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QE in a quasi-preferred habitat: The case of the Danish pension sector and the ECB asset purchase programme

Søren Lejsgaard Autrup
sla@nationalbanken.dk

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Jakob Roager Jensen

DANMARKS NATIONALBANK*

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*The paper was written while Jakob Roager Jensen was employed at Danmarks Nationalbank.

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Abstract

The portfolio rebalancing of Danish pension companies following the introduction of the ECB's asset purchase programmes is studied using a new and unique data set of their financial transactions and holdings since 2015. Due to a long-standing fixed exchange rate regime, Danish pension companies own large amounts of bonds eligible for purchase in ECB's programmes. This allows us to study cross-border spillovers in a fixed exchange rate regime from central banks' asset purchases. We document that pension companies reduced their demand for bonds eligible for ECB's asset purchases and increased their demand for Danish bonds in the first months after the beginning of ECB asset purchases in March 2015. However, the changes in bond demand disappeared after the initial phase of the ECB purchase programmes. We also show that pension companies act differently depending on the type of obligations to their pension plan holders. Companies without strictly binding guarantees to pension plan holders sold German government bonds, but increased their holdings of other bonds eligible for ECB purchases. Companies with strict guarantees to the pension plan holders reduced their demand for bonds eligible for ECB purchases initially, but increased their holdings of these bonds while ECB purchases were still ongoing at a high pace. Overall, our findings show that Danish pension funds, especially those with guaranteed obligations, can be considered having a quasi-preferred habitat in euro.

Resume

Et nyt og unikt datasæt med de danske pensionselskabers transaktioner og beholdninger siden 2015 anvendes til at analysere, hvordan selskaberne justerede deres porteføljer som følge af introduktionen af ECB's obligationsopkøb. På grund af fastkursregimet ejer danske pensionselskaber mange euroobligationer, som er inkluderet i ECB's opkøbsprogram. Det giver os mulighed for at nærstudere afsmittning fra opkøbsprogrammer igennem et fastkursregime. Vi viser, at pensionselskaberne nedbragte deres efterspørgsel efter de inkluderet obligationer og øgede efterspørgslen efter danske obligationer i de første måneder efter marts 2015, hvor ECB's opkøb begyndte. Ændringerne i efterspørgslen ophørte efter den initiale fase af opkøbsprogrammet. Vi viser også, at forskellige typer af pensionselskaber reagerede forskelligt. Selskaber uden bindende garantier solgte tyske statsobligationer, men øgede beholdningen af de øvrige obligationer inkluderet i ECB's opkøbsprogram. Selskaber med bindende garantier nedbragte deres efterspørgsel efter inkluderet obligationer til at starte med, men øgede deres beholdning, imens ECB's opkøb stadig var i fuld gang. Overordnet set viser resultaterne, at de danske pensionselskaber – særligt selskaberne med bindende garantier – har investeringer i euro som en kvasi-hjemstavn.

Key words

Monetary policy; Monetary-policy transmission; Capital flows; Financial assets.

JEL classification

E42; E52; E58; G10; G15; G22.

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The authors alone are responsible for any remaining errors.

QE in a quasi-preferred habitat: The case of the Danish pension sector and the ECB asset purchase programme*

Søren Lejsgaard Autrup[†] and Jakob Roager Jensen
Danmarks Nationalbank

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Abstract

The portfolio rebalancing of Danish pension companies following the introduction of the ECB's asset purchase programmes is studied using a new and unique data set of their financial transactions and holdings since 2015. Due to a long-standing fixed exchange rate regime, Danish pension companies own large amounts of bonds eligible for purchase in ECB's programmes. This allows us to study cross-border spillovers in a fixed exchange rate regime from central banks' asset purchases. We document that pension companies reduced their demand for bonds eligible for ECB's asset purchases and increased their demand for Danish bonds in the first months after the beginning of ECB asset purchases in March 2015. However, the changes in bond demand disappeared after the initial phase of the ECB purchase programmes. We also show that pension companies act differently depending on the type of obligations to their pension plan holders. Companies without strictly binding guarantees to pension plan holders sold German government bonds, but increased their holdings of other bonds eligible for ECB purchases. Companies with strict guarantees to the pension plan holders reduced their demand for bonds eligible for ECB purchases initially, but increased their holdings of these bonds while ECB purchases were still ongoing at a high pace. Overall, our findings show that Danish pension funds, especially those with guaranteed obligations, can be considered having a quasi-preferred habitat in euro.

JEL classification: E52, E42, E58, G10, G15, G22.

Keywords: Monetary policy, quantitative easing, fixed exchange rate regimes, insurance and pension, investor heterogeneity.

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[†]Address: Danmarks Nationalbank, Havnegade 5, DK-1093 Copenhagen. Email: sla@nationalbanken.dk.

1 Introduction

In recent years, several large central banks around the world have started buying assets on a large scale as part of their monetary policy. A main reason for the shift towards asset purchase programmes is that central banks have been hesitant to lower monetary policy interest rates into significantly negative territory. Instead asset purchases can potentially compress or contribute to containing the risk premiums that are key in the transmission of the low short-term monetary policy rates to financial conditions in the real economy. For the most part, central banks rely on the purchase of government bonds due to, e.g., the ease of conducting purchases on a large scale (as the market liquidity is higher), and to contain credit and reputational risks. While buying government bonds does not directly influence financing conditions in the broader economy, the purchases depress the future return on government bonds and financially incentivise private investors to invest in real assets or financial assets issued by the private sector. This can have an impact on financing conditions and real activity in the economy. In the literature on effects of quantitative easing, the mechanism where private investors find alternative investment opportunities as a result of central bank asset purchases is commonly referred to as a portfolio rebalancing channel, see, e.g., [Krishnamurthy and Vissing-Jorgensen \(2012\)](#).

In this paper, we analyse the portfolio rebalancing channel for insurance and pension companies (henceforth pension companies) in Denmark since 2015. We analyse the portfolio rebalancing using a novel and unique data set of transactions and holdings at the individual company and asset level of all major Danish pension companies. This allows us to get a detailed view of the pension companies' investment behaviour following the introduction of the European Central Bank's (ECB's) asset purchase programme (APP) in the beginning of 2015. We estimate bond demand functions and analyse whether the eligibility of bonds for purchase by the ECB is a significant factor in explaining the investment behaviour of the Danish pension companies.

In contrast to other studies, we can analyse cross-border spillovers of asset purchases and to what extent the pension companies' demand for Danish bonds changes with the ECB's bond purchases. Denmark's Nationalbank, the Danish central bank, has not conducted asset purchases in that period. Instead, we use that Danish pension companies due to a fixed exchange rate regime own considerable amounts of euro bonds that are eligible for the ECB's asset purchase programmes. The Danish fixed exchange rate regime began in 1982 to the D-Mark, and since 1999 the Danish krone has been pegged to the euro in the ERM2 agreement. There have been no changes to the central parity rate since 1987. As a result, the exchange rate risk between the euro and Danish kroner is low and bonds in euro and Danish kroner trade as close substitutes, which is why the ECB's APP could potentially lead investors to substitute euro bonds for Danish bonds.

We find evidence that the Danish pension companies during the first year of the APP actively rebalanced their portfolios away from government bonds purchased by the Eurosystem and into Danish bonds, particularly mortgage bonds. After the first year of the APP, we do not find a significant change in the Danish pension companies' demand for bonds purchased by the Eurosystem. From 2016 and throughout the period of high intensity purchases by the ECB until the end of 2017, the Danish pension companies

purchased small amounts of bonds eligible for purchase by the ECB. They sped up their purchases of those bonds during the period of tapered and later zero net asset purchases by the ECB from 2018 and until shortly before the Eurosystem restarted net purchases in late 2019. Overall for the period covering the different phases of asset purchases by the ECB, the Danish pension companies broadly maintained their investments in euro government bonds, suggesting that the euro bonds constitute a quasi-preferred habitat to complement their preferred habitat in Danish kroner bonds. We also show that Danish pension companies as a result of a growing balance sheet reduced the portfolio share in both bonds eligible for ECB purchases as well as Danish bonds.

Our paper contributes to the emerging literature of empirical studies that document the portfolio rebalancing flows, e.g. [Boermans and Vermeulen \(2018\)](#) and [Fidora et al. \(2020\)](#). While the complexities of portfolio rebalancing among different investor types and the implications are not yet fully documented, the channel is often mentioned by central bank policymakers when referring to the effectiveness and transmission of quantitative easing policies. To the best of our knowledge, analysis of specific sectors' portfolio rebalancing from the ECB's APP has mainly focused on investment funds (e.g. [Bua and Dunne \(2017\)](#)) and banks (e.g. [Paludkiewicz \(2019\)](#) and [Grosse-Rueschkamp et al. \(2019\)](#)). [Domanski et al. \(2017\)](#) analyse portfolio rebalancing of the euro area insurance and pension sector up to 2015 as a result of mismatches between the duration of assets and liabilities arising from the declining interest rates. They argue that those investor groups are very important for euro area bond markets. However, their sample stops before the APP. [Joyce et al. \(2017\)](#) analyse the reaction of UK insurance and pension funds to the Bank of England's gilt purchases and document some portfolio rebalancing activity. Pension funds' behaviour in light of the ECB's APP has not been studied in detail yet. The lack of focus on pension funds may, among other things, relate to challenges in analysing the sector as a result of opacity in their investments. The opacity is due to the extensive use of externally managed funds. According to [EFAMA \(2019\)](#), 51 per cent of assets held by European (ex-UK) pension funds, up from around 27 per cent in 2008, were assets issued by investment funds. With our data, we are able to cover a large part of the Danish pension companies' investments through domestic investments funds, cf. section 3. This is an important advantage of our data.

Our contributions in this paper are relevant for a number of reasons.

First, our analysis of the Danish pension companies' portfolio rebalancing can provide new insights for central bank policymakers as regards the characteristics of the investor base. [Kojen et al. \(2017\)](#) and [Kojen et al. \(2020\)](#) show that foreign investors are the most active sellers of bonds eligible to be bought by the ECB and they do not rebalance into other euro assets. They also document that insurance companies and pension funds buy bonds that are eligible to be bought by the ECB. We show that Danish pension funds, although being a foreign investor from the ECB's point of view, behave similarly to euro area long-term investors rather than to the aggregate group of foreign investors. [Eser et al. \(2019\)](#) use the changes in the investor base over time to estimate the impact of the APP on the euro area interest rate term structure. They show that APP purchases may have an increasing price impact per unit purchased as the investor base composition changes towards price-inelastic investors as the foreign investor share

declines. They do this under the assumption that euro domestic long-term investors tend to have a preferred habitat in euro government bonds and thus are more price insensitive than foreign investors, as the latter group is assumed not to have a preferred habitat in euro government bonds. While we do not dispute this assumption, our results show that policymakers need to consider the heterogeneity among foreign investor groups in analysing the effectiveness of asset purchases.

Second, we provide a unique look into how the complex pension sector invests and rebalances its portfolio. Most importantly, we analyse how the type of pension plan for a company affects the investment allocation and reaction to the ECB's APP. We find that companies with the traditional type of pension plans with nominal return guarantees slightly increase their investments in bonds eligible for purchase by the ECB in the period 2015-2020, although in the initial period of the APP, they appear to rebalance into Danish bonds. Companies with other pension plan types such as market rate plans act less predictably and with large variations. As a group they sell German government bonds, but somewhat increase their holdings in lower rated bonds eligible for purchase by the ECB. The heterogeneity within groups of companies with seemingly comparable liabilities means that the aggregate portfolio rebalancing for the sector can happen unpredictably and of a magnitude that is hard to foresee. This is an important policy finding for analyses of the pension sector's behaviour.

Finally, in the context of a fixed exchange rate regime such as the Danish case, the role of portfolio rebalancing of domestic investors is crucial to understanding the capital flows that are instrumental for the exchange rate. As a sector, Danish pension companies are by far the largest financial investor in Denmark. Their rebalancing of portfolios affects the dynamics in the krone exchange market. Direct rebalancing away from euro bonds into assets in Danish kroner will lead to an increased demand for Danish kroner. More indirectly, however, rebalancing away from euro bonds into bonds in currencies other than euro or kroner will most likely also lead to a higher demand for kroner. This results from a lower propensity for the pension companies to hedge their euro exposure compared to, e.g., their US dollar exposure where the exchange rate risk and the regulatory capital charge for it is much higher. As a result of the Danish fixed exchange rate regime, changes in demand and supply in the market for kroner beyond what the market can absorb itself is accommodated by Danmarks Nationalbank to keep the exchange rate vis-a-vis the euro stable. Understanding the spillovers from asset purchase programmes abroad and the resulting domestic portfolio rebalancing is therefore essential to Danmarks Nationalbank.

