Monetary Policy, the Dual Labor Market, and Consumption in Japan

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December 22, 2024

One of the prevailing puzzles in the recent Japanese economy is the sluggish response of consumption to the massive monetary expansion by the Bank of Japan. From our observations based on household panel data that the consumption response of households of non-regular workers are stronger than those of regular workers, we set up a New Keynesian model featuring the dual labor market in Japan. There are two types of worker households. One is unionized and monopolistically competitive (regular workers), and the other participates in a perfectly competitive market (non-regular workers). The model well replicates the weak rise of aggregate consumption to monetary policy easing. We show that the widening use of non-regular workers in recent years may have led to the weakening of the consumption response.

I. Introduction

There is a growing theoretical literature that re-examines how monetary policy stimulates consumption. In this literature, consumption due to rising labor income accounts for about 50 percent of the change in consumption from a monetary shock (Auclert (2019), Bilbiie (2020), and Morrison (2024)). If that is the case, then changing features of the labor market may affect how monetary shocks impact consumption. In this paper, we explore how the increasing proportion of non-regular workers–those with more informal attachments to the labor force–has affected the transmission of monetary shocks into consumption in Japan.

One of the prevailing puzzles in the Japanese economy between 2009 and 2019 is the slow growth in consumption, despite the deep cut in interest rates and the large quantitative easing. This paper relates this "low consumption response puzzle" to inequality in Japan, specifically to the dual structure of the labor force.

We develop a "Two-Agent New Keynesian (TANK)" model with regular and non-regular workers.[1] As explained below, non-regular workers have a more "ca-

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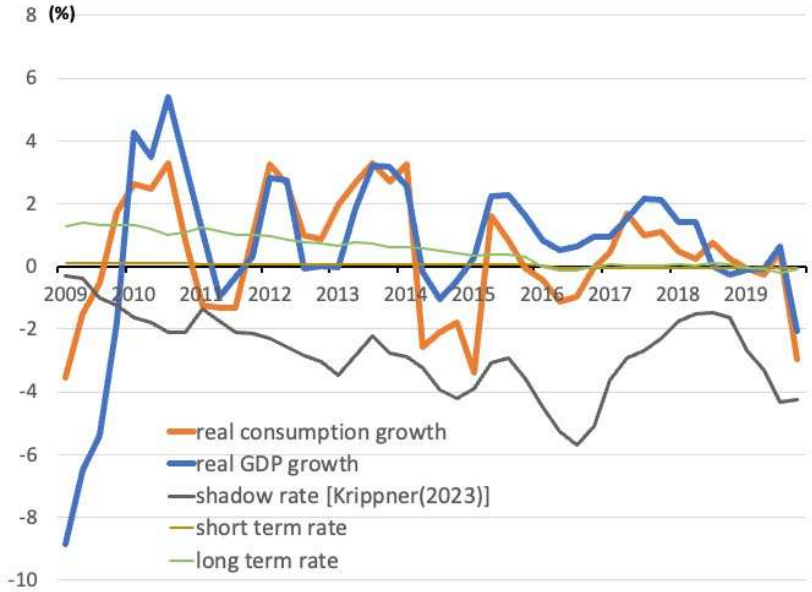
[1] Dualistic labor markets comprised of permanent (regular) and contract (non-regular) workers can also be observed in Italy, France, Sweden, Spain, Norway, Denmark, and Finland (Richard (2024)).

sual" attachment to a firm.[2] Their salary and benefits are lower than regular workers. In our TANK model, non-regular workers are paid their marginal product, while regular workers receive negotiated wages that are sticky. We show in our model simulations that as the proportion of non-regular workers increases, aggregate consumption becomes less sensitive to monetary shocks.

Loose Monetary Policies and Consumption

Figure 1 shows the relationship between the quarter-on-quarter change in real

FIGURE 1. INTEREST RATES AND GROWTH IN REAL GDP AND CONSUMPTION (QUARTER ON QUARTER)



Note: real GDP and consumption is seasonally adjusted.

Source: interest rates: Bank of Japan / GDP and consumption: Cabinet Office / shadow rates: Krippner's website[a]

[a]https://www.ljkmfa.com/visitors/

Richard (2024) finds in Italian Household data that those with fixed-term contracts have a 49 percent probability to be employed as a permanent worker during the next two years during economic expansions. The probability of non-regular workers being promoted to regular workers in Japan is lower. During the 2016-2018 expansionary phase, 17.9 percent of the non-regular workers were able to transfer to the regular category (RecruitWorksInstitute (2024)).

