Fisher Dynamics, Monetary Policy, and Household Indebtedness*

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Abstract

Growth in household debt-to-income ratios can be attributed to nominal debt changes or "Fisher dynamics" due to interest income and expenses, real income growth, and inflation. With microdata covering the universe of Norwegian households for more than 20 years, we decompose the importance of these channels for how debt-to-income ratios evolve over time and respond to monetary policy shocks. On average, debt changes outsize Fisher dynamics, but among highly leveraged households Fisher dynamics dominate. After interest rate hikes, debt changes and Fisher dynamics pull in opposite directions, with the former dominating, leading to a decline in debt-to-income ratios. This pattern is consistent across sub-groups, including highly indebted households, recent movers, households facing liquidity constraints, and households facing high unemployment risk.

JEL: E21, E52, D14, G51
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1 Introduction

Historical studies find that run-ups in household indebtedness are associated with deeper macroeconomic recessions and financial crises (Jordà, Schularick, and Taylor, 2013, 2015b, 2016; Mian and Sufi, 2018). Recent experiences fit into this pattern, as the macroeconomic consequences of the 2008 financial crisis were more severe in geographical areas where household debt had increased more before the crisis began (Glick and Lansing, 2010; Mian, Rao, and Sufi, 2013; Martin and Philippon, 2017). These findings have, in turn, shaped policy discussions over the last decade, where a particularly central and controversial question has been whether monetary policy should "lean against the wind" by raising the interest rate when household indebtedness accelerates (Gelain, Lansing, and Natvik, 2017; Svensson, 2017; Gourio, Kashyap, and Sim, 2018).[1]

Two empirical questions then naturally arise: What accounts for the evolution of different households' debt burdens over time, their debt growth or their nominal income growth? And how do interest rate changes affect different households' indebtedness? One conjecture is that tighter monetary policy motivates households to borrow less, consistent with textbook intertemporal substitution effects. On the other hand, higher interest rates are likely to reduce debtors' labor income growth and raise their interest costs. The latter will pull debt-to-income up, particularly among those with initially high debt levels, and thus are likely to be a main concern for financial stability authorities. Unfortunately, precise documentation of these opposing forces is missing and even the sign of how monetary policy affects household indebtedness is an unsettled empirical question.

We provide micro-level evidence on the relative importance of the channels mentioned above across different households, and we estimate how monetary policy shocks transmit to household indebtedness. To this end, we utilize administrative records covering the universe of Norwegian households for 22 years (1994 to 2015). These data allow us to dissect the dynamics of each household's debt-to-income ratio over time and estimate how it is affected by monetary policy shocks. Importantly for interpreting our results, this is a setting where nearly all debt consists of mortgage loans with adjustable interest rates. Hence, direct effects from interest rate changes on debtor cash flows will be rather immediate.

Our point of departure is the households' debt-to-income ratio, DTI_t. As a matter of accounting, changes in this ratio are either due to movement in the numerator, i.e., increased or reduced nominal

[1]The rationale for policies to stabilize debt rests on pecuniary or aggregate demand externalities. Farhi and Werning (2016) and Korinek and Simsek (2016) show how these externalities can justify macroprudential tools. But if this toolkit is limited, monetary policy might be called upon to prevent debt burdens from building up (Caballero and Simsek, 2020). Since the 2008 financial crisis, the central banks in Norway and Sweden have indeed explicitly justified their policy choices with such concerns.

debt, or the denominator, i.e., nominal disposable household income growth:

$$\Delta \mathrm{DTI}_t = \underbrace{\frac{B_t - B_{t-1}}{Y_{t-1}}}_{\text{Nominal debt change}} \underbrace{- \mathrm{DTI}_t \frac{Y_t - Y_{t-1}}{Y_{t-1}}}_{\text{“Fisher dynamics”}} \tag{1}$$

where B_t is nominal debt and Y_t is nominal income. We refer to the first term as nominal debt change, capturing how much a household increases or cuts its debt over the year. Nominal income growth can in turn be decomposed into real income growth, inflation, and net interest income. The latter is the difference between interest income and interest expenses. We follow Mason and Jayadev (2014) and term the total impact of these forces *“Fisher dynamics”*, referring to Irving Fisher's emphasis on how adjustments in prices, interest rates, and real income propagated problems of high indebtedness during the Great Depression (Fisher, 1933).[2]

Our first contribution is to quantify the role of nominal debt changes and Fisher dynamics in accounting for how household indebtedness has evolved in the microdata over time. The average debt-to-income ratio increased from 118% to 216% over our sample period, reflecting that positive nominal debt changes outsized the moderating effects of the Fisher variables. Among the latter variables, real income growth was the most important factor and in some years even made debt-to-income ratios fall despite positive nominal debt changes.

While the aggregate analysis points to nominal debt changes as the dominant force, a closer look across the distribution of households shows that Fisher dynamics are important in segments of the population. In particular, the relative importance of nominal debt changes and Fisher dynamics varies considerably across households with different initial debt levels. Among the 60 percent of households with the lowest debt-to-income ratios, Fisher dynamics are close to irrelevant. But among households in the top 20 percent of the debt-to-income distribution, Fisher dynamics outsize nominal debt changes and drive the debt-to-income ratios of the most heavily indebted households down. The variation across the debt-to-income distribution partly reflects the mechanical logic of equation (1), as Fisher dynamics are weighted by indebtedness. It also reflects that households with high debt relative to income tend to experience high real income growth.

Fisher dynamics will be particularly important for debt-to-income movements if households tend to follow given amortization schedules. Therefore, we distinguish between households who move to a new home and those who stay, under the conjecture that households are likely to readjust the terms of their mortgage contracts when they purchase a new house.[3] The data are consistent with this conjecture. Among movers, high nominal debt growth almost entirely drives

[2]One could also call the Fisher dynamics “contribution from nominal income growth” or similar. We prefer the term Fisher dynamics, as it encompasses the total mechanical influence of interest income and expenses, all other sources of income, and inflation.

[3]Bernstein and Koudijs (2024) find that empirically, amortization schedules have a strong effect on household saving, indicating that these schedules bind households' debt repayment.

debt dynamics. Among stayers, the Fisher variables contribute approximately to the same extent as nominal debt changes. Taken together, our micro evidence implies that the average Fisher dynamics we observe stem from households who do not move (the majority of households) and who have high debt-to-income ratios.

Our second contribution is to directly estimate how monetary policy shocks affect different households' debt-to-income ratios through nominal debt changes and Fisher dynamics. We use the Norwegian monetary policy shock series recently constructed with a narrative approach by Holm, Paul, and Tischbirek (2021). In line with the conventional logic that higher interest rates motivate saving (i.e., intertemporal substitution), we find that on average across households, nominal debt changes fall after interest rate hikes. Fisher dynamics pull in the opposite direction, but their responses are weaker than those of nominal debt changes. Hence, tighter monetary policy on average reduces debt-to-income moderately in the short run. The average debt-to-income response is similar when we instead identify monetary policy shocks from high-frequency market reactions to policy announcements. Moreover, when we separate interest rate hikes from cuts, the point estimates suggest that the average response is mostly driven by interest rate cuts, but the two responses are not statistically distinguishable.

The above pattern holds not just on average but remains surprisingly stable across different household groups. It holds among households who are highly indebted and therefore have a high weight on the Fisher component in accounting identity (1). It holds among households with high labor income risk who therefore are the most likely to experience that their earnings respond to monetary policy. It holds among households with low liquidity and among households who have recently moved and thus are unlikely to buy a new house in the coming years. The latter is striking because we would expect their debt repayment to be particularly connected to preset amortization plans, as suggested by our historical decomposition, a cursory look at repayment behavior in our data, and Dutch evidence by Bernstein and Koudijs (2024). Hence, our estimates indicate that even among those households where our historical decomposition unveils the greatest contribution from Fisher dynamics, the impact of monetary policy on indebtedness is dominated by the choice of how much more to borrow or repay.

The upshot of our results is that while nominal income growth matters for the historical evolution of debt-to-income ratios over time, the transmission of monetary policy shocks to household indebtedness is still dominated by household behavior rather than Fisher dynamics in our sample. As financial stability risk arguably concerns tail events, we find it notable that this conclusion holds not just for the average household but also among debtors who are likely to be most at risk, namely the households with high debt-to-income ratios, limited liquid reserves, or high income risk. However, we note that the quantitative effect of interest hikes on debt-to-income seems moderate. For instance, our baseline estimate implies that a one percentage point interest hike reduces the average debt-to-income ratio by 1.5 percentage points, in a sample where the average debt-to-income ratio is 161.5%.

Our estimates are informative for evaluating leaning-against-the-wind policies in economic models. Gelain et al. (2017) and Svensson (2017) argue that it makes little sense for monetary policy to target household indebtedness if debt dynamics are tied to predetermined amortization plans, as monetary policy mainly affects debt-to-income ratios through Fisher dynamics. In particular, if debt-to-income ratios respond positively to interest rate hikes, a policy of systematically hiking interest rates when the debt-to-income goes up could induce a detrimental self-reinforcing spiral. Our historical evidence supports the narrative that the long-term nature of mortgages is important for debt dynamics, but our estimates go against the latter part of the argument.

A related literature uses structural models to assess how details of household mortgage contracts interact with monetary policy more generally (Beraja, Fuster, Hurst, and Vavra, 2018; Wong, 2019; Berger, Milbradt, Tourre, and Vavra, 2021; Guren, Krishnamurthy, and McQuade, 2021; Kinnerud, 2025; Eichenbaum, Rebelo, and Wong, 2022). Moreover, the elasticity of asset demand, including debt, to interest rate changes can play a key role in understanding how long-run trends in inequality or demographics affect equilibrium interest rates (see, e.g., Auclert and Rognlie, 2018, Straub, 2018, Auclert, Malmberg, Martenet, and Rognlie, 2020, and Mian, Straub, and Sufi, 2021). Our study provides micro-level estimates to inform such quantitative analyses of how monetary policy affects household debt-to-income ratios in an environment with adjustable interest rate mortgages.

