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Master thesis

The Heterogenous Effects of Monetary Policy on Labor Income

Exploring the Extensive and Intensive Margin

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The R codes can be provided upon request.

Abstract

Studying the distributional effects of monetary policy has gained increased importance in monetary policy research in recent years. By utilizing detailed annual employer-employee and register-based data at the individual level on labor income and labor market transitions, this thesis will aim at estimating the distributional effects of monetary policy on *labor income* in Norway. Furthermore, this thesis aims to uncover the transmission channels by examining how changes in monetary policy impact labor income at the intensive and extensive margin. The main findings are that individuals at the bottom of the labor income distribution are more affected by a shock in the policy rate than individuals higher up on the labor income distribution. The findings mainly arise from the fact that individuals with lower incomes are more likely to exit the labor market following a contractionary monetary policy shock compared to those with higher incomes.

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1 Introduction

How does labor income respond to changes in the policy rate, and is the effect evenly distributed along the income distribution? Studying micro-level heterogeneity effects on labor income is important because of *welfare effects*, as low-income individuals tend to have a higher ratio of labor to capital income[1]. Thus, labor income movements are especially important to this group. It is also important to study because of *amplification effects*. Auclert (2019) decomposes different transmission channels of monetary policy and documents that earning heterogeneity amplifies the effects of the aggregate response of monetary policy (Auclert, 2019). The welfare and amplification effects underscore the importance of considering the heterogeneity in labor income movements when conducting optimal monetary policy. Moreover, Norges Bank states in its monetary policy strategy statement: "…the central bank must take into account income and wealth distribution in interest rate setting, among other reasons because it affects monetary policy transmission to aggregate demand." (Norges Bank, 2021).

By utilizing detailed annual employer-employee and register-based data at the individual level on labor income and labor market transitions, this thesis will aim at estimating the distributional effects of monetary policy on labor income in Norway. Furthermore, I aim to uncover the transmission channels by examining how changes in monetary policy impact labor income at the intensive and extensive margin. Changes in labor income of those continuously employed are *the intensive margin. The extensive margin* is work transitions out or to employment. To investigate the causal effect of monetary policy across the labor income distribution, I will use a contractionary monetary policy shock of 100 basis points constructed by Holm et al. (2021). The data used is register-based data on employment and employer-employee data from Norway from 2000 to 2014. Norway presents a good study environment due to the rich individual-level data. The Norwegian labor market is characterized by a high degree of employed individuals, low unemployment rates, high union membership rates, high wages and productivity, and high education levels (Bergsli, 2018). The population is divided into three groups based on their ex-ante labor income position: Bottom 50 percent, Middle 40 percent and Top 10 percent. This specific grouping is chosen because it assesses inequality development and allows the preservation of the sample size for estimation purposes (Hubert

[1] As documented by Holm et al., 2021, & Garbinti et al., 2018, & Andersen et al., 2021.

& Savignac, 2023). The analysis applied builds heavily on the analysis used by Hubert and Savignac (2023) and Amberg et al. (2022).

1.1 Results

The first result of this thesis is that the estimated effect of a contractionary monetary policy shock of 100 basis points on labor income in Norway is the largest for all income groups after four years. This is consistent with other research on labor income and monetary policy in Norway[2] and Sweden[3]. The effect is negative. The estimated effect is strongest at the bottom of the income distribution. Specifically, the bottom 50 percent experience a decrease of 1.3 percent in labor income relative to the group average after four years. In contrast, for the middle 40 and top 10 percent the estimated effect after four years is a decrease in labor income relative to the respective group average by approximately 0.4 percent.

Secondly, this thesis has analyzed the transmission of monetary policy to labor income. The documented heterogeneity in response to a contractionary shock arises primarily because monetary policy affects the extensive margin at the bottom of the income distribution. The bottom of the labor income distribution exits the labor market with a higher probability (increased separation rates) than the rest of the distribution after a shock in the policy rate. On the intensive margin, the strongest estimate is at the top 10 percent of the income distribution. This effect is related to a decrease in labor income, but they remain employed, suggesting either a wage decrease or a reduction in hours worked.

The outline of the rest of the thesis will be as follows: The remainder of Section 1 will be a literature review and contextualization of how my findings align with the existing literature. Section 2 describes the two main datasets that I combine to set up my analysis and theory on how monetary policy transmits to labor income. Section 3 describes the empirical framework. Section 4 estimates a baseline analysis of the framework built in section 4 and tests for the robustness of the results by modelling a fixed-effects model and evaluating an alternative grouping of the income groups. Section 5 investigates the response at the intensive and extensive margin. Section 6 concludes.

[2] Holm et al., 2022 document that the effect on labor income after a contractionary shock increases over the years.

[3] Andersen et al., 2021 document that the estimated effect tends to grow over time.

1.2 Literature review

Studying the distributional effects of monetary policy has gained increased importance in recent years (Amberg et al., 2022), partly due to the substantial rise in income inequality in developed countries over the last decades (Garbinti, 2018). Thus, a growing empirical literature exists on the effects of monetary policy on income inequality. As this thesis focuses on monetary policy's effect on *labor income inequality*, the most influential article is by Hubert and Savignac (2023). They use a similar baseline empirical framework as Amberg et al. (2022). Hence, the article by Amberg et al. is also influential for this thesis. Hubert and Savignac find that the effect of expansionary ECB monetary policy shocks on labor income in France is U-shaped along the labor income distribution using French-matched administrative-survey data (Hubert & Savignac, 2023). Consistent with my results, they find the largest effect of a monetary policy shock on labor income in the bottom 50 percent of the income distribution. At the extensive margin, the shock lowers the probability of unemployment the most for individuals in the bottom 50 percent, while it has no significant impact on the unemployment probability of people with higher labor income. The result from my thesis also estimates the most significant impact on unemployment probabilities at the bottom of the income distribution, but also positive and significant findings in the middle 40 percent. Hubert and Savignac show that for individuals continuously employed, at the intensive margin, the expansionary shock has a significantly positive effect only on the labor income of the top earners (ibid). The monetary policy shock disproportionally affects low-income individuals because they experience shifts in employment, while higher-income individuals are affected at the intensive margin but remain employed.

Amberg et al. (2022) analyze how total after-tax income responds to a monetary policy shock in Sweden and decomposes the effect into the three main components: labor income, capital income and transfer responses. Their dependent variable, total after-tax income includes transfer income (including pension income, unemployment insurance, student grants, parental benefits, sickness and disability insurance and income from job-training programs). Their income distribution is divided into quintiles depending on total after-tax income. Using administrative register data, they also find the U-shaped pattern (increase in total income of low-and high-income individuals relative to middle-income individuals) of the effect of monetary policy shocks on total after-tax income in the income distribution (Amberg et al., 2022). However, in the labor income response the effect is sizable at the bottom, while it is small and mostly insignificant at the middle and top of the distribution, in line with my findings. The small effect in labor income at the top of the distribution differs from Hubert and Savignac, who also found a sizable effect at the top of the distribution, but is consistent with my results. The effect on labor income at the bottom of the income distribution accounts for the strong total-income response of low-income individuals. In the top income distribution, the effect of monetary policy is due to disparities in capital income (ibid).

Another influential article is by Faia et al. (2023), which studies the distributional consequences of monetary policy through labor mobility. They use data from the Current Population Survey (CPS) for the United States and local projection methods. They find that contractionary monetary policy increases unemployment transitions, especially for bottom earners who remain out of the labor market (Faia et al., 2023). Bottom earners who remain in the labor market, the intensive margin, experience wage growth due to a selection effect. This selection effect leads to lower wage inequality and lower inequality to a contractionary monetary policy shock (ibid).

Borer et al (2021) find that income growth at the bottom of the income distribution is substantially more affected by monetary policy shocks than at the top of the income distribution in Germany using high-frequency administrative data (Borer et al., 2021). They find that the response of average earnings to a monetary policy shock is about three times as large at the bottom of the income distribution as the average response. They claim that poorer workers experience a stronger fall in the separation risk after an expansionary monetary policy shock.

