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Research Report

The corporate investment channel of monetary policy in Denmark

Economic Memo, No. 4

Provided in Cooperation with:

Danmarks Nationalbank, Copenhagen

Suggested Citation: Bonin, Simone Maria; Cucic, Dominic; Kuchler, Andreas; Otte, Alexander Meldgaard (2024) : The corporate investment channel of monetary policy in Denmark, Economic Memo, No. 4, Danmarks Nationalbank, Copenhagen

This Version is available at:

<https://hdl.handle.net/10419/301965>

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The corporate investment channel of monetary policy in Denmark

An important monetary transmission channel works through the impact of interest rate changes on non-financial firms' investment decisions. Higher monetary policy rates affect firms' investment decisions by raising the costs of external financing and lowering aggregate demand for goods and services. Using 20 years of firm-level data from Denmark, we find that an increase in monetary policy rates is associated with a reduction in corporate investment, particularly by smaller firms.

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**Higher monetary policy rates dampen investments**

Corporate investment in Denmark declines following an increase in monetary policy rates. The peak impact materialises after 2-3 years. The delayed response reflects, among other things, that typically, investment is planned well in advance.

**Limited role of firm heterogeneity in monetary policy transmission**

Heterogeneity in terms of firm characteristics plays a minor role in shaping the transmission of monetary policy to corporate investment in Denmark, with firm size being the notable exception. We find that smaller firms reduce investment more than larger firms after a monetary tightening.

**Investment has been resilient overall in the wake of tighter monetary policy**

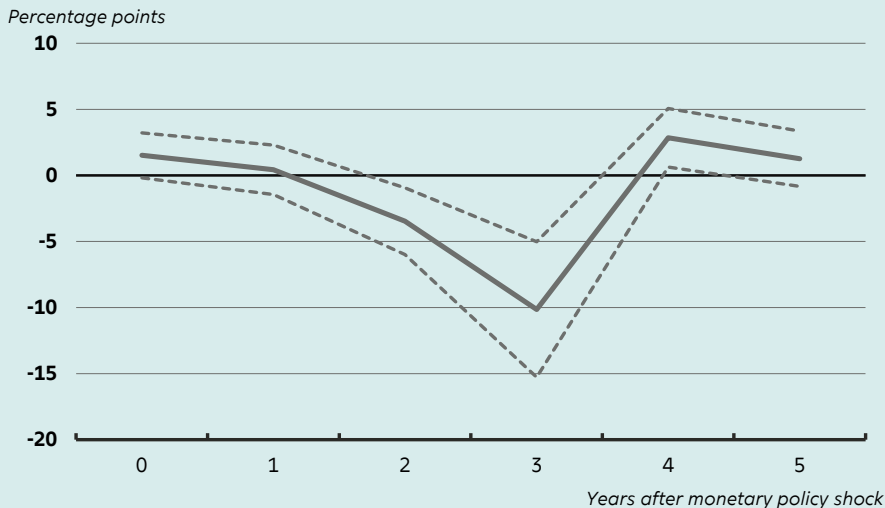
Our findings suggest that the increases in monetary policy rates in 2022-23 will keep weighing on investment in 2024. The contractionary effects might continue in 2025-26, given the estimated lag in adjustment of investment to monetary policy rate changes. Total corporate investment is driven by many factors and has weakened moderately to date.

Why is this important?

Danmarks Nationalbank is the monetary policy authority in Denmark responsible for setting the monetary policy rates. In line with Denmark's fixed exchange rate policy, Danmarks Nationalbank maintains a fixed exchange rate of the krone against the euro. An important part of the transmission of monetary policy to the real economy is the impact on firms' investment. Higher monetary policy rates affect firms' investment decisions by raising the costs of external financing and lowering aggregate demand for goods and services. A thorough understanding of the monetary transmission is important in order to assess the current macroeconomic situation and to formulate economic policy recommendations.

Main chart

Investment declines with a lag in response to an unanticipated increase in monetary policy rates



Note: Estimated average change in investment rate from year -1 to year t as response to a 100 basis points increase in monetary policy rates. The chart shows the point estimate as well as 95 percent confidence bands.

Source: Own calculations based on data from Statistics Denmark, Danmarks Nationalbank, and Jarociński and Karadi (2020).

Keywords

Households and corporations

Investments

Monetary policy interest rates

Research

01

Introduction and main insights

Monetary policy rates have increased sharply on a global scale since 2022 in order to combat the rise in inflation. Within a two-year span, the European Central Bank (ECB) increased its key monetary policy rates at the fastest pace in its history. Owing to the fixed exchange rate policy vis-à-vis the euro in Denmark, Danmarks Nationalbank increased its monetary policy rates comparably, which in turn impacted the debt financing costs of Danish firms, see chart 1.

Understanding the magnitude and timing of how changes in monetary policy rates affect the economy is crucial for assessing the macroeconomic conditions. Monetary transmission works through multiple channels. An important one is the investment channel, which is based on the idea that higher interest rates impact firms' investment decisions by increasing external financing costs as well as lowering the demand for the goods and services firms produce. Investment is among the most volatile components of GDP, see chart 2, and is often found to react strongly to monetary policy changes (Ottonello and Winberry, 2020).

Monetary policy impacts investment at firm level and in the aggregate

In this memo, we fill a gap in the literature by studying the dynamic investment response of Danish firms to changes in monetary policy rates over the past 20 years in Denmark and the euro area.^{1,2} The impact of monetary policy on investment cannot be directly observed by considering, for example, how investment develops after a change in monetary policy rates. Firstly, monetary policy rates and investment are both endogenous and driven by many factors.³ Secondly, the interest rate change may have been expected, implying that firms have already adjusted their investment plans before the change actually happened. For this reason, researchers have developed methods for assessing the effects of monetary policy, see review in box 2 in Andersen et al. (2024). To tackle the endogeneity of monetary policy decisions and provide a clear estimate of the causal effects, we follow the recent literature by focussing on the effects of *unanticipated* monetary policy rate changes – also referred to as 'shocks'. In doing so, we employ a panel Local Projection Instrumental Variable (LP-IV) framework similar to Jorda, Schularick, and Taylor (2020), instrumenting changes in Danish rates with unexpected changes in euro area monetary policy rates following Jarociński and Karadi (2020). The unanticipated changes are identified from reactions of financial markets in narrow windows around ECB monetary policy announcements, see the next section for more details.