Existing evidence on household debt dynamics primarily stems from macro data. Mason and Jayadev (2014) propose and apply a similar decomposition framework as we use.[4] They show that much of the historical variation (from 1929 to 2011) in the aggregate US household debt-to-income ratio is explained by Fisher dynamics. A set of papers have used time-series techniques to estimate how household debt responds to monetary policy shocks (Jordà, Schularick, and Taylor, 2015a; Bauer and Granziera, 2017; Robstad, 2018). Their evidence is mixed. Overall it seems that interest hikes moderately reduce household debt, while results on the macro-level response of debt-to-income are ambiguous.[5] Unlike this literature, our contribution is to use microdata which allows us to decompose debt and income components for different households.

Finally, our study fits into a growing set of papers that illuminate the transmission of monetary policy using microdata on households so as to gauge distributional and not just aggregate effects.[6] Within this literature, we are the first to focus on how monetary policy affects household

[4] As discussed in Section 2, we use a slightly different decomposition than Mason and Jayadev (2014) so as to ensure that the direct cash-flow effects of interest rate changes are included in Fisher dynamics only. Our results are not qualitatively altered if we apply their decomposition framework instead, but the results are then somewhat harder to interpret since cash flow effects of interest rates are present in both Fisher dynamics and the term for nominal debt changes.

[5] A related study focusing on financial crises rather than household debt is the historical investigation of Schularick, Ter Steege, and Ward (2021). They estimate that monetary policy has limited effects on financial crisis risk.

[6] Some recent prominent examples include Broer, Kramer, and Mitman (2021), Coglianese, Olsson, and Patterson (2025), Holm et al. (2021), Amberg, Jansson, Klein, and Picco (2022), Cantore, Ferroni, Mumtaz, and Theophilopoulou (2026), Faia, Kudlyak, Shabilina, and Wiczer (2022), Andersen, Johannesen, Jørgensen, and Peydro (2023), and Hubert and Savignac (2024).

indebtedness.

Section 2 presents our data and relevant aspects of the institutional setting. Section 3 gives a historical decomposition of debt-to-income movements. Section 4 reports responses to monetary policy shocks. Section 5 concludes.

2 Data

We here describe our data, how we decompose debt-to-income ratios, and key aspects of the institutional setting.

The data. We utilize data from Norwegian administrative registries. Because Norway taxes wealth and income, tax registry data provide a detailed annual account of household income and balance sheets over time. For our purposes, one should note that debt and income are third-party reported by financial intermediaries and employers and hence are of particularly high quality. All assets and liabilities are reported at the end of the year, on December 31st. This means that for each household (defined as either a married or cohabiting couple or a single individual) in the economy, we observe their annual income and their stock of debt at the beginning and end of each year. The sample period for our data is 1994 to 2015.[7]

Decomposition. Our empirical analysis starts with the definition of a household h's debt-to-income ratio $\mathrm{DTI}_{h,t} = \frac{B_{h,t}}{Y_{h,t}}$, where $B_{h,t}$ is end-of-period nominal debt and $Y_{h,t}$ is within-period nominal disposable household income. We use yearly data, so t indexes the calendar year. Note the timing convention where $\mathrm{DTI}_{h,t}$ is the ratio of debt at the end of year t relative to income obtained during year t.

The change in household h's debt-to-income ratio can be re-written as follows

$$\begin{aligned}\frac{B_{h,t}}{Y_{h,t}} - \frac{B_{h,t-1}}{Y_{h,t-1}} &= \frac{B_{h,t}Y_{h,t-1} - B_{h,t-1}Y_{h,t} + B_{h,t}Y_{h,t} - B_{h,t}Y_{h,t}}{Y_{h,t}Y_{h,t-1}} \\ &= \frac{B_{h,t} - B_{h,t-1}}{Y_{h,t-1}} - \frac{B_{h,t}}{Y_{h,t}}\frac{Y_{h,t} - Y_{h,t-1}}{Y_{h,t-1}},\end{aligned}$$

which is the expression in equation (1). Furthermore, the components of nominal income growth can be split into real income growth, inflation, and the difference between interest income and interest expenses as follows:

[7] For further details on the Norwegian registry data, see for instance Fagereng, Holm, and Natvik (2021).

$$\frac{B_{h,t}}{Y_{h,t}} \frac{Y_{h,t} - Y_{h,t-1}}{Y_{h,t-1}} = \frac{B_{h,t}}{Y_{h,t}} \left(\frac{Y^{non-i}_{h,t} - Y^{non-i}_{h,t-1}}{Y_{h,t-1}} + \frac{Y^{i}_{h,t} - Y^{i}_{h,t-1}}{Y_{h,t-1}} \right) \tag{2}$$

$$\approx \frac{B_{h,t}}{Y_{h,t}} \left(\frac{Y^{non-i}_{h,t-1}}{Y_{h,t-1}} \left(g_{h,t} + \pi_{h,t} \right) + \frac{Y^{i-inc}_{h,t} - Y^{i-inc}_{h,t-1}}{Y_{h,t-1}} - \frac{Y^{i-exp}_{h,t} - Y^{i-exp}_{h,t-1}}{Y_{h,t-1}} \right). \tag{3}$$

The first line splits total nominal income growth into non-interest income, $Y^{non-i}_{h,t}$, and net interest income, $Y^{i}_{h,t}$. The second line in addition decomposes non-interest income growth into real income growth, $g_{h,t}$, and inflation, $\pi_{h,t}$, and splits net interest income into interest income, $Y^{i-inc}_{h,t}$, and interest expenses, $Y^{i-exp}_{h,t}$. The last decomposition holds only as an approximation because $\left(1 + g_{h,t}\right)\left(1 + \pi_{h,t}\right) - 1 = g_{h,t} + \pi_{h,t} + g_{h,t}\pi_{h,t}$, whereas we ignore the term $g_{h,t}\pi_{h,t}$ in order to separate between real income growth and inflation.[8]

Definition of variables. We construct $\text{DTI}_{h,t}$ by dividing outstanding debt at the end of year t by disposable income received over the year t. Similarly, the debt-change term in equation (1), $\frac{B_{h,t} - B_{h,t-1}}{Y_{h,t-1}}$, is directly computed as debt at the end of year t minus debt at the end of $t-1$, divided by disposable income in year $t-1$. Debt includes all outstanding liabilities, including mortgages, car loans, and credit card debt. Disposable income $Y_{h,t}$ is the sum of labor income, transfers, interest income, and dividends, minus taxes and interest expenses. Each of these income components is third-party reported to the tax authorities. Hence, we directly observe $Y^{non-i}_{h,t}$ and $Y^{i}_{h,t}$, where the latter is interest income minus interest expenses.

Among the Fisher variables in equation (3), we compute $g_{h,t}$ as the growth rate of all non-interest income components net of taxes for every household h, adjusted for inflation $\pi_{h,t}$ in year t. We construct household-specific inflation rates using expenditure weights from the Norwegian Consumer Expenditure Survey 2012 that vary by age, family situation (adults, children under 18), and disposable income (quintiles within age bins). Appendix A in the Online Appendix presents details on how we compute household-specific inflation, and Figure A.1 there displays the dispersion in inflation across years.

In one exercise, we will separate people by their likelihood of becoming unemployed. To

[8] An alternative approach, used by Mason and Jayadev (2014) on aggregate US data, is to follow the sovereign debt literature (for instance Hall and Sargent, 2011) which considers the law-of-motion for public debt $b_t = d_t + \frac{1+r_t}{1+g_t+\pi_t} b_{t-1}$, where b is the debt-to-GDP ratio, r is the interest rate, g real GDP growth, and d_t is the primary deficit divided by GDP. Primary deficits differ from nominal debt changes ($B_t - B_{t-1}$) as they are net of interest expenses ($B_t - B_{t-1} - r_t B_{t-1}$). We use a slightly different decomposition, with nominal debt change rather than primary deficits, because we want the direct cash-flow effects of interest rate changes to enter only in Fisher dynamics so as to distinguish mechanical effects of interest expenses from households' new borrowing or repayment, and because the concept of primary deficits is more opaque for households than nations as the former tend to save (dissave) in many additional ways beyond repaying (accumulating) debt. Still, we have explored both ways to decompose the debt-to-income ratio. No results are substantively different if we proceed as in the sovereign debt literature.

that end, we compute the predicted job separation rate at the individual level using a probit regression with a dummy for receiving unemployment insurance in $t + 1$ on a full set of industry dummies and a second-order polynomial in tenure in year t. Figure B.1 in the Online Appendix shows the distribution of predicted job separation rates. Our sample for computing the predicted unemployment probability is restricted to individuals in the working-age population (24-62 years) who currently hold a job.

Sample selection. We restrict our analysis to households with adult members aged 24 years or older. We drop observations with extremely high debt or income (top 0.5% of each distribution) which will arise when households experience extraordinary events, such as bonus payments or housing transactions where they buy a new house in one calendar year and sell their old house in the next year. We also drop observations with income or implied spending less than the social security minimum, a debt-to-income ratio above 10, extreme changes in debt-to-income (top/bottom 1%), and extreme values of implied interest rates or real income growth (top/bottom 5%).

Summary statistics. Table 1 presents summary statistics for our sample of Norwegian households from 1994–2015. Focusing first on the whole sample, the average debt-to-income ratio is 162%. During our sample period the ratio increased, as seen from the positive average nominal debt growth of approximately 11% and the smaller average contribution from Fisher dynamics of approximately minus 7%.