In Denmark, Andersen et al. find that the effect of a monetary policy easing is increasing monotonically over income distribution by using individual-level tax records for the entire population in Denmark (Andersen et al., 2021). The top of the income distribution experiences higher business and stock market income, while the bottom has lower interest expenses. The effect on salary income is largest at relatively low-income levels, reflecting a sizable increase in employment for this group (ibid).

Back to Sweden, Coglianese et al. (2022) find that lower-earning workers are more sensitive to monetary policy shocks than higher-earning workers. They use a natural experiment (the Riksbank raised their interest rate substantially as the economy recovered from the Great Recession) to investigate how the labor market was affected. They find that bottom decile workers experience a 0.5 percentage point larger increase in unemployment than top decline workers. They use this result to state that "…indicating that the contractionary monetary policy shock exacerbates inequality". (Coglianese et al., 2022). This result is most present in unemployment among low-tenure, less-educated, and younger workers.

The results from the literature discussed above align with the results obtained from this thesis in that the largest effect of a monetary policy shock on labor income is found at the bottom of the income distribution. Consistent with Hubert and Savignac, Faia et al., Coglianese et al. and Broer et al. the results from this analysis find that the bottom 50 percent has a higher risk of separation following a monetary policy shock. In contrast to Hubert and Savignac, but similarly to Amberg et al. the analysis shows small, estimated effects on labor income at the top of the income distribution. The magnitude of my estimated effects is smaller in all income groups than that of Hubert and Savignac, as well as Amberg et al. for the bottom and top income groups.

3 Data and theory

The data used for this analysis combines register-based data on employment and employer-employee data. All registries contain unique identifiers at the individual level, allowing for linking information from multiple sources.

2.1 Register-based Data on Employment

The register-based employment statistics contain information about labor market status, gender, age, job characteristics, demographics, etc. The register-based employment statistics include residents in the age range 15-74 who have performed work for at least one hour during the reference week or who were temporarily absent from such work (Statistics Norway, 2023). The exception to this is individuals residing in Norway with a workplace abroad. From 2000 to 2014, the reference week was the third week of November (ibid).

2.2 Employer-employee data

The data for labor income consist of data from the employer-employee data. All employers that have employees or pay out wages, pensions or other benefits in Norway must register to the Norwegian Labour and Welfare Administration (NAV), Statistics of Norway and the Tax Authorities in accordance with "A-opplysningsloven" (A-opplysningsloven, 2012). The employer-employee data contains information from employers about employees' earnings, employment, and days worked, including other information. One benefit of this data is that it reports labor income pretax. The period of data is from 2000 to 2014. After 2014, there was a change in how the data was collected[4], and thus, the analysis for this thesis stopped in 2014, leaving the complete panel data to last 15 years. The data is not top-coded and includes all labor income for each worker (not including fringe benefits, which equals payments for job phone, work-related travel-cost, etc), such that I can investigate the top of the labor income distribution. Labor income is inflation-adjusted using the Consumer Price Index from Statistics Norway, where 2015 is the base year (2015 =100).

The first step of the analysis is to create a large panel data combining data from the register-based employment statistics with the employer-employee data. Combing the two datasets allows for studying the individual changes in annual labor income and labor market transitions.

2.3 Variable definitions

Employed individuals (follows the definition of Statistics Norway) are defined as an individual performing income-generating work for at least one hour in the reference week, as well as individuals who have such employment but were temporarily absent due to illness, vacation, paid leave, etc. (Statistics Norway, *Employment register-based*, 2023). For employed individuals with more than one employment during the reference week, one is determined as the primary employment (ibid). Information about individuals' job and company-related characteristics are only applied to the primary employment. The employment status of the main employer will be the employment status of all employers. I limit my data to include only individuals with up to three employers.

Unemployed individuals are defined as either "outside the workforce", "completely unemployed", or "not an employee". This is the individuals not employed. The dependent variable for the annual labor market transition is the change in individual employment. This transition equals zero when an individual is completely outside the labor market.

[4] After 2015 the data was merged to "A-ordningen".

Annual labor income is defined as the sum of all cash benefits from employer to employee per year, i.e. the total amount paid by an employer to an employee per year, including overtime compensations and fees, vacation pay and stock option benefits. Suppose an individual has multiple employers or holds more than one job simultaneously. In that case, the total annual labor income is equal to the sum of income from all employers, such that the annual labor income is one observation per year. If an individual is not present in the employer-employee data for a year and their employment status is set to either "outside the workforce", "completely unemployed" or "not an employee", then their labor income is set to zero that year.

2.4 Data manipulation and sample restriction

The dependent variable will be the change in labor income or labor market status at the individual level. The individuals are sorted into income categories, g, based on their ex-ante annual labor income. Dividing the individuals into income groups based on the lagged value of income guarantees that the grouping is not influenced by the shock in period t. The choice of the grouping; bottom 50 percent, middle 40 percent and top 10 percent, is, as mentioned, because it assesses inequality development and allows to preserve the sample size for estimation purposes (Hubert & Savignac, 2023). This way of grouping the income distribution is a common way of assessing income inequality. [5] The bottom 50 percent of the labor income distribution are those with income below the median. The middle 40 percent are those with labor income above the median but below the selected threshold for those in the top, the top 10 percent with the highest labor income. The income distribution is split into alternative groups in order to assess the results' robustness.

The finished panel data extends from 2000 to 2014 and contains 30 million observations, with one per individual per year and 3 million unique individuals. Furthermore, the panel data contain annual observations on the individual level, including employment status, labor income and days worked. One key feature of this structure is its ability to measure individual-level responses to changes in labor income resulting from a monetary policy shock over multiple years.

[5] See for example World Inequality Lab (2022) or The FED (2023).

The focus of this thesis will be on the labor force (people that are either employed or actively seeking employment). Individuals who are below the age of 30 and over the age of 67 are excluded from the sample to account for heterogeneity that arises from students and retired individuals. Each individual is observed with an average of 10 observation years, and the maximum observation years is 15 years, equal to the whole sample period. Those registered as self-employed throughout the estimation period are excluded from the analysis because these individuals account for heterogeneity and missing values and are therefore excluded from the analysis. Hubert and Savignac test for including and excluding the self-employed, and their results remain the same (Hubert & Savignac, 2023). The individual labor-income changes for each year are trimmed at 1%. For robustness, I check without trimming the data.

2.5 Descriptive statistics

Table 1: Descriptive statistics

	All	**Bottom 50**	**Middle 40**	**Top 10**
Mean Labor Income	334 139	131 811	448 988	886 383
% Women	52	65	44	17.5
Mean age	48	49	46.5	47
% Employed	76	56	97	98

Table (1) reports descriptive statistics for individuals in the respective income groups in the year t of the sample over the 2000 to 2014 period. The income groups are set in year *t-1*, such that in year *t* the groups include those who may have become unemployed and have zero labor earnings in year *t*. By comparing the mean income with statistics on income from Statistics Norway, the average labor income in the sample is in line with the average in Norway. The mean income is about six times as high in the top 10 percent compared to the bottom 50 percent. The bottom 20 percent of the income distribution has no labor income, and their income is derived from social insurance or other transfers. In this analysis, such income is assumed to be insensitive to the monetary policy shock. The employment rate is high (and higher than the average) in the top 50 percent while small (and smaller than the average) in the bottom 50 percent. The total mean employment rate is 76 percent, larger than the employment rate in Norway (approximately 70 percent for individuals between 15 and 74), due to the age restriction, which excludes, for instance, retired. The mean age in the different income categories does not differ substantially. There is, however, heterogeneity in the gender composition in the different income groups. There are more women in the bottom 50 percent than men and more men in the top 10 percent than women. Investigation of potential demographic heterogeneity in monetary policy is a natural extension of the analysis but will not be done further in this thesis. Evidence from Hubert and Savignac suggests that males and younger individuals are more affected by a monetary policy shock on labor income (Hubert & Savignac, 2023).