Our results based on both accounting data at firm level and aggregate data from the national accounts suggest that interest rate hikes typically take 2-3 years to affect corporate investment. First, we investigate the effects at firm level and find

¹ Earlier literature based on data from Denmark showed that unanticipated changes in Danish interest rates cause a decline in bank lending and a reduction in investment in the following year by the average Danish firm (Cucic and Gorea, 2022). Our memo focuses instead on the dynamic response of investment over time and heterogeneous responses across firms. Kuchler (2019), studying the role of the balance sheet channel in Denmark, finds that high leverage contributed to a slow recovery in investment during the downturn that followed the financial crisis, particularly for small and medium-sized enterprises.

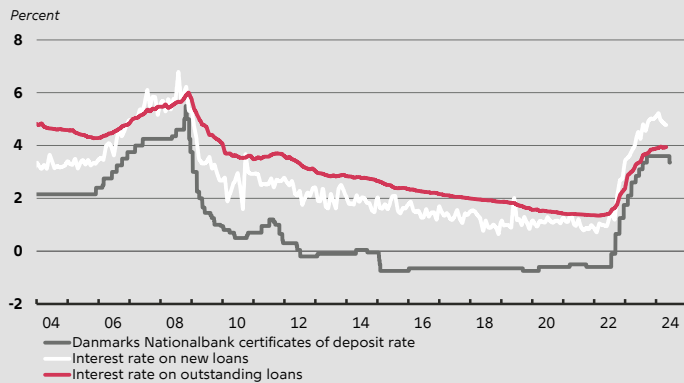
² We investigate the impact of a *common* change in rates since the monetary policy rates in Denmark closely follow the ones of the ECB due to the fixed exchange rate policy.

³ Danmarks Nationalbank sets its monetary policy rates with the sole objective of ensuring a fixed exchange rate of the krone vis-à-vis the euro, completely disregarding the general economic conditions in Denmark. However, in the data, Danish monetary policy rates are correlated with Danish economic conditions, since there is a tight connection between the business cycles in Denmark and the euro area, and Danish rates tend to follow the policy rates of the ECB, when the ECB alters its rates to stabilise the euro area economy.

that the average Danish firm reduces its investment rate – measured as the annual growth rate in its fixed assets – by approximately 10 percentage points in response to a 100 bps increase in interest rates. There is, however, considerable uncertainty surrounding the exact estimate. Next, we adapt our estimation strategy to quarterly data on aggregate investment from the national accounts and find consistent evidence of significantly negative effects materialising with a lag. The delayed transmission aligns with existing literature (Cloyne et al., 2023, Jungherr et al., 2022, Cao et al., 2023, Thürwächter, 2022), emphasising that firms’ investment decisions are typically planned well in advance, particularly when it comes to large investments that are made relatively infrequently.

CHART 1

Hikes in monetary policy rates have been transmitted to firms through higher debt financing costs

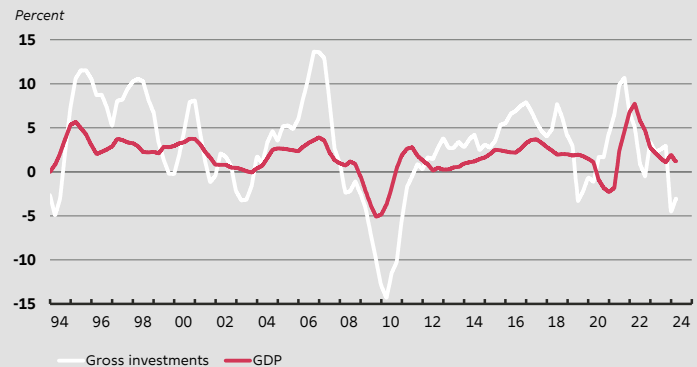


Note: Average interest rates on loans intermediated by Danish banks and mortgage banks.

Source: Danmarks Nationalbank.

CHART 2

Higher volatility of investment than GDP in Denmark



Note: Four quarters moving average of annual growth rates.

Source: Statistics Denmark and own calculations.

Regarding the recent monetary tightening, our results suggest that, all else being equal, higher interest rates will contribute negatively to investment throughout 2024-2026. However, as discussed in detail at the end of the memo, extrapolation of our empirical estimates should be done cautiously. Our estimates of the impact of unanticipated monetary policy changes may deviate from the impact of the recent monetary policy hikes, as those policy rate increases were anticipated well in advance.

The role of firm heterogeneity in shaping the impact on investment

We next explore the role of firm heterogeneity in the transmission of monetary policy, examining in particular how characteristics such as firm age, firm size, and industry affect the responsiveness of firms to changes in monetary policy. A key theoretical framework that helps explain these differential responses is the credit channel of monetary transmission (Durante et al., 2023; Cloyne et al., 2023; Ottonello and Winberry, 2020). The credit channel theory suggests that the transmission of monetary policy might be amplified through its influence on credit availability and credit costs, disproportionately impacting firms with more limited access to credit. Firm age works as a proxy for such ‘financial frictions’ since younger firms typically face greater informational asymmetries and have less established credit histories (Gertler, 1988).

We examine the role of heterogeneity in firms’ investment responses and find that it generally plays a minor role in Denmark. This aligns with a recent study on Norwegian firms (Cao et al., 2023) and is consistent with the broader literature

documenting small differential effects across firms (Durante et al., 2023). However, we do find indications of heterogeneous investment responses across firms of different sizes. We show that smaller firms reduce investment significantly more than larger firms following a monetary tightening in Denmark and the euro area. This may reflect the fact that we consider a regional policy tightening (in Denmark and the euro area), while some large firms are often more globally oriented, towards the United States, for instance. Thus, large firms are less exposed to changes in regional financing conditions and regional demand for their products and services.

