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Monetary Policy and Inequality

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ABSTRACT

We analyze the distributional effects of monetary policy on income, wealth, and consumption. We use administrative household-level data covering the entire population in Denmark over the period 1987 to 2014 and exploit a long-standing currency peg as a source of exogenous variation in monetary policy. We find that gains from softer monetary policy in terms of income, wealth, and consumption are monotonically increasing in ex ante income. The distributional effects reflect systematic differences in exposure to the various channels of monetary policy, especially nonlabor channels (e.g., leverage and risky assets). Our estimates imply that softer monetary policy increases income inequality.

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RECENT THEORY HIGHLIGHTS THE ROLE of heterogeneous households in monetary policy transmission through direct and indirect channels (Kaplan, Moll, and Violante (2018)). When households differ in terms of balance sheets and occupations, monetary policy may affect their income and wealth differentially. For instance, when the central bank reduces the policy rate, debtors may benefit from a drop in interest expenses, the unemployed from job creation, entrepreneurs from higher demand, and homeowners from increasing property prices. The distribution of the gains and losses across income groups is crucial for at least two reasons. First, it determines how monetary policy affects inequality in society (Bernanke (2015), Draghi (2016)). Second, it impacts the aggregate effects of monetary policy as the marginal propensity to consume varies systematically with income (Auclert (2019)).

Despite the importance of the distributional effects of monetary policy, the empirical evidence is scant. Existing papers mainly use survey data, where the tails of the income distribution are poorly represented (Ampudia et al. (2018)) and often focus on summary measures of inequality (Coibion et al. (2017), Mumtaz and Theophilopoulou (2017)). In this paper, we break new ground by using rich administrative microdata to analyze how monetary policy affects income, wealth, and a proxy for consumption of durables for households at different positions in the income distribution. We also shed light on the various channels of monetary policy by studying how changes in, for instance, interest expenses, housing prices, salaries, and business income contribute to overall gains and losses at each income level, and we summarize the implications for inequality by quantifying how monetary policy affects income shares through the income distribution.

Our main data source comprises individual-level tax records for the entire population in Denmark with detailed information about income and balance sheets for the period 1987 to 2014, more than 70 million individual-year observations. In the tax records, we observe all major components of households' disposable income (e.g., salaries, dividends, and interest expenses) as well as the main balance sheet components (e.g., housing, stocks, and debt). This information is generally reported by third parties such as employers and financial institutions, and therefore mismeasurement due to tax evasion is limited (Alstadsæter, Johannesen, and Zucman (2019)). Matching observations on unique personal identifiers, we link the tax records to the auto register with comprehensive information on car purchases, an important component of durable consumption. This granular information allows us to estimate how monetary policy differentially affects the income, wealth, and consumption dynamics of households at different income levels.

Our empirical strategy addresses the endogeneity of monetary policy by exploiting the long-standing commitment of the Danish monetary authorities to exchange rate stability: For more than three decades, the Danish krone has been pegged to the German mark (1987 to 1998) and the euro (1999 to 2023) and the exchange rate has been virtually constant throughout this period. With cross-border capital mobility, central banks cannot use the policy rate to maintain a fixed exchange rate and at the same time use it to pursue other policy

objectives (Fleming (1962), Mundell (1963)), so Denmark generally imports its monetary policy stance from Frankfurt. We show that this source of exogenous variation in Danish monetary policy rates can be harnessed in a simple local projections framework to deliver plausible estimates of monetary policy transmission to economic aggregates (e.g., output, prices, and consumption).

In our main analysis, we use household-level data to estimate how the effect of monetary policy varies over the income distribution. The dependent variable is the change in a household-level outcome, from the ex ante period to some future period, scaled by ex ante disposable income to allow for direct quantitative comparisons across outcomes. The main explanatory variable is the change in the Danish monetary policy rate interacted with indicators of households' position in the ex ante income distribution. We restrict the identifying variation in monetary policy to the component that is plausibly exogenous by instrumenting the change in the Danish monetary policy rate with the change in the German/euro area monetary policy rate while controlling for lagged, current, and projected values of German/euro area output growth and inflation (all interacted with income group indicators). Further, we add income group indicators that control for long-run changes in household outcomes at different positions in the income distribution to ensure that our results are not confounded by secular trends in inequality. Finally, we add time fixed effects that control for the average effect of all potentially confounding shocks. Our main estimates are therefore *differential effects*, that is, the effect of monetary policy at a given position in the income distribution over and above the effect for the reference group of households around the median income level. Differential effects are ultimately what matters for inequality. At the cost of stronger identifying assumptions, we also estimate the *absolute effects* of monetary policy for each income group by dropping the time fixed effects.

Our first set of results documents a striking income gradient in the effect of monetary policy on disposable income: When the monetary policy rate is lowered by 1 percentage point, the two-year effect on disposable income is around 3 percentage points larger for the top 1% of households than for the reference group in the middle of the income distribution and around 1 percentage point smaller for households at the lowest income levels.[1] Varying the time horizon, we find that the income gradient is steepest over horizons of two and three years.

We explore the economic channels underlying this key result by estimating the model for each component of disposable income separately. Consistent with theory and policy makers' perception (e.g., Draghi (2016)), softer monetary policy has the largest effect on salary income for households at the low end of the income distribution, reflecting a sizeable increase in employment for this group. However, most other components of disposable income contribute to a positive income gradient. Importantly, gains in the form of business income and stock market income are highly concentrated at the top of the income

[1] This result is related to earlier evidence that high-income households are more exposed to aggregate fluctuations in the economy (Parker and Vissing-Jorgensen (2009)).

distribution. We document that the income gradient in the effects of monetary policy is due in part to systematic differences in the composition of income and balance sheets. For instance, households with higher incomes benefit more from lower interest expenses when the monetary policy rate is lowered with this reflecting both a higher level of debt relative to disposable income and a higher pass-through rate given the level of debt.

Our second set of results shows a positive income gradient in the effect of monetary policy on the value of households' assets through changes in property prices and stock prices. Over a two-year horizon, the effect on asset values, measured in units of disposable income, is around 40 percentage points larger for the top 1% than for households around the median income level and around 5 percentage points smaller for households with the lowest incomes. The gradient reflects the fact that households with higher income hold more assets relative to their disposable income as well as the fact that the average asset returns created by softer monetary policy are higher for high-income households. Together with the first set of results, these findings suggest that the differential effects of monetary policy through changes in asset prices are much stronger than the effects through changes in disposable income.[2]

The key identifying assumptions are that German/euro area monetary policy shocks, first, do not coincide with other shocks that affect Danish households differentially over the income distribution and, second, do not themselves have such differential effects other than by moving Danish policy rates. A range of robustness tests support these assumptions. To absorb confounding shocks, we add more ex ante controls (i.e., evaluated before or in the same period as the monetary policy shock): We control for ex ante macroeconomic conditions in Denmark and for ex ante changes in the global financial cycle. We also take alternative approaches to identifying monetary policy shocks, using methods developed by Romer and Romer (2004) and Jarocinski and Karadi (2020). To shut down alternative channels through which monetary policy in Frankfurt could affect outcomes in Denmark, we sequentially add ex post controls (i.e., evaluated after the monetary policy shock): We control for ex post changes in exports and imports, for ex post changes in foreign assets and liabilities, and, to account as broadly as possible for business cycle spillovers, for ex post German/euro area macro outcomes (i.e., stock prices, GDP growth, and inflation). The main results remain qualitatively unchanged throughout these robustness tests. Finally, investigating the external validity of our analysis, we show that our findings are not driven by the relatively high levels of household debt in Denmark. The main results remain similar when we weight the observations in our Danish sample to match, within income groups, household debt in the United States or the euro area.

[2] Expressed relative to total asset values, our estimates imply capital gains of around 4% at the bottom and around 6% at the top when the monetary policy rate is reduced by 1 percentage point. The results for individual asset classes are broadly consistent with the literature on the effects of monetary policy on house prices (e.g., Taylor (2007)) and on stock prices (e.g., Rigobon and Sack (2004)).

As a first extension of the core analysis, we study the distributional effects of monetary policy on consumption and wealth accumulation. The intertemporal budget constraint requires that the gains created by softer monetary policy, whether in the form of higher disposable income or capital gains on assets, must be either consumed or added to the household's wealth. However, by changing market interest rates, monetary policy also affects consumption and savings through intertemporal substitution. Accounting for both of these channels of monetary policy as well as others (e.g., changes in asset holdings and leverage), we reestimate the model using household-level changes in car purchases and net wealth as outcomes. The results indicate that the gains of softer monetary policy in terms of consumption as well as in terms of net wealth are increasing in income. The effects on net wealth are similar to the estimated price effects on asset values, which is consistent with an important role for "saving by holding" (Fagereng et al. (2019)).

Second, we investigate the role of household debt in the transmission of monetary policy. Debt matters directly for exposure to several channels of monetary policy and may further shape consumption responses to the extent that it represents a financial constraint. We therefore estimate an augmented model in which the effect of changes in the policy rate is allowed to vary with ex ante leverage at each income level. Within income groups, we find that the estimated effects on disposable income, housing wealth, and consumption increase almost monotonically with leverage. Within groups with similar leverage, the income gradient is generally weaker than in the full sample. While these results point to an important role of debt in shaping the distributional effects of monetary policy, significant heterogeneity remains after accounting for leverage. Notably, the top 1% stands out with larger gains from softer monetary policy than any other income group at each level of leverage. Stock market gains are particularly large for households with high incomes and no debt.

Third, as exposure to the various channels of monetary policy varies systematically over the life cycle, we also examine the distributional effects of monetary policy in the age dimension. We find that effects on disposable income are hump-shaped in age, largest for the middle-aged, and smaller for the young and the elderly. This pattern reflects a host of differences, for instance, that the middle-aged are more often self-employed and have more debt than other age groups and therefore benefit more from higher business income and lower interest expenses when the monetary policy rate is lowered. By contrast, the effect on asset values is monotonically increasing in age, reflecting the fact that average stock portfolios and housing assets are increasing in age. In sum, softer monetary policy creates the largest benefits for the middle-aged through income and for the elderly through asset prices while the young benefit less through either channel.

Finally, to relate our findings to the broader literature on inequality (e.g., Piketty (2014)), we conduct a simulation exercise that summarizes the distributional implications of our estimates. The results suggest that softer monetary policy unambiguously increases income inequality by raising income shares at the top of the income distribution and lowering them at the bottom.

Specifically, accounting for direct as well as indirect channels, reducing the policy rate by 1 percentage point raises the share of aggregate disposable income for the top 1% by around 3% over a two-year horizon and lowers it by around 1.5% for the bottom income group.

It is important for the interpretation of our results that we restrict the identifying variation in monetary policy to the exogenous component (i.e., lowering the policy rate to keep the exchange rate fixed). Strictly speaking, we cannot be sure that the distributional effects are the same for the endogenous component (i.e., lowering the policy rate to support aggregate demand). A similar caveat applies to the large empirical literature that identifies the effect of monetary policy from exogenous shocks by controlling for the expected response of monetary policy to the business cycle or by isolating monetary policy surprises.

Our paper mainly contributes to the emerging empirical literature on monetary policy and inequality (Coibion et al. (2017), Mumtaz and Theophilopoulou (2017), Ampudia et al. (2018), Amberg et al. (2021)). This theme attracts significant attention from policy makers, with some arguing that softer monetary policy reduces inequality because it primarily helps low-skilled workers find jobs (Draghi (2016)), while others emphasize that the well-to-do also benefit through an increase in asset prices, in which case the net effect on inequality is ambiguous (Bernanke (2015)). Compared to our main result, Coibion et al. (2017) find that lower policy rates are associated with less income inequality. This may partly reflect differences in methodologies. We use administrative data covering the entire population rather than top-coded survey data, which is crucial given the key role of the upper tail for inequality, and we consider the effect on disposable income, accounting for tax payments and interest expenses, rather than total income. As our results agree with Coibion et al. (2017) that monetary policy has little or no effect on inequality in earnings, the difference relates to the effect on inequality in financial income. Our results indicate that softer monetary policy raises inequality through this channel because of differences in portfolio composition: Overall financial income increases for high-income groups, who hold many equities and therefore gain more through higher stock market income than they lose through lower interest income, while it decreases for low-income groups, who mainly hold deposits.[3] Consistent with our results, Amberg et al. (2021) find that a lower monetary policy rate creates the largest income gains at the top of the income distribution, driven mainly by increases in financial income. However, their results, unlike ours, also point to relatively large income gains at the bottom, driven by increases in labor income. To our knowledge, our paper is the first in this literature to study the effect of monetary policy on asset values, the most

[3] Coibion et al. (2017) also find that softer monetary policy reduces consumption inequality, which is consistent with predictions from the model by Auclert, Rognlie, and Straub (2020). These results are not directly comparable to ours, as we do not study consumption inequality but rather the effect on consumption at different positions in the income distribution. Another related paper is Gornemann, Kuester, and Nakajima (2021), who study theoretically the distributional effects of systematic monetary policy.

important source of differential gains and losses according to our results, and net wealth accumulation using administrative data.

Our results also inform theory models about the direct and indirect channels of monetary policy (Kaplan, Moll, and Violante (2018), Auclert (2019), Alves et al. (2020), Slacalek, Tristani, and Violante (2020)). In these models, the effect of monetary policy on macroeconomic aggregates depends on how shocks to the household budget pass through to consumption. As the marginal propensity to consume varies systematically over the income distribution, reflecting in part the correlation with wealth and liquidity, whether the gains and losses accrue to high-income or low-income households is a key factor.[4] Our results also highlight that nonlabor channels (e.g., leverage, dividends, risky assets) contribute importantly to both the aggregate and distributional effects of monetary policy. This resonates with recent developments of the Heterogeneous Agent New Keynesian (HANK) framework highlighting asset prices as an important transmission mechanism (Alves et al. (2020), Auclert, Rognlie, and Straub (2020)) and with theoretical work on monetary policy in the macrofinancial tradition (Brunnermeier and Sannikov (2012)).