In our later analysis, we will stratify households by debt-to-income quintiles. Table 1 shows how these groups differ in several dimensions. First, highly indebted households tend to be younger and have more formal education. Their high debt-to-income ratio is due to high debt, not low income. As they are young and income tends to increase with age, the highly indebted households have high income relative to their age.[9] Second, debt-to-income grows for households with low debt-to-income while it decreases among the most indebted households. This tendency for mean-reversion largely reflects that households borrow more when they upgrade their home and reduce their debt-to-income in the interim. Third, the most indebted households face slightly higher job separation risk, as predicted by the sector of employment and tenure in their current job. Fourth, highly indebted households also tend to have higher real income growth $g_{h,t}$. This pattern reflects that young individuals with high education tend to experience high income growth (see, e.g., Blundell, Graber, and Mogstad, 2015) and that highly indebted households tend to experience somewhat lower price growth. A consequence of the high real income growth is that the contribution from Fisher dynamics is relatively large among highly indebted households.

[9] Consistent with this observation, Bartscher, Kuhn, Schularick, and Steins (2025) use U.S. data from 1950 to 2022 and find that debt-to-income has increased most for households between the 50th and 90th percentile of the income distribution.

Variable	All	Debt-to-income Quintiles 1	2	3	4	5
Age	52.80	67.31	55.76	51.22	46.35	42.18
Less than high school education	0.31	0.48	0.36	0.28	0.23	0.21
High school education	0.38	0.34	0.38	0.39	0.40	0.38
College education	0.31	0.18	0.26	0.32	0.38	0.41
Debt-to-income in %	161.51	8.11	36.82	109.58	221.57	434.68
Debt (USD 1,000)	72.99	3.42	16.82	51.36	105.78	189.04
Income (USD 1,000)	42.41	34.40	42.88	45.24	46.66	43.82
Income excl. interest	44.34	32.92	42.47	46.57	50.18	50.62
Interest expenses	2.72	0.09	0.62	1.91	3.92	7.14
Interest income	0.79	1.56	1.03	0.58	0.40	0.33
Change in debt-to-income	3.81	6.47	11.77	8.05	3.73	-11.93
Nominal debt change	10.78	6.64	12.45	11.45	12.17	11.95
Fisher dynamics	-6.97	-0.17	-0.68	-3.40	-8.44	-23.88
Interest rate r in %	5.12	5.14	4.76	5.24	5.20	5.21
Real income growth g in %	3.86	2.68	2.35	3.31	4.20	6.69
Inflation π in %	1.75	1.91	1.78	1.71	1.67	1.66
Predicted job separation rate in %	5.50	5.48	5.19	5.20	5.43	5.97
Observations	48,492,324	10,739,666	8,611,913	9,715,957	9,713,530	9,711,258

Notes: The table presents the means of each variable across all household-year observations and within debt-to-income quintiles. For debt and income, our variables denote averages within the household denoted in 2011 USD. Quintile 1 contains more and quintile 2 contains fewer observations because there are years where more than 20% of the population hold no debt, in which case they belong to quintile 1.

Table 1: Summary statistics, 1994–2015.

Institutional setting. Around 80% of Norwegian households own a house in our sample period. Almost all debt (94%) in our sample consists of secured loans. The typical mortgage contract in Norway is a 25-year loan with an adjustable interest rate.[10] The debt contract is usually an annuity contract where the sum of debt repayment and interest costs is scheduled to be the same each month. For adjustable-rate contracts, interest rate adjustments happen within weeks following a change in the central bank's policy rate. When the interest rate changes, the schedule for monthly payments is also adjusted so that the sum of debt repayment and interest costs stays constant at a new level going forward. For our later analysis of monetary policy shocks, we note that this repayment adjustment induces a mechanical effect where interest rate hikes reduce debt repayment in the short run and thus raise debt levels in the future.[11]

In our sample period, monetary policy was formally conducted under a flexible inflation targeting regime since 2001 with an inflation target of 2.5%. De facto this regime was introduced

[10] More than 90 percent of all household debt has adjustable interest rates (Holm et al., 2021).

[11] As we shall see in Section 4, we instead find that debt *falls* after interest rate hikes, which indicates that the degree to which households adjust their borrowing and repayment behavior to interest rates dominates the mechanical amortization plan effect.

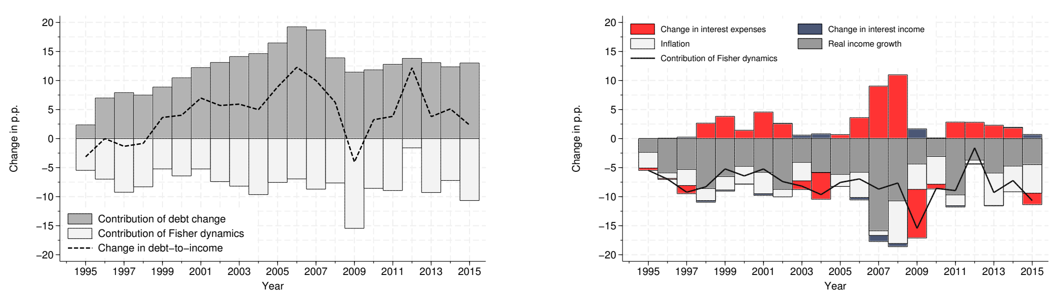
somewhat earlier, while at the beginning of our period, Norges Bank targeted the exchange rate. Following the 2007-2008 global financial crisis, Norges Bank has emphasized financial stability as a separate concern in addition to inflation and output.[12]

3 Historical Decomposition of Debt-to-Income Movements

This section dissects the annual change in debt-to-income ratios over our sample period into nominal debt changes and Fisher dynamics based on equation (1), an accounting identity that holds exactly. We further decompose the Fisher dynamics into real income growth, inflation, and interest income and expenses using (3).

3.1 Decomposition of Population Averages

Figure 1 decomposes the average debt-to-income growth across all households in each year of our sample period. In panel (a), the dashed curve displays each year's debt-to-income change, the dark bars show the contributions from nominal debt changes, and the light grey bars show the contributions from Fisher dynamics. The bars together sum up to the change in debt-to-income (the dashed line). We see that both nominal debt changes and Fisher dynamics have been important for debt-to-income growth. The two forces pull in opposite directions every year, and sometimes they almost cancel each other out. Still, nominal debt changes have clearly dominated in most years.



(a) Historical decomposition of debt-to-income

(b) Historical decomposition of Fisher dynamics

Notes: Figure (a) plots the sample average of changes in debt-to-income, and the contributions from nominal debt changes and Fisher dynamics as defined in (1). Figure (b) decomposes the contribution from Fisher dynamics into interest income, interest expenses, real non-interest income growth, and nominal non-interest growth due to inflation, based on equation (3).

Figure 1: Historical decomposition of debt-to-income changes and Fisher dynamics.

[12] The financial stability target was formalized in 2019 when the formulation "counteract the build-up of financial imbalances" was included in the central bank's mandate.

Panel (b) uses equation (3) to attribute each year's total contribution from Fisher dynamics to contributions from interest income and expenses, real income growth, and inflation. Because real income growth and inflation have been positive every year, they have always contributed to reducing debt-to-income growth and therefore consistently lie in the negative region of the plot. In contrast, the contributions from interest income and expenses switch sign several times due to years with sharp interest hikes or cuts. We also see that the contributions from variation in interest expenses dwarf those from interest income, which are hardly visible in the figure. On average, the contributions from interest expenses have been on the upside, meaning they have tended to raise the debt-to-income ratio over time. The reason is that household debt grew in this period, so interest expenses increased too, even though the interest rate level fell over the period as a whole. The takeaway from panel (b) is that real non-interest income growth is the most important component behind the Fisher dynamics, followed by changes in interest expenses. In the years where Fisher dynamics were particularly forceful in pulling debt-to-income growth down, especially in 2009, it was because interest expenses fell and thus contributed in the same direction as real income growth.

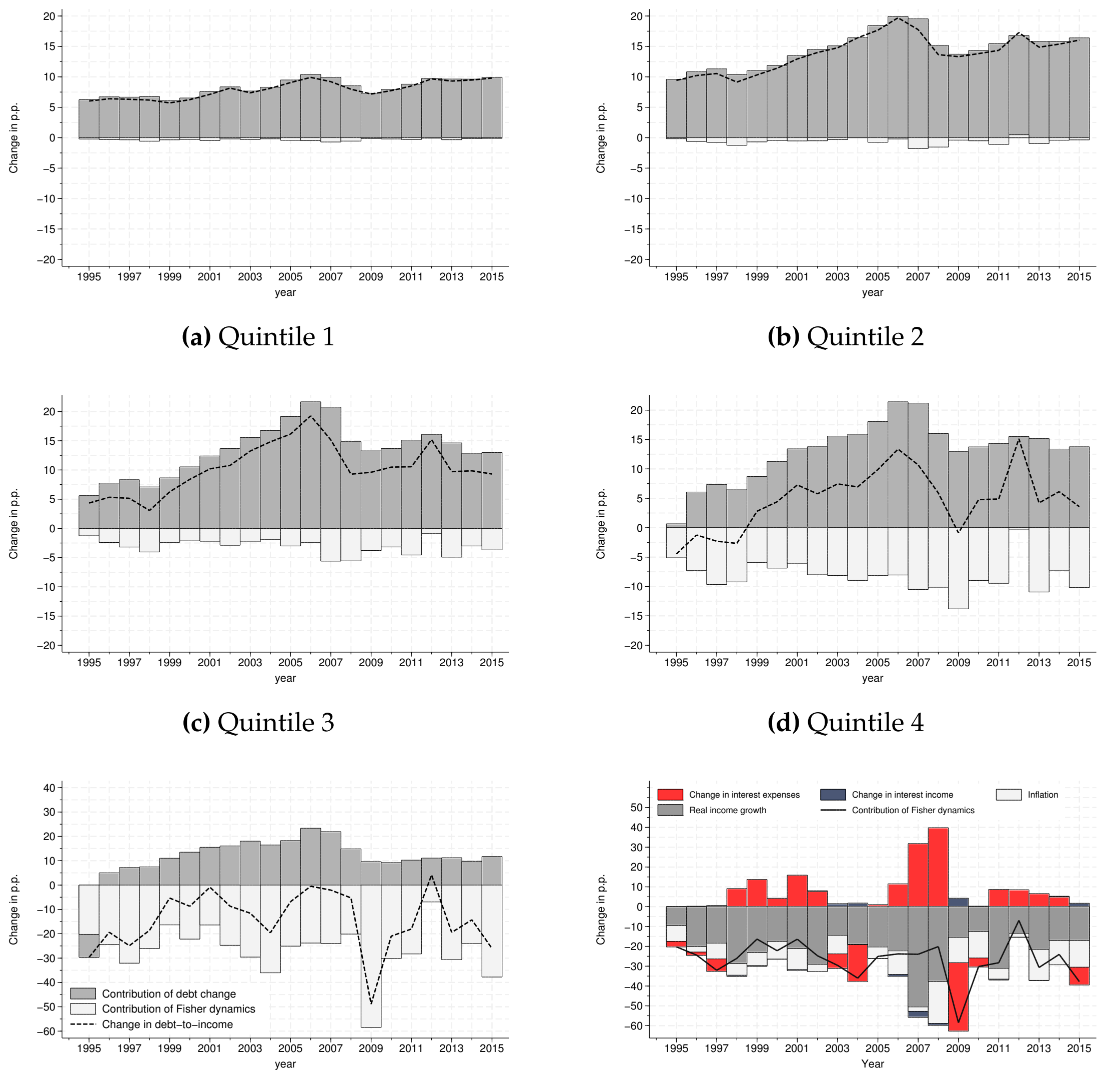
3.2 Decomposition along the Debt-to-Income Distribution