The remainder of the memo is structured as follows: First, we introduce the data and methodology. Then we present our baseline results for the average investment response at firm level. Next, we investigate the role of firm heterogeneity. After finalising the firm-level analysis, we adapt our methodology to aggregate investment data. The final section includes a discussion and concluding remarks focusing on the policy implications of our findings.

02

Data and methodology

We estimate the dynamic response of corporate investment to monetary policy changes in Denmark and the euro area. A major challenge in estimating the reaction of firms' investment to changes in monetary policy interest rates is that these changes are often anticipated. Consequently, firms may have already adjusted their investment plans prior to the announcement of monetary policy decisions. This is one of the reasons why the observed relationship between interest rate changes and real economic outcomes may not reflect the true effect of the changes in interest rates at the time when the monetary policy rate change happens. We address this endogeneity problem by instrumenting changes in Danish monetary policy rates with ECB monetary policy rate shocks. The shocks reflect changes to the ECB monetary policy rates that were unanticipated by financial market participants. These shocks are identified during narrow periods around ECB monetary policy announcements. Due to Denmark's fixed exchange rate policy vis-à-vis the euro, these unanticipated changes in euro area rates have a direct, unanticipated impact on Danish policy rates. Our approach has the advantage of providing a clean estimate of the reaction of investment to changes in monetary policy interest rates identified from high-frequency shocks. The flip side of this is that these estimates might not be extrapolated to situations where the rate changes were expected, see further discussion at the end of the memo. The econometric model is outlined in box 1.

In the main part of the memo, we use firm-level data from Statistics Denmark from the period 2000-2019. We focus on firms in the non-financial, non-agricultural sectors that are not coops, sole proprietorships, public entities or NGOs. We further restrict the sample to active firms with turnover and total assets of over kr. 375,000⁴ (EUR 50,000) and at least one employee. We also restrict the analysis to firms observed in the data for at least five consecutive years. The estimation dataset contains approximately 355,000 observations covering 53,000 firms with an average of 38 employees (and a median of nine). We trim the investment rate and the change in the investment rate to reduce the impact of outliers on our results. Moreover, we deflate all values to 2015 values using the consumer price index.

Flow data on investment is only available for a smaller sample of firms, so instead we follow the balance sheet based approach of Durante et al. (2022) to be able to use a larger part of the dataset. To be more specific, our measure of firm-level investment is the real net investment rate, denoted as I_{it} , representing the annual growth rate of firm i 's fixed assets k in year t , $I_{it} = \frac{(k_{it} - k_{it-1})}{k_{it-1}}$. The net investment rate in our sample is very volatile with an average of 8 per cent and a standard deviation of 62 percentage points. Fixed assets encompass the market value of buildings, machinery, patents, licences and long-term financial investments in stocks and bonds. It should be noted that the growth rate in (real) fixed assets includes both net investment (gross investment minus depreciation) and revaluation. Since we are ultimately interested in investment behaviour, revaluation in the wake of a shock to interest rates could be expected to be a source of bias in our results in particular for real estate firms. Our results are not sensitive to the exclusion of firms in the real estate industry. The unavailability of firm-level data on fixed asset subcomponents hinders the exploration of differential impacts of monetary policy on different kinds of assets such as tangible and intangible investments.

⁴ In real terms – 2015 used as base year.

BOX 1

Data and empirical methodology

Monetary policy shocks

Our measure of the Danish monetary policy rate is based on Danmarks Nationalbank's lending rate from January 2000 until November 2013 and subsequently on the deposit certificate rate, following Andersen et al. (2023). The Danish policy rates are being set with the sole objective of maintaining the fixed exchange rate policy. However, an endogeneity problem may still arise in the data as interest rates sometimes increase following a period of high investment, cf. footnote 3. To isolate the effects of policy rates on investment, we employ the high-frequency monetary policy shock series for the euro area by Jarociński and Karadi (2020). We apply the 'poor man's sign restriction' series, derived from movements in asset prices around ECB policy announcements and sign restrictions, which allows us to isolate pure monetary policy shocks from informational effects inherent in ECB policy decisions. To align the monthly frequency of the shock series with our annual investment data, we convert this shock measure into a level measure by summing the shocks within a year (Coibion, 2012; and Nelson et al. 2018).

Identification strategy

We adopt a panel LP-IV framework similar to Jorda, Schularick and Taylor (2020) to estimate dynamic causal effects of interest rate changes on investment based on microdata. This approach enables the estimation of impulse response functions on firm-level panel data, employing identified monetary shocks as instruments for interest rate changes. Utilising a shock as an instrument facilitates interpreting its size in terms of units of the endogenous variable, the interest rate (Stock and Watson, 2018). Our strategy, relying on euro area monetary policy shocks and leveraging the Danish currency peg to the euro, introduces a highly transparent source of exogenous variation in monetary policy. Similar empirical approaches have been implemented by Andersen et al. (2024), Larsen and Weissert (2024), Jordà et al. (2020), Cucic and Gorea (2023), Jiménez et al. (2012).

Empirical specification

In our benchmark specification, we estimate impulse response functions through an instrumental variable (IV) variation of the LP approach, denoted as LP-IV.

$$\Delta_h I_{i,t-h} = \alpha_i^h + \sum_{g=1}^G \beta_g^h \times D_{i,t-1}^g \times \Delta R_t + \sum_{g=1}^G \gamma_g^h \times D_{i,t-1}^g + \theta^h \Delta X_{i,t-1} + u_{i,t+h}$$

