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Monetary Policy and Earnings Inequality: Inflation Dependencies*

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Abstract

This paper studies the distributional effects of monetary policy and its dependence on inflation. We document a novel dependency in the earnings heterogeneity channel of monetary policy using high-frequency, administrative tax data from eurozone member Estonia. Monetary policy shocks substantially influence earnings inequality during high-inflation periods, with weaker effects during low-inflation periods. Extending our dataset with granular MPC estimates, we show that earnings heterogeneity amplifies the aggregate MPC and consumption response. In high-inflation periods, consumption and inequality respond more, even though the aggregate MPC may be lower. We rationalise our findings with a nonlinear tractable HANK model featuring inflation dependencies.

Keywords: Monetary policy, labour income inequality, inflation, state dependency, earnings heterogeneity channel, aggregate MPC

JEL classification: E52, D31, J31, J63

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1 Introduction

The recent inflation surge after the pandemic highlights the importance of studying the distributional consequences of monetary policy in a high-inflation environment. In this paper, we assess the impact of monetary policy on earnings inequality and its dependency on the inflation environment. Our focus is on the earnings heterogeneity channel of monetary policy (see e.g., Auclert 2019), which captures that the distributional implications of monetary policy are unequal with disproportional losses for some workers. We document a novel inflation dependency for this channel. Specifically, we show that the inflation environment alters the impact of monetary policy on earnings inequality using high-frequency administrative data from the euro area member Estonia. Exploiting the near real-time provision of the data, we show that monetary policy shocks have a quantitatively stronger impact on earnings inequality during high inflation levels - as reached from 2021 and 2023.

We then use our estimates to evaluate how the earnings heterogeneity channel of monetary policy affects the aggregate dynamics, in particular, the response of aggregate consumption. We complement our administrative data with household-level marginal propensity to consume (MPC) estimates. We can use this combined dataset to calculate the aggregate MPC for a monetary policy shock and back out the role of the earnings heterogeneity channel based on the approach of Patterson (2023). Our estimate assigns 5% of the impact of monetary policy shock on aggregate consumption to the earnings heterogeneity channel. We also find that the total impact on aggregate consumption and inequality is larger when inflation is high, even though our estimates suggest that the aggregate MPC may be lower in such a high-inflation regime. While this finding may seem contradictory at first glance, we rationalize our findings with a nonlinear tractable Heterogeneous Agent New Keynesian model, in which we incorporate inflation dependencies. The interplay between heterogeneity, nonlinearities, and aggregate dynamics can explain the observed dynamics.

The challenge in assessing inflation dependencies for inequality is the availability of access to granular data with a sufficiently high frequency. While individual-level administrative data features the granularity to assess the potential impact of monetary policy on wage inequality, such data is often only available or used at an annual frequency and is provided with substantial publication lag. However, such a low frequency substantially complicates, if not even prevents, an analysis of the relationship between earnings inequality and monetary policy during both regular and heightened inflation periods. The publication lag additionally excludes the use of this data for recent influential events, such as the inflation surge after the pandemic.

For this reason, we use individual-level administrative tax data from the euro area member Estonia to exploit several key features. The first is that wage and employment data are available for the entire population without top coding at a monthly frequency. Therefore, we can measure the distributional implications of monetary policy shocks at a monthly frequency, allowing us to evaluate short-lived but influential periods such as the recent inflation surge. A second advantage is that the data are available almost in real-time, covering the period from January 2006 until September 2023. This means we can evaluate the earnings distribution during the high-inflation environment starting in 2021. These administrative data can be used to assess state dependencies, which are important for aggregate variables, as shown for instance in Tenreyro and Thwaites (2016). Third, Estonia joined the euro area in 2011 and had a fixed exchange rate against the euro before that. Therefore, we can study the monetary policy shocks of the European Central Bank (ECB). We use a high-frequency approach that captures the changes in interest rates in a tight window around meetings of the Governing Council (Jarociński and Karadi 2020). Finally, we can combine the administrative tax data with survey data on the marginal propensity to consume. This combined dataset disentangles how the distributional impact of monetary policy affects aggregate consumption.

We first document that the effects of monetary policy are U-shaped over the wage distribution. Low labour-income households respond particularly strongly to monetary policy. While the average household's labour income responds less strongly, we document a slight increase in wage income for the top earners (0.1%). Using our granular data, we decompose the overall effect into the intensive margin of wage changes and the extensive margin of labour market entries and exits. The results for the low-income group are driven by the extensive margin, that is, by the entry and exit margin. The intensive margin plays a relatively larger role for households in the middle and at the top of the income distribution. Our high-frequency data also show that annual data overestimates the relative importance of the intensive margin. Our high-frequency data can capture shorter spells of unemployment better and so make a cleaner distinction between the intensive and extensive margins. To sum up, we find that the earnings heterogeneity channel is present in our data.

However, this baseline analysis hides potentially important state dependencies that drive key dynamics. In particular, we want to understand how much the impact on inequality depends on the inflation environment. Our main finding is that inflation dependencies are very present in the distributional impact of monetary policy. While monetary policy shocks have a substantial impact on wage inequality in a high-inflation environment, their effects on labour income along the distribution are much more dampened in a low-inflation environment.

The exposure of the different income groups also depends on the level of inflation. In particular, low-income workers are quantitatively much more affected than workers in the middle or at the top of the income distribution in a high-inflation environment. The extensive margin drives these results due to a substantial increase in exits as well as a reduction in entries for low-income workers in the high-inflation environment. Additionally, the exposure features a weak U-shape as the top 0.1% earners are slightly more affected. When inspecting the low-inflation regime, the effect across the whole income distribution is quantitatively much smaller. However, the relative differences between some income groups are larger then. While low and medium-income individuals are negatively affected, the effect is basically muted for top earners starting from the 90th quantile when inflation is low. Thus, the quantitative differences are much more pronounced in the high-inflation environment, while there are more relative differences in the low-inflation environment. The results are robust to controlling for the inflation threshold that classifies the regimes, alternative monetary policy shocks, geopolitical risk, sign asymmetries for the monetary policy shocks, and the use of nominal wages instead of real wages.

The next step is to evaluate the aggregate implications of the distributional impact of monetary policy - to what extent does the earnings heterogeneity channel of monetary policy amplify aggregate dynamics, and is the amplification state dependent? Specifically, we measure how monetary policy's distributional impact affects the aggregate consumption response based on the matching multiplier approach of Patterson (2023). This requires that we match the individual's exposure to the monetary policy shock with an estimate of their respective marginal propensity to consume (MPC). At this stage, our Estonian data becomes very handy again. We complement our dataset using household-level MPC estimates from the Household Finance and Consumption Survey for Estonia in 2021. We then match the surveyed households to their members' exposure to the monetary policy shock in our administrative data.

This approach results in an aggregate MPC that can be decomposed into two components: the income-weighted average MPC and the covariance between the individual-level response to monetary policy and the MPC. If the exposure to the shock and the MPC are positively correlated, the earnings heterogeneity channel amplifies the response of aggregate consumption to a monetary policy shock. Our calculation of the aggregate MPC finds that 5% of the response stems from the heterogeneous response of the workers to the shock and so can be attributed to the earnings heterogeneity channel. The reason is that households with low incomes have a high MPC, and these are the same households that are particularly affected by monetary policy shocks. Furthermore, the monetary policy shock increases earnings inequality, as measured with the Gini coefficient using our granular data.

We also evaluate how much the aggregate MPC depends on the inflation environment. As already discussed, the exposure to the shock depends on the inflation environment. However, we need to assume that MPCs are constant across inflation regimes because the survey on the MPCs was conducted when inflation was low.[1] We find that the aggregate MPC is slightly larger in the low-inflation environment (conditional on constant MPCs). This is because the exposure to the shock varies relatively more, e.g., the top decile is barely affected by the shock when inflation is low. However, focusing only on the aggregate MPC does not take into account the overall impact of the shock. The monetary policy shock has a much larger quantitative impact when inflation is high. Therefore, the total aggregate effect is considerably more pronounced in the case of high inflation.

Our results highlight the importance of jointly accounting for heterogeneity and state dependencies when studying the impact of monetary policy. To rationalize our findings, we build a nonlinear THANK model, in which the degree of heterogeneity and the direct aggregate impact of monetary policy vary with the level of inflation. We show that the interaction between heterogeneity and aggregate dynamics can explain the observed pattern using our model solved with global methods. Specifically, a larger direct aggregate impact of the monetary policy shock paired with a slightly reduced degree of heterogeneity, during high-inflation periods, results in increased inequality and a more elevated fall in consumption. At the same time, the reduced heterogeneity in the high-inflation period accounts for the reduced relative exposure to the monetary policy shock and thus explains the pattern for the aggregate MPC.

In addition to accounting for our results through the lens of a model, an important consideration for our findings is their external validity. One advantage is that Estonia is part of the euro area, and therefore, we can study the monetary shocks of the ECB. Importantly, our baseline findings, for which we do not condition on inflation or the size of shocks, are in line with similar studies that were conducted in Denmark, Norway, Sweden, Germany and France (Andersen et al. 2023, Holm et al. 2021, Amberg et al. 2022, Broer

[1] If the MPC of low-income workers raises proportionally more in a high-inflation environment, there would be a downward bias of the aggregate MPC for the high-inflation environment, which could be the case.

et al. 2022, Hubert and Savignac 2024). Furthermore, we also show that the aggregate risk exposure of individual earnings to GDP is very similar to the US, as studied in Guvenen et al. (2017). Additionally, the labour market features high flexibility, being much closer to the US than to Western Europe or Scandinavia. However, Estonia has been growing relatively strongly during this period, starting from a substantially lower economic level than the US or the average in the euro area. Furthermore, Estonia has a flat tax rate scheme, which could affect the incentives in the labour market.

Related literature This paper is part of the literature that studies the distributional impact of monetary policy using survey and administrative data. Coibion et al. (2017) find from survey data that monetary policy increases inequality in labour earnings in the US. Andersen et al. (2023), Holm et al. (2021), Amberg et al. (2022) use detailed yearly administrative data from Scandinavia to estimate the impact of monetary policy on inequality. Broer et al. (2022) estimate the distributional impact of monetary policy using monthly (top-coded) employment data from 1995 to 2013 for Germany. They argue that the extensive margin is very relevant for low-income workers. Hubert and Savignac (2024) use annual French matched administrative-survey data to evaluate the roles of the extensive and intensive margins. Our contribution to studying the (non-state dependent) impact is threefold. First, our results confirm previous empirical findings of these studies using a different country. Second, we use a high-quality administrative dataset without top coding from a euro area country that has not yet been used in this context, and that - importantly - is available to other researchers.[2] Third, we show that monthly data provide a cleaner estimation of the intensive and extensive margins as they account properly for the labour market spell of workers.

However, our study differs from the previous studies in a key dimension - we analyse the role of state dependencies, specifically the role of inflation, in the distributional impact of monetary policy. Tenreyro and Thwaites (2016) emphasize the importance of state dependencies for the monetary transmission of aggregate variables, and they condition the aggregate impact of monetary policy shocks on the business cycle. Gargiulo et al. (2024) use aggregate data for the US to find that monetary policy transmission depends on the inflation regime. They show that monetary policy can have stronger and more long-lasting effects when inflation is high. Canova and Pérez Forero (2024) also find that the transmission of monetary policy shocks for aggregate variables depends on the inflation

[2] The data can be accessed from Statistics Estonia, as explained on their website.

regime. They find the impact is more persistent when inflation is high, but the peak is less powerful. We contribute to this literature by outlining a novel inflation dependence in the earnings heterogeneity channel of monetary policy. By exploiting our high-frequency administrative data, we find that the distributional impact depends on the inflation rate.

We also contribute to the literature that disentangles the role of heterogeneity in aggregate amplification. Recent work on the matching multipliers by Patterson (2023) shows that the heterogeneous effect of business cycles or fiscal stimulus on households can amplify the aggregate consumption response if households that are more exposed also have a higher MPC. More recently, Bilbiie et al. (2025) estimate the aggregate MPC using Norwegian data. Adapting the approach of Patterson (2023) to our data and the transmission of a monetary policy shock, we estimate the role of the earnings heterogeneity channel. Our aggregate MPC estimate provides a benchmark for the strength of the earnings heterogeneity channel in HANK models. A key strength in our analysis is the possibility of matching our estimated exposure to monetary policy shocks in the administrative data with household-level survey data on MPCs. Thereby, our work complements recent work that uses an indirect approach that combines empirical evidence and theory to measure the consumption effects (e.g., Slacalek et al. 2020, Mäki-Fränti et al. 2022, McKay and Wolf 2023, Lenza and Slacalek 2024, and Pekanov 2024).

Finally, our work is related to the literature that studies HANK models, as coined by Kaplan et al. (2018). We follow the approach of using tractable HANK models, as explored in early work by Galí et al. (2007) and Bilbiie (2008). Recent contributions include Bilbiie (2020), Broer et al. (2020), Cantore and Freund (2021), Bilbiie (2024), Debortoli and Galí (2024), among others. We contribute by focusing on the interaction of heterogeneity, nonlinearities, and aggregate dynamics through the lens of a tractable HANK model solved with global methods. Our work also relates to recent papers that use quantitative HANK models to study nonlinear dynamics, such as Fernández-Villaverde et al. (2023) and Kase et al. (2022).

2 Data: Labour Income & Monetary Policy

This section first provides a brief institutional background on Estonia before outlining the employed administrative labour income data for the entire population at a monthly frequency. We then discuss the employed high-frequency monetary policy shock series.

2.1 Institutional Context: Labour Market & Monetary Policy

This paper uses data from Estonia, a small open economy that joined the euro area in 2011 and had before a fixed exchange rate with the Euro as an anchor currency as part of the European Exchange Rate Mechanism. Importantly, this allows us to study the monetary policy of the ECB. The transmission of monetary policy shocks to the Estonian economy has been documented, in Errit and Uusküla (2014) and Almgren et al. (2022), for instance. The growth rate of loans in Estonia is tightly related to policy interest rates, as there is a high dependency on flexible interest rates that are linked to the 6-month Euribor.

An important institutional feature is the flexible labour market, which is a key margin for absorbing shocks. The labour market is characterised by low nominal wage rigidity and adjustments to shocks through employment status as there is no regular job retention support scheme (Babecký et al. 2010).[3] The union power is very low, and the minimum wage is the most important labour market institution.Rises in the minimum wage have had a strong effect on wages at the lower part of the wage distribution (Ferraro et al. 2018b) with a limited negative effect on employment (Ferraro et al. 2018a). Taken together, the flexible labour market makes the institutional setting in Estonia, in our opinion, closer to that of the US than to those Western European countries such like France and Germany or the Scandinavian countries. Appendix A provides more details on the aggregate dynamics of the Estonian economy.

2.2 Monthly Administrative Data on Labour Income

Using Estonian administrative tax records gives us monthly and near-real-time data of the earnings distribution. The data on labour income are obtained from the administrative records of the Estonian Tax and Customs Board, which are based on employers' filings. Employers report wages paid to the Tax and Customs Board and all the related taxes of all their employees at a monthly frequency.[4] The resulting database covers the universe of employees, their total labour income, and their employers. The data are complete since there is no top coding, and the entire set of employees is covered.

We construct a database of labour income at the individual level and at monthly

[3] The exception was the Covid-19 crisis when Estonia, like many other EU countries, introduced a temporary job retention support scheme from March 2020 until May 2022. This was an on-off support scheme, which had a temporary effect that muted the reallocation of jobs between firms (Meriküll and Paulus 2024).

[4] These tax declarations are called form TSD, and the employer submits these to the tax office by the 10th day of the month following the payment.

frequency for our horizon from January 2006 to September 2023. There are roughly 410 to 510 thousand individuals observed each month, and in total, there are 900 thousand unique individuals. To trace entries and exits, we use a balanced panel of all the individuals who were employed in at least one month in the timespan observed, and we set the labour income equal to zero when the individual was not working. We restrict the age of individuals in our panel to be within the prime working age of 26-65. After balancing the panel, we have about 88 million observations.

