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Working Paper

The impact of (un)conventional expansionary monetary policy on income inequality - Lessons from Japan

Working Paper, No. 163

Provided in Cooperation with:

University of Leipzig, Faculty of Economics and Management Science

Suggested Citation: Israel, Karl-Friedrich; Latsos, Sophia (2019) : The impact of (un)conventional expansionary monetary policy on income inequality - Lessons from Japan, Working Paper, No. 163, Universität Leipzig, Wirtschaftswissenschaftliche Fakultät, Leipzig

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Wirtschaftswissenschaftliche
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Management Science

Working Paper, No. 163

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**The Impact of (Un)Conventional
Expansionary Monetary Policy on
Income Inequality –
Lessons from Japan**

November 2019

ISSN 1437-9384

The Impact of (Un)Conventional Expansionary Monetary Policy on Income Inequality – Lessons from Japan

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Abstract

This paper analyzes the impact of conventional and unconventional monetary policy on income inequality in Japan, using hitherto unexplored data from the Japan Household Panel Survey. Empirical evidence shows that expansionary monetary policy in Japan has contributed to diminishing the gender pay gap, but also to increasing the education pay gap. These effects may have materialized via the aggregate demand channel and the labor productivity channel. In contrast, expansionary monetary policy has had no significant impact on the development of the age pay gap.

JEL-Code: D31, D63, E52, E58

Keywords: Income inequality, Japan, monetary policy, low interest rate policy, unconventional monetary policy, monetary easing

I. Introduction

Increasing inequality in terms of income and wealth in developed countries has been documented widely in the literature. Even in Japan, whose income distribution has been regarded as relatively equal compared to other OECD countries, income inequality has increased (Lise et al., 2013). These developments have become a concern as increasing inequality may reduce economic growth (OECD, 2014), contribute to financial instability (Rajan, 2010; Bordo and Meissner, 2012; Kumhof et al., 2015), or increase social conflict due to lower social mobility (Wilkinson and Pickett, 2009; Corak, 2013; OECD, 2014).

Various potential drivers of inequality have been identified. For example, technological change, globalized production and trade may raise income inequality due to a skill-biased effect on the income distribution in advanced economies (Goldberg et al., 2007; Meschi et al., 2009; Bergh et al., 2010). Yet, empirical evidence on these effects is not clear-cut (Edwards, 1997; Kraay, 2006; Jaumotte et al., 2008; Feenstra and Hanson, 2008; Roine et al., 2009; Gimet et al., 2011; OECD, 2011; Alvaredo et al., 2013; Asteriou et al. 2014; Asteriou et al., 2014; Domanski et al., 2016). Moreover, the declining degree of unionization (Card, 2001; Jaumotte and Osorio Buitron, 2015), population aging (Heathcote et al., 2010; Karahan and Ozkan, 2013), and the relatively high rate of capital income (Piketty, 2014) may raise income inequality. Financial market openness may also increase income inequality as it disproportionately benefits high-income households, despite facilitating credit access for lower-income households (Jaumotte et al., 2008; Roine et al., 2009; Bergh et al., 2010; Gimet et al., 2011; Asteriou et al., 2014).

Rising income inequality may add to wealth inequality via a “snowball effect” (Domanski et al., 2016). Wealth concentration on the other hand may reinforce income inequality for given returns on capital and labor (Saez and Zucman, 2014). With the advent of unconventional monetary policies in advanced economies, policy makers and researchers have only recently linked rising inequality to asset price inflation (Coeure, 2012; Haldane, 2014; Cohan, 2014; Wolf, 2014; Mersch, 2014; Draghi, 2015; Yellen, 2015). Generally, empirical studies show a direct effect of expansionary monetary policy on asset prices (Aoki et al., 2002; 2004; Rigobon and Sack. 2004; Bernanke and Kuttner, 2005; Bordo and Landon-Lane, 2013; Aladangady, 2015; Domanski et al., 2016). This makes monetary policy another potential driver of inequality.

Saiki and Frost (2014) explicitly analyze this link for Japan and find that the Bank of Japan's (BoJ) unconventional policy measures have increased income inequality even prior to the implementation of *Abenomics* in 2013. However, there remain a number of conceptual challenges regarding the identification of transmission channels that work in opposite directions (Coibion et al., 2012; O'Farrell et al., 2016; Bundesbank, 2016). This makes further empirical research indispensable in order to better understand the complex connection between monetary policy and inequality.

This paper analyzes the impact of expansionary monetary policy on the labor income distribution in Japan. The contribution is twofold. First, the paper offers empirical evidence for Japanese labor income inequality using panel data provided by the *Japan Household Panel Survey*. Secondly, it narrows the focus to specific socio-economic features on the individual level, such as age, education and sex. The results complement and partly confirm the household level analysis conducted by Saiki and Frost (2014).

II. Data

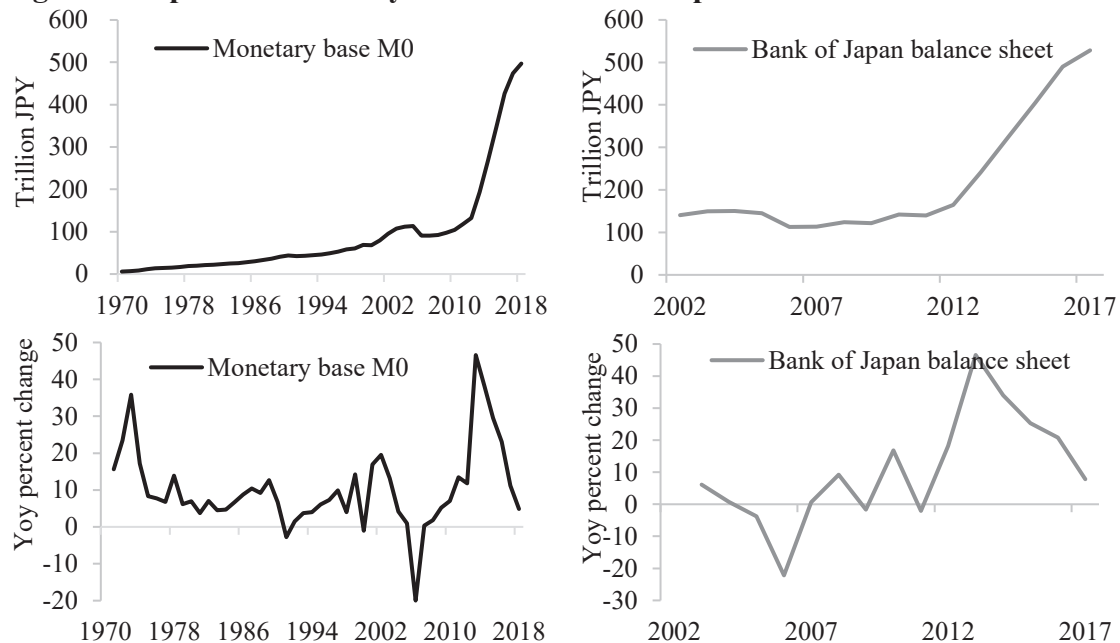
Japan has experienced prolonged conventional as well as unconventional expansionary monetary policy. Various monetary policy indicators reflect this policy path. However, continuous data on the development of the income and wealth distributions is scarce. The new Japan Household Survey Data (JHSD) from the Panel Data Research Center at Keio University (Japan) offers the possibility to trace some causal connections, despite its relatively short time span (from 2003 to 2014). As panel data follows the same statistical units over time, it can control for unobserved variables that change over time but not across units, such as business cycles or fiscal policies.

Monetary Policy Indicators and the Japanese Income Distribution

Indicators of monetary policy include the monetary base, the size of a central bank's balance sheet, and the so-called short-term shadow interest rate. The monetary base is under direct control of monetary authorities. In Japan, similar to other developed economies, the monetary base has substantially grown since the 1970s, particularly since the turn of the millennium. The Bank of Japan's balance sheet has significantly increased, capturing the acceleration of unconventional monetary easing (*quantitative easing*).

Figure 1 displays these two indicators. From January 1970 to February 2019, the money stock M0, which is directly supplied by the BoJ, has increased by a factor of 108 from less than ¥5 trillion to more than ¥493 trillion.¹ This corresponds to an average annual growth rate of 9.98%. Since the launch of *Abenomics* in January 2013, the monetary base has grown by 30.01% on average per year.

Figure 1: Japanese Monetary Base and Bank of Japan's Total Assets



Source: Bank of Japan.

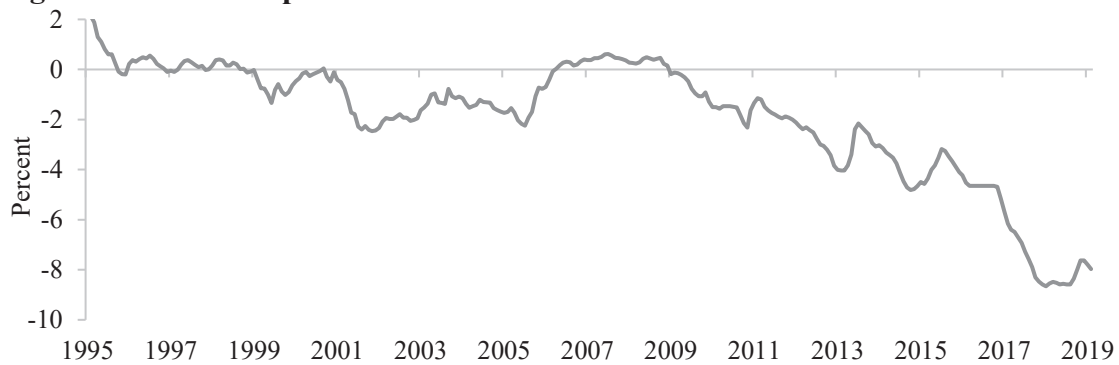
A third indicator of the monetary policy stance, which is based on the short-term interest rate, is the BoJ's short-term shadow rate. This indicator incorporates both conventional and unconventional monetary policies and translates them into a hypothetical interest rate measure that can go beyond the zero-lower bound. Krippner (2012) calculates and frequently updates one version of the shadow rate.²

Figure 2 shows the monthly shadow rate since 1995. Similar to the first two monetary variables, the shadow rate indicates an increasingly expansionary monetary policy stance. It has gradually decreased from about 2.2% in January 1995 to -8.66% at its through in January 2018.

¹ M0 is defined by the Bank of Japan as banknotes in circulation + coins in circulation + current account balances (current account deposits in the Bank of Japan).

