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Homeowners' budgets and debt servicing capacity projections

Rikke Rhode Nissen
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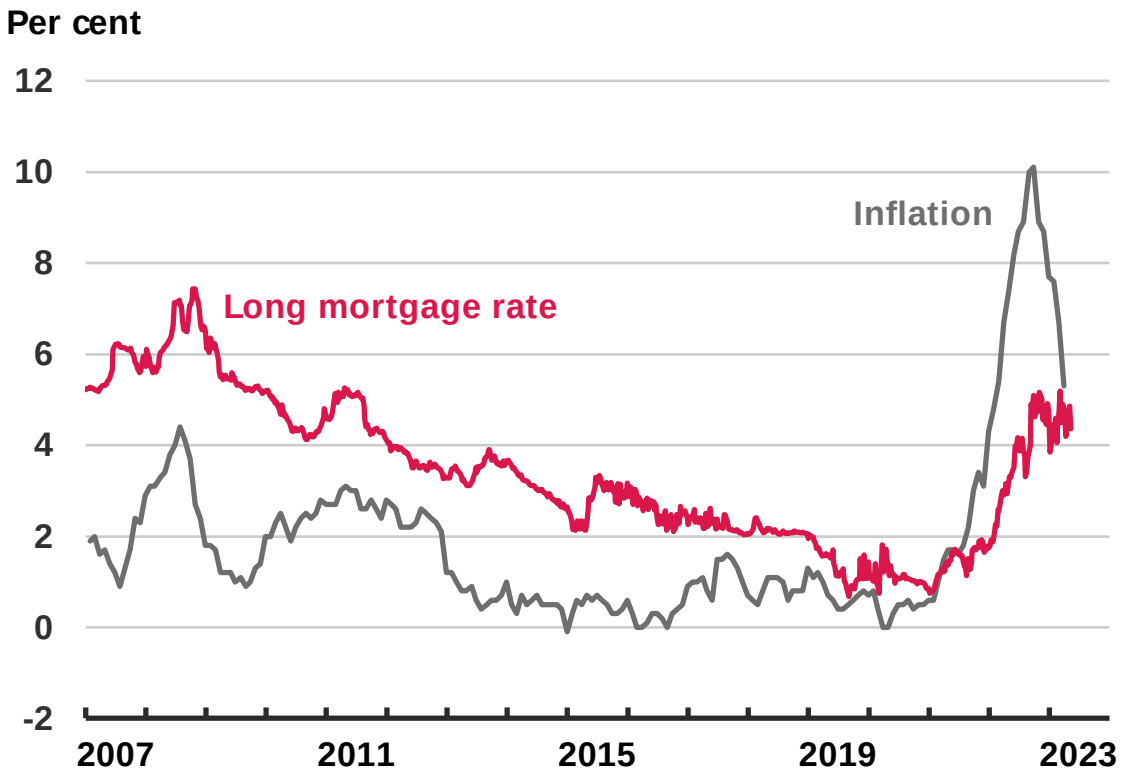
Inflation and interest rates are high, but historically unemployment has led to losses

Inflation and interest rates have risen, but unemployment is still low



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Note: Left panel: Inflation, measured in percentage compared to same month the year before, and weekly interest rates for 30-year mortgage bonds. Right panel: Gross unemployment covers persons both in and outside job activation. Numbers are seasonally adjusted.

Source: Left panel: Macrobond. Right panel: Statistics Denmark, AUS07.

We expect homeowners with budget deficits to increase by over 36,000 (3.4 pp.) by the end of 2023

1

Inflation and interest rates erode the robustness of Danish homeowners.

While many households used the capital gains to pay off expensive bank loans, the net effect of the mortgage refinancing wave of 2022 is negative.

2

An increase in the number of unemployed in Denmark by 54 thousand units will only results in the economic margin of 6.7 thousand homeowners to turn negative.

3

While the budget effect of unemployment is mitigated by unemployment insurance and spousal income, the margin of three out of four affected households will become negative or decrease by at least 20 per cent.

Estimating household budgets

We combine data from administrative registers, credit register, and the Danish consumption survey…

2021 household budgets and economic margin

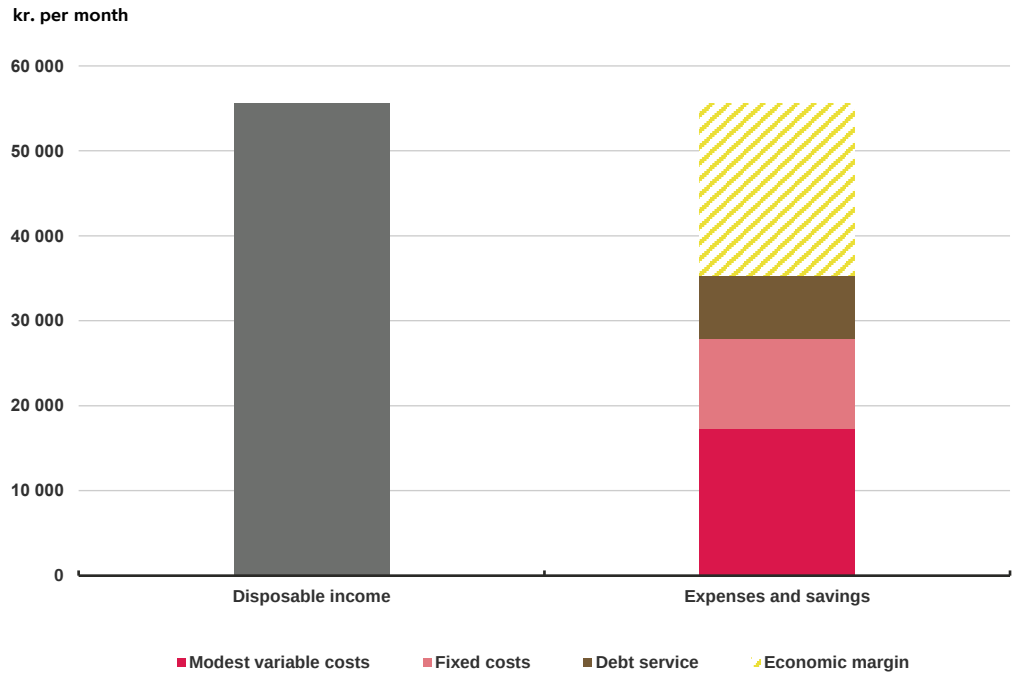
Disposable income: From admin registers

Fixed costs: Weighted (and scaled) aggregates from consumption survey

Debt financing costs: Households' debt payments for all loans in credit institutions

Variable costs: A minimum associated with a modest standard of living as recommended by the Danish FSA for banks' assessments of creditworthiness

Average budget and economic margin in 2021 for households in Horsens with adjustable-rate mortgages



Note: The figure shows as an example the computation of the economic margin for the average dual household in Horsens with two children and an adjustable-rate loan in 2021.

Source: Own calculations on Danmarks Nationalbank's credit register, and Statistics Denmark's population registers and consumption survey (Statistics Denmark, 2021).

… and project the 2021 baseline to the end of 2023

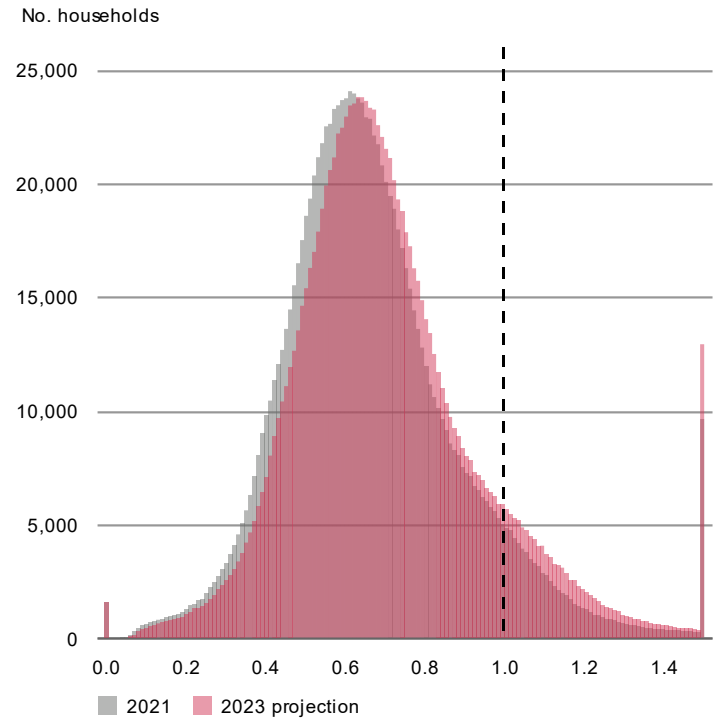
2023 projections

Disposable income: Scaled by expected wage growth (8.4 per cent)

Fixed and variable costs: Scaled by observed and expected inflation (by cost component. Full CPI: 13.2 per cent)

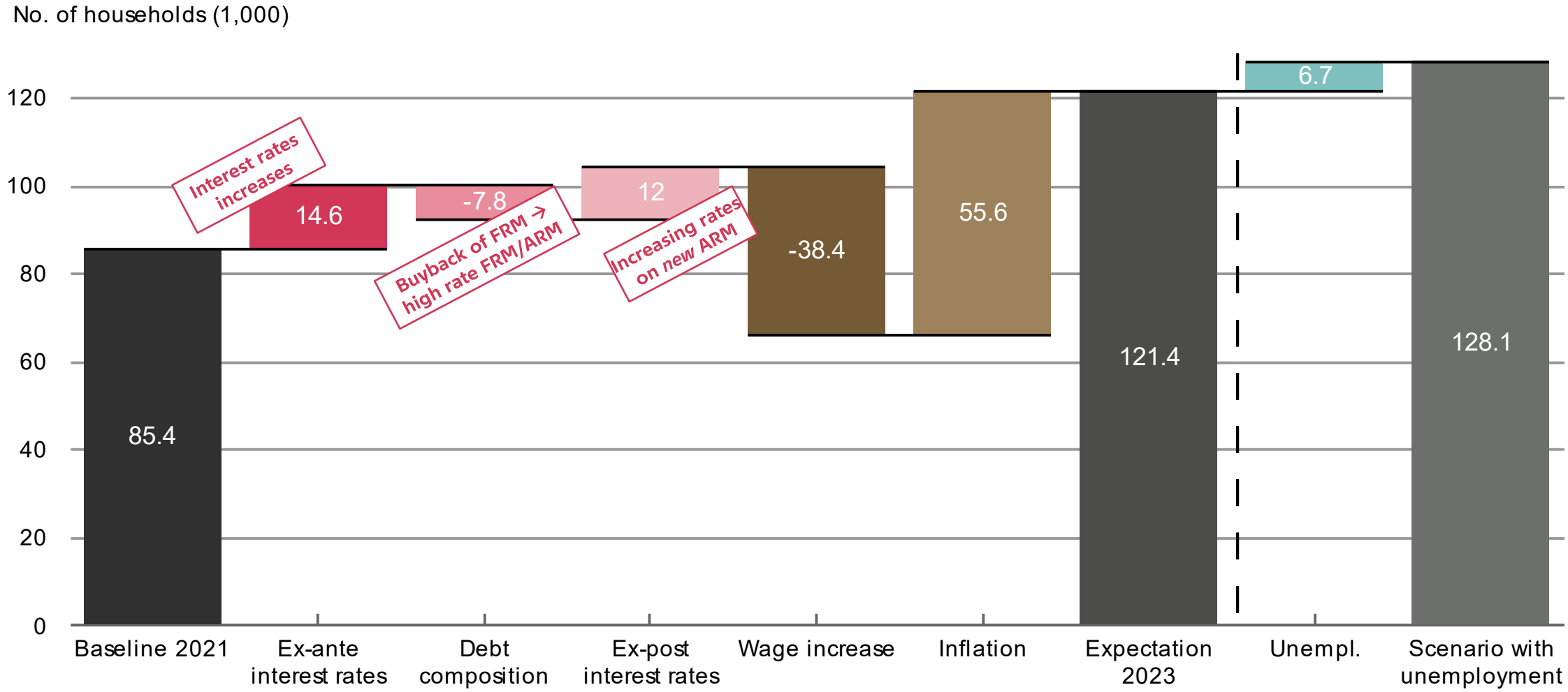
Debt servicing costs: Adjusted given interest rate forward curve and household's debt composition in 2022Q4 and fixation dates

Inflation and interest rates put pressure on household budgets despite wage growth



Note: The figure shows the distribution of the ratio of expected monthly expenses to disposable income. Values above one represent a negative economic margin. The distribution in blue shows 2021 data, while the purple distribution shows expectations for 2023 budgets after simulating the impact of inflation, interest rate growth, and wage growth.