The remainder of this paper is structured as follows. First, we provide the institutional background of the Danish pension sector in Section 2. We move on to describe our novel data in Section 3, present the descriptive analyses in Section 4, our econometric framework in Section 5, results in Section 6, analyse the effects of the heterogeneity within the sector in Section 7 and round off with our concluding remarks in Section 8.

2 The Danish pension sector and the Danish fixed exchange rate to the euro

Total net assets under management for the Danish pension sector amounted to roughly DKK 4100 bn (approximately EUR 500 bn), corresponding to almost 200 per cent of Danish GDP at the end of May 2020. This is the largest in the world relative to GDP. According to [OECD \(2019\)](#), in 2016 assets in Danish funded pension plans amounted to more than three quarters of the combined funded pension plan assets of the four largest euro area countries (Germany, France, Italy and Spain). In a euro area comparison, the assets of the Danish pension sector are only surpassed by those of the Dutch pension sector.

The growth of the Danish pension sector took off after a tripartite agreement between employer organisations, labour organisations and the government in 1987. The agreement significantly increased the population coverage of compulsory occupational pension schemes. The occupational schemes cover about 85 per cent of the employed labour force, and contribution rates are generally high at 10 to 18 per cent. Occupational pension schemes are fully funded, defined-contribution schemes. Different pension companies cover different parts of the labour market as governed by collective agreements. Still, the large majority of pension assets are managed by companies large enough to undertake active investment management in-house. In addition to the occupational pensions, the sector includes the Danish Labour Market Supplementary Pension Scheme (ATP) established in 1964 with mandatory contributions for all employees and some other groups. ATP is the largest Danish pension company.

The financial regulation relevant for Danish pension companies is Solvency II. This requires them to do a market-based valuation of their balance sheet which implies that both assets' and liabilities' valuations move with price changes in financial markets. The liabilities are their obligations to the pension plan holders. Therefore, the pension plan type has implications for their investment behaviour. With our data, we are able to split the companies into groups with similar pension plan types and analyse the heterogeneity within the groups. Pension plan returns can either follow a market return on the specific assets owned by the benefactor, or follow an average rate return. The former type is labelled market rate plans and the latter type average rate plans. Among companies offering average rate plans, there are plans with binding guarantees, plans with conditional guarantees and non-guaranteed plans. The guaranteed minimum nominal return, whether binding or not, serves to keep track of policyholders' core benefits. Market returns in excess of minimum guarantees are allocated to bonus reserves which act as buffers and provide for investment freedom and risk-taking in the search for long-term yields. Bonus reserves act as a buffer for fluctuations in annual market returns and aim to smooth out market returns over time. Hence, the following four groups may demonstrate distinct investment behaviour and different reactions to the ECB's asset purchases:

- Companies with guaranteed average rate plans: Expected behaviour is to invest to meet minimum guarantees and hedge interest rates. The financial risk from market movements is borne by the companies, e.g. if interest rates decline and the discounted value of their liabilities increase. Therefore, they typically hedge the interest rate risk of their liabilities using bonds or interest rate swaps.
- Companies with conditionally guaranteed average rate plans: Expected behaviour is to maximise

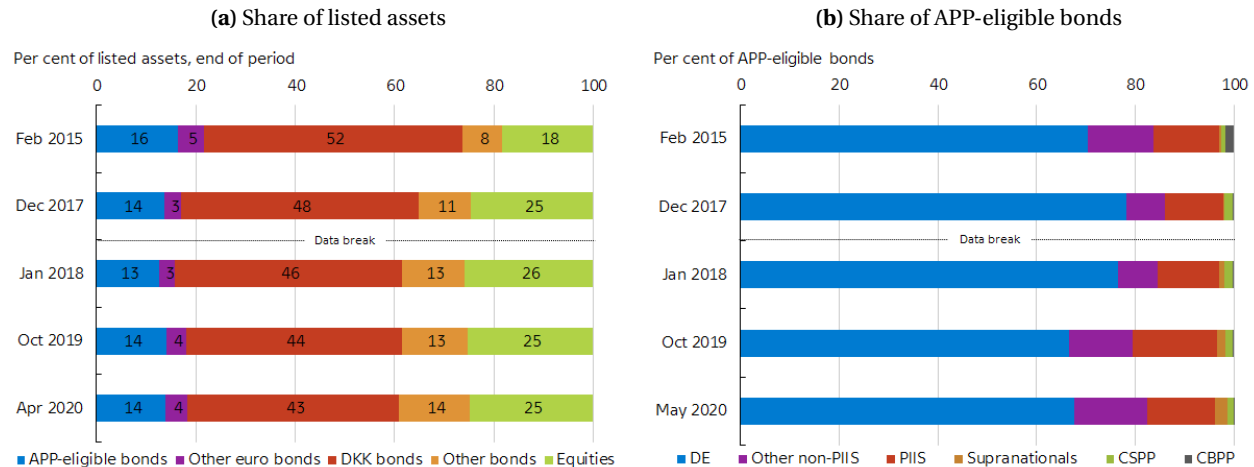
long-term asset returns, invest to meet minimum guarantees and hedge interest rate sensitive liabilities. The guaranteed returns are conditioned on the company's solvency, such that, e.g., severe and prolonged adverse developments in financial markets or an unexpected increase in life expectancy may lead to a change of the guaranteed return. Therefore, they have somewhat higher degrees of freedom than unconditionally guaranteed plans.

- Companies with non-guaranteed average rate plans: Expected behaviour is to maximise long-term asset returns. Buffers can be invested strategically for the long term. Thus, non-guaranteed average rate plans have investment freedom coupled with a long-term target return.
- Companies with market rate plans: The risk from market movements is borne by the customers. Market rate plans have the most investment freedom. Companies managing market rate plans mostly use fixed income products for diversification purposes to generate a return for customers and to reduce market risks for customers close to retirement.

In recent years, many pension companies have aimed to transfer existing customers from plans with hard guarantees to either average rate plans without hard guarantees or market rate plans. Many companies only offer market rate plans for new customers. Assets in market rate plans make up a bit less than half of all assets under management. Assets in market rate plans are growing whereas assets in guaranteed products have levelled off.

Danish pension companies own large amounts of both Danish and euro denominated bonds eligible for ECB purchases, cf. Figure 1a. In Solvency II, unhedged exchange rate risk entails a capital charge. The capital charge for euro exposure is sharply reduced to 2.39 per cent due to the fixed exchange rate under the ERM2 agreement compared to 15 per cent for other currencies. Capital charges for Danish government bonds as well as euro area government bonds are zero. Highly rated Danish mortgage bonds receive a preferential treatment under specific EU rules for covered bonds in terms of capital charges compared to otherwise similar non-mortgage, non-government bonds. This implies that euro area government debt and Danish mortgage and government bonds are close substitutes for pension companies in terms of capital charges. Thus, while Danish pension companies' first preferred habitat is Danish government and mortgage bonds due to the perfect match of assets and liabilities, they may have what we label a quasi-preferred habitat in euro government bonds, especially German government bonds. The majority of the companies' APP-eligible bonds are German government bonds as shown in Figure 1b. The Danish fixed income market is large relative to the size of the Danish economy, mainly owing to a very large domestic covered bond market close to the combined size of the German and French covered bond markets, cf. [European Mortgage Federation \(2019\)](#). Both government bonds and covered bonds have low credit risk and are triple-A rated, and about half of all covered bonds are 30-year bonds. Thus, both domestic covered bonds and government bonds in Danish kroner and euro can serve to fulfil the companies' demand for assets with duration and low credit risk.

To understand the effects of the rebalancing of Danish pension companies, it is important to understand the institutional setting for Denmark's monetary policy regime. As a result of the Danish fixed exchange

Figure 1: Portfolio allocation of Danish pension companies 2015-2020

Note: APP: Asset Purchase Programme, DE: Germany, PIIS: Portugal, Ireland, Italy and Spain, CSPP: Corporate sector purchase programme, CBPP: Covered bond purchase programme. DE, Other non-PIIS, PIIS and Supranationals are all part of the PSPP: Public sector purchase programme.

Source: Danmarks Nationalbank and own calculations.

rate regime to the euro, the purpose of the Danish monetary policy is to keep the exchange rate stable close to the central parity rate (1 euro = 7.46038 Danish kroner). The Danish monetary policy responses to conventional monetary policy decisions by the ECB, i.e. changing monetary policy rates, are generally straightforward by matching the change in monetary policy rates with an equal change in Danish monetary policy rates. However, as asset purchases have become important monetary policy tools of the ECB, mirroring the policy stance of the ECB is not as straightforward. Instead, the monetary policy stance in Denmark relies principally on spillovers from euro bond markets to domestic bond markets. If long-term bond yield spreads between Denmark and the euro area increase, investors will, *ceteris paribus*, increase their demand for Danish bonds and bring down the yields. Jensen et al. (2017) show that the response of Danish bond yields to a monetary policy shock in the euro area is similar to the response of German bond yields. They show that Danish bonds are close substitutes for euro area government bonds. However, they do not document the possible flows behind the spillovers in interest rates. The flows are important for the demand for kroner in the foreign exchange market.

3 Description of data

A proprietary data set reported to Danmarks Nationalbank by the Danish pension companies is used. Data consist of transactions and holdings at a monthly frequency starting in February 2015 and ending in May 2020. For each of the 27 companies in our sample, we know their entire portfolio of financial assets identified by ISINs and, e.g., unlisted assets and real assets identified by the companies' own identification system. In total, we have roughly 5 mn. observations of transactions and holdings in the data set. The statistical analysis focuses on fixed income products, which gives us a total of around 2 m observations. For the listed assets, we extract asset-specific information from the common European Centralised Securities

Database (CSDB), and Danmarks Nationalbank's Securities Statistics and the commercial data providers Refinitiv Eikon and Bloomberg. Data for transactions and holdings for the period 2015-2017 are based on the Securities Statistics while data after this period are based on the novel Insurance and Pension Statistics, both collected by Danmarks Nationalbank.

A comparative advantage of our data is that we are able to identify most of the assets that are held indirectly via investment funds. We use a so-called look through technique using data from the Investment Fund Statistics collected by Danmarks Nationalbank. Insurers' and pension funds' ownership of investment funds is concentrated in domestically domiciled funds (77 per cent for the European average and 85 per cent for Denmark), cf. [EFAMA \(2019\)](#). Looking through domestic funds is therefore already a valuable improvement to obtain the full picture of their investments. On a quarterly basis for the period 2015-2017, we manually look through investment fund vehicles where Danish pension funds own more than 90 per cent. From 2018 onward, the look through is done monthly in the official Insurance and Pension Statistics. The look through thus improves after 2018. At the year change 2018, the coverage of the pension companies' balance sheets therefore increases. As an example, the total holdings of bonds increase by 10 per cent. For that reason, charts displaying developments in asset holdings will include a vertical line marking the data issue, whereas the issue is negligible for the analysis of transactions. We only include pension companies for which we have liability data. Liability data are reported to Danmarks Nationalbank by the pension companies. For each company we know the extent of market rate plans and guaranteed plans.

We define whether an asset is eligible for ECB's APP programme as closely as possible by applying the publicly available eligibility criteria for the three APP programmes – PSPP for public sector bonds, CSPP for corporate bonds and CBPP3 for covered bonds – using the Bloomberg bond search function. We find the union of bonds eligible on specific dates (end of March 2015, 8 June 2016 coinciding with the beginning of CSPP purchases, end of November 2017, end of March 2019, December 2019 and June 2020) and use that for the entire period. Thus, we do not take account of bonds entering or leaving the eligible universe during the period, e.g. as a result of changes in eligibility criteria, rating changes or when once eligible bonds fall below the minimum maturity requirements. The eligible bonds transferred from the PSPP to CSPP in 2016 are included as CSPP. We do not include the ABSPP as this is by far the smallest programme, the Danish pension companies own insignificant amounts of euro ABS, and because the eligibility criteria for ECB purchases are not available. We exclude Greece from the PSPP as they were only eligible on an exception since 2020.

As our data set starts in February 2015, it does not include the period up to the APP, which would have been useful as a reference for the reaction to the introduction of the APP. Additional data based on, e.g., the Securities Statistics are used where necessary to provide perspectives on the findings.

4 Descriptive results

In this section, we present our descriptive analysis of the Danish pension companies' portfolio rebalancing from March 2015 to May 2020 and illustrate differences over time as the ECB changes the intensity of purchases. We first analyse transaction data to document the direct rebalancing of portfolios. We then analyse changes in portfolio shares to illustrate indirect rebalancing as the companies' portfolios are growing due to net inflows and positive market returns.