The importance of Fisher dynamics depends on households' debt-to-income levels, as equation (1) shows, being more important for highly indebted households. Moreover, financial stability concerns regard this group in particular. Figure 2 therefore decomposes debt-to-income changes as in Figure 1(a), but now differentiates households by their debt-to-income quintile in year $t-1$.

Panels (a), (b), and (c) in Figure 2 show that among the 60% least indebted households, the debt-to-income ratio has grown every year and nominal debt changes almost entirely account for this growth. Hence, the contribution from Fisher dynamics that we previously observed in the aggregate, stem from households who are relatively highly indebted. Panel (d) shows how the fourth debt-to-income quintile is a middle ground, where debt-to-income growth is moderate and influenced both by nominal debt changes and Fisher dynamics, which pull in opposite directions. Panel (e) shows that highly indebted households stand out. Their debt burden has fallen every year except one (2012). This has happened because Fisher dynamics, especially nominal income growth, have dominated small positive nominal debt changes.

Panel (f) dissects the Fisher dynamics in the top debt-to-income quintile. We see that the main driver is real income growth, which has been particularly high in this group as already shown in Table 1. Unsurprisingly, interest expenses have also been important in this group, but they are outsized by real income growth. In addition, we see that although inflation was low over this period, it still played a non-negligible role in curtailing the debt-to-income ratio among the most indebted households.

The takeaway from Figures 1 and 2 is that while Fisher dynamics are irrelevant for households with low debt burdens, they contribute strongly and outsize nominal debt growth among the



(a) Quintile 1

(b) Quintile 2

(c) Quintile 3

(d) Quintile 4

(e) Quintile 5

(f) Fisher dynamics in Quintile 5

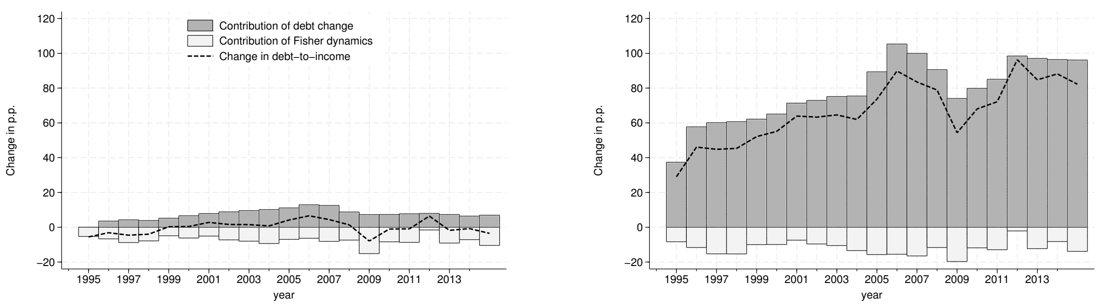
Notes: Panel (a)-(e) decomposes the average debt-to-income change within each quintile of beginning-of-year debt-to-income ratios according to equation (1). Panel (f) decomposes the Fisher dynamics in quintile 5 according to equation (2).

Figure 2: Historical decomposition of debt-to-income changes by quintiles of debt-to-income ratios in $t-1$.

most indebted households. For policy aimed at preventing financial instability, this observation is important. The reason is that highly indebted households will likely be the first to struggle to repay their debt, possibly inducing systemic strain if a large macroeconomic shock hits the economy. Our results show that Fisher dynamics, particularly real income growth, are key for the extent to which indebtedness builds up or is unwound among such households. More generally we see how the average evolution of debt-to-income ratios masks heterogeneity across households with different debt levels.

3.3 Decomposition among Stayers and Movers

If households tend to follow amortization plans that are set upon the origination of their mortgage, for instance because refinancing or re-adjusting their repayment schedule is costly, Fisher dynamics will be important. In contrast, if households flexibly choose how much to borrow or repay each year, the mechanical Fisher dynamics should be less important relative to nominal debt changes. One specific situation in which households are likely to re-set their amortization plan is when they change their home and get a new mortgage. Hence, to evaluate the importance of amortization plans, we separate between "movers" and "stayers". A household is a mover in the year it gets a new home address. A household is a stayer if it does not move.



(a) Decomposition of DTI among stayers

(b) Decomposition of DTI among movers

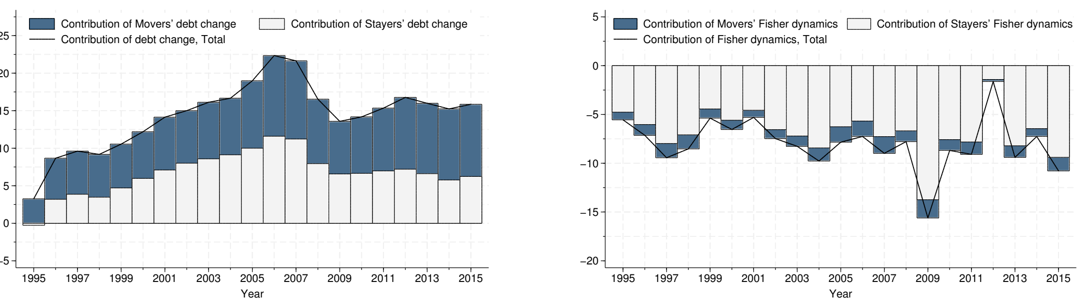
Notes: Panel (a) decomposes the debt-to-income ratio among households who do not change address within the year. Panel (b) decomposes the debt-to-income ratio among households who change address within the year.

Figure 3: Historical decomposition of debt-to-income changes for movers and stayers.

In Figure 3 we decompose debt-to-income growth in each of the two groups. From panel (a) we see that each year, nominal debt changes and Fisher dynamics are of approximately the same size among stayers. Panel (b) shows that this is very different in the year households move. Here nominal debt changes completely outsize Fisher dynamics.

Because relatively few households move in any given year (less than 10 percent), the population-wide average effects might be driven by stayers despite their relatively small movements per household. In Figure 4, we therefore consider the total nominal debt changes and attribute them to movers and stayers in panel (a). We do the same for Fisher dynamics in panel (b). Of the population-average nominal debt changes, approximately half stem from stayers and half from movers. In panel (b) we see that Fisher dynamics predominantly stem from stayers.

The insight here is that the extensive margin in the housing market, moving, makes a big difference in terms of what drives the debt-to-income ratio. Consistent with our priors, Fisher dynamics are more important among people who stay in their existing homes and thus are more likely to be under a pre-set debt amortization plan. This pattern is consistent with the results of Bernstein and Koudijs (2024). They find that in the Netherlands, amortization plans seem to bind and determine saving in the first years after households buy new homes. When we next estimate responses to monetary policy shocks, we will therefore zoom in on housing tenure to see if Fisher dynamics play a particular role among recent home buyers.



(a) Nominal debt changes

(b) Fisher dynamics

Notes: Panel (a) plots the total yearly nominal debt changes and decomposes them into contributions from households that change address and households that do not change address within the year. Panel (b) plots the total yearly Fisher dynamics and decomposes them into contributions from households who change address and households who do not change address within the year.

Figure 4: Movers' and stayers' contribution to nominal debt changes and Fisher dynamics.

4 Evidence from Monetary Policy Shocks

The descriptive results revealed that nominal debt changes have been the main driver behind the average household debt-to-income changes in our sample, while Fisher dynamics are important among households with high debt burdens. How do these results carry over to monetary policy effects? Do interest hikes lower debt burdens by reducing nominal debt growth or do they work in the opposite direction as higher interest rates reduce income growth and increase interest expenses? We next address these questions by direct estimation of how monetary policy shocks affect households' debt-to-income ratios.

Our empirical strategy relies on local projections (Jordà, 2005) together with a series of monetary policy shocks from Holm et al. (2021). These shocks are identified with a narrative approach following Romer and Romer (2004), using real-time forecasts by Norges Bank. This approach estimates the systematic relationship between interest rate setting and the Central Bank's view on the current and future state of the economy and then identifies shocks as deviations between the actual policy rate and what the systematic relationship implies that it should be. Further details are provided in Holm et al. (2021). In Section 4.2, we use high-frequency market reactions to policy announcements as an alternative identification strategy.

We report the shocks' main macroeconomic effects in Figure B.2 in the Online Appendix, based on the same type of local projections that we later use on our microdata, as specified in (5) and explained in the text below that equation. After a contractionary monetary policy shock, the policy rate remains high for an extended period before it undershoots below its starting value in response to low output and inflation. Output falls and then recovers in a hump-shaped manner, whereas the price level responds moderately. Hence, even before turning to our rich microdata, we know that nominal income responses at the micro level will not be due to the inflation term in the Fisher dynamics in Equation (3) above, and we therefore will not explore this channel further when dissecting how debt-to-income reacts to monetary policy.