² See <https://www.rbnz.govt.nz/research-and-publications/research-programme/additional-research/measures-of-the-stance-of-united-states-monetary-policy/comparison-of-international-monetary-policy-measures>

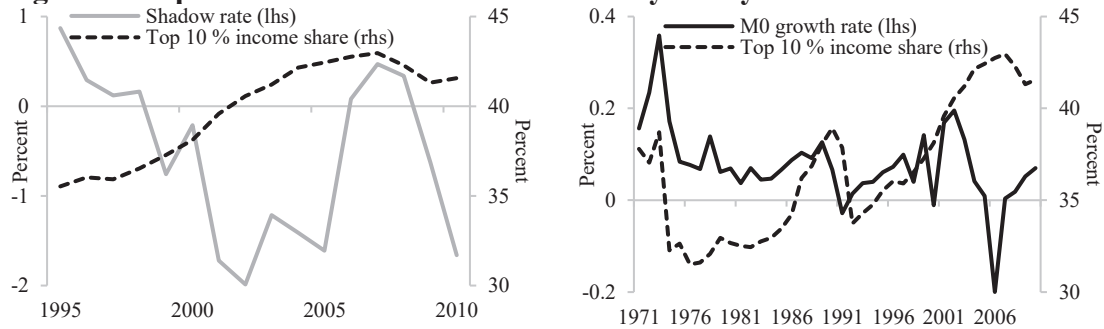
Figure 2: Bank of Japan's Short-term Shadow Rate from 1995 to 2019



Source: Reserve Bank of New Zealand, Krippner (2012).

Data on the development of the Japanese income and wealth distributions over an extended period of time are scarce. The World Inequality Database (WID) only contains the income share of the top-income earners until 2010. Data on the Japanese wealth distribution is not at all available. *Figure 3* shows that the top 10% income share follows an upward trend, indicating rising income for top-income earners relative to other individuals. Thus, income inequality has risen over time, despite substantial fluctuations during Japan's financial market booms.³ There appears to be a correlation between expansionary monetary policy and rising inequalities. The left-hand panel of *Figure 3* shows that gains of top income earners correlate with expansionary monetary policy as depicted by Krippner's shadow rate.

Figure 3: Top 10% Income Share and Monetary Policy Indicators until 2010

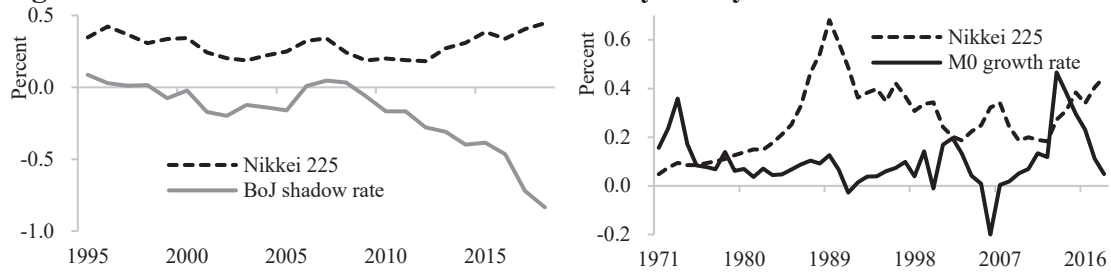


Source: World Inequality Database; Bank of Japan; Reserve Bank of New Zealand.

Figure 4 shows a similar upward trend for the Nikkei 225 index. To the extent that the distribution of financial assets is skewed towards top income earners, this positive trend may indicate rising income and wealth inequality. The Nikkei as shown in *Figure 4* surged with the advent of the strong monetary expansions of *Abenomics* since 2013.

³ These include the asset price bubble of the late 1980s, the dot-com bubble or the financial market frenzy before the 2007/8 Lehman crash.

Figure 4: Nikkei 225 Stock Index and Monetary Policy Indicators until 2019



Source: FRED Federal Reserve Bank of St. Louis; Bank of Japan; Reserve Bank of New Zealand.

Note: The Nikkei 225 is divided by 50,000.

The trends depicted in *Figures 3* and *4* are in line with the hypothesis that expansionary monetary policy may increase inequality through the asset price channel (Williamson, 2009; Ledoit, 2011; Rawdanowicz et al., 2013; Hülsmann, 2014; Israel 2017; Duarte and Schnabl, 2019).

The Japan Household Survey Data

The new Japan Household Survey Data integrates the older Keio Household Panel Survey (KHPS) into the Japan Household Panel Survey (JHPS) under the name of the latter covering the time period from 2003 to 2014. The KHPS has been conducted since 2004 in January of each year. The JHPS started in 2009.

For both surveys, the most recent data available for public use stems from January 2015. Every survey refers to the previous calendar year. The combined panel survey data includes four cohorts, three cohorts of the KHPS from 2004, 2007 and 2012, as well as the 2009 cohort of the JHPS. The highest number of people interviewed in one year for the combined data set is $n=7,434$ (in 2009). The lowest number of people interviewed in one year is $n=2,887$ (in 2006) during the third year of the first cohort of the KHPS (see *Figure A.1* in the *appendix*).

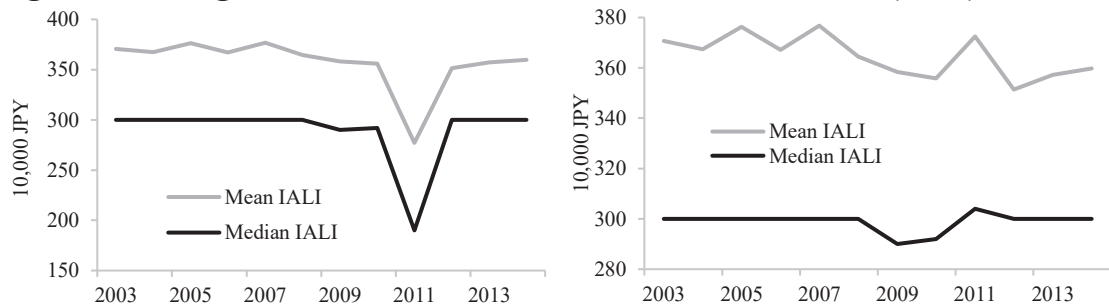
The survey subjects of the initial KHPS include women and men aged 20 to 69, while the original JHPS cohort includes women and men above age 20. Although the sampling populations overlap no respondent participated in both surveys. Even before their harmonization in 2014, both surveys gathered similar information on employment and income on the individual and household level. Thus, survey data on individual annual

labor income (IALI) as well as household total annual income (HTAI) is consistent throughout the period.

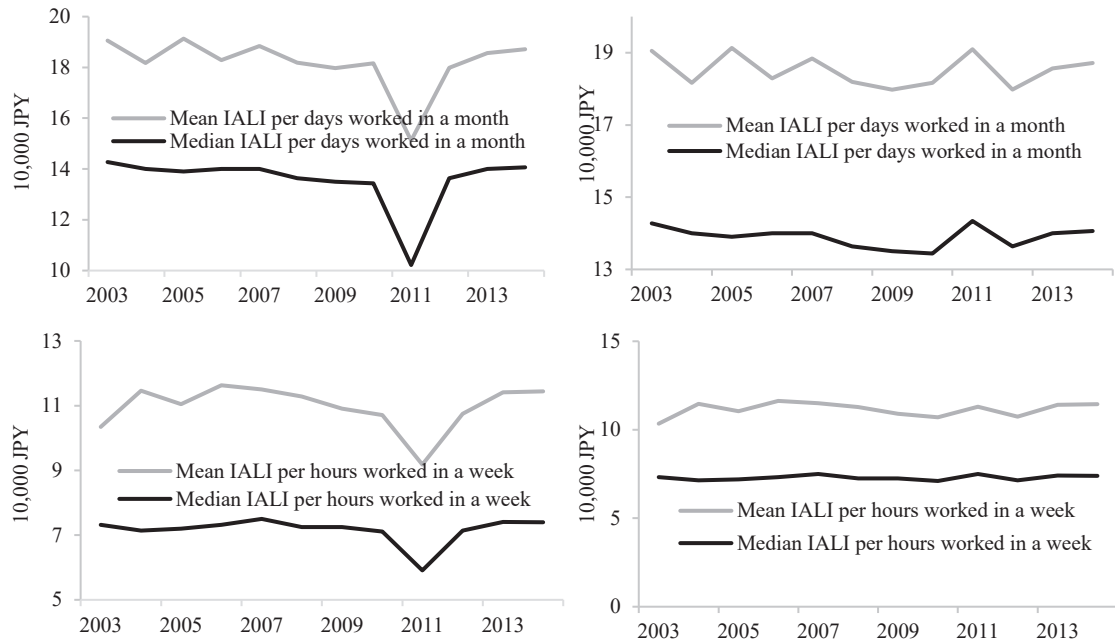
This paper focuses on individual annual labor income since individual income data allows capturing effects that differ across socio-economic groups. For instance, Japanese men and women have traditionally differed with regard to their employment type. While women have generally been employed as non-regular workers with lower wages, men have been employed as regular workers with higher wages as well as fixed-term employment contracts (Latsos, 2018). Household income data would aggregate such effects and hence bias empirical results.

Figure 5 plots the median and mean of individual annual labor income over the entire data set, which is reported in ¥10,000. Respondents reported both the average number of days worked per month and the average number of hours worked per week. This allows for taking working time into account. In 2011, the data show an irregularity: The median annual labor income dropped by about ¥1,000,000 and average annual labor income by more than ¥700,000. While this outlier coincides with the Fukushima nuclear disaster, the variation in the data may also indicate an inaccuracy in the survey method. The panels on the right show the same data using a linear interpolation for 2011 on the individual respondent level.⁴ In order to avoid a possible error in the data collection process, the remainder of the paper focuses primarily on the data with linear interpolation. As a robustness check, all statistical results are also calculated for the unaltered raw data.

Figure 5: Average and Median Individual Annual Labor Income (IALI)



⁴ For all individuals with reported values for 2010, 2011 and 2012, the value for 2011 has been replaced by the arithmetic mean of the values of 2010 and 2012.



Source: JHPS.

Note: Panels on the left display raw data, panels on the right display linearly interpolated data (for 2011).

There is no clear trend in the median or average annual labor income in the sample (Figure 5). The calculated medians have remained stable or slightly declined. The average IALI when corrected for by hours worked per week have slightly increased. It has remained stable when corrected for by days worked per month, and slightly decreased when not corrected at all by working time. However, the rise of average IALI per working hour may represent a statistical effect driven by the official reduction of working hours to 40 per week, related to a set of amendments of Japan's Labor Standards Law in 1987 and 1992 (Latsos, 2018). Thus, even though the JHPS is anonymous, there might be an upward bias in hourly IALI. Hourly wages may have increased less than the data indicates, or may even have declined over time. Moreover, there are significantly more missing values for hours worked per week than for days worked per month in the data set.⁵ For this reason, the remainder of the paper focuses primarily on annual labor income corrected for by days worked. Hours worked per week will be used for robustness checks.