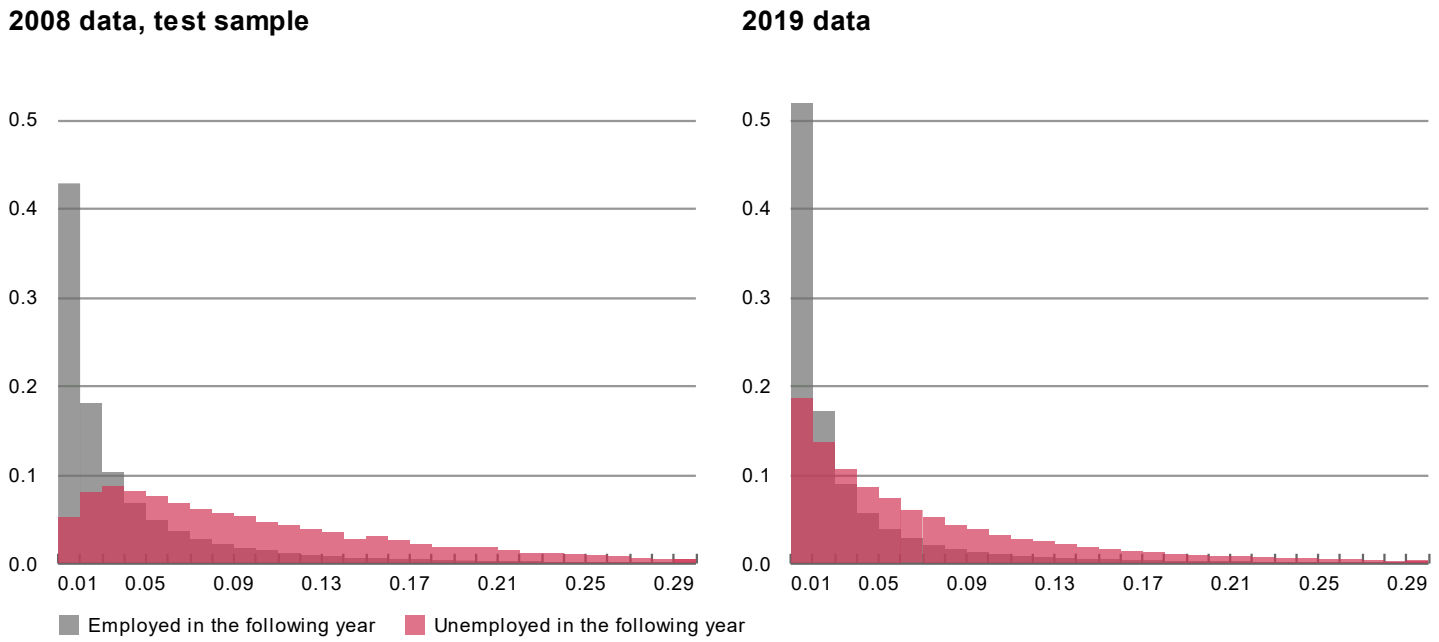
We expect homeowners with budget deficits to increase by over 36,000 (3.4 pp.) by the end of 2023



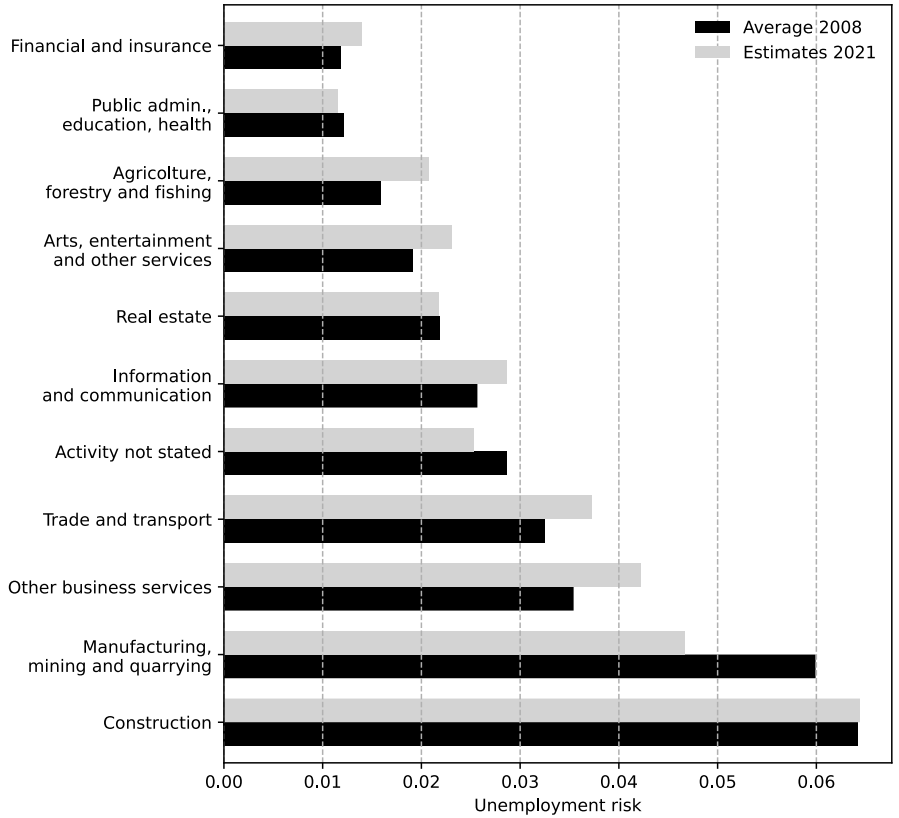
Estimating an unemployment shock

We train a ML model on microdata from the time of the financial crisis to assess current unemployment risk

The model allows us to construct distributions of unemployment risk from which we sample without replacement



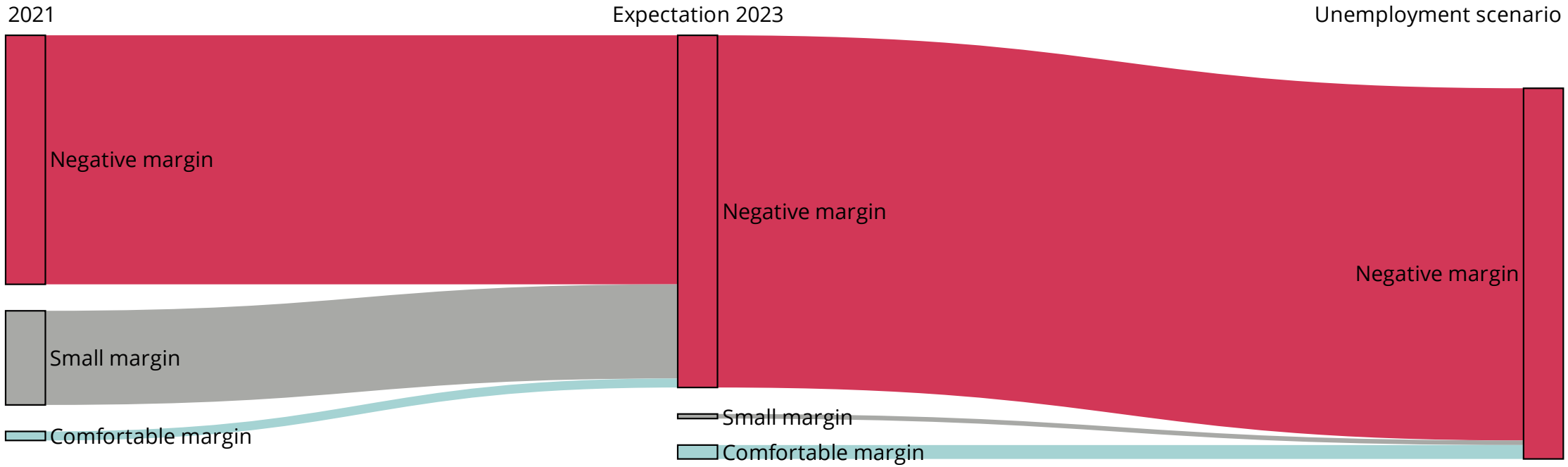
Note: The figure shows the distribution of estimated probability of unemployment in 2009 (left panel) and 2020 (right panel) based on data from 2008 and 2019, respectively. Neither dataset contains observations used to train the model. Blue columns show the distribution of estimated probabilities for people who end up being employed in the following year (negatives), while purple columns show estimated probabilities for people who end up experiencing an unemployment spell in the following year (positives).



Note: The figure shows in black the average share of individuals employed in 2008 and experiencing unemployment in 2009 by sector. The grey bars show the average probability of unemployment estimated by the machine learning model for individuals employed in the same sector using data from 2021.

A 54 thousand further unemployed results in the economic margin of 6.7 thousand homeowners to turn negative

While negative income margins resulting from inflation and rising interest rates come from households with a tight economy as a point of departure, most households with negative margins because of unemployment had a solid economy in 2021



Note: We divide households in groups defined by the size of economic margin available in Danish kroner. The Sankey diagram characterises households that we expect to have a negative economic margin (red) by the end of 2023. Flows into this group are coloured according to the group of origin, which can be those with a small (less than kr. 5,000) or comfortable (more than kr. 5,000) economic margin. The left part of the graph represents households' budgets at the end of 2021. The central part of the graphs represents the effect of interest rate increases, inflation, and wage growth. The right part of the graph represents the effect of increasing unemployment.

Despite mitigation, unemployment severely disrupts the budget of the affected households

Insurance and spouse income mitigates the impact of unemployment

	Percentage point impact		
	...on individual disposable income	..on household disposable income	Number of households
Single households, insured	-44.4	-44.4	2,646
Single household, uninsured	-99.5	-99.5	345
Dual household, insured	-41.1	-21.8	16,101
Dual household, uninsured	-96.7	-41.6	1,858
Total	**-47.4**	**-27.8**	**20,950**

Note: The table shows the impact on unemployment on individual disposable income of affected individuals, and household disposable income of affected households. As disposable income is net of, e.g., property taxes and alimonies, which are due even if gross income falls to zero, absolute percentage point impacts for some households can be larger than 100 per cent. The sample consists in homeowners with housing debt in 2022 affected by the unemployment shock. In the 139 households where two individuals are affected the insurance status of the highest earner is used. Less than 200 affected homeowners in the uninsured group are eligible for cash benefits (kontanthjælp).

!

The 6.7 thousand households pushed into having a negative economic margin because of unemployment have a **monthly deficit of about kr. 6,600 on average**.

The margin of a **further 9,000 households**, while remaining positive, would fall by at least 20 per cent due to the unemployment shock.