Finally, we contribute to the broader literatures using microdata to study the heterogeneous effect of monetary policy on firms (e.g., Kashyap and Stein (2000), Jimenez et al. (2012, 2014)) and the effect of pass-through from policy rates to market interest rates on household consumption (Di Maggio et al. (2017), Flodén et al. (2019), Cloyne, Ferreira, and Surico (2020),Di Maggio, Kermani, and Palmer (2020)). Most similar in terms of empirical approach is a paper that analyzes the heterogeneous effects of monetary policy using microdata from Norway (Holm, Paul, and Tischbirek (2021)). The two papers differ in terms of the fundamental research question: While they study heterogeneity by household *liquidity* to learn about the role of financial frictions for monetary policy transmission, we study heterogeneity by household *income* to understand the interplay between monetary policy and inequality. The flavor of the results also differs: While they find that the effect on disposable income varies nonmonotonically with liquidity, we find a perfectly monotonic relation with income and a crucial role for leverage and risky assets.

The paper proceeds as follows. Section I describes the data. Section II introduces the model. Sections III– V present the results. Section VI concludes.

I. Data

The main analysis uses microdata on income, wealth, and consumption from different administrative registers.[5] In this section, we specify the sample, describe the data sources, and provide summary statistics for the key variables.

[4] Auclert (2019) formally demonstrates the existence of a redistributive channel in monetary transmission if the distribution of gains and losses correlates with marginal propensities to consume. Luetticke (2021) shows that monetary policy transmission also depends on marginal propensities to invest in real assets.

[5] We also use standard macrodata on aggregate prices, output, consumption, and so on for both Denmark and Germany/euro area.

A. Sources, Variables, and Sample

The main source of microdata is the Danish tax register, which contains annual information about taxable income and wealth at the individual level for the period 1987 to 2014. The information derives from tax returns, and since tax filing is compulsory for all individuals with primary residence in Denmark, the data set covers the entire adult population. The information is generally reliable as it is overwhelmingly reported by third parties like employers and financial institutions (Kleven et al. (2011)) and therefore suffers little from underreporting by taxpayers themselves (Alstadsæter, Johannesen, and Zucman (2019)).

The tax register contains information about total taxable income as well as its various positive components (income) and negative components (deductions). The most important positive components are salary income, business income (from sole proprietorships), stock market income (dividends and realized capital gains), interest income (from deposits and bonds), government transfers (including public pensions), and private pension income (payouts from private pension accounts). The most important negative components are taxes and interest expenses. We define *disposable income* as the sum of the income components minus interest expenses and tax liabilities.[6]

The tax register also contains information about important categories of assets and liabilities. Specifically, we observe the value of deposits, listed stocks, and loans as reported by financial institutions as well as the value of real estate as assessed by the tax authorities for the purpose of property taxation. As the tax value of real estate often understates the market value, we use transaction prices retrieved from the real estate register to construct local market price indices, which allows us to approximate capital gains on real estate, including on properties that do not change hands in a given period, at market value (see details in Section II of the Internet Appendix).[7] The main wealth components for which no information is available on the tax return are loans from private persons and foreign banks (without a presence in Denmark), unlisted stocks, and savings in tax-favored pension accounts.[8]

To study household-level consumption, we retrieve information about car registrations from the auto register. We do not observe car values and therefore use the number of new cars registered in a given year as our key measure

[6] There exists a small residual income category, "other income," that is the sum of a large number of rare and highly diverse income types that do not fit any of the other categories. While we include other income in overall disposable income, we do not study this income component separately.

[7] The Internet Appendix is available in the online version of the article on *The Journal of Finance* website.

[8] Since the abolition of the net wealth tax in 1997 (Jakobsen et al. (2020)), taxpayers are not required to complement the information reported by domestic banks with self-reported information on loans from other sources or to provide estimated values of unlisted stocks. Tax-favored pension accounts are similar to 401ks in the United States: The accounts are personal and managed either by the individuals themselves or by private pension funds. Access to assets in pension accounts prior to pension age is possible but triggers a significant penalty.

of consumption. This approach has several advantages relative to other consumption measures used in the literature. It has population-wide coverage and includes cars paid without external financing, as opposed to measures based on auto loan balances obtained from financial institutions (e.g., Di Maggio et al. (2017)), and it is not mechanically related to income and wealth, as opposed to imputed measures of consumption (e.g., Holm, Paul, and Tischbirek (2021)).[9] However, the approach also has limitations: We cannot account for purchases of used cars and, because information on purchase prices is not available, we cannot distinguish between more and less expensive new cars.

Finally, the population register provides information on age and place of residence and defines households, which is our unit of analysis throughout the paper. Two adults are classified as belonging to the same household if they are married, registered partners, or cohabiting partners. For variables such as income and wealth, we always take averages over adults in the same household to ensure comparability across households with one and two adults. We define household age as the age of the oldest household member.

We limit the sample to households, for which the oldest adult member is at least 25 years old. Younger households with low incomes are often students with high life-time incomes receiving considerable financial support from their parents (Andersen, Johannesen, and Sheridan (2020)), so income rankings are not a good measure of economic resources for this group. We also exclude a small number of households with annual disposable income below a threshold of $10,000 (in 2015 prices), since a recorded income below this level presumably indicates that true income is not measured well.[10]

B. Descriptive Statistics

The main goal of the analysis is to estimate how the effects of monetary policy vary with the position in the income distribution. We capture positions in the income distribution by ranking households *within* age cohorts according to a three-year average of their total income and assigning them to income

[9] Consumption can be imputed from income and wealth data based on the accounting identity *consumption = disposable income + net capital gains − change in net wealth* (Browning and Leth-Petersen (2003), Jensen and Johannesen (2017), Eika, Mogstad, and Vestad (2020)). There are two reasons we do not adopt this measure. First, a recent paper shows that the imputation procedure may be associated with significant measurement error at the tails (Abildgren et al. (2018)). This is particularly problematic for studies with a distributional perspective like ours. Second, changes in market interest rates create (unobserved) capital gains and losses on mortgage loans, which introduces measurement error in the imputed consumption measure. If we were to use imputed consumption as an outcome, the measurement error would cause a systematic bias as it correlates with the dependent variable (changes in monetary policy rates). In principle, it may be possible to mitigate these measurement problems with exhaustive information about all household assets and liabilities, including information about within-year transactions, but such data are not available in our setting.

[10] To be precise, we use the threshold of 60,000 kroner, which is lower than social benefits at the lowest rate. Measurement problems could arise due to work in the informal sector, unreported emigration, or other similar reasons.

groups based on the rank. We prefer ranking within age cohorts as income, wealth, and consumption change systematically over the life cycle (Friedman (1957), Ando and Modigliani (1963)).

To provide a basis for understanding the various channels through which monetary policy may differentially affect households at different income levels, we describe the composition of income and net wealth by income group in Table I. For simplicity, the table employs only seven groups, each corresponding to 20% of the population with the top group further split into three subgroups (p80-90, p90-99, and top 1%) to highlight the pronounced heterogeneity at the top. Our regressions generally employ 21 groups, each corresponding to 5% of the population with the top group further split into two subgroups (p95-99 and top 1%).

Panel A provides a sense of the baseline inequality in Denmark during our sample period by showing each income group's disposable income measured relative to disposable income in the middle income group (p40–60). This metric ranges from 66% in the bottom group to 432% in the top 1%. The distribution of disposable income is much more equal than the distribution of market income, by accounting for government transfers and taxes as well as interest expenses.

Panel B summarizes the relative importance of the various types of income and expenses by income group. Each item is scaled by disposable income so that the sum of the income components minus interest expenses equals 100% within each group (except for rounding). Net government transfers are defined as transfers *from* the government in the form of pensions and benefits net of transfers *to* the government in the form of taxes. For the bottom income group (bottom 20%), salaries and government transfers are the main income components, whereas business income, stock market income, interest income, and private pension income are negligible. Moving up the income distribution, the importance of salary income increases until the 90th percentile and then decreases, while the importance of business income, stock market income, and, to a lesser extent, interest income increases throughout. In the top income group (top 1%), business income is almost as important as salary income and stock market income makes up a substantial part of disposable income. Reflecting the redistributive effects of government intervention, net government transfers decrease steeply as income increases. Interest expenses account for an increasing share of disposable income throughout the income distribution, reflecting the fact that, as we show below, household leverage tends to increase with income.

The differences in income composition are suggestive of how the quantitative effects of monetary policy may differ over the income distribution. For instance, if softer monetary policy increases salaries at the same rate for all income groups, then—everything else equal—it will lead to the largest relative increases in disposable income for the middle class whereas, if it increases business income at the same rate for all income groups, the top income group will enjoy the largest relative increase in disposable income. While these considerations are instructive, they also have clear limitations. First, the price effects need not be homogeneous across households; for instance, wage rates

Table I

Descriptive Statistics

The table describes the level of disposable income (Panel A), the composition of disposable income (Panel B), and net wealth (Panel C), and some important behavioral margins (Panel D) by income group. The income category *deposits* also includes bonds. All income and wealth measures are expressed as a fraction of disposable income. To define the income groups, we rank households within each agecohort. The seven income groups are: individuals up to the 20th percentile (*p0-20*), between the 20th and 40th percentile (*p20–40*), between the 40th and 60th percentile (*p40–60*), between the 60th and 80th percentile (*p60–80*), between the 80th and 90th percentile (*p80–90*), between the 90th and 99th percentile (*p90–p99*), and above the 99th percentile (*p99–100*). To construct Panels B and C, we aggregate each income and wealth component within each income group over the sample period and divide by disposable income aggregated similarly. In Panel B, *disposable income* sums salary income, business income, stock market income, interest income, private pension income, other income, and net government transfers and subtracts interest expenses. In Panel C, *net wealth* sums deposits, stocks, and housing and subtracts debt.

	p0–20	p20–40	p40–60	p60–80	p80–90	p90–99	p99–100
	Panel A: Level of disposable income (in % of middle group)						
	66%	85%	100%	115%	132%	170%	432%
	Panel B: Composition of disposable income (each component in % of overall disposable income)						
Salary income	40%	96%	118%	128%	135%	130%	73%
Business income	4%	5%	6%	8%	12%	27%	62%
Stock market income	0%	0%	1%	1%	2%	6%	41%
Interest income	1%	2%	2%	2%	3%	5%	10%
Private pension	4%	5%	6%	10%	15%	17%	11%
Other income	1%	1%	1%	1%	2%	3%	7%
Net government transfers	58%	5%	–18%	–35%	–51%	–67%	–80%
Interest expenses	8%	13%	15%	16%	18%	21%	23%
Disposable income	100%	100%	100%	100%	100%	100%	100%
	Panel C: Composition of balance sheets (each component in % of overall disposable income)						
Deposits	64%	67%	66%	82%	96%	129%	234%
Stocks	8%	10%	11%	16%	23%	42%	180%
Housing	283%	348%	366%	435%	506%	604%	578%
Debt	145%	210%	235%	263%	294%	337%	321%
Net wealth	210%	214%	208%	270%	331%	438%	670%
	Panel D: Descriptive indicators						
Is net creditor	64%	71%	74%	77%	81%	84%	87%
Has no debt	30%	25%	23%	20%	18%	16%	15%
Holds stocks	19%	27%	31%	40%	48%	58%	70%
Owns real estate	37%	54%	59%	68%	74%	82%	90%
Is self-employed	8%	9%	10%	12%	16%	26%	49%
Buys new car	1%	3%	3%	4%	5%	6%	7%

may increase more for some households than for others depending on the industries they work in and the type of loans they hold. Second, monetary policy may also have heterogeneous nonprice effects; for instance, unemployed workers may find jobs and start earning salary income when the business cycle improves. Our regression results generally account for heterogeneous price and nonprice effects.

Panel C summarizes the value of the various types of assets and liabilities by income group. Each item is scaled by disposable income so that summing across asset classes and subtracting debt gives the ratio of net wealth to disposable income (except for rounding). Balance sheets are quite similar for the three lowest income groups (bottom 60%): Net wealth amounts to around two times disposable income, real estate is by far the most important asset, and financial assets are almost exclusively in the form of deposits. Moving higher up in the income distribution, net wealth increases monotonically and reaches almost seven times disposable income in the top income group (top 1%). All three types of assets increase through the income distribution but not in the same proportions: Housing roughly doubles (relative to disposable income) when moving from the bottom to the top income group, while deposits more than triple and the value of stocks increases more than 20 times. Debt also increases almost monotonically through the income distribution, roughly doubling (relative to disposable income) when moving from the bottom to the top income group. This is tightly related to homeownership: Households in higher income groups are more likely to own their home, which typically involves a significant degree of debt financing.

The composition of the balance sheet is suggestive of how monetary policy may affect households differentially through asset prices. For instance, if softer monetary policy increases house prices at the same rate across income groups, the gains will be only slightly increasing through the income distribution when measured relative to disposable income, while if it increases stock prices uniformly across income groups, the gains will be highly concentrated within the top income group. Again, these considerations are instructive but do not account for heterogeneous price effects: If real estate prices are more responsive to monetary policy in high-income areas than in low-income areas, it will contribute to the heterogeneity in gains and losses across households belonging to different income groups. Our regression results capture this source of heterogeneity by accounting for local price variation.

Panel D describes six extensive margins: The fraction of individuals within each group that are net creditors, have no debt at all, hold any securities, own any real estate, have any income (positive or negative) from self-employment, and buy a new car. All six statistics are monotonically related to income: As we move up the income distribution, there are more net creditors, more stock market participants, more home owners, more self-employed, and more households buying new cars, but fewer households with no debt.