2.6 Monetary policy theory

Maintaining monetary stability is the main goal of the monetary policy conducted by the central bank. This is done by trying to keep inflation close to the inflation target of 2 percent over time. The inflation targeting is forward-looking and flexible to contribute to high and stable output and employment and counteracting the build-up of financial imbalances (Norges Bank, 2021). Monetary policy is transmitted in the economy by *direct* and *indirect effects*. *The direct effects* are effects through, for example, the intertemporal substitution; when real rates fall (or increase), households save less or borrow more (save more or borrow less) and therefore increase (decrease) their demand for consumption. *The indirect effects* are second-round general equilibrium effects created by the direct effects.

Monetary policy affects labor income through *the indirect income effect*. The indirect income effect is created by general equilibrium responses in households and firms' disposable income to a monetary policy shock. The indirect income transmission channel operates through a sequence of direct effects triggered by monetary policy, which subsequently impacts aggregated demand. When the policy rate increases, the direct effects of more expensive loans for households and firms lead to lower consumption and investment. This reduces the aggregate demand for labor, and thus puts downward pressure on employment and wages. Lower demand for labor leads to more unemployment. More unemployment means the workers have lower bargaining power in the wage settlements, which can reduce labor income. The indirect income effect is documented by Faia et al. to be stronger for bottom earners in the US and UK (Faia et al., 2023).

3 Empirical strategy

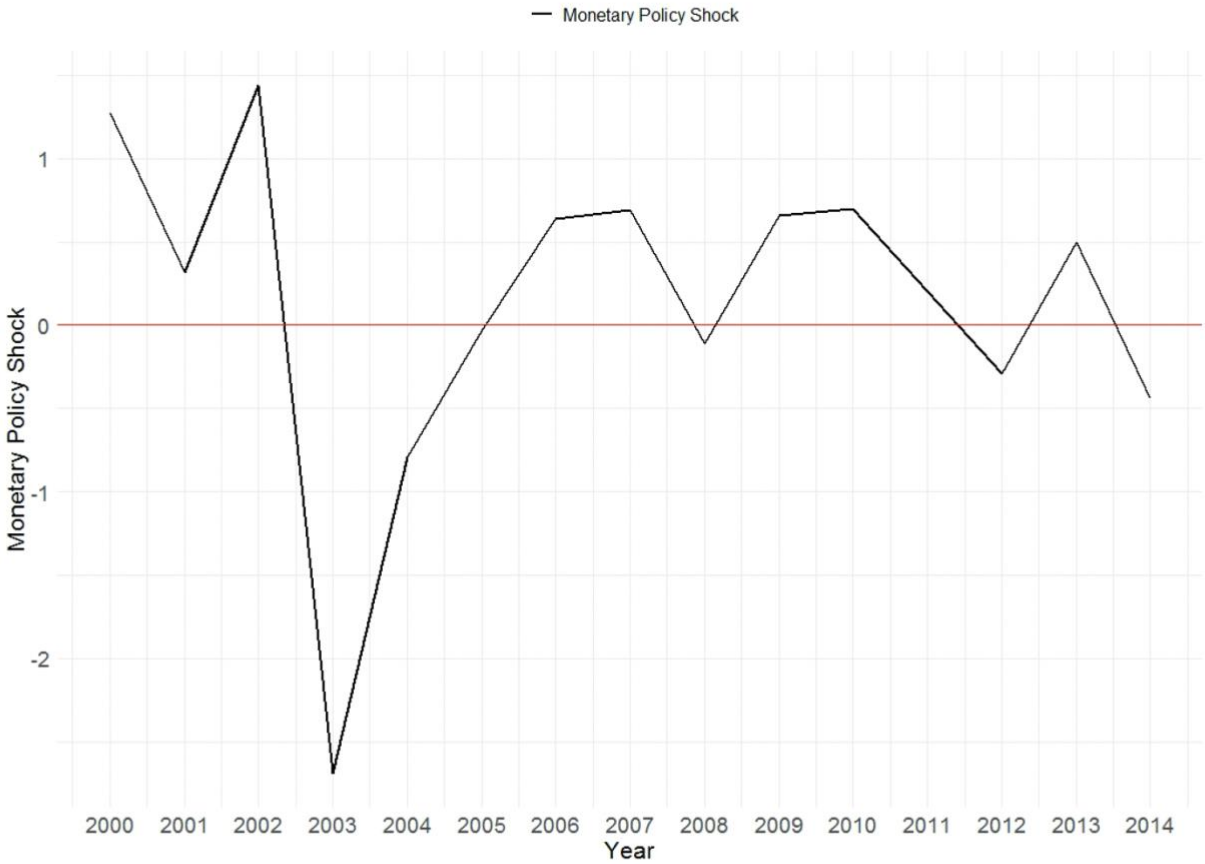
3.1 Monetary policy shocks

Monetary policy responds to the changes in the real economy. All other causes other than monetary policy should be restricted from affecting labor income while analyzing the effect of monetary policy on labor income. However, an obvious endogeneity problem occurs because labor income is also affected by real economic activity, similar to monetary policy. When the aggregated output in the economy is high, monetary policy might act as tightening to get the output gap down, while labor income may increase because of higher demand in the economy. To eliminate the endogeneity problem I use the series on monetary policy shock from Holm-Paul-Tischbirek (Holm et al., 2021), which is conducted from the methodology of Romer and Romer (2004). Since monetary policy responds to the economy, Holm-Paul-Tischbirek separates shocks in policy shifts from the bank´s normal responses to economic changes such that the resulting series overcomes monetary policy endogeneity. The identification strategy they use, allows for isolation of deviations in monetary policy from the normal response of the Norges Bank. This is achieved by using data from Norges Banks policy meetings. The series is constructed by removing the correlation between the policy rate changes and the central bank's forecasts of its economic targets. The resulting estimated residuals are a measure of monetary policy shocks.

$$\Delta i_m = \alpha_1 + \alpha_2 i_{m,-1} + \sum_{k=0}^{1} \beta_k^{\pi} \pi_{m,t+k} + \sum_{k=0}^{1} \beta^{\Delta\pi} \Delta\pi_{m,t+k} + \sum_{k=0}^{1} \beta_k^{y} y_{m,t+k} + \sum_{k=0}^{1} \beta_k^{\Delta y} \Delta y_{m,t+k} + \gamma_1 ex_{m,-1} + \gamma_2 I_m^{IT} \cdot ex_{m,-1} + \epsilon_m^{MP}, \quad (1)$$

From equation (1) the right-hand side is inputs of variables that determine the normal response to Norges Bank in the policy rate and residuals and the left-hand side is the monetary policy shock equal to the residuals. Δi_m is the change in the policy rate at meeting m, and $i_{m,-1}$is the previous policy rate before meeting m. The variables π and y measure the forecasts in output and inflation between meetings. Δy and Δπ measure the change in forecasts in output and inflation between each meeting. The variable ex measures the exchange rate the day before the meeting. I_m^{IT} is a dummy variable equal to one for the period prior to the inflation target. This term is also interacted with the exchange rate. The term for the residual ϵ_m^{MP}shows the unexplained changes (the shock or surprises in movements) in the policy rate associated with each policy meeting, which is equal to the monetary policy shock effect. The shock equals changes in the policy rate not made in response to the variables mentioned, e.g. the monetary policy committees' beliefs about how the economy is developing not related to the variables above. If the shock is positive, it represents a contractionary shock, if the shock is negative, it represents an expansionary shock.

Figure 1: Annual monetary policy shock



The figure shows the estimated effect for equation (1) where the dependent variable is the change in the policy rate at meeting m. The shock has annual frequency. The x-axis is the years used in the analysis; 2000 to 2014. The red line is shock equal to zero. The y-axis is the estimated Δi_m. [6]

3.2 The model

My empirical strategy follows closely from Hubert and Savignac (Hubert & Savignac, 2023), that perform analysis using an econometric model like Amberg et al. (Amberg et al., 2022):

$$\Delta Y_{i,t,h} = \mathbb{I}_{t-1}^{g} \cdot \left(\alpha_g + \beta_g \widehat{\Delta i_t}\right) + \varepsilon_{i,t} \tag{2}$$

[6] See Holm et al. for more information about the monetary policy shocks.