The dependent variable, $\Delta_h I_{i,t-h}$, is the h -year forward difference in the investment rate, i.e. $\Delta_h I_{i,t-h} = I_{i,t+h} - I_{i,t-1}$. We are interested in the effect of changes in monetary policy interest rates in year t (i.e. ΔR_t) on the dependent variable at horizons $h \in (0, 1, \dots, 5)$. To handle the endogeneity of changes in interest rates, we instrument ΔR_t with the annualised monetary policy shocks from Jarociński and Karadi (2020). The indicator variable $D_{i,t-1}^g$ takes on the value of one if firm i belongs to group g at time $t-1$. These group indicators enable us to study if investment by different types of firms, e.g. young compared to old or small compared to large firms, react differently to changes in interest rates. The baseline (average) results are estimated without the group specific terms. The vector of controls $\Delta X_{i,t-1}$ includes macroeconomic control variables (one-year lagged real GDP growth and inflation in Denmark) and two lags of the outcome variable as well as two years of lagged interactions between the group indicators and changes in interest rates, instrumented with the lagged monetary policy shocks. Lastly, we incorporate firm fixed effects α_i^h to exploit within-firm variation. Standard errors are clustered at firm and year-industry level – the latter to take into account that our monetary policy rate shock series is common for all firms in a given year. Our impulse response functions are estimated over a forecast horizon of five years, prompting us to restrict the sample to firms observed for at least five years.¹

¹ Firm survival is potentially an outcome and it could be particularly relevant when examining the heterogeneous effect across firm size and age. As a robustness check, we run the entire analysis including firms that are present continuously for less than five years. The results are similar and all conclusions still hold.

03 Baseline results

Significant decline in corporate investment following an interest rate increase

Our key finding reveals a significant decline in firms' average investment following an increase in monetary policy rates. Specifically, a temporary 100 basis point hike in the monetary policy rate leads to an approximate 10 percentage point decrease in investment rates after three years, as shown in chart 3. The impact is also significant in year 2 and due to estimation uncertainty (as illustrated by the confidence bands) not necessarily much different from the impact in year 3. To put the size of this effect into perspective, the average investment rate in the estimation sample is 8 per cent. The volatility of investments over time and across firms is substantial, with the standard deviation of the investment rate being 62 percentage points. Moreover, note that what we estimate is the response to a 100 basis points increase in monetary policy rates identified through surprises in monetary policy rates. These surprises are typically relatively small, with the mean surprise (i.e., the mean shock to monetary policy rates used in our first stage) being only 4 basis points over the sample period, and a standard deviation of 9 basis points.

The observed delay in the response of corporate investment to changes in monetary policy is consistent with the typically multi-year nature of investment planning. Recent evidence indicates variability and uncertainty associated with the exact timing of the investment response, depending on the region and depending on the exact estimation methods being applied. Durante et al. (2023) suggest that the peak response of investment to changes in monetary policy in the euro area occurs after 1-2 years. However, Thürwächter (2022) presents contrasting findings, indicating that the peak effect on investment in Europe is more pronounced in years 2 and 3. In the United States, Jeenas (2019) and Cloyne et al. (2023) identify a peak effect occurring in year 3. Finally, Cao et al. (2023) and Norges Bank (2023) find a peak effect occurring in year 3 and 4 in the case of corporate investments in Norway. A large degree of estimation uncertainty is common for all studies, implying that the exact timing of the peak is surrounded by uncertainty, which warrants caution when comparing different studies.⁵

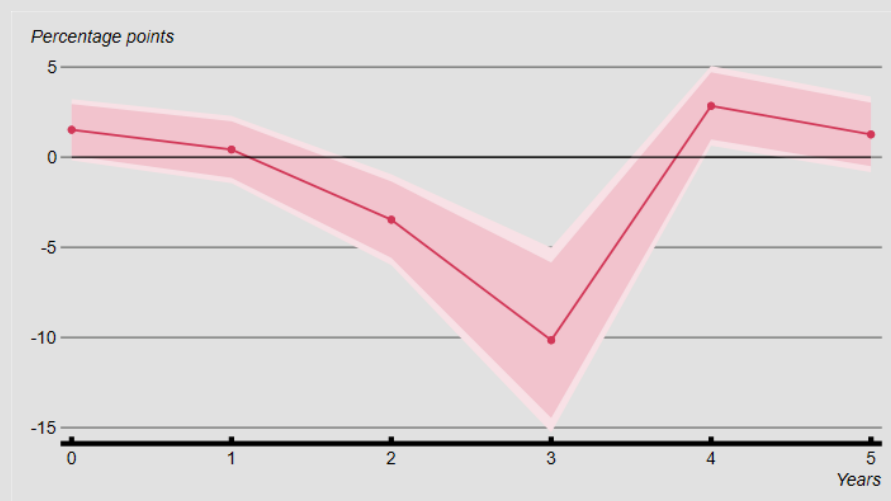
Time aggregation bias might challenge identification of the exact timing

Determining the precise timing of the response of investment to monetary policy changes is challenging, particularly when relying on annual data. This limitation is underscored by recent research emphasising the role of 'time aggregation bias' — a phenomenon where the aggregation of data over time can obscure the actual underlying patterns as it may shift information in the data to lower frequencies and confound the lags in the transmission of a shock (Jacobson et al., 2023; Buda et al., 2023). Consequently, while our findings offer valuable insights, the interpretation of the exact shape and magnitude of the investment response profile should be done cautiously.

⁵ Moreover, all the studies do not measure investment in the exact same way.

CHART 3

**Firms' average investment declines with a lag
in response to an unanticipated increase in monetary policy rates**



Note: Estimated change in investment rate from year -1 to year t as response to a 100 basis point increase in monetary policy rates. Shaded areas represent the 90 and 95 per cent confidence bands, see box 1 for details about estimation methodology.

Source: Own calculations based on data from Statistics Denmark, Danmarks Nationalbank and Jarociński and Karadi (2020).

04

Heterogeneity in the investment response to monetary policy shocks

To deepen our understanding of the heterogeneous impacts of monetary policy shocks on corporate investment, this section examines the differential responses across different types of firms, considering three key dimensions: age, size and industry.