In what follows, we first study average effects across all households in our sample. We then show that the average effects are robust to using market-based monetary policy shocks, and we explore whether interest rate hikes and cuts have asymmetric effects. Next, we explore how the responses vary across subgroups of the population where we have reasons to believe that debt-to-income ratios will behave differently. Finally, we consider how two alternative measures of households' financial vulnerability respond to monetary policy shocks.

4.1 Average Responses to Monetary Policy

To estimate the impact of monetary policy, we apply a two-stage approach where the monetary policy shocks are instruments for interest rate changes:

$$\Delta i_t = \alpha + \beta \epsilon_t^{MP} + \delta' \mathbf{X}_{h,t-1} + \varepsilon_t \tag{4}$$

$$y_{h,t+j} - y_{h,t-1} = \delta_h^j + \beta^j \widehat{\Delta i}_t + \gamma_h'^j \mathbf{X}_{h,t-1} + u_{h,t}^j. \tag{5}$$

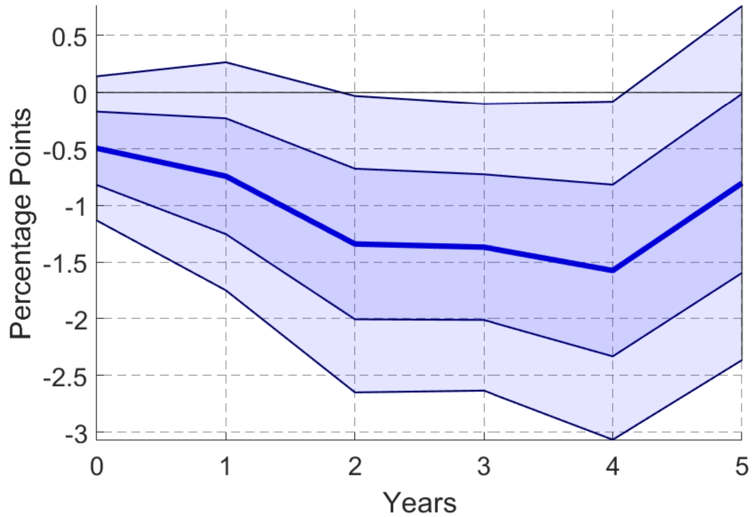
Here $y_{h,t+j}$ is the outcome variable of interest for household h observed j years after the shock occurred, Δi_t is the change in the policy rate from beginning to end of the year, ϵ_t^{MP} is the monetary policy shock in year t, δ_h^j is a household-fixed effect, $\mathbf{X}_{h,t-1}$ is a set of controls, and $u_{h,t}^j$ and ε_t are error terms. Our baseline specification includes two lags of the right-hand side variables and three lags of the shock in the vector of controls.[13]

Figure 5 shows our estimated response of the debt-to-income ratio to a 1 percentage point increase in the interest rate.[14] Figure 6 decomposes the debt-to-income response to contributions from nominal debt changes and Fisher dynamics in panels (a) and (b), and then decomposes the

[13]We show in Figure B.3 in the Online Appendix that our results are insensitive to excluding years after the financial crisis where financial stability concerns are believed to have influenced the central bank interest rate decisions.

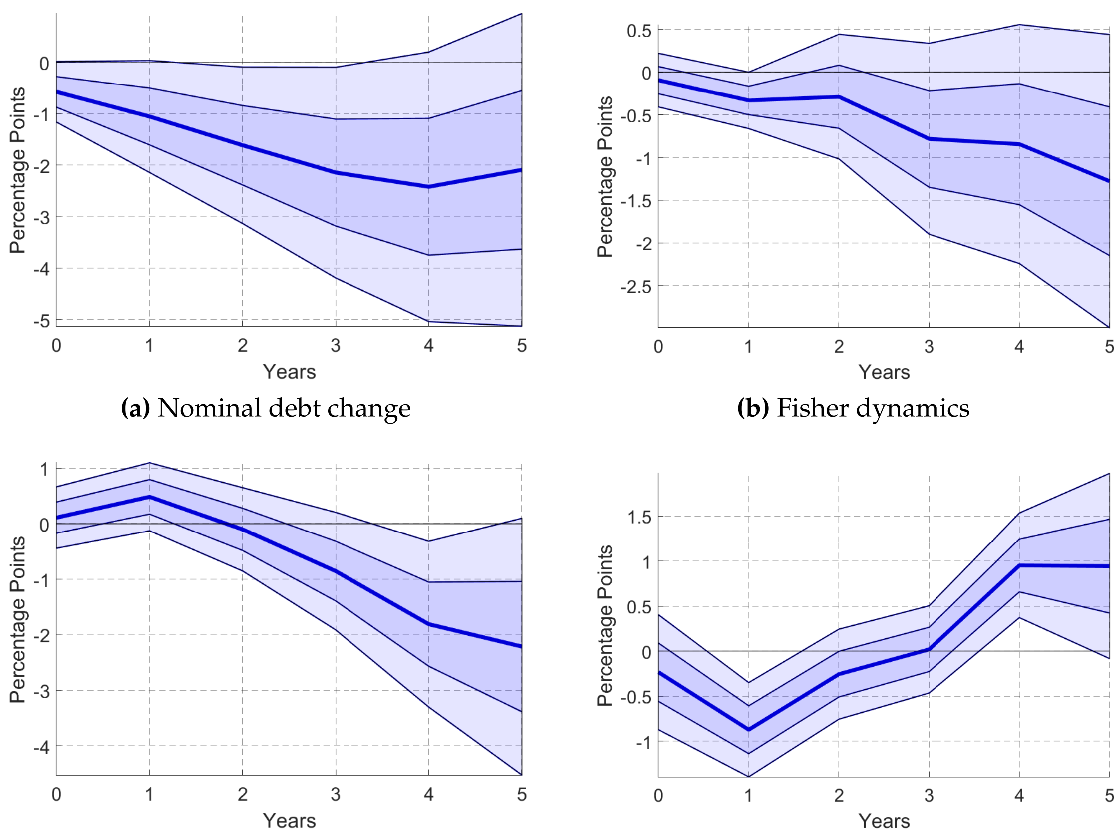
[14]In the empirical estimation, we use the following decomposition to estimate the effects of monetary policy on debt-to-income, nominal debt changes, and Fisher dynamics

$$\mathrm{DTI}_{h,t+j} - \mathrm{DTI}_{h,t-1} = \frac{B_{h,t+j} - B_{h,t-1}}{Y_{h,t-1}} - \frac{B_{h,t+j}}{Y_{h,t+j}} \frac{Y_{h,t+j} - Y_{h,t-1}}{Y_{h,t-1}}$$



Notes: The response of debt-to-income to a one percentage point contractionary monetary policy shock. The shaded areas display 68 and 95 percent confidence bands, computed using Driscoll and Kraay (1998) standard errors.

Figure 5: The debt-to-income response to monetary policy



(a) Nominal debt change

(b) Fisher dynamics

(c) Non-interest income

(d) Net interest income

Notes: Impulse responses to a one percentage point contractionary monetary policy shock. The shaded areas display 68 and 95 percent confidence bands, computed using Driscoll and Kraay (1998) standard errors.

Figure 6: Decomposition of the debt-to-income response to monetary policy

Fisher dynamics into non-interest and interest components using equation (2).

The average debt-to-income response after a monetary tightening is negative, small, and relatively short-lived, as seen in Figure 5. The maximum response after 2-4 years is around 1.5 percentage points (compared to an average debt-to-income ratio of 161.5%) and the effect reverts toward zero after five years.[15]

Figure 6 shows that the debt-to-income response is driven by reduced nominal debt (note that the scale on the vertical axis varies across the four plots). That is, households on average repay faster or take up less new debt than otherwise when the interest increases, as seen in panel (a).[16] Note that this happens despite the fact that households in our sample predominantly hold annuity loan mortgage contracts where the short-run amortization is schematically adjusted down when the interest rate goes up. The mechanics of amortization contracts alone thus work to elevate nominal debt levels after interest rate hikes, which works in the opposite direction of what we observe in Figure 6(a). As expected, Fisher dynamics tend to lower the denominator of debt-to-income ratios, as seen in panel (b). Qualitatively, this aligns with the argument that tighter monetary policy will reduce disposable nominal household income, which in turn elevates debt burdens (see, e.g., Svensson, 2017). However, the total contribution from the Fisher variables is small and outsized by the reduction in nominal debt.

In panels (c) and (d), where the Fisher variables are split into non-interest and net interest income, we see why their sum is low. In the short run, net interest income drops somewhat because interest rates increase and households have more debt than deposits, but the effect on total nominal income is negligible since non-interest income does not fall until some time later. At horizons four and five years, there is a sizable drop in non-interest income, but by this time the net interest income response is in positive territory as households have reduced their debt and because the interest rate is endogenously lowered 4 years after the initial shock.

In brief, the conventional view that tighter monetary policy reduces household indebtedness by making households accumulate less debt holds qualitatively in our sample. Quantitatively, however, the effect is moderate. The debt-to-income ratio falls by at most two percentage points

where j is the horizon as in (5). We thus replace the left-hand side variable in (5) with its counterpart in the equation above at each horizon j.

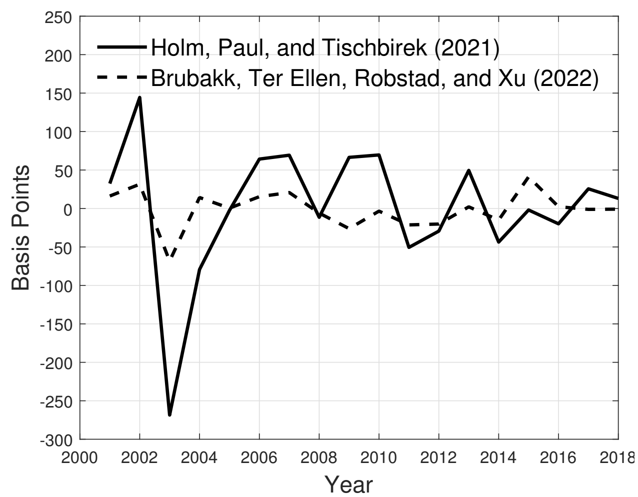
[15] Moreover, the monetary policy shocks are relevant instruments for the interest rate change, with an F-statistics of 14.26.