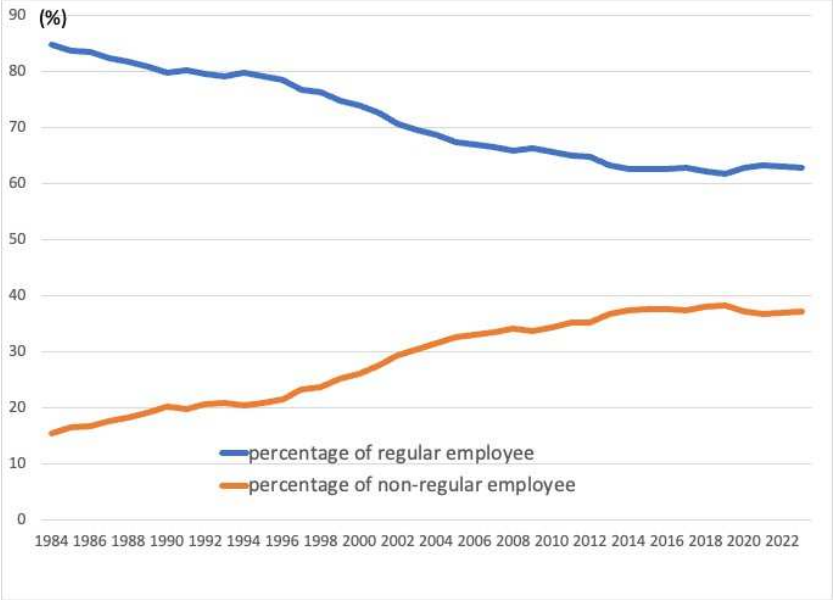
[2]Non-regular workers are assumed to be different from regular workers in the following respects. First, they have lower human capital than regular workers. Second, non-regular workers are paid their marginal product, while regular worker wages are negotiated with the employer through their union. Third, the adjustment (layoffs) of non-regular workers are costless to the employer, while the adjustment of regular workers entail a cost. Fourth, the wages of regular workers can only adjust at fixed reset probabilities, while those of non-regular workers can adjust continuously with the shock.

household consumption and short-term (overnight call rate) and long-term (10-year bond rate) interest rates from 2009 to 2019. The figure includes the "shadow" interest rates estimated by Krippner (Krippner (2013) and Krippner (2015)). These "shadow" rates are intended to capture the hypothetical interest rates that would pervade, given the unconventional monetary policies enacted in Japan near the zero lower bound.

Since 2010, while short-term rates were already at the zero lower bound, long-term rates, as well as the "shadow" rates declined under the expansionary monetary policies of the Bank of Japan. However, despite these relaxed monetary conditions, consumption growth has been tepid, almost always staying below the growth in real GDP.

Regular and Non-regular Workers and Wages

Figure 2. Growing Share of Non-regular Employees



Note: non-regular employees are shorter hours workers, mainly consisting of part time workers

Source: Labor Force Survey

In Figure 2, we depict the trends in regular and non-regular workers. In 1984, the proportion of regular workers was 85 percent and the proportion of non-regular workers was 15 percent. By 2017, the proportion of regular workers declined to

63 percent, and the proportion of non-regular workers rose to 37 percent.[3] Kondo (2024) shows that the acceleration in the proportion of non-regular workers in the early 1990s–especially of men–is related to the severe slowdown in the Japanese economy. Japan's entry level job market is characterized by an immediate transfer from school to work. The disadvantage of this smooth transition from school to work is that when the economy is weak, entry level jobs are few, and those who cannot get the regular worker jobs are stuck in the non-standard worker category. The post-graduation labor market into regular jobs is unstructured and small. Compared to the pre-1990s period, even now many of the school graduates still cannot get the desirable regular jobs right after graduation. Kondo (2024) finds empirical evidence that since the mid-2000s, many new graduates still had to enter non-regular jobs like their immediate predecessors. During expansions, about 20 percent of non-regular workers find regular worker jobs (RecruitWorksInstitute (2024)), but the total proportion of non-regular workers remains constant as recent graduates continue to enter non-regular jobs.

As shown in Table 1 below, part of the rise in non- regular (part-time) employment is due to the increase in non-regular or part-time labor by women. This secular increase in the rise in female part-time labor is induced by the stagnating wages of their husbands from the early 1990s, as married women enter the labor force to supplement their household incomes (Iwasaki, Kubota, Muto and Shintani, 2022).

Figure 3 depicts the hourly wages of regular and non-regular workers. Before 2004, we do not have statistics on the wages of non-regular workers, so we used the wages of part-time workers instead. Real hourly wages of full-time workers have been about 2.2 to 2.3 times higher than the hourly wages of part-time workers. A similar gap persists between the wages of regular and non-regular workers after 2004.

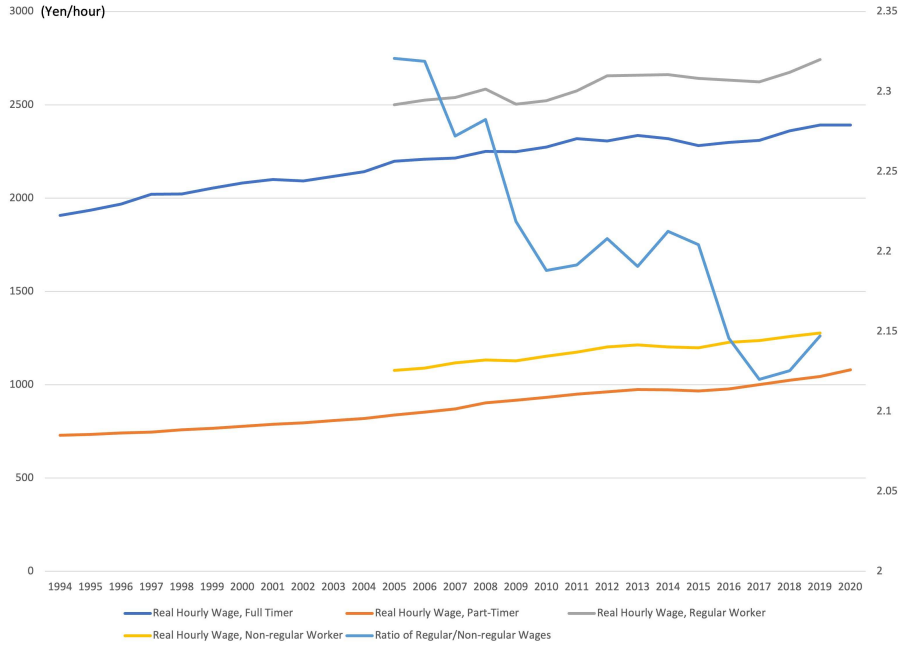
Figure 2 and 3 show that there has been a dramatic relative increase in the number of non-regular workers, who are paid less than half of regular workers. If so, we would expect that the average worker wage will stagnate in Japan, as lower wage workers start to make up a larger proportion of the labor force.