From equation (2) the left-hand side, $\Delta Y_{i,t,h}$, is the individual annual change in labor income between *t-1* and *t+h*. The dependent variable is defined in this way because log or log deviation would leave out negative numbers. Hubert and Savignac's dependent variable is a little bit different, where I subtract the lagged value of income the year before the shock Y_{t-1}, they subtract income the year of the shock Y_t. $\mathbb{I}_{t-1}^{g}$ is a dummy variable equal to 1 if the individual belong in the income group g={All, B50, M40, T10} in year *t-1*. α_g is the group-specific intercept, and Δi_t is the monetary policy shock in year t. β_g is the coefficient that captures the absolute change in labor income over an h-year horizon from individuals in income group g. β_g show how changes in income react to a change in the policy rate by one unit equal to 100 basis points. The standard errors are clustered at the individual level for robustness. When estimating the relative response in $\Delta Y_{i,t,h}$ compared to the income group, the dependent variable is of the following form:

$$\Delta Y_{i,t,h} = \frac{Y_{t+h}^{i} - Y_{t-1}^{i}}{\overline{Y^{G}}}$$

i.e the change in individual i's labor income $Y_{i,t}$between year *t-1* and *t+h* compared to a group mean $\overline{Y^{G}}$ that is set in year *t-1*. This way of creating the dependent variable allows for evaluating group differences. The dependent variable allows for negative/zero changes equal to average relative change in labor income in percentage.

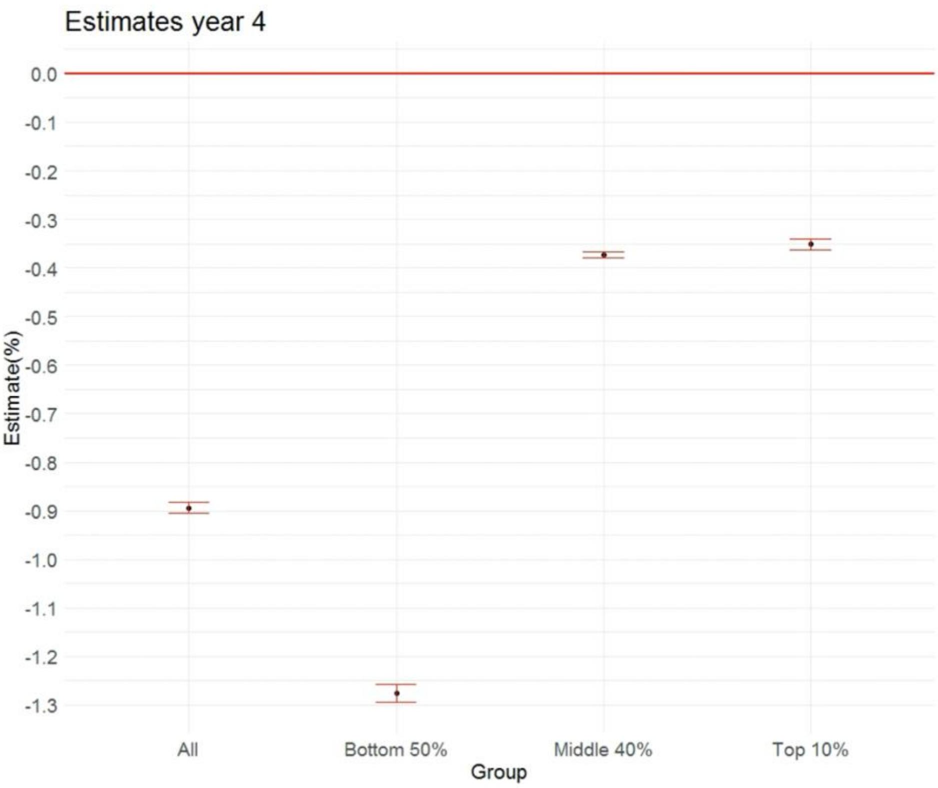
4 Distributional income effects of monetary policy

This section investigates the effect of a contractionary monetary policy shock on labor income. The four-year effect turns out to be the strongest. This is consistent with what was discussed in section 2.6 about monetary policy theory, that the general-equilibrium spillover effects through indirect transmission channels cause the changes in the labor income and that these effects take some years to reach their full effect. Year one shows positive estimates. Years two and three show small and both positive and negative estimates. The estimated four-year effect is the largest. In the fifth year, the estimated aggregate effect is smaller than the four-year effect, suggesting that the peak of the effect has been reached in year four. The coefficients for the relative change in labor income compared to a group mean from year one to four is included in the Appendix in Table 4 A.

Hubert and Savignac find that there are much more limited effects after two years compared to the one-year effect, especially for the bottom 50 percent. They claim that "the monetary policy effect on labor income is likely to occur mostly right after the shock and vanish afterwards" (Hubert & Savignac, 2023). The difference between this analysis and Hubert and Savignac's analysis could arise from differences in the labor market conditions in Norway and France. The wage settlement in Norway is once a year through collective bargaining and tripartite collaboration. This could result in a slower transmission of monetary policy on labor income in Norway compared to other countries. Romer and Romer also find that the impact of a contractionary monetary policy shock of a 100 basis points reaches the maximum impact on industrial production after 48 months (4 years) (Romer & Romer, 2004). Aggregated demand affects labor income through the indirect income effect, as mentioned; thus, labor income using some years to show its impact in Norway is not surprising.

4.1 Baseline estimates

Figure 2: Change in labor income to a 100 basis points contractionary monetary policy shock in relative to each groups average labor income in year 4



The figure shows the estimated effect for equation (2) in percentage, where the dependent variable is the change in individual i´s real labor income $Y_{i,t}$between year t-1 and t+h, where h=4, in % of each group's average labor income $\bar{Y}_{t-1}^{g}$. The x-axis is the different income *groups and the aggregate effect. The y-axis is the estimated β^g in % and their respective standard errors. The red line is β^g equal to 0 effect.*

Figure (2) shows the estimated effect of a contractionary shock of 100 basis points in year four. A one percentage point rise in the policy rate, not considering information about future economic developments following equation (1), decreases relative labor income for all income groups by approximately 0.9 percent. All four coefficients are statistically significant at a 1% level. The effect is not distributed equally over the income distribution. The shock decreases labor income most for the bottom 50 percent, who experience a decrease of 1.3 percentage points in labor income relative to the group mean. The estimated effect for the top 50 percent of the income distribution is more limited. The shock decreases labor income for the middle 40 percent of the income distribution by 0.37 percent relative to the group mean and by 0.35 percent for the top 10 percent relative to the group mean.

The estimated effects from Figure (2) do not exhibit the U-shape pattern that Hubert and Savignac observe. The estimated effect is smaller than the estimates from Hubert and Savignac and Amberg et al. This indicates that monetary policy shocks affect labor income inequality less in Norway than in France and Sweden. This might be due to institutional differences in the labor markets, such as wage settlements and union participation.

In this analysis, the strongest estimate in year four is found for the bottom 50 percent. Amberg et al. and Hubert and Savignac also find the strongest effect at the bottom of the income distribution. Amberg et al. documents small and insignificant effects on labor income at the top of the distribution. The documented effect shown in Figure (2) at the top of the income distribution is thus similar to Amberg et al. Amberg et al. investigate Sweden, and it is reasonable that the estimates in this thesis align more with their results than estimates from Hubert and Savignac, who investigated France. The estimated effects for those in the middle of the income distribution are also more present in this analysis, similar to Broer et al. (2021). The results of the individuals in the bottom 50 having a larger estimated effect may emerge from different general equilibrium effects in the different income groups. For instance, individuals working in low-income sectors, such as retail, hospitality and construction, may have a bigger income effect because the indirect income effects are stronger for these sectors. It is also likely that low-income individuals work more part-time and, thus, potentially, are offered fewer working hours in response to the shock through the decrease in aggregated demand. In section 5, I will investigate the transmission of the shock on labor income.