We have been through several stages of intensity of asset purchases from the Eurosystem. We use this to analyse how the portfolio decisions of the pension funds have varied accordingly. Specifically, we define the below subperiods based on net APP purchases by the Eurosystem. The first three subperiods are overlapping and represent phases of the period of high-intensity APP purchases by the Eurosystem:

- March 2015 – March 2016: Initial phase with purchases of EUR 60 bn per month
- March 2015 – March 2017: As above plus period of purchases of EUR 80 bn per month
- March 2015 – December 2017: As above plus subsequent period of purchases of EUR 60 bn per month
- January 2018 – October 2019: Tapering phase (30 to 15 to zero (from 2019))
- November 2019 – May 2020: Restart of APP and PEPP (Pandemic Emergency Purchase Programme) introduced

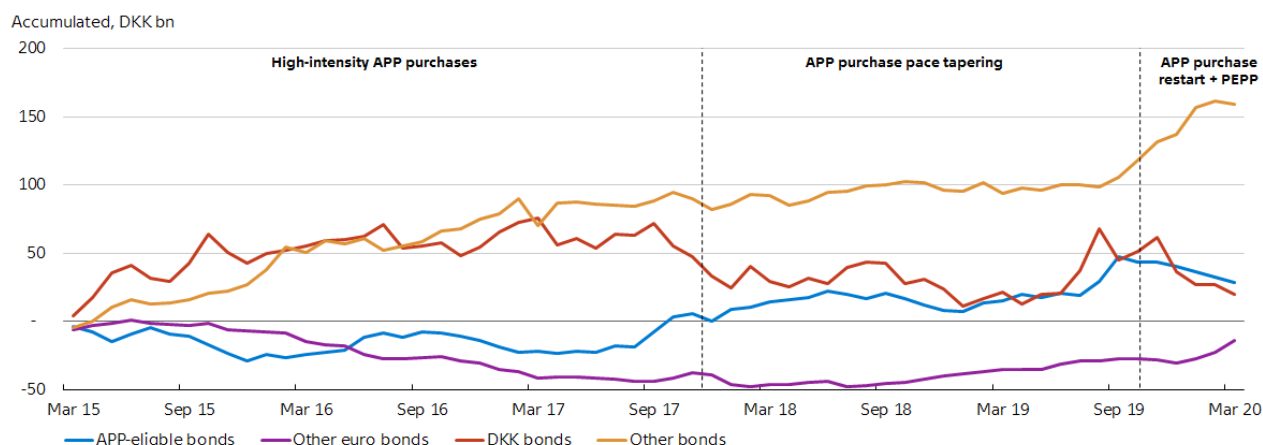
When the Eurosystem started its bond purchases in March 2015, the Danish pension companies in our sample owned APP-eligible bonds amounting to DKK 320 bn, slightly more than EUR 40 bn. The majority of those were German government bonds. As APP-eligible bonds are used by the pension companies to hedge future long-term pension obligations in Danish kroner, we would not expect to see the pension companies selling a sizable share of their APP-eligible bond holdings without replacing them by buying substitutes. Danish bonds are close substitutes and an even more natural investment class for the pension companies. Therefore, we concentrate on identifying portfolio rebalancing from APP-eligible bonds into Danish bonds. Alternatively, the companies could buy substitute bonds in other currencies and hedge the currency exposure by means of derivatives, or replace the duration using interest rate swaps. We also show their purchases of foreign bonds, but unfortunately our data do not include currency or interest rate derivatives. As another option, companies could try to escape low-yielding bonds and increase their share of equities.

4.1 Direct rebalancing away from APP bonds in the first stage of the APP

In Figure 2 we show the net transactions in bonds since 2015. The figure suggests some selling of APP-eligible bonds throughout 2015 but it remains of modest intensity. During 2015, the pension companies also appear to increase their demand for Danish bonds. During the still high-intensity APP phases from 2016 until the end of 2017, the pension companies tentatively return as buyers of APP-eligible bonds. The holdings of Danish bonds level off at the higher level. Over the same period, the companies sell

non-APP-eligible euro bonds, but buy bonds in currencies other than kroner and euro. During the period of low APP purchase intensity and later in the period with no APP purchases in 2018 and until the restart of the APP in November 2019, purchases shifted back to APP-eligible bonds and partly also to other euro bonds. Transactions in Danish bonds and other bonds are close to being balanced. From November 2019, as the APP purchases restart and PEPP is introduced, Danish pension companies again sell APP-eligible bonds, but this time at a smaller scale and together with Danish bonds. Instead they purchased bonds in other currencies.

Figure 2: Net purchases of bonds since the introduction of ECB's APP in March 2015



Note: Accumulated since March 2015.

Source: Danmarks Nationalbank and own calculations.

4.2 Indirect rebalancing away from APP-eligible bonds and Danish bonds

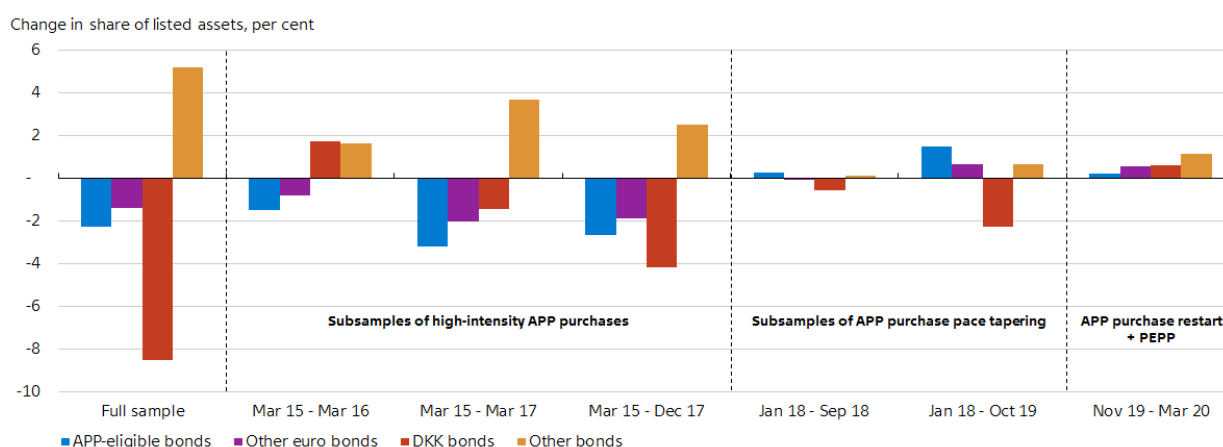
During the period 2015-2018, when the pension companies' holdings of APP-eligible bonds were overall unchanged in absolute terms, the total assets of pension companies increased by around 20 per cent. One hypothesis of investment behaviour related to the introduction of the APP is that the pension companies may refrain from selling APP-eligible bonds, but instead decide not to purchase APP-eligible bonds as their portfolio grows. That would result in a lower portfolio weight and therefore be an indirect portfolio rebalancing. Pension companies have reduced their exposure to APP-eligible bonds over the full sample, cf. Figure 3. The shift from high-intensity APP purchases to low-intensity purchases at the end of 2017 is noticeable. Until the end of 2017, the pension companies markedly reduced their relative exposure to APP-eligible bonds. As APP purchases were scaled back and in net terms discontinued, the companies in turn increased their relative exposure to APP-eligible bonds. The reaction to the restart of the APP from November 2019 and the introduction of the PEPP in light of the Covid-19 financial turmoil is very modest up to and including our time sample ending at the end of May 2020.

Indirect rebalancing can significantly change the dynamics in the market for kroner over time despite not leading to actual transactions. The Danish pension sector continues to accumulate assets on behalf of Danish households. In that way, from a macroeconomic perspective the sector plays an important role

in investing Denmark's recurring balance of payments surplus in foreign assets and foreign currency. If the pension companies as a result of the ECB monetary policies decide not to invest in euro bonds, they may end up with a lower net exposure to euro and potentially also a lower stock of foreign assets. In that case, other sectors, or eventually Danmarks Nationalbank, need to step in to balance the demand and supply of kroner which is consistent with a stable exchange rate of kroner vis-à-vis the euro. In a similar vein, if the available net supply of euro bonds were to increase, e.g. if the Eurosystem were to discontinue its bond purchases or eventually reduce its bond holdings, Danish pension companies could increase their demand for euro bonds again. Hypothetically, if euro bonds as a share of their total assets were to go back to the pre-APP level, it would entail a large demand for euro and a lower net demand for Danish kroner.

Seen over the full sample, the pension companies have strongly reduced their exposure to Danish bonds. As actual purchases of Danish bonds were slightly positive, the reduction reflects a strong dilution effect as the companies' portfolios grow because of the high initial portfolio share of Danish bonds, about 52 per cent of listed assets. During the first year of APP purchases, the companies increased their exposure to Danish bonds to a broadly similar extent as their combined reduction in APP-eligible bonds and other euro bonds. As time passes and purchases continue, the companies, however, cease to rebalance into Danish bonds. Instead, they increase their exposure to bonds denominated in currencies other than euro and kroner. This mostly reflects an increase in the holdings of bonds denominated in Swedish kroner, cf. Figure A.1 in the appendix. The purchase of Swedish kroner bonds is to a large extent matched by an increase in repo financing in Swedish kroner and is therefore most likely not directly related to a rebalancing due to the ECB's asset purchases. The pension companies continue to reduce their exposure to Danish bonds throughout the active phases of the APP and the phase with reinvestments only.

Figure 3: Changes in portfolio shares over subperiods of the ECB's APP



Note: Changes in the portfolio weights of the specified asset classes over the periods of the APP, per cent. The full sample excludes the change from December 2017 to January 2018 due to the shift in the data source as described in the data section.

Source: Danmarks Nationalbank and own calculations.

4.3 Rebalancing into assets other than bonds

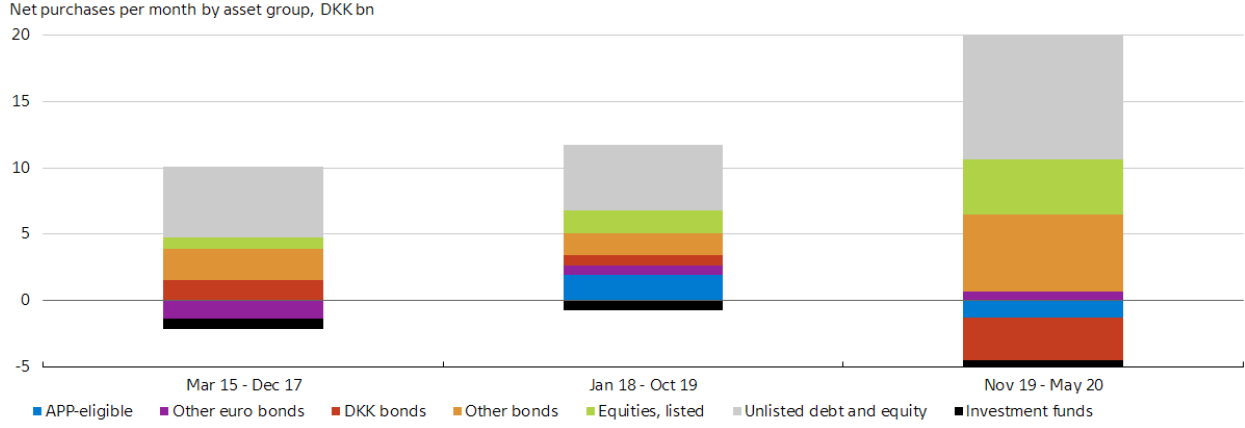
The low interest rate environment partly caused by asset purchase programmes and by expectations of low future short-term rates may have induced the companies to rebalance their portfolios away from bonds and into asset classes with a better perceived risk-return trade-off. For example, equities appear to provide a roughly unchanged expected return over the last 20 years despite the steep decline in expected bond returns, cf. [Autrup and Hensch \(2020\)](#). Figure 4 shows the net purchase of assets over different stages of the APP. The companies do not appear to actively rebalance into listed equities on a large scale. The most noticeable net purchases are in unlisted debt and equities. Particularly, the companies increased their holdings of unlisted equity (see further currency and asset group split in Figure A.2 in the appendix). This is probably not a direct consequence of the APP. Investments in unlisted assets are likely to react more slowly than investments in listed assets due to a greater need for thorough due diligence, negotiations and integration into internal systems and risk management frameworks. However, the general trend towards unlisted assets may have been strengthened by the APP and the compression of risk premia. There is also some direct rebalancing towards unlisted debt in kroner and euro, but none in other currencies. This is in contrast to listed debt (bonds) and indicates that the companies were not shunning debt in euro and kroner in general, but only rebalancing away from segments directly impacted by the APP or indirectly through compressing yields. The expected returns on unlisted debt are not available to us. It is likely that there is also a compression of returns as investors flock to higher yielding assets. But the return compression may still be smaller than for bonds as the unlisted assets are less perfect substitutes for APP-targeted bonds. Finally, we note a slight rebalancing away from investment funds. Consequently, the pension companies do not appear to use these funds to rebalance towards more specialised asset classes.