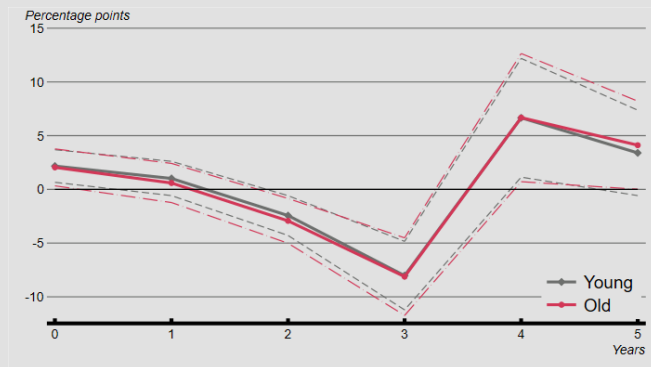
Exploring the heterogeneous investment reactions across these firm characteristics is important due to their association with financial frictions⁶ through what is known as the credit channel. The credit channel refers to the idea that, through credit availability and the cost of credit, monetary policy might disproportionately impact firms with more limited access to credit, thereby amplifying the effect of monetary policy on corporate investment.

The results are presented in two graphs to provide a comprehensive analysis. The first graph for each dimension showcases impulse response functions for different groups, allowing us to compare their response shapes and check whether the responses differ significantly from zero for each group. The second graph illustrates the difference in point estimates of the response between the groups and can be used to ascertain whether the differences are statistically significant. For methodological details on these estimations, see box 1.

⁶ Financial frictions are often defined as impediments in financial markets that hinder the best capital allocation. These obstacles, such as informational asymmetry between borrowers and lenders or constraints on obtaining external financing, create inefficiencies and disrupt the flow of funds.

CHART 4

Investment responses by young and old firms

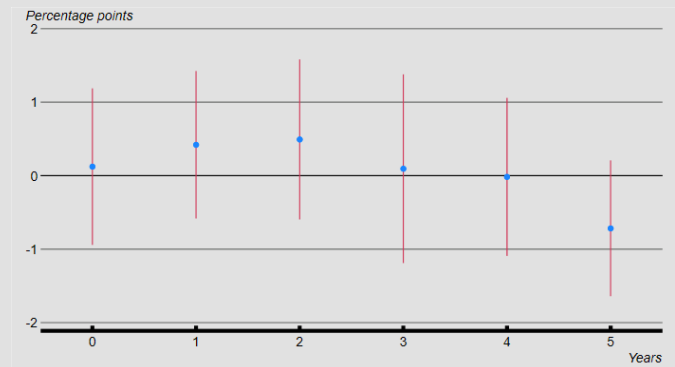


Note: See notes to chart 3. Young firms are between 1 and 10 years of age and old firms are older than 20.

Source: Own calculations based on data from Statistics Denmark, Danmarks Nationalbank, and Jarociński and Karadi (2020).

CHART 5

Test for difference in response between age groups



Note: The chart shows the point estimate as well as 95 per cent confidence intervals for an F-test of the difference between young and old firms (i.e. the difference between β_{young}^h and β_{old}^h in the model presented in box 1).

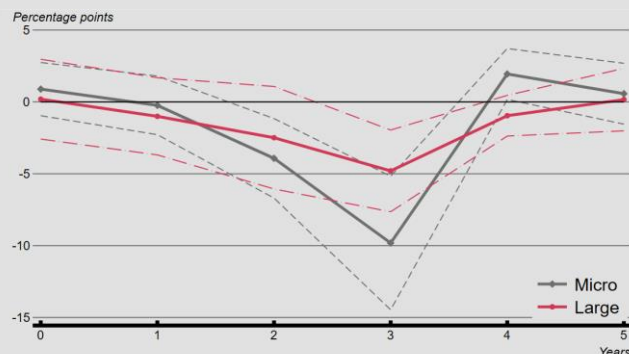
Source: Own calculations based on data from Statistics Denmark, Danmarks Nationalbank, and Jarociński and Karadi (2020).

No significantly different response to monetary policy shocks across firms of different ages

Young firms are typically smaller and have less established credit histories, higher leverage and fewer liquid assets, making them more susceptible to financial frictions than older firms (Gertler, 1988). Moreover, while other factors such as leverage and liquidity also characterise financial health, they are endogenously determined by the firm's previous decisions and current performance, making age a more reliable exogenous indicator of inherent financial frictions. To assess differences by age, we compare young and old firms where young firms are between 1 and 10 years of age and old firms are older than 20. We find that both young and old firms react similarly to monetary policy changes, see chart 4. The differences between young and old firms are insignificant, see chart 5. This indicates that financial frictions did not play an important role in amplifying monetary policy shocks in the sample period in Denmark. This is also in line with results from Andersen and Kuchler (2016), who showed that Danish firms were generally less financially constrained than firms in other European countries, also when comparing firms in similar industries or with similar positions in the productivity distribution. This could potentially explain why Durante et al. (2022) find differential responses across age groups for euro area firms while we do not find that for Danish firms.

CHART 6

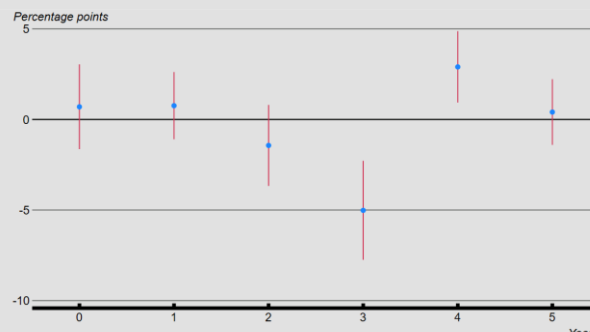
Investment responses by micro and large firms



Note: See notes to chart 3. Micro firms are firms with up to 10 full-time employees. Large firms are firms with more than 250 full-time employees.
Source: Own calculations based on data from Statistics Denmark, Danmarks Nationalbank, and Jarociński and Karadi (2020).

CHART 7

Test for difference in response between size groups



Note: The chart shows the point estimate as well as 95 per cent confidence intervals for an F-test of the difference between micro firms and large firms (i.e. the difference between β_{micro}^h and β_{large}^h in the model presented in box 1).
Source: Own calculations based on data from Statistics Denmark, Danmarks Nationalbank, and Jarociński and Karadi (2020).