4.2 Estimates of labor supply

Faia et al. observe positive wage growth in UK and US households on the bottom of the income distribution after a contractionary monetary policy shock. In this analysis, the income effect after years one and two is positive for the bottom 50 percent, but negative in years three and four. The aggregate one-year effect is approximately a 0.6 percent increase in labor income relative to the group mean. In comparison, the bottom of the income distribution increases labor income by 1 percent in the first year (See Table 5 A in the Appendix). This estimate may be related to the bottom of the income distribution increasing their labor supply (by working more hours) to respond to the increase in the policy rate. The register-based data on employment includes information about individual hours worked. However, the variable has significant measurement errors (Halvorsen et al., 2022).[7] It is thus excluded from further analysis. However, since the positive estimates at the bottom of the income distribution are big and significant in the first two years, the theory of individuals at the bottom of the income distribution increasing their labor supply to account for a contractionary monetary policy shock deserves further investigation, maybe by applying a similar method as Halvorsen et al., that includes adding data from more sources. When running equation (2) with the dependent variable equal to the annual individual change in days worked (included in the employer-employee data) as a response to the contractionary shock, the results indicate that the bottom 50 percent of the income distribution increases their labor in the first two years to account for the increase in the policy rate, and more so than the top 50 percent. The increase in days worked is 4.8 in the first year and 4.3 days in the second year. The estimated effect for the top 50 percent is smaller and negative in the first year. The estimates from year two indicate that all income groups work more days in response to a contractionary shock in the second year after the shock. The estimated effects in years three and four are negative for all income groups, more so for the bottom 50 and 40 percent than for the top 10 percent. For the top 10 percent the estimates are insignificant in years 3 and 4, suggesting that days worked do not change to the shock for this income group.

[7] See Halvorsen et al. pages 8 to 11 for more information about the measurement errors in the variable for hours worked in the employer-employee data.

4.3 Robustness test

In order to determine whether the baseline results are robust, the income distribution is divided into an alternative grouping, a fixed effect model is considered, and the estimates are considered without trimming the sample at 1% and 99% on the difference in income between year *t-1* and *t+h*. The point estimates without trimming the data remain relatively similar. However, the point estimates for the bottom 50 percent and top 10 percent are bigger in magnitude, especially for the top. The standard errors are larger for the top 10 percent without trimming the data.

4.3.1 Alternative grouping

The alternative splitting of the income groups is by the bottom 40 percent and top 60 percent of the first lagged value of labor income. The alternative grouping confirms the results from figure (2). The estimates from equation (2) with the alternative grouping, the bottom 40 percent has a decrease in labor income after four years by 2 percent relative to the group mean. The estimated effect in the top 60 is smaller when estimating with the alternative grouping, with a decrease of 0.33 in labor income relative to the group mean. The results are included in Table 7 A in the Appendix. The original division of the income groups in the bottom 50 percent, middle 40 percent, and top 10 percent are likely to overestimate the estimates of the richest individuals in the bottom 50 percent.

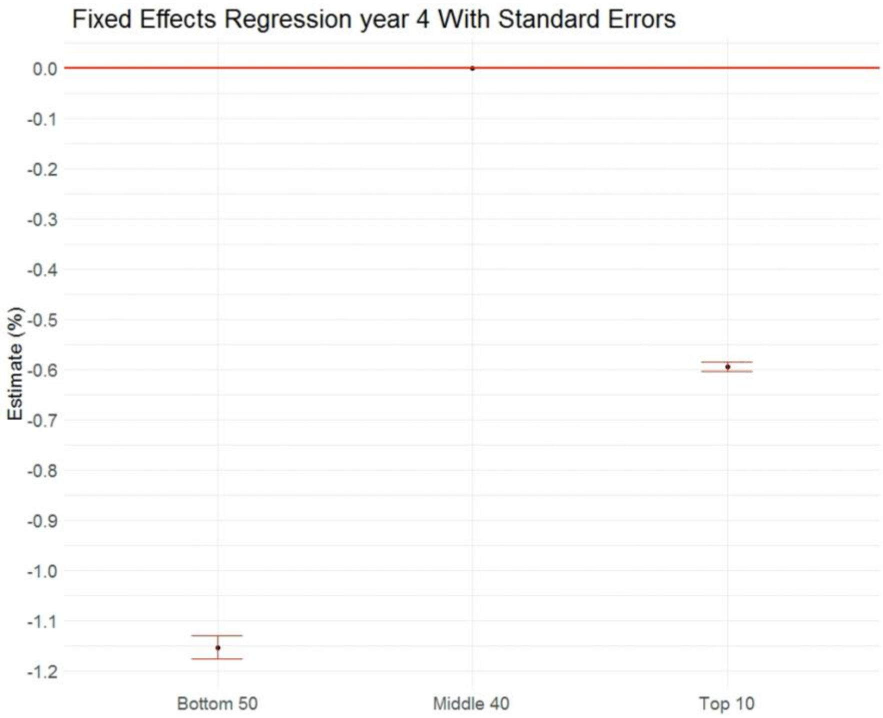
4.3.2 Fixed effects model

To check for time-invariant unobserved individual characteristics that might affect labor income, such as other macroeconomic shocks during a year, I also estimate a fixed effects model. The model is similar to Hubert and Savignac. The fixed effects model can be used to rule out other confounding factors that affect the estimates for labor income. If the results from a fixed effects model is very different from the baseline estimate, there could be a potential endogeneity problem.

$$\Delta Y_{i,t,h} = \beta_g\left(\widehat{\Delta i_t} \cdot \mathbb{I}_t^g\right) + \gamma_i + \gamma_t + \varepsilon_{i,t} \qquad (3)$$

Equation (3) estimates the marginal effect of monetary policy of labor income for individuals in the bottom or top of the distribution relative to a reference group, which in this case is the middle 40 percent. The reason for this is that I want to confirm the pattern observed in Figure (2). $\mathbb{I}_t^g$ equals one for individuals in the income group *g*={B50, T10} and zero for individuals in for the reference group, the middle 40 percent. β_g is the coefficient of interest that represents the effect of monetary policy on the groups top and bottom. γ_i and γ_t is the fixed effects variables, where the first represents the individual fixed effects and the second represents the time fixed effects. $\varepsilon_{i,t}$ is the residuals of the model which captures the unexplained variation in the dependent variable for individual *i* at time *t* after accounting for all the other variables and fixed effects.

Figure 3: Fixed effects



The figure shows the estimated effect of equation (3). The dependent variable is the change in individual i's labor income $Y_{i,t}$ between years t-1 and t+h compared to each group's mean income $\bar{Y}^g_{t-1}$. The estimated coefficient for the middle 40 percent is set to 0 by construction. The x-axis is the income groups; bottom 50 percent and top ten percent. The y-axis is the estimated β^g and their respective standard errors. The red line is β^g equal to 0 effect.

Figure (3) reports the marginal effects of monetary policy for individuals in the bottom 50 percent or top 10 percent relative to the middle 40 percent. The estimates suggest similar marginal effects for labor income in response to monetary policy for the bottom 50 percent of the income distribution compared to the baseline estimates. The estimated effect for the bottom 50 percent is a 1.15 percent decrease in labor income relative to the middle 40 percent, which is very similar to the baseline estimates. The estimate for the top 10 percent compared to the middle 40 percent is bigger in the fixed-effects model than in the baseline model. The estimated effect is a decrease of 0.7 percent relative to the middle 40 percent. This could be because there is some unobserved individual-specific time-invariant factor that may be correlated with both the independent variable and the dependent variable not accounted for in the OLS for the top 10 percent. Nevertheless, the pattern confirms that monetary policy shocks lead to larger effects on labor income at the bottom of the income distribution compared to the middle 40 percent in year four. The estimate suggests that factors other than monetary policy do not drive the baseline results. However, to properly assess the impact of the shock in the top 10 percent, more analysis is required since the effect from the baseline and fixed-effects models differ. The results from the fixed effects model indicate that the estimated effect in the top 10 percent may be underestimated in the baseline model.