Finally, to assess whether our results are likely to extend to other settings, we compare the structure of household balance sheets in Denmark to those in the United States and the euro area along dimensions that are key to the

transmission of monetary policy: homeownership, stock market participation, debt market participation, and debt-to-income ratio. Using tabulations from the Survey of Consumer Finance for the United States and the Household Finance and Consumption Survey for the euro area, Figure IA.1 in the Internet Appendix shows that both the United States and the euro area exhibit an overall positive income gradient in all four dimensions that is qualitatively similar to what we observe in the Danish sample. Moreover, as shown in Figure IA.2 in the Internet Appendix, the household debt structure has evolved in a qualitatively similar fashion in Denmark and the United States over the sample period. Overall, Denmark mainly stands out by households having relatively elevated debt-to-income levels. We explore the implications of this difference by estimating the effects of monetary policy in our Danish sample reweighted so that it resembles households in the United States and the euro area in terms of debt structure.

II. Empirical Design

The aim of the analysis is to estimate how monetary policy differentially affects the income, wealth, and consumption dynamics of households at different income levels. The key methodological challenge relates to the endogeneity of monetary policy. In this section, we first briefly describe the long-standing Danish currency peg. We then show how the peg can be used to isolate plausibly exogenous variation in Danish monetary policy. Finally, we use a model that exploits this variation to estimate differential effects of monetary policy over different time horizons.

A. The Currency Peg

The monetary policy rule in Denmark is simpler than in many other countries such as the United States, the United Kingdom, the euro area, and other Scandinavian countries (Taylor (1993)). Since 1987, the Danish krone has been pegged to the German mark and the euro, and exchange rate stability remains the overriding objective of monetary policy. In the words of Bodil Nyboe Andersen, then Governor of the Danish Central Bank, "[Our] aim is to ensure that the Krone's rate against the Euro is stabilized close to the central rate within ERM II, and the exchange rate is the sole basis for our monetary policy deliberations." [11]

This currency peg is useful for identification by creating a plausibly exogenous source of variation in Danish monetary policy. Theory tells us that to keep the exchange rate fixed in an open economy, the central bank must use the policy rate to control the demand for local currency and therefore cannot use it at the same time to control other local economic conditions (Fleming (1962), Mundell (1963)). In normal times, therefore, Denmark imports its monetary policy stance from Frankfurt: When the European

[11] Speech at the Danish Bankers Association on December 4, 2002, quoted in Abildgren (2010).

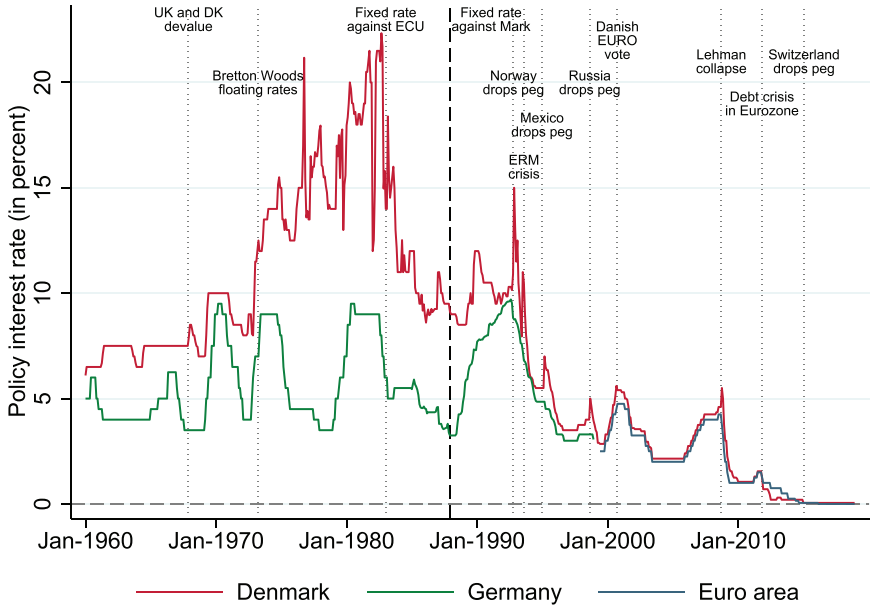

Figure 1. Monetary policy rates. The figure shows the leading policy interest rates for Denmark, Germany (January 1960 to December 1998) and the euro area (January 1999 to December 2018). The leading policy rate is the lending rate until November 2013 and then the deposit certificate rate (Denmark); the Lombard rate until 1987 and then the repo rate (Germany); and the major refinancing operations rate until November 2013 and then the deposit rate (euro area). The dashed lines indicate major events affecting monetary policy rates. The bold dashed line marks the beginning of the peg to the German mark. (Color figure can be viewed at wileyonlinelibrary.com)

Central Bank (ECB) changes its leading interest rate to pursue some policy objective for the euro area, the Danish central bank (Danmarks Nationalbank) generally changes its rate by the same amount on the same day to restore the interest rate differential that is consistent with a fixed exchange rate.

Figure 1 illustrates this point. After a convergence period in the 1980s, Danish monetary authorities generally followed the interest rate decisions made in Frankfurt; only in rare periods with turmoil in global markets have they temporarily adjusted the interest rate spread to defend the exchange rate. In the Internet Appendix, we provide more details about the currency peg (Section III) and document that the exchange rate of Danish kroner relative to the German mark (1987 to 1998) and euro (from 1999) has indeed been extremely stable, in line with the policy objective (Figure IA.3).

To be clear, the currency peg does not imply that the monetary policy stance imported from Frankfurt is orthogonal to economic conditions in Denmark. As business cycles are positively correlated, the imported policy will generally be closer to the one appropriate for the Danish business cycle than a

random draw.[12] However, the business cycle correlation is far from perfect, which means that the exogenous component of monetary policy will be much stronger under a currency peg than if inflation and output growth were the objectives of the Danish central bank. In brief, our estimation strategy uses the variation in Danish monetary policy created by the currency peg while absorbing the potentially confounding effect of correlated business cycles with a comprehensive set of macro controls.

B. Aggregate Effects of Monetary Policy

We exploit the currency peg to isolate exogenous variation in Danish monetary policy and use this variation to estimate the effect of monetary policy on a range of macro aggregates (see Jordà, Schularick, and Taylor (2020)). This preliminary step allows us to assess the plausibility of the identification strategy before adapting the model to household-level outcomes. To make the macroanalysis fully equivalent to the microanalysis, we use the same sample period and the same annual frequency.

The explanatory variable of interest is the change in the Danish monetary policy rate between period $t-1$ and period t (Δi_t). To address potential endogeneity of this variable, we instrument it with the change in the German/euro area monetary policy rate (Δi_t^*) and include a set of control variables that captures current macroeconomic conditions as well as the outlook over future periods in Germany/euro area (X_t^*).[13] The dependent variable (Y) is the change in some Danish macro variable between period $t-1$ and some future period $t+h$, where h denotes the time horizon over which the effects of monetary policy are estimated (Jordà (2005)). Formally, we estimate the local-projections model:

$$\frac{Y_{t+h}-Y_{t-1}}{Y_{t-1}} = \alpha_h + \beta_h(-\Delta i_t) + \phi_h X_t^* + \mu_t, \tag{1}$$

[12] As shown in Figure IA.4 in the Internet Appendix, the correlation coefficient between macro outcomes in Denmark and Germany/euro area is around 0.3 and 0.4 for quarterly GDP growth and inflation, respectively, which is lower than the corresponding correlation coefficients of around 0.45 and 0.55 for Denmark and the United States. The correlation between macro outcomes in Denmark and Germany was essentially zero in the subperiod with a peg to the German mark, which encompasses the German reunification (coefficients of around 0.1 and −0.1 for GDP growth and inflation), while the correlation between Denmark and the euro area was stronger in the subperiod with a peg to the euro (coefficients of around 0.5 and 0.6). The correlation between macro outcomes in Denmark and the United States is suggestive of the importance of global shocks.

[13] The results are the same if we first estimate the German/euro area monetary policy shock as the residual variation in Δi_t^* after regressing it on X_t^*, and then use this shock as an instrument in equation (1). Figure IA.5 compares the German/euro area monetary policy shocks (blue bars) to the actual change in the German/euro area policy rate (red line) and in the Danish policy rate (green line). The controls absorb a lot of the variation, suggesting that German/euro area monetary policy is highly endogenous to local conditions. For instance, the largest negative change in the German/euro area policy rate occurred in 2009 just after the financial crisis, but after purging for the effect of the macro environment, the monetary policy shock is slightly positive.

where the vector X^* includes actual GDP growth and inflation in periods $t-1$ and t as well as forecasts of GDP growth and inflation for period $t+1$ and the lagged dependent variable.[14] The currency peg ensures that the instrument is highly relevant while the set of control variables restricts the identifying variation to the German/euro area monetary policy shocks (i.e., the variation in Δi_t^* that is orthogonal to X_t^*).[15] Since the change in the policy rate enters the model with a negative sign, the estimated coefficients measure the effect of lowering the monetary policy rate by 1 percentage point, a *softening* of monetary policy.

Figure 2 illustrates the estimated effects of a 1 percentage point decrease in the monetary policy rate. The effect on the Danish monetary policy itself exhibits some persistence but dies out over the full four-year horizon (Panel A). The estimated effect on GDP reaches around 2.5% over a three-year horizon, after which it starts to dissipate (Panel B). By contrast, the effect on prices is small in both the short and the medium term (Panel C). Aggregate consumption follows a pattern similar to GDP although with a slightly lower peak and a more pronounced reversal at the end of the estimation period (Panel D). Aggregate car purchases are qualitatively similar, but the effects are larger by almost an order of magnitude, highlighting the fact that cars constitute a volatile component of aggregate consumption (Panel E). Aggregate labor income appears to be more sluggish, with the effect of monetary policy emerging and dissipating somewhat slower than the effects on GDP and consumption (Panel F). Taken together, the results are broadly consistent with the empirical literature on the macroeconomic effects of monetary policy shocks (e.g., Jordà, Schularick, and Taylor (2020)).

C. Distributional Effects of Monetary Policy

In the main analysis, we employ an equivalent empirical framework to estimate the heterogeneous effects of monetary policy on income dynamics using household-level data. The explanatory variable of interest remains the change in the Danish policy rate, which is now interacted with income group indicators to allow for heterogeneous effects. The dependent variable is the change in some household-level outcome y, such as disposable income, measured over varying horizons and scaled by ex ante household disposable income. Formally, we estimate the following model, where j, t, k, and h denote the household, calendar year, income group, and time horizon, respectively:

$$\frac{y_{j;t+h} - \overline{y}_{j;<t}}{\overline{d}_{j;<t}} = \sum_{k=1}^{21} \mathbb{1}[j \in k]\left[\alpha_h^k + \beta_h^k(-\Delta i_t) + \gamma_h^k X_t^*\right] + \theta_t + \varepsilon_{j,t}. \tag{2}$$

[14] Macro variables for Denmark come from Statistics Denmark, macro variables for Germany and the euro area are from the OECD, the World Bank, and Eurostat and forecasts are from OECD Economic Outlook.

[15] In the first stage, the F-statistic on the excluded instrument is around 36.

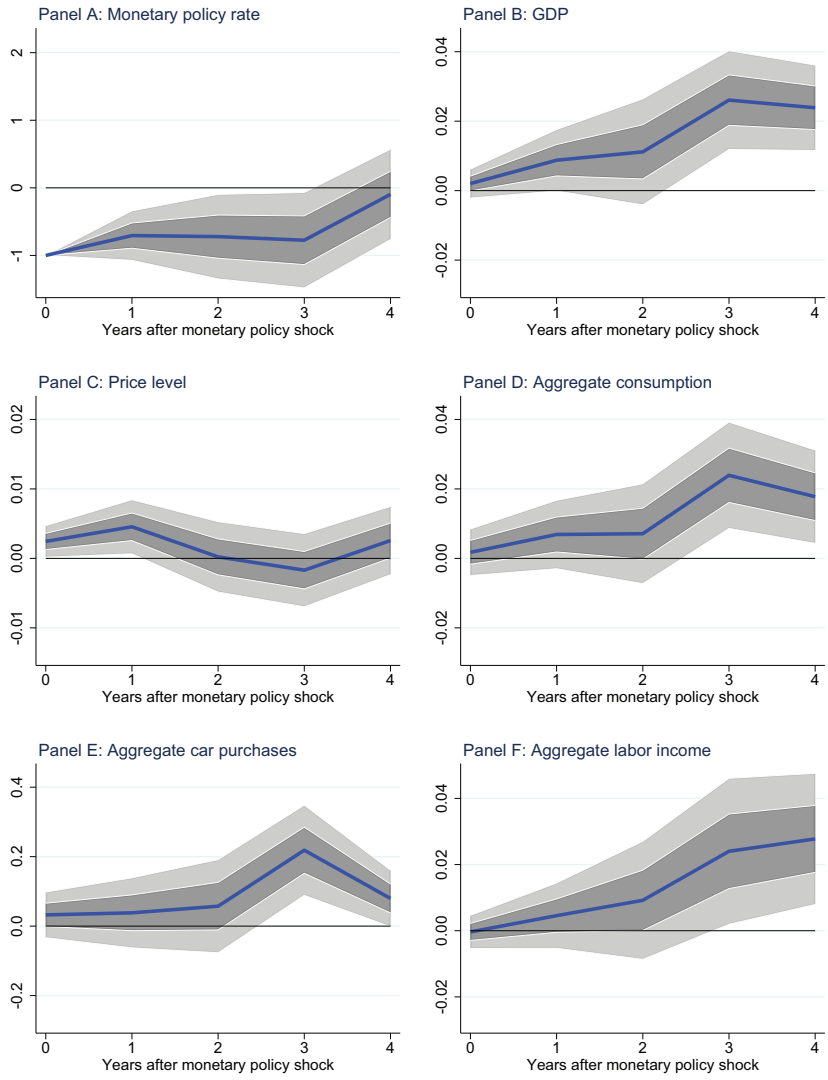

Figure 2. Macro effects of monetary policy shocks. The figure shows the estimated dynamics in Danish macro variables associated with a 1 percentage point decrease in the Danish monetary policy rate (in period 0). The estimates come from a local projections framework that instruments changes in the Danish monetary policy rate with changes in the German/euro area monetary policy and controls for lagged, current, and projected German/euro area output growth and inflation. The outcomes are the monetary policy rate (Panel A), the level of GDP (Panel B), the price level (Panel C), aggregate consumption (Panel D), aggregate car purchases (Panel E), and aggregate labor income (Panel F). The figure shows point estimates (blue line) and confidence bounds based on one standard error (dark gray) and two standard errors (light gray). (Color figure can be viewed at wileyonlinelibrary.com)

On the left-hand side, $\overline{d}$ expresses the ex ante level of disposable income, that is, the level before the policy rate change in year t, which we capture as the average taken over the three years before year t to reduce the effect of transitory shocks in a single year; $\overline{y}$ expresses the ex ante level of the outcome defined analogously.[16] On the right-hand side, $\mathbb{1}[j \in k]$ indicates whether household j belongs to income group k, X^* denotes the vector of German/euro area macro variables as defined above, and θ_t is a vector of time fixed effects. The change in the Danish policy rate Δi_t is instrumented with the change in the German/euro area policy rate Δi_t^*. We estimate the model using household-level data for the period 1987 to 2014 and report standard errors that are clustered at the level of households and year-municipality.