Thank you

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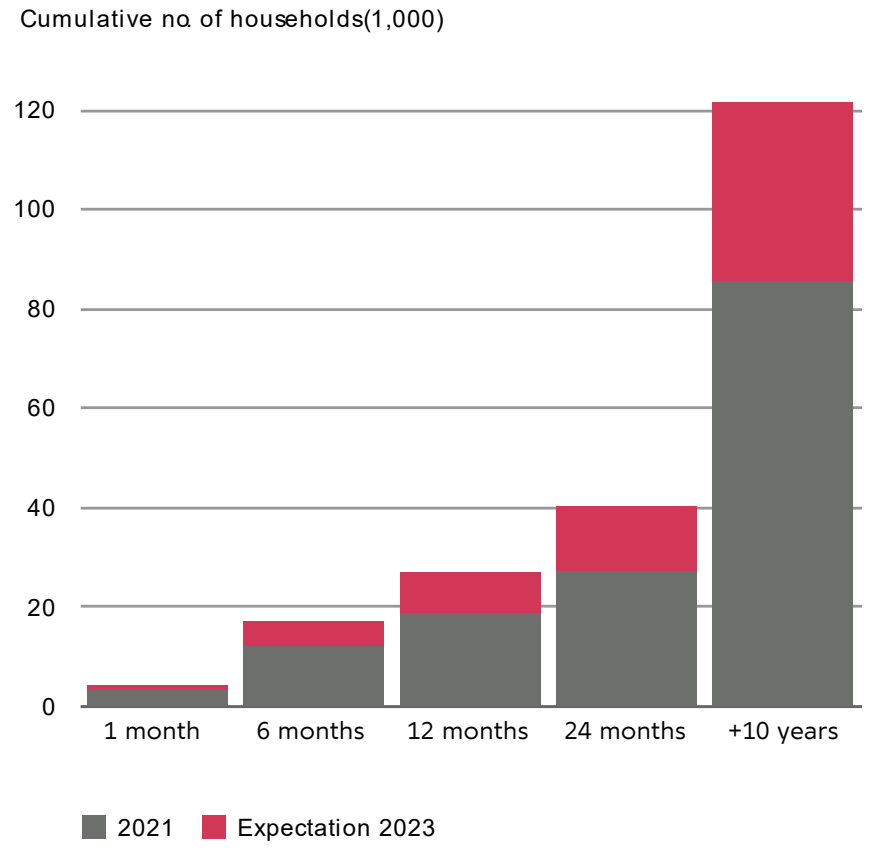
Extra: Inflation and interest rates erode the robustness of Danish homeowners

Expected deficits are often small: Most households can cover them for at least 2 years by depleting liquid assets



!

However, a further **55,000 households** would maintain a positive economic margin, but see it fall by **at least 20 per cent**, and at least by kr. 1,000 per month.

If these households are unable to adjust their consumption accordingly, **they might end up deplete their liquid assets as well**.

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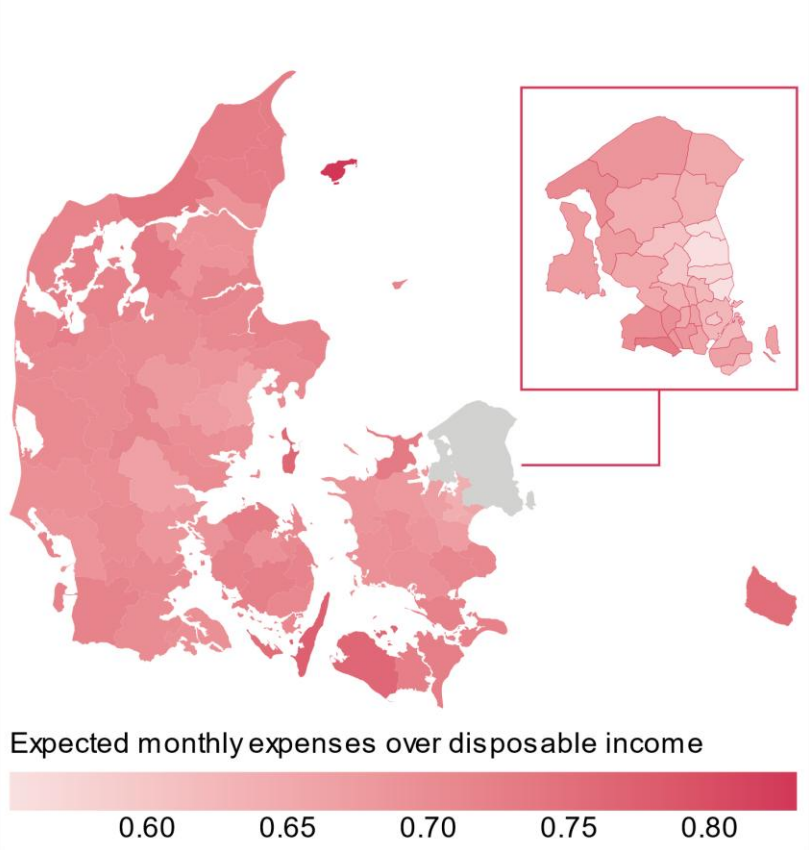
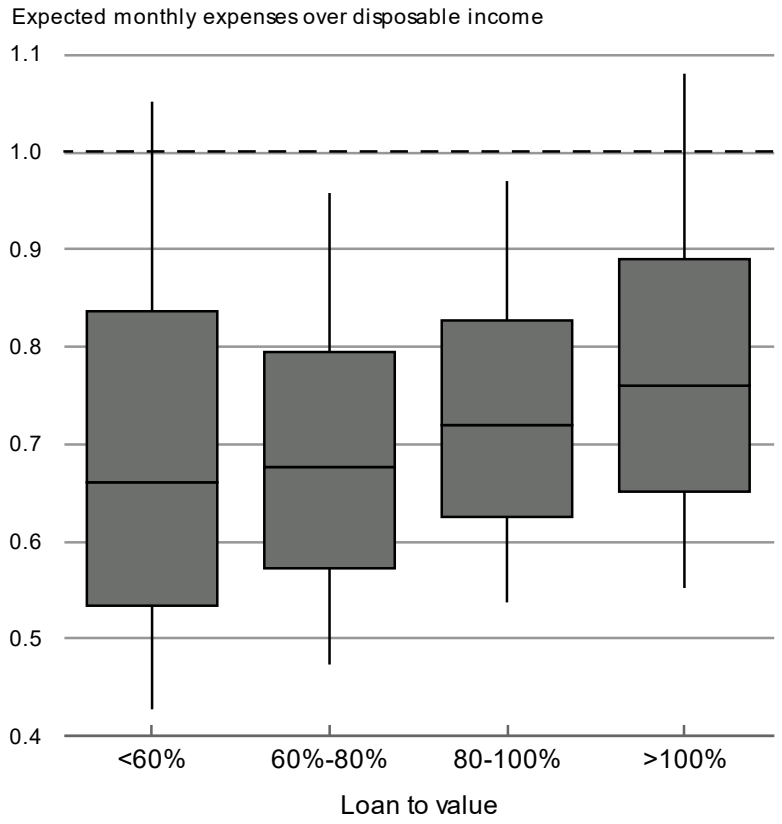
Note: The figure shows the cumulative number of households with negative economic margin grouped according to how many months it would take to deplete their liquid assets by financing the deficit in economic margins.

Extra: Economic margins are lower in sparsely populated small municipalities and for highly indebted households





Highly indebted households not only represent a risk for credit institutions in terms of higher debt exposure in case of default, but **are also more vulnerable to worsening economic environments.**

Note: The figures show the median ratio between monthly expected expenses and disposable income by Danish municipality (left) and a boxplot of the same metric by household indebtedness (right) measure by loan to value, i.e. size of debt over value of collateral. The boxplot whiskers show the range between the 10th and 90th percentile of the distribution.

ECONOMIC MEMO

MICRO DATA SCIENCE

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Homeowners' budgets and debt servicing capacity projections

Abstract

We assess the solidity and debt servicing capacity of Danish homeowners by simulating the impact on household budgets of inflation, rising interest rates and a potential unemployment shock, and calculating the remaining economic margin. A negative economic margins means the household would not have been able to obtain its current debt from a credit institution.

Rising interest rates and inflation will increase the number of households with a negative monthly margin by 36,000 (3.4 per cent of homeowners with mortgages) by the end of 2023. An additional 55,000 will see their margin reduced by at least 20 per cent. While the budget effect of unemployment is mitigated by unemployment insurance and spousal income, the margin of three out of four affected households will become negative or decrease by at least 20 per cent.

Overall, we show that household budgets are tighter in sparsely populated municipalities and for highly indebted households.

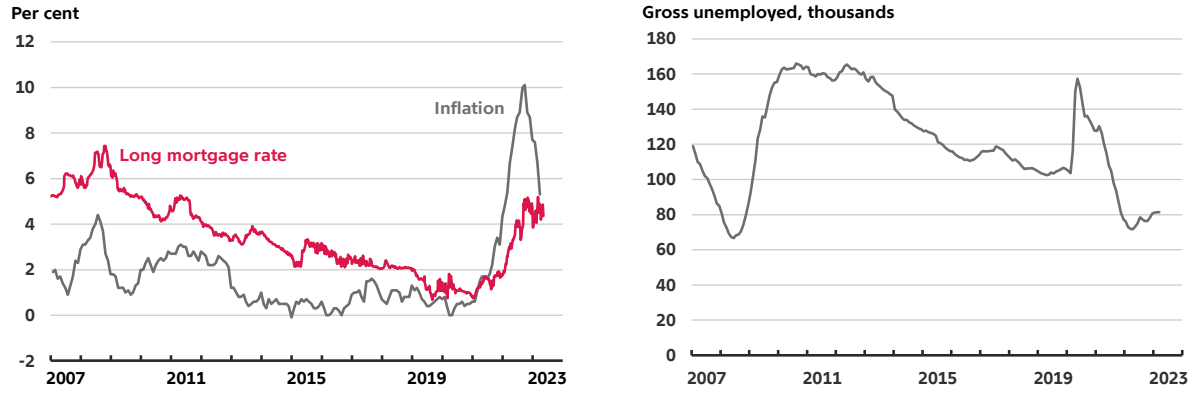
At the end of 2022, Danish households held 54 per cent and 24 per cent of all outstanding loans from mortgage institutions and banks respectively.[1] This debt, totalling kr. 2,064 billion, corresponds to 74 per cent of the Danish GDP. The size of this debt alone makes the financial robustness of households and their ability to service their debt payments an important pillar for the stability of the Danish financial system.

Inflation and rising interest rates are already putting significant economic pressure on Danish households, as both have risen substantially in 2022, see Chart 1. Chart 1 also shows that the current unemployment rates in Denmark are at an historically low level, only matched by the unemployment rates observed at the onset of the 2008 financial crisis. Given that most households rely on labour income, adverse changes in employment conditions put further pressure on their financial robustness. The sudden and substantial increase of unemployment rates during a potential recession represents a significant tail risk.

We leverage Danish microdata from administrative registers and the Danish credit register to estimate the vulnerability of households to these shocks. We proceed in two steps. First, we estimate the monthly budget for each household in accordance with the guidelines set by the Danish Financial Supervisory Authority (FSA). These guidelines do not aim at assessing a comprehensive household budget, but rather a minimum budget necessary for maintaining a modest standard of living. For example, we estimate such necessary expenses for a dual household in Horsens Municipality with an adjustable-rate loan and 2 children to be kr. 35,300 per month on average in 2021.

1 These numbers represent all loans from banks and mortgage institutions to households (sector 1430) in nominal values, MFI statistics.

Inflation and interest rates have risen, but unemployment is still low Chart 1



Note: Left panel: Inflation, measured in percentage compared to same month the year before, and weekly interest rates for 30-year mortgage bonds. Right panel: Gross unemployment covers persons both in and outside job activation. Numbers are seasonally adjusted.
Source: Left panel: Macrobond. Right panel: Statistics Denmark, AUS07.

We refer to the difference between monthly disposable income and this budget as the *economic margin* of a household.[2] The average disposable income for our example of a dual family in Horsens with a adjustable interest loan is kr. 55.600, so that their economic margin is about kr. 20.300 on average.

Second, we simulate the impact of changes in interest rates, salary adjustments, inflation and an increased unemployment rate on economic margins, and assess the financial resilience of all Danish homeowners. As an household with a negative economic margin would not be able to obtain their current loans from a Danish credit institution given the Danish FSA guidelines, we focus specifically on households whose economic margin becomes negative as a result of these shocks.

We begin by showing that the economic margin of the average Danish household was kr. 18,736 in 2021. Yet 85,000 households already had a negative economic margin in 2021. Estimating budgets at the micro-level allows us to reveal isolated pockets of risks in the Danish population.

We proceed by first simulating the impact of interest rate hikes by end 2023 given the current interest rate forward curve and micro-level information on the terms and conditions (e.g. adjustable vs fixed interest rates, bond maturity etc.) of each household debt; second, that of increasing inflation, given Danmarks Nationalbank's forecast of inflation by types of consumption (Danmarks Nationalbank, 2023); third, that of salary growth, given the observed 2022 wage growth and Danmarks Nationalbank's expectation for 2023; and fourth, that of increasing unemployment, given current social safety nets, observed enrolment in unemployment insurance systems, and individually estimated unemployment risk from a machine learning model trained on microdata from the 2008 financial crisis.