The total labour income is derived as the sum of two income sources: i) wage income (from permanent and temporary contracts), and ii) income of employees who serve as executives or board members. While the two types of labour income, wages and remuneration for board members, are very similar in their function and subject to taxation, the executive remuneration is not subject to unemployment insurance payments. Most income comes from wage income; the pay for board members makes only a small contribution, but it could be very important to measure the labour income of the highest income earners. Our labour income covers all wage income, bonuses, and holiday payments and is reported in gross terms.[5] Labour income is deflated to real terms using the Harmonised Index of Consumer Prices (HICP) in 2015 prices.

We sort the individuals into twelve income groups each month by gender and age. The income bins use cutoffs at the 10th, 20th, ..., 90th, 99th, and 99.9th percentiles. The age groups are divided as follows: 26-35, 36-45, 46-55, 56-65.[6] We sort into income groups using a proxy of permanent income - the average labour income during the last 12 months.[7] Although it is common to base permanent income measures on a longer history, we explicitly limit the past income to one year only to keep the years around the Great Recession in the sample. These years were characterised by high inflation, so our sample covers two episodes of high inflation. Our effective sample in the empirical analysis starts from 2008M1; the income group's derivation requires the first 12 months of data, and conditional on income groups, we can derive the yearly income growths starting from

[5]As cross-validation, we show that our calculated labour income data aligns with the labour income reported by Statistics Estonia, the statistical agency that provides the official labour income statistics. More details on the sources and comparison is given in Appendix B.

[6]This implies that the 12 permanent income groups are derived for the eight segments of workers by gender and age. Due to the conditional nature of these income groups, the income level within a single income group can be different for different segments of workers.

[7]Note that the necessary condition for entering into the analysis is that an individual has to report labour income in at least one month in the past year. We prefer average yearly income over average monthly income as it gives a better link to the existing literature using yearly data, where monthly income and transitions are not observed.

2008M1. More details on the data are provided in Appendix B.

External Validation: GDP Betas in Estonia and in the USA As part of the external validity evaluation, we compare our labour market data to the US. Specifically, we estimate how growth in the real labour income of workers depends on aggregate real GDP growth, i.e., the worker betas as introduced by Guvenen et al. (2017). They estimate this relationship for US data and find the workers' exposure to economic growth to be U-shaped. The income of high and low earners is the most sensitive to aggregate growth. A similar pattern is also observed in a related paper using Swedish data by Amberg et al. (2022). However, the estimated U-shape for Sweden is not symmetric, and the lower part of the distribution is affected proportionally more.

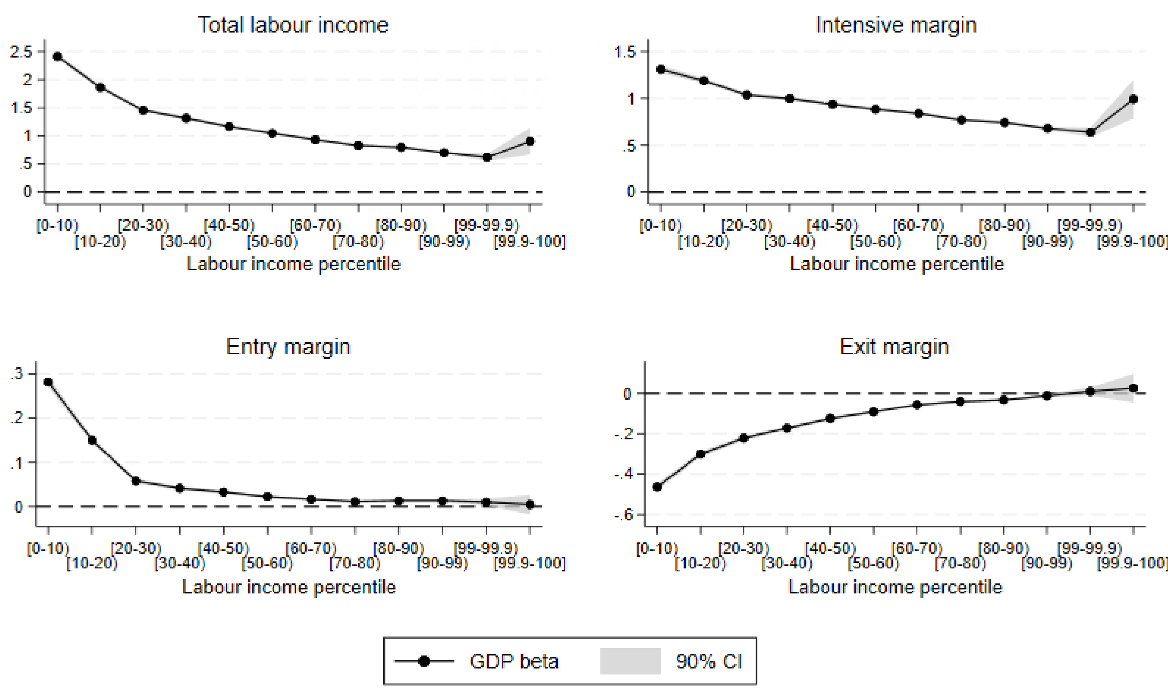

Figure 1: The GDP betas by income groups, yearly data, 2008-2022.

Figure 1 shows the estimates for Estonian data, where we aggregate our monthly data to get yearly data for comparison. The figure presents the responses of total labour income, the intensive margin (labour income growth conditional on participation), the entry margin, and the exit margin. The intensive margin shown in the upper-right panel replicates the estimates of Guvenen et al. (2017) and shows very similar estimates to those found from the US data. The only deviation from the US estimates is that the upswing at the upper end is more modest, as both of the top income groups from the top 1% in the US were more sensitive to aggregate growth. This pattern is weaker in Estonian data and is only seen for the top 0.1%.[8] Like the US data, the most affected segment in our data is at the lower end of the distribution, and this asymmetry is much more pronounced in our data. Additionally, the reaction is also similar to that of the US in terms of gender and age groups, as discussed in Appendix C.

2.3 Monetary Policy Shocks: A High-Frequency Approach

We use a high-frequency approach to obtain the monetary policy shock series for our monthly sample from 2008M1 to 2023M9. We are focusing on the ECB's monetary policy for our entire sample. Estonia joined the euro area in 2011. Before that, it had a fixed exchange rate as part of the European Exchange Rate Mechanism and, therefore, imported its monetary policy from the ECB during the entire sample. Another advantage of Estonia is that monetary decisions can be seen as exogenous because of the relatively small size of the country.

We compute the monetary policy surprises based on high-frequency changes in interest rates around Governing Council meetings following Jarociński and Karadi (2020).[9] The changes in the interest rates are based on the Euro Area Monetary Policy Event-Study Database (Altavilla et al., 2019), which covers all Governing Council meetings between January 1999 and September 2023.[10] The measure is based on the changes in the 1-month, 3-month, 6-month, and 1-year OIS rates, for which the principal component is calculated. The change in the OIS rates is the difference between the median quote before the press release and the median quote after the press conference. To focus on surprise monetary shocks and disentangle them from central bank information effects, we use the poor man's sign restriction approach of Jarociński and Karadi (2020), which imposes restrictions on the rates and the stock market response. As a robustness check, we later also use sign restrictions based on Jarociński and Karadi (2020), and the change in the 3-month OIS rate directly - ignoring potential information effects - as in Broer et al. (2022) for example.

[8] The level of income at these top income percentiles is also of a completely different magnitude in the US. While the top 0.1% labour income earners have a median yearly income that can be above a million dollars, the top 0.1% labour income earners in our sample get 11,000 euros per month, see Table B.1.

[9] The high-frequency approach to identifying monetary policy shocks was first introduced in Kuttner (2001), Bernanke and Kuttner (2005), and Gürkaynak et al. (2005). For a recent discussion on high-frequency identification of monetary policy surprises, see, for instance, Bauer and Swanson (2023).

[10] We drop the Governing Council meeting on October 8, 2008, as is commonly done, since this was an unscheduled meeting enacting a coordinated interest rate cut by several central banks.

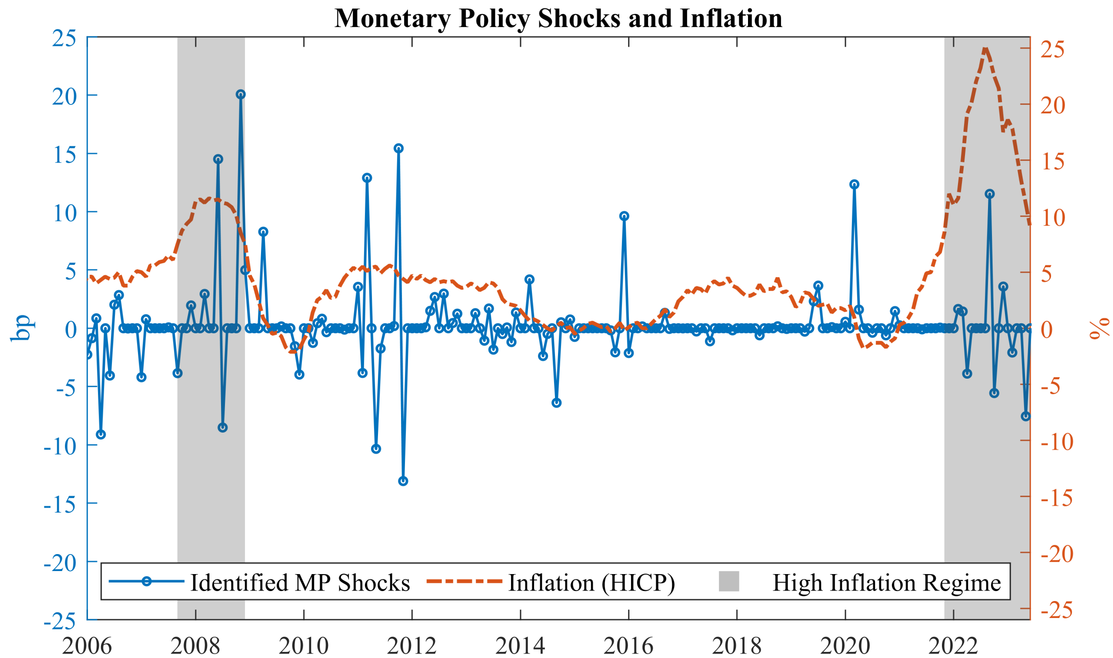

Figure 2: High-frequency identification of monetary policy shocks following Jarociński and Karadi (2020). The blue line shows the shocks identified, while the red line shows inflation.

Figure 2 shows the identified monetary surprises at a monthly frequency. An important point is that the monthly frequency of the Estonian administrative data enables us to use this shock series directly - without aggregating it into yearly data as is usually done in this strand of the literature. Exploiting this larger sample means we can analyse potential state dependencies and sign asymmetries. Additionally, the higher frequency allows for a cleaner composition, since we can now measure the impact on the extensive and intensive margins using our monthly observations. Our data can track exactly when a person is or is not working during the year. In contrast to an analysis with yearly data, a person who works only one month and generates a positive income would count as employed throughout the year.

Importantly, both data sources - monetary surprises and administrative data - cover the recent inflation surge. Therefore, we can shed light on possible inflation dependencies for the distributional impact of monetary policy. We define a high-inflation regime as a period in which inflation exceeds 7%. This threshold corresponds to inflation being half a standard deviation above its mean. While the 7% threshold may seem large, inflation in Estonia has been on average well above 2%, as can be seen in Figure 2.[11] We observe two periods of high inflation - around the Great Recession in 2008 and in the follow-up to the pandemic. The period between these events is characterised as a low-inflation regime. The figure also highlights that inflation in Estonia has been above the average for the euro area, and shows that it peaked at around 20% after the pandemic. This all makes Estonia particularly suitable for our analysis of inflation dependencies.

One concern in our analysis could be that there is a systematic relationship between the monetary shocks and the inflation regime. But, the figure shows that there does not seem to be a relationship between the direction or size of the high-frequency monetary policy shock and the inflation regime.

3 Distributional Impact of Monetary Policy

We estimate the distributional impact of the monetary policy shock without accounting for the role of inflation. This provides our benchmark result for analysing the earnings heterogeneity channel of monetary policy, which we also contrast with the findings of studies from other countries as external validation. In the next section, we analyse how the level of inflation affects the earnings heterogeneity channel of monetary policy.

3.1 Empirical Specification

We estimate first how high-frequency monetary policy shocks affect individual wage-earners across the wage distribution, following the related papers on heterogeneous effects of monetary policy (e.g., Holm et al., 2021; Andersen et al., 2023; Amberg et al., 2022). We use a monthly frequency for our estimation, exploiting our administrative data, while the related papers usually use a yearly frequency. An exception is Broer et al. (2022), who also use a monthly frequency. In the beginning, we do not condition on the different inflation regimes so that we can get a benchmark for our results.

The empirical specification for estimating the impact of aggregate monetary policy shocks on individual wage-earners by labour income groups is:

$$\Delta y_{i,t+h} = \alpha_g^h + \beta_g^h \Delta i_t + \Gamma_g^h \Delta X_{t-1} + \epsilon_{i,t+h}, \tag{1}$$

where the dependent variable $\Delta y_{i,t+h} = (y_{i,t+h} - y_{i,t}) \, / \, ((y_{i,t+h} + y_{i,t})/2)$ is the mid-point

[11] Additionally, we also conduct for our empirical analysis a robustness check with a lower threshold.

average growth of labour income of individual i in month $t + h$. The advantage of the mid-point average growth rate over the conventional log difference growth rate is that it also allows zero incomes in the base or reference year to be taken into account. This means we can account for the adjustment in the extensive margin resulting from job creation and destruction (Davis et al. 1996). The horizon of our estimation is determined by h. Our baseline specification studies the effect over twelve months ($h = 12$), but we also evaluate alternative labour income growth rates for 6, 18, and 24 months.[12]

The monetary policy shock in month t is denoted by Δi_t. As positive values of the shock correspond to a contractionary shock, we expect them to lead to lower labour income growth, that is a negative coefficient for $\beta_g < 0$ for the different income groups, at least on average. We also allow for control variables X_{t-1}. Following related literature, we opt for quite a parsimonious specification for the control variables. In our baseline specification, we control for the economic activity in the month before the monetary policy shock using GDP growth ΔGDP_{t-1}.[13]

We estimate this empirical specification separately for each of our 12 permanent income groups g conditioned on age and gender following Guvenen et al. (2017). The coefficient α_g shows the income group-specific intercept. β_g estimates the income group-specific effect of monetary policy on labour income and allows the distributional impact of monetary policy to be assessed. The income groups are based on the average labour income in the last 12 months before the monetary policy shock.[14]

Disentangling the total effect: The extensive and intensive margins. Equation (1) is estimated for the change in total labour income captured by $\Delta y_{i,t+h}$. To disentangle the roles of the intensive and extensive margins, we also estimate the equation separately for i) the intensive margin change where $\Delta y_{i,t+h}$ is derived only for these observations where both $y_{i,t+h}$ and $y_{i,t}$ have positive values; ii) the entry margin that is derived as a binary 0,1 variable for all the observations with some value of total labour income change and taking value 1 when $\Delta y_{i,t+h}$ equals to 2; and iii) the exit margin that is derived as a binary 0,1 variable for all the observations with some value of total labour

[12] The seasonality is addressed by using year-on-year growth rates when $h = 12, 24$ and including monthly dummies for the specifications with $h = 6, 18$.

[13] Real GDP at quarterly frequency is converted into monthly frequency using the interpolation approach of Chow and Lin (1971). The interpolation uses the related series of the unemployment rate, industrial production and retail trade as in Almgren et al. (2022).

[14] This implies that a first-time worker does not affect the entry margin. The first-year labour income of a newly entering worker is used to derive the labour income group.

income change and taking value 1 when $\Delta y_{i,t+h}$ equals to -2.[15] The effect of monetary policy on total labour income is then the sum of these three components: the effect of the intensive margin multiplied by the fraction of workers participating in both periods $y_{i,t+h}$ and $y_{i,t}$; the effect of entry multiplied by two; and the effect of exit multiplied by minus two.