The identification strategy in the household-level analysis is equivalent to the macro-level analysis above. We effectively use German/euro area monetary policy shocks, the variation in monetary policy that remains after conditioning on the macro environment (X^*), as a source of exogenous variation in the Danish monetary policy rate. The macro controls are now interacted with income group indicators to allow for a heterogeneous correlation between business cycles and the outcome across different income groups. However, as we are ultimately interested in inequality and thus how monetary policy affects income groups differentially, we go one step further and include time fixed effects in the model. This absorbs the macro effect of any potentially confounding aggregate shock, but it also means that we can only identify the effects of monetary policy relative to the effects for a reference group, which we choose to be the middle income group (p45–50). The estimates delivered by the baseline model with time fixed effects are therefore *differential effects* measuring the effect of monetary policy at a given position in the income distribution relative to the effect around the median income level. We sometimes also report results from models without time fixed effects. The estimates from such models capture the absolute effects of monetary policy for each group rather than the differential effects relative to the reference group. The estimates of the absolute effects mainly serve to better understand the differential effects and check their plausibility. Importantly, they also rely on stronger identifying assumptions, namely the change in the German/euro area monetary policy rate does not correlate with other shocks affecting aggregate income conditional on the controls, which are not necessary to estimate the differential effects.

We address a number of identification concerns with the baseline model itself and in further robustness tests. First, one may wonder whether our results could be confounded by long-run trends in inequality (Piketty (2014)). All of our models, including the baseline, control flexibly for such trends with income group fixed effects (α^k) that absorb differences in average income growth at different positions in the income distribution. Second, one may be concerned

[16] To be precise, we construct the ex ante level of disposable income and the outcome by taking the average over year $t-3$, $t-2$, and $t-1$, but the results are not sensitive to simply using the value in $t-1$.

that our baseline model does not isolate exogenous monetary policy shocks but instead uses variation that is endogenous to confounding differential shocks. We address this concern by adding ex ante controls (i.e., evaluated at time $t-1$ and t) for the Danish macro environment and for the global financial cycle. We also check the robustness of our results to using alternative monetary policy shocks, based on the methodologies of Romer and Romer (2004) and Jarocinski and Karadi (2020), as detailed in Section IV of the Internet Appendix. Third, one may worry that our estimates are effectively picking up spillover effects of the monetary policy conducted in Germany/euro area working through changes in the demand for Danish exports or assets. Such spillover effects do not affect our baseline estimates if they affect all income groups in the same way, but could bias our results if, say, increased demand for Danish exports induced by expansionary monetary policy in Frankfurt raises the incomes of high-income business owners more than the incomes of low-income workers. We purge our estimates of such differential spillovers by augmenting the model with a range of ex post controls (i.e., evaluated at time $t+h$). Some of these controls, such as changes in Danish exports, imports, external assets, and external liabilities, aim to capture specific types of spillovers, while others, such as German/euro area stock prices, output growth, and inflation, aim to shut down foreign business cycle spillovers more broadly.

We investigate the *channels* through which disposable income is affected by monetary policy by applying the model separately to each of its positive and negative components: salary income, business income, stock market income, interest income, private pension income, net government transfers, and interest expenses. In these regressions, we continue to scale with disposable income on the left-hand side (rather than the ex ante level of the income component itself). This delivers an approximate decomposition of the total effect on disposable income and allows us to assess which income components contribute most to the overall distributional effect.

In addition to the effects on disposable income, we estimate the differential gains and losses induced by monetary policy through its effect on asset prices. Our analysis focuses on two major asset classes, stocks and housing assets, and uses a slightly modified framework.[17] Letting P and Q denote prices and quantities, respectively, we define the capital gain on a given asset over time horizon n as $P_{j,t+n}Q_{j,t-1} - P_{j,t-1}Q_{j,t-1}$ and use this as the outcome in the model (scaled by disposable income). By holding ex ante quantities constant (i.e., fixing the portfolio), this concept of capital gains is unaffected by potentially endogenous portfolio adjustments, but may differ from actual capital gains and from actual changes in wealth in the presence of such adjustments.

[17] Mortgage loans with a fixed rate are also a potentially important source of capital gains and losses in Denmark. Like in the United States, borrowers have an option to repay mortgage loans at the market price of the underlying bonds and the market value of existing loans therefore varies inversely with the market interest rate. However, we are unable to include mortgage loans in the analysis of price effects, as we cannot distinguish capital gains on loans from loan repayments in the available data (Andersen et al. (2020)).

The practical implementation varies slightly for the two types of assets due to data differences. For stocks, we observe the market value of each household's portfolio at the end of each year but have no information on the underlying securities. In practice, we therefore approximate capital gains and losses with the percentage change in the national stock market index multiplied by the ex ante value of the portfolio.[18] This approach yields capital gains estimates that are roughly correct in the aggregate (assuming that most Danish households invest in Danish stocks or foreign stocks with similar returns). The income gradient in the capital gains estimates captures differences in the effects of monetary policy working through systematic differences in portfolio sizes, but not through differences in portfolio composition (Calvet, Campbell, and Sodini (2007), Fagereng et al. (2020)). For housing assets, we know the location of each property and construct local price indices based on real estate transaction data. We compute the capital gain on each property as the ex ante market value of the property multiplied by the percentage change in the local housing price index (see details in Section II of the Internet Appendix). The fact that we observe heterogeneous price developments across local areas is a major advantage compared to the analysis of stocks. The income gradient in the capital gains estimates captures differential effects of monetary policy working through systematic differences in the value of housing assets across income groups, as well as through systematic differences in the responsiveness of house prices to monetary policy.

Finally, we study the differential effects of monetary policy on wealth accumulation and consumption across the income distribution. More specifically, we estimate the effect of monetary policy on wealth accumulation by using the change in net wealth (scaled by ex ante disposable income) as an outcome. Compared to the analysis of capital gains and losses, we no longer hold quantities constant (do not fix the portfolio), we make no assumptions about stock returns (as we observe the market values of stock portfolios), and we include all observable balance sheet components in the net wealth measure (including deposits and loans). We study the effect of monetary policy on consumption by using the change in the number of new cars registered by the household compared to the ex ante period as an outcome.

III. Main Results

A. *Disposable Income*

A.1. Income Gradient

Figure 3 shows the differential effects of a 1 percentage point reduction in the policy rate on disposable income over a two-year horizon. The estimated effects exhibit a striking income gradient: The gains created by a softer

[18] Formally, the approximation is $(P_{j,t-1}Q_{j,t-1})((\Pi_{t+n} - \Pi_{t-1})/\Pi_{t-1})$, where Π is the national stock price index.

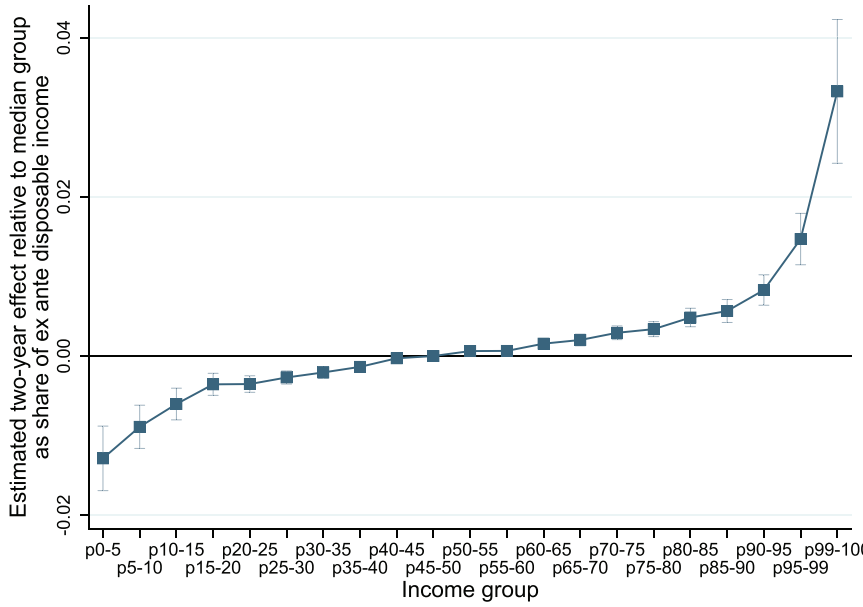

Figure 3. Differential effects of monetary policy on disposable income. The figure shows the estimated differential effect of a 1 percentage point decrease in the monetary policy rate on disposable income at different positions in the income distribution over a two-year horizon. The estimates are relative to the median group (p45–50). (Color figure can be viewed at wileyonlinelibrary.com)

monetary policy in the form of disposable income are increasing monotonically in the baseline level of income. Relative to the middle of the income distribution, the effect is around three percentage points larger for the top 1% and around 1 percentage point smaller for the lowest income levels.

Figure 4 illustrates how these estimates at select positions in the income distribution vary with the time horizon. The income gradient emerges already with a short horizon of one year, but gets noticeably stronger as the horizon is extended to two years. At longer horizons of three and four years, the differential gains are roughly stable with some signs that they start to dissipate, notably at the bottom and the middle of the income distribution. Motivated by these patterns, the rest of the analysis focuses on the two-year horizon.

A.2. Channels

We explore the channels of monetary policy and how each contributes to the overall income gradient highlighted in Figure 3 by applying our model to each component of disposable income in turn. In this case, we use a model *without* time fixed effects, which produces estimates of the effects of monetary policy in absolute rather than differential terms. This is useful because it allows us to make a quantitative comparison across income components and thus assess

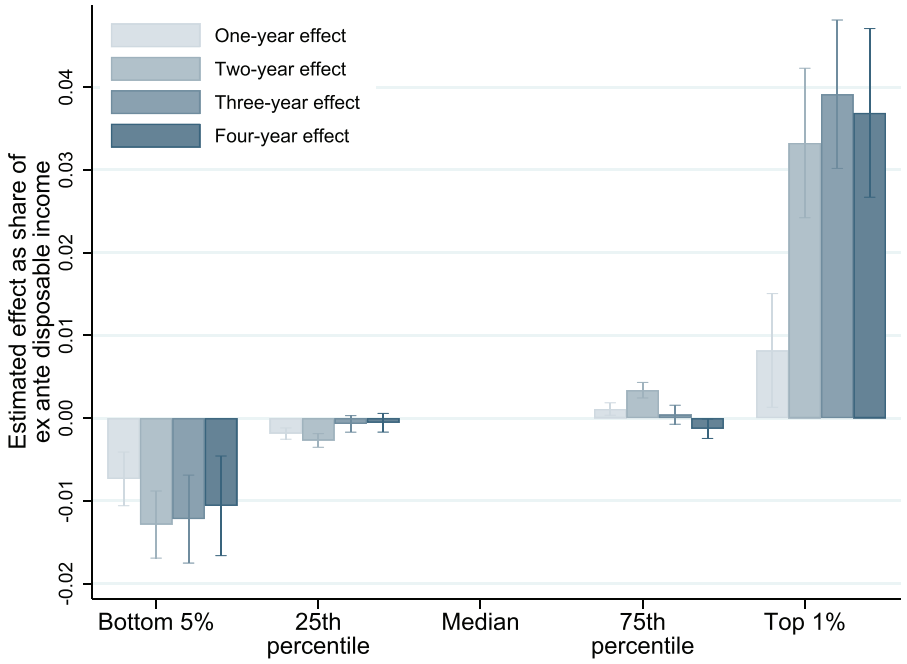

Figure 4. Differential effects on disposable income by time horizon. The figure shows the estimated differential effect of a 1 percentage point decrease in the monetary policy rate on disposable income at selected positions in the income distribution over a one-, two-, three-, and four-year horizon. The estimates are relative to the median group (p45–50). (Color figure can be viewed at wileyonlinelibrary.com)

which channels of monetary policy are more important at each position in the income distribution. Moreover, it allows us to verify that the main result, the income gradient in the effect on overall disposable income, is based on a set of plausible estimates of the absolute effect for a range of income components. However, it comes at the cost of stronger identifying assumptions, as discussed above. The results are reported in the eight panels of Figure 5, each with the same scale on the *y*-axis to make magnitudes directly comparable.