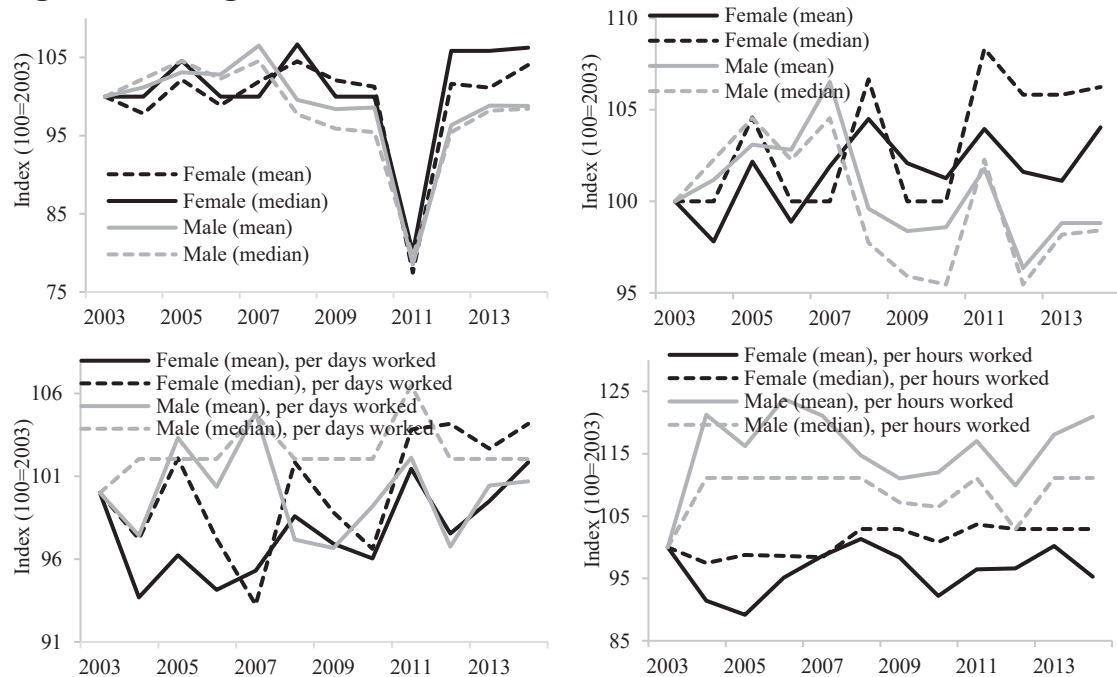
Figures A.2, A.3 and A.4 (see appendix) contain aggregated measures of inequality. Figure A.2 shows some fluctuations in the Gini coefficient, but without a clear trend. Again, 2011 is an outlier in the raw data. The outlier is even stronger in relative terms when it comes to the ratio of the 90th to 10th percentile of the distribution as shown in

⁵ Over the entire panel data set, across both dimensions of time and statistical unit, 1,156 observations are lost when correcting by days worked per month, and 2,038 observations are lost when correcting by hours worked per week.

Figure A.3. While the ratio fluctuates around 11 for most of the period, it jumps to above 125 in 2011. This supports the suspicion regarding data accuracy during that year. With linear interpolation for 2011, the ratios for all three measures of IALI show a downward trend. *Figure A.4* does not show a clear trend for the labor income share of the top 10%. The outlier of 2011 is less pronounced. When corrected by hours worked per week, there does not seem to be an outlier at all. Overall, the aggregated measures of inequality do not show a clear trend.

In contrast, the separation of the data according to socio-economic factors such as sex, education and age, yields findings in terms of changing labor income inequality. First, *Figure 6* shows average and median income by sex. In absolute terms, labor income has increased for women and slightly decreased for men. Thus, the gender pay gap has declined. In 2003, average annual labor income for men was 2.65 times as high as for women, but only 2.51 times as high in 2014.

Figure 6: Average and Median IALI for Women and Men



Source: JHPS.

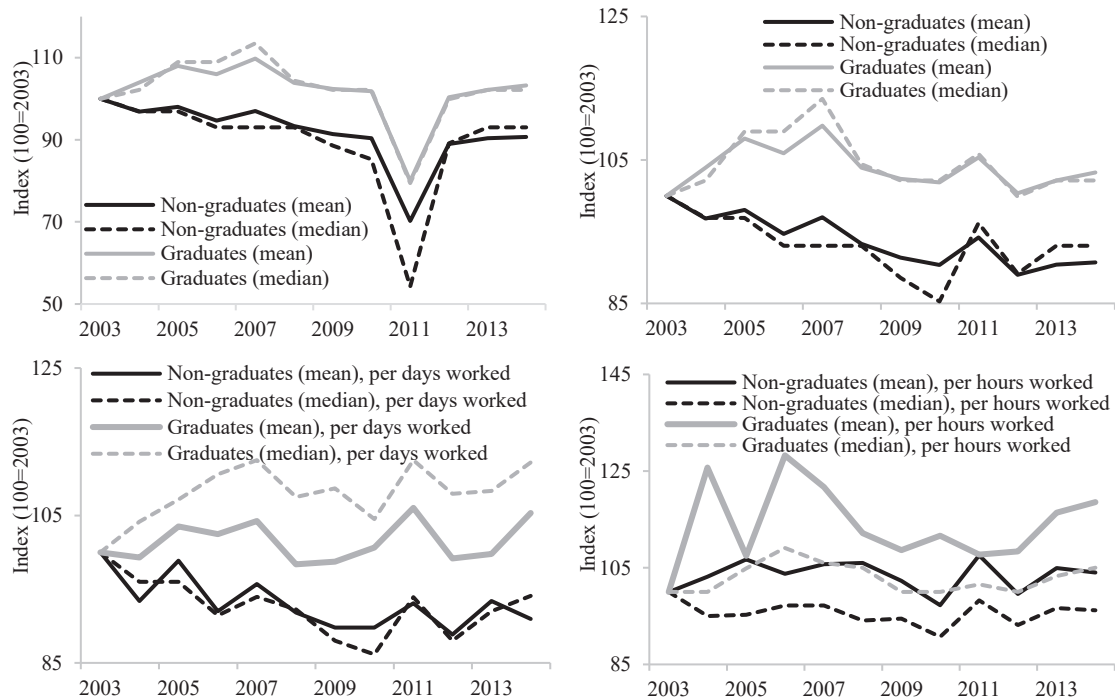
Note: The upper left panel displays raw data, while all other panels display interpolated data.

However, when divided by the average number of days worked per month, the advantage in labor income development for women almost disappears. When divided by hours worked per week, the pay gap between women and men even increases. This indicates that women have increased their overall annual labor income primarily through

increases in working hours relative to men. In fact, both women and men in the sample have on average reduced their number of working hours. Yet, for men the reduction was 9.0% between 2003 and 2014, while for women it was only about 4.7%. Moreover, it appears that the increased pay gap per hour between women and men is mostly due to the pre-crisis period of 2003 to 2006, where male labor income per hour increased substantially, while female labor income per hour decreased. Since then, however, the pay gap has more or less remained constant.

Secondly, *Figure 7* plots the same data by education status, separating the sample into two groups: those with university degree and those without. In all three cases there is increasing inequality over the whole period (education pay gap). Individuals with completed university education saw their annual labor incomes increase while those without saw them stagnate or even fall. This development is most pronounced when labor income is divided by the number of days worked per month. In this case, the ratio between average annual labor income of university graduates and those without university degree increased from 1.55 in 2003 to 1.80 in 2014, that is, by about 15.8%.

Figure 7: Average and Median IALI for University (Non-)Graduates

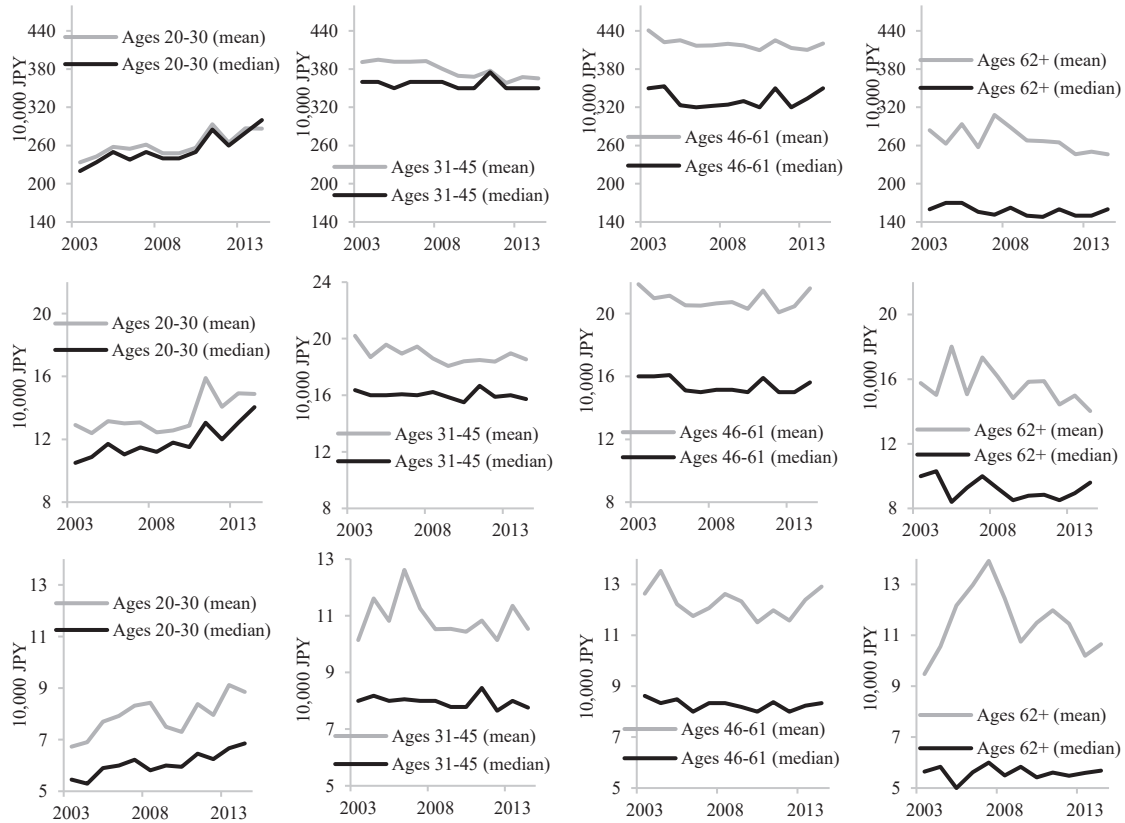


Source: JHPS.

Note: The upper left panel displays raw data, while all other panels display interpolated data.

Lastly, the sample is separated into four age groups: age 20-30, age 31-45, age 46-61 and all individuals above 62 years (*Figure 8*). The choice of groups remains arbitrary to some extent. The oldest group starts at age 62 which corresponds to the average retirement age in Japan. Yet, many Japanese remain part-time employees even after their retirement. In the JHPS sample, the rate of individuals above 62 who continued to work increased from 34.3% in 2003 to 37.4% in 2014.