Figure 4 shows the average wage if the proportion of regular workers stayed at its 1994 share. The relative wages between regular and non-regular workers are assumed to be the same as in Figure 3. Figure 4 shows that wages per worker would be higher. Thus, the growth in non-regular workers puts large downward pressure on average wages.

An example can illustrate how the aggregate shift to lower paid non-regular employment can lower the responsiveness of aggregate consumption to aggregate shocks, such as monetary shocks. Say a shock raises wages of all workers by 1 percent. If regular workers are earning more than non-regular workers, then the 1 percent increase in wages will increase aggregate wages by a smaller percent-

[3]Non-regular workers include part-time workers, albeit or temporary workers, dispatched workers from temporary labor agencies, contract workers, and some other minor categories.

Figure 3. Hourly Wages of Regular and Non-regular Workers



Note: wages are seasonally adjusted.

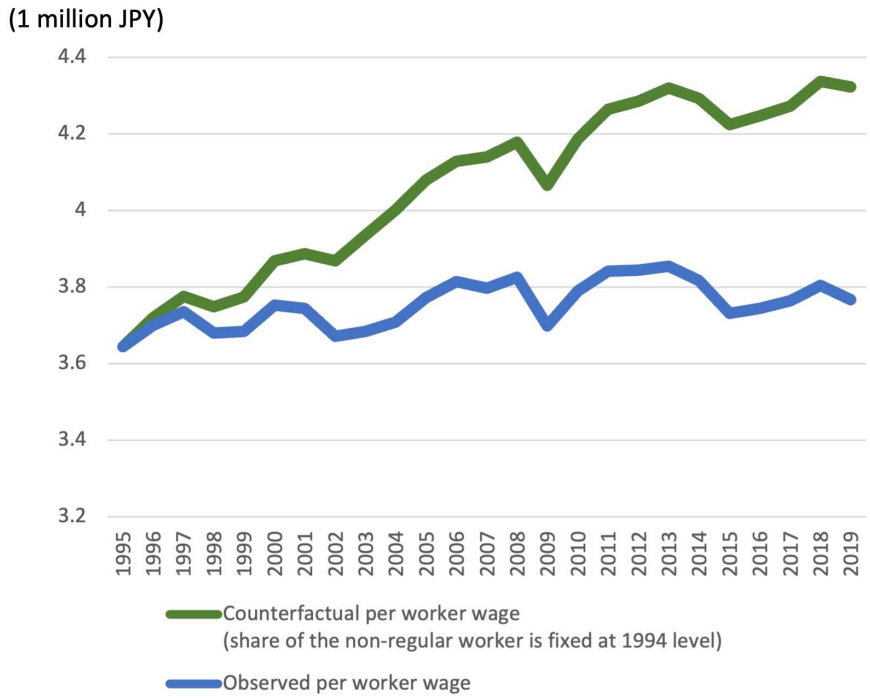
Source: wages of full timer and part timer: Monthly Labor Survey / wages and composition of regular and non-regular workers: Basic Survey of Wage Structure

age when the proportion of non-regular workers is higher. Suppose aggregate consumption is a simple linear function of aggregate wages, then the change in aggregate consumption will be lower when there are proportionately more lower paid workers.

Of course the economy is more complicated than this simple example. The wages of nonregular workers may respond by more than that of the regular workers. The shock may change the relative firm demands and household supplies of regular and non-regular workers. The consumption functions of the regular and non-regular workers may be different. In our TANK model, we will model the salient differences between the regular and non-regular workers, to examine the response of aggregate consumption to monetary shocks in a more realistic setting.

In our model simulations below, when an economy is hit by a positive monetary shock, when non-regular workers are more prevalent, firms adjust their labor inputs more readily by hiring non-regular workers. Since this raises the wages of non-regular workers, the wages and labor supplies of regular workers are suppressed. As low wage non-regular workers are substituted for high-wage regular workers, the change in aggregate wages are suppressed, and consumption growth that depends on wages is also lowered.