[16] A natural question is which type of debt accounts for the decline in nominal debt. Broadly speaking, Norwegian households hold three types of debt: mortgages, student loans, and consumer debt. Except for student loans in part of our sample, the *type* of debt is not observed in the data. We can, however, imperfectly infer debt type from account-level data on interest payments and debt levels, which are available for the later part of our sample period (after 2004). In this period, about 2% of household debt is consumer debt, 4% is student loans, and the remaining 94% is secured long-term debt, mostly mortgages. Given that mortgages make up such a large share of total debt, variation in mortgage debt almost certainly accounts for the bulk of the nominal debt response we estimate. Our data do not allow us to separate lower new mortgage borrowing from faster repayment of existing mortgages. Section 4.5 shows, however, that debt-to-income responds similarly among households who have recently moved and are therefore unlikely to take up a new mortgage in the following years, which suggests that the decline in nominal debt is not only due to lower new borrowing.

(after two years) in a sample where the average debt-to-income ratio is 161.5%.

Robustness. One might be concerned that Norges Bank has increased its emphasis on financial stability after the 2008 financial crisis after which our policy shocks are correlated with subsequent debt growth through the endogenous component of monetary policy. Figure B.3 in the Online Appendix displays the results when excluding all monetary policy shocks after 2008, when the Norwegian Central Bank included "Financial Stability" as part of its monetary policy targets. The results are similar. A second concern is whether our results hold for the main alternative strategy to identify monetary policy shocks, namely that of using high-frequency market reactions to monetary policy announcements. We address this concern next.

4.2 Market-Based Monetary Policy Shocks

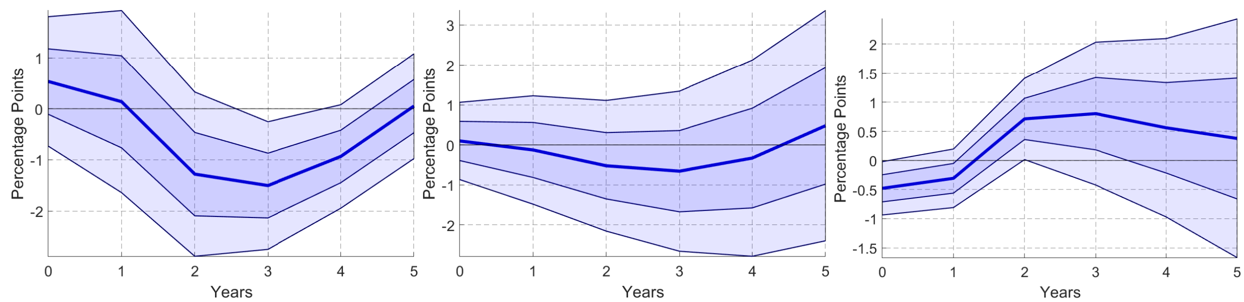


Notes: The figure displays the narratively identified monetary policy shocks from Holm et al. (2021) and the market-based monetary policy shocks from Brubakk, Ter Ellen, Robstad, and Xu (2022) in the period where both series exist.

Figure 7: Monetary policy shock series.

Our baseline estimates rely on the narratively identified monetary policy shocks of Holm et al. (2021). All approaches to identifying monetary policy shocks have their limitations, and we therefore also estimate the responses using the market-based monetary policy shocks for Norway constructed by Brubakk et al. (2022). These shocks are identified from movements in short-term interest rates in a window from 10 minutes before to 20 minutes after monetary policy announcements. Brubakk et al. (2022) focus on identifying forward guidance shocks, but in the process they also separate out conventional monetary policy shocks. Specifically, they apply a sign restriction methodology based on Jarociński and Karadi (2020) to separate changes in the monetary policy target rate from forward guidance and information effects: a target shock positively affects the short and long rates but negatively impacts the stock market.

Figure 7 compares the two shock series in the period where both exist. The market-based shocks are smaller in magnitude than the narrative shocks. Importantly, both approaches identify large monetary policy shocks in 2002 and 2003, an episode put forward as a policy mistake by external observers of monetary policy at the time (Bjørnland, Ekeli, Geraats, and Leitemo, 2004). One major drawback of the market-based shocks is that they are only available from 2001, due to the availability of financial markets data needed to construct the shock series. The sample is therefore shorter than in our baseline analysis.



(a) Debt-to-income change **(b)** Nominal debt change **(c)** Fisher dynamics

Notes: Impulse responses to a one percentage point contractionary monetary policy shock, using the market-based shocks from Brubakk et al. (2022) as instruments for the interest rate change in equation (4). The sample period is 2001–2015. The shaded areas display 68 and 95 percent confidence bands, computed using Driscoll and Kraay (1998) standard errors.

Figure 8: Decomposition of the debt-to-income response to monetary policy using market-based shocks.

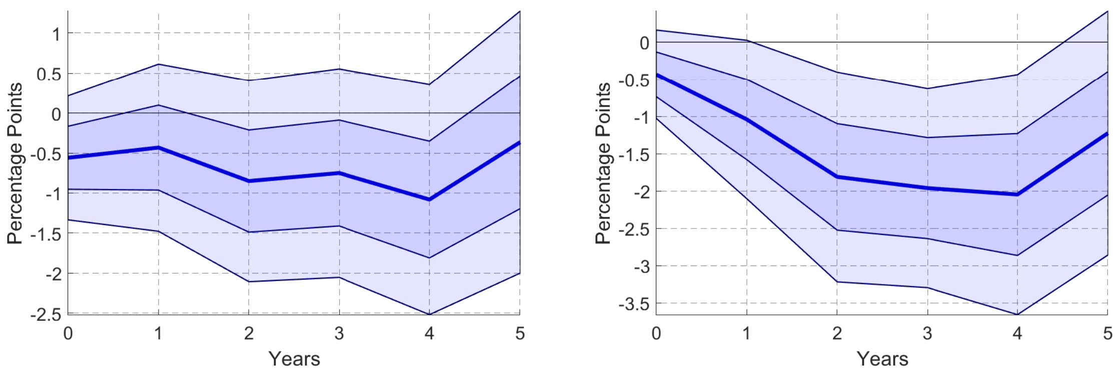
Figure 8 shows the results when we use the market-based shocks as instruments for the interest rate change in equation (4), with the sample starting in 2001 and the estimation setup otherwise unchanged.[17] The debt-to-income response in panel (a) is similar to our baseline estimate in Figure 5, both in magnitude and timing: debt-to-income falls by about 1.5 percentage points two to three years after the shock and reverts toward zero after five years. The decomposition in panels (b) and (c) is less precisely estimated given the shorter sample. Nominal debt falls, although by less than in the baseline and not statistically significantly, whereas the Fisher dynamics point estimate turns positive after two years, meaning that nominal income growth contributes to lowering debt-to-income at these horizons. Importantly for our main conclusion, there is no sign that Fisher dynamics make debt-to-income increase after interest rate hikes when we use market-based shocks either.

[17]The market-based monetary policy shocks are also relevant instruments for the interest rate change, with a first-stage F-statistic of 16.45.

4.3 Interest Rate Hikes versus Cuts

Our baseline specification imposes that interest rate hikes and cuts have symmetric effects on household indebtedness. In this section, we examine whether this holds. To investigate potential asymmetries, we re-estimate equations (4) and (5) by setting either the negative or positive monetary policy shock to zero, leaving the rest of the estimation setup unchanged.

Figure 9 displays the estimated debt-to-income responses. Panel (a) shows the response when only interest rate hikes are used to identify the effect of monetary policy, whereas panel (b) shows the response when only interest rate cuts are used. Both responses are normalized to a one-percentage-point increase in the interest rate to ease comparison. The point estimates suggest that interest rate cuts primarily drive the average response in Figure 5. However, the confidence bands are wide and we cannot conclude that the two responses differ.



(a) Interest rate hikes only

(b) Interest rate cuts only

Notes: Impulse responses of debt-to-income to a one percentage point increase in the interest rate. In panel (a), only positive monetary policy shocks (interest rate hikes) are used as instruments, with negative shocks set to zero. In panel (b), only negative monetary policy shocks (interest rate cuts) are used as instruments, with positive shocks set to zero. The shaded areas display 68 and 95 percent confidence bands, computed using Driscoll and Kraay (1998) standard errors.

Figure 9: The debt-to-income response to interest rate hikes and cuts.

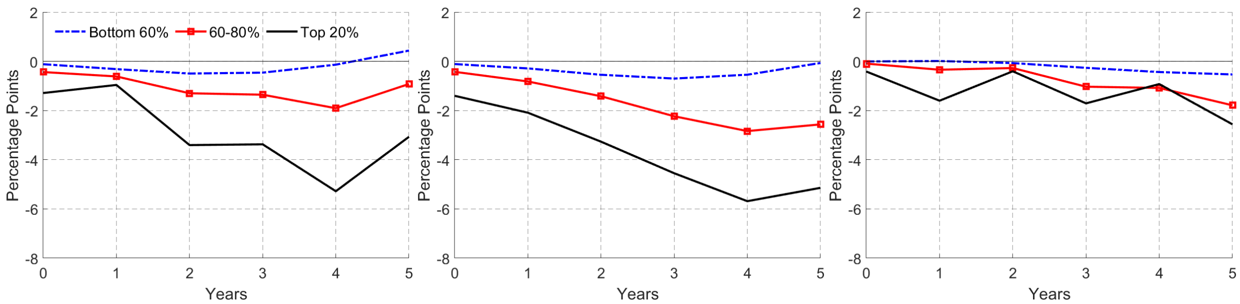
4.4 Responses to Monetary Policy by Initial Indebtedness

Our historical decomposition exercise revealed that Fisher dynamics were unimportant for the evolution of debt-to-income ratios among low and moderately indebted households, but mattered a great deal for highly indebted households. Moreover, high-debt households are the main group of concern when it comes to financial stability. It is therefore natural to ask if the average results found above mask important heterogeneity across households with different degrees of indebtedness.