We show that as a consequence of inflation and rising interest rates the number of households with a negative economic margin will increase by about 36,000, reaching a level corresponding to 11.3 per cent of Danish homeowners with mortgages. Part of the effect is due to the increased sensitivity of households to rising interest rates due to the widespread mortgage refinancing seen in 2022. Households whose economic margin becomes

2 The concept of economic margin has previously been analysed by Andersen et. al. (2012). See Appendix A for details on the calculation of this margin.

negative due to these shocks have enough liquid assets to sustain a modest standard of living for long periods of time. However, homeowners used to a high consumption level may find it difficult to reduce spending to the modest standard of living outlined in the FSA guidelines, and still service their debt. Despite maintaining a positive economic margin, an additional 55,000 households will experience at least a 20 per cent a reduction in their economic margin as a consequence of inflation and rising interest rates.

A further large unemployment shock would be heavily mitigated by the prevalence of unemployment insurance and dual-income households. A nationwide increase in the number of unemployed by 54,000 would cause the economic margin of only about 6,700 households to turn negative. Yet their budget would be affected relatively more compared to the effects from inflation and interest rates.

Overall, the memo highlights that a microsimulation of household budgets and economic margins is a powerful tool for identifying risk pockets related to the sustainability of debt issued to finance residential housing. We show that economic margins are tighter in sparsely populated rural municipalities, and that highly indebted households also have tighter budgets. Highly indebted households thus represent a concentration of risks for credit institutions due to the combination of higher debt levels and a higher risk of not being able to service it.

The rest of the memo is organised as follows. The first section provides an overview of the data and approaches we exploit in our analysis. The second section shows and discusses the impact of increasing interest rates, wages and inflation alone. The third section discusses the impact of increasing unemployment. The fourth and final section interprets our results from the perspective of credit institutions and concludes.

Data and approach

Our main sample consists of Danish households with housing debt in 2022.[3] This section begins by describing the data sources and methodology used to compute their budgets and economic margins in 2021, the last year for which we have complete data. We then briefly explain how we simulate the impact of inflation, wage growth, interest rate increases and unemployment shocks on household's economic margin by the end of 2023. Appendix A and B contain more details about each of these steps.

Calculating household budgets and economic margins

The data used for the analysis consists of three data sources. The first is a combination of administrative register microdata made available through Statistics Denmark. It includes data on income and wealth at the individual level, third-party-reported for tax purposes, family composition, employment status and membership of an unemployment fond. The second data source is the Danish credit register, which contains microdata on each loan issued by a credit institution to Danish households. Finally, we enrich this data with publicly available aggregate data from the Danish consumption survey.

We identify households with housing debt through quarterly data from the Danish credit register, which covers the full population of outstanding mortgages and bank loans in Denmark. Homeowners in our sample are thus households with at least one person having secured debt in a residential property.

We define the economic margin of a household as the difference between a household's monthly income and expected costs, calculated according to the instructions released by the Danish Financial Supervisory Authority in their official recommendations (Finantilsynet, 2021), see Appendix A. Specifically,

[3] The definition of a household in our sample derives from Statistics Denmark, see appendix A. Housing debt in the credit register includes debt from both banks and mortgage institutions with collateral in privately-owned residential housing.

$$Economic\ Margin = Disposable\ Income - Debt\ Financing\ Costs - "Modest\ Standard\ of\ Living"\ Variable\ Costs - Fixed\ Costs$$

Our latest measure of disposable income is based on 2021 tax registers. Disposable income is the total of labour market income, business profits, capital income, public transfers and private pension payments, deducted total taxes and alimony payments.

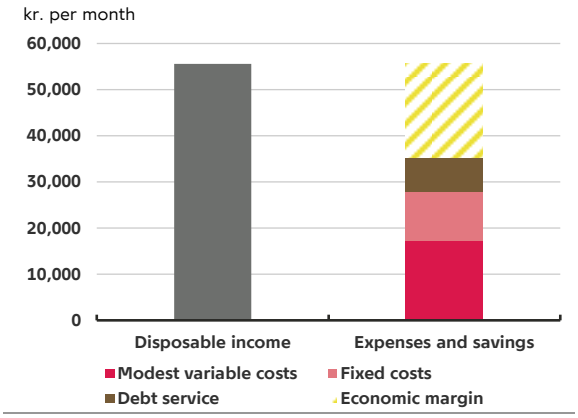
Debt financing costs consist of the households' debt payments for all loans in credit institutions. Debt payments are based on detailed information for each loan on a borrower level from the credit register, and interest tax deduction value is subtracted.

Variable costs are conditional on household composition and cover the running costs for food, clothes, leisure activities, etc. We set variable costs to a minimum associated with a modest standard of living as recommended by the Danish FSA for banks' assessments of creditworthiness. For example, variable costs for a couple without children are set to kr. 11,400 per month in 2021.

Chart 2 shows as en example the calculation of the economic margin (yellow) for our example of a dual household with two children and adjustable-rate loan in Horsens. The economic margin thus measures the remaining income of each household after it has serviced its debts and paid the necessary living costs. Crucially, households with a negative economic margin would not be able to obtain their current loans from a Danish credit institution with their current budgets given the Danish FSA guidelines. Moreover, we expect households with negative economic margins to have to deplete their savings in order to both service their debt and maintain a modest standard of living.

While a negative economic margin indicates a tight budget, it does not necessarily imply that a household cannot service its debts in the short run. The household can deplete its existing liquid assets, reduce its expenses below the expected level, sell illiquid assets, and with time increase its income. Moreover, our measure of economic margin relies on imputation of fixed costs, and is thus subject to measurement error. Similarly, a positive economic margin does not necessarily mean that a household is able to consistently save money every month. Households whose imputed economic margin is positive can have living standards requiring higher consumption and monthly expenses, and run a balanced budget or even monthly deficits. Nonetheless, Andersen and Duus (2013) show a positive correlation between even a rough measure of the economic margin of a household and the risk of late payments on their mortgage.

Average budget and economic margin in 2021 for households in Horsens with adjustable-rate mortgages Chart 2



Note: The figure shows as an example the computation of the economic margin for the average dual household in Horsens with two children and an adjustable-rate loan in 2021.
Source: Own calculations on Danmarks Nationalbank's credit register, and Statistics Denmark's population registers and consumption survey (Statistics Denmark, 2021).

We calculate that 85,000 homeowners had a negative economic margin in 2021. This result does not necessarily imply bad lending practice by credit institutions. First, loans might have been granted under different circumstances, and the households' financial situation might have changed, for example

as a consequence of temporary unemployment.[4] Second, as we state in Appendix A, our imputation of households' fixed costs is subject to measurement error, whereas credit institutions are obliged to individually assess household-specific fixed costs in their credit scoring process.

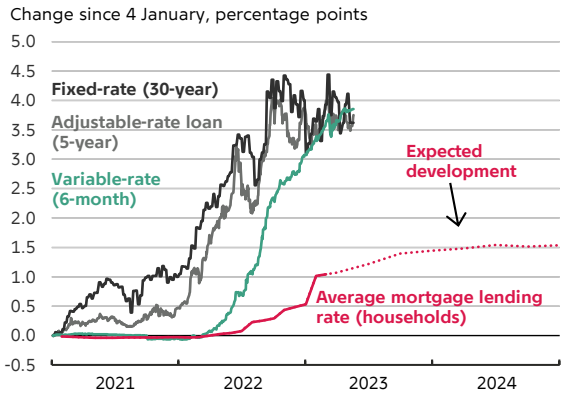
Rising interest rates: In 2023, servicing the debt of homeowners requires an extra 850 million monthly with respect to 2021

Since the beginning of 2022, interest rates have risen substantially. While in 2021 the reference rate for a fixed-rate mortgage was lower than 1 per cent, by late 2022 it was above 4 per cent, see Chart 1. However, the structure on the Danish mortgage market implies that homeowners are affected by the rising interest rates with delay due to interest rate fixation.[5] Given current interest rate forward curves, the average interest rate for Danish homeowners is expected to have the largest pickup in the spring of 2023, see Chart 3.

Most of these effects have already materialised. Inflation has been decreasing in 2023, and Chart 3 shows that about two thirds of the expected interest rate growth indicated by bond futures has already been transmitted to households by the first quarter of 2023.

In total, by the end of 2023, Danish homeowners will pay about kr. 850 million more per month to service their debt than in 2021 – an increase of 15 per cent (see Chart 10 in Appendix B).[6] This impact is borne by households with adjustable rates, whose payments will increase by kr. 2,100 per month on average.

Gradual pass-through of rising interest rates Chart 3



Note: The long mortgage bond rate is an average rate on issuances. The interest rates on adjustable-rate loans are estimated par rates. The change in the variable interest rate is calculated on the basis of the change in the reference rate (CIBOR 6m) assuming a constant interest rate spread between the variable interest rate on the mortgage bond and CIBOR 6m. Interest rates on outstanding mortgage lending are calculated as an average of interest rates paid by households and are only available on a monthly basis. The expected development in mortgage lending rates is calculated based on the assumption that the current forward rates from 19 May 2023 apply on future pay dates. The most recent observations are from 19 May

Source: Refinitiv Eikon, Nordea Analytics, Danmarks Nationalbank and own calculations .

Increasing interest rates sharply reduced the market value of outstanding fixed-rate mortgages, giving households the opportunity to refinance their mortgage through bond buyback (H. Y. Andersen, Grenestam, Læssøe, Otte, & Steffensen, 2023). Yet not all households who refinanced exploited the fall in the market value of their mortgage in order to reduce their indebtedness. While some households refinanced in order to pay of their more expensive debt and reduce their overall indebtedness, others extracted home equity and increased their sensitivity to rising interest rates.

We observe the composition of the debt portfolios of households at the end of 2021 and 2022. Given a

[4] Half of the homeowners with negative economic marginal in 2021 exceed their monthly budget by less than ten per cent. Of the remaining homeowners, 7,000 have liquid assets to cover monthly deficits for at least ten years, and another 16,000 have granted their loan more than three years prior, potentially under different financial circumstances.

[5] The Danish mortgage framework have a large share of fixed-rate callable mortgages, which is 48 per cent of the total debt. 25 per cent is adjustable-rate mortgages with interest rate fixation every fifth year, and 21 per cent is adjustable-rate mortgages with interest rate fixation at least once a year.

[6] Difference between total (after tax) debt payments for homeowners in 2021 and expected 2023 payments for homeowners in 2022.

household's debt composition, the rate fixation date, and the current interest rate forward curve, we can precisely compute not only the expected increase in debt servicing costs for each household by the end of 2023, but also how much the debt servicing costs would have increased if the debt composition were the same as in 2021, i.e. absent refinancing. By decomposing the total effect of rising interest rates through these components as shown in Appendix B, we can assess the impact of mortgage refinancing on the sensitivity of vulnerable households to rising interest rates.

Inflation and wage growth

The Danish consumer price index increased by 8.5 per cent in 2022, and is expected to increase 4.0 percent in 2023 (Danmarks Nationalbank, 2023). We project the impact of this rising pressure on household budgets in two ways.

First, we inflate the expected costs associated with a modest standard of living throughout the board by the general consumer price index in 2022, and Danmarks Nationalbank's expectations for 2023.[7] Overall, this means that if the standardised costs associated with a modest standard of living for a couple without children were kr. 11,400 in 2021, we expect them to be 12,899 in 2023, corresponding to a 13.2 per cent increase in two years.

Second, we inflate components of fixed costs separately according to their type, their specific price growth for that good or service in 2022, and the inflation expectations of Danmarks Nationalbank. For example, costs associated with childcare are inflated according to the average growth in childcare services in Denmark in 2022, and Danmarks Nationalbank's expectations for the 2023 growth in public sector prices.