Large equity price increases over the period entailed that the share of equity in the portfolios increased sharply from 18 per cent of listed assets in early 2015 to around 25 per cent from the end of 2017 onwards. Thus, although there were only small net purchases of equities, there was a large indirect rebalancing towards equity instruments.

5 Econometric approach

The main goal of our statistical analysis is to validate the descriptive results for fixed income assets and determine whether the companies in reaction to the ECB's APP behaved differently for bonds eligible for the APP and the closest Danish substitutes compared to bonds exhibiting otherwise identical properties.

For this purpose, we estimate bond demand functions over the period 2015-2020 and the subperiods described in Section 4. We are thus able to investigate whether the changes in the intensity of APP purchases statistically change the demand for APP-eligible bonds or the Danish substitute bonds. The method of estimating bond demand functions and accumulating transactions over predefined periods follows [Fidora et al. \(2020\)](#). Accumulating the transactions over periods reduces the effects of noise from selling in one month and buying in, e.g., the next that a time series approach would be prone to. We limit our analysis to fixed income assets to be able to include the control variables such as credit ratings, yield-to-maturity and

Figure 4: Net purchases of asset groups over different phases of ECB's APP

Average over the periods.

Source: Danmarks Nationalbank and own calculations.

years-to-maturity. We also limit the sample to bonds for which all those variables are available:

$$\begin{aligned}
 Net\ transactions_{i,a,t} = & \beta_1 \mathbb{1}_{aCSPP} + \beta_2 \mathbb{1}_{aCBPP3} + \beta_3 \mathbb{1}_{aPSPP} + \beta_4 \mathbb{1}_{aDKKmortgage} + \beta_5 \mathbb{1}_{aDKKgovernement} \\
 & + \beta_6 \ln(A_{i,a,t-1}) + \beta_k x_{k,i,a,t} + \gamma_i + \gamma_a + \varepsilon_{i,a,t}
 \end{aligned} \tag{5.1}$$

$Net\ transactions_{i,a,t}$ are the net transactions in million Danish kroner by company i in asset a during the time interval t . $\mathbb{1}_j$ is an indicator function taking the value 1 if the underlying asset is of class j and 0 otherwise. j 's are classes of bonds eligible under each of the three purchase programmes under the ECB's APP (CSPP, CBPP3 and PSPP) and Danish mortgage bonds or Danish government bonds - denominated in Danish kroner. $\ln(A_{i,a,t-1})$ is the log holdings of asset a for company i at the start of the time interval. $x_{t,k}$ is a vector of controls that include the share of guaranteed pension plans for the pension company, the market value of the asset, its average residual maturity, average effective yield and the average credit rating. We use the average from three rating agencies, DBRS, Standard & Poor's and Fitch Ratings. We include dummies for whether the asset is denominated in US dollar and euro. We also include an intercept, pension company fixed effects in γ_i and fixed effects per geographic continent of the issuer of the asset in γ_a . We cluster the robust standard errors at the company level.

6 Results

6.1 Direct rebalancing from euro bonds into Danish bonds in first period of ECB purchases

In this section, we focus on the direct rebalancing channel from actual sales and purchases of bonds. We present the results of the estimation of the baseline specification given in (5.1) in Table 1. A table containing all variables can be found in Table A.1 in the appendix.

In the initial phase of ECB's purchases of government bonds from March 2015 to March 2016, the pension companies' demand for bonds eligible under the PSPP programme declined significantly, according to column (1). The coefficient on the PSPP dummy implies that the pension companies in the period from March 2015 - March 2016 reduced their holdings of each ISIN eligible for PSPP purchases with an amount of DKK 54 mn. On average, the pension companies hold 54 unique ISINs eligible for PSPP, and the estimated average effect of the PSPP programme in this period corresponds to sales of eligible bonds of DKK 2.9 bn per company in the sample, or DKK 61 bn in total for the 21 pension companies owning PSPP-eligible bonds. This suggests that pension companies responded to the introduction of the ECB's APP.

The reasons for the observed decline in demand could be manifold. Most importantly, asset purchases potentially change the yields of the targeted bonds and the premia that compensate for risk. [Altavilla et al. \(2015\)](#) among other studies found that the introduction of asset purchases lowered euro area bond yields significantly. They find an impact of 30-50 basis points for 10-year euro area government bonds and about twice that for lower-rated euro area sovereign bonds. The changed risk return trade-off may have induced the Danish pension companies to reduce their exposure to the bonds targeted by the ECB. Asset purchase programmes also affect the liquidity conditions of euro area bond markets. The Eurosystem is only on the buying side of the market and follows benchmarks for purchases, and is not very price sensitive. A new, large buyer in the market with that behaviour can improve the market liquidity of bonds for investors aiming to sell bonds. Thus, Danish pension companies may have considered that the beginning of the APP was a favourable time to rebalance portfolios because the ease of selling APP-eligible bonds improved. For buying bonds, the effect of the APP may have been the opposite. As shown in [Schlepper et al. \(2017\)](#), liquidity conditions worsened in the market for German government bonds when the Eurosystem purchases bonds. In that way, it may have become more cumbersome and more expensive for the Danish pension companies to buy additional bonds or reinvest maturing bonds in bond markets where the Eurosystem is also buying.

In contrast to the reduced demand for APP-eligible bonds, Danish pension companies significantly increased the demand for Danish mortgage bonds in the first year of the APP. There is no statistically clear effect on the demand for Danish government bonds. The market for mortgage bonds is larger than the market for government bonds by a factor of around four. Mortgage bonds are therefore at least as central to the Danish financial markets and for the foreign exchange market as government bonds. Therefore, the higher demand for Danish mortgage bonds is an important finding of spillovers of ECB policies to Danish financial markets. A spillover of monetary policy does not necessarily entail any transactions and flows

between currencies. As an example, a Danish pension company holding euro bonds and Danish bonds will not necessarily want to change its portfolio although the yields of the euro bonds change as a result of ECB asset purchases if the yields of the Danish bonds change by the same amount. Our finding that the Danish pension sector rebalanced its portfolio as a result of the APP in the initial phase of the APP therefore complement the finding of a strong spillover in bond yields in [Jensen et al. \(2017\)](#).

The substitution of PSPP-eligible bonds with Danish mortgage bonds took place in spite of interest rate developments in the first half of 2015. Interest rates on Danish bonds fell more than the interest rate on euro bonds with similar characteristics in the initial period after the introduction of the APP, cf. [Figure A.3](#) in appendix. The reason for that notable development was that Danmarks Nationalbank lowered the main monetary policy rate to -0.75 per cent from -0.05 per cent at the end of 2014. Furthermore, at the end of January 2015, the Danish Ministry of Finance suspended the issuance of government bonds as a means of limiting the supply of Danish bonds. Both policy responses were introduced following a heightened demand for Danish kroner triggered by the Swiss central bank's decision to abandon its temporary exchange rate floor to the euro in mid-January 2015, see [Danmarks Nationalbank \(2015\)](#). After the summer of 2015, the yield spread between Danish bonds and euro bonds had returned to the level prevailing before the APP.

In early 2015, owning German government bonds on a currency-hedged basis became less attractive than owning Danish bonds owing to the cost of hedging euro exposure to Danish kroner exposure increasing sharply amid the rate cuts by Danmarks Nationalbank and the heightened demand for kroner, cf. [Figure A.4](#) (left) in the appendix. This may have contributed to the reduction in PSPP-eligible bonds and the rebalancing towards Danish bonds. Another financial development in the euro bond market that may have reduced the demand for euro government bonds is the relative pricing of those bonds versus interest rate swaps. [Figure A.4](#) (right) in the appendix shows that swap spreads for German bonds declined into more negative territory in late 2014 and early 2015 as the ECB purchase programme influenced the pricing of euro government bonds. Relative to overnight indexed swaps, German bonds went from trading at 15 basis points above swaps to 15 basis point below, indicating that changes in interbank risk did not play a role.

We also note that the substitution into Danish bonds is not a result of a larger supply of Danish bonds. In fact, the net supply of both Danish government bonds and mortgage bonds was negative in 2015, cf. [Figure A.5](#) in the appendix. Therefore, the pension companies have increased their ownership share in these two bond segments. The outstanding amounts of the bonds are also included as a control variable in the regression.

For a perspective on the finding, supplementary data sources need to be used as the data set did not start until February 2015. In the period 2010-2014 before the APP, the correlation between the pension companies' net purchases of euro government bonds and Danish mortgage and government bonds hovered around zero, cf. [Figure A.6](#) (right) in the appendix. In 2015, the correlation turned negative, which is consistent with our findings of the substitution from bonds eligible for the APP to Danish mortgage

bonds. The more negative correlation in that period shows that the documented substitution effect stands out from the normal investment behaviour of the pension companies in the years leading up to 2015.

The supplementary data also show that the pension companies sold euro government bonds as early as late 2014 and in the first two months of 2015, but in small amounts, cf. Figure A.6 (left) in the appendix. It also appears that they bought Danish bonds. Jensen et al. (2016) and Grønlund and Risbjerg (2020) show that in January and February 2015, Danish pension companies purchased Danish kroner on a large scale, although mainly as a result of an increased demand for foreign exchange hedging. In isolation, the rebalancing away from euro bonds and into Danish bonds in the course of 2015 led to a higher demand for Danish kroner. After March 2015, it was, however, more than offset by a lower demand for currency hedging by the pension companies, cf. Figure A.7 in the appendix.

We do not find any statistically significant changes in the demand for other types of bonds in the first period.

Table 1: Accumulated net transactions in fixed income products by company and over subperiods

VARIABLES	(1) Mar 2015 - Mar 2016	(2) Mar 2015 - Mar 2017	(3) Mar 2015 - Dec 2017	(4) Jan 2018 - Oct 2019	(5) Nov 2019 - May 2020	(6) Full sample
CSPP	10.88 (7.00)	12.35 (8.45)	10.52 (7.18)	1.04 (2.45)	-2.25 (1.97)	2.75 (3.81)
CBPP3	1.85 (23.72)	27.58 (27.09)	37.26 (28.32)	-0.72 (7.68)	-21.37* (12.36)	30.84 (20.10)
PSPP	-54.22** (19.48)	9.78 (37.21)	28.30 (39.97)	54.82 (33.13)	1.81 (12.46)	42.18 (29.29)
MTG_{DK}	43.84** (17.09)	30.44* (17.07)	30.10** (14.24)	16.36** (7.38)	-1.90 (10.01)	30.34** (11.65)
GOV_{DK}	78.59 (107.91)	184.02 (131.26)	212.44 (157.53)	37.13 (49.66)	100.85 (72.45)	209.31 (154.79)
CVR FE	YES	YES	YES	YES	YES	YES
Continent FE	YES	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES	YES
Observations	23,880	34,408	40,490	55,212	48,544	84,267

Note: CSPP only became part of the asset purchase programme beginning in June 2016. Full sample is March 2015 to May 2020. Robust standard errors in brackets. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The table shows the regression of accumulated net transactions in fixed income products by company and over varying time horizons.

Source: Danmarks Nationalbank and own calculations.

6.2 No direct rebalancing after the first period of ECB asset purchases

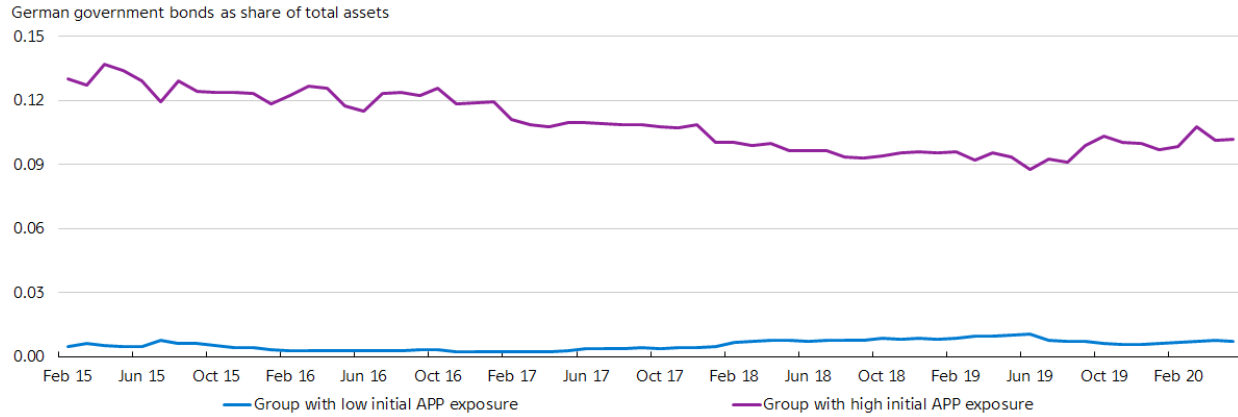
Looking beyond the first year of the APP, we do not find any significant changes in the demand for PSPP-eligible bonds, neither in any subperiod nor for the duration of the APP as a whole, see Table 1, column 2-6. For the other bond types, the most important result is that the demand for mortgage bonds has somewhat increased in most periods, but not in the last period of restarting the APP and the first months of the PEPP to address the Covid-19 financial market turmoil.