3.2 Results

The effect on labour income of a monetary policy shock is shown by income groups in Figure 3. The shock has a negative effect on total labour income throughout the entire income distribution. However, the effect is unequally distributed, as low-income workers are much more strongly affected than high-income workers. This highlights how the exposure of workers to a monetary policy shock is heterogeneous. Disentangling the effect shows that workers are unequally affected by the different adjustment margins. Low-income workers are affected most by the extensive margin, as shown by their strong response through the entry and exit margins; middle-income workers from the fourth decile to the eighth decile are affected by both the intensive and extensive margins, with the extensive margin becoming less important as income rises; and the two highest income deciles are barely affected at all by the extensive margin. Low-income workers are consequently affected most by monetary policy because they transition into and out of employment status. In contrast, high-income workers hardly enter or exit employment status because of monetary policy, but have real wage adjustments. These findings on the intensive and extensive margins overlap with the findings of related papers on the earnings heterogeneity channel (Broer et al., 2022; Hubert and Savignac, 2024).

An important observation is that the adjustment patterns differ for monthly and yearly data. The yearly data misses a lot of within-year transitions into and out of employment. A majority of the monetary policy effect on low-income people originates from the intensive margin by construction.[16] Specifically, we find that the intensive margin accounts for one-third of the total effect in monthly data, but for two-thirds of it in yearly data. Using our higher frequency data thus identifies the impact of the intensive and extensive margins better. The details are in Appendix D.1.

[15] There can be periods as long as one month of no labour income in the data because of vacations. We do not want to treat these as entries or exits. To avoid this, we impose that the spell of the employment status change needs to last for at least two months.

[16] Our estimates with yearly data for the intensive margin are very close to the estimates of Amberg et al. (2022).

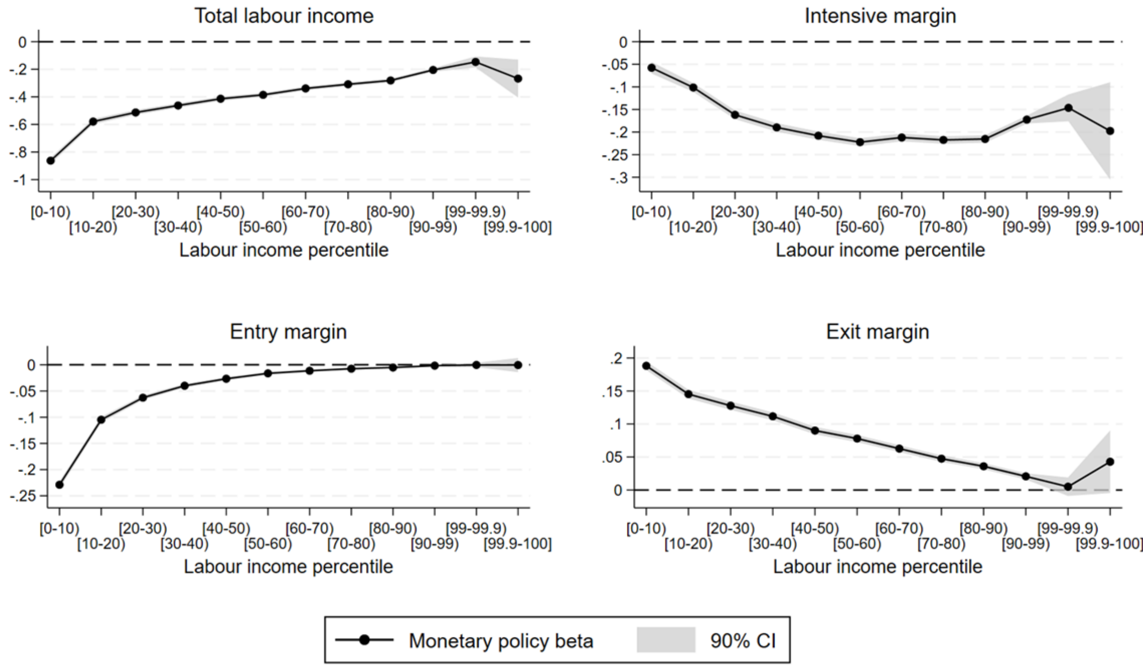

Figure 3: The effect of a monetary policy shock (100 bps) on labour income growth by income groups, 2008M1-2023M9. The effect on total income, the intensive margin, the entry margin and the exit margin are shown.

Our baseline specification studies how monetary policy affects labour income growth over twelve months. Additionally, we also estimate equation (1) with alternative horizons. We use labour income growth rates over 6, 18 or 24 months ($h = 6, 18, 24$). The results are in line with related literature on aggregate dynamics. Most of the effect of monetary policy materialises by month 12, and it peaks in month 18. The effect by months 18 and 24 does not differ for the total labour income. The pattern along the income distribution is also stable. More details are given in Appendix D.2. The same appendix also shows that the effects depend on gender and age group. Men and older workers are more exposed to monetary policy shocks than women and younger workers are.

4 Inflation Dependent Distributional Impact

We now analyse how the level of inflation affects the earnings heterogeneity channel of monetary policy. In particular, we study whether the inflation environment affects the distributional impact of monetary policy.

4.1 Inflation-Dependent Empirical Specification

We now extend our baseline specification to account for the impact of the inflation environment. To evaluate how the earnings heterogeneity channel of monetary policy depends on the inflation environment, we estimate the distributional impact in a low-inflation and high-inflation regime:

$$\begin{aligned}\Delta y_{i,t+h} =& \alpha_g^h + \beta_g^{h,L}\Delta i_t(\Pi_{t-1} < 7\%) + \beta_g^{h,H}\Delta i_t(\Pi_{t-1} \geq 7\%) \\ &+ \Gamma_g^{h,L}X_{t-1}(\Pi_{t-1} < 7\%) + \Gamma_g^{h,H}X_{t-1}(\Pi_{t-1} \geq 7\%) + \epsilon_{i,t+h},\end{aligned} \quad (2)$$

We now have two coefficients for the monetary policy impact: $\beta_g^{h,L}$ captures the impact of monetary policy for income group g in the low-inflation regime (inflation below 7%), and $\beta_g^{h,H}$ captures the impact in the high-inflation regime (above 7%). We determine the inflation regime by using the annualized inflation rate from the previous month to ensure that the monetary policy shock does not affect the chosen regime. The control for economic activity is also interacted with the inflation regime to account for the potentially heterogeneous impact of economic growth on earnings at different levels of inflation.

The parameters $\beta_g^{h,L}$ and $\beta_g^{h,H}$ determine the role that the inflation regime might play in the earnings heterogeneity channel of monetary policy. While we expect the direction of the shock to be rather constant across the regimes, so that $\beta_g^{h,L}$ and $\beta_g^{h,H}$ are mostly similar, the magnitude of the impact may be very different. For instance, if $\mid \beta_g^{h,H} \mid > \mid \beta_g^{h,L} \mid$, monetary policy has a stronger effect for income group g in the high-inflation regime than in the low-inflation regime. The shape of the distribution may also be affected. We also disentangle the effects to evaluate the intensive and extensive margins separately, allowing response mechanisms to be different in a low- and high-inflation environment.

4.2 Inflation-Dependent Results

Figure 4 presents the distributional impact of a monetary policy shock in a low-inflation regime and in a high-inflation one. The first key takeaway is that the impact of monetary policy on labour earnings is substantially amplified during the high-inflation period. The response of total labour income is much more negative, and this pattern is consistent along the income distribution. All households, independent of their income, are relatively much more affected by the monetary policy shock in the high-inflation environment.

The figure also demonstrates that the exposure to monetary policy across the income distribution depends on the inflation regime. In particular, low-income workers are quan-

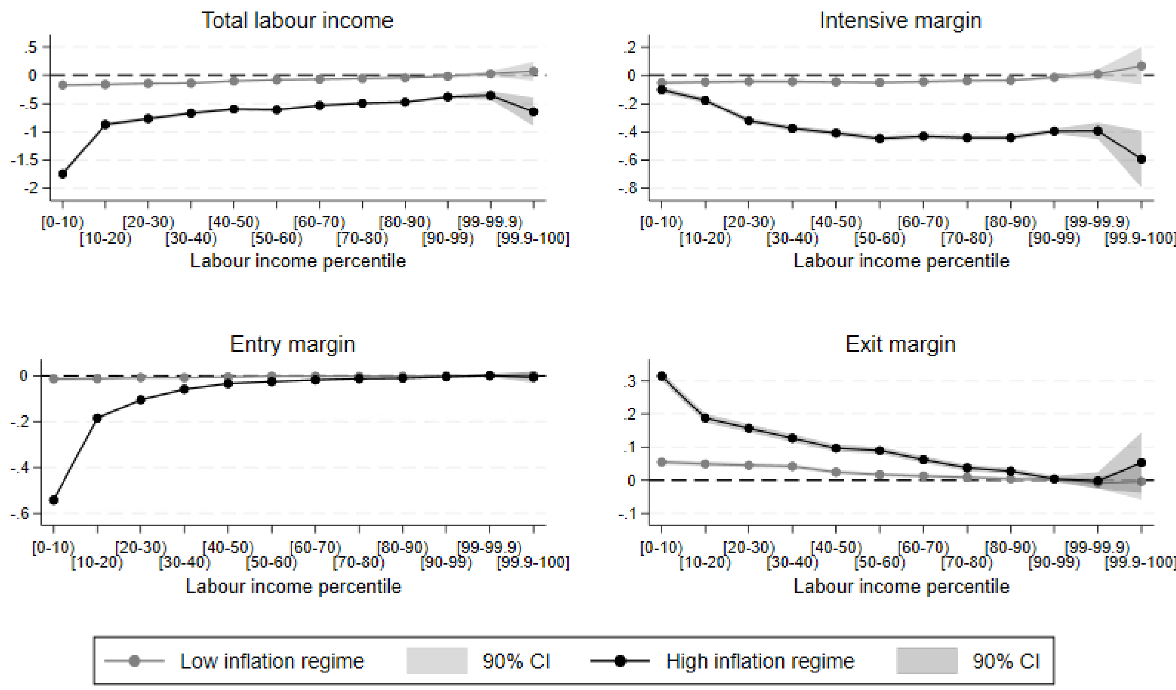

Figure 4: The effect of monetary policy shock (100 bps) on labour income growth by inflation regime and income groups, 2008M1-2023M9. The effect on total income, the intensive margin, the entry margin, and the exit margin is shown.

titatively affected much more than workers in the middle or at the top of the income distribution in a high-inflation environment. Additionally, the exposure features a weak U-shape as the top 0.1% earners are affected slightly more. In the low-inflation regime, the effect is quantitatively much smaller across the whole income distribution. However, the relative differences are larger for some parts of the distribution. While low and medium-income individuals are negatively affected, the effect is basically muted for top earners starting from the 90th quantile. This is in contrast to the high-inflation regime, when every agent is affected negatively. Furthermore, the slightly stronger response of the top 0.1% income households is not present in the low-inflation regime. As a result, the exposure to the monetary policy shock declines monotonously across income groups in a low-inflation regime.

The inflation regime also impacts the adjustment margins. While the stronger effect of the monetary policy shock in the high-inflation regime holds for all adjustment margins, there are relevant differences. The lowest income deciles are more exposed to the monetary policy shock in the high-inflation regime primarily because of the extensive margin. Entries and exits in the labour market dominate the response. For instance, for the lowest decile, 96% of the response is explained by the entry and exit margins, as Table D.2 in the appendix details. In the low-inflation regime though, the exposure of the low-income workers stems to a much larger extent from the intensive margin.

Taken together, this shows that the earnings heterogeneity channel of monetary policy depends on the inflation environment. Specifically, the quantitative impact for low-income households is substantially stronger when inflation is high. This effect is mainly driven by labour market entries and exits. Nevertheless, the relative differences may be even larger in the low-inflation environment, because there are qualitative differences in the exposure of different groups. While there is a weak U-shape in the high-inflation regime, the top decile is not affected at all when inflation is low.

4.3 Robustness Checks

We run a set of robustness checks by varying the inflation threshold that classifies the regimes, using nominal wages instead of real wages, estimating the impact based on alternative measures of the monetary policy shock, changing the set of control variables, employing alternative standard errors and evaluating potential sign asymmetries between positive and negative shocks. Figure 5 summarises most of the results.

Inflation Threshold for the Regimes. We re-estimate our state-dependent specification using an alternative inflation threshold for the regime classification. We now use a 5% threshold inflation value to distinguish between the low- and high-inflation regimes.[17] The upper left panel of Figure 5 demonstrates that our results are robust to this specification as we find very similar inflation dependencies for the monetary policy shock across the entire distribution. At the same time, the difference between the two inflation regimes narrowed to some extent. Consequently, the strong impact of monetary policy shocks during a high-inflation regime does not hinge on the exact cutoff value chosen, even though it affects the quantitative differences to a limited extent.

Nominal Wages. We re-evaluate the effect of monetary policy using nominal wages instead of real wages. The results with nominal wages as the dependent variable are shown in the upper right panel of Figure 5. Whether the dependent variable is deflated or not has almost no impact on the results. The response with nominal wages shows there to be a slightly stronger effect throughout the distribution in the low-inflation regime and vice

[17] The 5% threshold corresponds to the 75th percentile of the inflation distribution in our data.

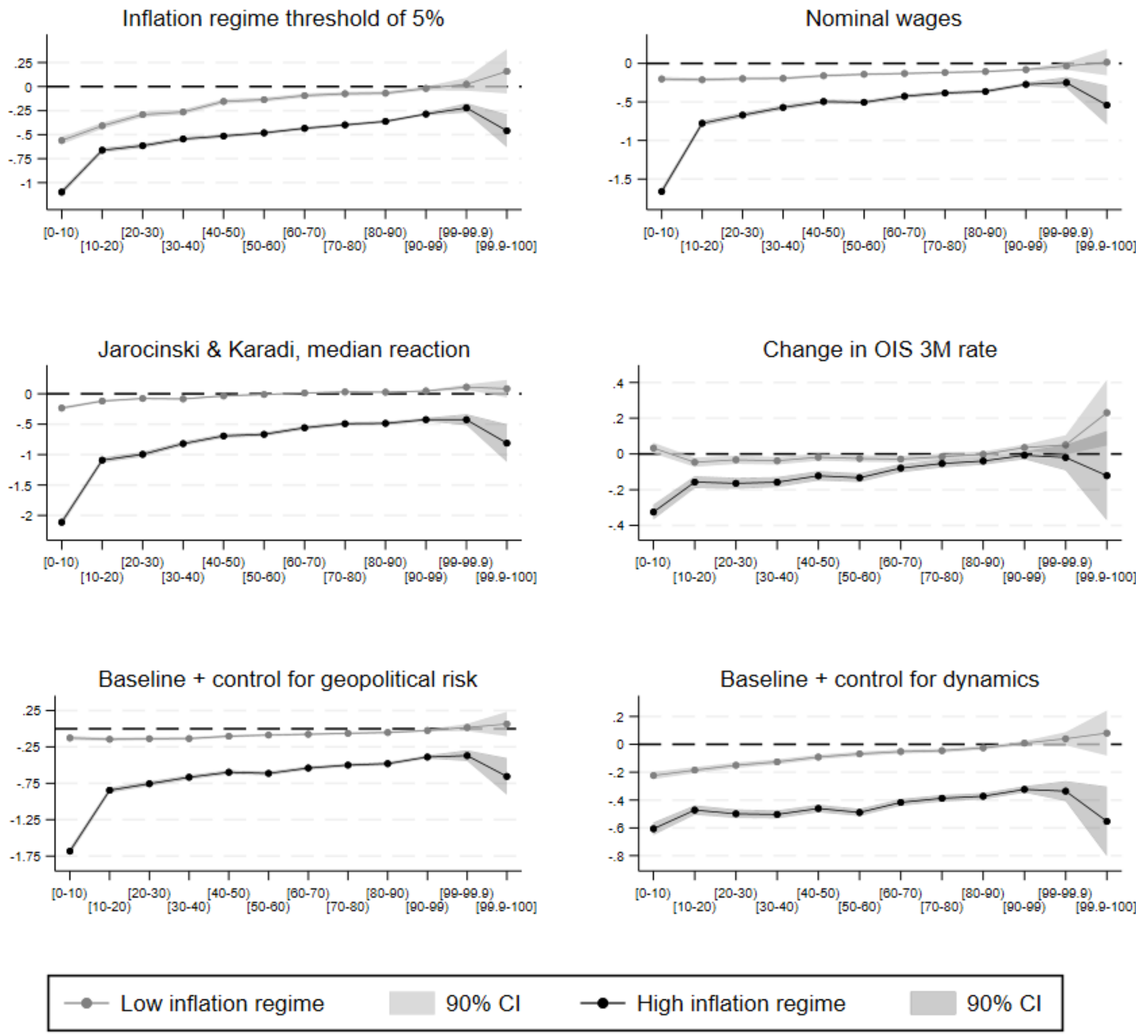

Figure 5: The effect of a monetary policy shock on total labour income by inflation regime and income groups for alternative empirical specifications, 2008M1-2023M9. Upper left panel: Impact of using an inflation threshold of 5%. Upper right panel: Impact of using nominal wages instead of real wages as the dependent variable. Middle left panel: Impact of a 100 bps monetary policy shock, which is identified with sign restrictions, by inflation regime. Middle right panel: Impact of a 100 bps direct change in the 3-month OIS rate. Lower left panel: Impact of including geopolitical risk as an additional control variable. Lower right panel: Impact of additionally controlling for each individual's past labour income growth.

versa in the high-inflation regime. This comes from how inflation affects real wages. For instance, in the low-inflation regime, the negative effect on nominal wages is compensated for by lower inflation, and there is only a small effect of monetary policy on real wages. However, the inflation effect is quite small so the estimated results with nominal and real wages are very similar.