The first results indicate that softer monetary policy tends to increase disposable income by raising salary income (Figure 5, Panel A). The gain is largest for households at the 25th percentile of the income distribution, where a 1 percentage point decrease in the policy rate increases salary income by almost 1% of disposable income, smaller above the median income level where the estimated effect drops to around 0.5% of disposable income, and close to zero at the bottom. Conceptually, the estimates may reflect quantity effects or price effects: Salary income may go up because employees work more hours or because the hourly wage rate goes up. In Figure IA.6, we show that a similar hump-shaped relation between the effects of monetary policy and the income level emerges when we use weeks of employment as the outcome, suggesting

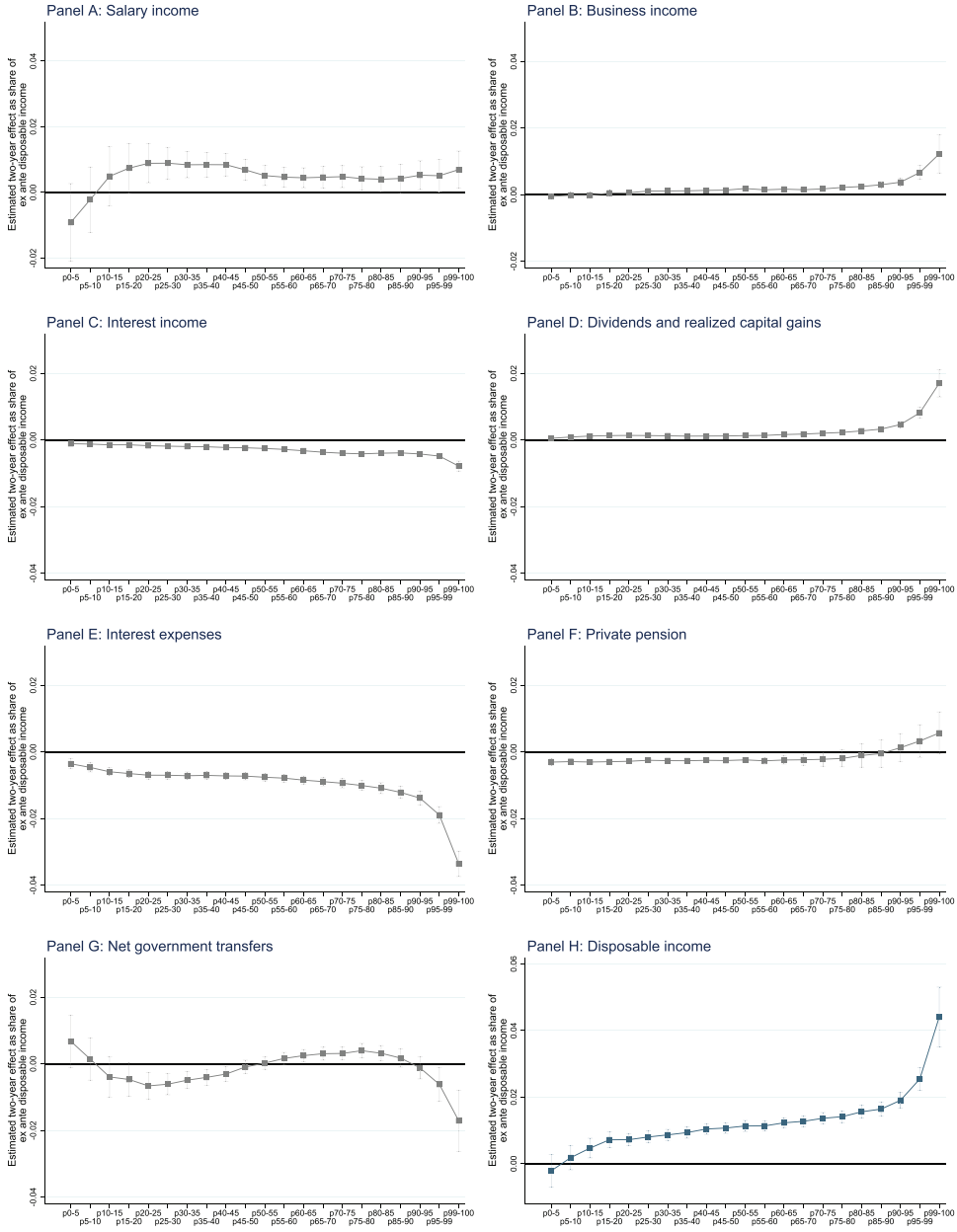

Figure 5. Heterogeneous effects on disposable income by component. The figure shows the estimated two-year effect of a 1 percentage point decrease in the monetary policy rate on the components of disposable income (Panels A to G) and on overall disposable income (Panel H) at different positions in the income distribution. (Color figure can be viewed at wileyonlinelibrary.com)

that quantity effects contribute at least in part to the income gradient in salary income. Overall, these results are consistent with the view that the gains created by monetary policy through the labor channel are concentrated among relatively low-income workers. However, the results also highlight that the most disadvantaged groups, who have very low employment rates through the business cycle, do not appear to reap any gains through the labor channel.

Moreover, softer monetary policy increases disposable income by raising income earned by self-employed through their own businesses (Figure 5, Panel B). While this effect is positive at all positions in the income distribution, it increases monotonically with the baseline level of income: A one percentage point decrease in the policy rate increases business income by 0.1% to 0.2% of disposable income in the middle of the income distribution and by more than 1% of disposable income at the top. This pattern is driven at least in part by the fact that the propensity to be self-employed is increasing in income, as shown in Table I. However, the strong nonlinearity in the estimated effects also suggests that self-employed at different positions in the income distribution may be differentially exposed to monetary policy.

The next set of results show that monetary policy has opposing effects on interest income (Figure 5, Panel C) and stock market income in the form of dividends and realized capital gains (Figure 5, Panel D). A decrease in the policy rate generally lowers interest income, suggesting pass-through to interest rates on bank deposits and bonds,[19] but at the same time raises stock market income, which is consistent with a stimulating effect of monetary policy on corporate profits and stock prices. Both effects increase monotonically in the baseline level of income: Households with higher incomes lose more interest income but also gain more stock market income when the policy rate is lowered. However, the net impact varies with the position in the income distribution. At high income levels, the gain in stock market income dominates the loss of interest income and, for the top income group, the net effect of a 1 percentage point decrease in the policy rate is an increase in overall financial income of around 1% of disposable income. At lower income levels, the net impact on financial income is negative.

Further, a decrease in the policy rate generally increases disposable income by lowering interest payments (Figure 5, Panel E), suggesting pass-through to interest rates on bank loans.[20] There is a pronounced income gradient in these gains as households with higher incomes tend to experience a larger drop in interest expenses when the policy rate is reduced. Specifically, a 1 percentage point decrease in the policy rate reduces interest expenses by more than 3% of disposable income in the top income group compared to less than 1% around

[19] In the middle of the income distribution, with an estimated effect of around −0.25% of disposable income and deposits of around 60% of disposable income, the estimates suggest a pass-through rate of around 0.4.

[20] In the middle of the income distribution, with an estimated effect of around 0.75% of disposable income and debt amounting to 230% of disposable income, the estimates suggest a pass-through rate of around 0.35.

the middle and less than 0.5% at the bottom. The income gradient in the estimates is consistent with the increasing ratio of debt to disposable income documented in Table I.[21]

While private pension payments are largely unaffected by monetary policy (Figure 5, Panel F), we find sizeable and nonmonotonic effects on government transfers and taxes (Figure 5, Panel G). The income gains created by a softening of monetary policy are generally subject to taxation and affect the eligibility to social transfers, but the estimates may, in principle, also reflect that the government attempts to offset the effects of monetary policy shocks on aggregate economic activity with changes in fiscal policy. Consistent with the former channel, we find the most negative effect on net government transfers for the top income group where the overall income gain is largest and around the 25th percentile where the large employment gains reduce net government transfers through both higher tax payments and lower unemployment benefits.[22] In other parts of the income distribution, the effects on net transfers are smaller. In Figure IA.7, we show formally that the differential effect of monetary policy on *market disposable income*, which is measured before government transfers and payments, exhibits an even steeper income gradient between high and low incomes than the baseline results, suggesting that the fiscal system actually attenuates the distributional effects of monetary policy.

Lastly, we report the effect on overall disposable income that emerges from the model without time fixed effects (Figure 5, Panel H).[23] The income gradient is the same as in Figure 3, but the estimates now reflect the absolute effects of monetary policy rather than differential effects. The results imply that a 1 percentage point decrease in the policy rate increases disposable income by around 1% in the middle of the income distribution, which compares to more than 4% for the top income group and almost precisely zero for the lowest incomes.

A.3. Decomposition

Our analysis shows that the effects of monetary policy are highly heterogeneous. A question that then arises is whether this is mainly due to the systematic differences in income composition and balance sheets highlighted in

[21] One may wonder how the reduction in households' interest expenses can be larger than the reduction in their interest income at all income levels. This is because only a small fraction of outstanding mortgage bonds, the majority of total lending, is held by households, whereas the vast majority is held by banks, insurance companies, pension funds, and foreign investors (see Table IA.I in the Internet Appendix). The indirect effect on households of a reduction in the interest income of financial intermediaries is captured in the analysis of households' stock market income (Figure 5, Panel D) and stock portfolio values (Figure 9, Panel B).

[22] The combined marginal tax rate on labor income is particularly high for the unemployed who transition into low-wage employment, as they lose generous unemployment benefits and pay high marginal taxes on the modest income gain.

[23] As shown in Figure IA.8, the income gradients in the components of disposable income add up to the income gradient in disposable income almost perfectly.

Table I or to monetary policy creating different incentives and inducing different behavioral responses across the income distribution. A couple of examples serve to illustrate the distinction. First, the gradient in the effect of monetary policy on interest expenses may simply reflect the fact that high-income households have more debt relative to their disposable income but also that they more often take advantage of opportunities to refinance mortgage loans when interest rates change (Andersen et al. (2020)). Second, the large effect of monetary policy on salary income for low-income households may be because salaries make up a large share of their overall disposable income, so that they benefit more from a proportional increase in wage rates or hours, or because they work in occupations or industries more sensitive to monetary policy. Third, the large effect of monetary policy on stock market income (i.e., the sum of dividends and realized gains) for high-income households may merely reflect the fact that they hold more stocks relative to their disposable income, but also that they hold stocks with different dividend policies and risk characteristics (Fagereng et al. (2020)) and exhibit different propensities to realize capital gains over the business cycle (Hoopes et al. (2016)).

We make a simple decomposition of the differential effects of monetary policy into the part that can be explained by systematic differences in income structure and balance sheets and the part that is unexplained by such differences and therefore reflects heterogeneous effects of monetary policy on incentives and behavior. The decomposition is obtained in the following way. For each income component, we isolate the distributional effects of monetary policy explained by compositional differences by scaling the effect estimated at the median at each position in the income distribution. For instance, debt in the top income group is 40% higher than debt at the median (relative to disposable income), and the balance sheet structure therefore predicts that the effect on interest expenses in the top income group is 40% higher than the effect estimated at the median. We use balance sheets to decompose the effect on capital income (stock market income, interest income, interest expenses) and the income structure to decompose the effect on noncapital income (salary income, business income, private pension, net government transfers). Summing these predictions across all income components, we obtain an estimate of what can be explained by compositional differences and, by subtracting this from the total effect on disposable income, an estimate of what is unexplained.

The results are mixed, as shown in Figure 6. On the one hand, they suggest that most of the large effect of monetary policy at the top can be explained by the particular income structure and balance sheets of high-income households. On the other hand, they suggest that the gradient elsewhere in the distribution, notably at the bottom reflects such factors to a much lesser extent. To provide further understanding of these patterns, we show the decomposition separately for each income component in Figure IA.9. For some income components, the income gradient in the estimates mirrors the income structure and balance sheets almost perfectly, for instance, interest income, stock market income, and business income. For other income components, there is a substantial unexplained part. For instance, the income gradient in

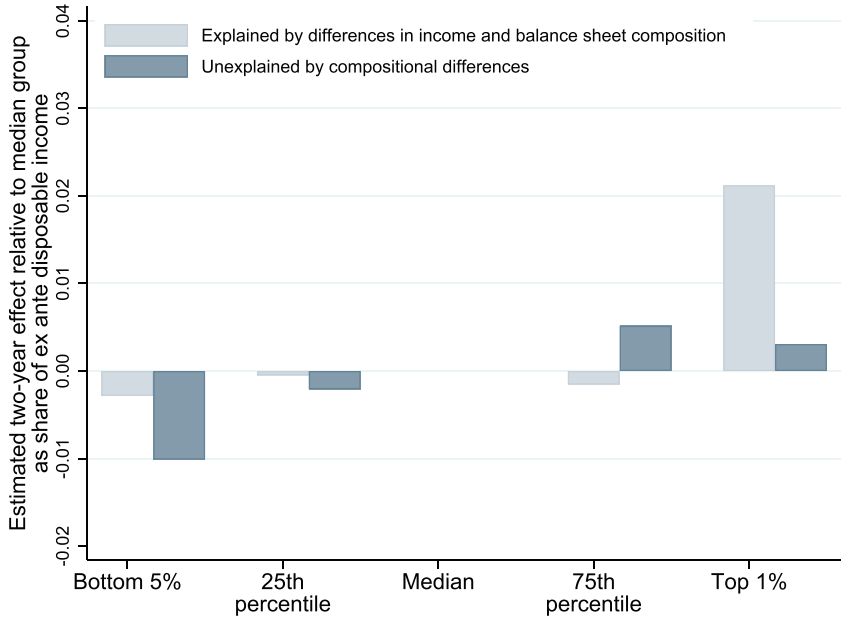

Figure 6. The role of income and balance sheet composition. The figure shows the estimated two-year effect on disposable income of a 1 percentage point decrease in the monetary policy rate at selected positions in the income distribution decomposed into a part that is explained by differences in the composition of income and balance sheets (light blue bars) and a part that is unexplained by compositional differences (dark blue bars). The estimates are relative to the median group (p45–50). (Color figure can be viewed at wileyonlinelibrary.com)

the effect on interest expenses is not fully explained by the income gradient in leverage, suggesting an important role for differences in loan characteristics and refinancing behavior. Moreover, the unexplained part of the effect on salary income is strongly negative at the bottom of the income distribution but strongly positive for incomes around the 25th percentile, suggesting that the employment gains are very small for the former group and large for the latter.