Figure 8: Average and Median IALI by Age Groups



Source: JHPS.

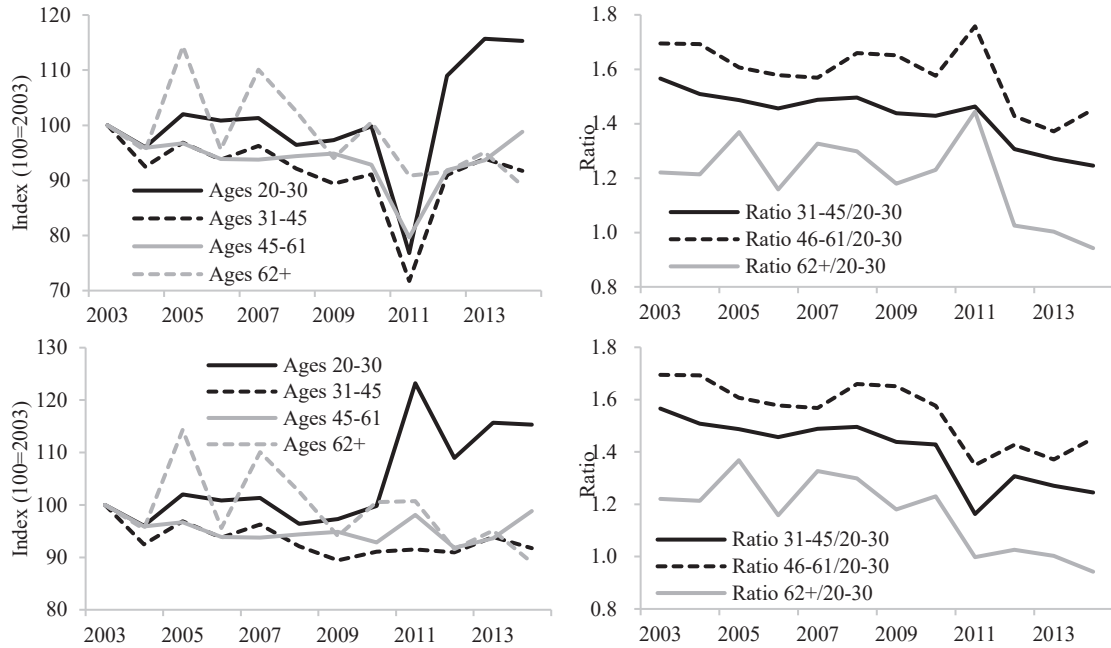
Note: Panels display linearly interpolated data.

Figure 8 depicts average and median annual labor income in the different age groups using data with linear interpolation for 2011 (see *Figure A.5* in the *appendix* for raw data). First, labor income has increased consistently only for the youngest age group. For the older age groups, it has stagnated or slightly declined. This implies that inequality in labor income between young and old generations has generally declined, specifically between those at age 20 to 30 and those between 31 and 61 years of age (age pay gap). Secondly, the distribution of labor income appears to become more positively skewed with age. This suggests that the inequality within the groups increases with age. In fact, in 2014 the Gini

coefficients for annual labor income divided by days worked were 0.30, 0.39, 0.46 and 0.48, respectively, within the four age groups in ascending order.

Figure 9 shows the average annual labor income as indexes for each age group as well as the ratios of average labor income between the older groups and the youngest. Again, the pay gap between old and young has diminished over time. The ratio between average annual labor income per days worked of the 31 to 45-year-olds and the 20 to 30-year-olds declined from 1.57 in 2003 to 1.25 in 2014.

Figure 9: Index and Ratios of Average IAILI per Days Worked by Age Groups



Source: JHPS

Note: The upper panels display raw data, the bottom panels display interpolated data.

III. Estimation Results and Robustness Checks

Estimation results provide evidence that expansionary monetary policy is associated with an increased education pay gap, that is, increased inequality between university graduates and non-graduates. Moreover, expansionary monetary policy is associated with a lower gender pay gap. It does not appear to have a systematic effect on the age pay gap. These results are tested for robustness, using the raw instead of the corrected survey data as well as alternative measures for monetary policy and for annual labor income.

Model and Estimation Results

As a first step, the following linear panel regression model that incorporates all socio-economic factors simultaneously is estimated:

$$\log(IALI_{it}^D) = \beta_0 + \beta_1 * Male_{it} + \beta_2 * Age_{it}^{[31-45]} + \beta_3 * Age_{it}^{[46-61]} + \beta_4 * Age_{it}^{[62+]} + \beta_5 * Uni_{it} + \varepsilon_{it} \quad (1)$$

where the explanatory variables are dummies that take on the value 1 when the statistical unit i in year t has the signified property of being male ($Male_{it}$), being between the age of k and m ($Age_{it}^{[k-m]}$) or holding a university degree (Uni_{it}). The dummies are 0 otherwise. Hence, the baseline socio-economic group in this regression are females aged 20 to 30 without university degree. The explained variable is the logarithm of individual annual labor income per days worked ($IALI_{it}^D$).⁶ The error term ε_{it} is assumed to be independent and normally distributed.

The regression results using the raw data are summarized in *Table 1*. All explanatory variables are highly significant except the oldest age group. Interestingly, the strongest difference between socio-economic groups in terms of the size of the estimate emanates from sex.

Table 1: Linear Regression of IALI per Days Worked on Socio-economic Factors

IALI per days worked	
Male	0.84*** (0.01)
ages 31-45	0.30*** (0.02)
ages 46-61	0.39*** (0.02)
ages 62+	0.02 (0.02)
university	0.33*** (0.01)
Constant	1.62*** (0.02)
Total sum of squares	49461
Residual sum of squares	39379
R-squared	0.20385
Adj. R-squared	0.20375
Prob > F	2071.62***

⁶ Following conventional practice in regression analysis with income data, the logarithm of IALI is used due to the skewness of the distribution.

Note: The linear regression uses raw data. Standard errors are reported in parentheses. The significance of coefficients is reported at the 10%, 5%, 1% and 0.1% level, indicated by ', *, **, ***, respectively.

Implementing a Lagrange Multiplier Test based on Breusch and Pagan (1980) suggests highly significant time effects in the coefficients of the model ($p < 0.00001$). Thus, the following regression uses the established model, but allows for the estimated coefficients to vary over time. The results as summarized in *Table 2* underline once again the outlier of 2011 (also see *Figure A.6* in the *appendix*). In the following the corrected data with a linear interpolation for 2011 is used.⁷

Table 2 summarizes the descriptive results of the previous section in a multivariate regression setting. First, while the gender pay gap fluctuates to some extent over the time period considered, it has overall decreased slightly. Between 2003 and 2007, the gender pay gap increased by 13.2%, but fell by 17.0% until 2014. Overall, this corresponds to a fall by about 6.0%.

Table 2: Linear Regression of IALI per Days Worked on Socio-economic Factors with Time-varying Coefficients

Raw data						
	male	ages 31-45	ages 46-61	ages 62+	university	constant
2003	0.88	0.32	0.38	-0.01	0.24	1.70
2004	0.91	0.31	0.39	0.03	0.30	1.65
2005	0.88	0.21	0.26	-0.12	0.29	1.79
2006	0.92	0.29	0.34	-0.01	0.32	1.69
2007	1.00	0.17	0.22	-0.09	0.32	1.75
2008	0.84	0.26	0.35	-0.00	0.35	1.73
2009	0.84	0.29	0.35	-0.06	0.35	1.71
2010	0.88	0.20	0.26	-0.10	0.36	1.76
2011	0.53	0.81	1.04	1.03	0.35	0.51
2012	0.83	0.23	0.28	-0.17	0.34	1.80
2013	0.87	0.23	0.28	-0.17	0.34	1.80
2014	0.83	0.14	0.22	-0.25	0.35	1.90
Interpolated data						
2003	0.88	0.32	0.38	-0.01	0.24	1.70
2004	0.91	0.31	0.39	0.03	0.30	1.65
2005	0.88	0.21	0.26	-0.12	0.29	1.79
2006	0.92	0.29	0.34	-0.01	0.32	1.69
2007	1.00	0.17	0.22	-0.09	0.32	1.75
2008	0.84	0.26	0.35	0.00	0.35	1.73
2009	0.84	0.29	0.35	-0.06	0.35	1.71
2010	0.88	0.20	0.26	-0.10	0.36	1.76
2011	0.84	0.09	0.17	-0.23	0.35	1.95
2012	0.83	0.23	0.28	-0.17	0.34	1.80
2013	0.87	0.23	0.28	-0.17	0.34	1.80

⁷ However, the robustness checks incorporate the raw data.

2014	0.83	0.14	0.22	-0.25	0.35	1.90
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Secondly, the age pay gap has gradually and significantly fallen over time. In particular, the pay gap between the youngest age group and those aged 31 to 45 decreased by 56.8% over the entire period (*Table 2*). However, this effect is to be expected to some extent when using panel survey data. Since the youngest respondents stand at the beginning of their professional careers, they are more likely to progress faster during the follow-up period than older respondents. The latter have already advanced in their careers and are thus more likely to have reached the peak of their career and level of labor income. Moreover, the between-cohort effect of a declining pay gap may partly be driven by the fast aging of the Japanese population (Latsos, 2018).

Thirdly, the education pay gap has increased overall. According to the above estimates, it has increased by 42.5% between 2003 and 2014 (*Table 2*). The coefficient for the education dummy is the only one that does not substantially change after using the corrected data with a linear interpolation for 2011. All other coefficients, including the intercept, change to a large extent.

It remains to be analyzed to what extent these trends can be tied to monetary policy. Therefore, an extended model is estimated that incorporates Krippner's short-term shadow rate as a measure of the monetary policy stance of the Bank of Japan as well as the Nikkei 225 index as a general measure of business activity and outlook. Since Krippner's rate incorporates both conventional and unconventional monetary policies it is preferred over the other monetary policy indicators, such as Japan's monetary base or the size of the BoJ's balance sheet. The latter are however used for robustness checks. Interaction terms of the shadow rate with the socio-economic factors of sex, education and age are included to investigate the impact of monetary policy on the different socio-economic groups.