Alternative Monetary Policy Shocks. We consider alternative measures of the monetary policy shock by adding and relaxing the restrictions for identifying shocks. [18] We first add restrictions by considering the sign-restriction approach of Jarociński and Karadi (2020).[19] We also remove restrictions by using direct changes in the 3-month OIS rate. In this case, we do not account for possible information effects. The results for these two series are shown in the middle left and right panels of Figure 5. The estimates for the response of total labour income with more restrictions are very close to our baseline estimates and confirm that the inflation regime impacts the distributional effects. The estimates with no restrictions also imply that monetary policy has a stronger effect when inflation is high. However, the distributional effects are different for the lowest-income decile during the low-inflation regime.

Alternative Controls. We also add the geopolitical risk measure from Caldara and Iacoviello (2022) as an additional control variable to the baseline specification. The advantage of this control is that geopolitical risk is unlikely to be affected by monetary policy shocks, and so it can enter contemporaneously with income. Controlling for it can be very important because geopolitical risk has affected the dynamics of income in Estonia substantially. This was especially so when inflation was high after the start of the full-scale war in Ukraine in 2022 and also, to some extent, stemmed from the associated surge in energy prices. The results are shown in the lower left panel of Figure 5. The results are very assuring because they are very close to our baseline estimates. Monetary policy shocks having a strong impact when inflation is high seems not to be driven by geopolitical tensions.[20]

We also estimate the impact of monetary policy by additionally controlling for the individual's past labour income growth, that is $\Delta y_{i,t}$, similar to the setup of Holm et al. (2021). The estimation results confirm our baseline, as shown in the lower right panel of

[18] Brennan et al. (2024) discusses how different data series and methods create differences in the series of identified shocks.

[19] Like with the poor man's sign restriction for our main series, the goal of this is to focus on surprise monetary shocks and disentangling them from central bank information effects. In this case, we use their sign restriction approach, which imposes restrictions on the rates and the stock market response. The median response then provides the shock series.

[20] Of course, geopolitical tensions affect the inflation regime, through energy prices, for example.

Figure 5. While there is a smaller impact of monetary policy in the high-inflation regime, the inflation dependencies are still pronounced.

Standard Errors We use heteroscedasticity-robust standard errors as the default, but we also employ standard errors clustered at the individual level, as in Hubert and Savignac (2024) for instance. The lower left panel of Figure D.6 in the Appendix illustrates that this does not change our findings.

Sign Asymmetries. We compare the effect of accommodative and contractionary monetary policy shocks on labour income. The results for the shock asymmetry are shown in the lower right panel of Figure D.6 in the Appendix. Our results highlight that contractionary shocks are the main driver, while expansionary shocks have a much more limited impact. The shape of the response for the different percentiles also differs to some extent. This implies that there is an important sign asymmetry in the distributional impact of monetary policy. However, the sign asymmetry cannot explain our observed inflation dependency, as we observe a mix of both shocks under both inflation regimes.

5 Aggregate Implications of the Earnings Heterogeneity Channel

This section evaluates the aggregate implications of the earnings heterogeneity channel. In particular, we determine how different exposures to monetary policy across the income distribution amplify or dampen the response of aggregate consumption. To achieve this, we must complement our individual-level estimates of income risk to monetary policy shocks with information on the MPC. We again exploit the advantages of using our Estonian data by merging our administrative data with household-level MPC estimates from the Household Finance and Consumption Survey (HFCS) for Estonia.[21] Using this merged dataset, we evaluate the aggregate MPC in response to a monetary policy shock. We also analyse the impact of a monetary policy shock on total labour income and the Gini coefficient. Furthermore, we account for inflation dependencies when assessing the aggregate impact.

[21] The Household Finance and Consumption Survey is an ECB-coordinated survey of household assets, liabilities, and consumption. It is analogous to the US Survey of Consumer Finances.

5.1 The Aggregate Marginal Propensity to Consume

The aggregate MPC can be disentangled into two components, as shown in Patterson (2023). These are the income-weighted average MPC and the income-weighted covariance between the household-level response to aggregate shocks and the MPC:

$$\text{Aggregate MPC} = \sum_j \frac{dC_j}{dE_j}\frac{dE_j}{dY} = \sum_j \frac{E_j}{Y}\frac{dC_j}{dE_j} + cov\left(\frac{dC_j}{dE_j}, \gamma_j\right) \tag{3}$$

where E_j is the labour income of household j, C_j is the consumption of household j, Y is the aggregate labour income, and $\gamma_j = \frac{dE_j}{dY}\frac{Y}{E_j}$ is the elasticity of household j labour income to aggregate output. The first term on the right-hand side is the income-weighted average MPC of households. The second term captures the income-weighted covariance between household-level income elasticity and household-level MPCs. Note that we express this equation at the household-level terms due to the availability of MPC estimates. When describing the data below, we explain how we adjust our initial estimates to have them on a household level.

We focus here entirely on the labour income change that originates from a monetary policy shock. In that regard, we are calculating the aggregate MPC for a monetary policy shock, which enables us to examine the role of the earnings heterogeneity channel. It is the second term that determines the contribution of the earnings heterogeneity channel to the monetary policy shock transmission. A positive covariance between the household-level MPC and earnings elasticity, $cov(\cdot) > 0$, amplifies the monetary shock due to earnings heterogeneity. A negative correlation in contrast, $cov(\cdot) < 0$, would dampen the impact. Similarly, if the household-level response to a monetary policy shock is unrelated to their MPC, $cov(\cdot) = 0$, the earnings heterogeneity channel would not contribute to the transmission of monetary policy.

Inspecting the different terms reveals that we have access to most of the required objects using our administrative dataset and results. We can calculate the income share of household j, E_j/Y, and we can estimate the income response to the monetary policy shock, that is dE_j/dY. Thus, we have the elasticity of the labour income of household j to the monetary policy shock, γ_j. However, we are missing household-level estimates of the marginal propensity to consume, that is dC_j/dE_j.

5.2 Merged Dataset with MPCs

To obtain MPC estimates, we are using the HFCS for Estonia conducted in 2021. The survey provides a household-level MPC estimate using the unexpected windfall gain question[22]. It has been shown that such self-reported MPC measures provide very similar MPC estimates to those revealed from actual behaviour and are highly informative in predicting actual spending (Parker and Souleles 2019). Table 1 shows the average MPC for the different labour income percentiles. We observe a substantial heterogeneity in the MPCs over the income distribution, like in related literature by Jappelli and Pistaferri (2014).[23] We link the sample of Estonian households that were interviewed in the HFCS with our administrative data-based estimates of responsiveness to monetary policy at the individual-level, so that we have all the household-level data we need to determine the aggregate MPC. We are switching here to the household level, j, as the MPC in the HFCS is measured at the level of the household and not the individual. We derive the γ_j and dE_j due to monetary policy shock for each household using the heterogeneous β_g in equation (1) or (2). We re-estimate separately β_g for 11 labour income groups conditional on gender and age as before. We merge the two highest income groups as the HFCS survey data does not allow us to observe the income group of the top 0.1%. Taking the 88 different β_g for the various socio-economic groups, we derive the response of each individual to a monetary policy shock given their socio-economic group and labour income in 2020, and aggregate the individual responses to the household members.[24] This way, we obtain the household reaction to a monetary policy shock. Note that only those households are included that have at least one member of prime working age, 26-65, who has received labour income. Our final sample contains then 1527 households.

5.3 Aggregate Results

We calculate and analyse the aggregate MPC estimates, as shown in Table 1. We first characterise a baseline scenario in which we assume that monetary policy has an equal

[22]The exact phrasing of the MPC question is (HFCS question HIZ040a): "Imagine you unexpectedly receive money from a lottery, equal to the amount of income your household receives in a month. What per cent would you spend over the next 12 months on goods and services, as opposed to any amount you would save for later or use to repay loans". The reference unit is the household.

[23]Our average MPC estimate is 37% for all the households with at least one member of prime working age in employment. This is somewhat lower than the estimates using exactly the same wording of the windfall gain question in Jappelli and Pistaferri 2014 and the revealed-preference estimates from spending after income shocks such as unemployment or tax rebates in Patterson 2023.

[24]The 2021 wave of the HFCS reports the income from the last calendar year.

effect on all income groups. This corresponds to the income-weighted MPC captured by the first term on the right-hand side of equation (3) and abstracts from the earnings heterogeneity channel. The income-weighted aggregate MPC equals 0.328, as shown in column (1). In such a world, a contractionary monetary policy shock of one standard deviation would lead to a decline in consumption of 0.49%. This measure is calculated as the response of total labour income to a monetary policy shock, which is 0.015 (see also Table D.1) times the income-weighted MPC ($0.015 \cdot 0.328$).

However, the income groups are not affected equally by the monetary policy shocks, as shown in the previous sections. Low-income groups with high MPCs are affected much more by the monetary policy shock. There is a positive correlation between the labour income elasticity with respect to monetary policy and the MPC, as shown in detail in Figure E.1 in the Appendix. Since households are not equally affected by monetary policy, the aggregate MPC rises to 0.347. This matching multiplier calculation assigns 5% of the impact of monetary policy on aggregate consumption to the earnings heterogeneity channel. A contractionary monetary policy of one standard deviation shock leads to a decline in consumption 0.52% ($0.015 \cdot 0.347$). Furthermore, a monetary policy shock of one standard deviation increases inequality by 0.35%, which we measure using the Gini coefficient for labour income[25]. The heterogeneous reaction of households to monetary policy shocks thus amplifies the impact of monetary policy and increases earnings inequality.

We can also condition the aggregate impact on the inflation environment. Using the inflation-dependent estimates, the aggregate MPC in equation (3) is calculated with the elasticity γ_j^L and γ_j^H for the low and high inflation regimes, respectively. However, the survey data on MPC for 2021 only covers the low-inflation regime.[26] Thus, the household-level MPCs are necessarily based on the low inflation environment. This implies that our aggregate MPC only partly accounts for the different inflation regimes. However, we believe this is a cautious assumption, as we would expect the MPCs to increase in a high-inflation environment. Similarly, the effect should be largest for low-income groups as they spend the largest part of their income already on essentials. Therefore, we likely downward bias the aggregate MPC for the high-inflation environment and provide a downward estimate. It should still provide a useful starting point because there is also evidence that MPCs are quite stable over the business cycle (Patterson 2023).

The results are shown in the last two columns of Table 1. The covariation between the

[25]The labour income Gini was 0.4029 in our sample in 2020.

[26]The interviews in 2021 were conducted between January and August, stopping shortly before the surge in inflation.

Table 1: The MPCs and monetary policy effects by household income groups

Labour income percentile	MPC	(1) Income weight	(2) MP effect weight	(3) MP weight by inflation regime: Low inflation	(4) MP weight by inflation regime: High inflation
[0 – 10)	0.465	0.013	0.026	0.038	0.028
[10 – 20)	0.420	0.033	0.052	0.084	0.047
[20 – 30)	0.436	0.046	0.059	0.088	0.054
[30 – 40)	0.351	0.061	0.078	0.113	0.071
[40 – 50)	0.391	0.073	0.085	0.114	0.079
[50 – 60)	0.328	0.086	0.095	0.098	0.093
[60 – 70)	0.375	0.105	0.112	0.106	0.111
[70 – 80)	0.353	0.130	0.135	0.134	0.133
[80 – 90)	0.302	0.169	0.155	0.131	0.157
[90 – 99)	0.265	0.229	0.172	0.093	0.186
[99 – 100]	0.227	0.056	0.032	0.000	0.040
Weighted Aggregate MPC		0.328	0.347	0.367	0.345
Consumption response to MP shock		0.49%	0.52%	0.11%	0.83%
Income Gini response to MP shock		-	0.35%	0.15%	0.42%

Notes: The table shows the MPC, the income weight, the weight adjusted by the response to monetary policy shocks, and the weight adjusted by the response to the shock conditional on being in the low inflation and high inflation regimes for the different income groups. The aggregate MPC is calculated using the different weighting schemes numbered (1) to (4), which come from income or exposure to the monetary policy shock. The last two rows show the response of consumption and inequality to a contractionary monetary policy shock of one standard deviation. The response is conditioned on the different weighting schemes and the size of the monetary policy shock.

exposure to a monetary policy shock and the MPC is stronger during the low-inflation regime than during the high-inflation regime. As a consequence, the aggregate MPC is larger in the low-inflation regime. This result may seem surprising at first glance, but the stronger response of the aggregate MPC is due to two reasons. The first is that the middle-income groups are relatively more affected by the shock when inflation is low. The second is that the high-income groups are much less affected in the low-inflation environment. In fact, the top 1% are not affected by a monetary shock. The correlation between the exposure to the shock and the MPC is consequently stronger in the low-inflation environment. More details on the covariation are shown in Figures E.2 and E.3.

The earnings heterogeneity channel accounts for 11% of the response in aggregate consumption during a low-inflation regime and 5% of the response during a high-inflation regime. To assess the effect fully however, we need to account for the average impact of a monetary policy shock. A one standard deviation monetary policy shock is much stronger in a high-inflation regime as it has an impact of -0.3% relative to -2.4% on average earnings; see Table D.2. Given the dominant effect of monetary policy when inflation is high, the total effect of monetary policy on inequality is still stronger in this regime. A one standard deviation monetary policy shock has roughly an eight times larger effect on consumption in a high-inflation regime than in a low-inflation regime. To assess the impact on inequality, we simulate our microdata and find that the effect of monetary policy on income inequality is also stronger during a high-inflation regime.

6 Tractable HANK with Inflation Dependencies

Our empirical analysis finds that the aggregate MPC is larger in a low-inflation environment, while the total effect on labour income and on inequality is substantially stronger in a high-inflation environment. While the result may seem contradictory at first glance, we conceptualize our findings by using a nonlinear tractable HANK model that features inflation dependencies. In particular, we discuss to what extent amplification or dampening via heterogeneity can explain the dynamics. We also evaluate how an altered aggregate transmission unrelated to changes in heterogeneity contributes to the findings.

6.1 Model

Our starting point is a THANK model using elements from Bilbiie (2020, 2024) and Debortoli and Galí (2024) to capture parsimoniously important micro-heterogeneity. We extend the nonlinear version of the THANK model by introducing state dependencies to capture low and high inflation periods. Specifically, the degree of heterogeneity depends on the inflation environment, resulting in a changing amplification via heterogeneity. We also condition the direct impact of a monetary shock on the inflation environment. While the model is described in detail below, the equilibrium conditions are shown in Appendix F.1.