B. Asset Values

B.1. Income Gradient

Figure 7 shows the differential effects of a 1 percentage point reduction in the policy rate on asset values over a two-year horizon, measured relative to ex ante disposable income. The estimates capture the "price effects" of monetary policy, the effects on asset values that work through changes in house prices, and stock prices holding ex ante portfolios constant, but not the effect, that work through changes in the portfolios. The results exhibit a clear income gradient: The gains created by a softer monetary policy in the form of higher asset values increase in household income. Relative to the middle of the

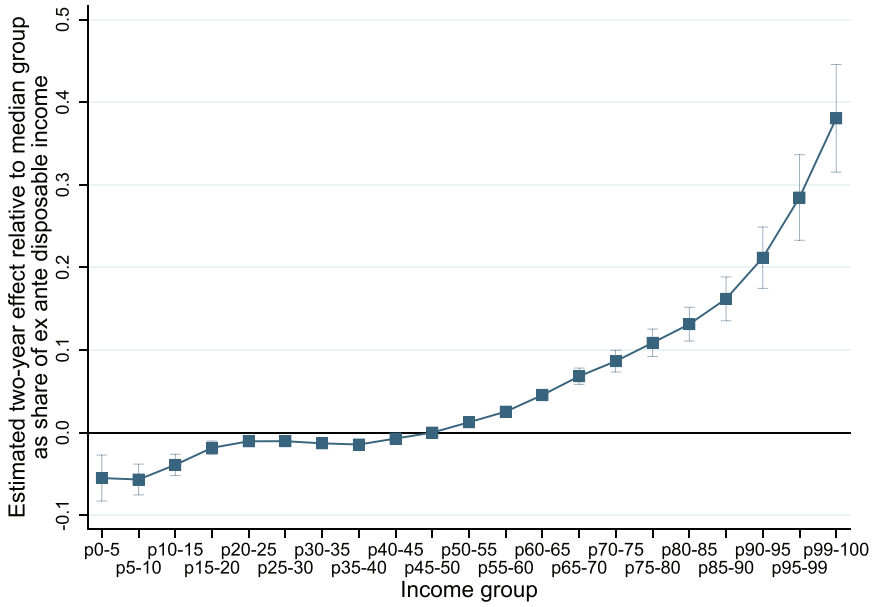

Figure 7. Differential effects of monetary policy on asset values. The figure shows the estimated differential "price effect" of a 1 percentage point decrease in the policy rate on the combined value of housing assets and stock portfolios at different positions in the income distribution over a two-year horizon. The estimates are relative to the median group (p45–50). (Color figure can be viewed at wileyonlinelibrary.com)

income distribution, the effect is around 40 percentage points larger for the top 1% and around 5 percentage points smaller for the lowest income levels.

Figure 8 illustrates how these estimates vary with the time horizon at select positions in the income distribution. The income gradient is already discernible when the effects are estimated over a one-year horizon and gradually becomes more pronounced when the horizon is extended to longer horizons. The results are consistent with a lagged effect of monetary policy on asset prices also identified in previous studies. For instance, Coibion et al. (2017) find that the effect of monetary policy on housing prices continues to increase over a horizon of four years.

B.2. Channels

We explore the channels underlying the estimated effect on overall asset values by showing the contributions from housing assets and stocks. As in the case of disposable income, we use the model *without* fixed effects to quantify the channels so that the estimates can be interpreted in absolute rather than differential terms.

The first results indicate that softer monetary policy generally increases the value of housing assets at all income levels (Figure 9, Panel A). The magnitude

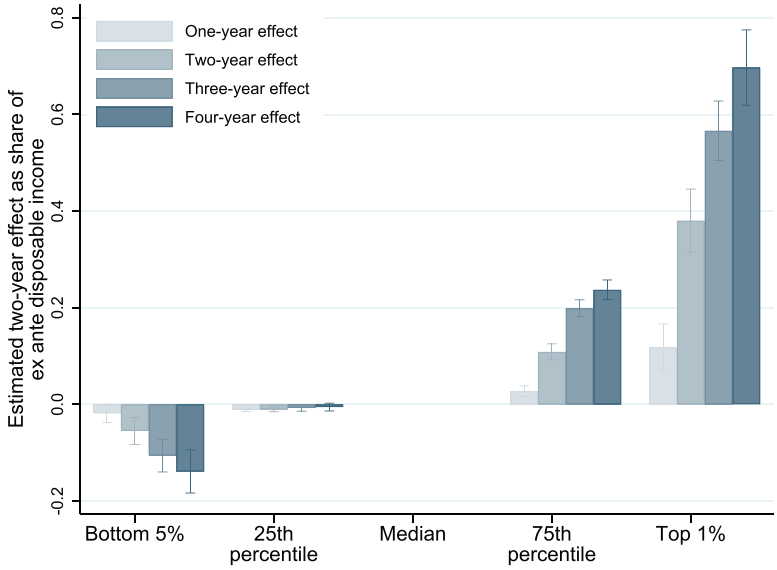

Figure 8. Differential effects on asset values by time horizon. The figure shows the estimated differential "price effect" of a 1 percentage point decrease in the monetary policy rate on the combined value of housing assets and stock portfolios at selected positions in the income distribution over a one-, two-, three-, and four-year horizon. The estimates are relative to the median group (p45–50). (Color figure can be viewed at wileyonlinelibrary.com)

of the effect increases roughly monotonically in income: A 1 percentage point decrease in the policy rate creates a gain through this channel of around 15% of disposable income at the bottom of the income distribution and around 40% of disposable income at the top. Given the ratios of housing assets to disposable income, these estimates are equivalent to an increase in the value of housing assets of around 4% at the bottom of the income distribution and almost 7% at the top.[24] Thus, the income gradient reflects both that high-income households own more housing assets relative to their disposable income and that housing prices exhibit differential sensitivity to interest rates over the income distribution. In a robustness test reported in Figure IA.10, we show that using the raw changes in the appraisal values of property rather than the imputed changes in market values gives similar results, although with a steeper slope at the very top of the income distribution.

The next results show that a lower monetary policy generally increases the value of household portfolios of stocks, but that these gains are highly concentrated at the top of the income distribution (Figure 9, Panel B). The estimated gain created by a 1 percentage point decrease in the policy rate is around 15% of disposable income in the top income group and entirely negligible below the median income level. As we use the same index return to impute stock market

[24] This is similar to the estimates of the elasticity of house prices with respect to the monetary policy rate of around 8%–9% often cited in the literature (e.g., Taylor (2007)).

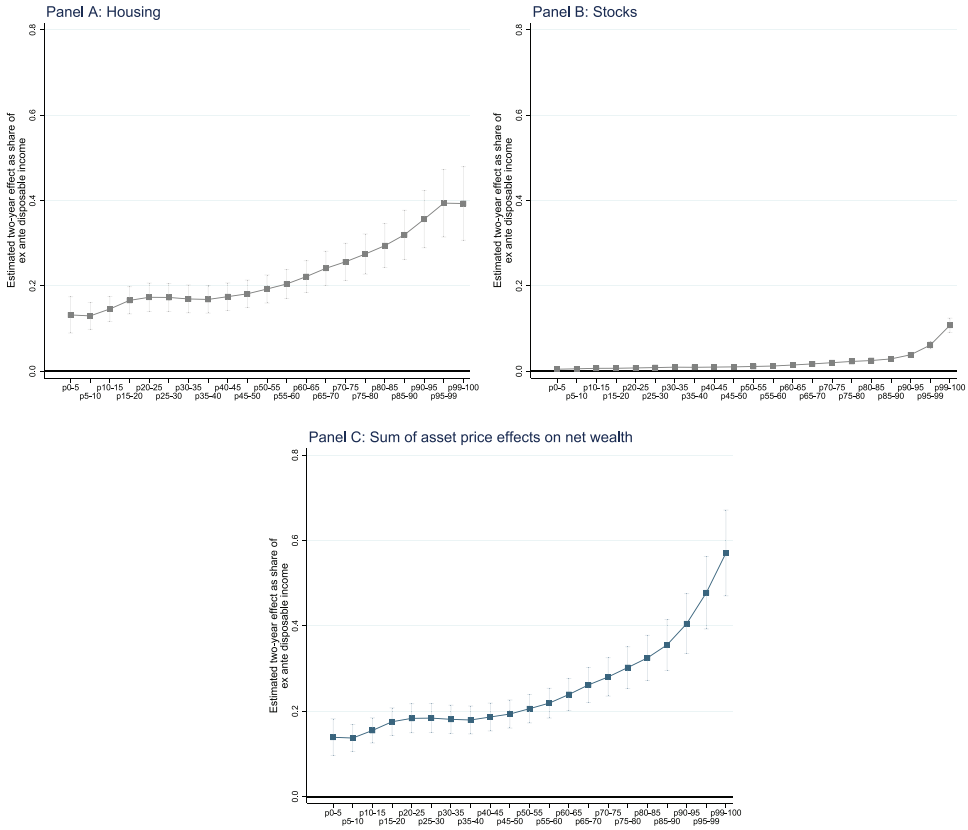

Figure 9. Heterogeneous effects on asset values by asset categories. The figure shows the estimated two-year "price effect" of a 1 percentage point decrease in the monetary policy rate on the value of housing assets and stock portfolios (Panels A and B, respectively) and the combined value of these asset categories (Panel C) at different positions in the income distribution. (Color figure can be viewed at wileyonlinelibrary.com)

gains for all income groups, the income gradient in these estimates reflects the overwhelming concentration of stock ownership in the highest income groups. Given the value of stock portfolios relative to disposable income, the estimate for the top income group is equivalent to an increase in the value of stocks of around 6%.[25]

The final results show the effect on total asset values delivered by the model without time fixed effects (Figure 9, Panel C).[26] While the income gradient is the same as in Figure 7, these estimates now capture the absolute rather than the differential effects of monetary policy. The estimated effects are positive

[25] This is close to the widely cited estimate of the elasticity of stock prices with respect to the monetary policy rate of 6.8% (Rigobon and Sack (2004)).

[26] As shown in Figure IA.11, the income gradients in the components of total asset values add up to the income gradient in total asset values almost perfectly.

at all income levels as softer monetary policy boosts asset prices. Specifically, the estimates suggest that a 1 percentage point decrease in the policy rate increases asset values by around 15% of disposable income at the bottom of the income distribution and by around 60% of disposable income at the top. This suggests that the gains in the form of higher asset values are substantially larger than the gains in the form of higher disposable income. Given the ratio of asset values to disposable income (Table I), the estimated effects are equivalent to an increase in asset values of around 4% at the bottom and around 6% at the top. Thus, the income gradient in the figure indicates that high-income households have more assets relative to their disposable income and that the prices of the assets they hold are more sensitive to monetary policy.

Our analysis of asset values is incomplete in the sense that there are balance sheet components that it does not cover. First, monetary policy may create gains and losses on mortgage debt. In Denmark, mortgage bonds are traded on a public market and mortgage borrowers can repay their loans at market value at any point in time. A softening of monetary policy increases the price of existing bonds, which means that the market value of outstanding debt increases and borrowers incur a capital loss. Unfortunately, the size of these losses depends on loan characteristics and borrower behavior that are unobservable in the data (e.g., variable versus fixed rate, time to maturity, refinancing choices) and thus we are unable to include this channel in the analysis. Second, monetary policy creates gains and losses on assets held in tax-favored pension accounts. These assets have grown significantly over the sample period, from near zero in the early 1990s to a level of around 300% of GDP (Greenwood and Vissing-Jørgensen (2018)). Unfortunately, as microdata on pension accounts exists only from 2014, we are unable to include these assets in the analysis. However, based on data for 2014 showing that pension assets increase with income in roughly the same way as nonpension assets except at the very top of the income distribution (Figure IA.12), we conjecture that including pension assets in the analysis may accentuate rather than attenuate the income gradient in the effects of monetary policy on assets values.[27]

C. Robustness, Inference, and External Validity

We conduct a range of additional tests to assess the robustness of our main results, revisit the statistical inference under alternative sets of assumptions, and explore the external validity of the findings. We report the results in Figures IA.13 to IA.18.

First, we add controls for Danish macroeconomic conditions and the global financial cycle and we address confounders in the form of serially correlated

[27] In a recent paper, Catherine, Miller, and Sarin (2020) argue that future social security benefits should be considered an asset for the purposes of studying wealth inequality. In this vein, one could study how monetary policy affects asset values at different positions in the income distribution through its effect on the net present value of future public pensions. We do not pursue this type of analysis in this paper.

monetary policy shocks and nonconventional monetary policy. Specifically, we augment the set of macro controls with GDP growth and inflation in Denmark in periods t and $t-1$ (red line), to control for a possibly differential importance of local economic conditions on households in different income groups, and with the change in the U.S. VIX index in period t (blue line) to control for global financial shocks (Rey (2013)). We also add policy rate changes in period $t+1$ (green line) to account for possible serial correlation in the monetary policy interventions that would bias our estimates of monetary policy in period t. Each of these new controls is interacted with a full vector of income group indicators. Further, we adopt an alternative measure of euro/German monetary policy, namely, the change in the shadow rate, which accounts for the zero lower bound (brown line). The shadow rate is not bounded at zero and captures the effect of both conventional and unconventional monetary policy measures (Wu and Xia (2016)). As shown in Figure IA.13, these changes to the model have little effect on the estimates.

Second, we sequentially add a number of ex post controls (i.e., changes from period $t-1$ to period $t+h$) that absorb the direct effect of monetary policy in Frankfurt on economic outcomes in Denmark through channels other than the Danish policy rate. Specifically, we add (i) the ex post change in exports from Denmark (red line) to control for the effect on external demand for Danish goods and services and, analogously, the ex post change in imports to Denmark (green line), (ii) the ex post change in foreign liabilities (brown line) to control for the effect on external demand for Danish assets and, analogously, ex post foreign assets (blue line), and (iii) the ex post stock price returns in Germany/euro area (orange line), and ex post GDP growth and inflation in Germany/euro area (gray line) to control for any other spillover effects of foreign business cycles. Again, all of the additional controls are interacted with a full vector of income group indicators. As shown in Figure IA.14, the results are robust to these additional controls. In the most saturated model that adds controls for ex ante GDP growth and inflation in Denmark, ex post changes in trade and foreign assets and liabilities, and ex post stock market returns, GDP growth, and inflation in Germany/euro area, decreasing the policy rate by 1 percentage point leads to a differential gain in disposable income for the top income group of 4.3 percentage points (compared to 3.3 percentage points in the baseline model) and a differential increase in asset values of 20% of disposable income (compared to 38% in the baseline model).