Small firms are more sensitive to monetary policy changes

Another important dimension of heterogeneity is firm size. Simplifying our analysis for clarity, we contrast the responses between micro firms and large firms.⁷ The data indicate that investment among large firms exhibits a less pronounced reaction to monetary policy rate changes than that of smaller firms, see chart 6. The difference is statistically significant, see chart 7. One possible explanation is that larger firms, with a much higher share of exporters⁸ and broader access to international funding markets, are less susceptible to changes in regional (Danish and euro area) monetary conditions than smaller firms.⁹ Moreover, even in local credit markets, size matters, as larger firms tend to have relationships with multiple banks and have better negotiation positions with each bank. Multiple banking relationships mitigate the risk of experiencing bank liquidity shocks (Kosekova et al., 2023).

Insignificant differences between durable and non-durable goods producers

According to the empirical literature, see Dedola and Lippi (2005) and Durante et al. (2022), a consistent finding is that investment among manufacturing firms producing durable goods tends to be more sensitive to changes in monetary policy. Theory suggests that this is due to the demand for durable goods being more elastic to changes in monetary policy than non-durable goods, as, among other things, purchasing durable goods often requires credit financing. This directly impacts the output of durable goods manufacturers and, hence, their investment. Moreover, durable goods manufacturers also have a higher capital dependency, which could translate into a larger dependency on external financing. Our empirical findings indicate that firms producing durable goods exhibit slightly higher sensitivity to monetary policy shocks (as measured by the

⁷ Firm size here is defined in terms of employment. Micro firms employ less than 10 employees, large firms more than 250.

⁸ On average across the sample period, 80 percent of all large firms are exporters, while only 25 percent of micro firms are exporters. A firm is considered an exporter if its exports are higher than kr. 10,000 in a given year.

⁹ A related explanation could be that large firms are less exposed to regional demand conditions than smaller firms.

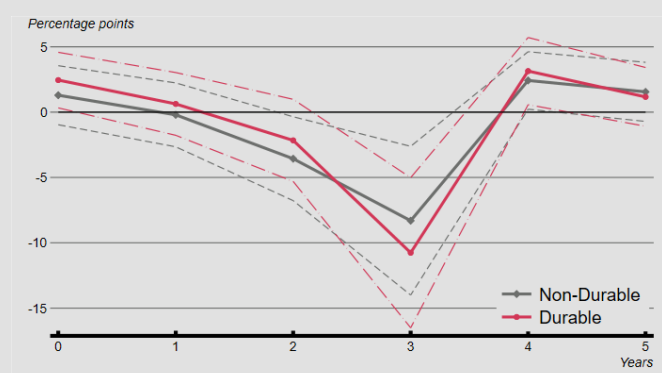
peak effect) than their counterparts producing non-durable goods, see chart 8. However, the difference is not statistically significant at the 5 per cent level, see chart 9.

Heterogeneity seems to play a minor role in shaping investment responses

Overall, our study suggests that firm heterogeneity, except for differences by firm size, plays a limited role in the transmission of monetary policy in Denmark. The lack of variation in response across the firm age distribution points to a background of inclusive financial intermediation, where access to credit and financial services does not vary significantly with firm age. This may suggest that financial frictions, which can stand in the way of smaller or younger firms securing financing, do not have a large impact in a Danish context, and, thus, do not seem to amplify the transmission of monetary policy to firm investment. However, the significant difference between small and large corporations may suggest that factors such as access to multiple banking relationships or international credit markets, which are potential reasons for this difference, could provide a buffer against monetary policy shocks.

CHART 8

Investment responses by industry (durable and non-durable manufacturing)

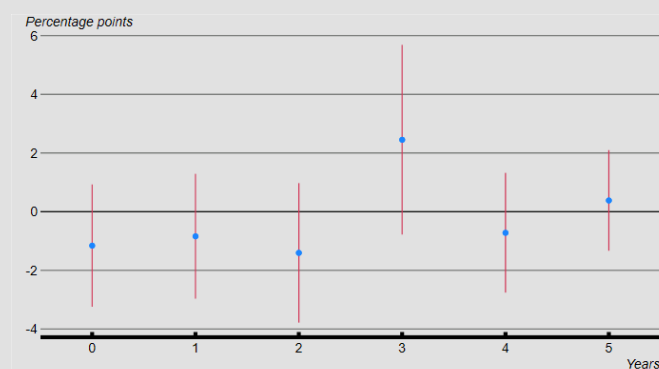


Note: See notes to chart 3.–

Source: Own calculations based on data from Statistics Denmark, Danmarks Nationalbank, and Jarociński and Karadi (2020).

CHART 9

Test for difference in response across industries



Note: The chart shows the point estimate as well as 95 per cent confidence intervals for an F-test of the difference between firms in non-durable and durable manufacturing industries (i.e. the difference between $\beta_{non-durable}^h$ and $\beta_{durable}^h$ in the model presented in box 1).

Source: Own calculations based on data from Statistics Denmark, Danmarks Nationalbank, and Jarociński and Karadi (2020).

05

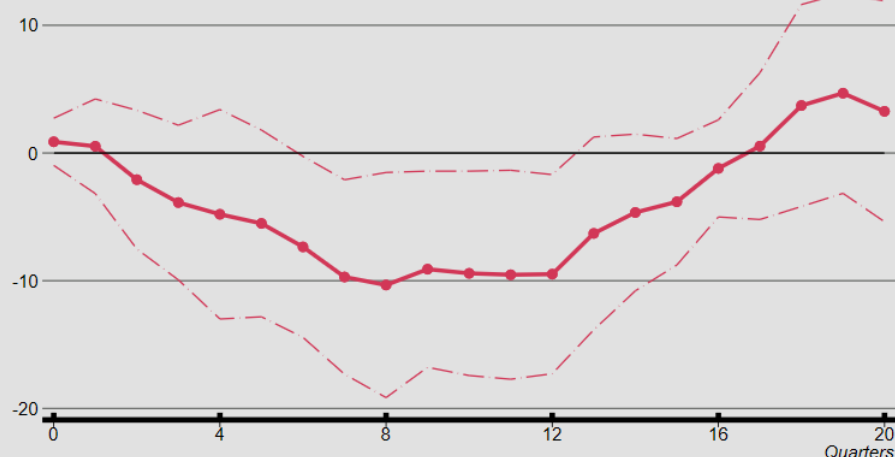
The aggregate investment response

What does our analysis of the firm-level investment response to monetary policy shocks imply for aggregate investment in Denmark? To answer this question, we adapt our estimation strategy to quarterly data on aggregate investment from the national accounts. Higher frequency data, which are not available at firm level, allow us to increase the number of observations in the time dimension and reduce the potential bias from the time-aggregation of our monetary policy shocks.

