent variable is the share of R&D workers. The dummy variable $PFI_{it}$ takes value one if at least one domestic pension fund is among the shareholders of firm $i$ in period $t$. In all columns, we include the following control variables: firms' productivity, capital intensity, share of female workers and share tertiary-educated workers, as well as year fixed effects. In addition in columns 1, 2, 3, 5, 6 and 7, we also include the firms' number of patent applications (weighted by citations) in the pre-sample period (1978–2002) normalised by the total number of patent applications (weighted by citations) in the pre-sample period and a dummy for firms that do not have a patent application (weighted by citations) in the pre-sample period, following the approach developed by Blundell et al. (1999). Standard errors clustered at the firm level are in parentheses. The row "Mean Y" gives the mean of the dependent variable. The rows "N" and "N PF" show the number of observations and the number of observations with pension fund investment, respectively. The rows "# Firms" and "# Firms PF" detail the number of firms and the number of firms receiving pension fund investment in the sample, respectively. Significance levels: ***1%, **5%, *10%.

# Data Appendix

# Data Appendix

This Data Appendix presents additional information on the two novel datasets about the domestic investments of Danish pension funds used in this thesis.

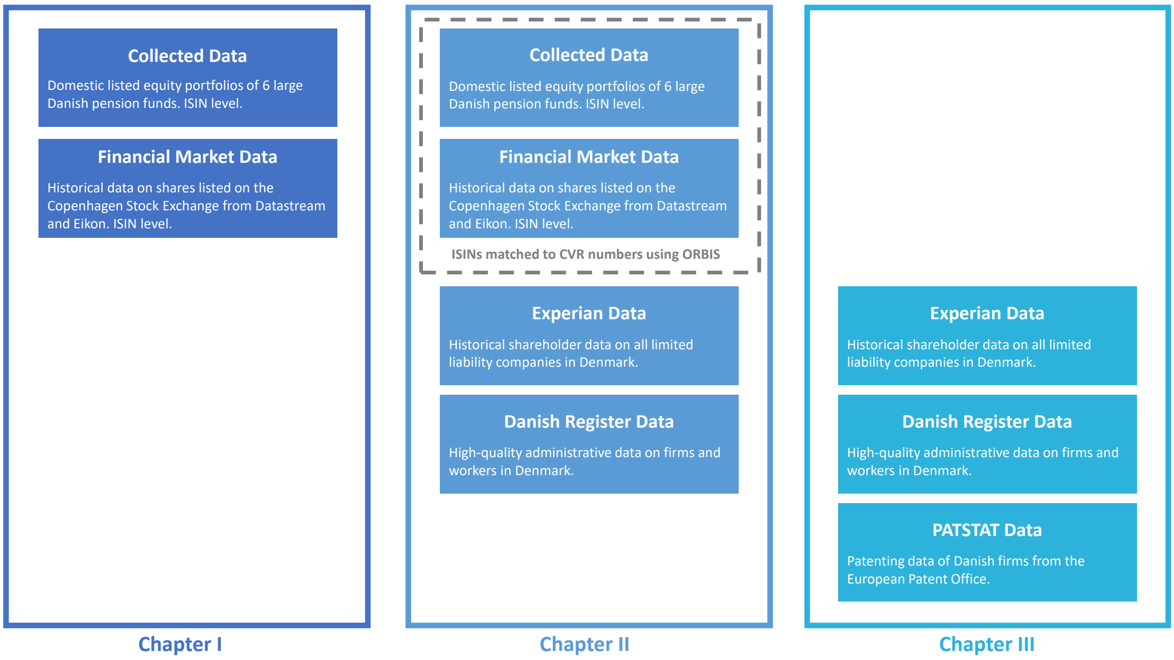
The datasets used in the different chapters of this thesis are summarised in Figure D.1. The two datasets on the left-hand side of the Figure are presented in detail in Section I.2 of Chapter I. The first chapter uses the Collected Data as the source for pension fund investment information, combined with Financial Market Data from the Refinitiv databases Eikon and Datastream. The Experian Data is the primary source of information for pension fund investment in Chapters II and III, while the Collected Data is also used in some parts of the analysis of Chapter II. The data construction process for the Experian Data is described in Section D.2. Chapters II and III also use high-quality Danish register data based on administrative information compiled by Statistics Denmark. Lastly, Chapter III additionally uses patenting data of Danish firms from the European Patent Office further described in Section III.2 of Chapter III.[15]

In order to use the Collected Data and Financial Market Data in conjunction with Danish register data, it is necessary to match the ISINs (International Securities Identification Numbers) contained in the two former datasets to the company identifiers (CVR numbers) in the register data. Section D.1 describes the matching procedure I have developed to connect the ISINs to the CVR numbers of the companies that emitted the financial instruments.