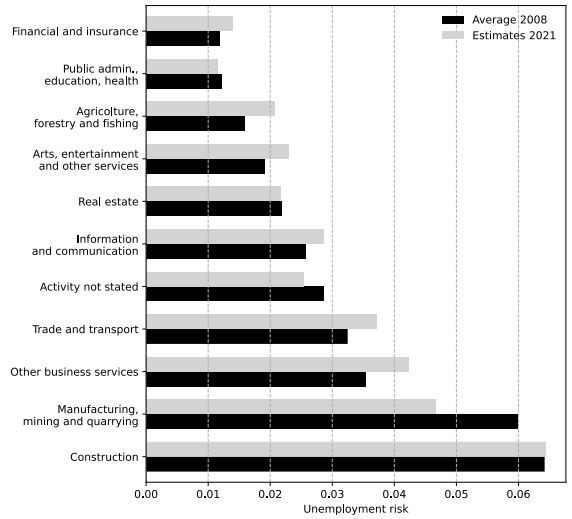
The highest inflationary pressure in decades has also deeply affected collective sector bargaining, and pushed wages upwards. We account for the resulting wage growth by scaling disposable income by the hourly wage growth in 2022 and expectations for 2023 from Nationalbanken (2023), which totals an 8.4 per cent increase.

Unemployment shock: Our estimated unemployment risk is lowest for high-income homeowners

We simulate the impact of a weaker labour market by sampling workers into unemployment according to our estimate of unemployment risk. Box 1 shows how we estimate unemployment risk by training a machine learning model on financial crisis microdata.

The resulting unemployment risk probabilities follow expected patterns, and replicate closely demographic differences in unemployment rates observed during the financial crisis.

Construction workers have the highest unemployment risk Chart 4



Note: The figure shows in black the average share of individuals employed in 2008 and experiencing unemployment in 2009 by sector. The grey bars show the average probability of unemployment estimated by the machine learning model for individuals employed in the same sector using data from 2021.
Source: Own calculations.

Chart 4 compares the observed probability of unemployment between 2008 and 2009 and

[7] All inflation and wage growth numbers used for simulating the impact of inflation in 2022 and 2023 to economic margins refer to Danmarks Nationalbank (2023).

estimated current unemployment risk given 2021 data across industries. As expected, labour-intensive industries that experienced larger separation rates during the financial crisis, such as the construction industry, are also those where we expect unemployment risk to hit hardest if a crisis materialises in the current economic environment.

Similarly, Table 1 shows that the properties of our estimated unemployment risk confirm to expectations. High-income wage earners and homeowners have lower unemployment risk than the rest of the population. Differences across regions are limited, with the Capital Region and Region Zealand (Sjælland) having marginally lower average probability of unemployment.

Estimated unemployment risk by home ownership, income quintile and region Table 1

	Median	Mean	Standard deviation
Homeowner	0.009	0.021	0.037
Not homeowner	0.021	0.044	0.059
Income quintile 1	0.021	0.046	0.063
Income quintile 2	0.027	0.052	0.066
Income quintile 3	0.012	0.026	0.038
Income quintile 4	0.008	0.016	0.025
Income quintile 5	0.007	0.012	0.017
Hovedstaden	0.012	0.029	0.046
Sjælland	0.011	0.029	0.049
Midtjylland	0.013	0.031	0.05
Syddanmark	0.013	0.031	0.05
Nordjylland	0.012	0.032	0.052

Note: The table shows median, mean and standard deviation of unemployment risk estimated by our machine learning model using microdata from 2022, divided by home ownership rate, income quintile, and geographic region.
Source: Own calculations on Statistics Denmark's population registers.

We extrapolate the unemployment risk probabilities to the population of employed individuals in 2021, and set the number of random draws according to size of the unemployment scenario. In the results discussed in the third section, we assess a scenario where we draw 54,000 individuals from employment to unemployment. This number corresponds to an increase in the yearly unemployment average of 160,000 individuals, which is about the level seen in the years following the financial crisis.

When we draw an employed individual to unemployment, we estimate the resulting disposable income depending on the individual's eligibility for cash and unemployment benefits ('kontanthjælp' and 'dagpenge'). See Appendix B for more details.

The next two sections are structured as follows. First, we discuss the effect on economic margins of rising interest rates and inflation, leaving unemployment unchanged. This scenario corresponds to the latest prognosis published by Danmarks Nationalbank (Danmarks Nationalbank, 2023). Second, we discuss the effects of an isolated increase in unemployment of over 50,000 individuals.

We estimate unemployment risk by training a machine learning model on financial crisis unemployment

Box 1

We train a machine learning model on micro-level data from the financial crisis (2008-2009) to estimate the probability of unemployment for each individual in our sample. We fit a gradient-boosted trees model on whether a person employed in November 2008 was unemployed by November 2009, given the person's 2008 data on non-capital income, salary, current employment status, labour market experience, the industry of employment, employment position (i.e. manager, high or low seniority employee etc.), length of service to the current employer, field (e.g. chemistry, economics, etc.) and level of highest educational level, time since the highest achieved education, and enrolment in an unemployment insurance scheme (*a-kasse*).

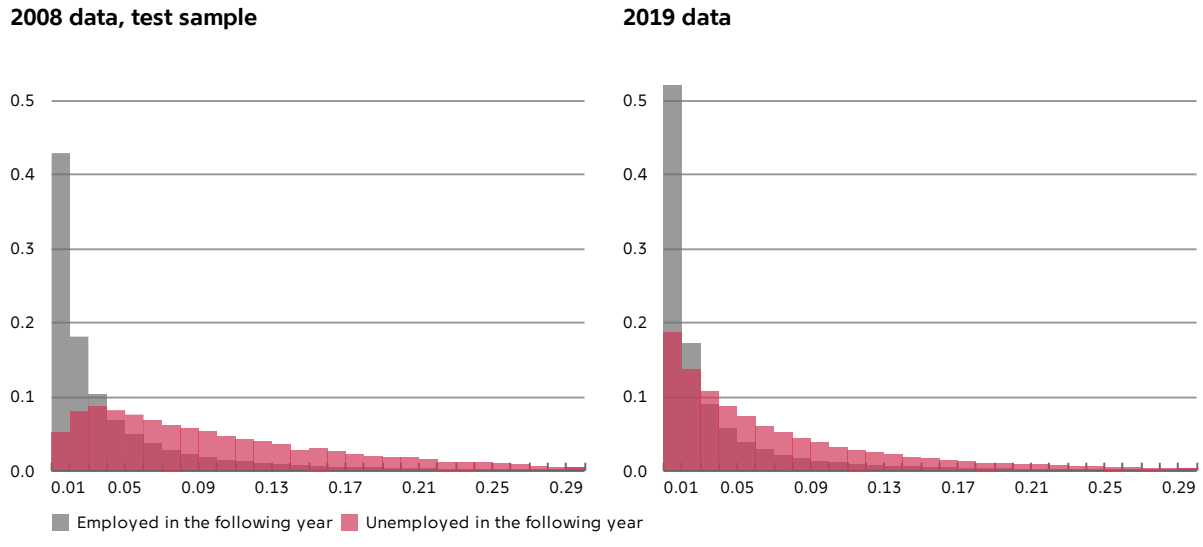
The model is trained on data from 2008 and minimises the differences between individuals' predicted risks and their actual unemployment outcome in 2009 (we use the sum of log loss as the minimisation criterion). Features used to explain the unemployment spells are pre-processed using a data pipeline trained on the same data, which handles missing observations, groups rare categories, and standardises continuous metrics. We did not tune hyperparameters other than setting the maximum tree depth to 5 for each tree in the boosting process and implemented early stopping.

The model is trained on 80 per cent of the 2008 employed sample (about 2.3 million individuals, 68,000 of whom became unemployed in 2009), while the remaining 20 per cent is kept as test, to evaluate the performance of the model in the same economic environment. We further test model performance on 2019 data for employed, predicting the likelihood of a person becoming unemployed during the onset of the COVID-19 pandemic. The 2019 data indicates how well the model performs when faced with a very different economic environment and source of unemployment shock.

In both cases, the model manages to separate the distributions of unemployment probability given the observed outcome. Generally, the predicted risk is higher for individuals ending up unemployed in the following year in both test sets. The model achieves a performance of 0.84 as measured by the area under the receiver operating characteristic (ROC) curve in the train set. In the 2008 test set, this metric only falls to 0.83, indicating little overfitting. In the 2019 data, this metric falls to 0.75, showing that the model has a harder time assigning probabilities in a different macroeconomic context, but still achieves acceptable performance levels.

We apply the model to 2021 data to estimate the risk we use to draw of additional persons into unemployment and simulate budget shocks.

The model produces separate probability distributions depending on actual outcome in the test data



Note: The figure shows the distribution of estimated probability of unemployment in 2009 (left panel) and 2020 (right panel) based on data from 2008 and 2019, respectively. Neither dataset contains observations used to train the model. Blue columns show the distribution of estimated probabilities for people who end up being employed in the following year (negatives), while purple columns show estimated probabilities for people who end up experiencing an unemployment spell in the following year (positives).
Source: Own calculations on Statistics Denmark's population registers.

Inflation and interest rates erode the robustness of Danish households

This section focuses on the impact of rising interest rates and inflation. We show that these factors will tighten the budget of households by the end of 2023, increasing the number of households with negative economic margin by over 40 per cent (36,000 households, or 3.4 per cent of Danish homeonwers) with respect to 2021, despite expected wage growth.

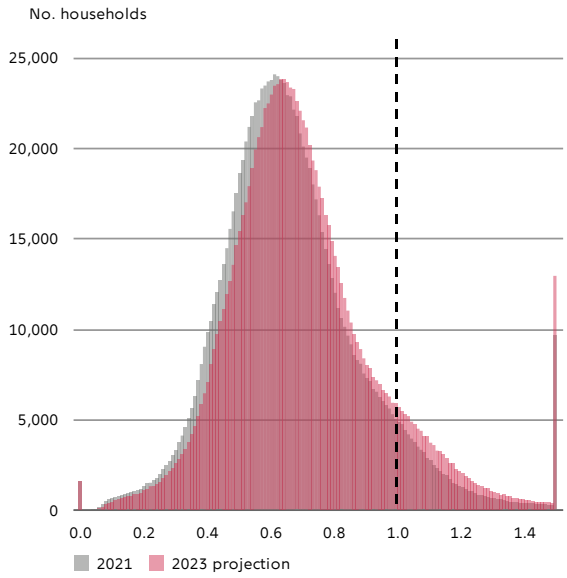
These impacts are broad across the population but relatively mild for the affected households. The majority of households can sustain the additional expenses by depleting their accumulated liquid assets or reducing their consumption.

Chart 5 shows the distribution of households' expected monthly expenses relative to their monthly disposable income before and after we simulate the effect of interest rates, inflation, and wage growth on their 2021 budget. Values exceeding one represent a negative economic margin, i.e. a situation where households are expected to either decrease their consumption below that of a modest standard of living or deplete their liquid assets to make ends meet. As a result of inflation and rising interest rates, the minimum expenses associated with a modest standard of living increase by 14 per cent (kr. 3,500) on average for Danish homeowners. For our initial example of a dual household in Horsens with an adjustable-rate loan and 2 children, these expenses increase by kr. 3.700 on average.