The estimated model is

$$\begin{aligned}
\log(ALI_{it}) = & \beta_0 + \beta_1 * Male_{it} + \beta_2 * Age_{it}^{[31-45]} + \beta_3 * Age_{it}^{[46-61]} + \beta_4 * Age_{it}^{[62+]} + \\
& \beta_5 * Uni_{it} + \beta_6 * SSR_t + \beta_7 * \Delta SSR_t + \\
& \beta_8 * NIKKEI_t + \beta_9 * \Delta NIKKEI_t + \\
& \beta_{10} * SSR_t * Uni_{it} + \beta_{11} * \Delta SSR_t * Uni_{it} + \\
& \beta_{10} * SSR_t * Male_{it} + \beta_{11} * \Delta SSR_t * Male_{it} + , \\
& \beta_{12} * SSR_t * Age_{it}^{[31-45]} + \beta_{13} * \Delta SSR_t * Age_{it}^{[31-45]} + \beta_{14} * SSR_t * Age_{it}^{[46-61]} +
\end{aligned} \tag{2}$$

$$\beta_{15} * \Delta SSR_t * Age_{it}^{[46-61]} + \beta_{16} * SSR_t * Age_{it}^{[62+]} + \beta_{17} * \Delta SSR_t * Age_{it}^{[62+]} + \varepsilon_{it} ,$$

where $NIKKEI_t$ indicates the average value of the Nikkei 225 index in year t , and SSR_t corresponds to the average of Krippner's short-term shadow interest rate for Japan in year t . ΔSSR_t corresponds to the first-order difference, that is, the absolute change of the shadow rate from year $t-1$ to t , while $\Delta NIKKEI_t$ signifies the percentage change of the average value of the Nikkei 225 index from year $t-1$ to t .

Table 3 summarizes the estimation results. Many of the estimated coefficients are statistically insignificant so that the model is reduced in the following.

Table 3: Linear Regression Model of IALI per Days Worked on Socio-economic Factors and Monetary Policy Indicators

IALI per days worked	
	0.89*** (0.01)
Male	
Age 31-45	0.26*** (0.02)
Age 46-61	0.33*** (0.02)
Age 62+	-0.02 (0.02)
Uni	0.33*** (0.01)
SSR	-0.04** (0.01)
ΔSSR	0.00 (0.02)
NIKKEI	0.00 (0.02)
$\Delta NIKKEI$	-0.05' (0.03)
Uni*SSR	0.00 (0.01)
Uni* ΔSSR	-0.02' (0.01)
Male*SSR	0.01 (0.01)
Male* ΔSSR	0.02* (0.01)
Age 31-45*SSR	0.01 (0.01)
Age 46-61*SSR	0.01 (0.01)
Age 62+*SSR	0.04** (0.01)
Age 31-45* ΔSSR	0.02 (0.02)
Age 46-61* ΔSSR	0.01 (0.02)
Age 62+* ΔSSR	0.02

	(0.02)
Constant	1.67*** (0.03)
Total sum of squares	32875
Residual sum of squares	22513
R-squared	0.32
Adj. R-squared	0.31
Prob > F	945.52***

Note: The linear regression uses interpolated data. Standard errors are reported in parentheses. The significance of coefficients is reported at the 10%, 5%, 1% and 0.1% level, indicated by ', *, **, ***, respectively.

The interaction terms between the age groups and the first-order difference of the short-term shadow rate are all insignificant, similar to the interaction terms between the short-term rates and both sex as well as education. The coefficient for the annual average of the Nikkei 225 index is insignificant, unlike its rate of change (at least on the 10% level). Hence, those variables are excluded from the model.

The interaction terms between the short-term shadow rate and the age groups are also discarded, although the term for the group above 62 years is statistically significant. As pointed out previously, this group constitutes a special case as it consists of individuals after the average retirement age. The short-term rate is statistically insignificant in explaining the reduced inequality between individuals below the retirement age. When using the uncorrected raw data instead of the data with linear interpolation for 2011, all the interaction terms for age groups turn out to be statistically insignificant (see *appendix Table A.7*). This is not the case for the other socio-economic factors.

After removing the interaction terms between the age groups and the short-term shadow rate, the reduced version of the initial model reads as follows:⁸

$$\begin{aligned} \log(ALI_{it}) = & \beta_0 + \beta_1 * Male_{it} + \beta_2 * Age_{it}^{[31-45]} + \beta_3 * Age_{it}^{[46-61]} + \beta_4 * Age_{it}^{[62+]} + \\ & \beta_5 * Uni_{it} + \beta_6 * SSR_t + \beta_7 * \Delta SSR_t + \beta_8 * \Delta NIKKEI_t + \\ & \beta_9 * \Delta SSR_t * Uni_{it} + \beta_{10} * \Delta SSR_t * Male_{it} + \varepsilon_{it}. \end{aligned} \quad (3)$$

The estimation results for the reduced model are shown in *Table 4*. All estimated coefficients are statistically significant, except for those of the rate of change of the Nikkei index and the first-order difference of the short-term shadow rate. The interaction

⁸ The first-order difference of the short-term shadow rate remains in the reduced model even though it is not statistically significant. It is kept as its interaction terms with both sex and education are significant, following standard econometric practice.

terms of the latter, including education as well as sex, are significant at the 5% level. In the initial model, the interaction term with the education dummy was significant only at the 10% level. Excluding the rate of change of the Nikkei index does not change the estimates for the other variables significantly.

Table 4: Reduced Linear Regression of IALI per Days Worked on Socio-economic Factors and Monetary Policy Indicators using Corrected Data

IALI per days worked	
Male	0.88*** (0.01)
Age 31-45	0.25*** (0.01)
Age 46-61	0.31*** (0.01)
Age 62+	-0.09*** (0.02)
Uni	0.33*** (0.01)
SSR	-0.01** (0.00)
Δ SSR	0.01 (0.01)
Δ NIKKEI	-0.03 (0.03)
Uni* Δ SSR	-0.03* (0.01)
Male* Δ SSR	0.03** (0.01)
Constant	1.73*** (0.01)
Total sum of squares	32875
Residual sum of squares	22527
R-squared	0.31
Adj. R-squared	0.31
Prob > F	1793.33***

Note: The linear regression uses interpolated data. Standard errors are reported in parentheses. The significance of coefficients is reported at the 10%, 5%, 1% and 0.1% level, indicated by *, **, ***, respectively.

These results suggest that monetary policy as specified by Krippner's short-term shadow rate can help explain the observed developments of inequality between the sexes (gender pay gap) as well as growing inequality between university graduates and non-graduates (education pay gap). The observed development of inequality between generations (age pay gap) seems to be driven by other factors.

First, the coefficient for the interaction term of the sex dummy ($Male_{it}$) and the first-order difference of the short-term shadow rate (ΔSSR_t) is positive (0.033) and statistically

significant at the 1% level. This implies that a reduction in the shadow rate, that is expansionary monetary policy, is associated with a reduction of the gender pay gap. More precisely, a 1% reduction of the shadow rate is estimated to reduce this pay gap between men and women on average by about 3.7%.⁹

The link between expansionary monetary policy and the declining Japanese gender pay gap may relate to the *aggregate demand channel* (Rawdanowicz et al., 2013; Coibion et al., 2012) and is potentially linked to earnings heterogeneity between men and women. Women have traditionally been employed as low-income workers with a high degree of capital substitutability and employment flexibility (non-regular employees). In times of expansionary monetary policy and increased aggregate demand, low income employment (of women) would disproportionately rise, decreasing income inequality between the genders.

The decrease of the gender pay gap may also relate to the *labor productivity channel*. In the long run expansionary monetary policy can hamper productivity gains and may thus lead to real wage repression (Schnabl, 2015; Hoffmann and Schnabl, 2016a; Latsos, 2018). This would incentivize women to work longer, and shift from part-time to full-time employment, in order to keep the household's standard of living. As a consequence, women gain more working experience and catch up in terms of labor income.

Secondly, the estimated coefficient of the interaction term between the education dummy (Uni_{it}) and the first-order difference of the shadow rate is negative (-0.025). This implies that a reduction of the shadow rate by 1% is estimated to increase the pay gap between university graduates and non-graduates on average by 7.6%. Monetary easing is thus associated with increased inequality between individuals with different educational backgrounds.

The link between expansionary monetary policy and the increase of the education pay gap may also relate to *the labor productivity channel*. Given a heterogeneous income composition, low-skilled workers may fare worse under expansionary monetary policy as they tend to be disproportionately affected by shocks to labor productivity and real wage declines. They have low bargaining power since they are relatively easily replaced.

⁹ This value is given by the ratio of the estimated coefficient of the interaction term (0.0327456) and the estimated coefficient of the dummy variable for sex (0.878686).

In contrast, high-skilled workers with university degrees can be more easily employed in capital intensive, technology-driven production processes. Dolado et al. (2018) show, for example, that highly qualified employees experience less labor market frictions after monetary policy shocks.

Robustness Checks

The robustness of the empirical results can be assessed in three ways. First, abstaining from interpolation of the raw data ensures that the empirical results are not simply caused by this change. Yet, the results do not differ substantially (see *Tables A.7* and *A.8* in the *appendix*). The effect of monetary policy on inequality between university graduates and non-graduates increases. It decreases slightly for the difference between the sexes, which is statistically significant only at the 10% level (*Table A.8*).

Moreover, the monetary policy variables as such are now statistically significant. The coefficient for the shadow rate turns positive while the one for its first-order difference turns negative when using the raw data. This suggests that expansionary monetary policy in terms of a reduction of the shadow rate exerts a short-term positive effect on the general level of labor income as estimated through the coefficient of the first-order difference. Yet, in the longer term lower levels of the shadow rate are associated with lower labor income.

Table A.9 (see *appendix*) contains an alternative reduced model as compared to *Table 3*. The alternative model only keeps the terms that are significant in *Table A.7*. Again, in comparison to the benchmark reduced model, the effect of monetary policy on inequality between university graduates and non-graduates has increased, while the effect on inequality between the sexes turns out weaker. It remains statistically significant, even at the 1% level. The difference is that the latter effect is directly estimated through the interaction term with the shadow rate instead of its first-order difference.

Secondly, monetary policy can be specified differently in the model. So far, this analysis uses Krippner's short-term shadow rate as a measure that incorporates both conventional and unconventional monetary policies. Alternatively, the size of the Bank of Japan's balance sheet as well as its rate of change can be used. *Table A.10* (see *appendix*) contains the estimation results for the respective reduced model (as in *Table 4*), where the short-term shadow rate is replaced by the size of the BoJ's balance sheet,

and the first-order difference of the short-term rate is replaced by the percentage change of the size of the balance sheet.

The estimated coefficient for the interaction term of the percentage change of the balance sheet and the university dummy remains statistically significant. As the sign of the estimated coefficient has changed, the direction of the effect remains the same. An increase of the balance sheet, which corresponds to a reduction of the shadow rate, is a proxy for expansionary monetary policy. Since the estimated coefficient is now positive, expansionary monetary policy remains associated with an increase in the education pay gap.

Once again, the effect on the gender pay gap is statistically insignificant. The sign of the estimated coefficient does not change, suggesting that, if anything, the effect of expansionary monetary policy is to increase the gender pay gap. However, this changes if raw instead of the corrected data are used. For the raw data, expansionary monetary policy as measured by the percentage change of the central bank's balance sheet has a diminishing effect on the gender pay gap. The effect remains statistically significant. When the monetary base M0 is used to specify monetary policy, the effect on the education pay gap turns out to be insignificant, while the effect on the gender pay gap remains significant as summarized in *Table A.11*.