Households The model features two types of households: Hand-to-mouth households H with a share λ and savers S with a share $1-\lambda$. Households transition between the states based on an exogenous Markov Chain. The probability to stay type H and S is h and s, respectively. The share of type H households is $\lambda = (1-s)/(2-s-h)$ in equilibrium. When the households are savers, they can adjust their bond holdings without constraints. However, when they are hand-to-mouth households, they cannot hold bonds and just receive the payoff from previously accumulated bonds. In equilibrium, the bonds are only priced but not held.

The households belong to a family. The family head maximizes the utility of the family, given both types their respective population weight, and can only redistribute resources within the specific types S and H, respectively. The maximization problem is

$$W_t = \max_{\{B_t, C_t^S, C_t^H, N_t^S, N_t^H\}} (1-\lambda)U(C_t^S, N_t^S) + \lambda U(C_t^H, N_t^H) + \beta E_t W_{t+1} \tag{4}$$

where the utility function is

$$U(C_t^i, N_t^i) = \frac{C_t^i 1-\sigma}{1-\sigma} - \psi \frac{N_t^{i\,1+\varphi}}{1+\varphi}, \quad \text{for } i = S, H \tag{5}$$

The households differ in their productivity Ξ^i, with the hand-to-mouth households being less productive. The household-specific productivity is normalized so that it would add up to 1 in case both types choose the same labour supply. Embedding this feature results in a scenario where the steady state interest rate is below the representative agent benchmark.

Additionally, the government redistributes between hand-to-mouth and saver households, where their respective tax or transfer is $\tau_t^H(\Pi_t)$ and $\tau_t^S(\Pi_t)$, respectively. The redistribution and thus the degree of heterogeneity depend on the inflation environment, as we detail when describing the government. The budget constraints of the households can be written as follows:

$$C_t^H = \Xi^H W_t N_t^H + \tau_t^H(\Pi_t) + \frac{R_{t-1}}{\Pi_t}\frac{1-\lambda}{\lambda}(1-s)B_t \tag{6}$$

$$C_t^S + B_{t+1} = \Xi^S W_t N_t^H + D_t^S + \tau_t^S(\Pi_t) + \frac{R_{t-1}}{\Pi_t} s B_t \tag{7}$$

where the described structure of bond market participation is accounted for. The first order conditions are:

$$N_t^{i\varphi} = C_t^{i-\sigma} \Xi^i W_t, \quad \text{for } i = S, H \tag{8}$$

$$C_t^{S-\sigma} = \beta E_t \frac{R_t}{\Pi_{t+1}} \left(s C_{t+1}^{S\ -\sigma} + (1-s) C_t^{H-\sigma} \right) \tag{9}$$

We measure inequality Υ_t by comparing the relative consumption of the different household types:

$$\Upsilon_t = \frac{C_t^S}{C_t^H} \tag{10}$$

Firms The production sector consists of a competitive final good firm that combines intermediate goods, which are owned by the saver households. Intermediate firms use labour to produce output, which they sell to final good producers. They operate under monopolistic competition. The government implements a subsidy that induces pricing as in a world without monopolistic competition. The subsidy is financed by the firms themselves. Finally, firms are paying quadratic adjustment costs a la Rotemberg, resulting in a New Keynesian Phillips curve. We also supplement the New Keynesian Phillips curve with a markup shock μ_t. The full derivation is delegated to F.2.

The firm side can be summarised using the production function, total profits, and the New Keynesian Phillips curve:

$$Y_t = N_t \tag{11}$$

$$D_t = Y_t - W_t N_t \tag{12}$$

$$\xi \frac{\Pi_t}{\Pi}\left(\frac{\Pi_t}{\Pi} - 1\right) + \epsilon = \epsilon W_t + \xi \beta E_t \left[\left(\frac{C_{t+1}}{C_t}\right)^{-\sigma} \frac{\Pi_{t+1}}{\Pi}\left(\frac{\Pi_{t+1}}{\Pi} - 1\right)\frac{Y_{t+1}}{Y_t}\right] + \mu_t \tag{13}$$

The (nonlinear) New Keynesian Phillips curve is supplemented with a markup shock μ_t. The markup shock is assumed to be a Markov Process with a binary outcome: low value and high realization, e.g. $\mu_t \in \{\mu_L, \mu_H\}$ with $\mu_H > \mu_L$. The shock can be calibrated to ensure that the economy is in a low inflation environment when μ_L and in a high inflation environment when μ_H. Therefore, we can then easily condition the equilibrium to be in the low or high inflation regime using the markup shock.[27]

Government The government redistributes by taxing a share of the profits and rebating them to the hand-to-mouth households. The transfer τ_t^H to the hand-to-mouth as well as the dividend income adjusted for the tax of the savers is given as:

$$\tau_t^H = \frac{\tau^D(\Pi_t)}{\lambda} D_t \quad \text{and} \quad D_t^S + \tau_t^S = \frac{1 - \tau^D(\Pi_t)}{1 - \lambda} D_t \tag{14}$$

To capture varying degrees of heterogeneity, the share of taxed profits depends on the

[27] We could alternatively model this as an AR(1) process, and condition our analysis on a sequence of markup shocks.

inflation environment:[28]

$$\tau^D(\Pi_t) = \begin{cases} \tau^D_L & \text{if } \Pi_t < \bar{\Pi} \\ \\ \tau^D_H & \text{otherwise} \end{cases}$$

Monetary Policy Monetary policy follows a Taylor rule and faces monetary policy shocks:

$$R_t = R\left(\frac{\Pi_t}{\Pi}\right)^{\phi_\Pi} + \zeta(\Pi_t)exp(mp_t) \tag{15}$$

where R is the steady state interest rate.[29] Monetary policy follows an AR(1) process:

$$mp_t = \rho_{mp} mp_{t-1} + \sigma_{mp}\epsilon^{mp}_t \tag{16}$$

Note that we make the impact of the monetary policy shock depend on the inflation environment via

$$\zeta(\Pi_t) = \begin{cases} \zeta_L & \text{if } \Pi_t < \bar{\Pi} \\ \\ \zeta_H & \text{otherwise} \end{cases}$$

The idea of this state-dependent transmission is to allow for an amplification/dampening of the monetary policy shock - independent of changes in heterogeneity. While we abstain from a microfoundation, such dynamics could be generated via rational inattention. Specifically, recent work (Korenok et al. 2023, Pfäuti 2023, Bracha and Tang 2024, and Weber et al. 2025) emphasizes the increasing degree of attention to rising inflation and finds evidence for inflation thresholds, in which the attention to monetary policy changes. The latter observation also motivates our modelling of two regimes.

Market Clearing To close the model, we require clearing in the goods and labour market, that is

$$Y_t = C_t = \lambda C^H_t + (1-\lambda)C^S_t \tag{17}$$

$$N_t = \lambda N^H_t + (1-\lambda)N^S_t \tag{18}$$

[28] Bilbiie (2020) derives an analytical expression for the aggregate MPC in a related linearized model, and shows that the τ^D is a key parameter to determine the aggregate MOPC.

[29] When calculating the steady state interest rate, we assume that structural parameters that change in the regime are at their ergodic mean.

Table 2: Parameter values of the THANK model with inflation dependencies

Par.	Value	Description	Par.	Value	Description
β	0.987	Discount factor	τ_L^D	0.1	Taxed profits if $\Pi_t < \bar{\Pi}$
σ	1.0	Relative risk aversion	τ_H^D	0.25	Taxed profits if $\Pi_t \geq \bar{\Pi}$
φ	1.0	Inverse Frisch	ζ_L	1.0	Amplification MP if $\Pi_t < \bar{\Pi}$
s	0.96	Probability to stay S	ζ_H	3.0	Amplification MP if $\Pi_t \geq \bar{\Pi}$
Ξ^H	0.75	Productivity H	σ_{mp}	0.0025	Std. Dev MP shock
Ξ^S	1.17	Productivity S	ρ_{mp}	0.9	Persistence MP shock
λ	0.41	Mass of H	μ_L	-0.25	Markup shock low value
χ	100	Rotemberg pricing	μ_H	1.25	Markup shock high value
ϵ	10	Elasticity of substitution	p_{LL}	0.95	Prob. of staying μ_L
Π	1.01075	Inflation target	p_{HH}	0.75	Prob. of staying μ_H
ϕ_Π	1.5	MP response inflation			

Notes: The parameters are calibrated to a quarterly frequency. .

Global Solution Method and Calibration of Parameters We solve the model in its fully nonlinear specification, accounting for both the low- and high-inflation regimes, using global solution methods. Specifically, we use a time iteration algorithm based on Richter et al. (2014), which has also been used, for example, in Bianchi et al. (2021). The state variables are the monetary policy shock mp_t and the markup shock μ_t. The policy functions are C_t^H, C_t^S, W_t, and Π_t. To capture the distinct inflation regimes, we use a piecewise approximation of the policy functions. In practice, this means solving for eight policy functions rather than four. Additional details on the global solution method are provided in Appendix F.3.

Table 2 summarizes the calibration. The central bank targets an inflation level of 4.3%, consistent with the sample period used in the estimation. For the markup shock, we set the probability to stay in the low inflation regime (p_{LL}) to 0.95, while the probability to stay in the high inflation regime (p_{HH}) is lower, at 0.75. This implies an unconditional probability of 17% for being in the high-markup (and thus high-inflation) regime, in line with the Estonian data. The realizations of the markup shock are calibrated to target average inflation rates of approximately 3.5% in the low-inflation regime and 10.0% in the high-inflation regime.

We vary the degree of redistribution through profit taxation, thereby altering the extent of heterogeneity across regimes. In particular, we set to profit tax 0.1 and 0.25, resulting in reduced heterogeneity in the high-inflation regime. The additional aggregate transmission of the monetary policy shock in the high-inflation regime, denoted ζ_H, is

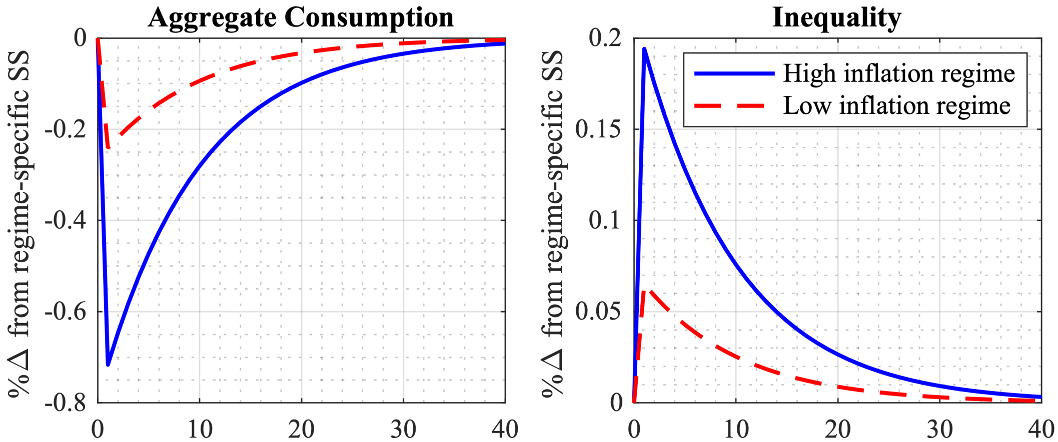

Figure 6: IRFs to a one-standard-deviation monetary policy shock are shown for both high (blue solid) and low (red dashed) inflation regimes. The IRFS are expressed as percentage deviations from the regime-specific steady state, which is the point to which the economy converges when the markup shock persistently remains at either its low or high value and the monetary shock is zero.

set to 3.0, while we normalize ζ_L to 1. This implies that monetary policy shocks are amplified when inflation is high. The standard deviation of the monetary policy shock is normalized to 0.0025, and its persistence is set to 0.9.[30] The remaining parameters are set to conventional values and are listed in Table 2.

6.2 Results

Figure 6 shows the impact of a one-standard-deviation monetary policy shock under both low- and high-inflation regimes. The responses of aggregate consumption and inequality are shown.[31] In both regimes, aggregate consumption declines following the shock, while inequality increases. The impulse responses further show that the effects on both aggregate consumption and inequality are more pronounced in the high-inflation regime.

The simulations demonstrate that our model successfully replicates the empirical findings. We incorporate two key features that contribute to this result: the degree of heterogeneity and the direct impact of monetary policy shocks both depend on the inflation

[30] A persistent monetary policy shock helps to highlight regime-specific differences by generating more gradual responses. However, the insights remain valid under an iid shock specification.

[31] The impulse response functions are expressed as deviations from the regime-specific steady state - defined as the point to which the economy converges when the markup shock persistently remains at either its low or high value, and the monetary policy shock realization is zero. Importantly, agents continue to expect monetary policy shocks and regime switches similar to the risky steady state.

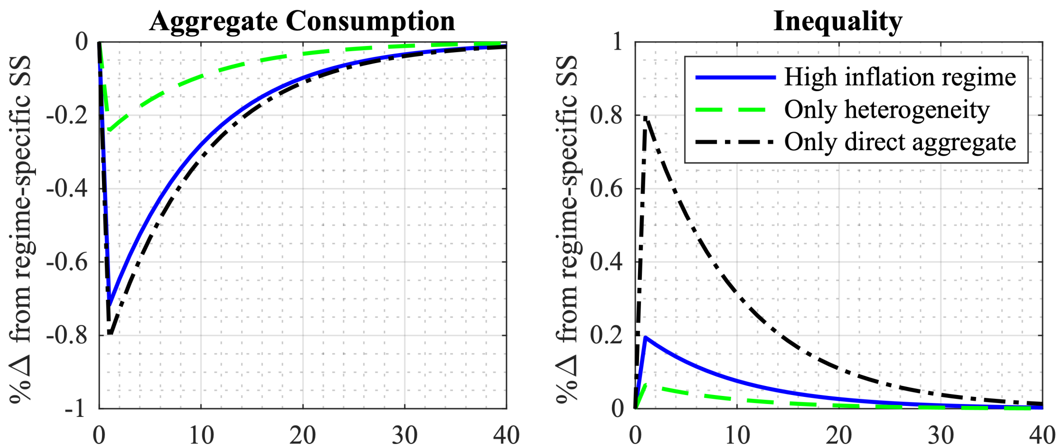

Figure 7: IRFs to a one-standard-deviation monetary policy shock in the high regime for different scenarios. The effect for the full model (blue solid), with only state-dependent heterogeneity (green dashed), and with only state-dependent direct aggregate amplification (black dash-dotted) are shown. The IRFS are expressed as percentage deviations from the regime-specific steady state.

environment. To disentangle the underlying mechanism, we need to take into account that the aggregate MPC in our data is smaller in the high inflation environment. This suggests that, absent any direct amplification through aggregate dynamics as captured in our model by $\zeta(\Pi_t)$, a monetary policy shock would have a smaller effect on aggregate consumption and inequality in high inflation environment.

Figure 7 breaks down these channels. A lower degree of heterogeneity dampens both aggregate amplification and inequality, as shown by the green dashed line. At the same time, the increased direct propagation independent of heterogeneity for a high inflation level amplifies the response of consumption and inequality (see black dash-dotted). Overall, we calibrate the model so that this second channel dominates, resulting in a larger overall decline in aggregate consumption and a sharper rise in inequality, consistent with our empirical findings.

In summary, our model indicates that heterogeneity acts as a dampening force on the transmission of monetary policy shocks in high-inflation regimes compared to low-inflation regimes. When monetary policy shock affects households more uniformly, the amplification of the consumption response is reduced. Nevertheless, the overall impact of monetary policy shocks is substantially stronger in high-inflation environments. As a result, aggregate consumption declines more sharply and total inequality rises - despite the lower degree of heterogeneity. These findings underscore the crucial interaction between heterogeneity and aggregate dynamics, in line with the patterns observed in the data.