Figure 4. Wages per Worker: Actual versus Constant 1994 Regular Worker Shares



Note: seasonally adjusted hourly wages are multiplied by the hours worked, 12 (number of months), and the number of workers to prepare a computed yearly wages per worker.
Source: Monthly Labor Survey

Composition of Non-regular Employees

Table 1 depicts the composition of the growth in non-regular employees during the last 20 years. Women have always been overrepresented in the proportion of non-regular employees, but the percentage point increase in male non-regular employees has been larger than that for women between the early 2000s and today. From 2002 to 2023, the proportion of female non-regular workers increased by 9 percentage points, while that for men increased by 7.6 percentage points. Thus, the low salaries and uncertain employment of non-regular employees are not exclusively about women, but also affect men in increasing numbers. An important reason for the increase in male non-regular workers in particular is the change in Japanese employment laws. Traditionally, Japan has legally limited the industries in which non-regular workers are allowed. In 1999, laws were liberalized so that with the exeption of manufacturing and medical industreis, all industries could employ non-regular workers.In the early 2000s, non-regular workers were allowed in even the manufacturing industry.

A substantial proportion of prime age men (excluding the aged) are subjected

Table 1—Comparison between KHPS/JHPS data and Japanese Official Statistics

	Proportion of Non-regular Workers (Total) (%)	Proportion of Non-regular Workers (Men) (%)	Proportion of Non-regular Workers (Women) (%)
2002	29.4	15.0	49.3
2003	30.4	15.6	50.6
2004	31.4	16.3	51.7
2005	32.6	17.7	52.5
2006	33.0	17.9	52.8
2007	33.5	18.3	53.5
2008	34.1	19.2	53.6
2009	33.7	18.4	53.3
2010	34.4	18.9	53.8
2011	35.1	19.9	54.4
2012	35.2	19.7	54.5
2013	36.7	21.2	55.8
2014	37.4	21.8	56.7
2015	37.5	21.9	56.3
2016	37.5	22.1	55.9
2017	37.3	21.9	55.5
2018	37.9	22.2	56.1
2019	38.3	22.8	56.0
2020	37.2	22.2	54.4
2021	36.7	21.8	53.6
2022	36.9	22.2	53.4
2023	37.1	22.6	53.2

Notes: details on LFS (Labor Force Survey) is in the appendix. Percentage share is the fraction among the employed workers (regular workers and non-regular workers).

to non-regular jobs. From the Labor Survey tables of employment by age, we can calculate the percentage of employees between 18 and 60 (prime-age workers) in non-regular jobs.[4] In 2023, of the percentage of all prime age workers, 0.30 percent were non-regular employees. For men 18-59, 14 percent were non-regular employees. Thus, even for prime-age men, the percentage of non-regular workers is non-negligible, and this percentage has increased over time.

Self-Employed and Family Workers

From the Labor Survey, we can also calculate the rates of self-employment and family work (working for the family business). Self-employment and family workers as a percentage of total workers dropped from a high of 58 percent of the labor force in 1953 to 28 percent in 1980, all the way down to 9.5 percent in 2023. In 2023, self-employment and family workers were 8 percent of all male workers and 11 percent of all female workers. In our model below, we divided the total of workers into two categories, those essentially subject to high firing costs and sticky wages (regular workers), and those facing the free market (non-regular workers) . Since self-employed and familty workers are likely to face the free market, we put them in the non-regular worker category below.

Literature Review

There are several papers that discuss the weak response of aggregate consumption to monetary shocks in Japan. Hausman, Unayama, and Wieland (2021) observes that during the rapid monetary expansion period from 2012 to 2018, GDP grew at an annual rate of 1.1 percent, while the growth in consumption was 0.4 percent (as shown in Figure 1). Hausman et al. (2021) carefully examine the heterogeneous response of household consumption during the rapid monetary growth era using Japanese household data. They find that what contributes to the high aggregate consumption response in the U.S. such as the larger consumption response of young people (Wong et al. (2019)) and homeowners (Cloyne, Ferreira, and Surico (2020)) to monetary shocks, is not observed in Japanese household level data. Our study adds to this explanation of weak aggregate consumption by focusing on another dimension in workers' characteristics, namely, the types of jobs they are engaged in.

Inui, Sudou, and Yamada (2017) construct a New Keynesian model of two types of workers; those attached to the firm, and those free to move across firms. They then examine the impact of monetary policies on aggregate consumption. Their argument is that as the proportion of unattached workers rise, the consumption and income inequality are less affected by monetary shocks, since mobile workers are better able to move from the rigid price firms to the flexible price firms. In our model of labor market dualism, workers engaged in non-regular type of work

[4]In Japan, mandatory retirement can still be enforced by companies. The age at which mandatory retirement applies is variable, but is usually between 55 and 65. A common arrangement is that those facing mandatory retirement are hired back either to their original firm or at a subsidiary at reduced wages. Over 75 percent of those who still work past age 65 are non-regular employees.

are stuck in flexible wage jobs and they cannot move to flexible wage type jobs. Matsui and Yoshimi (2015) also build a model of two distinct labor markets.[5]

There is a related literature discussing the role of part-time labor in Japan in response to monetary shocks and in recessions and booms. Hoshi and Kashyap (2020), while not concerned with the aggregate consumption response to monetary shocks as we do here, show that the response of aggregate wages to business cycles are impacted by the ratio of regular and non-regular workers. Iwasaki, Kubota, Muto, and Shintani (2022) deals with the response of labor force participation to monetary policy shocks. To explain the asymmetric response to the monetary easing of the labor force participation in Japan (rise) and that in the US (decline), they write a New Keynesian model featuring labor force participation decision and downward nominal wage rigidity. They find that these opposite responses are attributable to the differences in wage rigidity, which is lower in Japan than in the US. Our paper, on the other hand, discusses the responses to monetary policy of the consumption of the different types of worker households. Mukoyama, Shintani, and Teramoto (2021) discusses the business cycle behavior of the part-time employment rate, which rises during the recession whereas the full-time employment rate falls. Based on their observation that the distinction matters in the worker flows from and to both types of employment (full-time/part-time) and status of employment (employed/unemployed), they embed the segmented labor market of part-time employment into a New Keynesian search-and-matching model. While their model features a representative household, our model has two distinct households that differ in the types of jobs they are engage in.