As specified in Section I.2 of Chapter I, the Collected Data only records pension fund investment in publicly listed companies. Section D.2 of this Data Appendix describes the extensive efforts undertaken to construct a second dataset identifying the equity stakes of domestic pension funds in all limited liability companies in Denmark, based on data from Experian.

[15]Note that Statistics Denmark anonymises the firm identifiers when matching external data to Danish register data. Therefore, all company identifiers, as well as the individual identifiers of workers, in the data used in Chapters II and III have been anonymised.

**Figure D.1.** Data Overview




# D.1 Merging the Collected Data to Danish Register Data

Section I.2 of Chapter I describes the data collection and verification process of a new dataset on the domestic holdings of six large Danish pension funds. I collected this data directly from six large Danish pension funds and hereafter refer to it as the "Collected Data".

The Collected Data can be used to identify pension fund investment in a stock and naturally the company that emitted that stock. However, to use this novel data in conjunction with high-quality register data on Danish firms and employees from Statistics Denmark, it is necessary to match each stock, identified by an ISIN, to the CVR number identifying the company that emitted the stock. CVR numbers uniquely identify a company in the Danish business register. Therefore, in order to use the Collected Data to analyse the effects of pension fund investment on firms, connecting ISIN and CVR number is a crucial task. This section describes two procedures that I have developed for this purpose. Both procedures rely on the database ORBIS maintained by Bureau van Dijk. ORBIS contains the ISIN of a company's main stock and the company's trade register number, equivalent to the CVR number for firms in Denmark.

In the first procedure, I match the financial instruments in the Collected Data to companies in ORBIS using the name of the issuing company as given by Refinitiv Eikon. I then manually review the matches. If ORBIS does not find any match, I modify the company name after manual inspection[16], or use the stock name to find the most appropriate ORBIS company. I verify each manual match using additional information such as the time period that the stock was active and the previous names of the company.

The second approach, intended to verify the matches resulting from the first approach, entails feeding the ISIN numbers instead of the company names into ORBIS. If no ORBIS record is found for the ISIN, I search for the company name as listed in Datastream.[17]

I carefully inspect cases where the matched CVR numbers from the first and second approaches differ and choose one CVR number (keeping a record of the alternative one for eventual future robustness checks).[18] I also carefully inspect observations where the matched company is not a stock-based corporation ("Aktieselskab" or "A/S" in Danish) according to ORBIS. This is for example the case if a company underwent a change in corporate form after delisting from the stock exchange.

## D.2 Constructing a Dataset of Danish Pension Funds' Investments in Public and Private Domestic Firms

An obvious limitation of the Collected Data is that it only contains information on the investments of Danish pension funds in publicly listed Danish firms. Investments in unlisted firms, however, are becoming more popular among pension funds (OECD, 2023). Furthermore, the low number of listed firms in Denmark limits the representativeness of the sample. This section describes the construction of a second dataset that identifies

[16]For example removing the word "Oploest" in some cases.

[17]I use the name in Datastream instead of Eikon as another difference to the first approach. The two names are very similar in most cases.

[18]To guide this choice, I search for all CVR numbers obtained from either approach in the Danish Central Business Register (Virk, 2022), and compare information on the most recent sector and company start year.

the investments of Danish pension funds in listed and unlisted firms in Denmark. This dataset is based on business relationship data from the data provider Experian.

The Experian data covers all limited liability firms in Denmark and contains two modules on ownership: one about ownership stakes of individuals in Danish firms and another about ownership of corporations in other firms in Denmark. I only use the latter dataset to identify pension fund investment in Danish firms. Therefore, the stakes of individuals in corporations are not recorded in the final dataset. This section describes the construction of the final dataset mapping the investment of Danish pension funds in listed and unlisted firms in Denmark. The final dataset is used in Chapters II and III.

### D.2.1 Constructing the Panel Dataset

The raw ownership data is delivered by Experian each year, containing information on the most recent year as well as information on earlier years already present in previous deliveries. This leads to duplicate observations and is addressed below. Firms are identified by their Experian identification numbers. The first step is to construct a panel dataset containing one observation for each year of an active ownership relationship. Each observation should list an owning firm, an owned firm, a year and the fraction of the owned firm's equity held by the owner. It is important to note that the dataset only contains information on equity stakes and not on the distribution of voting rights. Therefore, I treat the equity stake as representative of the share of voting rights an owner holds.