There are at least three financial developments that could have contributed to increase the pension companies' demand for euro government bonds from 2016 onwards.

The first is that the ECB's asset purchases contributed to a general scarcity of highly rated collateral in euro area bond markets, see [Brand et al. \(2019\)](#). The scarcity, which culminated in late 2016, resulted in repo rates for especially German government bonds to trade well below ECB's deposit facility rate. Repo rates on specific bonds in high demand, special repos, were very negative, meaning that the owner could make a large profit by offering the bond in a repo. The repo market developments may have increased the pension companies' demand for owning German government bonds to lend out. We are not able to formally analyse this transaction motive in detail. However, we note that the average maturity of the companies' holdings of German government bonds and the distribution of the bonds on maturity buckets is close to unchanged from early 2015 to the end of 2016, cf. Figure A.9 in the appendix. Were the companies to have significantly changed their bond holdings to take advantage of the repo squeeze, it may have resulted in a change in the composition of the debt. Still, repo market developments in 2016 may have contributed to stopping the selling of APP eligible bonds taking place in 2015.

The second factor that could increase the demand for euro government bonds is an increasing need for being able to access euro funding markets. The companies' derivative portfolios are subject to variation margin calls. If they clear their derivatives through a centralised clearing party (CCP) and, e.g., interest rates increase, they typically need to post euro as cash collateral. The share of clearing through a CCP has been increasing during our time sample, as the companies are preparing for the end of an exemption for not using centralised clearing. As government bonds and in particular German are the best instruments to be used to be used in repos for accessing euro liquidity, the pension companies' demand for particularly German government bonds may have been increasing over time. Figure 5 shows that companies that initially owned few bonds eligible for ECB purchases somewhat increased their holdings of German government bonds from 2018 onwards. The increase is driven by companies with guaranteed average rate plans. These are the companies that are most likely to use interest rate derivatives and where the need for collateral thus more likely could become a motive to buy German government bonds according to this explanation. Companies with a high exposure to APP eligible bonds initially are not expected to increase their demand for this purpose as they already have access to repo markets and do not use derivatives as much. These companies reduced their holdings of German bonds throughout, giving further support to this transaction motive.

The third potential explanation is that changes in the regulation of pension companies could also have played a role too, for instance the full implementation of Solvency II from 2016 with its more advanced risk measurement and risk-sensitive capital requirements. In Solvency II, by switching EU sovereign bonds to other types of assets, a pension company would see an increase in capital requirements and the consequent reduction in its solvency coverage ratio. This may have increased the pension companies' demand for government bonds from 2016 although they had probably been preparing their portfolios for the change for a while up to that date.

Figure 5: Holdings of German bonds by initial, relative exposure to APP-eligible bonds

Note: Only includes companies with a significant share of guaranteed liabilities (group "Guarantees" cf. later). Includes German government bonds of all maturities, i.e. also bonds not eligible for ECB purchases due to too short time to maturity. Companies are split into two groups of comparable size according to their initial exposure to APP-eligible bonds.

Source: Danmarks Nationalbank and own calculations.

Figure A.8 in the appendix shows the regression coefficients of APP eligibility and of Danish bond dummies over time using six-months rolling windows. The rolling window regressions confirm that APP eligibility entailed a lower demand in periods of 2015 and early 2016 and a higher demand for Danish bonds, particularly in 2015. A significantly higher demand for APP-eligible bonds is observed from late 2017 and for the first half of 2018 and again in the latter half of 2019.

6.3 Indirect rebalancing of portfolios

To formally analyse the indirect rebalancing channel described in the descriptive results section, we adjust the actual transactions according to equation (6.1) by subtracting the hypothetical transaction by company that would serve to maintain constant portfolio weights as the company's total assets change.

$$\widetilde{Net\ transactions}_{a,i,t} = Net\ transactions_{a,i,t} - \frac{s_{c,i,t-1} \times \Delta AUM_{i,t}}{N_{c,i,t}} \quad (6.1)$$

where $s_{c,i,t-1}$ is the weight of asset class c for company i at the beginning of the period, $\Delta AUM_{i,t}$ is the change in total assets under management for company i (including listed and unlisted equities), and $N_{c,i,t}$ is the number of unique assets in asset class c for company i . Asset classes are divided into APP-eligible bonds, other foreign bonds, Danish mortgage bonds, Danish government bonds, other Danish bonds, Danish equities and foreign equities.

We can now estimate the same model as in equation 5.1, but using the accumulated, adjusted net transactions to see how the pension companies' portfolios have been influenced by the APP when including the effects of indirect rebalancing. The results of the regression are presented in Table 2.

For the first period, the findings are identical to the findings for the direct rebalancing, as we find a substitution from PSPP-eligible bonds to Danish mortgage bonds. We do not find evidence of substitution from APP-eligible bonds to Danish bonds after the initial period. We no longer find a significantly higher demand for Danish mortgage bonds after the initial period.

The reduction in the holdings of Danish bonds and unchanged demand for them after 2016 may at first seem counter-intuitive as these are the best substitutes for APP-eligible bonds. One potential explanation for the fading substitution from 2016 onwards is that the yield spread between Danish government bonds and German government bonds compressed, and the yield pickup in mortgage bonds compressed sharply. Foreign investors purchased large amounts of Danish mortgage bonds, cf., e.g., [Danmarks Nationalbank \(2020\)](#), in a global search for yield competition triggered by low monetary policy rates, use of forward guidance and asset purchase programmes in many developed economies. Interest rates on Danish bonds therefore declined at least as much as those on euro bonds from 2016 onwards, cf. Figure A.3 in the appendix. This may have induced the pension companies to indirectly rebalance their portfolio away from Danish bonds.

Another explanation could be that the first stages of the APP caught the pension companies by some surprise. It can take time to adjust systems, human capital and investment mandates to new market circumstances. In that case, if a pension company decides to reduce its APP-eligible bond holdings, it will need an alternative asset to invest in. Most, if not all, pension companies have capabilities and may already have mandates to invest in Danish bonds, whereas rebalancing into more exotic bonds or other assets may take time to prepare. Finally, if pension funds opportunistically wanted to react to the APP by selling the bonds bought by the Eurosystem, they might have done it towards the beginning of the programme.

6.4 Comparison to other studies

The findings for the first period of the APP are consistent with the findings of [Joyce et al. \(2017\)](#) who find that the Bank of England's QE policy resulted in some portfolio rebalancing behaviour by UK insurance companies and pension funds, who reduced their gilt holdings and shifted to corporate bonds (relative to their counterfactual). Our study benefits from a longer period of asset purchases by the central bank, and we find that the active rebalancing ceases even when there are still active APP purchases by the Eurosystem. In that way, our findings especially for the later stages of the APP, are comparable to the findings of [Fidora et al. \(2020\)](#) for euro area pension funds, who show that they do not rebalance away from APP-eligible bonds. While statistically significant, the Danish pension companies maintain the majority of their APP-eligible bonds throughout the initial period of the APP. Together with the findings of no rebalancing afterwards, it shows a high degree of preferred habitat for APP-eligible bonds by the Danish pension companies. Our findings therefore also complement the findings in [Boermans and Vermeulen \(2018\)](#) that euro area insurance and pension funds have a preferred habitat in euro government bonds and did not change their demand for domestic debt as a result of the APP.

Table 2: Accumulated net transactions adjusted for growing assets over time

VARIABLES	(1) Mar 2015 - Mar 2016	(2) Mar 2015 - Mar 2017	(3) Mar 2015 - Dec 2017	(4) Jan 2018 - Oct 2019	(5) Nov 2019 - May 2020	(6) Full sample
CSPP	11.84 (7.40)	12.72 (8.95)	10.20 (7.44)	0.68 (3.21)	-2.44 (1.94)	2.05 (3.86)
CBPP3	3.08 (24.29)	30.69 (29.29)	40.76 (30.66)	1.32 (7.64)	-21.14 (12.57)	35.90 (22.61)
PSPP	-57.90** (21.21)	-13.14 (32.87)	6.23 (34.20)	7.93 (34.75)	-1.73 (9.37)	-1.65 (14.16)
MTG_{DK}	43.43** (20.51)	25.17 (23.62)	25.44 (20.04)	0.73 (8.49)	-1.05 (9.93)	13.09 (14.43)
GOV_{DK}	28.58 (90.59)	31.14 (91.70)	31.88 (99.14)	-231.18 (166.45)	69.38 (48.71)	-159.81 (112.64)
CVR FE	YES	YES	YES	YES	YES	YES
Continent FE	YES	YES	YES	YES	YES	YES
Controls FE	YES	YES	YES	YES	YES	YES
Observations	23,880	34,408	40,490	55,212	48,544	84,267

*Note: CSPP only became part of the asset purchase programme beginning in June 2016. Full sample is March 2015 to May 2020. Robust standard errors in brackets. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The table shows the regressions of adjusted, accumulated net transactions in fixed income products by company and over varying time horizons.*

Source: Danmarks Nationalbank and own calculations.

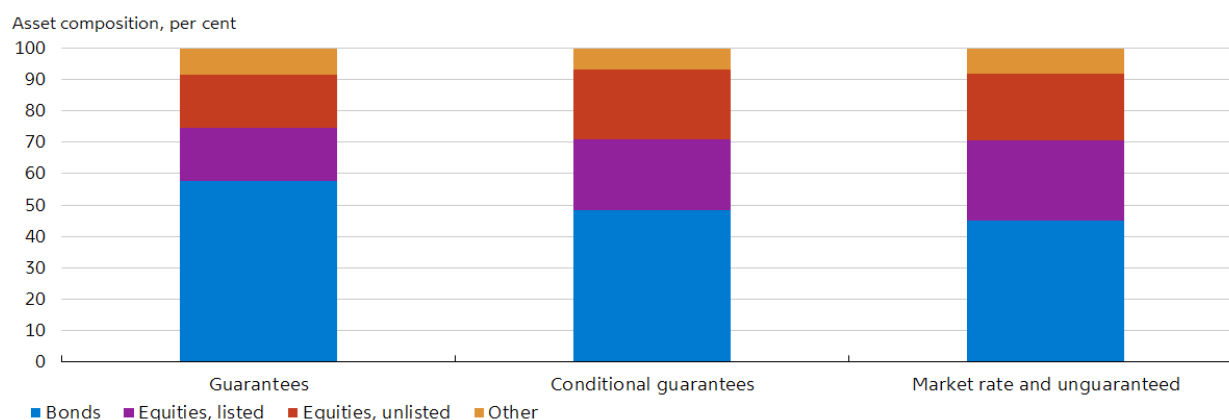
7 Portfolio rebalancing behaviour by type of company liabilities

In this section, we analyse whether the types of company liabilities are a determinant of the reaction to the asset purchase programmes. Almost all companies have a mix of pension plan types, and we do not know specifically which assets belong to which pension plan type. Instead, we split the companies into groups based on the distinction in Section 2: If plans with hard guarantees make up more than 1/3 of liabilities for a company by the end of 2019, we include the company in a group called "Guarantees". If a company mostly has plans with conditional guarantees, we include it in the group "Conditional guarantees". For confidentiality reasons, we group the two smaller groups of companies mostly having unguaranteed average rate plans and companies mostly having market rate plans. Economically, these two groups are also fairly similar in that both plan types transfer market risks to the plan holder. The three groups cover assets worth DKK 2500 bn, DKK 650 bn and DKK 900 bn respectively at the end of 2019.

Companies in the guaranteed group on average hold more bonds and fewer listed and unlisted equities than companies with conditional guarantees, who own more bonds and fewer equities than the group of market rate and unguaranteed pension plans, cf. Figure 6. This is consistent with the notion that more binding guarantees result in a higher demand for duration and thus lower freedom in the portfolio allocation. As a result of the relatively low threshold for inclusion in the guaranteed group, the group's assets also include a substantial amount of plans without hard guarantees, including market rate plans. Thus, the assets owned specifically to cover the guaranteed plans may include a larger proportion of bonds than for the group as a whole. For some companies, the publicly available Solvency and Financial

Condition Report (SFCR) discloses the aggregate assets by plan type. They point to a higher bond share for guaranteed plans than for market rate plans within companies.