5 The transmission channels of monetary policy

What causes the repones in labor income documented in section 4? This section will investigate the transmission of monetary policy on labor income by investigating the intensive and extensive margin. As mentioned in the introduction, I define the intensive margin as changes in income for those continuously employed, while the extensive margin is transitions to or from employment. The former measures how much to work, while the latter determines whether or not to work. Thus, it is insightful to understand the difference between the two.

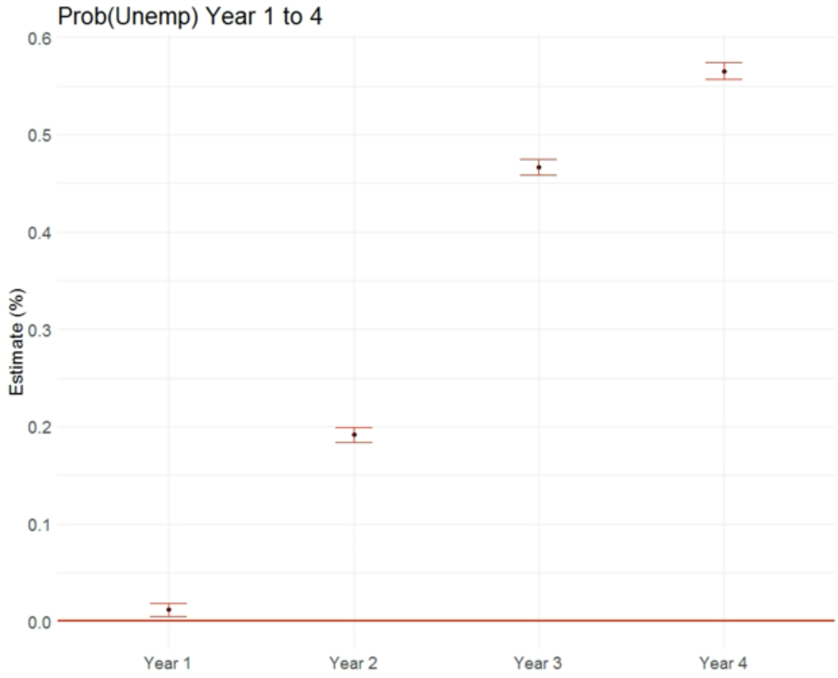
5.1 Impact of monetary policy shocks on the extensive margin

The extensive margin is the transitions in employment status between *t-1* and *t + h*.

$$\Delta \mathbb{I}_{i,t,h}^{Unemp} = \mathbb{I}_{t-1}^{g} \cdot \left(\alpha_g + \lambda_g \widehat{\Delta \iota_t}\right) + \varepsilon_{i,t} \tag{4}$$

$\Delta \mathbb{I}_{i,t,h}^{Unemp}$ is the individual transition from/to unemployment between *t-1* and *t+h*. The employment status is a dummy variable that equals one if the individual was unemployed at time *t-1*, and zero if employed. The dependent variable is the change in the employment dummy from period *t-1* to *t+h*. λ_g is the variable of interest and captures the effect of monetary policy shocks on the probability of transitioning to unemployment at time *t+h* for individuals in income group g.

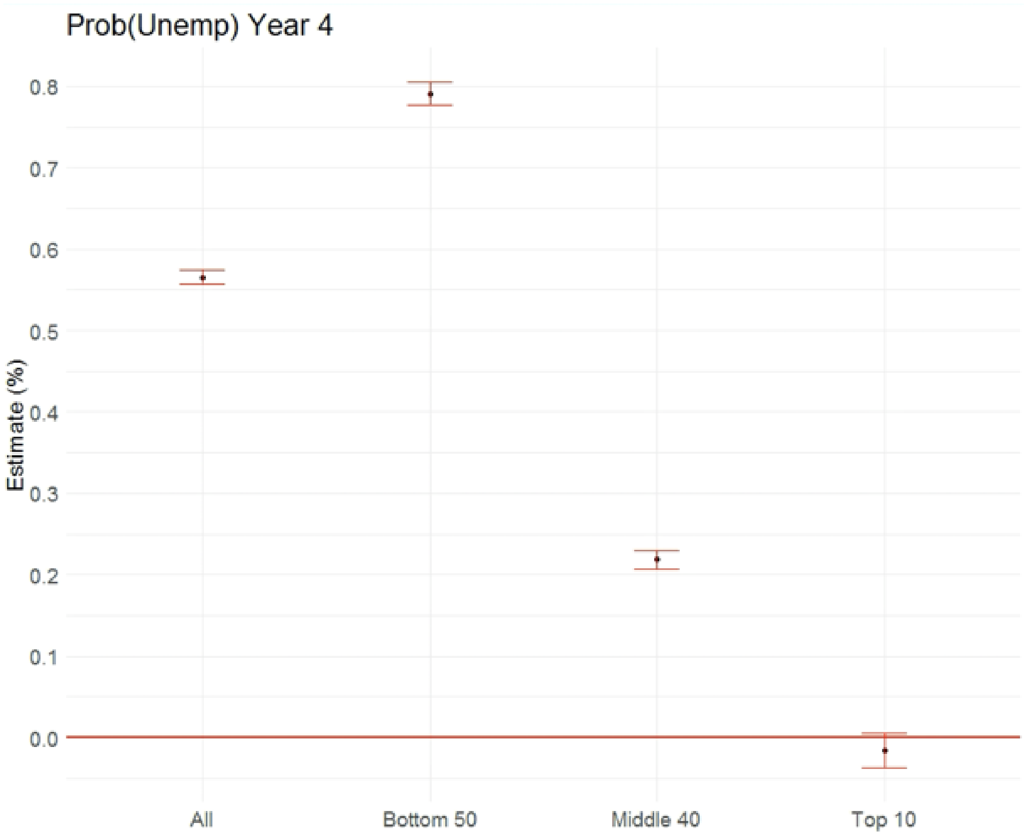
Figure 4: Extensive Margin year 1 to 4



The figure shows the estimated effect for equation (4). The x-axis is years 1 to 4. The y-axis is the estimated λ_g and their respective standard errors for the aggregated response of equation (4). The red line is $\lambda_g$equal to 0 effect.

Figure (4) reports the estimated λ_g for equation (4), the extensive margin where the dependent variable is the individual transition from/to unemployment. As seen from the figure, the aggregated estimated effect grows from years one to four. Years two to four all have the same estimated pattern; the bottom 50 percent have a larger probability of becoming unemployed. The effect is strongest in year four.

Figure 5: Extensive margin year 4



The figure shows the estimated effect for equation (4). The x-axis is the different income groups and the aggregate effect. The y-axis is the estimated λ_g and their respective standard errors. The dependent variable is the change in individual i's labor market status $\Delta\mathbb{I}_{i,t,h}$ between year t-1 and t+h where $\Delta\mathbb{I}_{i,t,h}$ is the annual change between employed and unemployed.

Figure (5) reports the estimated λ_g for equation (4), the extensive margin where the dependent variable is the individual transition from/to unemployment. As seen from the figure, the bottom 50 percent has a substantially larger probability of becoming unemployed than the other two income groups. The estimated effect for the top 10 percent is minimal and insignificant, while the bottom 50 percent has a probability of becoming unemployed of 0.8 percent after four years. The larger probability of becoming unemployed for the bottom 50 percent may be caused by this group working in jobs more vulnerable to unemployment due to an increase in the policy rate. As mentioned in the theory about the indirect income transmission channel, general equilibrium effects, such as households having less disposable income because of the shock, lead to households having less money for consumption. Thus, all jobs related to the consumption of goods (such as jobs in retail) may be more affected by these general equilibrium mechanisms. Because of this, the sectors that are the most affected by the shock experience higher separation rates than in other occupations. It can also be related to jobs in construction, where the construction of new houses is highly correlated with the policy rate. When the policy rate increases, loans become more expensive, and individuals thus cannot afford to buy new houses. Consequently, individuals working in construction may experience a higher probability of being laid off than individuals working in more high-income occupations, such as doctors or lawyers, where the general equilibrium response possibly is smaller. Doctor and lawyer services are likely more insensitive to a shock in the policy rate because health issues or legal needs are less influenced by the policy rate. Additional sectoral and occupational heterogeneity investigation is required to conclude with why low-income individuals are the most affected at the extensive margin.