CHART 10

Aggregate investment decline with a lag in response to higher interest rates

Percentage points



Note: Estimated change in the annual growth rate of aggregate gross investment from quarter -1 to quarter t in response to a 100 basis point increase in monetary policy rates. The dashed lines represent the 95 percent confidence bands based on robust standard errors, see box 1 and footnote 10 for details of estimation methodology.

Source: Own calculations based on data from Statistics Denmark, Danmarks Nationalbank, and Jarociński and Karadi (2020).

Aggregate investment declines with a delay, consistent with the micro evidence

We estimate the impact of monetary policy shocks on gross investment at the aggregate level using a similar LP-IV estimation approach to the one described

in box 1.^{10,11} The main takeaway from our aggregate analysis is that, consistent with individual firm behaviour, higher interest rates generally suppress aggregate investment and the effects come with a lag, see chart 10. The largest effects of a 100 basis points change in interest rates occur between 8 and 12 quarters after the change, consistent with the timing identified in our firm-level analysis. The peak response occurs after eight quarters when the annual growth rate in aggregate investment contracts by approximately 10 percentage points.

The magnitude of our estimated effects is considerable, in line with the finding by Ottonello et al. (2020) that aggregate investment is one of the most responsive components of GDP to monetary policy shocks. However, as was also the case for the micro-based results, the size of the effect should be seen in light of the fact that we estimate the response to a 100 basis points increase in monetary policy rates identified through relatively small surprises in monetary policy rates. Moreover, the estimates should be approached with caution due to the inherent estimation uncertainty illustrated by the large confidence bands.

In conclusion, the results on firm-level and macro-level data convey a consistent narrative about the influence of interest rates on firms' investment behaviour. Note, however, that the exact estimates from the different levels of analysis are not directly comparable due to differences in measurement as well as in the econometric specification.¹²

The large concentration of investment among large firms dampens the aggregate interest rate sensitivity

One key aspect that emerged from the previous section is that large firms tend to react less to an interest rate change. According to firm accounting data, large firms are responsible for most of the investment in Denmark, as depicted in chart 11. If the composition of investment in the national accounts resembles the micro data with a tilt toward large firms, the interest rate sensitivity of aggregate investment would be dampened by the less interest rate sensitive large firms. Note, however, that investment at the firm level and in the national accounts do not match perfectly. For instance, the national accounts only capture domestic investments, while the firm-level data contain all investment on the balance sheets of firms that are resident in Denmark. In that sense, while all fixed investments abroad by large firms (or by any firm) do not appear in the national accounts, investments by foreign companies on Danish soil do appear. Consequently, it is unclear whether investments in the national accounts should be tilted more or less towards large (domestic and foreign) firms compared to the accounting data.

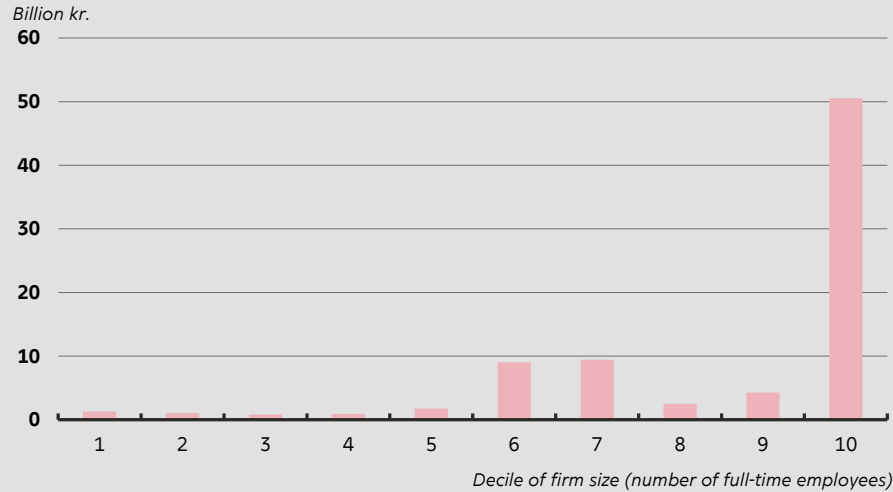
¹⁰ Aggregate investment can be measured in multiple ways. Gross investment is our preferable measure since it is available in constant prices and allows us to assess the adjustments in investments and not the evolution of the fixed capital stock, cf. discussion in data section. Alternatively, we could have modelled the effects on net investments or investment relative to GVA. Note, gross investments also include investments by sectors other than non-financial corporations. Robustness checks on a constructed series only for the non-financial companies yield a similar response function albeit more volatile.

¹¹ The outcome variable (the annual growth rate of aggregate gross investments) is at different horizons regressed on the change in interest rates at year 0 (instrumented by quarterly monetary policy shocks) as well as a set of control variables, including four lags of the outcome variable, annual inflation rates and gross value added. The data sample is 2000-2022.

¹² Firstly, investments are measured differently in the macro-level and micro-level estimations. The national accounts only capture domestic investments, while the firm-level data are based on the fixed assets on firm balance sheets, disregarding the geographical location of those assets. Moreover, the unit of the investment variable differs across the two analyses: in the micro analysis it is measured as the annual percentage change in fixed assets, whereas in the macro analysis it is the annual percentage change in gross investments. Finally, the micro-level estimates capture the within-firm responses due to the inclusion of firm fixed effects in the regressions.

CHART 11

Accounting data suggests a large concentration
of investment among the largest firms



Note: Distribution of total (net) investment by deciles of full-time employment. To obtain total investment by decile, we sum total capital within decile of employment in every year and compute the change in total capital within decile between years. Finally, we average the difference across time.