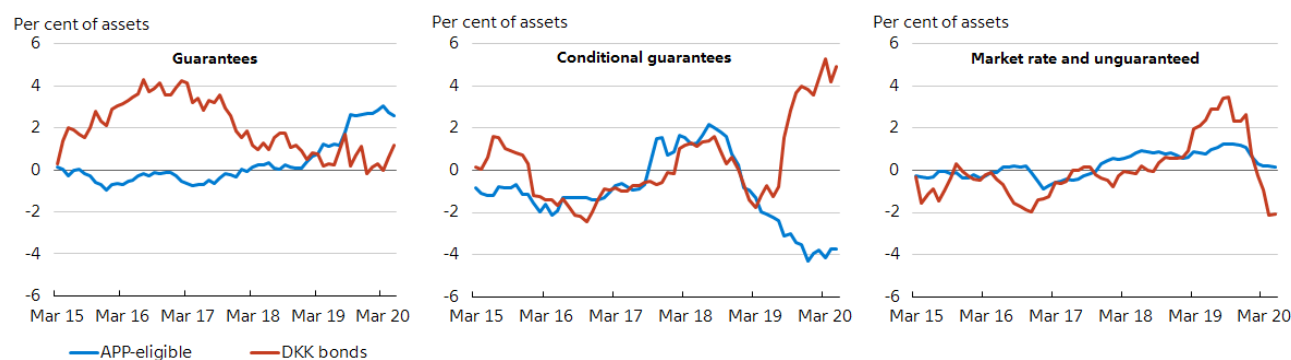
Figure 6: Composition of assets depending on pension companies' liability structure



*Note: The figure shows the difference in asset allocation based on the dominant liability structure of the companies.
Source: Danmarks Nationalbank and own calculations.*

There are differences between the rebalancing behaviour of the three groups, cf. Figure 7. Both the group of companies with hard guarantees and the group of conditional guarantees sold APP-eligible bonds within the first year after the introduction of the APP in March 2015. Companies with guarantees bought Danish bonds at a high pace, while companies with conditional guarantees only bought Danish bonds in the first months after March 2015. Companies with market rate plans slightly reduced PSPP-eligible bonds, but from a low starting point.

Figure 7: Transactions by type of company - DKK bonds and APP-eligible bonds



*Note: Accumulated net transactions divided by average total assets in the period March 2015 - May 2020.
Source: Danmarks Nationalbank and own calculations.*

We run the regressions based on (5.1) on the three subsamples of groups to investigate whether one or more groups of companies are driving the rebalancing from APP-eligible bonds into Danish bonds in the

initial period until March 2016. The results are presented in Table 3. The large group of companies with guarantees is the only group to significantly reduce its demand for PSPP-eligible bonds. The increase in the demand for Danish mortgage bonds is just short of being statistically significant using the two-tailed test at normal significance levels. Grouping Danish mortgage and government bonds together leads to a significant increase in the demand for Danish bonds for the group of guaranteed companies. The increase in the demand for Danish mortgage bonds alone is only statistically significant for the group of companies with unguaranteed plans and market rate plans. This partly owes to a shift from Danish government bonds to mortgage bonds for this group. Thus, while we find some evidence of a substitution effect from PSPP-eligible bonds to Danish mortgage bonds, we do not find strong evidence that one type of companies alone is driving the result. However, it should again be noted that we do not have a clean split of assets by pension plan type within the companies.

Table 3: Accumulated net transactions for groups of companies - March 2015 to March 2016

VARIABLES	(1) Guarantees	(2) Conditional	(3) Market rate
CSPP	8.30 (8.08)	16.58 (32.00)	5.12 (3.72)
CBPP3	-2.10 (16.63)		9.45 (54.13)
PSPP	-48.64** (24.15)	-65.51 (87.60)	-14.95 (16.76)
MTG_{DK}	36.87 (23.87)	89.91 (55.65)	33.48*** (11.39)
GOV_{DK}	144.34 (347.84)	150.68* (91.05)	-43.60 (103.17)
CVR FE	YES	YES	YES
Controls	YES	YES	YES
Continent FE	YES	YES	YES
Observations	13,164	3,159	7,557

*Note: Accumulated transactions during the period March 2015 to March 2016. CSPP was not yet active during this period. No observation for CBPP3 for the group of conditional guarantees. Robust standard errors in brackets. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The table shows the regressions of adjusted, accumulated net transactions in fixed income products by company and over varying time horizons.*

Source: Danmarks Nationalbank and own calculations.

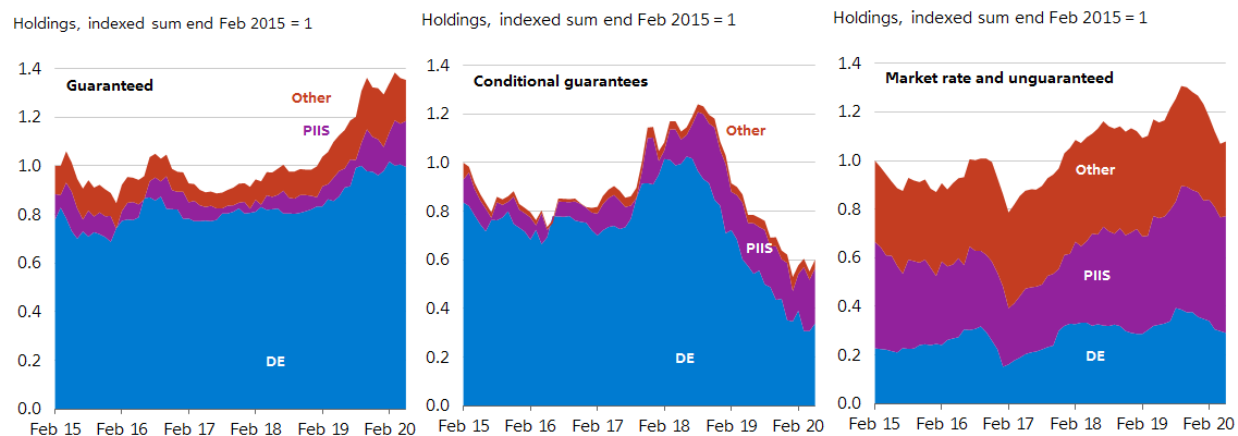
After the initial period of the APP, we observe some remarkable differences in investments in APP-eligible bonds among the groups. Companies with guaranteed plans increased their purchase of APP-eligible bonds particularly from late 2018 when the intensity of APP purchases by the ECB was going down before being reduced to zero from 2019. Overall, companies with guarantees have increased their holdings of APP-eligible bonds during the period March 2015 - May 2020. In relative terms, they have increased their holdings by slightly more than the growth in their assets. Thus, companies with guarantees have maintained APP-eligible bonds as a preferred habitat despite the ECB's asset purchases.

Companies with conditional guarantees on the contrary strongly reduced their APP-eligible bond holdings starting from 2018, and from late 2019 increased their purchases of Danish bonds. Figure 8 shows a split

of the groups' APP holdings by issuer country. The reduction in APP holdings for the companies with conditional guarantees came via a reduction in German bond holdings.

According to Figure 8, the composition of APP-eligible bond holdings for companies with market rate plans and unguaranteed plans differs widely from that of the other two groups: Bonds issued by countries experiencing the most financial stress during the sovereign crisis make up a much larger share of their APP holdings. German bonds, however, make up a much smaller part. This indicates that these companies use the APP-eligible bonds differently in their portfolio as they have a smaller need for hedging of interest rate risk. Nonetheless, the introduction of the APP did not appear to motivate these companies to rebalance their portfolio away from APP-eligible bonds. Beginning around the time when the ECB reduced the pace of asset purchases in early 2018, the group of companies appears to increase their holdings of APP-eligible bonds issued by the countries experiencing the most stress during the sovereign debt crisis. The increase in APP holdings ceased in late 2019 close to the time when the ECB announced it would restart its asset purchases.

Figure 8: Decomposition of APP holdings by issuer country by type of pension company



Note: APP-eligible bonds by issuer country. DE: Germany, PIIS: Portugal, Ireland, Italy and Spain. Each series shows the change in holdings in market value over time. The series is indexed to sum to 1 at the end of February 2015.

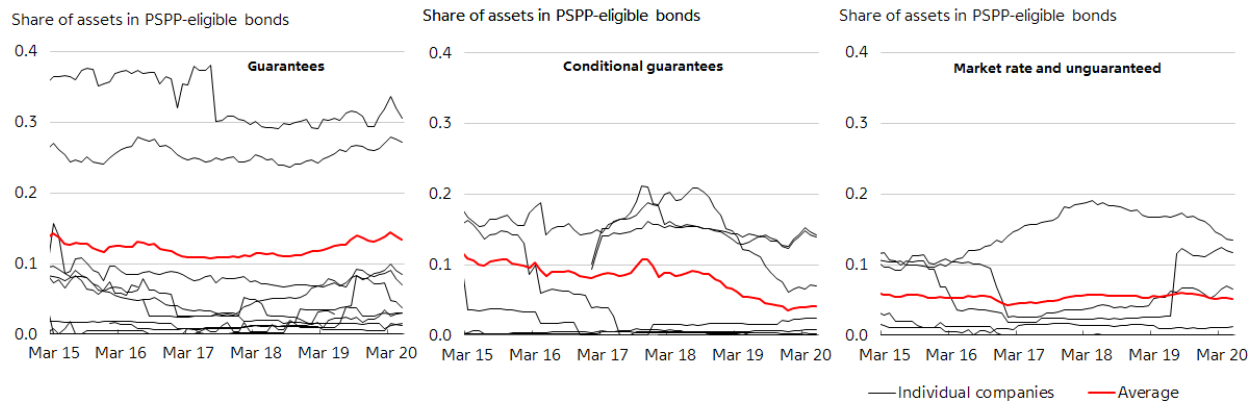
Source: Danmarks Nationalbank and own calculations.

7.1 Heterogeneity within groups of companies

A final, remarkable observation is that seemingly similar companies display very different investment strategies and reactions, cf. Figure 9. A high average holding of PSPP-eligible bonds for companies with guarantees masks a very large heterogeneity within the group. Many companies hardly hold any PSPP bonds whereas PSPP bonds make up a substantial share of the entire portfolio of some companies. This may be related to a decision by some companies to rely on interest rate derivatives to obtain duration. Unfortunately, our data set does not include these. For the group of companies with guarantees, the individual companies behave in a relatively similar manner, with a declining share of APP-eligible bonds initially and an increase in the latter part of the time sample. For the two other groups of companies, there

are substantial differences in the reactions of the individual companies. For the majority of companies, there seems to be a reduction of the PSPP share in 2015 and 2016, but at differing speeds and with different timing. From mid-2016, some companies increased their holdings while others decreased them, and there is no obvious common trend in these groups. This is consistent with the notion that these companies use euro government bonds in a less structural way compared to companies with guarantees.

Figure 9: Heterogeneity within and between groups of companies



*Note: Weighted average for groups. Data for individual companies are anonymised.
Source: Danmarks Nationalbank and own calculations.*

That companies react to general market conditions so differently and at different points in time is an important insight. It makes it incredibly difficult to predict the reaction of the pension sector as a whole both in terms of the expected reaction and its timing. A sudden large change in the investment behaviour of all companies concurrently would have a large impact on financial markets, for instance if the sector were to be hit by an economic shock that affects all companies at the same time. Apparently, the ECB's APP was not such a shock.

8 Concluding remarks

This paper uses a novel data set to examine the portfolio rebalancing of Danish pension companies in relation to the ECB asset purchase programmes. A unique feature of the data is its granularity and coverage of both assets and liabilities. The data cover all major individual Danish pension funds' transactions and holdings of individual assets at a monthly frequency spanning from February 2015 to May 2020. Detailed information on the bonds enable us to identify which bonds are eligible for the ECB's asset purchase programme that began in March 2015 and are used as controls for identifying the portfolio rebalancing effects. For the individual pension companies, we have information on which types of pension plans they manage. We use this to investigate whether the portfolio rebalancing depends on the company characteristics.

In our empirical analysis, we follow the individual pension companies' transactions in the bonds eligible for ECB purchases during the different stages of intensity of ECB purchases. Of specific interest is whether

the pension companies rebalance their portfolios towards Danish bonds. Such a rebalancing can affect the demand for Danish kroner. Thus, to the best of our knowledge, this is the first paper analysing cross-border spillovers from asset purchases in a fixed exchange rate regime. Overall, we conclude that euro government bonds remained a quasi-preferred habitat for the Danish pension companies to complement their preferred habitat in Danish kroner bonds. During the phase of high-intensity purchases by the ECB from March 2015 to the end of 2017, the pension companies' net transactions of bonds eligible for ECB purchases were zero, with no statistical effect on the demand for bonds from ECB purchase eligibility. However, we found that the pension companies in the initial phase of the APP in 2015 and early 2016 sold bonds purchased by the Eurosystem. Their demand for Danish bonds concurrently increased. The rebalancing from APP-eligible bonds into Danish bonds died out in early 2016 even though the Eurosystem was still buying bonds at a rapid pace. The results are the same when we analyse an indirect rebalancing channel to account for the effect of portfolio growth over time.