The estimated effect of the probability of becoming unemployed is smaller than estimated by Coglianese et al. in Sweden to a contractionary monetary policy shock of 1 percentage point. Coglianese et al. find that the largest effect on the employment rate to a monetary policy tightening shock is after three years, where the unemployment rate increased by 2 percent after a one percentage points increase in the interest rate (Coglianese et al., 2022). The different responses in Sweden and Norway could be related to differences in the labor markets in Norway and Sweden. For instance, Sweden generally has a higher unemployment rate than Norway (Statistics Sweden, 2023).

5.2 Impact of monetary policy shocks on the intensive margin

The intensive margin equals the change in hours worked by individuals i^*condition on that the individuals has positive worked hours between *t-1* and *t* + *h*:

$$\Delta Y_{i^*,t,h} = \mathbb{I}_{t-1}^{g} \cdot \left(\alpha_g + \delta_g \widehat{\Delta \iota_t}\right) + \varepsilon_{i^*,t} \tag{5}$$

$\Delta Y_{i^*,t,h}$ is the change in labor income for individuals i^* with positive hours worked between *t-1* and *t+h*. $\Delta Y_{i^*,t,h}$ is individual annual change in labor income in percentage of the respective income groups labor income. $\delta_g$is the variable of interest and captures the effect of monetary policy shocks on labor income changes for individuals in income group g who have positive hours between *t-1* and *t+h.*

Figure 6: Intensive Margin

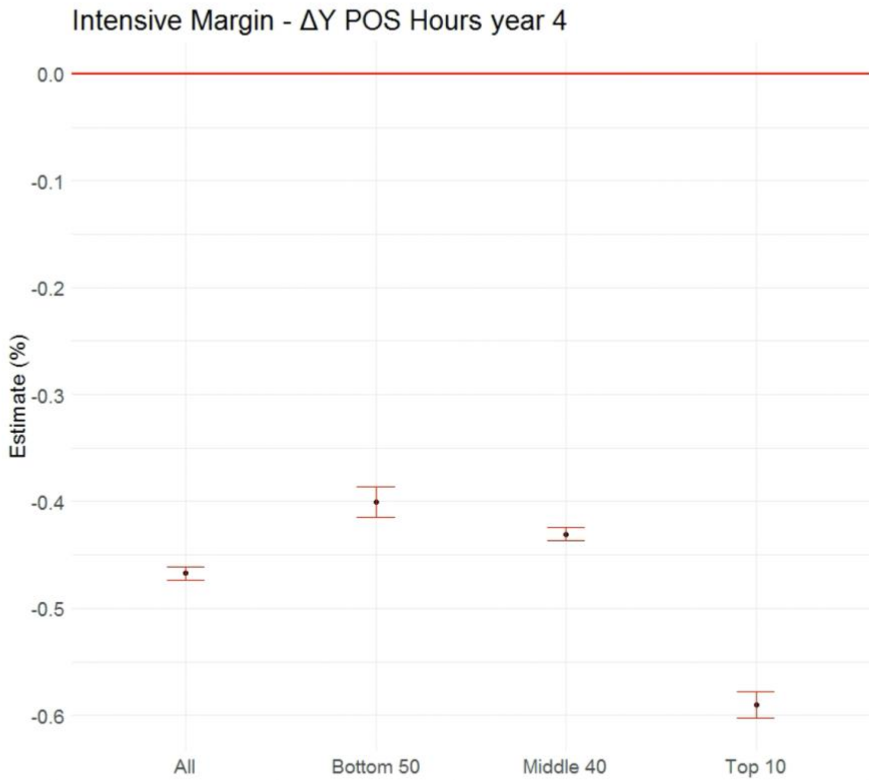


Figure 6 show the estimated effect, δ_g, of equation (5) for individuals with continuously positive hours worked from period t-1 to t+h. h = 4. The dependent variable is the change in individual i's labor income $Y_{i*,t}$between years t-1 and t+h compared to the group mean.*

Figure (6) reports the estimated δ_g from equation (5) for individuals with positive hours from period *t-1* to *t+h*. The result remains the same if restricting on employment throughout the period. The estimated aggregate effect of those continuously employed is approximately a 0.5 percent decrease in labor income. Compared to the overall estimated effect (0.9 percent) the decrease for those employed the whole period is smaller, suggesting that the labor market transitions account for over 1/2 of the overall effect of labor income. The results are less heterogenous than the response in labor income for everyone.

The results suggest that the estimates of labor income for individuals with continuously positive hours are mostly affected at the top of the income distribution, either because they work less or get lower wages. This could imply different price-setting mechanisms at the jobs that the top of the income distribution inhabits. A possible explanation is that the spill-over effects for individuals at the top of the income distribution are larger than at the bottom. For example, individuals at the top may decrease their performance-based income, such as bonuses. Figures (5) and (6) imply that the full overall effect on labor income for the top 10 percent is because of a wage decrease, not because they increase separations. For the bottom of the income distribution, the estimates for those with positive hours in the period *t-1* to *t+h* are smaller than the estimates for everyone. This implies that the changes in employment account for most of the overall effect on labor income for the bottom 50 percent.

The results are in line with the results from Hubert and Savignac, who finds that expansionary monetary policy shock has a significant effect on labor income of only top earners on the intensive margin (Hubert & Savignac, 2023), and also similar to Broer et al. which finds that the estimates of the individuals continuously employed are substantially smaller in magnitude and less heterogenous (Broer et al., 2021).

The results from Figure (5) and (6) shows that the pattern observed in Figure (2) is primarily driven by the extensive margin at the bottom of the income distribution. The increase in separation rates accounts for more than half of the overall effect on labor income at the bottom 50 percent of the income distribution.

6 Conclusion

In this thesis, I have examined the effect of monetary policy on labor income and investigated how the effect is distributed in the labor income distribution. The analysis has been done by using register-based data on employment and employer-employee data. First, I estimated the effect on labor income to a contractionary shock of 100 basis points. Furthermore, I tested for the robustness of the results and found some unobserved heterogeneity in the top 10 percent of the income distribution. Then I investigated the transmission of monetary policy on labor income, focusing on the intensive and extensive margins. The estimated effect on labor income is heterogeneous depending on where the individual is in the income distribution. The results suggest that the estimates of a contractionary monetary policy shock on labor income are most severe at the bottom of the income distribution. The effect results from the bottom 50 percent of the income distribution increasing their probability of becoming unemployed to the shock (increased separation rates). For the individuals continuously employed in between periods *t-1* and *t+4* (at the intensive margin), the shock has the most effect for the top 10 percent. The response at the intensive margin is more heterogeneous.

The results from this thesis make two prominent suggestions for further research. One is other causes of heterogeneity at the micro level, especially sectoral and occupational heterogeneity, as well as the effect on high- and low-skilled workers and demographic heterogeneity. Some sectors and workers in the different income groups are likely more sensitive to the effects estimated in this thesis. The second suggestion for further research is the role of labor supply and monetary policy. My results on the role of labor supply suggest that more examination might yield interesting findings, especially in the first two years after the shock.

To conclude, this thesis has documented inequality in the labor income response to a monetary policy shock, where the bottom of the labor income distribution responds more strongly. What are the policy implications of such a result, and how much should the central bank consider inequality in labor income when conducting optimal policy? The answer remains open to more investigation, but based on the welfare and amplification effects, more labor income inequality as an implication of monetary policy cannot be disregarded when conducting optimal monetary policy, one reason being that it has implications for the transmission of monetary policy.

7 References

Amberg, Niklas, Thomas Jansson, Mathias Klein, and Anna Rogantini Picco. (2022). Five Facts about the Distributional Income Effects of Monetary Policy Shocks. *American Economic Review: Insights, 4 (3):* 289-304.

Andersen, A,L., Johannesen, N. Jørgensen, M. & Peydró, J-L. (2021). Monetary Policy and Inequality. *Economics Working Papers 1761, Department of Economics and Business, Universitat Pompeu Fabra.*

Auclert, A. (2019). Monetary Policy and the Redistribution Channel. *American Economic Review, 109*, 2333-2367.