In this paper, we show that the rise in the share of non-regular workers has contributed to lowering the response of aggregate consumption to monetary shocks. The characteristics of Japanese non-regular workers that differ from regular workers, albeit stylized, are their lower human capital (suggested by their lower wages), and the flexibility of their wages and demand for their services. Regular workers are subject to adjustment costs to their employment and their wages are not as flexible.

Since our focus is on short-run monetary policy responses, we assume that the expansion of non-regular workers over the past three decades is structural and exogenous to the shocks in our model. In Section 2, we show using Japanese household panel data that there is heterogeneity in the consumption responses between regular and non-regular workers with respect to monetary shocks. In Section 3, we present a New Keynesian model featuring two distinct labor markets, one for regular and the other for non-regular worker households. We assume that these two household types are distinct, and households cannot switch from one

[5]One is a perfectly competitive market where the wage rate is determined in the market as the marginal productivity of labor, the other is a unionized labor market where the workers and the firm negotiate the wage rate through Nash bargaining. Our model adds two changes to the unionized workers. First, we allow unions to monopolistically competitively set the wage rate. Second, we introduce adjustment costs of the demand for the regular type of workers.

type to another at the business cycle frequency. We justify this assumption by the low annual rate of movement (4 percent) of non-regular workers to regular workers during economic expansions. In Section 4, we calibrate the model using disaggregated Japanese data.

In Section 5, we simulate our calibrated New Keynesian model and conduct policy experiments. We conduct five policy experiments, in addition to our benchmark simulations. In all of our simulations, we shock our model with a 1 percent monetary shock according to the calibrated Taylor rule embedded in our model.

In the benchmark simulation, we take our calibrated values, and the current proportion of non-regular workers, 37%. We then trace out the consumption, labor supplies, and wages of the regular workers, non-regular workers, and in the aggregate.

In our first policy experiment, we examine the effects of lowering the proportion of non-regular workers to the level in the 1990s, 20%. We find that upon the monetary shock, aggregate wages and aggregate consumption would have been higher. Thus, a rise in the non-regular worker proportion will lower the aggregate consumption response to monetary shocks. The essential mechanisme here is that the presence of more non-regular worker households expands non-regular worker employment after the monetary shock, thereby suppressing the change in wages of the regular workers, reducing the increase in consumption.

In our second experiment, we lower the human capital of non-regular workers. Compared to the baseline, where the productivities of the two types of workers are equal, the lower productivity of the non-regular workers reduces aggregage consumption upon the monetary shock.

In our third experiment, we allow differing compositions of regular workers to non-regular workers like in the first experiment, but allow the quality of labor of the non-regular type to be lower than that of the regular type.

In the final two experiments, we 1) raise the costs to firms of adjusting the number of regular workers; and 2) allow unions to reset the wages of regular workers more frequently. Both of these experiments correspond to recent changes in Japanese labor market institutions. The higher adjustment costs and the higher frequency of wage changes both dampen the growth in regular worker employment, and lower the changes in aggregate wages and in consumption.

II. Monetary Shocks and the Consumption of Regular and Non-regular Workers

A. Data

Our data source is the Japan Household Panel Survey (JHPS/KHPS) conducted by the Panel Data Research Center at Keio University. KHPS and JHPS were originally distinct household panel surveys conducted separately beginning in 2004 and 2009. The surveys have been combined since 2014. The JHPS/KHPS collects income, asset and consumption data in addition to demographic information for a

stratified random sample of households; the same households continuously answer the survey questions[6]. One caveat of the JHPS/KHPS is that consumption is surveyed for only one month (January of the survey year), while income and assets data are surveyed at both monthly (the same timing as consumption) and annual frequencies. For consumption, we use total monthly expenditures including mortgage payments. To lower the influence of outliers, we drop all observations below the 10th and above the 90th percentiles in consumption.

As mentioned, the JHPS/KHPS classifies workers based on three steps. First, the respondents were asked **whether they worked or not** the year before the survey. For those who worked in the previous year, the second classification is **the type of employment**. While some workers are engaged in self-employed jobs and professional jobs, the vast majority of workers are wage workers. We classify wage workers into **"regular" type of workers (or regular workers)** if they (1) are directly employed, (2) have contracts without a limited term, and (3) work full time. The other wage workers are all classified into **"non-regular" type of workers (or non-regular workers)**. Non-regular type of workers include part-time jobs, dispatched workers and any other wage workers that violate at least one of the above three conditions. JHPS/KHPS does these classifications for both primary respondents and their partners if any in the household. Since our analysis is based not on individual workers but on households, we classify a household into a "non-regular" type if neither of the respondents or their partners has a regular type of job and at least one of them is engaged in a non-regular type of job. However, if either the respondent or a partner is engaged in a regular type of job, such households are classified as regular types of households.