Source: Own calculations based on Statistics Denmark.

06

Discussion and concluding remarks

Contractionary interest rate shocks tend to dampen investment

In this memo, we estimate the causal effects of monetary policy shocks on investment in Denmark. We devote the remainder of the analysis to relating the estimates we have obtained to recent investment developments. Our key finding based on historical data is that investment declines in response to a contractionary monetary policy shock, with the peak impact occurring 2-3 years after the shock and associated with considerable uncertainty. Thus, our results suggest that the tightening of monetary policy in the euro area and Denmark in 2022-23 is still weighing on investments, supporting the bank's assessment presented most recently in Danmarks Nationalbank (2024a).

To date, investment has remained relatively resilient overall

On the back of the global monetary policy tightening, total gross fixed investment in Denmark has been steadily levelling off following several years of generally positive trend growth, see chart 12. Similar aggregate investment developments are seen in the euro area and the United States. Note, however, that the various subcomponents of Danish aggregate investment have responded differently during the current hiking cycle, reflecting different interest rate sensitivities. Investment in intellectual property products (IPP), which is less interest rate sensitive and less cyclical than investment in dwellings, has increased a great deal in Denmark in recent years.¹³ Those investments mostly reflect large one-off investments and recurring research and development activities, see Danmarks Nationalbank (2024a). Overall, disregarding intellectual property, there has been a modest decline in total investment since 2022.

Several reasons for the observed resilience of investment

How can the relative resilience of investment and our indications of rather significant effects from monetary policy shocks be reconciled? Firstly, investment decisions are driven by many factors besides monetary policy. The Danish and the global economy have remained relatively strong amid higher inflation and interest rates, see Danmarks Nationalbank (2024a). This is likely to have positively influenced demand for goods and services. In fact, the global economy has fared better than many forecasters expected in 2022 and despite many Danish manufacturing firms expecting, as of late 2022, to lower investments in 2023, they ended up increasing their investments, see Statistics Denmark (2024).

Secondly, our results suggest a delayed impact of interest rate increases on investment. This has also been the case for external financing costs and external financing flows of firms. Total external financing costs of Danish firms have increased sluggishly and more slowly than the cost of debt during the current hiking cycle due to the cost of equity only edging up slowly, see Danmarks Nationalbank (2024b). In turn, this has contributed to a very gradual decline in the uptake of total external financing, including bank and mortgage debt, bond,

¹³ See Döttling and Ratnovski (2022) for a study of the interest rate sensitivity of intangibles versus tangibles.

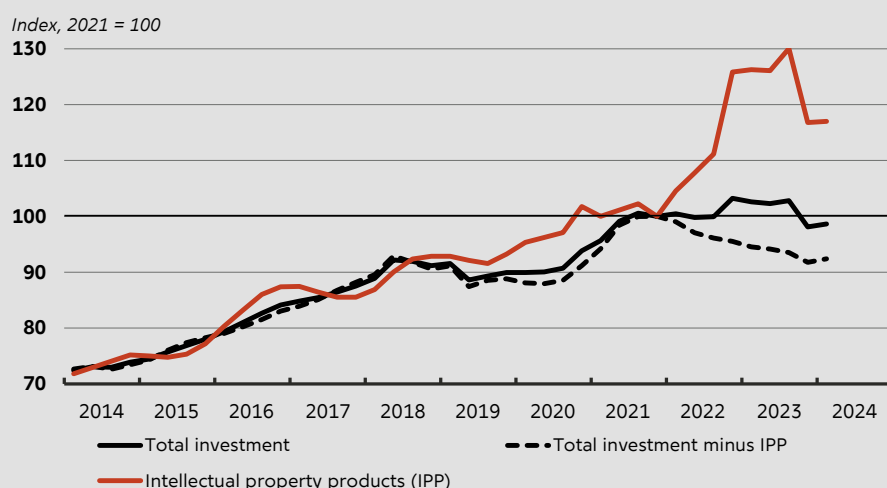
and equity issuances, which just turned negative in the second half of 2023. Moreover, small and medium-sized enterprises in both Denmark and the euro area continued to report in the first quarter of 2024 that their loan demand kept falling, as documented in the Bank Lending Surveys. Firms in the euro area report that part of the reason for weaker loan demand is a continued decline in investments. These observations are consistent with the lagged impact of higher policy rates on investment, with the peak impact potentially still pending.

Extrapolation of empirical estimates should be done with caution

The strength of our approach is that it provides a clear estimate of the causal relation between two highly endogenous variables – monetary policy rates and investment. However, the extent to which our estimates may be extrapolated to the recent hiking cycle is unclear. A naïve extrapolation of our study would suggest substantially negative effects on investment coming from the recent monetary policy tightening materialising between the end of 2024 and early 2026, with sizeable peak effects in 2025. However, estimates based on monetary policy shocks cannot be applied to directly form an estimate of the total impact of the actual interest rate increases that have taken place since 2022, see Andersen et al. (2024) for further discussion. Firstly, while our empirical approach identifies the effects of interest rate changes from monetary policy surprises, the lift-off in monetary policy rates in Denmark and the euro area from July 2022 onwards was expected well in advance due to elevated inflation levels in the euro area. Our estimates of the timing and magnitude of the impact are thus unlikely to be transferable one-for-one to the recent monetary policy hikes.

CHART 12

Aggregate investment in Denmark has been levelling off since the monetary policy tightening began in 2022



Note: Four quarters moving average of Danish gross fixed capital formation in constant prices. The picture is similar for a constructed measure of net investments though exhibiting more volatility.
 Source: Own calculations based on Statistics Denmark.

Secondly, the effects cannot necessarily be scaled up linearly by the size of the accumulated rate hikes. Evidence is building that monetary policy transmission is non-linear, meaning that the first rate hike in a hiking cycle is more contractionary than the following ones, see Schnabel (2024). Finally, our point estimates are associated with uncertainty, which is evident from the wide confidence bands in the charts. Among other things, this may reflect the fact that investments are highly volatile and lumpy, thus challenging the estimation.

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