Bergsli, A.T. (2018). Arbeidsmarkedet i tall og fakta. *Forskningsstiftelsen Fafo.* Retrived from: https://www.arbeidslivet.no/arbeid/arbeidsmarkedet/arbeidsmarkedet-i-tall-og-fakta

Broer, T. Kramer, J. Mitman, K. (2022). The curious Incidence of Monetary Policy Shocks Across the income Distribution. *SVERIGES RIKSBANK WORKING PAPER SERIES, 416.*

Cogliansese, J. Olsson, M. (2023). Monetary Policy and the Labor Market: A Quasi-Experiment in Sweden. *RESEARCH / BFI WORKING PAPER, NO. 2023-123.*

Faia, E., Kudlyak, M., Shabalina, E. & Wiczer, D. (2023). MONETARY POLICY AND WAGE INEQUALITY: THE LABOUR MOBILITY CHANNEL. *CEPR Discussion Papers 17741, C.E.P.R. Discussion Papers.*

Garbinti,B. Goupille-Lebretb, J. & Piketty, T. (2018) Income inequality in France, 1900–2014: Evidence from Distributional National Accounts (DINA). *Journal of Public Economics.* Volume 162, June 2018, Pages 63-77.

Halvorsen, E. Holter, Hans, A. Ozkan,S. Storesletten, K. (2022). Dissecting Idiosyncratic Earnings Risk. *FEDERAL RESERVE BANK of ST. LOUIS. Earnings Risk. Working Paper 2022-024C.*

Holm, M., Paul, P., & Tischbirek, A. (2021). The Transmission of Monetary Policy under the Microscope. *Journal of Political Economy, 129,* 2861-2904.

Hubert, P. & Savignac, F. (2023). Monetary Policy and Labor Income Inequality: the Role of Extensive and Intensive Margins. *Bank of France. Working Paper Series, 913.*

Lov om arbeidsgivers innrapportering av ansettelses og inntektsforhold m.m. (2012). A-opplysningsloven (LOV-2012-06-22-43). Lovdata. https://lovdata.no/dokument/NL/lov/2012-06-22-43

Norges Bank. (2021). Norges Bank's monetary policy strategy statement. Retrived from: https://www.norges-bank.no/en/topics/Monetary-policy/monetary-policy-strategy/

Romer, C, D. & Romer, D. (2004). A New Measure of Monetary Shocks: Derivation and Implications. *American Economic Review, 94,* 1055–1084.

The FED. (2023, 22. September) *Distribution of Household Wealth in the U.S. since 1989*. https://www.federalreserve.gov/releases/z1/dataviz/dfa/distribute/table/

Statistics Norway. (2023). *Consumer Price Index.* Retrieved from: https://www.ssb.no/priser-og-prisindekser/konsumpriser/statistikk/konsumprisindeksen

Statistics Norway. (2023). *Employment, register-based.* Retrieved from: https://www.ssb.no/arbeid-og-lonn/sysselsetting/statistikk/sysselsetting-registerbasert

Statistics Sweden. (2023). Labour Force Surveys (LFS). Retrived from: https://www.scb.se/en/finding-statistics/statistics-by-subject-area/labour-market/labour-force-surveys/labour-force-surveys-lfs/

WORLD INEQUALITY LAB. (2022). *World Inequality report.* Retrieved from: https://wir2022.wid.world/category/glossary/,

Appendix

Table 2 A: Annual Monetary Policy Shock

Year	MP shock
2000	1,27
2001	0,32
2002	1,44
2003	-2,69
2004	-0,79
2005	-0,03
2006	0,64
2007	0,69
2008	-0,11
2009	0,66
2010	0,70
2011	-0,51
2012	-0,29
2013	0,50
2014	-0,44

Table 3 A : Effect of a 100 basis points contractionary monetary shock on labor income year 4

	All	Bottom 50	Middle 40	Top 10
MP shock year 4	-1612***	-1586***	-1809***	-7241***
	(17)	(26)	(41)	(368)
N (in millions)	26.8	13.6	10.9	2.7

*Table for estimation results for equation (2) where the dependent variable is the change in individual i´s real labor income $Y_{i,t}$ between year t-1 and t+h, where h=4. Standard errors are reported in parenthesis. P-value is reported in stars, where * is equal to p-value < 0.5, ** is equal to p-value< 0.01 and *** is equal to p-value< 0.001.*

Table 4 A: Effect of a 100 basis points contractionary monetary shock on labor income year 1 to 4

	All	Bottom 50	Middle 40	Top 10
β_{t+1}^{g}	0.0064***	0.0099***	0.0041***	0.0031***
	0.00015313	(0.0003)	(0.0001)	(0.0002)
β_{t+2}^{g}	-0.0005 ***	0.0012***	-0.0011***	-0.0019***
	(0.0001)	(0.0002)	(0.0001)	(0.0001)
β_{t+3}^{g}	0.0015***	0.0019***	0.0016***	0.0010***
	(0.0001)	(0.0002)	(0.0001)	0.0001
β_{t+4}^{g}	-0.0089***	-0.0128***	-0.0037***	-0.0035***
	(0.0001)	(0.0002)	(0.0001)	(0.0001)

*Table for estimation results for equation (2) where the dependent variable is the change in individual i´s real labor income $Y_{i,t}$between year t-1 and t+h in % of each group mean labor income, where h=4. Standard errors are reported in parenthesis. P-value is reported in stars, where * is equal to p-value < 0.1, ** is equal to p-value< 0.05 and *** is equal to p-value< 0.001*

Table 5 A: Change in days worked years 1 to 4

	All	Bottom 50	Middle 40	Top 10
β_{t+1}^{g}	1.84***	4.82***	-0.67***	-1.02***
	0.078945)	(0.11623)	(0.11653)	(0.17981)
β_{t+2}^{g}	2.61***	4.33***	1.66***	0.90***
	(0.086984)	(0.12966)	(0.12445)	(0.19601)
β_{t+3}^{g}	-4.36***	-4.99***	-2.39 ***	-0.050
	(0.10389)	(0.15969)	0.13895	(0.217262)
β_{t+4}^{g}	-5.44***	-5.07 ***	-3.74***	-0.03
	(0.11419)	(0.18145)	(0.14635)	(0.223472)

*Table for estimation results for equation (2) where the dependent variable is the change in individual i´s days worked $Y_{i,t}$between year t-1 and t+h, where h=4. Standard errors are reported in parenthesis. P-value is reported in stars, where * is equal to p-value < 0.1, ** is equal to p-value< 0.05 and *** is equal to p-value< 0.001*

Table 6 A: Effect of a 100 basis points contractionary monetary shock on labor income year 4 without trimming the sample at 1% at the top and bottom.

	All	**Bottom 50**	**Middle 40**	**Top 10**
β^{g}_{t+4}	-0.0101***	-0.0139***	-0.0040***	-0.0081***
without trimming	(0.0001)	(0.0002)	(0.0001)	(0.0004)

*Table for estimation results for equation (2) where the dependent variable is the change in individual i´s real labor income $Y_{i,t}$between year t-1 and t+h in % of each group mean labor income, where h=4. Standard errors are reported in parenthesis. P-value is reported in stars, where * is equal to p-value < 0.1, ** is equal to p-value< 0.05 and *** is equal to p-value< 0.001*

Table 7 A: Alternative Grouping: Effect of a 100 basis points contractionary monetary shock on labor income year 4

	Bottom 40%	**Top 60%**
MP shock	-0.0199***	-0.0033***
year 4	(0.0003)	(0.0001)
N (in millions)	11	16

*Table for estimation results for equation (2) where the dependent variable is the change in individual i´s real labor income $Y_{i,t}$between year t-1 and t+h in % of each group mean labor income, where h=4. Standard errors are reported in parenthesis. P-value is reported in stars, where * is equal to p-value < 0.1, ** is equal to p-value< 0.05 and *** is equal to p-value< 0.001. Trimmed at 1% at the difference in income from t-1 to t+h.*