In our estimation below, we also use another, broader definition of regular and 'non-regular' workers that covers every type of worker. This broader category of non-regular workers include the self-employed, wage workers that work at a family business, or at home without an employee relationship. Professional workers such as lawyers, accountants, and doctors are included in the regular workers category.

Descriptive Statistics

Table 2 compares some of the descriptive statistics of our dataset built from JHPS/KHPS with the counter part among the official government statistics in Japan in 2017. The statistics in this table treats primary respondents and his/her partner in a given household to be separate observations. Shares of the regular workers and non-regular workers among employed workers are compared with statistics from more representative datasets such as the Labor Force Survey. We find three broad patterns. First, the composition of non-regular workers is high for young people ages 15 to 24. This is because workers in this age category

[6]One of the most standard official household surveys in Japan is the Family Income and Expenditure Survey (FIES) by Ministry of Internal Affairs and Communication. This survey has coverage of roughly 8,000 households at a monthly frequency, but based on rotating panels where the same households are surveyed only for up to six months. In this paper, we prefer to control for household fixed effects, and use the JHPS/KHPS dataset.

Table 2—Comparison between KHPS/JHPS data and Japanese Official Statistics

	KHPS/JHPS	LFS	MLS
share of Non-regular workers (%)	38%	37%	
- among age 15-24	40%	47%	
- among age 25-34	27%	26%	
- among age 35-44	31%	29%	
- among age 45-54	34%	32%	
- among age 55-64	39%	47%	
monthly wage of Reg. workers (1,000 Yen)	34.84		31.06
- among age 15-24	16.38		20.98
- among age 25-34	25.05		26.27
- among age 35-44	33.08		32.81
- among age 45-54	39.10		38.63
- among age 55-64	41.09		35.22
monthly wage of Non-reg. workers (1,000 Yen)	15.00		21.08
- among age 15-24	14.50		18.37
- among age 25-34	14.85		20.51
- among age 35-44	12.24		21.01
- among age 45-54	12.98		20.61
- among age 55-64	17.46		22.07

Notes: details on LFS (Labor Force Survey) and MLS (Monthly Labor Survey) are in the appendix. The statistics in this table treat primary respondents and his/her partners in a given household to be separate observations. All the descriptive information is as of the fiscal year 2017. Percentage share is the fraction among the employed workers (regular workers and non-regular workers).

mostly work only part-time. Second, the composition of the non-regular workers is lowest for the group of age 25 to 34. The main reason is that in Japan, most regular workers are hired as new school graduates. Third, the composition of non-regular workers rises as workers age. There are several reasons for this. For example, it is pointed out that women's labor force participation drops at about the age when they experience childbirth. After that point, many return to the labor force, but often at lower paid non-regular jobs. Another reason is that it is harder for those who lose their regular type of jobs in their 40s or 50s to find a regular type of job.

For wage comparisons, we choose the monthly wage as our measure of income. Therefore we compare monthly wage receipt data in our dataset with that in the Monthly Labor Survey. The gap in monthly wages between regular and nonregular workers is wider in the Monthly Wage Survey.

Table 3—Descriptive Statistics of KHPS/JHPS data

	Type of statistic	Regular type of HH	Non-regular type of HH
Age of the Primary Respondent	Mean	46.90	56.97
	Standard Deviation	10.62	13.49
Proportion of Married Household	Mean	83.18%	66.23%
	(Standard Deviation)	(0.37)	(0.47)
Number of Family Members	Mean	3.56	3.06
	(Standard Deviation)	(1.39)	(1.39)
Monthly Wage Earning of Primary Respondent	Mean	325	190
	(Standard Deviation)	(181)	(142)
	(Within Variation)	(73)	(75)
	Correlation with Monetary Policy Shock	−0.52%	2.41%
Total Household Expenditure	Mean	284	239
	(Standard Deviation)	(167)	(152)
	Correlation with Monetary Policy Shock	−1.69%	−2.24%

Note: money amount is in units of ten thousand Yen. Unit of observation is a household, which is classified into 'Regualr type of HH' if either of the primary respondent or his/her partner is a regular type of worker, and 'Non-regular type' if neither of the primary respondents nor his/her partner is regular type but either of them is engaged in non-regular type of job. 'Within Variation' means standard deviation of observations across time.

In Table 3, we look at several demographic variables on a household basis. We classify a household to be a 'regular type' if either the primary respondent or his/her partner is a regular type of worker. On the other hand, if neither the primary respondents nor his/her partner is a regular type but either of them is engaged in a non-regular type of job, then such a household is classified as a 'non-regular type.' For the age of the primary respondent, that of the non-regular workers households is higher than that of the regular workers households. For marital status and family size, however, there is not much difference between the two types of households.

As has been studied in the Figure 3, the monthly wage of the primary respondent in the regular type of workers household is almost twice as high as that of the primary respondent in the non-regular type of workers household. While this level difference leads to larger standard deviation of the wage of the regular workers, when seen on an individual household basis over time, this 'within' variation of the monthly wage is larger for the non-regular type of workers.[7] The correlation of these variables with the monetary policy shock, to be defined in the next section, is higher among non-regular workers households.