7 Conclusions

Our results shed new light on the earnings heterogeneity channel of monetary policy. We document that monetary policy shocks have a stronger quantitative impact on earnings inequality in an environment of high inflation, resulting in a novel inflation dependency. Our findings also raise the concern that taming high inflation affects low-income workers disproportionately because they are more exposed to monetary policy shocks at a time of high inflation.

Turning to the aggregate implications, we show that the earnings heterogeneity channel amplifies aggregate fluctuations and increases inequality. We assign approximately 5% of the impact of monetary policy on aggregate consumption to the earnings heterogeneity channel. The total impact on aggregate consumption and inequality is larger when inflation is high, even though our estimates suggest that the aggregate MPC may be lower in such a high-inflation regime. Our THANK model with inflation dependencies rationalizes our findings and points to important interactions between heterogeneity and aggregate dynamics.

References

Almgren, M., Gallegos, J.E., Kramer, J., Lima, R., 2022. Monetary Policy and Liquidity Constraints: Evidence from the Euro Area. American Economic Journal: Macroeconomics 14, 309 – 340.

Altavilla, C., Brugnolini, L., Gürkaynak, R.S., Motto, R., Ragusa, G., 2019. Measuring euro area monetary policy. Journal of Monetary Economics 108, 162 – 179.

Amberg, N., Jansson, T., Klein, M., Picco, A.R., 2022. Five Facts about the Distributional Income Effects of Monetary Policy Shocks. American Economic Review: Insights 4, 289 – 304.

Andersen, A.L., Johannesen, N., Jorgensen, M., Peydró, J.L., 2023. Monetary Policy and Inequality. The Journal of Finance 78, 2945 – 2989.

Auclert, A., 2019. Monetary Policy and the Redistribution Channel. American Economic Review 109, 2333 – 2367.

Babecký, J., Caju, P.D., Kosma, T., Lawless, M., Messina, J., Rõõm, T., 2010. Downward Nominal and Real Wage Rigidity: Survey Evidence from European Firms. The Scandinavian Journal of Economics 112, 884 – 910.

Bauer, M.D., Swanson, E.T., 2023. A reassessment of monetary policy surprises and high-frequency identification. NBER Macroeconomics Annual 37, 87–155.

Bernanke, B.S., Kuttner, K.N., 2005. What explains the stock market's reaction to federal reserve policy? The Journal of Finance 60, 1221 – 1257.

Bianchi, F., Melosi, L., Rottner, M., 2021. Hitting the elusive inflation target. Journal of Monetary Economics 124, 107–122.

Bilbiie, F.O., 2008. Limited asset markets participation, monetary policy and (inverted) aggregate demand logic. Journal of economic theory 140, 162–196.

Bilbiie, F.O., 2020. The new keynesian cross. Journal of Monetary Economics 114, 90–108.

Bilbiie, F.O., 2024. Monetary policy and heterogeneity: An analytical framework. Review of Economic Studies , rdae066.

Bilbiie, F.O., Galaasen, S.M., Gurkayna, R.S., Maehlum, M., Molnar, K., 2025. Hanksson. Technical Report. Faculty of Economics, University of Cambridge.

Bracha, A., Tang, J., 2024. Inflation levels and (in) attention. Review of Economic Studies , rdae063.

Brennan, C.M., Jacobson, M.M., Matthes, C., Walker, T.B., 2024. Monetary Policy Shocks: Data or Methods? Technical Report 2024-011. Board of Governors of the Federal Reserve System. Washington.

Broer, T., Harbo Hansen, N.J., Krusell, P., Öberg, E., 2020. The new keynesian transmission mechanism: A heterogeneous-agent perspective. The Review of Economic Studies 87, 77–101.

Broer, T., Kramer, J., Mitman, K., 2022. The Curious Incidence of Monetary Policy Across the Income Distribution. Sveriges Riksbank Working Paper Series 416.

Caldara, D., Iacoviello, M., 2022. Measuring geopolitical risk. American Economic Review 112, 1194–1225.

Canova, F., Pérez Forero, F.J., 2024. Does the transmission of monetary policy shocks change when inflation is high? Technical Report.

Cantore, C., Freund, L.B., 2021. Workers, capitalists, and the government: fiscal policy and income (re) distribution. Journal of monetary economics 119, 58–74.

Chow, G.C., Lin, A.l., 1971. Best linear unbiased interpolation, distribution, and extrapolation of time series by related series. The Review of Economics and Statistics , 372–375.

Coibion, O., Gorodnichenko, Y., Kueng, L., Silvia, J., 2017. Innocent bystanders? monetary policy and inequality. Journal of Monetary Economics 88, 70 – 89.

Davis, S.J., Haltiwanger, J.C., Schuh, S., 1996. Job Creation and Destruction. MIT Press Books, The MIT Press.

Debortoli, D., Galí, J., 2024. Heterogeneity and aggregate fluctuations: Insights from tank models. Technical Report. National Bureau of Economic Research.

Errit, G., Uusküla, L., 2014. Euro area monetary policy transmission in Estonia. Baltic Journal of Economics 14, 55 – 77.

Fernández-Villaverde, J., Hurtado, S., Nuno, G., 2023. Financial frictions and the wealth distribution. Econometrica 91, 869 – 901.

Ferraro, S., Hänilane, B., Staehr, K., 2018a. Minimum wages and employment retention: A microeconometric study for Estonia. Baltic Journal of Economics 18, 51 – 67.

Ferraro, S., Meriküll, J., Staehr, K., 2018b. Minimum wages and the wage distribution in Estonia. Applied Economics 50, 5253 – 5268.

Galí, J., López-Salido, J.D., Vallés, J., 2007. Understanding the effects of government spending on consumption. Journal of the European Economic Association 5, 227–270.

Gargiulo, V., Matthes, C., Petrova, K., 2024. Monetary Policy across Inflation Regimes. FRB of New York Staff Report 1083.

Gürkaynak, R.S., Sack, B., Swanson, E., 2005. The sensitivity of long-term interest rates to economic news: Evidence and implications for macroeconomic models. American Economic Review 95, 425 – 436.

Guvenen, F., Schulhofer-Wohl, S., Song, J., Yogo, M., 2017. Worker Betas: Five Facts about Systematic Earnings Risk. American Economic Review: Papers & Proceedings 107, 398 – 403.

Holm, M.B., Paul, P., Tischbirek, A., 2021. The Transmission of Monetary Policy under the Microscope. Journal of Political Economy 129, 2861 – 2904.

Hubert, P., Savignac, F., 2024. The heterogeneous effects of monetary policy on labor income: Disentangling the extensive and intensive margins. Journal of Political Economy Macroeconomics, forthcoming.

Jappelli, T., Pistaferri, L., 2014. Fiscal policy and MPC heterogeneity. American Economic Journal: Macroeconomics 6, 107 – 136.

Jarociński, M., Karadi, P., 2020. Deconstructing Monetary Policy Surprises – The Role of Information Shocks. American Economic Journal: Macroeconomics 12, 1 – 43.

Kaplan, G., Moll, B., Violante, G.L., 2018. Monetary policy according to hank. American Economic Review 108, 697–743.

Kase, H., Melosi, L., Rottner, M., 2022. Estimating nonlinear heterogeneous agents models with neural networks. CEPR Discussion Paper DP17391.

Korenok, O., Munro, D., Chen, J., 2023. Inflation and attention thresholds. Review of Economics and Statistics , 1 – 28.

Kuttner, K.N., 2001. Monetary policy surprises and interest rates: Evidence from the fed funds futures market. Journal of Monetary Economics 47, 523 – 544.

Lenza, M., Slacalek, J., 2024. How does monetary policy affect income and wealth inequality? Evidence from quantitative easing in the euro area. Journal of Applied Econometrics , 1 – 20.

Mäki-Fränti, P., Silvo, A., Gulan, A., Kilponen, J., 2022. Monetary policy and inequality in a small open economy. Bank of Finland Research Discussion Paper .

McKay, A., Wolf, C.K., 2023. Monetary policy and inequality. Journal of Economic Perspectives 37, 121–144.

Meriküll, J., Paulus, A., 2024. Were jobs saved at the cost of productivity in the covid-19 crisis? European Economic Review 161, 104618.

Parker, J.A., Souleles, N.S., 2019. Reported effects versus revealed-preference estimates: Evidence from the propensity to spend tax rebates. American Economic Review: Insights 1, 273 – 290.

Patterson, C., 2023. The matching multiplier and the amplification of recessions. American Economic Review 113, 982 – 1012.

Pekanov, A., 2024. Monetary policy and the redistribution channel in the euro area. Technical Report. WIFO Working Papers.

Pfäuti, O., 2023. The inflation attention threshold and inflation surges .

Richter, A.W., Throckmorton, N.A., Walker, T.B., 2014. Accuracy, speed and robustness of policy function iteration. Computational Economics 44, 445–476.

Slacalek, J., Tristani, O., Violante, G.L., 2020. Household balance sheet channels of monetary policy: A back of the envelope calculation for the euro area. Journal of Economic Dynamics and Control 115, 103879.

Tenreyro, S., Thwaites, G., 2016. Pushing on a string: Us monetary policy is less powerful in recessions. American Economic Journal: Macroeconomics 8, 43 – 74.

Weber, M., Candia, B., Afrouzi, H., Ropele, T., Lluberas, R., Frache, S., Meyer, B., Kumar, S., Gorodnichenko, Y., Georgarakos, D., et al., 2025. Tell me something i don't already know: Learning in low-and high-inflation settings. Econometrica 93, 229–264.

Appendices

A Estonian Economy: Aggregate Dynamics

Estonia has a dynamic economy where the growth rate and inflation have been larger than on average in the euro area, but with more pronounced ups and downs, see Figure A.1. GDP volatility is high due to strong exposure to foreign shocks and limited automatic fiscal stabilisers. The country experienced a vast decline during the Great Recession, followed by a fast recovery and then solid growth for a decade until the Russo-Ukrainian war led to another substantial interruption of growth. The coincidence of a post-pandemic recovery and a surge in energy prices due to the war raised inflation above 20% in 2022 – a level unseen for decades and rarely witnessed in high-income economies, making it an excellent case study for inflation dependencies. There is another high-inflation period in our sample - during the Great Recession. This was mostly a demand-driven inflation episode driven by the housing boom.

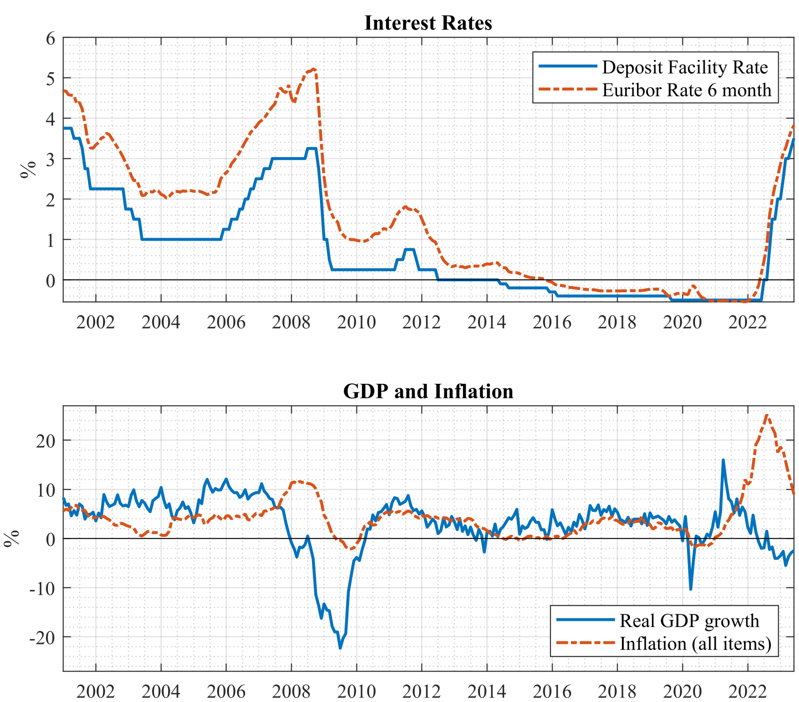

Figure A.1: Aggregate time series, 2001M1-2023M6. Upper chart: Deposit Facility Rate & the 6 month Euribor interest rate. Lower chart: real GDP growth (interpolated at monthly frequency) & inflation (HICP all items).

B Data

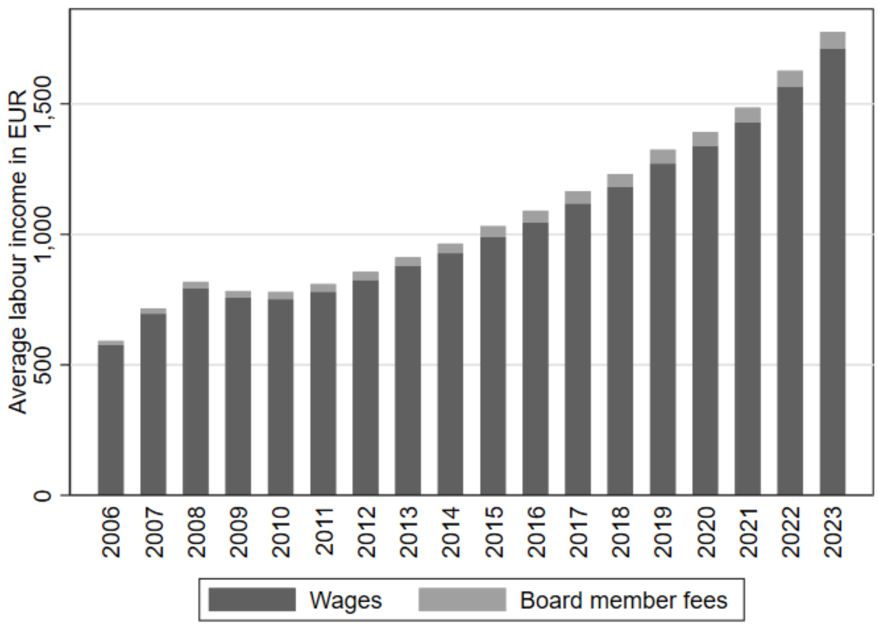

Figure B.1: Average labour income by type in 2006-2023M9.

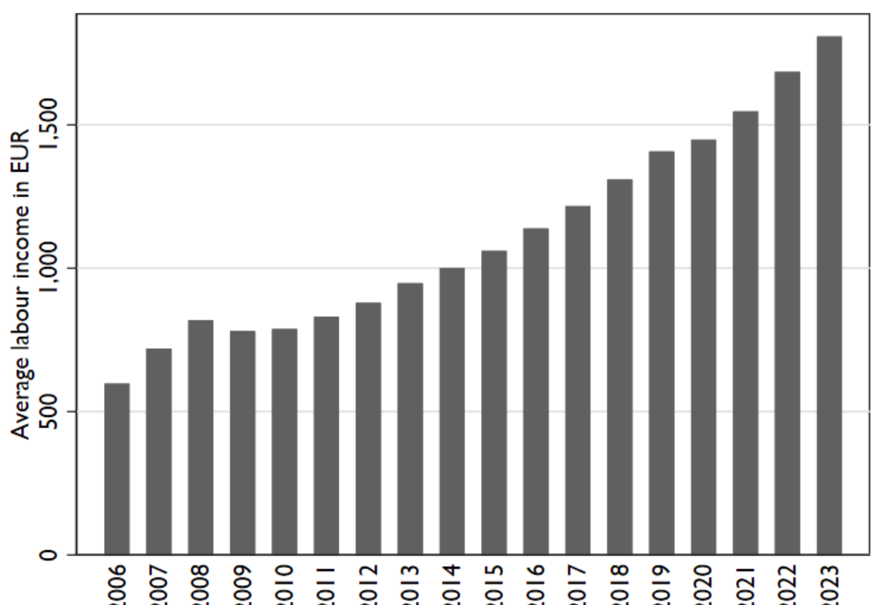

Figure B.2: Average labour income by Statistics Estonia in 2006-2023M9.