We argue that Danish pension companies behaved comparably to the insurance and pension sector in the euro area as documented by other studies. Thus, there can be a case for euro area central bankers to analyse which and how many other foreign investors have a quasi-preferred habitat in euro bonds, as it may affect the effectiveness and transmission of additional asset purchases.

In recent years, there has been a shift in the Danish pension industry away from guaranteed pension plans towards market rate plans. Based on the split of companies by pension liability type, we concluded that companies with guaranteed plans exhibit the strongest signs of having euro government bonds as a preferred habitat as they hold the most bonds and even slightly increase their holdings through the period of the ECB asset purchases. The composition of euro government bonds for companies with unguaranteed plans or with market rate plans is skewed towards bonds issued by lower-rated countries. The reaction to the APP was very inhomogeneous among seemingly similar companies within this group. A shift towards market rate plans therefore reduces the demand for certain types of euro government bonds, and makes it more difficult to predict the aggregate response of the pension sector.

Our findings provide important insights into spillovers from euro area monetary policy to Denmark as Danish pension companies' transactions and investments play a central role in the Danish foreign exchange market due to their size. A spillover of monetary policy does not necessarily involve financial transactions, but we find that in the first year of the ECB's asset purchase the spillover led to such, whereas the later stages of the ECB's purchases did not. The rebalancing away from euro bonds and into Danish bonds from March 2015 and during the following year led to a higher demand for Danish kroner. In this episode, however, the effect was offset by a strong, probably unrelated decline in the pension companies' demand for currency hedging. In future, a rebalancing event of the same magnitude as the one in 2015 could therefore potentially lead to a more pronounced change in the demand for kroner.

Our analysis suggests that central banks should carefully follow and analyse trends in the pension sector and engage in frequent dialogues with companies to stay on top of developments in their investment strategies.

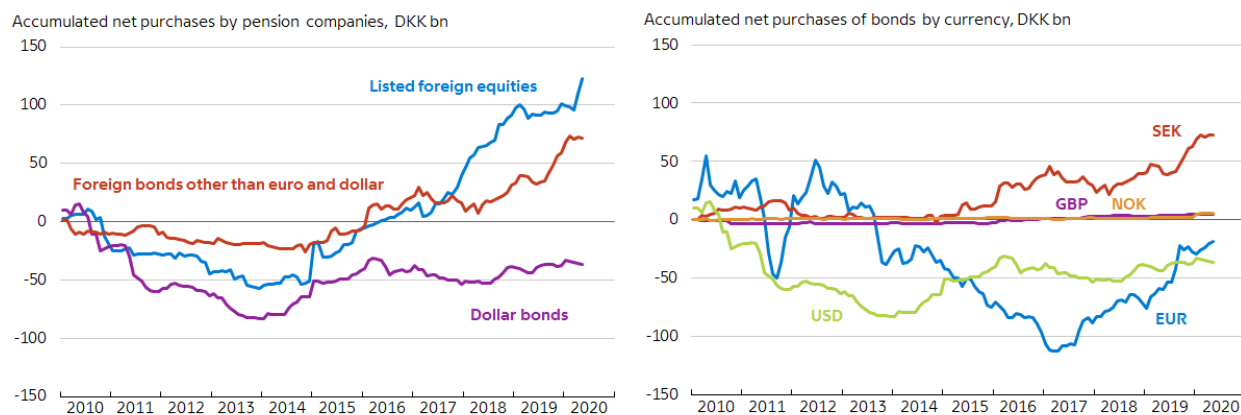
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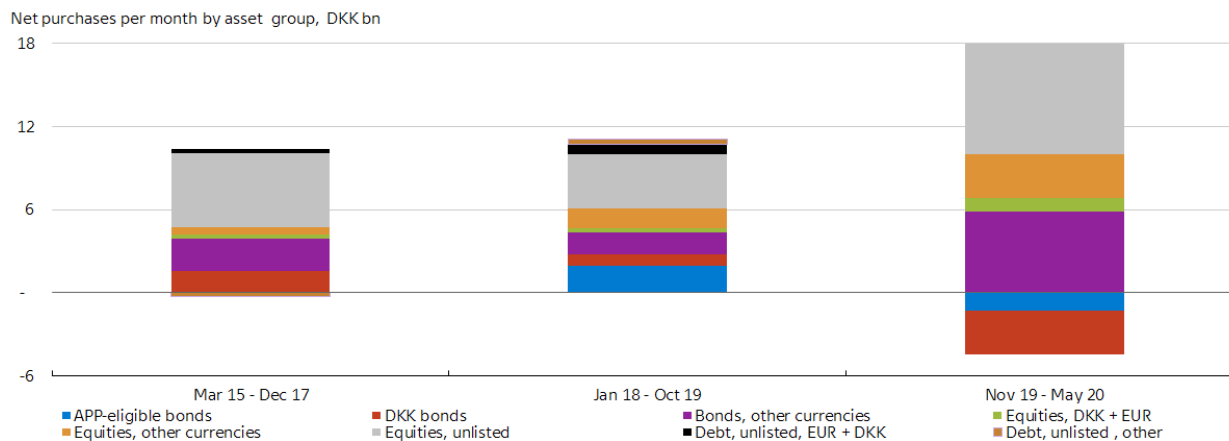
Appendices

Figure A.1: Accumulated net purchases by pension companies of selected foreign assets in 2010-2020



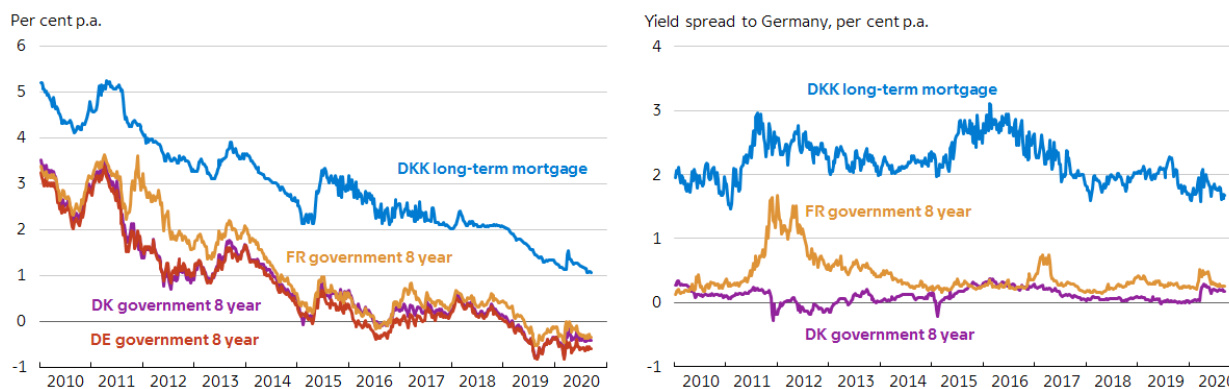
Note: Based on Danmarks Nationalbank's foreign portfolio investment statistics. Only aggregate data available. No look through of investment funds.

Source: Danmarks Nationalbank and own calculations.

Figure A.2: Net purchases of asset groups during different APP phases - further breakdown

Note: Total net purchases over periods.

Source: Danmarks Nationalbank and own calculations.

Figure A.3: Development in bond yields (left) and yield spreads to Germany (right)

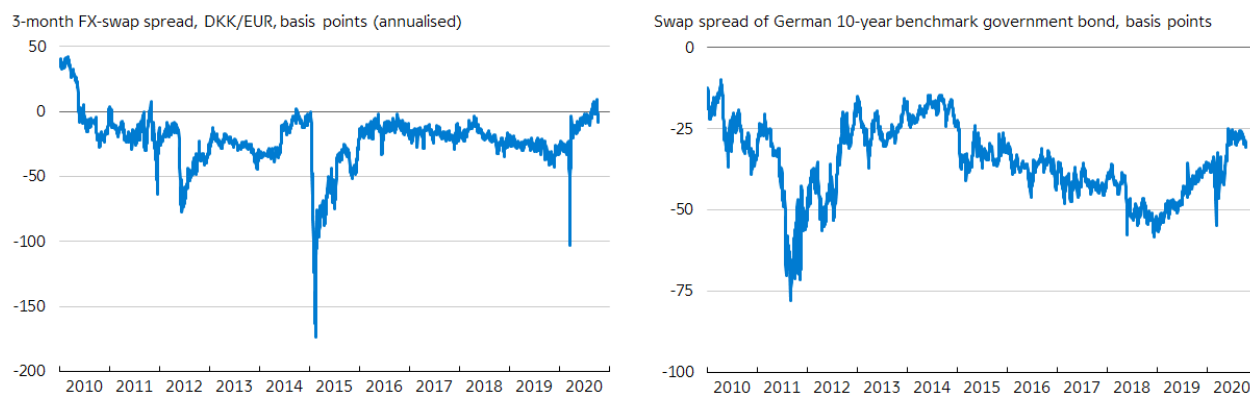
Note: Government bonds are eight year estimated zero coupon yields sourced from Bloomberg. The data for mortgage bonds are the average yield to maturity of 30-year amortising bonds issued the last week and sourced from Refinitiv Eikon. Danish long-term mortgage bonds are issued under the balance principle, and the loan includes a prepayment option at par for the borrower. The duration of the bond therefore changes significantly when interest rates change. The option-adjusted duration of the displayed mortgage bond yield series is around 10 years, but varies.

Table A.1: Accumulated net transactions in bonds by company and over time periods - all variables

VARIABLES	(1) Mar 2015 - Mar 2016	(2) Mar 2015 - Mar 2017	(3) Mar 2015 - Dec 2017	(4) Jan 2018 - Oct 2019	(5) Nov 2019 - May 2020	(6) Full sample
CSPP	10.88 (7.00)	12.35 (8.45)	10.52 (7.18)	1.04 (2.45)	-2.25 (1.97)	2.75 (3.81)
CBPP3	1.85 (23.72)	27.58 (27.09)	37.26 (28.32)	-0.72 (7.68)	-21.37* (12.36)	30.84 (20.10)
PSPP	-54.22** (19.48)	9.78 (37.21)	28.30 (39.97)	54.82 (33.13)	1.81 (12.46)	42.18 (29.29)
MTG_{DK}	43.84** (17.09)	30.44* (17.07)	30.10** (14.24)	16.36** (7.38)	-1.90 (10.01)	30.34** (11.65)
GOV_{DK}	78.59 (107.91)	184.02 (131.26)	212.44 (157.53)	37.13 (49.66)	100.85 (72.45)	209.31 (154.79)
dUSD	-12.13 (9.97)	-7.04 (8.48)	-2.60 (8.26)	-3.22 (6.12)	-1.03 (2.53)	-7.64 (7.62)
dEUR	-7.62 (7.53)	-6.89 (8.64)	-2.72 (7.06)	-2.00 (6.90)	0.23 (2.38)	-4.73 (6.03)
TTM	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	-0.00 (0.00)	0.00 (0.00)
Rating	1.31 (1.37)	-0.60 (1.42)	-1.01 (1.16)	-0.05 (0.22)	-0.27 (0.32)	-0.26 (0.48)
YTM	-0.19 (0.31)	-0.02 (0.26)	0.17 (0.31)	-0.77*** (0.19)	-0.08 (0.10)	-0.47*** (0.17)
Marketvalue	0.00** (0.00)	0.00 (0.00)	-0.00 (0.00)	-0.00** (0.00)	0.00 (0.00)	-0.00** (0.00)
Holdings	-16.29*** (5.10)	-25.25*** (8.34)	-30.71*** (11.04)	-16.32*** (4.47)	-5.85*** (1.76)	-40.70*** (14.26)
Avgrateshare	-1,077.5** (430.4)	-620.3*** (99.2)	-471.5*** (81.6)	-1,151.3*** (285.6)	968.4 (667.6)	-301.3*** (72.8)
Constant	1,152.42** (438.19)	776.11*** (86.80)	611.91*** (68.50)	1,180.15*** (286.01)	-928.70 (668.58)	367.74*** (69.48)
CVR FE	YES	YES	YES	YES	YES	YES
Continent FE	YES	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES	YES
Observations	23,880	34,408	40,490	55,212	48,544	84,267

*Note: Full sample is March 2015 to May 2020. Robust standard errors in brackets. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The table shows the regression of accumulated net transactions in fixed income products by company and over varying time horizons. dUSD and dEUR are dummies for denomination in US dollar and euro respectively. TTM is time to maturity at the beginning of the period, Rating is the average rating over the period from the three agencies for which we have data: AAA or the equivalent equals 1, AA+ equals 2 and so forth. and YTM is the yield to maturity at the beginning of the time period. Marketvalue is the change in the total market value of the asset over the time period. Holdings are the initial holdings of the asset by company. Avgrateshare is the share of average rate plans for each company. Source: Danmarks Nationalbank and own calculations.*