One OWNER-OWNED observation in the raw dataset denotes a relationship between two firms: an owner firm and an owned firm. The stake variable describes the percentage of equity held by the owner and can be an integer or a bracket. In the case of brackets, I always choose the lower bracket except in two cases. If the bracket is (0%, 5%], I replace the stake with 2.5%. If the bracket is (50%, 67%], I replace the stake with 51%. Each observation also includes a start date and an end date. I take the following steps to assign a year to each observation in order to construct a panel dataset:

1. Drop observations if any of the following variables is missing: ID of the owning firm, ID of the owned firm, stake.

2. Exclude observations with missing start or end date if another observation is identical in all variables but the missing date.

3. If no start date is given, I assume that the relationship exists from 2003 until the reported end date. If no end date is given, I assume that the relationship currently exists.

4. If the reported end date is later than November $15^{\text{th}}$ of the given calendar year, I record the relationship as existing for that calendar year. If the reported end date is before November $15^{\text{th}}$, I record the relationship as having ended with the previous calendar year. The choice of November $15^{\text{th}}$ as the cut-off date follows the approach of Statistics Denmark.

5. I assign a year to each observation based on the reported start and end dates of the ownership relationship. To avoid the introduction of survival bias into the dataset, only the information from the first delivery containing that year is used. Remembering that the data is delivered yearly but that each delivery contains information for all prior years, several deliveries contain information for the same period. Later deliveries can contain modified information for earlier periods. However, these modifications to the previously delivered information are only made for active firms. Since the modified information is contingent on the firm still existing at the time that the updated data is compiled, including such modified information could introduce survival bias in the sample. I address this issue by only using data from the earliest delivery that contains data on a specific OWNER-OWNED-YEAR combination.[19] Such a case is illustrated by firm A in Table D.1 and the treatment is explained in the text below the table.

6. At this stage, a small number of OWNER-OWNED-YEAR duplicates remain. I proceed as follows to eliminate instruments:

   a) I keep the observation with the larger stake.

   b) If a pair of duplicates contains one exact stake and one stake given in brackets, keep the observation with the exact stake.

7. Having processed the data as described above, I use the Experian identifiers to connect each owner and owned firm in the dataset to its CVR number.

[19]While this decision deletes information that could be valuable, only approximately 3% of observations are dropped following this rule.

The result of these steps is a dataset in which one observation corresponds to an OWNER-OWNED-YEAR combination. Each observation describes a relationship between two firms in a given year.

*Timing example*

**Table D.1.** Timing Example

Original Data:

| Owner | Owned | Year | Delivery | Stake |
|---|---|---|---|---|
| B | A | 2010 | 2011 | 0.5 |
| B | A | 2011 | 2012 | 0.5 |
| B | A | 2012 | 2013 | 0.5 |
| B | A | 2013 | 2014 | 0.5 |
| B | A | 2014 | 2015 | 0.5 |
| C | A | 2012 | 2015 | 0.5 |
| C | A | 2013 | 2015 | 0.5 |
| C | A | 2014 | 2015 | 0.5 |
| C | A | 2015 | 2016 | 0.5 |
| C | A | 2016 | 2017 | 0.5 |

Final Panel Data:

| | | | | |
|---|---|---|---|---|
| B | A | 2010 | 2011 | 0.5 |
| B | A | 2011 | 2012 | 0.5 |
| B | A | 2012 | 2013 | 0.5 |
| B | A | 2013 | 2014 | 0.5 |
| B | A | 2014 | 2015 | 0.5 |
| C | A | 2014 | 2015 | 0.5 |
| C | A | 2015 | 2016 | 0.5 |
| C | A | 2016 | 2017 | 0.5 |

Table D.1 provides an example to illustrate the issue outlined in step 5 above. Starting with the 2015 data delivery, firm C appears as an owner of firm A dating back to the year 2012. The deliveries prior to 2015 show that firm B was the only owner of firm A before 2014. Therefore, the 2015 delivery includes retroactively updated information on the ownership of firm A. Including this updated information would introduce a form of survival bias because information only gets updated for still-existing firms. Therefore, the information that firm C owned firm A in 2012 and 2013 is only available because firm A was still active when the 2015 data delivery was computed. If firm A would have been inactive in 2015, the data would not have been updated. To avoid introducing such survival bias, I discard updated information for earlier years. Therefore, I use the 2013 delivery as the sole information for the year 2012 and the 2014 delivery for the year 2013. The 2015 delivery is only used for the year 2014, as can be seen from the lower panel of Table D.1.