Table B.1: Labour income descriptives by permanent income group, 2008M1-2023M9

Income percentile from $t-13$ to $t-24$	(1) Mean income in 2015 prices	(2) Mid-point average income growth over 12 months	(3) Intensive margin growth over 12 months	(4) Entry rate over 12 months	(5) Exit rate over 12 months	(6) Number of observations
$[0-10)$	548.9	0.351	0.140	0.316	0.175	11,431,991
$[10-20)$	564.5	0.014	0.073	0.110	0.130	8,933,066
$[20-30)$	641.8	-0.053	0.045	0.066	0.111	8,677,750
$[30-40)$	747.1	-0.088	0.023	0.043	0.096	8,534,858
$[40-50)$	862.1	-0.101	0.010	0.029	0.084	8,494,491
$[50-60)$	992.0	-0.109	0.004	0.019	0.075	8,465,227
$[60-70)$	1147.2	-0.111	0.000	0.013	0.068	8,453,494
$[70-80)$	1349.0	-0.114	-0.005	0.009	0.063	8,446,902
$[80-90)$	1670.5	-0.117	-0.011	0.006	0.060	8,455,514
$[90-99)$	2558.4	-0.127	-0.021	0.004	0.058	7,617,517
$[99-99.9)$	5196.1	-0.138	-0.040	0.005	0.055	764,947
$[99.9-100]$	11183.0	-0.186	-0.062	0.006	0.070	86,012
All sample	1135.1	-0.032	0.022	0.070	0.095	88,361,769

Notes: Labour income is deflated by HICP in 2015 prices. Number of observations refers to the observations in the second, fourth and fifth column. The number of observations for the third column, intensive margin, is smaller and corresponds to observations where labour income was reported at time t and $t-12$.

C External validation: GDP Betas

Figures C.1 and C.2 show the GDP betas conditional on gender and age. The results are similar to that of the US. The labour income of men is more sensitive to aggregate growth than the one of women. Similarly to the US, we find that the youngest workers are the most sensitive to aggregate growth.

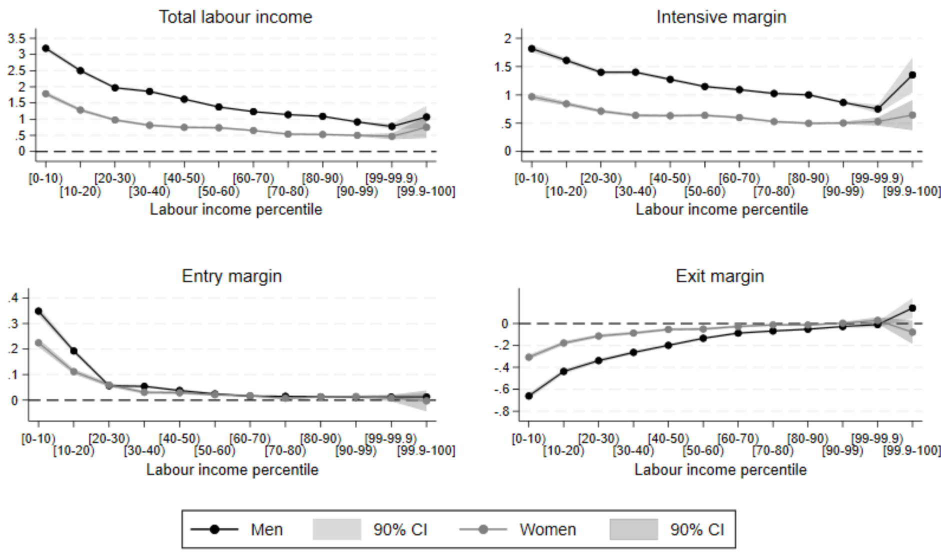

Figure C.1: GDP betas by income groups & gender, yearly data, 2008-2022.

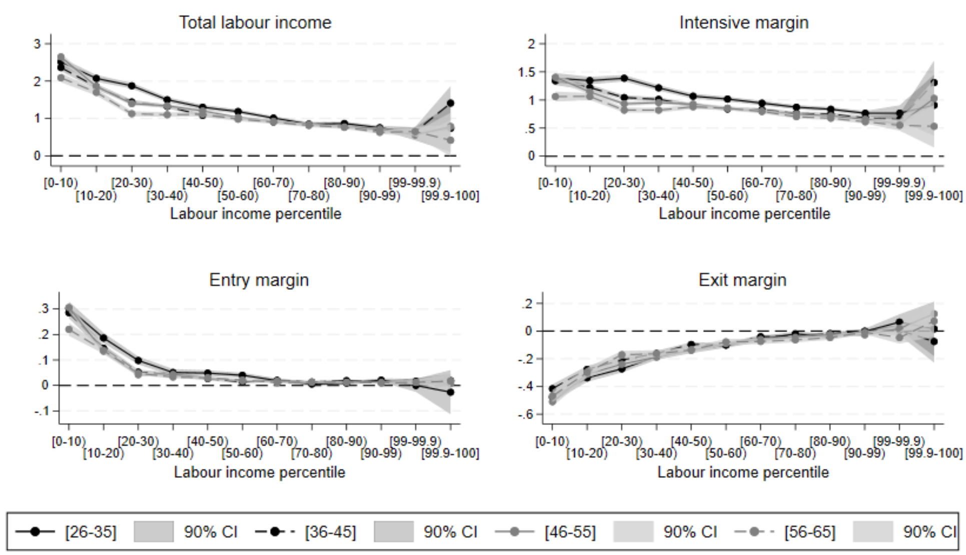

Figure C.2: GDP betas by income & age groups, yearly data, 2008-2022.

D Robustness Tests

D.1 Benchmark: Yearly versus Monthly Frequency

Figure D.1 shows the total impact and decomposition in intensive and extensive margins for an annual frequency. A comparison of the decomposition at monthly and annual frequencies, as shown in Figure D.2, highlights important differences. Specifically, it shows that the annual data substantially overestimates the intensive margin, as it misses a lot of within-year transitions into and out of employment. Thus, a majority of the monetary policy effect originates by construction from the intensive margin for the annual data. Consequently, the intensive margin at monthly frequency only accounts for half of the adjustment relative to annual data, as shown in Table D.1.

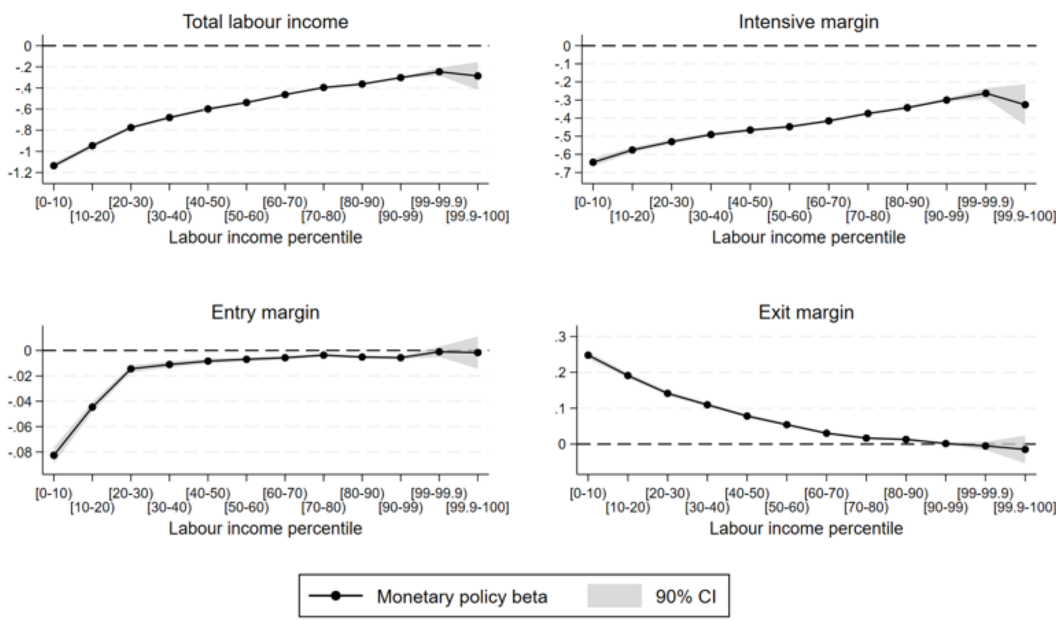

Figure D.1: The effect of monetary policy shock on labour income by income groups, comparison between monthly and yearly data, 2008-2022. The estimates at yearly frequency do not control for lagged GDP growth, because we cannot follow the same dynamic structure.

Table D.1 also demonstrates the economic size of the estimated effects. The shocks at monthly and yearly frequencies are not directly comparable because the expansionary and contractionary shocks cancel each other out at the yearly frequency. By standard deviation terms, the yearly shock is three times larger than the monthly shock (9.5 basis points versus 3.2 basis points). A one standard deviation contractionary shock reduces

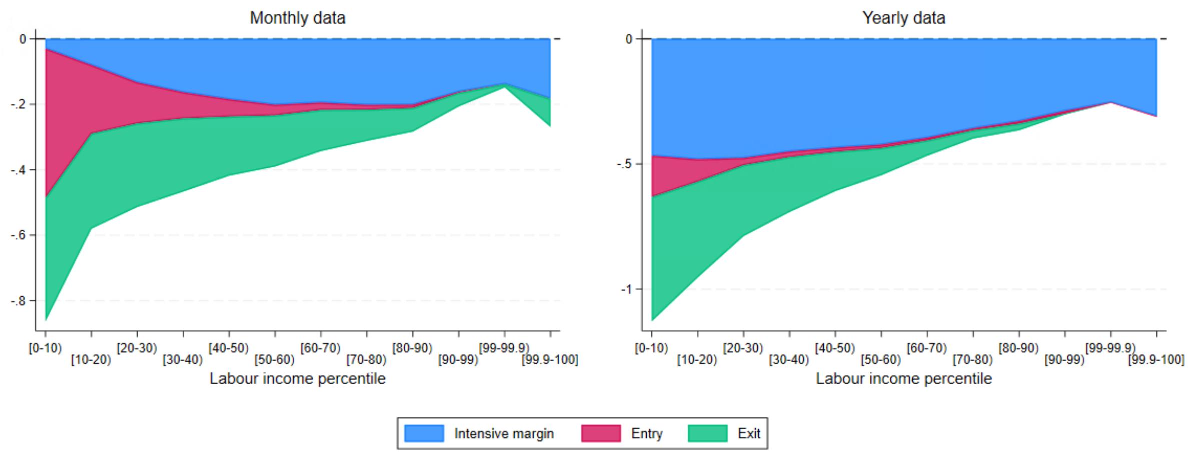

Figure D.2: Comparison of the decomposition in the different margins between monthly data (left panel) and annual data (right panel), 2008-2022.

real wage growth by month 12, the intensive margin, by 3.9% in our yearly data and by 0.5% in the monthly data. This estimate aligns with findings that monetary policy has a stronger pass-through in Estonia than in other euro area countries. For example, Hubert and Savignac (2024) find that a one standard deviation shock reduces total wage income, intensive margin, by 0.44% in French data at yearly frequency. Broer et al. (2022) estimate a 0.45% fall for the aggregate wage growth, intensive margin, with German monthly data. The number aligns with Almgren et al. (2022), who find the peak and cumulative effect of monetary policy in Estonia to be 6-7 times larger than in France and 2-3 larger than in Germany.

Table D.1: The effect of 1SD monetary policy shock on labour income by income groups

	Monthly frequency 2008M1-2023M9		Yearly frequency 2008-2022	
	(1) Total labour income	(2) Intensive margin	(3) Total labour income	(4) Intensive margin
[0 – 10)	-0.027***	-0.001***	-0.108***	-0.044***
[10 – 20)	-0.018***	-0.002***	-0.090***	-0.046***
[20 – 30)	-0.016***	-0.004***	-0.074***	-0.045***
[30 – 40)	-0.015***	-0.005***	-0.065***	-0.043***
[40 – 50)	-0.013***	-0.006***	-0.057***	-0.041***
[50 – 60)	-0.012***	-0.006***	-0.051***	-0.040***
[60 – 70)	-0.011***	-0.006***	-0.044***	-0.037***
[70 – 80)	-0.010***	-0.006***	-0.038***	-0.034***
[80 – 90)	-0.009***	-0.006***	-0.035***	-0.031***
[90 – 99)	-0.006***	-0.005***	-0.029***	-0.027***
[99 – 99.9)	-0.005***	-0.004***	-0.023***	-0.024***
[99.9 – 100]	-0.008***	-0.006***	-0.027***	-0.029***
All sample	-0.015***	-0.005***	-0.057***	-0.039***

Notes: Labour income is deflated by HICP in 2015 prices. 1SD corresponds to a 3.2 basis point shock at monthly frequency and a 9.5 basis point shock at yearly frequency. ***, ** and * refer to statistical significance at 1, 5 and 10% level based on Huber-White heteroscedasticity robust standard errors.

D.2 Extensions: Horizon Length, Gender and Age

We present further results for our benchmark specification here. We estimate with alternative horizons and condition the impact on age and gender.

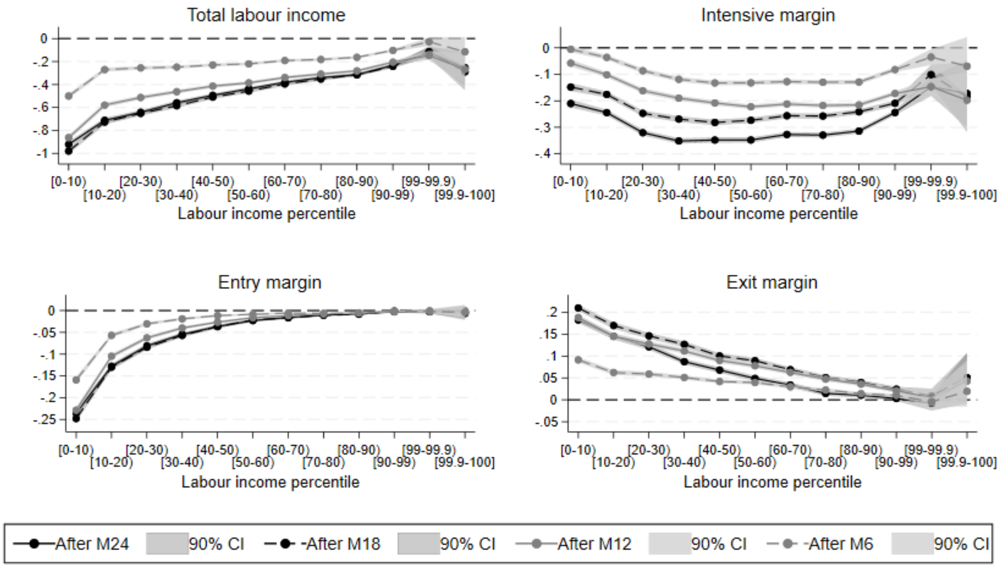

Figure D.3: The effect of monetary policy shock on labour income by income groups, local projections by month 6, 12, 18, 24, 2008M1-2023M9.

Figure D.4: The effect of monetary policy shock on labour income by income groups and gender, 2008M1-2023M9.

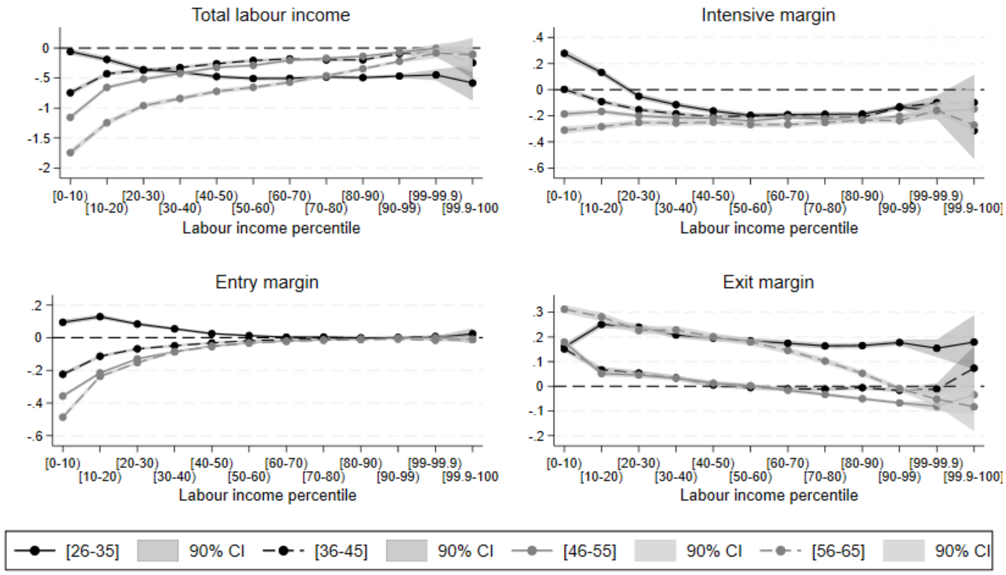

Figure D.5: The effect of monetary policy shock on labour income by income groups and age, 2008M1-2023M9.