Thirdly, alternative measures of annual labor income are used. In the initial model annual labor income is divided by days worked per month to take working time into account and retain as many observations as possible. By using annual labor income regardless of working time, the estimation results widely remain the same (*Table A.12* in the *appendix*). As before, the results become stronger if the raw data were used instead of the data with linear interpolation for 2011.

If annual labor income is divided by the number of hours worked per week, only the effect on the gender pay gap remains statistically significant as shown in *Table A.13* (in the *appendix*). If the raw data are used instead of the corrected data, both estimates fall short of being statistically significant.¹⁰ However, given legislative regulation concerning

¹⁰ For the education pay gap the p-value would be 0.16 and for the gender pay gap it would be 0.22.

the maximum number of working hours in Japan, data may be biased if the actual number of working hours is not truthfully reported.

Overall, the statistical results are robust to the above changes in the specification of the model. The analysis suggests that expansionary monetary policy increases the education pay gap between university graduates and non-graduates, and lowers the gender pay gap between males and females. A longer and more detailed data set would be required to substantiate these empirical findings further. Detailed data on wealth would be necessary to reveal an impact of monetary policy on wealth inequality.

5. Policy implications

This paper analyzes the impact of expansionary monetary policy on the labor income distribution in Japan. The analysis incorporates effects of conventional as well as unconventional monetary easing. It investigates effects on labor income inequality between different socio-economic groups using the Japan Household Survey Data, which has thus far not been subject to systematic analysis.

The empirical analysis suggests that expansionary monetary policy is associated with a decreased gender pay gap, but an increased education pay gap, which may both be related to the *labor productivity channel*. No significant effects are found with respect to the pay gap between different age groups. The latter appears to be driven by other factors, such as demographic developments.

These empirical findings may have implications for monetary policy. While (un)conventional expansionary monetary policy may appear to prevent economic downturns in the face of financial crises, prolonged monetary easing can have redistribution effects. In particular, as the evidence of this paper suggests it may increase income inequality between high-skilled and low-skilled workers. To the extent that the public perceives this effect as undesirable, policymakers have to reconsider their monetary policy stance.

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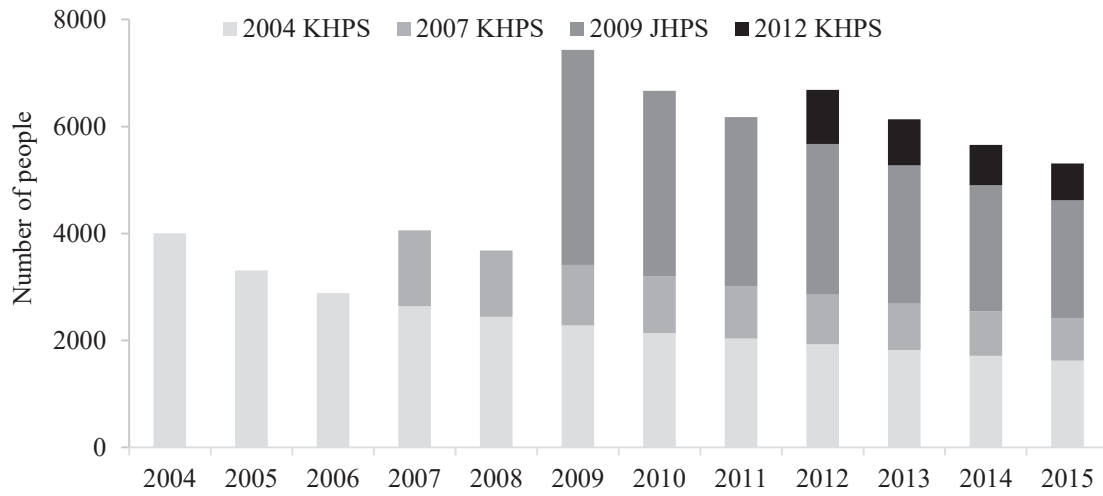
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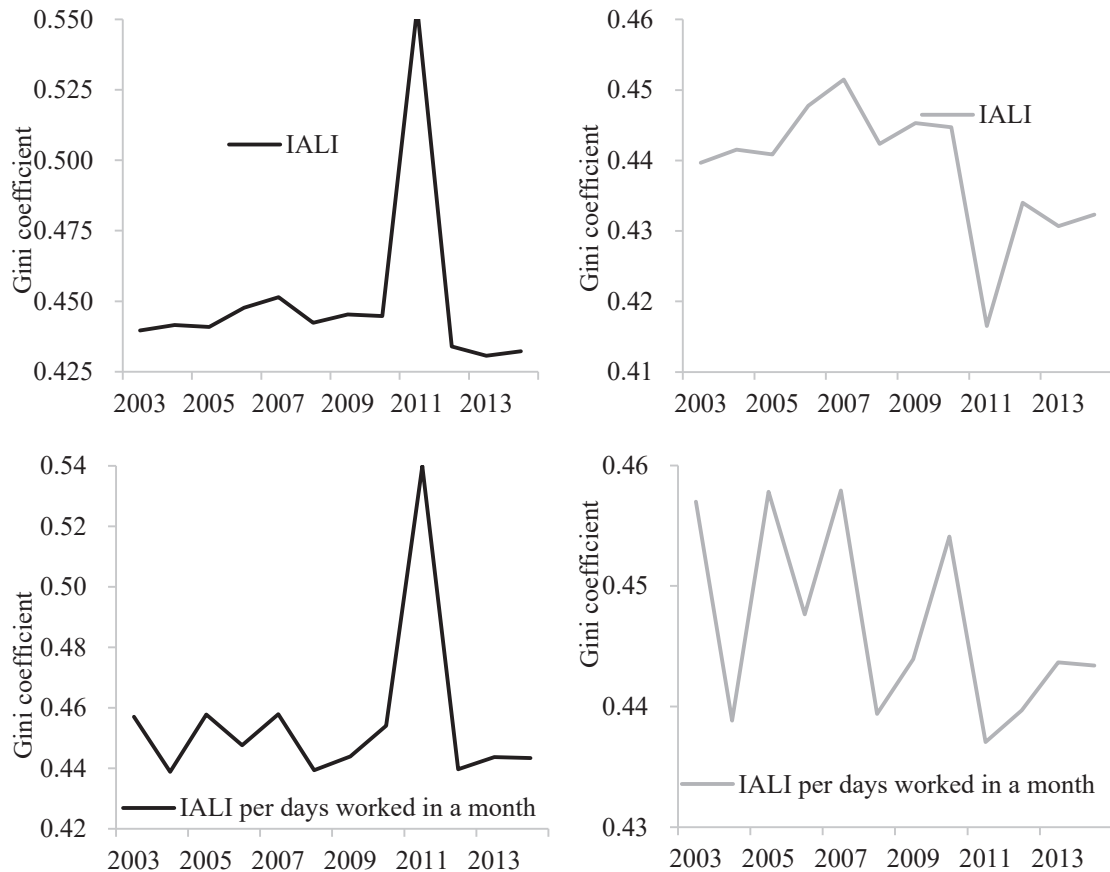
Appendix

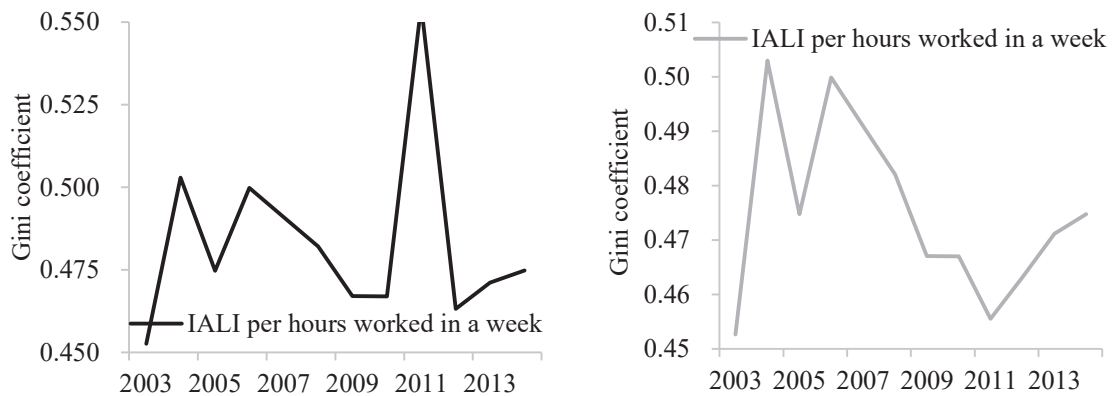
Figure A.1: Sample Distribution of the Japan Household Survey Data by Cohort



Source: JHPS.