Lastly, I keep information on earlier years than the year directly preceding the delivery year if no earlier delivery contained information on the owned firm. So if the 2015 delivery would have been the first data delivery to include data on the owners of firm A, I would use the information from the 2015 delivery for 2014 and prior years.

## D.2.2 Identifying Ultimate Owners

At this point, the panel data only contains direct ownership relationships. In the example shown in Table D.1, firms B and C directly own firm A, but it is unknown if other firms hold stakes in firm A *through* ownership of companies B and C. However, it is very common that an "owner" firm is itself owned by another firm to some extent. The object of interest for the analyses in this thesis is the *ultimate owner*, or the owner at the end of the ownership chain. Therefore, it is necessary to iterate through the ownership levels for each firm until all its ultimate owners are identified.

To illustrate the issue: let pension fund A own its subsidiary B to 100%, and let B own any firm C by 100%. To correctly identify that firm C receives pension fund investment, it is necessary to connect pension fund A (the firm at the "top" of the ownership chain) to firm C (the firm at the "bottom" of the ownership chain). Given the size of the dataset, iterating through all levels of ownership for all firms is a complex task. Furthermore, it is necessary to establish a number of rules for the iteration. These rules are described below.

*Majority Ownership*

The first issue that needs to be addressed is how to quantify the stake of the ultimate owner given multiple levels of ownership. Table D.2 illustrates the issue and how this situation is resolved in the final dataset. Simply multiplying the stakes in the below example would yield that firm E owns $0.7 \times 0.7 = 49\%$ of firm A. However, firm E is the controlling shareholder of firm C which in turn is the controlling shareholder of firm A.

The simple multiplication of the stakes would not accurately reflect this fact. To address this, I set a stake equal to 1 in calculations if the stake is above 50%. This is illustrated by Table D.2. In the final dataset, firm E owns 70% of firm A since it owns > 50% of firm C which in turn owns 70% of firm A.

An obvious drawback of manipulating stakes is that total ownership in a firm can surpass 100%. To partially address this, I keep the stake closest to the bottom of the chain if there is majority ownership throughout the chain.[20]

**Table D.2.** Majority Ownership Example

Original Data:

| Owner | Owned | Year | Stake |
|---|---|---|---|
| C | A | 2010 | 0.7 |
| E | C | 2010 | 0.7 |
| F | C | 2010 | 0.3 |

Final Data:

| Owner | Owned | Year | Stake | Chain |
|---|---|---|---|---|
| E | A | 2010 | 0.7 | C |
| F | A | 2010 | 0.3 | C |

*Intermediate Owners*

When iterating through the ownership levels, it is important to account for intermediary firms. In Table D.3, both B and C are almost entirely owned by other firms. This suggests that these firms are pure intermediaries and that therefore their owners, firms D, E and A, are the firms that should actually be analysed. Therefore, I define a threshold for the total share of the equity of a firm that is owned by other firms. If a firm is owned by more than this threshold by other firms in the dataset, I do not identify it as an owner in the dataset. I set this threshold at 80%. In the example of Table D.3, Firms B and C are both owned to more than 80% by other firms, and therefore do not figure as ultimate owners of firm A in the final dataset.

Table D.3 also illustrates a further calculation rule. I adjust the stake that an owner X holds in another firm for the share of the equity of X held by other owners. Going

[20] This issue does not affect a large part of the dataset. Total ownership of a firm exceeds 100% only for 3.09% of observations in the final dataset. Nevertheless, this decision rule is a trade-off between data accuracy and keeping track of majority ownership stakes.

back to Table D.3, I reduce the stake of company G in company A by the share of the equity of G owned by firm H. Therefore the stake of G in A is $0.2 \times (1 - 0.3) = 0.14$. Conceptually, this is the stake in A that G "controls". This adjustment of stakes is done after all levels of ownership have been iterated over.

**Table D.3.** Intermediate Owners Example

Original Data:

| Owner | Owned | Year | Stake |
|---|---|---|---|
| B | A | 2010 | 0.1 |
| C | A | 2010 | 0.7 |
| G | A | 2010 | 0.2 |
| D | B | 2010 | 0.9 |
| E | C | 2010 | 0.7 |
| F | C | 2010 | 0.3 |
| H | G | 2010 | 0.3 |

Final Data:

| Owner | Owned | Year | Stake | Chain |
|---|---|---|---|---|
| D | A | 2010 | 0.1 | B |
| E | A | 2010 | 0.7 | C |
| F | A | 2010 | 0.3 | C |
| G | A | 2010 | 0.14 | |
| H | A | 2010 | 0.06 | G |

*Circular Ownership*

Another issue is that in some cases firm A owns a stake in firm B and firm B owns a stake in A. Without addressing this, the iteration would enter a circle. To prevent this, I exclude an ownership relationship if the inverse relationship is observed at a lower level. A level of 1 means that the owner directly holds the according stake in the particular company. A level of 2 reflects that the owner holds equity of the firm through investing in one other firm, etc.