We explore heterogeneous effects with the same strategy as outlined above, but with the modification that the regression equation (5) applies within groups. The specification we now use is

$$y_{i,t+h} - y_{i,t-1} = \delta_i^h + \beta_g^h \epsilon_t^{MP} + \gamma_g' \mathbf{X}_{i,t-1} + u_{i,t}^g, \qquad \forall\, i \in g \tag{6}$$

where the responses to monetary policy shocks are allowed to differ between household groups g. The notation is the same as in equation (5) above. To study heterogeneity by indebtedness, we consider the distribution of debt-to-income ratios each year and group households according to which quintile they are in at the beginning of the year. Then we estimate equation (6) separately for every quintile.



(a) Debt-to-Income **(b)** Nominal Debt Change **(c)** Fisher Dynamics

Notes: Impulse responses to a 1 percentage point contractionary monetary policy shock for households along the distribution of initial debt-to-income. Debt-to-income groups are defined in year $t-1$ and kept fixed throughout the estimation period. Confidence bands are displayed in Figure B.4 in the Online Appendix.

Figure 10: Monetary policy responses by initial debt-to-income

Figure 10 displays impulse responses of debt-to-income, nominal debt changes, and Fisher dynamics across the debt-to-income distribution in period $t-1$. In the figure we have collapsed quintiles 1 to 3 into one group because their responses are very similar. Among households in these three bottom quintiles, very little happens to their debt-to-income ratio after a monetary policy shock. The average responses shown above were instead driven by households in the two upper quintiles. Among these households, the debt-to-income ratios fall, particularly among the households that are the most indebted initially. As we saw for the average effects, the response is driven primarily by reduced nominal debt.[18]

The upshot is that there is no sign that Fisher dynamics make indebtedness respond positively to interest hikes among high-debt households. This is a stark result, given that this is the group where Fisher dynamics have the strongest potential to affect indebtedness, as mathematically seen in equation (1), and where Fisher dynamics have been quantitatively important over our sample period, as seen in Figure 2. But still, even among the most indebted households, monetary policy has worked primarily by influencing households borrowing and repayment activities, not

[18]Responses across the debt-to-income distribution with confidence bands are provided in Figure B.4 in the Online Appendix.

mechanically by moving their nominal income.

4.5 Responses to Monetary Policy by Housing Tenure

Section 3.3 showed that the relative importance of nominal debt changes and Fisher dynamics varies greatly between households who move and households who stay. The differences align with a prior that homeowners tend to follow pre-set amortization schedules, but when they buy a new home they take up new debt or repay independently of what their previous schedule stipulated. By the same logic, we would expect that the mechanical Fisher dynamics are more important for responses to monetary policy among households who are more constrained by their amortization schedules. We here investigate whether this is the case.

Unlike in Section 3.3, when we study a monetary policy shock it is problematic to separate between households who move and households who stay *after* the shock occurred, as moving is a choice likely to be influenced by the interest rate. Instead, we separate between households with short and long tenure in their current residence before the shock hit (i.e., in $t-1$). This distinction is motivated by the aforementioned study of Bernstein and Koudijs (2024), whose evidence suggests that amortization plans are more binding for households who have recently bought a new home. To gauge the incidence of this mechanism and set an informed cutoff between recent and non-recent movers in our sample, we compute the hypothetical evolution of debt per household if it followed the amortization plan of a 25-year annuity loan contract with a 2.5% interest rate.[19] Then, we compute the deviation of each household's actual debt evolution from this hypothetical repayment schedule. Because the hypothetical schedule is a very crude approximation of exactly which debt contract households enter, we classify households as either deviating or not, with a 15% deviation from the counterfactual plan as cut-off.

Figure 11 displays the resultant share of households who are not deviating according to this definition, by housing tenure. At tenure 0, all households follow their hypothetical amortization schedule (by construction). With time, more and more households deviate from their schedule. 5 years after a house purchase, only 10% of households are still not deviating from their hypothetical amortization schedule.

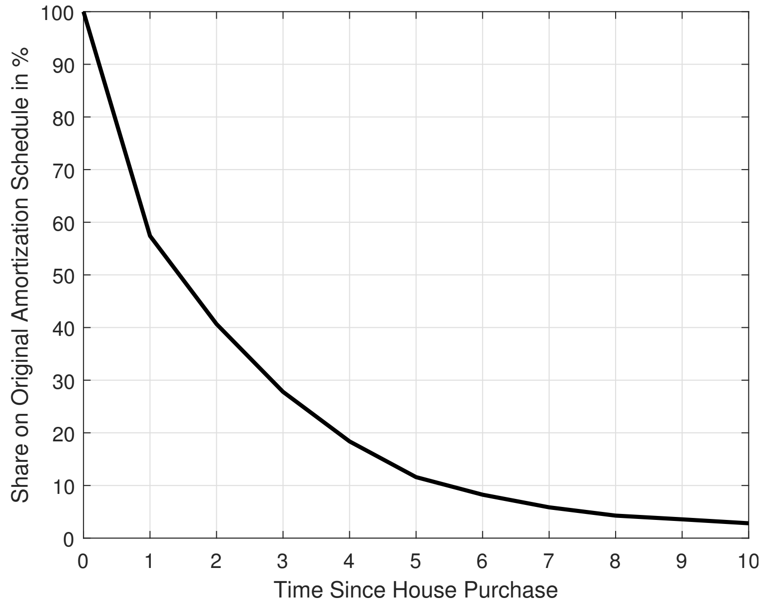
Based on Figure 11, we distinguish between households who have moved within the last two years ("Recent movers") and households who have lived three years or longer in their current

[19] To compute the amortization schedule of this type of contract, we first compute the amortization as

$$\text{amortization} = \frac{\text{interest rate} \cdot \text{debt}}{1 - (1 + \text{interest rate})^{-25}}.$$

Next, we compute the counterfactual debt level for each year as

$$\text{debt}_{CF,y} = \text{amortization} \cdot \frac{1 - (1 + \text{interest rate})^{-(25-y)}}{\text{interest rate}}.$$

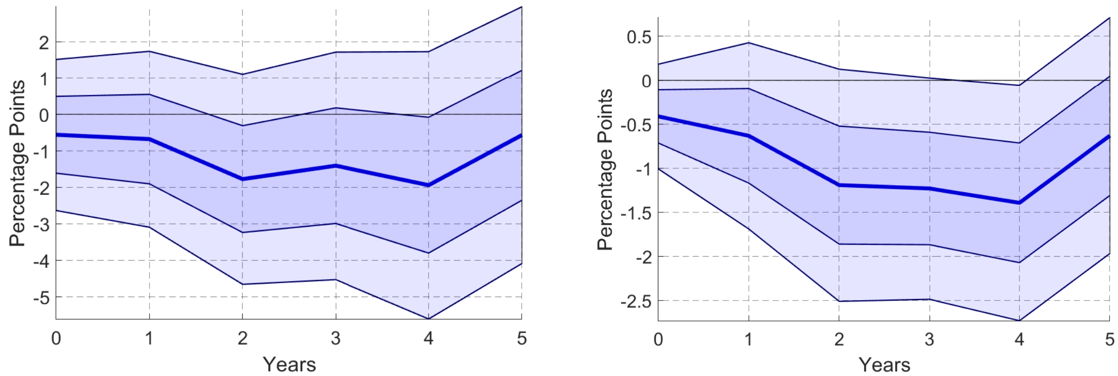


Notes: We first sort households by their time since house purchase. We next compute a hypothetical debt schedule, assuming that debt originated at house purchase follows a 25-year annuity contract with 2.5% interest rate. A deviation is defined as more than 15% deviation from this schedule.

Figure 11: Share of Households whose Debt Deviates from a Hypothetical Amortization Schedule

home ("Non-recent movers"). Estimated impulse responses for these two distinct groups are presented in Figure 12. We see that they react very similarly. The estimates are naturally more precise in the group of households who have not recently moved, as this is the bigger sample, but the point estimates lie close to each other. While not displayed here, the same qualitative pattern holds for nominal debt changes and Fisher dynamics – they are similar across groups defined by housing tenure.

The main takeaway is the same as in Section 4.4. Even within the group where we a priori have particular reason to believe the Fisher dynamics could be large and make households' debt-to-income ratios increase after an interest hike, there is no sign that this actually happens.



(a) Recent movers **(b)** Non-recent movers

Notes: Impulse responses of debt-to-income ratios after a one percentage point contractionary monetary policy shock. Recent movers are households who have moved within the last two years before the shock. Non-recent movers are households who have lived at the same address for three years or more before the shock. The shaded areas display 68 and 95 percent confidence bands, computed using Driscoll and Kraay (1998) standard errors.