The total household expenditure is close between regular and non-regular workers household. Their correlation with the monetary policy shock is, however, larger in magnitude for non-regular workers than for regular workers.

B. Monetary Policy Shocks (Kubota and Shintani (2022))

As our measure of monetary policy shocks, we use data from the Euro-Yen futures market prepared by Kubota and Shintani (2022). They identify monetary policy shocks from a so called high-frequency method, which is used in many preceding studies (Nakamura and Steinsson (2018), Nakamura, Sudo, Sugisaki et al. (2021)). The idea is that Euro Yen futures are determined in efficient financial markets. Kubota and Shintani (2022) collect these surprises at a 30-minute window following announcements by the BOJ for the 3-month, 6-month, 9-month, and 12-month Euro-Yen futures market. They use the following equation regressing stock prices and JGB yields on those 'exogenous' Euro-yen movements:

$$\Delta y_t = \alpha + \beta \Delta x_t + \varepsilon_t$$

The authors decompose these surprises into 2 factors; the "path factor", which affects the expected path of future short rates, and the "target factor", which mainly affects the current short-term rates.

We choose to use the path factor in our empirical work below given that consumption decisions are forward looking. Since the frequency of our dataset is annual, we aggregate these shocks into annual frequencies.

[7] If we take into account the level difference in monthly wage earning between regular and non-regular type by computing the variation coefficient, the wage of the non-regular workers households (39.5) is larger than that of the regular workers households (22.5).

C. Consumption Response to Monetary Shocks

The main specification we use in our estimation of the impact of monetary shocks on the consumption of regular and non-regular households is:

$$\Delta \log c_{ht} = \sum_{k=0}^{1} \beta_k * \varepsilon_{t-k} + \alpha_3 Non_{ht} + \sum_{k=0}^{1} \beta_{Non,k} Non_{h,t-k} * \varepsilon_{t-k} + \alpha_4 Full_{ht} + \sum_{k=0}^{1} \beta_{Full,k} Full_{h,t-k} * \varepsilon_{t-k} + \alpha X_{ht} + \lambda_h + v_{ht}$$

The dependent variable is the total expenditures of the household. The controls X include the age brackets of the primary respondent in 3 categories (the young if up to 34 years old, the middle if between 35 and 64 years old, and the elderly otherwise), the number of family member, the number of children, the 8 region block dummies and city size dummies (living in the 21 largest cities, other cities, and towns or villages), the city and region dummies are meant to take into account the difference in living costs across regions.

Table 4—Broader Definition

	(1)	(2)	(3)	(4)	(5)
Effect on Non-reg. HH	-0.994	-0.904	-0.994	-0.904	-0.844
	(0.32)	(0.32)	(0.22)	(0.23)	(0.35)
	[0.078]	[0.111]	[0.035]	[0.058]	[0.156]
Effect on Full HH	-0.374	-0.302	-0.374	-0.302	-0.539
	(0.17)	(0.18)	(0.13)	(0.13)	(0.20)
	[0.433]	[0.529]	[0.355]	[0.462]	[0.292]
Difference	-0.620	-0.602	-0.620	-0.602	-0.305
	(0.14)	(0.14)	(0.09)	(0.10)	(0.15)
	[0.162]	[0.177]	[0.084]	[0.096]	[0.502]
Controls	No	Yes	No	Yes	Yes
HH Random Effect	No	No	Yes	Yes	No
HH Fixed Effect	No	No	No	No	Yes
Num. Obs.	44846	44761	44846	44761	44761

Notes: numbers in parenthesis and brackets are standard errors and p-values, respectively.
Coefficients on contemporaneous and lagged effects are combined using delta method.
Data source: JHPS/KHPS

The results are depicted in Table 4 (broader definition of regular and non-regular workers) and in Table 5 (narrower definition of regular and non-regular

Table 5—Narrower Definition

	(1)	(2)	(3)	(4)	(5)
Effect on Non-reg. HH	-0.712	-0.639	-0.712	-0.639	-0.635
	(0.52)	(0.52)	(0.35)	(0.35)	(0.57)
	[0.322]	[0.376]	[0.228]	[0.283]	[0.400]
Effect on Full HH	-0.038	-0.013	-0.038	-0.013	-0.267
	(0.13)	(0.13)	(0.09)	(0.10)	(0.16)
	[0.929]	[0.975]	[0.916]	[0.971]	[0.559]
Difference	-0.675	-0.626	-0.675	-0.626	-0.369
	(0.39)	(0.39)	(0.25)	(0.26)	(0.41)
	[0.311]	[0.349]	[0.209]	[0.247]	[0.589]
Controls	No	Yes	No	Yes	Yes
HH Random Effect	No	No	Yes	Yes	No
HH Fixed Effect	No	No	No	No	Yes
Num. Obs.	41185	41101	41185	41101	41101

Notes: numbers in parenthesis and brackets are standard errors and p-values, respectively.
Coefficients on contemporaneous and lagged effects are combined using delta method.
Data source: JHPS/KHPS

workers). We find in Table 4 that compared to the baseline category (the unemployed and the retired), an increase in the magnitude of the monetary policy shock lowers the consumption of both the non-regular and regular types of households. We find that in all specifications, non-regular households have a greater decline in household total expenditures than do regular households. This suggests that expansionary monetary policies do raise household expenditures, but the most affected were non-regular type of households. The differences between households are less significantly estimated in Table 5 with the narrower definition of regular and non-regular workers.