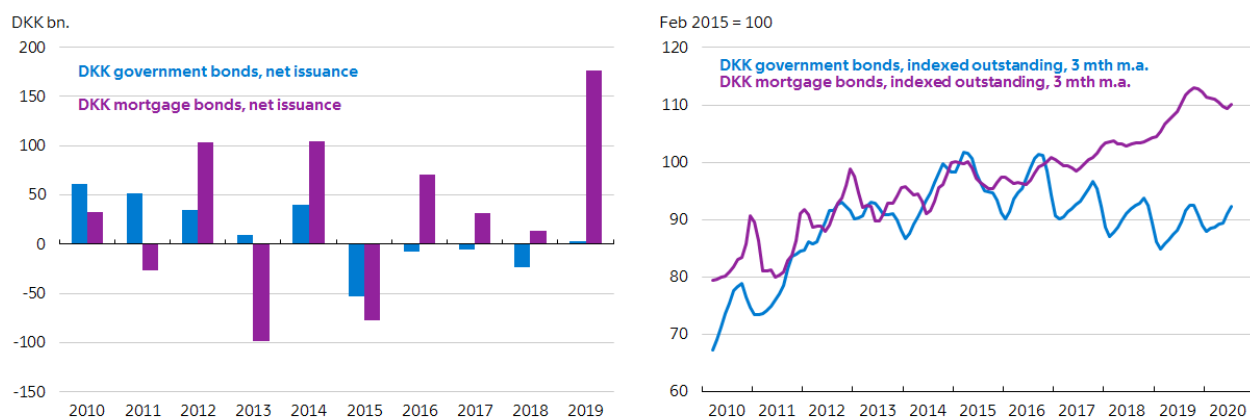
Figure A.4: Developments in hedging cost of euro to kroner (left) and swap spreads of German 10-year government bonds (right)



Note: Left-hand chart: A positive value entails a positive carry of hedging euro exposure into Danish kroner using a three-month FX swap.

Source: Refinitiv Eikon and own calculations.

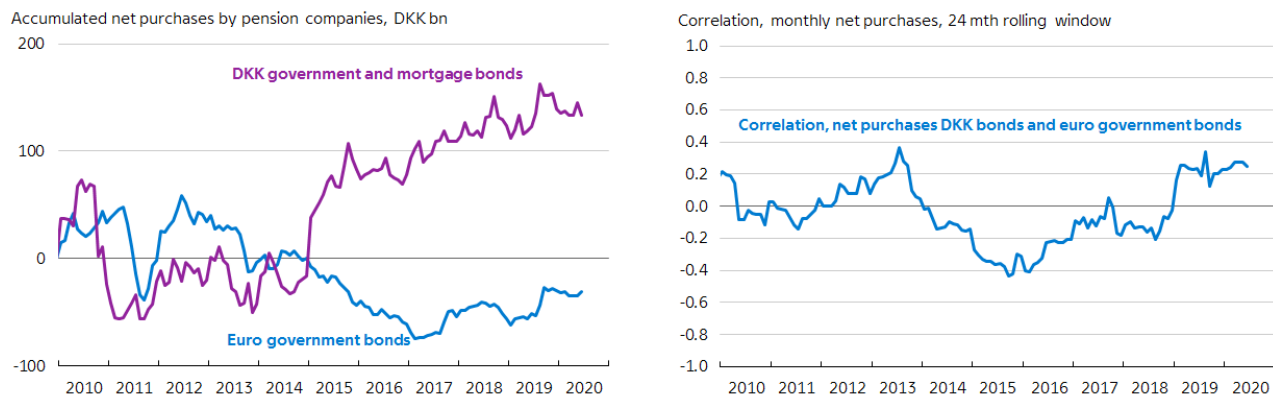
Figure A.5: Net issuance of Danish bonds (left), and development in outstanding amounts (right)



Note: Based on Danmarks Nationalbank's securities statistics. Market values.

Source: Danmarks Nationalbank and own calculations.

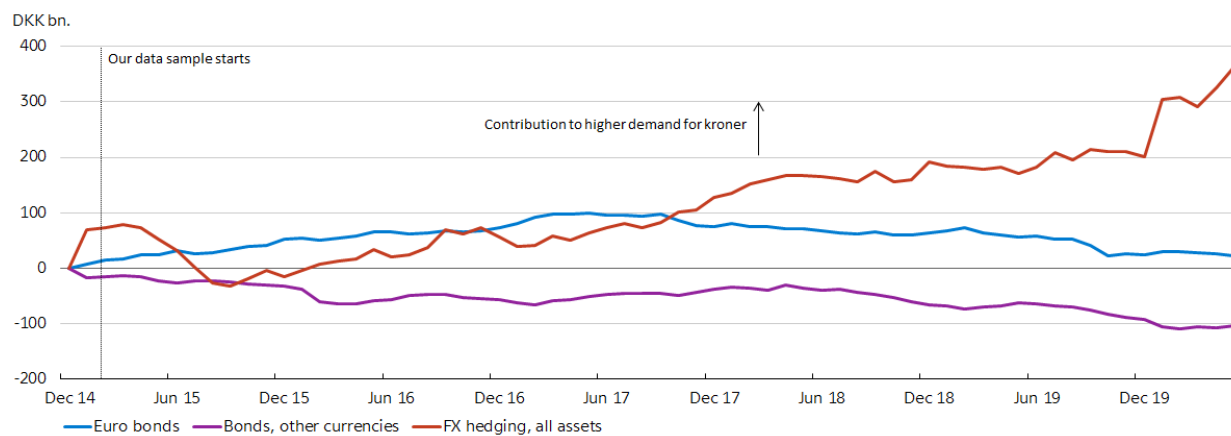
Figure A.6: Accumulated net purchases in 2010-2020 by pension companies based on alternative data sources (left) and correlation of purchases



Note: Based on Danmarks Nationalbank's securities statistics and foreign portfolio investment statistics. Only aggregate data are available. No look through of investment funds. The correlation in right-hand chart is the simple correlation coefficient of net purchases for the given months and the preceding 23 months.

Source: Danmarks Nationalbank and own calculations.

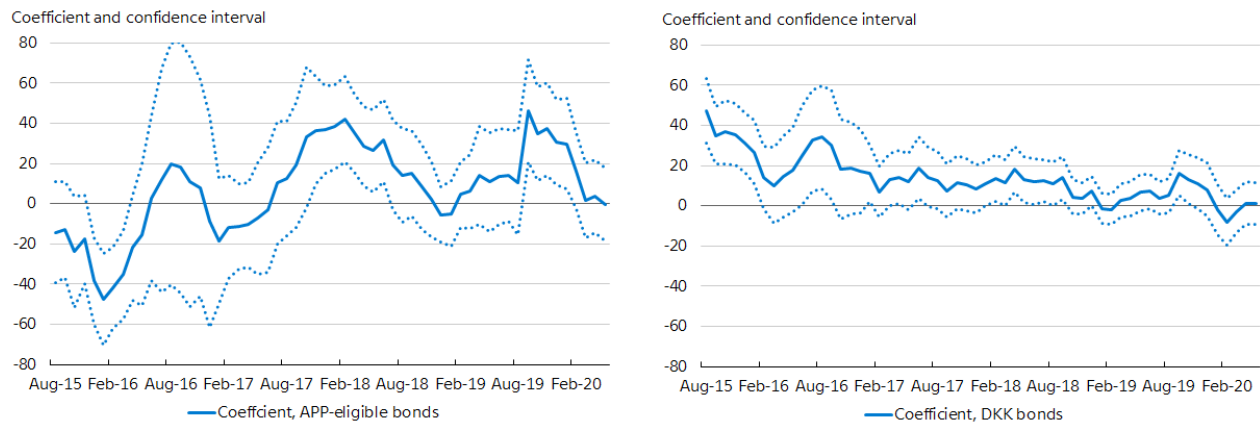
Figure A.7: Drivers of pension companies' net demand for kroner



Note: Accumulated since January 2015.

Source: Danmarks Nationalbank and own calculations.

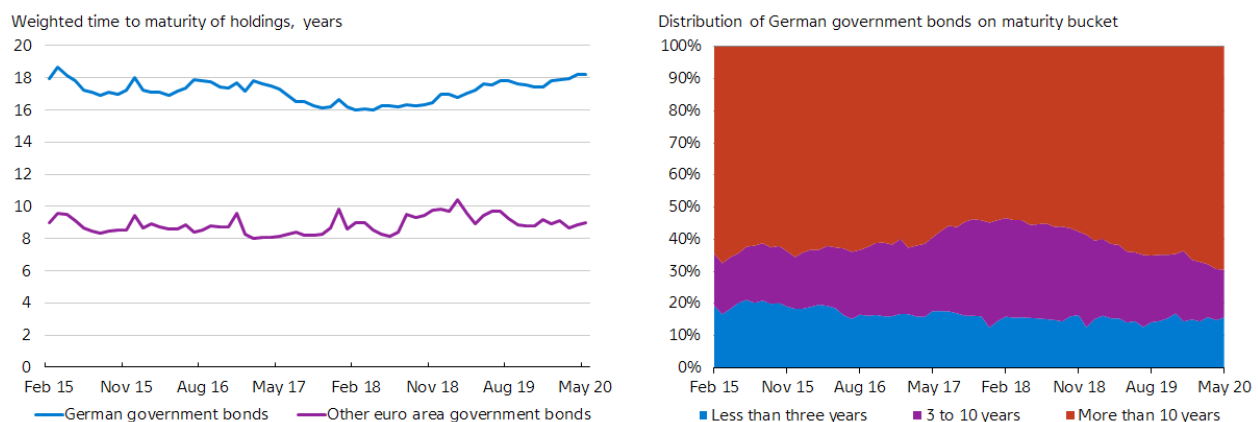
Figure A.8: Regression coefficient and confidence interval for APP eligibility (left) and Danish bonds (right) - six-month rolling window



Note: Due to shorter time samples compared to Table 1, one APP eligibility dummy includes the three eligibility dummies for the PSPP, CBPP3 and CSPP. Likewise, the dummy for Danish bond covers the dummies for Danish government bonds and mortgage bonds. The time axis shows the last month of the sample period, such that August 2015 covers transactions in the period March 2015 to August 2015.

Source: Danmarks Nationalbank and own calculations.

Figure A.9: Weighted time to maturity and maturity distribution of German bonds



Note: Includes all euro area government bonds denominated in euro, i.e. also bonds not eligible for the PSPP due to short time to maturity.

Source: Danmarks Nationalbank and own calculations.

Low for long

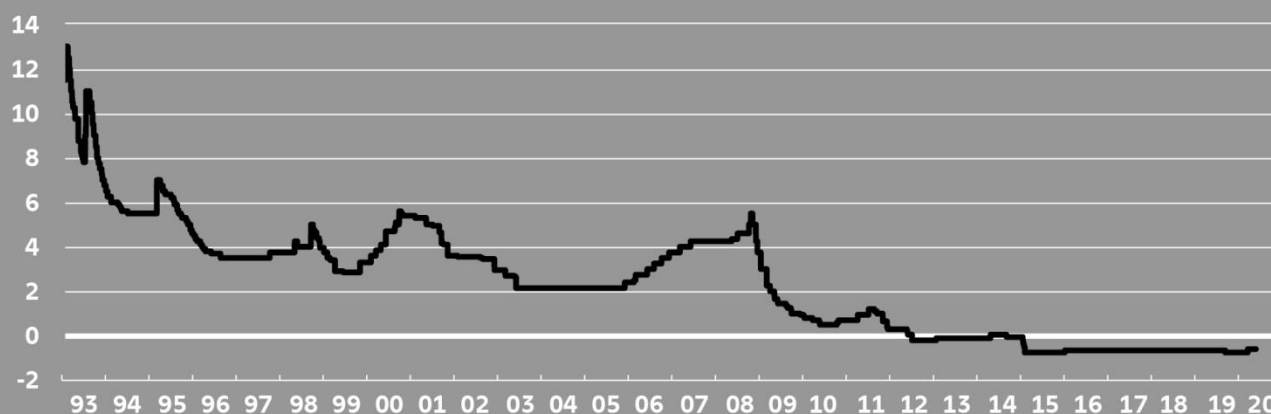
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Very low and in some cases negative interest rates have characterised the past decade across the advanced economies. There are several reasons why interest rates have fallen to the current low levels. Low interest rates reflect the fact that inflation has been subdued in many countries, but structural changes in household and corporate savings and investment behaviour are also part of the explanation.

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Danmarks Nationalbank's interest rate

Per cent



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