D.3 Inflation Dependent Specification: Further Results

Here, we present further results for our inflation dependent specification.

Table D.2: The effect of 1SD monetary policy shock on labour income by income groups and inflation regime, 2008M1-2023M9

	Low inflation		High inflation	
	(1) Total labour income	(2) Intensive margin	(3) Total labour income	(4) Intensive margin
$[0-10)$	-0.005***	-0.001***	-0.055***	-0.002***
$[10-20)$	-0.005***	-0.001***	-0.028***	-0.004***
$[20-30)$	-0.005***	-0.001***	-0.024***	-0.008***
$[30-40)$	-0.004***	-0.001***	-0.021***	-0.010***
$[40-50)$	-0.003***	-0.001***	-0.019***	-0.011***
$[50-60)$	-0.003***	-0.001***	-0.019***	-0.013***
$[60-70)$	-0.002***	-0.001***	-0.017***	-0.012***
$[70-80)$	-0.002***	-0.001***	-0.016***	-0.013***
$[80-90)$	-0.001***	-0.001***	-0.015***	-0.013***
$[90-99)$	-0.001**	0.000**	-0.012***	-0.012***
$[99-99.9)$	0.001	0.000	-0.011***	-0.012***
$[99.9-100]$	0.002	0.002	-0.020***	-0.017***
All sample	-0.003***	-0.001***	-0.024***	-0.010***

Notes: Labour income is deflated by HICP in 2015 prices. 1SD corresponds to a 3.2 basis point shock. ***, ** and * refer to statistical significance at 1, 5 and 10% level based on Huber-White heteroscedasticity robust standard errors.

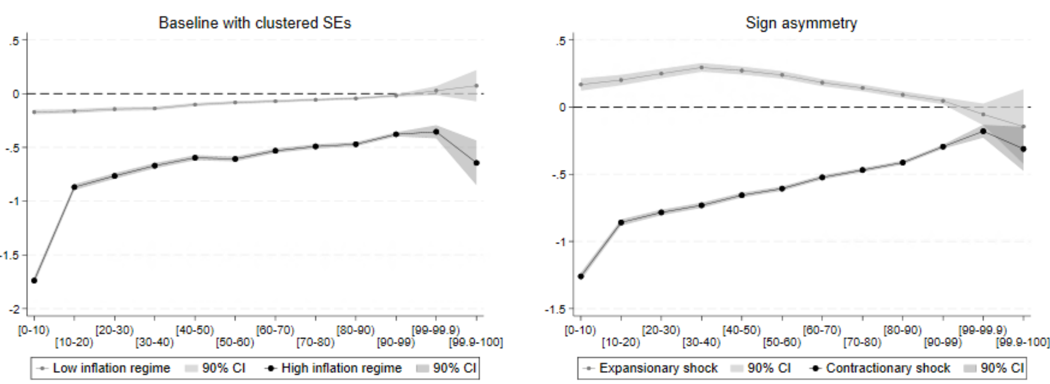

Figure D.6: The effect of monetary policy shock on total labour income for alternative empirical specifications, 2008M1-2023M9. Left panel: State dependent estimation with standard errors clustered at the individual level. Right panel: Impact of an accommodative (-100 bps) and contractionary (100 bps) shock.

E Aggregate Implications

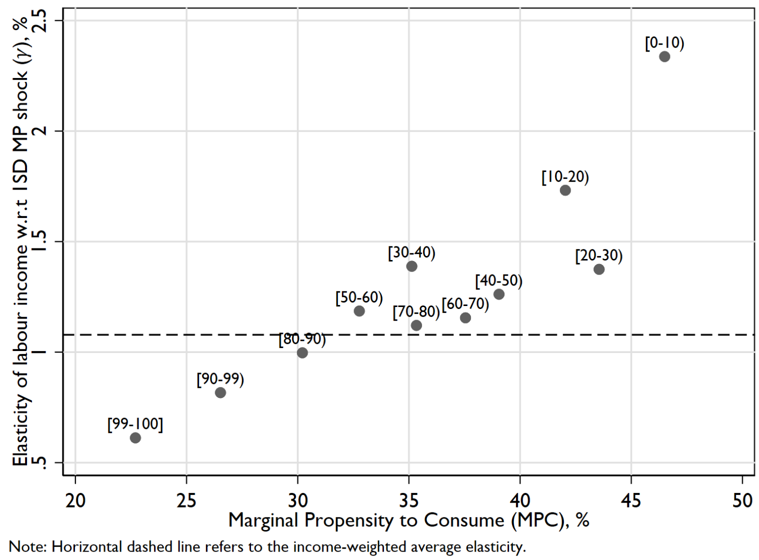

Figure E.1: MPCs and labour income elasticity with respect to monetary policy by income groups, simulation on HFCS data from 2021.

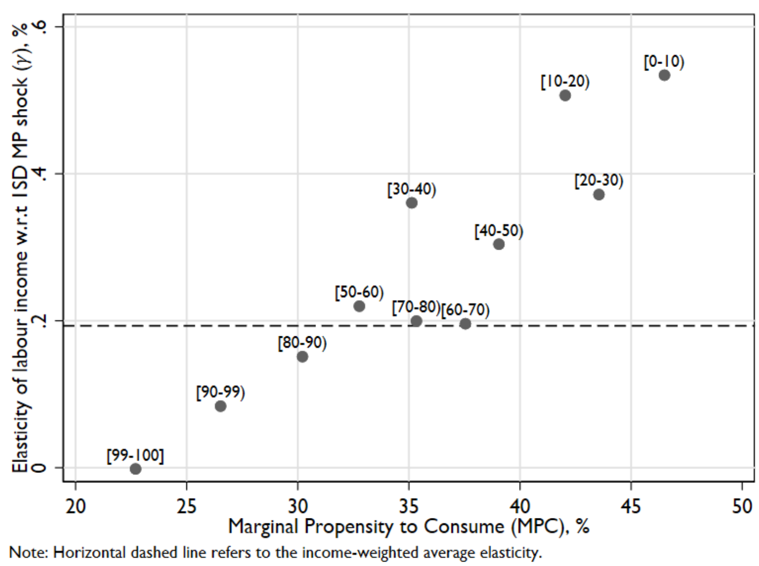

Figure E.2: MPCs and labour income elasticity with respect to monetary policy by income groups during low-inflation regime, simulation on HFCS data from 2021.

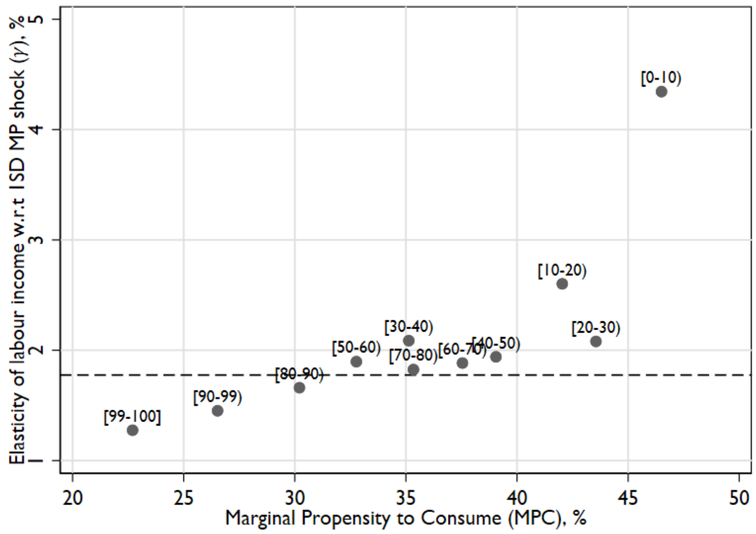

Figure E.3: MPCs and labour income elasticity with respect to monetary policy by income groups during high-inflation regime, simulation on HFCS data from 2021.

F Tractable HANK with Inflation Dependencies

F.1 Equilibrium Conditions

The set of equilibrium conditions is:

$$C_t^H = \Xi^H W_t N_t^H + \frac{\tau^D(\Pi_t)}{\lambda} D_t \tag{F.1}$$

$$C_t^S = \Xi^S W_t N_t^S + \frac{1-\tau^D(\Pi_t)}{1-\lambda} D_t \tag{F.2}$$

$$N_t^{H\varphi} = \Xi^H C_t^{H-\sigma} W_t \tag{F.3}$$

$$N_t^{S\varphi} = \Xi^S C_t^{S-\sigma} W_t \tag{F.4}$$

$$C_t^{S-\sigma} = \beta E_t \frac{R_t}{\Pi_{t+1}} \left(s C_{t+1}^{S\ -\sigma} + (1-s) C_{t+1}^{H\ -\sigma} \right) \tag{F.5}$$

$$\xi \frac{\Pi_t}{\Pi} \left(\frac{\Pi_t}{\Pi} - 1 \right) + \epsilon = \epsilon W_t + \xi \beta E_t \left[\left(\frac{C_{t+1}}{C_t} \right)^{-\sigma} \frac{\Pi_{t+1}}{\Pi} \left(\frac{\Pi_{t+1}}{\Pi} - 1 \right) \frac{Y_{t+1}}{Y_t} \right] + \mu_t \tag{F.6}$$

$$R_t = R \left(\frac{\Pi_t}{\Pi} \right)^{\phi_\Pi} + \zeta(\Pi_t) exp(\epsilon_t^{mp}) \tag{F.7}$$

$$mp_t = \rho_{mp} mp_{t-1} + \sigma_{mp} \epsilon_t^{mp} \tag{F.8}$$

$$D_t = Y_t - W_t N_t \tag{F.9}$$

$$C_t = \lambda C_t^H + (1-\lambda) C_t^S \tag{F.10}$$

$$N_t = \lambda N_t^H + (1-\lambda) N_t^S \tag{F.11}$$

$$Y_t = N_t, \tag{F.12}$$

$$Y_t = C_t \tag{F.13}$$

To capture varying degrees of heterogeneity, the share of taxed profits depends on the inflation environment:

$$\tau^D(\Pi_t) = \begin{cases} \tau_L^D & \text{if } \Pi_t < \bar{\Pi} \\ \tau_H^D & \text{otherwise} \end{cases}$$

Similarly, the impact of the monetary policy shock depends on the level of inflation:

$$\zeta(\Pi_t) = \begin{cases} \zeta_L & \text{if } \Pi_t < \bar{\Pi}, \\ \zeta_H & \text{otherwise} \end{cases}$$

F.2 Derivation of the firms' problem

The production sector consists of a competitive final good firm that combines intermediate goods, which are owned by the saver households. Intermediate firms use labour to produce output, which they sell to final good producers. They operate under monopolistic competition. The government implements a subsidy that induces pricing as in world without monopolistic competition. The subsidy is financed by the firms themselves. Finally, firms are paying quadratic adjustment costs a la Rotemberg.

Final output good Y_t is a CES aggregate of a continuum of intermediates j

$$Y_t = \left(\int_0^1 Y_t(j)^{\frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\epsilon}{\epsilon-1}} \tag{F.14}$$

The aggregate price level is given as

$$P_t = \left(\int_0^1 P_t(j)^{1-\epsilon} dj \right)^{\frac{1}{1-\epsilon}} \tag{F.15}$$

Intermediate firms produce with a constant returns to scale technology using labour:

$$Y_t(j) = N_t(j) \tag{F.16}$$

They face a downward sloping demand schedule from the final good firms' maximisation problem:

$$Y_t(j) = \left(\frac{P_t(j)}{P_t} \right)^{-\epsilon} Y_t \tag{F.17}$$

From the cost minimisation problem, we have

$$mc_t = W_t \tag{F.18}$$

Total profits of the firm are given as

$$D_t(j) = (1+\tau^S) \left(\frac{P_t(j)}{P_t} \right)^{1-\epsilon} Y_t - W_t N_t(j) - \frac{\xi}{2} \left(\frac{P_t(j)}{\Pi P_{t-1}(j)} - 1 \right)^2 Y_t - T_t^F \tag{F.19}$$

The taxes/transfer T_t depends on two components. T_t finances the subsidy τ^S per unit of output, but rebates the cost from the Rotemberg adjustment costs so that we have

$$T_t^F = \tau^S Y_t - \frac{\xi}{2} \left(\frac{P_t}{\Pi P_{t-1}} - 1 \right)^2 Y_t \tag{F.20}$$

We can now derive the New Keynesian Phillips curve:

$$\xi \frac{\Pi_t}{\Pi}\left(\frac{\Pi_t}{\Pi}-1\right) = (1+\tau^S)(1-\epsilon)+\epsilon mc_t+\xi\beta E_t\left[\left(\frac{C_{t+1}}{C_t}\right)^{-\sigma}\frac{\Pi_{t+1}}{\Pi}\left(\frac{\Pi_{t+1}}{\Pi}-1\right)\frac{Y_{t+1}}{Y_t}\right] \tag{F.21}$$

where we set $\tau^S = (\epsilon - 1)^{-}1$ to avoid a markup in the steady state.

Note also that as all firms behave the same, we have

$$Y_t = N_t \tag{F.22}$$

The dividends are given as

$$D_t = Y_t - W_t N_t \tag{F.23}$$

F.3 Global Solution Method

We solve the model in its fully nonlinear specification, accounting for both the low- and high-inflation regimes, using global solution methods. This involves numerically determining the steady state of the model, followed by time iteration to compute the policy functions and the equilibrium.

To find the steady state, we numerically solve for the steady state interest rate R, which enters the Taylor rule in the equilibrium conditions. A numerical root-finding algorithm is used to obtain the steady-state values. For the state-dependent structural parameter τ^D, we use its ergodic mean, computed based on the regime probabilities implied by the underlying Markov process.

For the global solution of the equilibrium, we employ a time iteration method based on Richter et al. (2014), which has also been used, for example, in Bianchi et al. (2021). Before solving for the equilibrium, we specify the state variables of the model: monetary policy shock mp_t and the markup shock μ_t. The policy functions are C_t^H, C_t^S, W_t, and Π_t.

To account for the binary nature of the markup shock, we use a piecewise approximation of the policy functions. That is, each policy function is defined separately for the low- and high-markup regimes. Expectations conditional on the realization of the markup shock are evaluated using Gauss-Hermite quadrature, while the expectations over future markup regimes are computed directly using the transition probabilities from the Markov process.

The time iteration algorithm employs the following steps:

1. We first discretise the grid for the continuous states, which is the monetary policy

shock. We also set up the integration nodes for the monetary policy shock

2. We guess the policy functions for our policy variables. Note that each guess consists of two parts to account for the different realisations of the markup shock. We use as a guess the steady state of the model.

3. We use our guess for the policy variables to solve the remaining variables in period t. We then calculate the continuous state variables at each integration node for both markup shock realisations. For each integration node and each markup shock realisation, we calculate the policy variables and solve the variables in period $t+1$. We then take the expectations, where we use the nodes and weights based on Haussian-Hermite quadrature for each markup shock realisation. The probability of the markup shock realisations is taken directly from the Markov transition matrix.

4. We then calculate the errors of the Euler equation of the savers, the budget constraint of the hand-to-mouth, the New Keynesian Phillips Curve and the market clearing.

5. We use a numerical root finder to minimise the Euler equation errors for the four equations by changing our policy function guess for period t.

6. We update the policy functions until convergence up to a sufficiently small error for the entire discretised state space.

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