Table D.4 below illustrates this issue via an example. The object of interest in this scenario is the ultimate owners of firm A. Firm B directly owns 100% of firm A. Company D owns B through C, but B also owns D. In such a case, I stop the iteration for that branch at D, meaning that the owners of D through company B will not be in the set of owners of firm A in the final dataset. However, I continue the iteration from D up the branch containing E, since there is no circularity issue with E. The final dataset only contains the stake that F holds in A. D is not included as an owner in the final dataset since it is owned to more than 80% by other firms in the dataset and therefore is excluded under the previous rule.

**Table D.4.** Circularity Example

Original Data:

| Owner | Owned | Year | Stake |
|---|---|---|---|
| B | A | 2010 | 1 |
| C | B | 2010 | 1 |
| D | C | 2010 | 1 |
| E | D | 2010 | 0.5 |
| B | D | 2010 | 0.5 |
| F | E | 2010 | 1 |

Final Data:

| Owner | Owned | Year | Stake | Chain |
|---|---|---|---|---|
| F | A | 2010 | 0.5 | E; D; C; B |

*Duplicates*

In the example in Table D.5, the object of interest are the owners of firm A. Companies B, C and D each own 33% of A. Furthermore, E owns 100% of A directly. This is very likely an issue related to the raw data coming from different delivery years.

To address such situations, I establish the rule that if the algorithm yields multiple OWNER-OWNED-YEAR-STAKE combinations, I keep the observation with fewer intermediary owners (so to speak the “more direct” ownership relationship, or the ones with a lower level). It is important to note that this rule only excludes observations if the exact same stake is observed for two different owners after the iteration. Lastly, I drop an owner if all its owners are duplicate holdings from a “shorter” branch. In this example, since E is only owned by B, C and D, and the stakes of those three firms in A are all perfect duplicates, I drop firm E as an owner.

**Table D.5.** Duplicate Owners Example

First round of iteration:

| Owner | Owned | Year | Stake | Level |
|---|---|---|---|---|
| B | A | 2010 | 33 | 1 |
| C | A | 2010 | 33 | 1 |
| D | A | 2010 | 33 | 1 |
| E | A | 2010 | 100 | 1 |

Second round of iteration:

| Owner | Owned | Year | Stake | Level |
|---|---|---|---|---|
| B | E | 2010 | 33 | 2 |
| C | E | 2010 | 33 | 2 |
| D | E | 2010 | 33 | 2 |

Final Data:

| Owner | Owned | Year | Stake | Level | Chain |
|---|---|---|---|---|---|
| B | A | 2010 | 33 | 1 | |
| C | A | 2010 | 33 | 1 | |
| D | A | 2010 | 33 | 1 | |

*Pseudo-Algorithm*

I now briefly sketch the algorithm used to execute the iteration through the ownership levels. Let $i \in I$ be the universe of firms in the dataset. Let $J \subset I$ be the set of firms that are owned by at least one other firm and simultaneously own at least one other firm. Let $K \subset I$ be the set of firms that are owned by at least one other firm, but do not hold stakes in any other firms.

1. Drop observations with missing stakes, missing firm identifier or foreign owners.

2. Drop observations where the owner or owned firm is not headquartered in Denmark

3. For each remaining firm $i \in J$:

   3.1 Start with firm $i$ as the owned firm.

   3.2 Look for the direct owners of firm $i$. Let this set be called $i \in Z_1$.

   3.3 Look for the direct owners of each firm $i \in Z_1$. Let this set be called $Z_2$

3.4 Stop the iteration on a branch if circularity arises.

3.5 Multiply the stakes according to the established rules. Record the distance between firm $i$ and the owner. Direct owners of firm $i$ have distance 1.

3.6 Repeat steps 3.1 - 3.5 until $Z_2 = \emptyset$.

At this stage the ownership structure of all firms $i \in J$ is complete.

4. Merge the ownership structure of each firm $i \in J$ onto the set of firms $i \in K$ that it owns.

5. Apply the established calculation rules.

6. Adjust the stakes for the percentage of the owner firm held by other firms.

7. Only keep relationships where the ultimate owner is owned to at most 80% by other firms.

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