Figure A.2: The Gini Coefficient of IALI

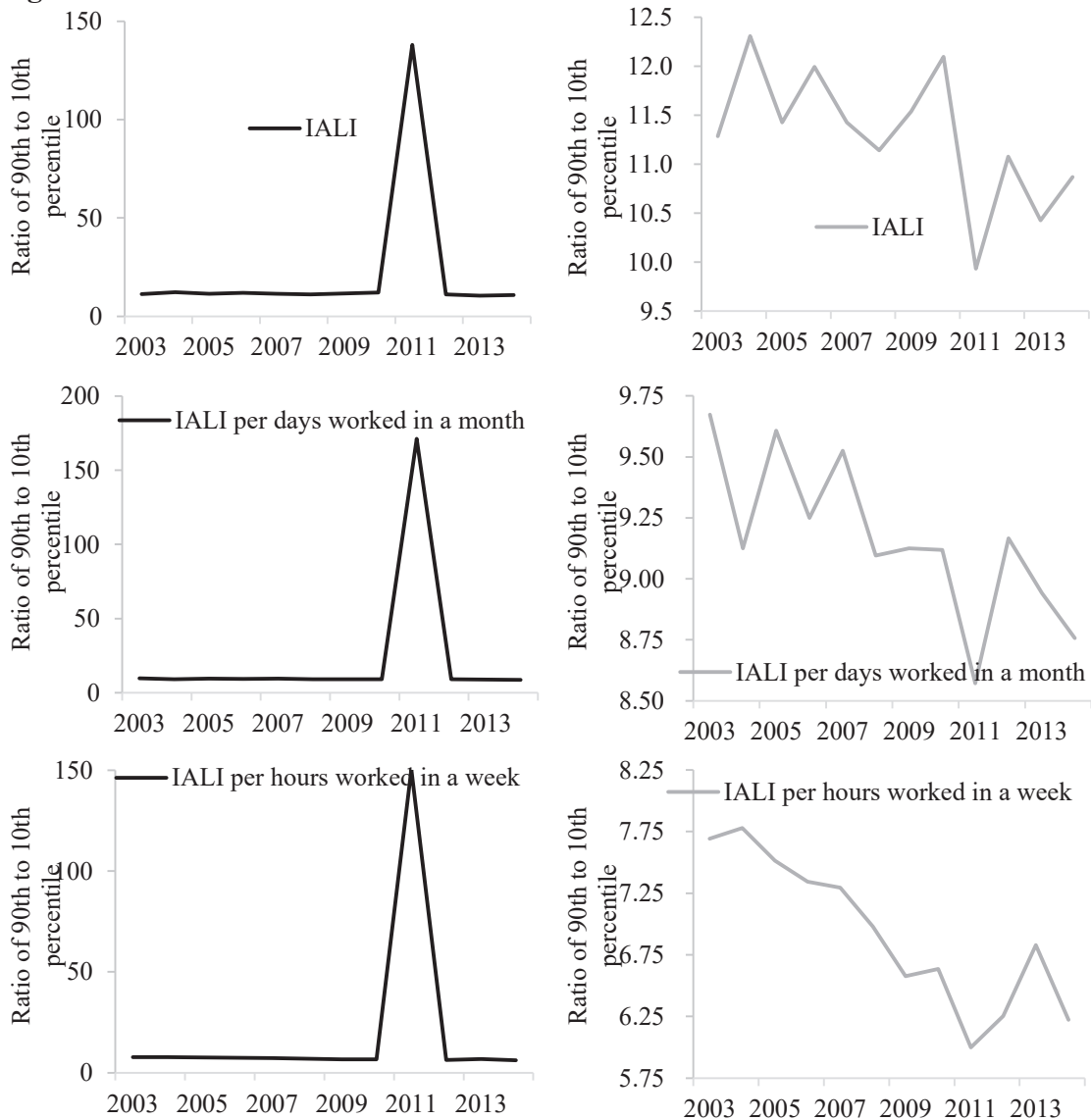




Source: JHPS.

Note: The panels on the left display raw data, the panels on the right display interpolated data (for 2011).

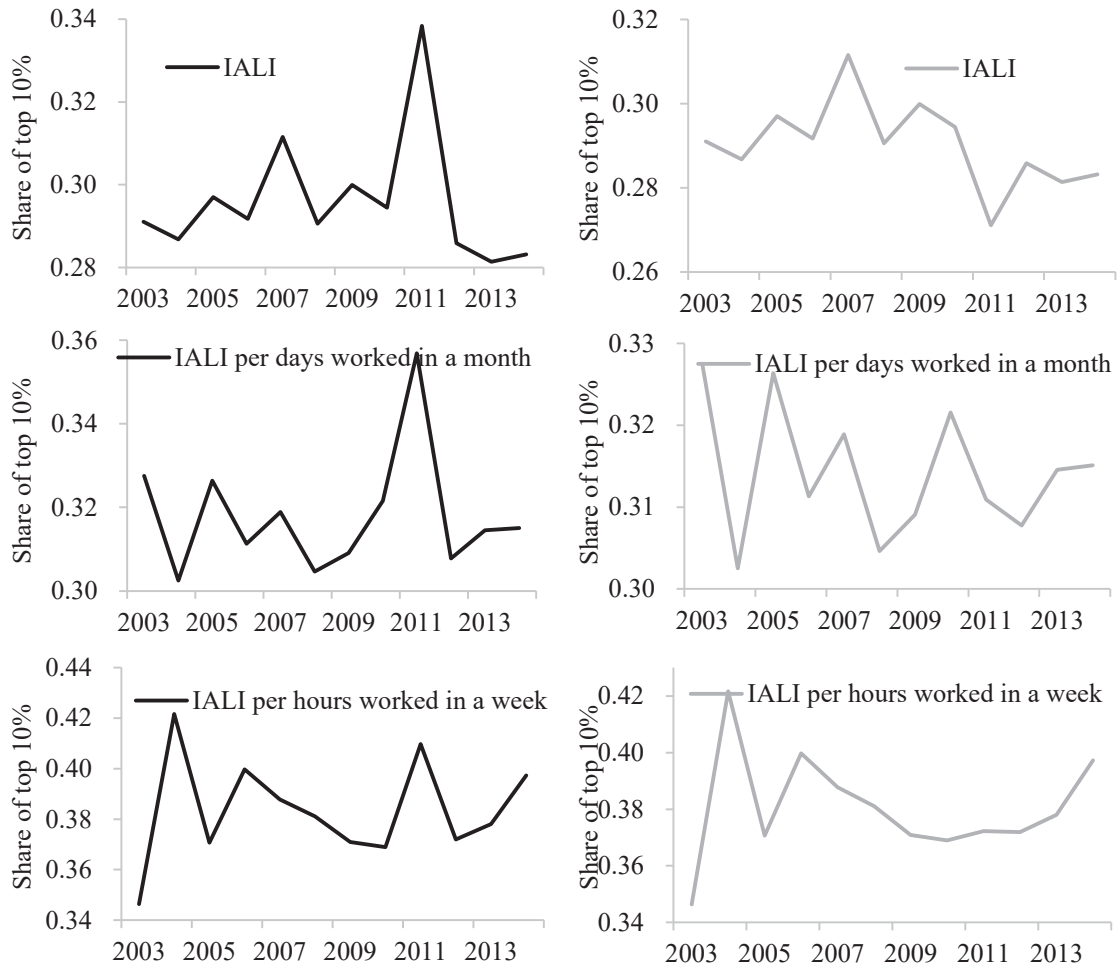
Figure A.3: The Ratio of the 90th to 10th Percentile of IALI



Source: JHPS.

Note: The panels on the left display raw data, the panels on the right display interpolated data (for 2011).

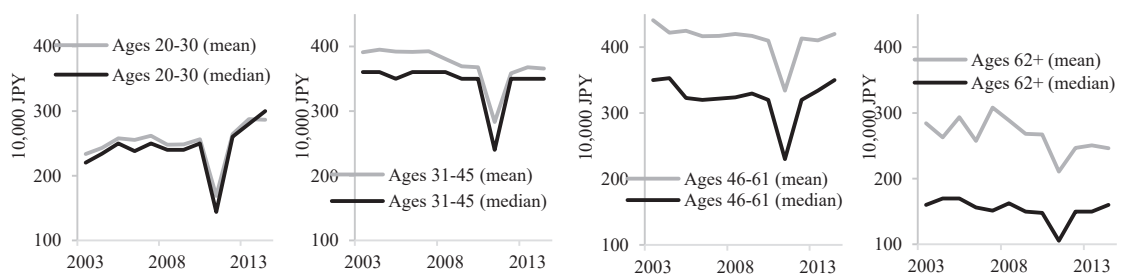
Figure A.4: The Top 10% Share of IALI

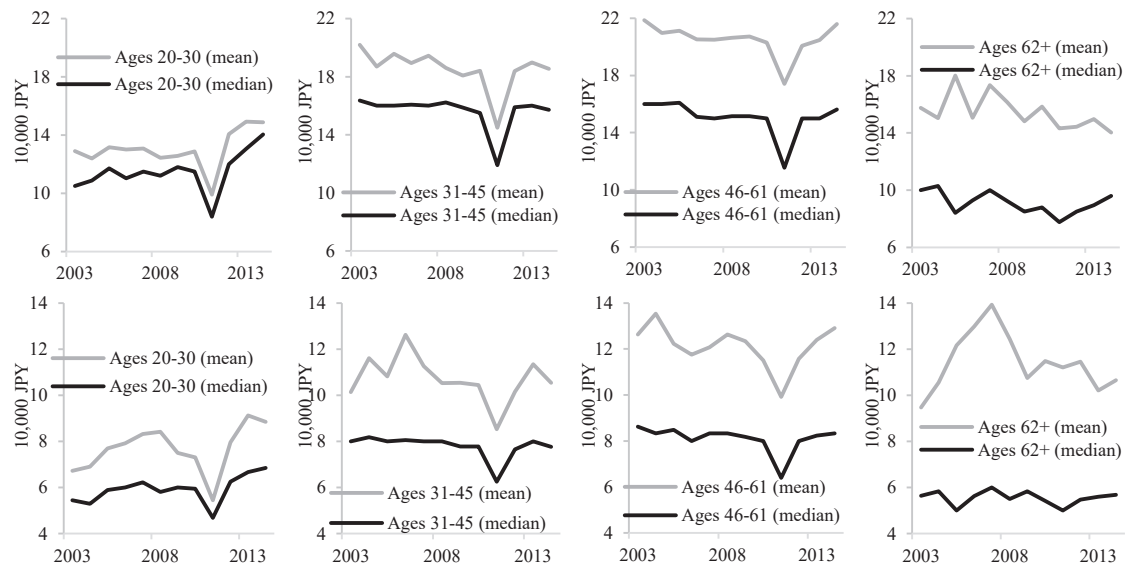


Source: JHPS.

Note: The panels on the left display raw data, the panels on the right display interpolated data (for 2011)