The transmission from interest rates to debt servicing costs has also been affected by the wave of mortgage refinancing that took place in 2022. About ten per cent of all households' fixed-rate mortgages have been converted to mortgages with adjustable interest rates in 2022, potentially decreasing the nominal amount of their debt, but increasing their exposure to high interest rates (H. Y. Andersen et al., 2023).[8]

Inflation and interest rates put pressure on household budgets despite wage growth

Chart 5

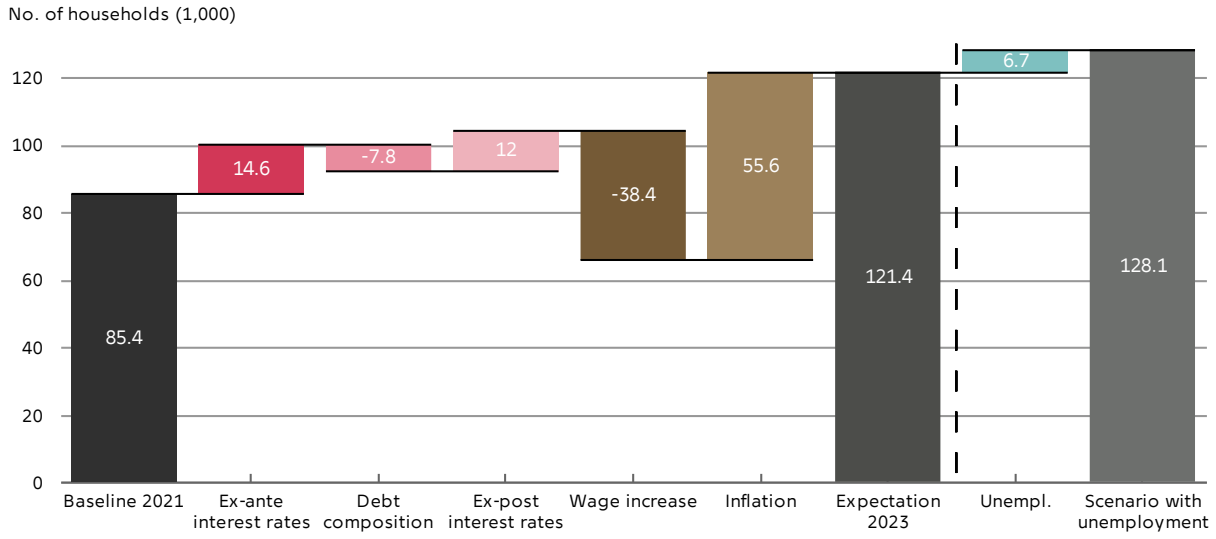


Note: The figure shows the distribution of the ratio of expected monthly expenses to disposable income. Values above one represent a negative economic margin. The distribution in blue shows 2021 data, while the purple distribution shows expectations for 2023 budgets after simulating the impact of inflation, interest rate growth, and wage growth.
Source: Own calculations.

[8] Andersen et al. (2023) characterise the refinancing wave in detail, and describe the characteristics of homeowners who decided to refinance their mortgage, and the potential consequences on their finances.

The number of households with negative economic margin is expected to increase by over 36,000 (3.4 per cent of homeowners) by the end of 2023.

Chart 6



Note: The figure decomposes the role of subsequent simulated shocks to the number of households with negative economic margin. The numbers shown in the middle of the full columns show the total number of households with negative economic margin. The numbers shown in the middle of the other bars represent the difference between the total number of households with negative economic margin before and after the shock, each rounded, and are therefore subject to rounding errors. The first three floating bars in red decompose the effect of increasing interest rates, see Appendix B. The dark brown bar represents the effect of wage increases. The light brown bar represents the effect of inflation. The green bar represents the effect of unemployment.

Source: Own calculations on Danmarks Nationalbank's credit register, and Statistics Denmark's population registers and consumption survey (Statistics Denmark, 2021).

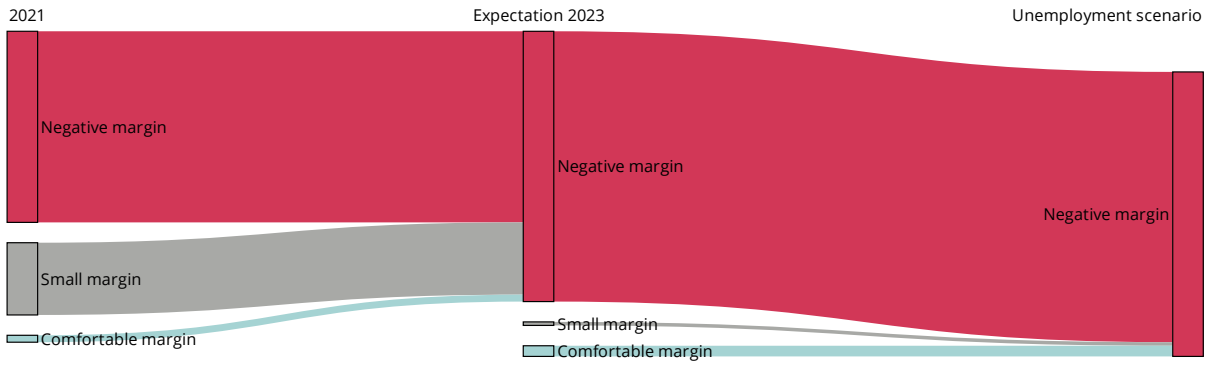
We take this endogenous behaviour into account by using the observed debt composition of households at the end of 2022 to simulate the impact of the expected further increase in rates during 2023. Further, we decompose the total impact of increasing interest rates in three components as shown in Appendix B. First, the ex-ante impact corresponds to the effect of increasing interest rates had households not refinanced during 2022. Second, the impact of debt composition represents the ex-ante effect of refinancing, which most often decreased the debt servicing burden of households had interest rates been the same as in 2021. Third, the ex-post effect of interest rates represents the effect of increasing interest rates since 2021 under the new debt composition.

Chart 6 shows how the expected number of households with negative economic margin (i.e. the mass on the right of the dashed black line in Chart 5) changes according to the effect computed on their budgets. The first three blue columns decompose the effect of increasing interest rates, and show that while households with low economic margin did improve their robustness in 2022 by adjusting their debt composition and decreasing their nominal debt, their vulnerability to interest rate hikes increased as a whole. An additional 19,000 households will have a negative economic margin in 2023 as a result of increasing interest rates.

Inflation also has broad effects across the population, causing the economic margin of an additional 17,000 households to turn negative despite wage growth. Overall, we expect the stock of Danish homeowners with negative economic margin to increase by 3.4 percentage points by the end of 2023. The debt of households with negative economic margin in 2023 amounts to kr. 135 billion, corresponding to 8.4 per cent of the outstanding stock of housing debt, see Table 3.

While negative income margins resulting from inflation and rising interest rates come from households with a tight economy as a point of departure, most households with negative margins as a consequence of unemployment had a solid economy in 2021

Chart 7



Note: We divide households in groups defined by the size of economic margin available in Danish kroner. The Sankey diagram characterises households that we expect to have a negative economic margin (red) by the end of 2023. Flows into this group are coloured according to the group of origin, which can be those with a small (less than kr. 5,000) or comfortable (more than kr. 5,000) economic margin. The left part of the graph represents households' budgets at the end of 2021. The central part of the graphs represents the effect of interest rate increases, inflation, and wage growth. The right part of the graph represents the effect of increasing unemployment.
Source: Own calculations.

Overall, the expected monthly costs of the median Danish household will increase by 7.3 per cent of their disposable income once expected wage growth is accounted for. While these additional costs can potentially impact the economy through lower aggregate spending and consumption, most households are likely to be able to contain them.

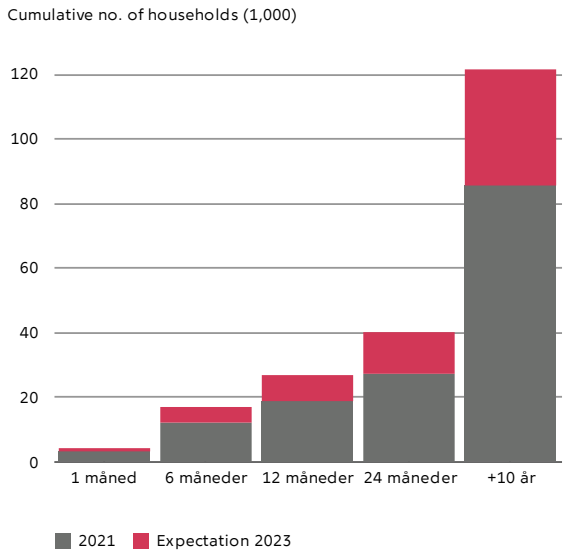
The effect of these shocks on economic margin is nonetheless larger for households which already had a tight budget in 2021. Among households with a positive economic margin but lower than kr. 5,000 in 2021, the median monthly cost increase is 13.1 per cent of their disposable income. Chart 7 shows that this group represents the majority of households whose economic margin becomes negative in 2023 as a result of inflation and increasing interest rates.

Chart 7 further highlights how these shocks affect most households, but mildly. The figure divides households in three groups; those with a negative economic margin, those with an economic margin smaller than kr. 5,000, and those with an economic margin higher than kr. 5,000, and shows how the different shocks affect the flows between these groups. The figure shows, as expected, that most of the households whose economic margin turns negative as a result of inflation and rising interest rates already had a tight margin to begin with.

The monthly expenses of the majority of households whose margin turns negative will exceed their disposable income by less than kr. 5,000. As a consequence, Chart 8, which shows how many households would be unable to finance their budgets through their liquid assets for a given period of time, outlines that the majority of households with negative economic margin have enough liquid assets to sustain their deficit for more than a year.

Most households with negative economic margin can finance the extra costs by depleting their liquid assets

Chart 8



Note: Cumulative number of households with negative economic margin grouped according to how many months it would take to deplete their liquid assets by financing the deficit in economic margins.
Source: Own calculations.

Unemployment disrupts the budgets of affected households despite mitigation

In this section we focus on the consequences of a potential unemployment shock, calibrated to match the number of unemployed in the years following the financial crisis, and simulate drawing 54,000 more employed persons to unemployment. We do not aim at simulating a financial crisis scenario with associated macroeconomic effects. This section solely aims at assessing the robustness of households to a widespread unemployment shock seen in isolation.

Unemployment is by nature a different shock than inflation and interest rate increases. It hits fewer people, but has potentially large consequences for individual budgets. If unemployment shocks are concentrated on highly indebted households, it can have a severe impact on the expected losses of credit institutions.

This section shows that even a sizable unemployment shock alone would not have a large effect on the stability of Danish households as a whole. The effects of an unemployment shock are mitigated by three factors.

First, homeowners have individually lower unemployment probability, as resulting by a machine learning model calibrated on microdata from the financial crisis, see Box 1 and Table 1.

Second, Denmark has a solid formal unemployment insurance scheme (*a-kasse*). Enrolment in such schemes are voluntary, but about three in four employed Danes are covered by the scheme. While the coverage of this insurance depends on the level of income, it has a meaningful impact on the expected income loss from unemployment. Table 2 shows that individual disposable incomes on average fall by 40 per cent for the covered individuals we sample into unemployment, as opposed to a fall of 96 per cent for uninsured individuals, due a to a very low-level eligibility for cash benefits. Note that a loss of gross income due to unemployment can lead to negative disposable incomes, as unemployed are still liable to, e.g., property taxes and alimonies.

Third, partners in a dual household provide each other partial insurance through their income. It is possible but rare that two individuals in the same household become unemployed in the same year – in our simulation we observe 139 such cases. The percentage loss in households' income due to unemployment is therefore further reduced by this informal insurance. Table 2 shows that, in dual households covered by formal unemployment insurance (76 per cent of the sample selected into unemployment in our simulations), although the affected individual experiences a disposable income loss of about 41 per cent due to unemployment, the household as a whole experiences a disposable

income loss of 22 per cent of their disposable income.

Unemployment insurance and spouse income mitigates unemployment impact Table 2

	Percentage point impact		
	...on individual disposable income	..on household disposable income	Number of households
Single households, insured	-44.4	-44.4	2,646
Single household, uninsured	-99.5	-99.5	345
Dual household, insured	-41.1	-21.8	16,101
Dual household, uninsured	-96.7	-41.6	1,858
Total	**-47.4**	**-27.8**	**20,950**

Note: The table shows the impact on unemployment on individual disposable income of affected individuals, and household disposable income of affected households. As disposable income is net of, e.g., property taxes and alimonies, which are due even if gross income falls to zero, absolute percentage point impacts for some households can be larger than 100 per cent. The sample consists in homeowners with housing debt in 2022 affected by the unemployment shock. In the 139 households where two individuals are affected the insurance status of the highest earner is used. Less than 200 affected homeowners in the uninsured group are eligible for cash benefits (*kontanthjælp*).
Source: Own calculations of expected disposable income in case of unemployment based on Statistics Denmark's population registers.

As a consequence of these safety nets, and that homeowners are a minority among households, simulating 54,000 additional unemployed persons in Denmark results in the economic margin of only about 6,700 households to become negative as a consequence of unemployment.