Third, we employ two alternative approaches to identifying German/euro area monetary policy shocks, drawing on the work by Romer and Romer (2004) and Jarocinski and Karadi (2020). The former approach estimates shocks at the frequency of the monetary policy meetings at the ECB, controlling for the information set available to members of the Governing Council. The latter approach identifies monetary policy shocks from high-frequency movements in interest rates and stock prices around the time of monetary policy announcements by the ECB. In both cases, we collapse the estimated monetary shocks to the annual frequency and use the resulting annual series to instrument for changes in the Danish monetary policy rate. More details on the construction

of the alternative series of monetary policy shocks are available in Section IV of the Internet Appendix. As shown in Figure IA.15, the results are similar when we use these alternative approaches to identification. Specifically, the differential effects on disposable income are slightly larger than the baseline results under either of the two alternative approaches whereas the differential effects on asset values are somewhat larger than the baseline results under the Romer-Romer approach and somewhat smaller under the Jarocinski-Karadi approach.

Fourth, we estimate a version of the baseline model augmented with household fixed effects. Given that our outcomes are *changes* in income or asset values, household fixed effects effectively allow for a household-specific linear trend in the level of the outcome, which absorbs a significant amount of variation. As shown in Figure IA.16, the results are qualitatively robust to this demanding extension of the model. The gradient in the income gains is steeper than in the baseline, with estimated income gains to the top 1% exceeding gains to the median income group by more than 5 percentage points, whereas the gradient in the gains of asset values is moderately flatter than in the baseline model.

Fifth, we probe the sensitivity of the standard errors to assumptions about the correlation structure in the error term and present the results in Figure IA.17. Specifically, we display the baseline results with four different confidence intervals based on clustering at the level of (i) households, (ii) households and year-municipality, (iii) households and year-municipality-income group, and (iv) households and municipality-income group. While clustering at the level of households corrects standard errors for autocorrelation in the error term (Bertrand, Duflo, and Mullainathan (2004)), we add a second dimension of clustering to reflect the fact that the monetary policy stance varies over time and local economic conditions and that the variation in the main explanatory variable is at the level of income groups and time (Moulton (1986), Abadie et al. (2017)). We also report confidence intervals based on the Driscoll-Kraay standard errors, which are robust to very general forms of cross-sectional and temporal correlation (Driscoll and Kraay (1998)) and are employed by some of the most closely related papers (e.g., Coibion et al. (2017)). The income gradient continues to be statistically significant in all cases.

Finally, we investigate whether the baseline results are driven by particularities in the balance sheets of Danish households. In particular, we ask how the results might have looked like if Danish households were similar to households in other economies in terms of their exposure to debt markets. We address this question by reestimating our baseline model while weighting the observations so that our Danish sample effectively matches households in the United States and the euro area, within each income group and each year, in terms of the share participating in the debt market and the median debt-income ratio for those with positive debt. More details on the weighting approach are available in Section V of the Internet Appendix. As shown in Figure IA.18, the results from the reweighted sample are very similar to the baseline, suggesting that the relatively high levels of debt in Denmark are not a major driver of the

estimated *differential* effects of monetary policy, thus strengthening the case for the external validity of our results.[28]

IV. Additional results

A. Net Wealth and Consumption

We now turn to the effect of monetary policy on wealth accumulation and consumption. This relates directly to our main analysis because the gains created by a softening of monetary policy, whether in the form of disposable income or increased asset values, are necessarily either consumed or added to the wealth stock due to the intertemporal budget constraint. However, monetary policy also affects wealth accumulation and consumption through other channels. Most importantly, by changing market interest rates, it affects the overall fraction of income saved for future consumption through intertemporal substitution. Moreover, it may induce households to restructure their balance sheets, with possible implications for wealth accumulation, for instance, by increasing leverage or changing the share of risky assets.

Figure 10, Panel A, shows the differential effects of a 1 percentage point reduction in the monetary policy rate on wealth accumulation over a two-year horizon, measured relative to ex ante disposable income. There is a clear income gradient in the estimates: the wealth gains created by softer monetary policy are systematically larger at higher income levels. Relative to the middle of the income distribution, the effect on net wealth is around 40 percentage points larger at the top and around 5 percentage points smaller at the bottom. These estimates are strikingly similar to the estimated "price effects" on asset values (Figure 9). The similarity is consistent with existing evidence that only a small fraction of the gains and losses created by asset price changes are channelled into consumption in the short term (Aladangady (2017), Di Maggio, Kermani, and Majlesi (2020), Andersen, Johannesen, and Sheridan (2021)). It is also consistent with an important role for "saving by holding" (Fagereng et al. (2019)) whereby capital gains on, for instance, homes are transformed into consumption only to a limited extent through a reduction in liquid assets or new mortgage loans (Andersen and Leth-Petersen (2019)).

Figure 10, Panel B, shows the analogous estimates for new car purchases. Cars are arguably the most important durable consumption good and many empirical papers use changes in car consumption to approximate changes in total durable consumption (e.g., Di Maggio et al. (2017)). The results indicate that the effect of monetary policy on car consumption tends to increase with household income, at least through the upper half of the income distribution.

[28] Variable rate loans have coexisted with fixed rate loans on the mortgage loan market in Denmark since they were introduced in 1998. It would be useful to distinguish between loans with fixed and variable rates in the empirical analysis, but we do not observe loan characteristics in the data. Andersen et al. (2020) argue that the Danish mortgage system is similar to the U.S. system in that long-term fixed-rate mortgages are common and can be refinanced without penalties, but differs in that Danish households are free to refinance at any time.

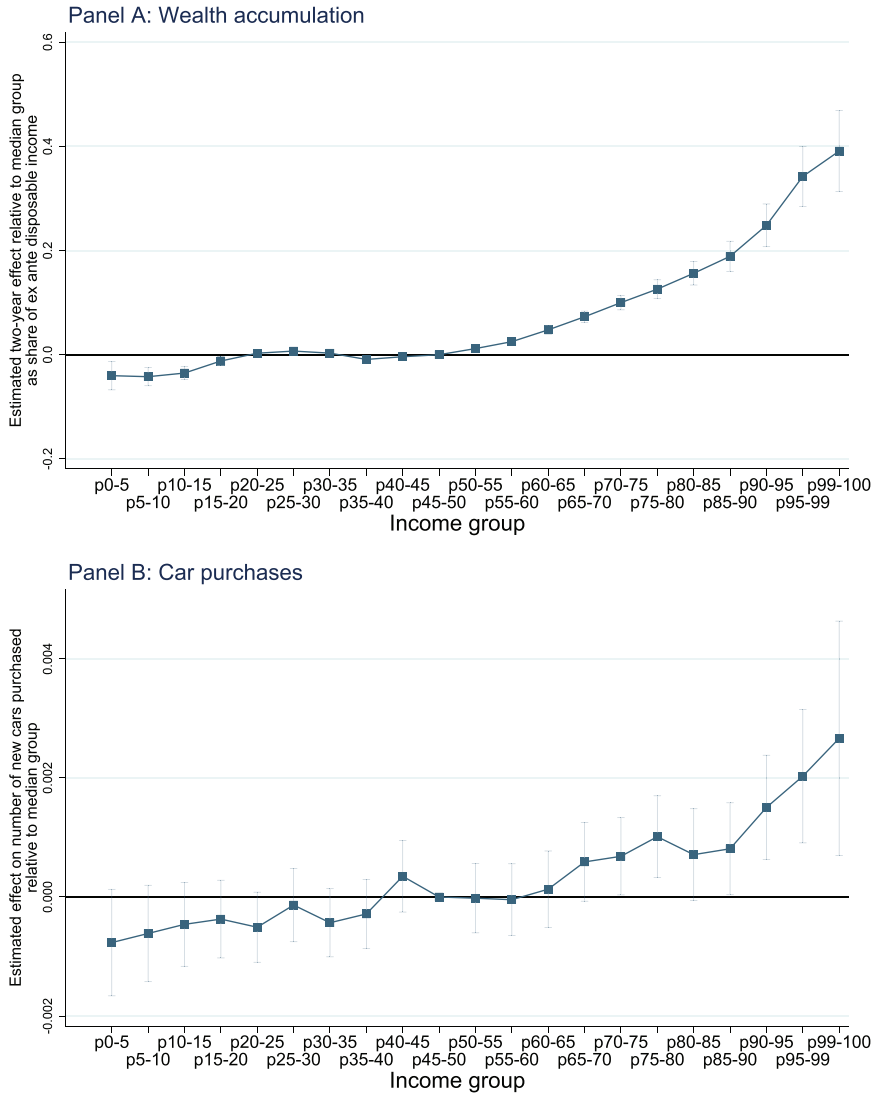

Figure 10. Implications for wealth accumulation and consumption. The figure shows the estimated differential effect of a 1 percentage point decrease in the policy rate on the change in net wealth (Panel A) and the number of newly registered cars (Panel B) at different positions in the income distribution over a two-year horizon. The estimates are relative to the median group (p45–50). (Color figure can be viewed at wileyonlinelibrary.com)

Relative to the median income level, the effect of a 1 percentage point reduction in the monetary policy rate is larger in the top income group by around 0.002 cars (equivalent to around 3% of the baseline new car purchases in this group). This result suggests that the differential income gains and capital gains created by a softening of monetary policy are also associated with a differential

increase in consumption for high-income households. However, we cannot be sure that this conclusion is robust to using a broader measure of consumption, as cars may account for a larger share of marginal consumption at higher income levels.

B. Leverage

We next investigate the role of household leverage in shaping the distributional effects of monetary policy. While the baseline model includes interactions between the policy rate variable and indicators of ex ante income, here we interact each of these terms with indicators of ex ante leverage.[29] Specifically, we define leverage as the ratio of debt to gross income and consider four groups defined with reference to the within-year sample distribution of this ratio: households with no debt, low debt ($<20^{\text{th}}$ percentile), medium debt (20^{th}–80^{th} percentile), and high debt ($>80^{\text{th}}$ percentile). We use the version of the model without time fixed effects, which produces estimates in absolute rather than differential terms and therefore allows us to make quantitative comparisons across income groups, leverage groups, and outcomes.

We start by considering how leverage mediates the effect of monetary policy on interest expenses. Specifically, Figure 11, Panel A, shows the estimated gain in the form of lower interest expenses associated with a decrease in the policy rate at different positions in the income distribution and for each leverage group separately. Comparing within income groups, the gains increase monotonically in leverage. Comparing within leverage groups, the gains are roughly the same size across households with different income levels. The main exception is that gains are larger for the top income group than for households with comparable leverage in other income groups.[30]

As shown in Figure 11, Panel B, the striking monotonicity in leverage remains when we consider the effect of softer monetary policy on overall disposable income: At each position in the income distribution, the increase in disposable income following a decrease in the policy rate is larger for households with more leverage. Only in the top income group do households with no debt appear to gain more from a softer monetary policy than households with moderate leverage, suggesting that they have large gains through channels other than lower interest expenses. As before, comparing households with

[29] We also include a full set of three-way interactions between macro controls, income group indicators, and leverage indicators.

[30] Pass-through may be stronger for high-income households to the extent that they more frequently have mortgage loans with a variable rate or have a higher propensity to exploit opportunities to refinance mortgage loans with a fixed rate. Alternatively, it may be the case that households in the top income group have higher leverage than the other groups within each leverage group and that leverage itself responds more strongly to the interest rate in the top income group. The gains estimated for households with no debt likely reflect the extensive margin of borrowing: households with no ex ante leverage take on debt and thus start incurring interest expenses when the policy rate is raised (for instance, because they buy a house in response to falling house prices induced by the tighter monetary policy).

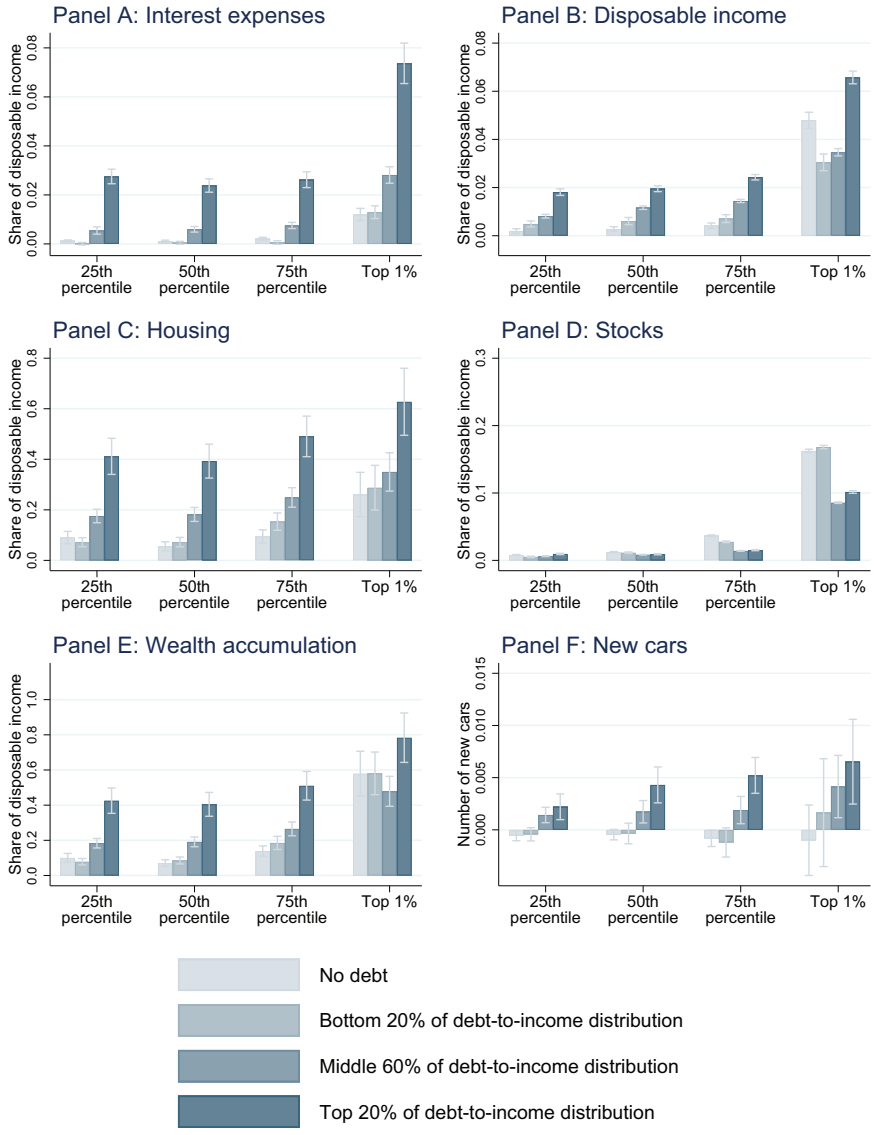

Figure 11. The mediating role of leverage. The figure shows the estimated two-year gain created by a 1 percentage point decrease in the monetary policy rate through lower interest expenses (Panel A), higher overall disposable income (Panel B), appreciation in housing assets (Panel C), appreciation in stock portfolios (Panel D), change in net wealth (Panel E), and number of newly registered cars (Panel F) at select positions in the income distribution and for households with different ratios of debt to income. To derive the results, we split the sample into four groups based on their ratio of debt to income (DTI) and interact the explanatory variables in the baseline model with indicators for belonging to one of the four groups in the ex ante period. The four income groups correspond to households between the 20^{th} and 25^{th} percentiles ("25^{th} percentile"), between the 45^{th} and 50^{th} percentiles ("50^{th} percentile"), between the 70^{th} and 75^{th} percentiles ("75^{th} percentile"), and above the 99^{th} percentile ("top one percent"). (Color figure can be viewed at wileyonlinelibrary.com)