Figure A.5: Average and Median IALI by Age Groups

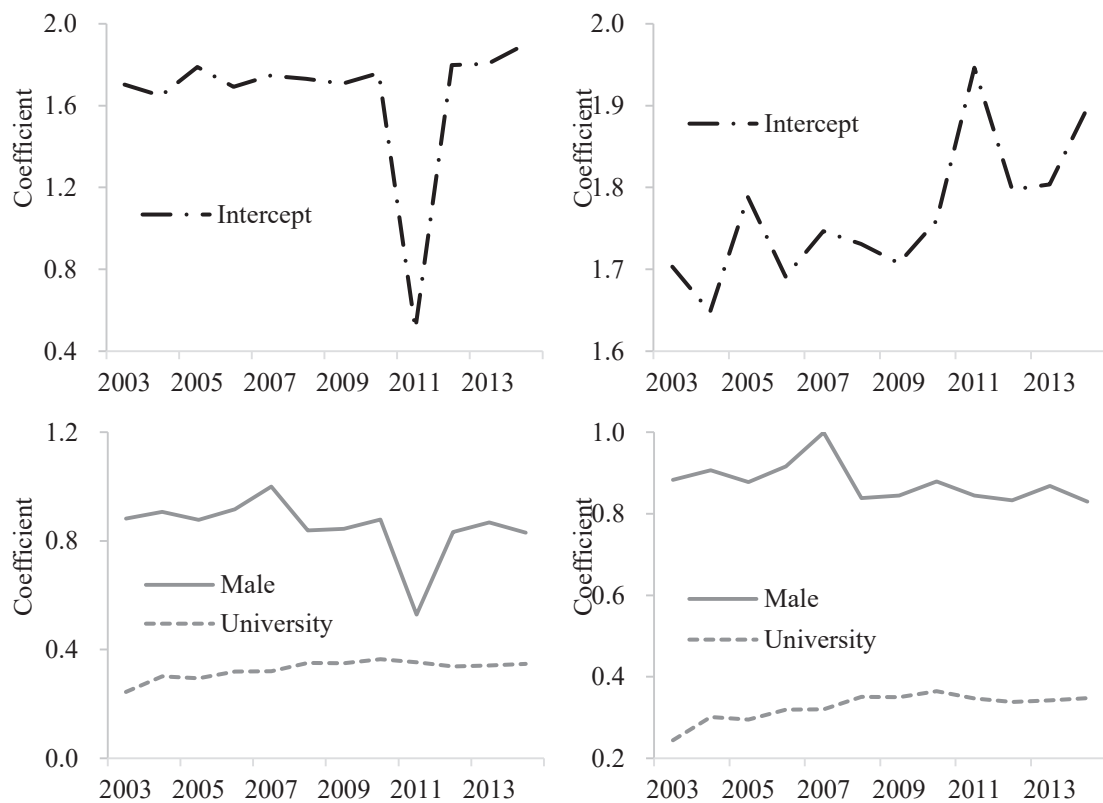


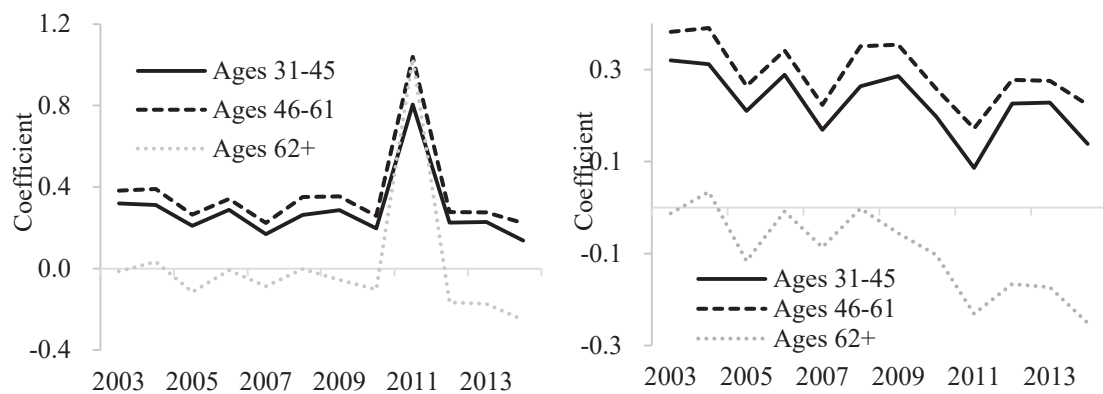


Source: JHPS.

Note: Panels display raw data.

Figure A.6: Time-varying Coefficients of Linear Regression of IALI per Days Worked on Socio-economic Factors





Source: JHPS.

Notes: The panels on the left display coefficients of regressions using raw data, the panels on the right display coefficients of regressions using interpolated data.

Table A.7: Linear Regression Model of IALI per Days Worked on Socio-economic Factors and Monetary Policy Indicators

IALI per days worked	
Male	0.87*** (0.02)
Age 31-45	0.27*** (0.02)
Age 46-61	0.35*** (0.02)
Age 62+	0.02 (0.03)
Uni	0.33*** (0.02)
SSR	0.08*** (0.02)
ΔSSR	-0.19*** (0.02)
NIKKEI	0.00*** (0.00)
ΔNIKKEI	0.32*** (0.04)
Uni*SSR	0.01 (0.01)
Uni*ΔSSR	-0.05** (0.02)
Male*SSR	0.02' (0.01)
Male*ΔSSR	0.01 (0.02)
Age 31-45*SSR	-0.02 (0.02)
Age 46-61*SSR	-0.02 (0.02)
Age 62+*SSR	0.01 (0.02)
Age 31-45*ΔSSR	0.01 (0.02)
Age 46-61*ΔSSR	0.01 (0.02)

Age 62+* Δ SSR	0.02 (0.03)
Constant	1.22*** (0.04)
Total sum of squares	49461
Residual sum of squares	38714
R-squared	0.22
Adj. R-squared:	0.22
Prob > F	590.89***

Note: The linear regression uses raw data. Standard errors are reported in parentheses. The significance of coefficients is reported at the 10%, 5%, 1% and 0.1% level, indicated by ', *, **, ***, respectively.

Table A.8: Reduced Linear Regression of IALI per Days Worked on Socio-economic Factors and Monetary Policy Indicators

IALI per days worked	
	0.85*** (0.01)
Male	
Age 31-45	0.29*** (0.02)
Age 46-61	0.38*** (0.02)
Age 62+	0.01 (0.02)
Uni	0.32*** (0.01)
SSR	0.10*** (0.01)
Δ SSR	-0.17*** (0.01)
Δ NIKKEI	0.60*** (0.03)
Uni* Δ SSR	-0.04** (0.01)
Male* Δ SSR	0.03' (0.01)
Constant	1.71*** (0.02)
Total sum of squares	49461
Residual sum of squares	38986
R-squared	0.21
Adj. R-squared:	0.21
Prob > F	1086.84***

Note: The linear regression uses raw data. Standard errors are reported in parentheses. The significance of coefficients is reported at the 10%, 5%, 1% and 0.1% level, indicated by ', *, **, ***, respectively.

Table A.9: Alternative Reduced Linear Regression of IALI per Days Worked on Socio-economic Factors and Monetary Policy Indicators

IALI per days worked	
	0.87*** (0.01)
Male	
Age 31-45	0.29*** (0.02)
Age 46-61	0.37*** (0.02)

Age 62+	0.00 (0.02)
Uni	0.32*** (0.01)
SSR	0.07*** (0.01)
Δ SSR	-0.18*** (0.01)
NIKKEI	0.00*** (0.00)
Δ NIKKEI	0.32*** (0.04)
Uni* Δ SSR	-0.04** (0.01)
Male*SSR	0.02** (0.01)
Constant	1.21*** (0.03)
Total sum of squares	49461
Residual sum of squares	38723
R-squared	0.22
Adj. R-squared:	0.22
Prob > F	1019.79***

Note: The linear regression uses raw data. Standard errors are reported in parentheses. The significance of coefficients is reported at the 10%, 5%, 1% and 0.1% level, indicated by ', *, **, ***, respectively.

Table A.10: Linear Regression Model of IALI per Days Worked on Socio-economic Factors and Alternative Monetary Policy Indicators

IALI per days worked	
Male	0.84*** (0.01)
Age 31-45	0.29*** (0.02)
Age 46-61	0.37*** (0.02)
Age 62+	0.00 (0.02)
Uni	0.31*** (0.01)
Bal. Sh.	0.00*** (0.00)
Δ Bal. Sh.	0.00*** (0.00)
Δ NIKKEI	0.11*** (0.03)
Uni* Δ Bal. Sh.	0.00* (0.00)
Male* Δ Bal.Sh.	0.00 (0.00)
Constant	1.70*** (0.02)
Total sum of squares	49461
Residual sum of squares	39181
R-squared	0.21
Adj. R-squared:	0.21

Prob > F	1061.31***
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Note: The linear regression uses interpolated data. Standard errors are reported in parentheses. The significance of coefficients is reported at the 10%, 5%, 1% and 0.1% level, indicated by ', *, **, ***, respectively.

This regression corresponds to the reduced model in *Table 4*, where the short-term shadow rate was replaced by the size of the Bank of Japan's balance sheet (Bal. Sh.) and the first-order difference of the short-term shadow rate was replaced by the percentage change of the balance sheet (Δ Bal. Sh.).

Table A.11: Linear Regression Model of IALI per Days Worked on Socio-economic Factors and Alternative Monetary Policy Indicators

IALI per days worked	
Male	0.85*** (0.01)
Age 31-45	0.30*** (0.02)
Age 46-61	0.38*** (0.02)
Age 62+	0.02 (0.02)
Uni	0.33*** (0.01)
M0	0.00*** (0.00)
Δ M0	-0.47*** (0.07)
Δ NIKKEI	0.16*** (0.03)
Uni* Δ M0	0.05 (0.07)
Male* Δ M0	-0.13* (0.06)
Constant	1.47*** (0.02)
Total sum of squares	49461
Residual sum of squares	39228
R-squared	0.21
Adj. R-squared:	0.21
Prob > F	1055.24***

Note: The linear regression uses interpolated data. Standard errors are reported in parentheses. The significance of coefficients is reported at the 10%, 5%, 1% and 0.1% level, indicated by ', *, **, ***, respectively.

This regression corresponds to the reduced model in *Table 4*, where the short-term shadow rate was replaced by the base money stock (M0) and the first-order difference of the short-term shadow rate was replaced by the percentage change of the base money stock (Δ M0).

Table A.12: Linear Regression Model of IALI Regardless of Working Time on Socio-economic Factors and Monetary Policy Indicators

IALI per days worked	
Male	1.05*** (0.01)
Age 31-45	0.26*** (0.01)
Age 46-61	0.34*** (0.01)

Age 62+	-0.24*** (0.02)
Uni	0.28*** (0.01)
SSR	-0.01* (0.01)
Δ SSR	0.00 (0.01)
Δ NIKKEI	-0.04 (0.03)
Uni* Δ SSR	-0.03* (0.01)
Male* Δ SSR	0.04*** (0.01)
Constant	4.62*** (0.01)
Total sum of squares	41023
Residual sum of squares	26732
R-squared	0.35
Adj. R-squared:	0.35
Prob > F	2132.74***

Note: The linear regression uses interpolated data. Standard errors are reported in parentheses. The significance of coefficients is reported at the 10%, 5%, 1% and 0.1% level, indicated by ', *, **, ***, respectively.

This regression corresponds to the reduced model in *Table 4*, where annual labor income per days worked in a month was replaced by annual labor income regardless of working time.

Table A.13: Linear Regression Model of IALI per Hours Worked on Socio-economic Factors and Monetary Policy Indicators

IALI per days worked	
Male	0.56*** (0.01)
Age 31-45	0.28*** (0.01)
Age 46-61	0.36*** (0.01)
Age 62+	0.10*** (0.02)
Uni	0.28*** (0.01)
SSR	0.00 (0.00)
Δ SSR	-0.01 (0.01)
Δ NIKKEI	0.01 (0.03)
Uni* Δ SSR	-0.01 (0.01)
Male* Δ SSR	0.02* (0.01)
Constant	1.35*** (0.01)
Total sum of squares	28180
Residual sum of squares	23449
R-squared	0.17

Adj. R-squared:	0.17
Prob > F	770.75***

Note: The linear regression uses interpolated data. Standard errors are reported in parentheses. The significance of coefficients is reported at the 10%, 5%, 1% and 0.1% level, indicated by ', *, **, ***, respectively.

This regression corresponds to the reduced model in *Table 4*, where annual labor income per days worked in a month was replaced by annual labor income per hours worked in a week.

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