However, Chart 7 shows that, contrary to the effect of inflation and interest rates, these households are most often sampled among those with healthy budgets in 2021. These households are also more indebted than those already with negative economic margin, holding alone about kr. 10 billion in housing debt, see Table 3.

Household exposure by unemployment shocks Table 3

	Count	Share of households (per cent)	Housing debt (kr. billions)	Share of housing debt (per cent)
Baseline 2021	85,439	7.9	89	5.1
Expectation 2023	121,419	11.3	135	7.8
Scenario with unemployment	127,527	11.9	145	8.4

Note: Descriptive statistics on households with a negative economic margin. Baseline 2021 is compared with the expectation of 2023 and lastly, the additional negative shock to unemployment.
Source: Own calculation of Danmarks Nationalbank's credit register, and Statistics Denmark's population registers and consumption survey.

Moreover, the consequences of this shock are pronounced. Even if moderated by safety nets, the average fall in disposable income as a consequence of unemployment is approximately 28 per cent among affected households, an order of magnitude larger than the effect of interest rate hikes and inflation.

As a consequence, the average households pushed into having a negative economic margin as a consequence of unemployment has a deficit of about kr. 6,600 monthly. For comparison, households having a negative economic margin as a consequence of inflation and rising interest rates have a deficit of only kr. 2,400.

Yet while we focus primarily on households with a negative economic margin for being particularly at risk, as even under a modest living standard their income would not match their monthly costs, not all households would rapidly be able to adjust their consumption to modest levels. As a consequence of inflation and rising interest rates alone, a further 55,000 households would maintain a positive

economic margin, but see it fall by at least 20 per cent, and at least by kr. 1,000 per month.

Similarly, the economic margin of a further 9,000 households, while remaining positive, would fall by at least 20 per cent due to the unemployment shock. Overall, three in four households hit by unemployment would experience a sudden and harsh reduction in their consumption possibilities, severely impacting their liquid wealth in the short run and, eventually, their ability to service their debt in the long run.

Implications for credit institutions

In this memo, we have calculated the economic margin for the entire population of Danish homeowners, and computed the impact of inflation, rising interest rates and unemployment on these margins. We estimate that by the end of 2023, inflation and rising interest rates alone will increase the number of households with a negative economic margin by 36,000 units, corresponding 3.4 per cent of all homeowners.

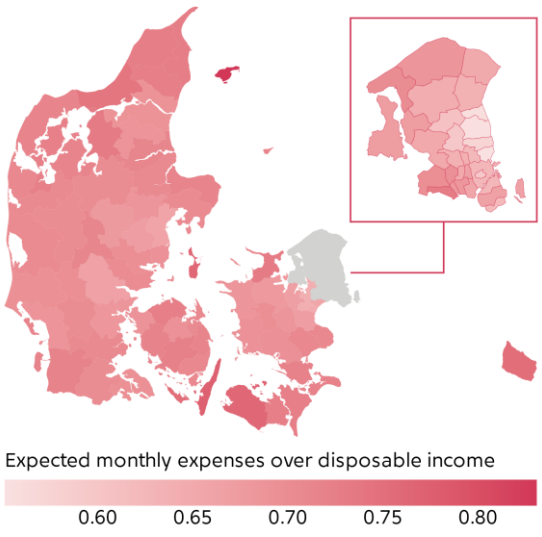
While a large unemployment shock would be attenuated in the population by existing formal and informal insurances, it would heavily disrupt the budgets of the affected households, and turn the economic margin of 6,700 households negative. Households affected by unemployment would have to markedly reduce their consumption and deplete their liquid assets to timely service their debt (A. L. Andersen & Duus, 2013).

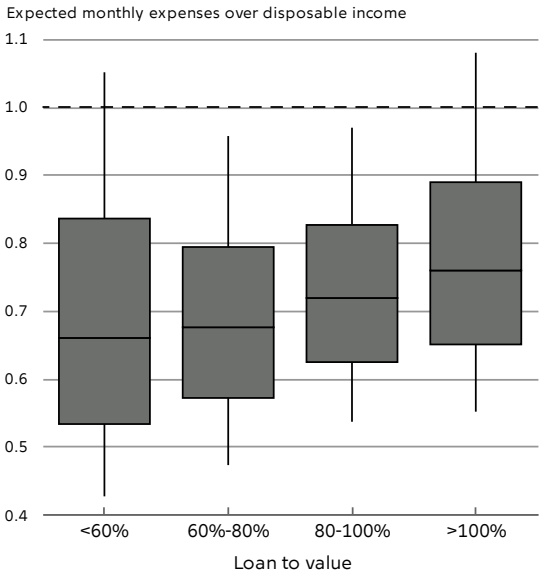
Mapping economic margins across the country and simulating the effect of macroeconomic shocks on households' budgets is not only a valuable tool for monitoring the financial vulnerability of Danish households, but also reveals where financial risks are concentrated in the household sector.

The left panel of Chart 9 shows that homeowners in small, sparsely populated municipalities are more

The ratio between expected monthly expenses and monthly disposable income is higher in sparsely populated small municipalities and for highly indebted households

Chart 9





Note: The figures show the median ratio between monthly expected expenses and disposable income (see Chart 5) by Danish municipality (left) and a boxplot of the same metric by household indebtedness (right) measure by loan to value, i.e. size of debt over value of collateral. The boxplot whiskers show the range between the 10th and 90th percentile of the distribution.
Source: Own calculations

vulnerable to these shocks. The median ratio between imputed expenses and disposable income as a consequence of inflation, rising interest rates, and unemployment shocks, see Chart 5, ranges from 83 per cent in Læsø to 55 per cent in Gentofte.

Similarly, the right panel of Chart 9 shows that highly indebted households also have lower economic margins, primarily as a result of higher debt servicing costs. These households not only carry a risk for credit institutions in terms of higher debt exposure in case of default, see Danmarks Nationalbank, 2023, but are also more vulnerable to worsening economic environments.

By documenting our approach, based on granular microdata and enriching it using machine learning techniques, this memo contributes to the ongoing development of macro-prudential surveillance tools that, by enhancing awareness and monitoring of growing risk factors, strengthen the ability of authorities of protecting financial stability and securing Denmark a stable and robust economy.

Appendix A: Components of economic margin

Household definition

The population is based on administrative register microdata made available through Denmark Statistics. We only consider individuals residing in Denmark that are fully liable to income tax. Individuals are aggregated into households defined as families living on the same address, based on Statistics Denmark's definition of E-families.[9]

Household income

Information on household income comes from register microdata.[10]

We compute disposable income[11] as

$$\begin{aligned} &Disposable\ income \\ &\quad = Pre\ tax\ income - Paid\ taxes \\ &\quad - Tax\ relief\ on\ interest \\ &\quad - Paid\ alimony \end{aligned}$$

Pre tax income is total personal income. *Paid taxes* is total taxes including tax relief on interest. We compute debt payments after tax relief, so we subtract *tax relief on interest* from disposable income. We observe only total interest expenditures, however, the large majority of households' interest expenditures are paid to credit institutions, and are thus observable through the credit register. *Paid alimony* is alimony paid to children or spouse. Disposable income is transformed into monthly income and aggregated on household level.

To account for wage growth we project disposable income with the growth of hourly manufactyring wages in 2022 and the expected growth of 2023 from Danmarks Nationalbank (2023), 3.5 and 4.7 per cent, respectively.

Fixed costs

We impute fixed costs for each household's given aggregate consumption data from the household consumption survey. Specifically, we use publicly available data from tables FU03, FU05, FU07, and FU08 in Statistics Denmark's databank, which aggregate consumption data according to household type, income group, region and age group, respectively.

For each aggregate, we extract 2021 consumption of the following goods and services:

04.3: Maintenance and repair of the dwelling
04.4: Water supply and miscellaneous services relating to the dwelling
04.5: Electricity, gas and other fuels
07.2: Operation of personal transport equipment
07.3: Transport services
08.2: Telephone and telefax equipment
08.3: Telephone and telefax services
12.4: Social protection
12.5: Insurance

The choice of these categories follows the guidelines set by the Danish FSA (Finantilsynet, 2021). From this list, we explicitly exclude debt servicing costs, which we compute through the credit register. Further, as group 07.3 (Transport services) also includes airline travel, and data on more granular consumption groups is only available for the full population, we downscale it by the proportion of airline travel in the group using full population consumption data (table FU02).

By combining each household aggregate, we obtain 875 combinations of these costs by household type, income group, region and age group. For each of these household groups, we estimate a weighted average of the costs. That is, if – for simplicity's sake – we had two aggregates tables a and b containing aggregate costs for consumption type i varying across aggregate household groups j_a and j_b, we

[9] Statistics Denmark (2023).
[10] Top/bottom 1 per cent of the income distribution is winsorized.
[11] The computation of disposable income differs from Statistics Denmark's in two ways. First, we do not add net annual value and subtract interest expenditures. Second, we subtract tax relief on interest as this is included in the computation of debt servicing costs.

aggregate observations x_{i,j_a} and x_{i,j_b} and weigh them to get the cross-products x_{i,j_a,j_b} for each cost x_i.

We use to weights for this aggregation. The first weight varies across rows j_a of an aggregate table a, and is constant across consumption groups x_i. Denoting the number of households represented by each aggregate j_a (see table FU01) as $|j_a|$, it is computed as

$$iw_{j_a} = \frac{\sum_{j_a} |j_a|}{|j_a|}$$

and represents an inverse population weight. The intuition is that if I have data on a consumption aggregate representing a very specific part of the population, and another representing a very wide portion of the population, given that I know that a household belongs to both groups, the more specific aggregate carries relatively more information.

The second weight is constant across rows j_a of an aggregate table a, and varies across consumption groups x_i. It represents how much variation a specific split of the data has, and therefore how much explanatory power it has to infer the consumption of a subgroup. It is simply computed as the in-sample variance for each variable in each table

$$vw_{i_a} = Var_a(x_i)$$

The weighting procedure is best explained by an example. Let's say we want to compute average costs x for a cross-aggregate group. We then

1. Create the cross-join of all table (i.e., all possible combinations)
2. Compute the weights
3. Average the observations out

so that the final variable x_j is computed for each cross-row j and across tables k as

$$x_j = \frac{\sum_k vw_{i_k} \cdot iw_{j_k} \cdot x_i, j_k}{\sum_k vw_{i_k} \cdot iw_{j_k}}$$

Modest variable costs

After covering fixed costs, households need to cover the remaining variable running costs for food, clothes, subscriptions, leisure activities and presents, holidays and personal expenses for smoking, hairdressers, medicine etc. Variable costs also include replacement and maintenance of durables goods such as mobile phones, computers, fridges etc.

In Finanstilsynet (2021), the Danish Financial Supervisory Authority provides general guidelines on the assessment of the creditworthiness of consumers by creditors. The income left after fixed costs and debt service (*'rådighedsbeløb'*) needed to cover variable costs should be assessed individually, but with the following amounts[12] as a benchmark for a modest standard of living in 2021. Kr. 6,720 (11,400) per month for a single (dual) person household with additional supplements per child in the household: Kr. 1,840 under the age of two, 2,350 until the age of seven, and 3,370 from age seven to eighteen.

To account for inflation-driven cost increases, we project the amounts with the growth of the consumer price index in 2022 and the forecast of Danmarks Nationalbank (2023) for 2023, 8.5 and 4.0 per cent, respectively.

Debt financing cost

Households' debt financing costs are computed based on data from the Danish credit register containing quarterly reported observations covering the full population of outstanding mortgages and bank loans in Denmark.[13] The credit register contains detailed information for each loan on borrower-level which allows us to calculate the exact series of payments for each individual and each loan. Furthermore, we account for loan-specific

[12] The amounts originate from the law on debt relief: *Bekendtgørelse om gældssanering nr. 1363 af 19. december 2008* and Bekendtgørelse om ændring af bekendtgørelse om gældssanering nr. 1850 af 07/12/2020.