roughly the same leverage, the increase in disposable income is roughly similar across income levels, suggesting that differences in leverage account for a significant part of the income gradient in the effect of monetary policy on disposable income. The only exception to this pattern is the top 1%, where gains are considerably larger than elsewhere in the income distribution at all levels of leverage, suggesting larger gains through nondebt channels.

Next, we study how the effect of monetary policy on wealth through asset prices varies with leverage. Specifically, in Figure 11, Panels C and D show the "price effect" on the value of housing assets and stock portfolios for households with different income and leverage. The patterns for the two asset classes are strikingly different. On the one hand, leverage can account for most of the income gradient in the effect on housing assets: When comparing households with the same leverage, the gain is similar across income levels. This reflects the fact that most real estate is financed in part with debt, so that highly levered households have more housing assets and therefore benefit more from increases in housing prices. This mechanism applies to a lesser extent to the top income group, where owning significant housing assets without debt is more prevalent. On the other hand, leverage accounts for almost none of the income gradient in the effect on stock values: When comparing households with the same leverage, the income gradient remains highly pronounced. Moreover, when comparing households in the same income group, the effect is generally stronger for households with less debt. These patterns reflect the fact that leverage and stock holdings tend to be negatively correlated, both in the full sample and within income groups.

Finally, we consider how leverage mediates the effect of monetary policy on wealth accumulation and car consumption. Figure 11, Panel E, shows that the effect on wealth accumulation is roughly similar to the combined "price effects" on housing and stocks for all income and leverage groups. Figure 11, Panel F, shows that the effect of monetary policy on new car purchases exhibits a striking monotonicity in leverage: The estimated effect is growing in leverage within each income group. This pattern indicates that households with more leverage reap larger gains from a softening of monetary policy in terms of disposable income and housing values (as shown above), but it is also consistent with leveraged households having a higher marginal propensity to consume because they are more financially constrained.

C. Age

While our analysis until now has focused on the differential effects of monetary policy across income groups, this section investigates differential effects along an entirely different dimension: age. Exposure to the various channels of monetary policy varies across age groups due to life cycle patterns in labor market participation, borrowing, and wealth accumulation, as summarized in Table IA.II in the Internet Appendix. Our model remains the same as the baseline except that the change in the policy rate is now interacted with indicators of age rather than with indicators of income. The omitted category is the

youngest age group (below age 35), so the age-specific estimates of the effect of monetary are measured relative to this age group.

Figure 12 illustrates the estimated differential effects on disposable income (Panel A) and asset values (Panel B). There is a hump-shaped relation between the effects on disposable income and age: the effects are larger for the middle-aged (35–65 years) than for the young (below age 35) and the elderly (above age 75). By contrast, the effect on asset values is almost monotonically increasing in age. These relationships indicate that exposure to the various direct and indirect channels of monetary policy change markedly over the life cycle (Table IA.II). Importantly, the middle-aged have most debt relative to disposable income and therefore benefit most from lower interest expenses when the policy rate is lowered, while the elderly have most assets and therefore benefit most from higher prices on stocks and houses.

In sum, the results suggest that the disposable income channel of softer monetary policy is stronger for middle-aged households, whereas the asset price channel is stronger for old households. Younger households have the smallest gains through both channels.

V. Income Inequality

The strong income gradient in the effects of monetary policy suggests that there may be important implications for inequality. In this section, we use our estimates of the heterogeneous effects of monetary policy to conduct a simple simulation exercise that quantifies the effect of a 1 percentage point decrease in the policy rate on one of the most commonly used distributional measures: income shares (e.g., Piketty (2014)).

We first determine the *actual* shares of aggregate disposable income for each of the 21 income groups. We then compute the gain in disposable income for each household over a two-year horizon in a *counterfactual* scenario where the policy rate is lowered by 1 percentage point. To establish the counterfactual, we assume that the effects of a decrease in the policy rate vary across income groups in the way we estimated in our baseline model without time fixed effects (Figure 5, Panel H), accounting for direct as well as indirect channels. Figure 13 plots the percentage difference between the counterfactual shares and the actual shares of aggregate disposable income.

The results show that the effect of monetary policy on income shares is strongly monotonic: A lower policy rate increases the income share for high-income households and decreases it for low-income households. Specifically, lowering the policy rate by 1 percentage point increases the share of aggregate disposable income by around 3% for the top 1% and decreases it by almost 1.5% for the bottom income group.[31] Hence, our results suggest that monetary policy, through a range of direct and indirect channels, makes the distribution of disposable income significantly more unequal.

[31] If the income share of the top 1% is initially 10%, the results suggest that lowering the policy rate by 1 percentage point increases this share to 10.3%.

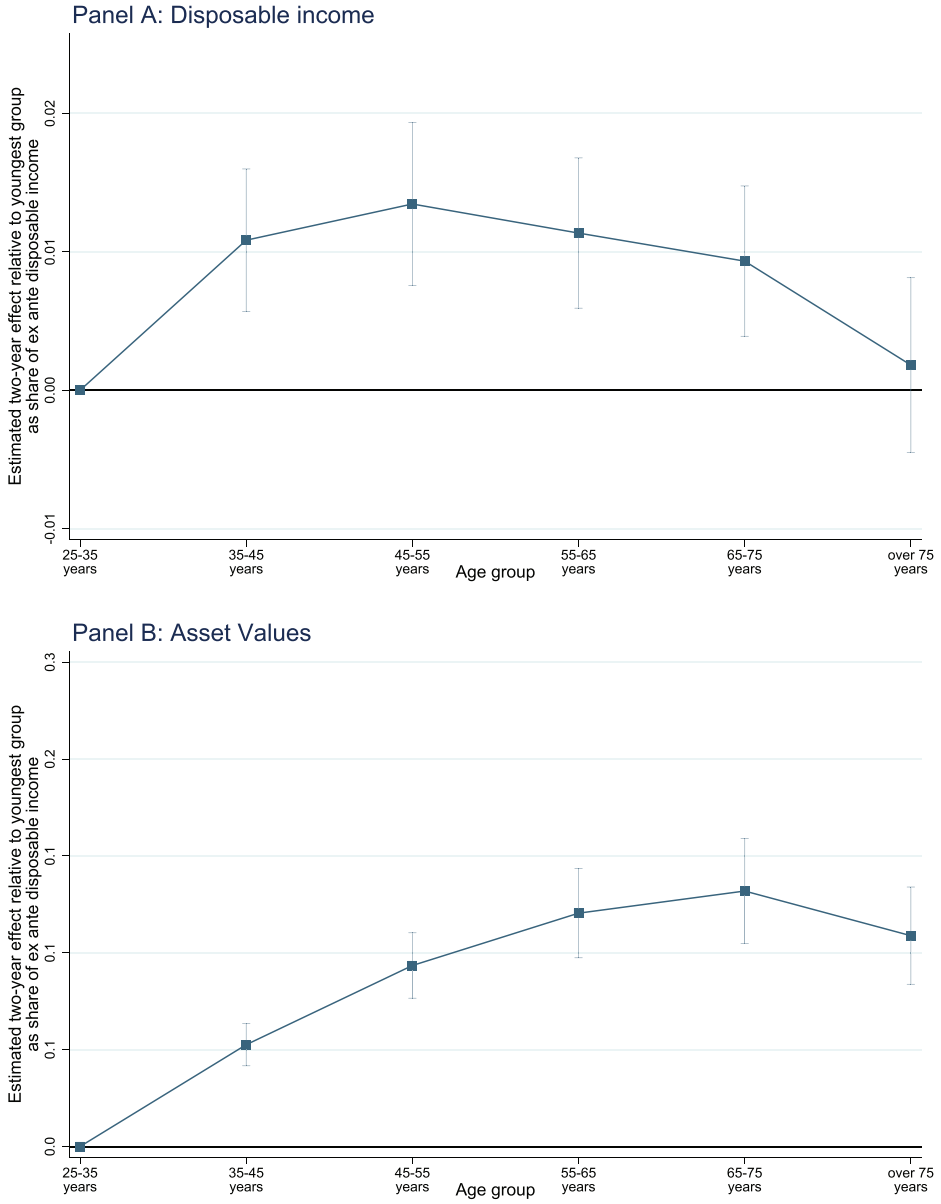

Figure 12. The differential effect of monetary policy by age. The figure shows the estimated differential effect of a 1 percentage point decrease in the policy rate on disposable income (Panel A) and asset values (Panel B) for different age groups over a two-year horizon. The estimates are measured relative to the youngest group (25–35 years). (Color figure can be viewed at wileyonlinelibrary.com)

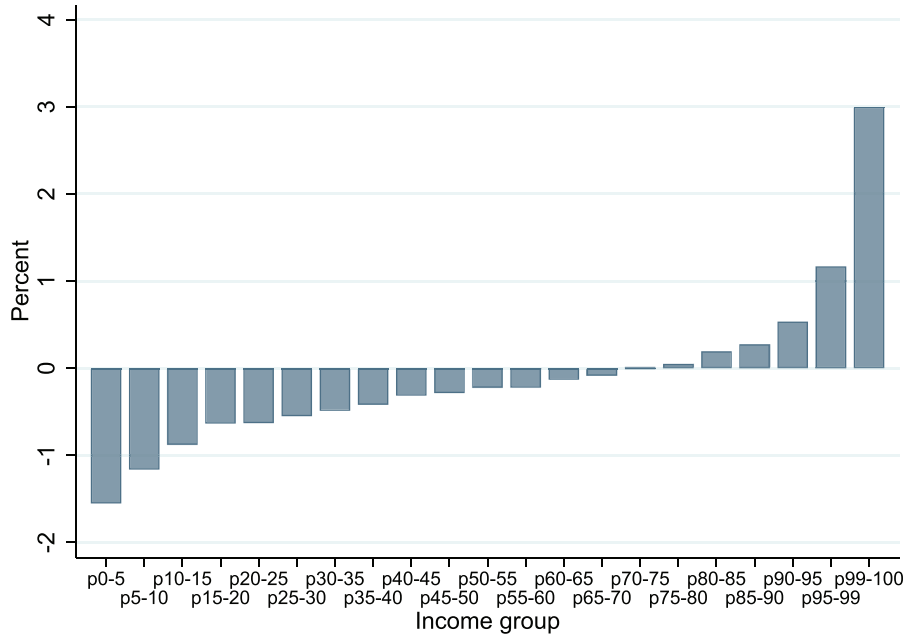

Figure 13. Implications for income inequality. The figure shows the simulated percentage change in each income group's share of total disposable income resulting from a 1 percentage point decrease in the policy rate. Applying the two-year coefficients from Figure 4, the simulation first computes the counterfactual income gain accruing to each household given its position in the income distribution if the policy rate were lowered by 1 percentage point and, then, computes the resulting counterfactual shares of total disposable belonging to each income group. The bars indicate the percentage difference between the actual and counterfactual income shares. (Color figure can be viewed at wileyonlinelibrary.com)

To put these estimates into perspective, we note that the income share of the top 1% in Denmark has increased by around 50% over our sample period, from around 7.5% in 1990 to around 11% in 2013 (World Inequality Database (2020)).[32] Importantly, however, the income concepts are different. Specifically, our estimates concern the distribution of disposable income, whereas most of the literature, including the study cited here, concerns the distribution of market income before government transfers and taxes. Because government transfers and taxes generally mute the income gradient in the effects of monetary policy on income, as shown in Figure 5, Panel G, our simulation results likely understate the effect of monetary policy on inequality in market income. Finally, the simulation does not account for the distribution of the gains created by the wealth channel, shown in Figures 9 and 10.

[32] World Inequality Database, https://wid.world/, accessed April 27, 2020.

VI. Conclusion

In this paper, we study the *distributional effects* of monetary policy across income groups. Our results document a strong income gradient in the gains from expansionary monetary policy: A lower policy rate creates relatively larger gains for households at higher income levels in the form of disposable income, asset values, net wealth, and durable consumption. The distributional effects reflect systematic differences across income groups in the exposure to the direct and indirect channels of monetary policy. The results suggest that monetary policy has a sizeable effect on inequality.

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Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's website:

Appendix S1: Internet Appendix.
Replication Code.