Figure 12: The debt-to-income response to monetary policy by housing tenure

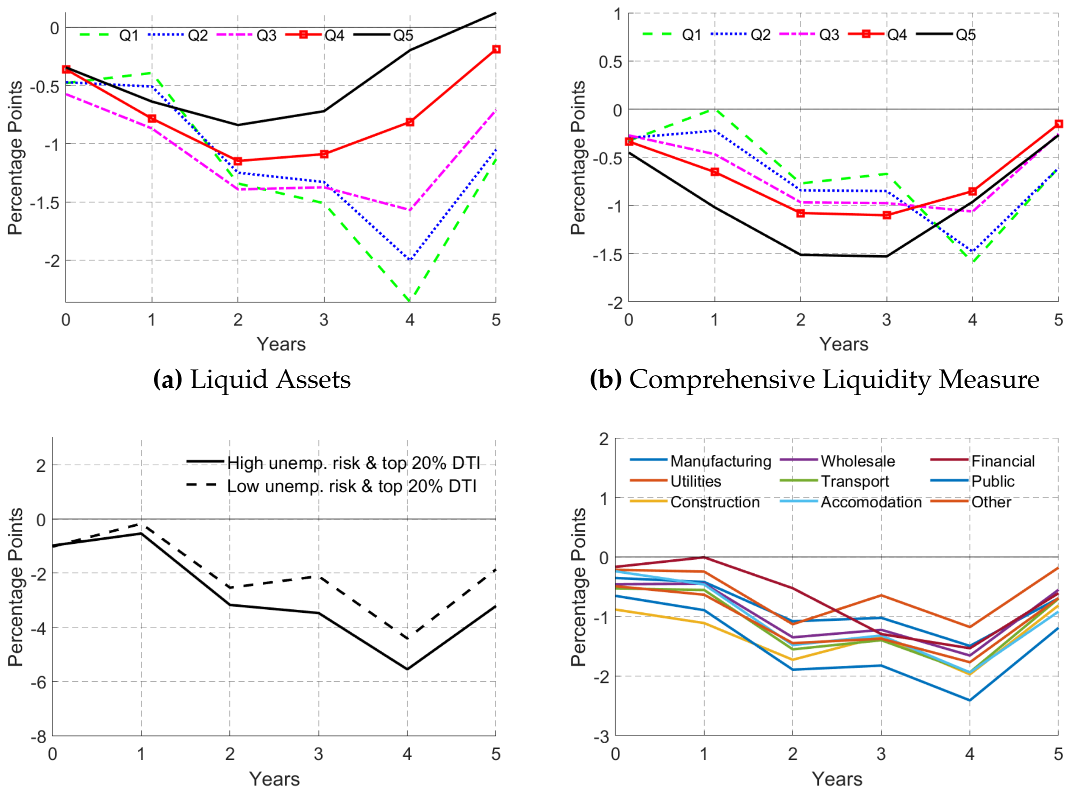
4.6 Responses to Monetary Policy by Liquidity and Income Risk

The policy concern with high debt-to-income ratios is mainly rooted in the fear that indebtedness makes households vulnerable to sudden income drops, in particular unemployment, as such events would force them to cut consumption radically or default on their debt contracts. Moreover, earnings and thus Fisher dynamics might well be the most responsive to monetary policy shocks among exactly those workers who generally have the most volatile income and face the highest probability of suddenly losing income.

We therefore consider the role of liquidity, as low-liquidity households might struggle more after a sudden income shortfall, as well as income risk. Liquidity is measured in two alternative ways. First, we simply stratify households by deposits held at the beginning of the year of the monetary policy shock. Second, we consider a comprehensive measure of available resources which includes home equity beyond a threshold of 30 percent, meant to capture that households with low leverage can use their home equity as a credit line. We also include income above a "reference consumption level" as defined by an external third party, SIFO.[20] Our comprehensive liquidity measure is then deposits plus income minus reference consumption plus the maximum

[20] Reference consumption is computed by the Norwegian institution SIFO, and its calculator is available at https://www.oslomet.no/en/about/sifo/reference-budget. Inputs to the algorithm are the number of persons with their gender and age, the number of cars, and income per household. Its formal description: "Based on baskets of goods and services that are necessary for an acceptable standard of living, the reference budget presents ordinary consumer expenditure for different types of households. The budget can be adapted to households of different sizes as well as to different age and gender compositions. It covers both current expenses such as food, clothing, toiletries, etc., and expenses related to less frequent purchases, such as furniture and electrical appliances. [...] A reasonable, or acceptable, standard of living assumes a consumption level that is generally accepted in Norwegian society".

of zero and 70% of housing value minus debt. Unemployment risk is obtained from a probabilistic regression model where future job loss (unemployment) is regressed on predetermined characteristics (time- and industry-fixed effects and a second-order polynomial in tenure).[21] Across sectors, public sector workers are probably the most interesting since their jobs are highly secure relative to privately employed workers.



(a) Liquid Assets

(b) Comprehensive Liquidity Measure

(c) Predicted Unemployment Risk

(d) Sector of Employment

Notes: Debt-to-income responses to a 1 percentage point contractionary monetary policy shock for different household groups. Liquid assets are measured as deposits. Our comprehensive liquidity measure is the sum of deposits, income, and home equity above 30% of the house value, minus reference consumption as computed by the external third-party SIFO. Predicted unemployment risk is based on a probabilistic regression model. The sector of employment is defined by the sector in which the household's main earner worked in the year before each monetary policy shock. All groups are defined in year $t-1$ and kept fixed throughout the estimation period.

Figure 13: The debt-to-income response to monetary policy by liquidity, predicted unemployment risk and sector of employment

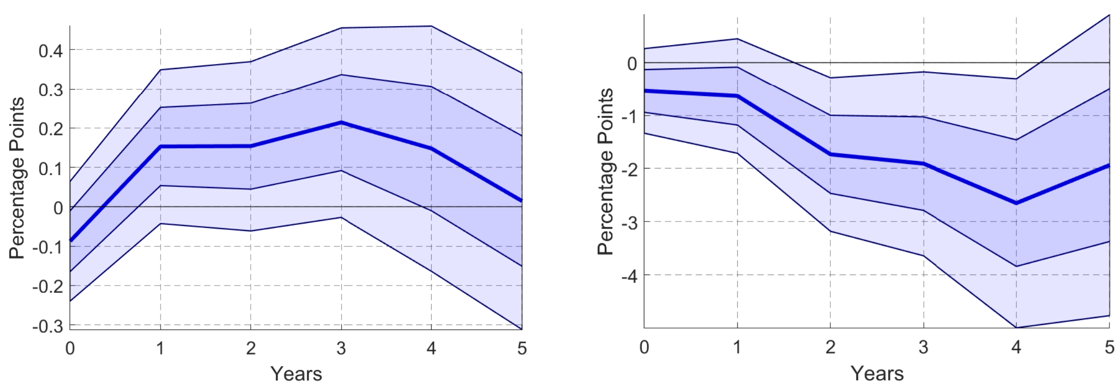
Figure 13 shows the results. The main takeaway here is that the same main pattern of negative debt-to-income responses holds across different households. Panel (a) shows that the debt-to-income response reverts faster back to zero among households with higher deposits initially, which

[21]Figure B.1 in the Online Appendix shows the distribution of predicted unemployment risk in our data. We here present results by unemployment risk within the top quintile of debt-to-income ratios only. Results do not differ in any important way if we differentiate by unemployment risk in the entire population.

is largely due to reduced interest income from the endogenous drop in interest rates four and five years after the shock. Panel (b) shows that households with high values of our comprehensive liquidity measure cut debt-to-income somewhat more in the short run than households with low values. Panel (c) shows a slightly lower debt-to-income drop for households with low predicted unemployment risk. Panel (d) shows that there is a somewhat larger drop in debt-to-income ratios among public sector workers than in some of the private sectors. But overall these differences are small, and the main finding is the same.[22] When the interest rate rises, households tend to borrow less or repay more, in line with standard intertemporal substitution effects, while the counteracting Fisher dynamics are too small to undo this response.

4.7 Loan-to-Value Ratios and Net Debt

Our entire analysis has focused on households' ratio of debt relative to their income. While this is the main measure of household debt burdens emphasized in the literature, one might consider other measures too. One such measure is the ratio of debt relative to the value of households' homes, i.e., the loan-to-value ratio. Moreover, we are zooming in on a limited part of the household balance sheet by focusing on debt. It might well be that our estimated responses to monetary policy hikes reflect that households run down liquid assets to repay their debt.



(a) Loan-to-Value **(b)** Net Debt-to-Income

Notes: Impulse responses to a one percentage point contractionary monetary policy shock. The shaded areas display 68 and 95 percent confidence bands, computed using Driscoll and Kraay (1998) standard errors.

Figure 14: Loan-to-value and net debt responses to monetary policy

We therefore estimate responses of loan-to-value ratios and net debt relative to income. Net debt is computed as debt minus deposits divided by disposable nominal income. We employ the same local projection framework as before. Figure 14 displays results as impulse responses.

[22]Responses with confidence bands are reported in Figures B.5, B.6, B.7, and B.8 in the Online Appendix.

We see that the average loan-to-value ratio responds moderately, and to some extent positively after an interest hike. Hence, focusing on this measure there is something to the qualitative argument that interest hikes are counterproductive for reducing household leverage. The reason is that house prices fall. However, the response is small and not statistically significant at any horizon.

The ratio of net debt relative to income falls after interest hikes. The response is quite similar to what we saw for the debt-to-income ratio in Figure 5. Hence, our results suggest that households are *not* running their liquid reserves down to reduce their debt.

5 Conclusions

With precise balance-sheet data, we have documented how different households' debt burdens are driven by nominal debt changes on the one hand and the combined influence of interest income and expenses, real income growth and inflation, collectively termed Fisher dynamics, on the other. There are two main findings. As a matter of accounting, Fisher dynamics have been important for yearly changes in debt-to-income ratios among highly indebted households over the 22-year sample we observe. But when it comes to the effects of monetary policy shocks, monetary policy has worked mainly through nominal debt changes, not Fisher dynamics. Moreover, the latter result is remarkably stable across different households. In this sense, households' choice of how much to borrow and repay has dominated the mechanical Fisher dynamics in transmitting monetary policy shocks to household indebtedness.

In terms of the debate on whether monetary policy should lean against the wind, our estimates align with the conventional belief that higher interest rates lower household indebtedness. But the effect is modest. For instance, after a one percentage point shock to the policy rate, the average debt-to-income ratio drops by 1.5 percentage points after two years. This does not come across as a large effect in a sample where the average debt-to-income ratio is 161.5% and should be factored in when concerns for household indebtedness are traded off against other monetary policy objectives.

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