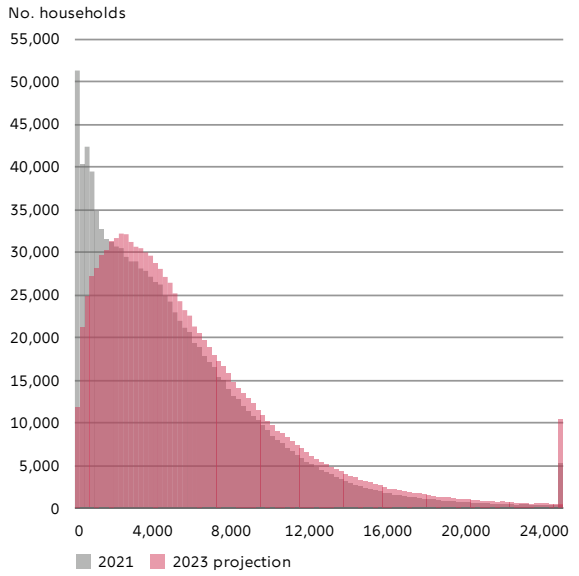
[13] We restrict the population to only containing loans from *full reporting* institutions due to lag on reportings from *tail reporting* institutions. Full reporting institutions covers all mortgage institutions and the vast majority of commercial banks. However, individuals financing a property partly through tail reporting institutions and partly through a mortgage institution will be excluded to ensure we have information on the full loan finance.

characteristics such as repayment method, time to maturity, interest-only etc. Calculated payments are after interest rate tax deductions. Baseline debt financing costs are computed based on data from end of 2021.

Appendix B: Simulating shocks to economic margin

Impact of interest rate growth

Rising interest rates increase debt servicing costs for the majority of Danish homeowners Chart 10



Note: Distribution of total debt payments for households in 2021 and expected payments in 2023. Includes all debt for households owning a house in 2022. Projections of 2023 are based on the current forward curve (as of 26 April 2023).
Source: Danmarks Nationalbank's credit register.

Data from the Danish credit register are available with a shorter lag and we are thus able to use the latest data from end of 2022 to compute expected debt payment after shock. We shock all loans with interest rate fixation in 2023 with interest rates corresponding to the current forward curve (as of 26 April 2023) and interest differentials on the loan. As for the baseline-debt financing costs in Appendix A, debt payments are after interest rate tax deductions.

A combination of 2021 and 2022 data, respectively allow us to deduct the effects from both rising interest rates and refinancing behaviour. Specifically, we compute debt payments pmt_t^y corresponding to end of time *t* and based loan compositions in year *y* for *t*={21, 23} and y={21,22}.

$$pmt_{23}^{22} = pmt_{21}^{21} + \underbrace{(pmt_{23}^{21} - pmt_{21}^{21})}_{\Delta Interest\ rate\ (ex\ ante)} + \underbrace{(pmt_{23}^{22} - pmt_{21}^{22})}_{\Delta Interest\ rate\ (ex\ post)} + \underbrace{(pmt_{21}^{22} - pmt_{23}^{21})}_{\Delta Debt\ composition}$$

Δ*Interest rate (ex ante)* caputes the effect from higher interest rates given no change in debt composition, and is computed as the change in debt payments between 2021 and 2023, based on the 2021 loan composition. Similarly, Δ*Interest rate (ex post)* is computed as the change in payments, but based on the 2022 loan composition.

Δ*Debt composition* captures the change in payments due to a changed debt profile given the change in interest rates. Specifically, it is the difference between payments in 2021 based on the 2022 loan composition and payments in 2023 based on the 2023 loan composition.

Chart 10 plots the distributions of pmt_{21}^{21} and pmt_{23}^{22}, and shows how the costs of debt servicing have increased for Danish homeowners. Due to rising interest rates and mortgage refinancing, the number of Danish households with debt servicing costs lower than one thousand kroner will decrease from 19 per cent in 2021 to 10 per cent in 2022.

Impact of inflation

We simulate the impact of inflation by inflating both our estimation of fixed costs and the required expenses to sustain a modest standard of living (Finantilsynet, 2021).

We group fixed costs components according to the primary driver of prices in the consumption basket between energy, services or the public sector. We then inflate these costs according to the increase in

net consumer prices observed in 2022 within each cost component (see table PRIS111) and Danmarks Nationalbank's prognosis for inflation in gross prices in 2023 within each price driver. Specifically, we observe three price levels for each fixed cost component i:

1. $p_{i,22}^{dst}$: The (observed) net price growth between 2021 and 2022 for costs component i (source: Denmark statistics, *dst*)
2. $p_{i,22}^{nb}$: The (observed) (observed) gross price growth between 2021 and 2022 for cost component i (source: Denmark Central Bank, *nb*)
3. $p_{i,23}^{nb}$: The (observed) (expected) gross price growth between 2022 and 2023 for cost component i (source: Denmark Central Bank, *nb*)

To account for the difference between net and gross price growth and for the fact that we have an estimate for a whole price driver for 2023, but that developments in 'varegrp' price growth might be slower or faster than average for the specific cost component i, we correct $p_{i,23}^{nb}$ by the correction factor $p_{i,22}^{dst}/p_{i,22}^{nb}$ as follows

$$\widehat{p_{i,23}^{nb}} = \frac{p_{i,22}^{dst}}{p_{i,22}^{nb}} p_{i,23}^{nb}$$

We use $p_{i,22}^{dst}$ to scale our imputed costs, and this corrected price growth estimate to scale our imputed costs from 2022 to 2023.

Further, we scale variable costs necessary for a modest standard of living according to the consumer price index for 2022 and 2023 according to Danmarks Nationalbank's prognosis (Danmarks Nationalbank, 2023).

Impact of expected wage growth

Our latest measures on income are based on 2021 tax registers. We therefore account for the resulting growth by scaling income by the observed Danish wage growth in 2022 at 3.5 per cent, and the announced outcome of the 2023 collective sector bargaining, which is expected to result in a 4.7 per cent increase in hourly wages in 2023. We scale all incomes equally, also counterfactual income.

Impact of unemployment shock

To increase the number of full-time unemployed to 160,000, approximately the level after the financial crisis, we draw persons employed end of November 2021 to unemployment. Since the average annual unemployment in 2021 was 106,000 it implies shifting 54,000 persons from employment to unemployment. We draw from the 2021 population of employed (incl. self-employed) who did not become unemployed during the year and had a positive income ('erhvervsindkomst' including labour market income and business profits).

To account for the varying risk of unemployment, we predict individual risk for the population using the estimated machine learning model described in the section Data and Approach. This yields a probability distribution used for draws.

When a person is drawn to unemployment, we substitute the person's disposable income with the expected counterfactual the person would receive in case of unemployment, see Box 2.

To assess the sampling sensitivity of how many households the unemployment shock pushes to a negative economic margin we repeat the sampling and budget estimation procedure 1,000 times. Chart 11 concludes that the simulation sensitivity is low, since the distribution of repeated simulations is narrow and the mean is close to our reported result from the initial simulation.

Counterfactual disposable income in case of a draw to unemployment

Box 2

When we draw an employed individual to unemployment, we estimate the resulting disposable income depending on the individual's eligibility for cash and unemployment benefits.

If the individual has been a member of an unemployment fund at least since 2020, we consider the individual suitable for unemployment benefits ('dagpenge'). Rates of unemployment benefits are based on public schemes from January 2023.[1] According to the rules, we set benefits to the maximum of 90 per cent of earned income and the rate.

Individuals not suited for unemployment benefits can receive cash benefits ('kontanthjælp') if liquid assets are below kr. 10,000 (20,000 for a dual household). Spousal income is partly deducted.[2]

Both unemployment benefits and cash benefits are adjusted yearly based on the rate of wage increases two years before subtracting 0.3 percentage points for the mandatory pension fund and 0.75 percentage points for lesser regulation.[3]

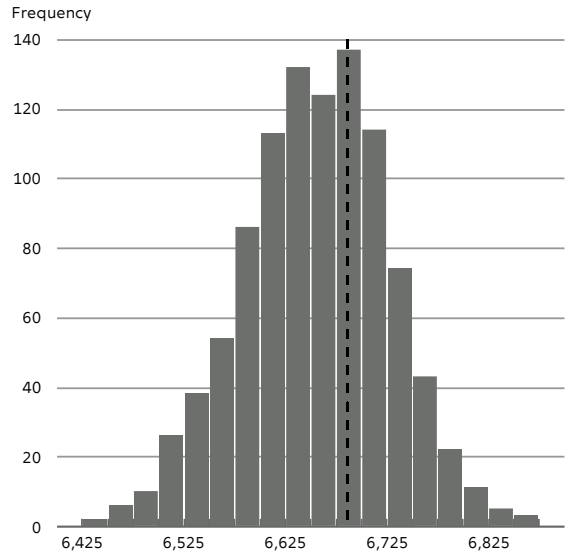
Individuals not eligible for either unemployment benefits or cash benefits will get zero as income.

Counterfactual disposable income is then defined based on the above income definition computed after tax. Furthermore, we add public child allowance and subtract child alimony and housing taxes from the registers. Finally, due to our simplistic application of the benefit rules, we impose unchanged income if a person is gaining monthly disposable income from transitioning to unemployment. Our approach does not include potentially continued capital income streams.

1. Schemes for unemployment benefit scan be found here: borger.dk, Arbejdsløshedsdagpenge, borger.dk/arbejde-dagpenge-ferie/Dagpenge-kontanthjaelp-og-sygedagpenge/Arbejdsloeshedsdagpenge, accessed May 22th 2023.
2. Styrelsen for Arbejdsmarked og Rekruttering, Satser på Styrelsen for Arbejdsmarked og Rekrutterings områder, star.dk/ydelser/satser-og-udbetaling/satser, accessed May 22th 2023.
3. Finansministeriet, Regneprincipper på beskæftigelses- og overførselsområdet, September 2021.

Simulation sensitivity of households with negative margin due to unemployment shock

Chart 11



Note: Histogram based on 1,000 simulations of the total number of households that end up with a negative economic margin after the unemployment shock. Mean = 6,654, std. dev. = 73.
Source: Own calculations on Danmarks Nationalbank's credit register, and Statistics Denmark's population registers and consumption survey (Statistics Denmark, 2021).

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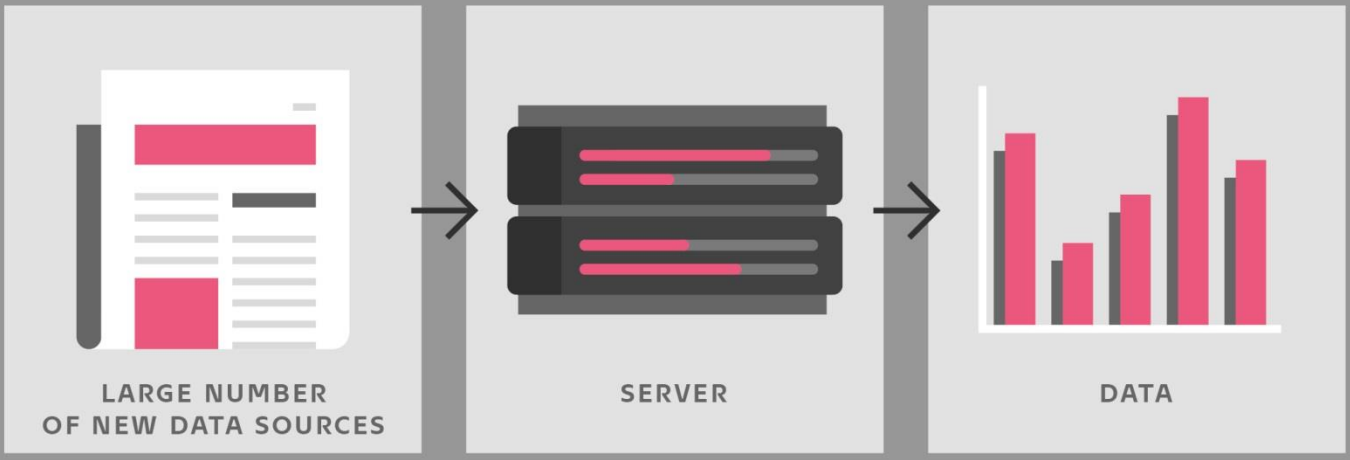

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