In the model developed in the next section, we will rationalize this finding of the stronger consumption response of the non-regular type of households to monetary easing.

III. Model

Below we develop a Two Agent New Keynesian (TANK) model with households consisting of regular workers and non-regular workers respectively. The non-regular workers face a perfectly competitive labor market. The regular workers, on the other hand, are assumed to belong to unions, which monopolistically set a wage rate. There are a continuum of industries and unions associated with each regular worker.

A. Households

Non-regular workers take the market wage as given and work for firms, while **regular workers**, who each belong to unions, sell their labor not to firms, but to an intermediary **labor packer**. Flow utility, discounted by β, for both type of households given by $(i = R, n)$:

$$U\left(C_t^i, L_t^i\right) = \frac{{C_t^i}^{1-\sigma}}{1-\sigma} - \psi \frac{{L_t^i}^{1+\chi}}{1+\chi}$$

The budget constraint facing the regular type of households, written in nominal terms, is:

$$P_t C_t^R + B_t^R \leq W_t^R L_t^R + R_{t-1} B_{t-1}^R + \kappa {B_t^R}^2 + DIV_t^R \tag{1}$$

The household can save via a one period bond (B_t^R) with the gross nominal interest rate R_t, but selling and buying them incurs an adjustment cost ($\kappa {B_t^R}^2$). W_t^i is the nominal wage which their monopolistically competitive unions set. Here the regular type of households are assumed to have a higher fraction of ownership of the firms in the economy (DIV_t^R), getting the bulk of the dividends.

The problem faced by non-regular workers is the same as that by regular workers. The only difference is that they are paid at W_t^n, which is the competitive market wage in the non-regular type of labor market. While the union to which regular workers belong solves the dynamic problem to choose the reset wage, non-regular type of workers just take the market-determined W^n as given.

B. Labor Market Players

Regular workers belong to **labor union**s, which are monopolistically competitive and allocate homogeneous labor into differentiated labor for each industry. Labor unions collect labor from regular workers, and sell them to a **labor packer**. A labor packer then sells the aggregated (regular type) labor to **wholesale firms** at a competitive price. Note that while a non-regular worker's wage is perfectly competitive and flexible, regular workers' wage is not only rigid but also includes a markup. Wages of regular workers depart from marginal productivity because of the seniority wage system and un-modeled firm level benefits such as housing and recreational facilities.

Labor Packer

There are a continuum of industries indexed by $l \in [0, 1]$, and associated labor unions. The labor unions sell regular type of labor to a labor packer at $W_t^R(l)$. The labor packer combines union labor into a final labor input available

to wholesale firms via a CES technology:

$$L_{d,t}^R = \left[\int_0^1 L_t^R(l)^{\frac{\epsilon_w - 1}{\epsilon_w}} dl\right]^{\frac{\epsilon_w}{\epsilon_w - 1}}$$

Profit maximization yields a demand curve for each union's labor and an aggregate wage index for regular workers:

$$\begin{aligned} L_t^R(l) &= \left(\frac{W_t(l)}{W_t}\right)^{-\epsilon_w} L_{d,t} \\ W_t^{R1-\epsilon_w} &= \int_0^1 W_t^R(l)^{1-\epsilon_w} dl \end{aligned}$$

Labor Unions

Unions have market power in one of the industries they belong to and set wages. With probability $1 - \phi_w$, a union can update its wage. The problem for a union given the opportunity to update is to pick $W_t^R(l)$ to maximize the present discounted value of real dividends, where discounting is by the household's real SDF, $\Lambda_{t,t+1}^R$, and the probability that the price chosen today will be in effect in the future. The solution to the maximization problem is the price they set, and is called the reset wage. The maximization problem is shown in more detail in the Appendix.

C. Firms in the Goods Markets

The only input of production is labor, which has the two types. There are three layers of firms. **Wholesale firms** collect non-regular labor from non-regular workers directly, and regular workers indirectly through the labor packer. **Retail firms** purchase wholesale products, and sell them to a final good firm. Retail firms transform homogeneous wholesale products into differentiated intermediary products, giving retail firms market power as in the canonical New Keynesian model. **A final goods firm** buys these differentiated products from retail firms, and sells the products to regular and non-regular workers households.

Final Goods Firm

The final goods firm combines retail outputs into a final good. Retail output is transformed into final good via:

$$Y_t = \left[\int_0^1 Y_t(f)^{\frac{\epsilon_p - 1}{\epsilon_p}} df\right]^{\frac{\epsilon_p}{\epsilon_p - 1}}$$

Profit maximization by the final goods firm yields a demand for each retail output and a price index.

$$\begin{aligned} Y_t(f) &= \left(\frac{P_t(f)}{P_t}\right)^{-\epsilon_p} Y_t \\ P_t^{1-\epsilon_p} &= \int_0^1 P_t(f)^{1-\epsilon_p} df \end{aligned}$$

Retail Firms

Retail firms purchase wholesale output at $P_{w,t}$ and costlessly repackages the output, and sells the output to a competitive final goods firm at $P_t(f)$, where retailers are indexed by $f \in [0,1]$. Retailers can only adjust their price with probability $1-\phi_p$. Their price-setting problems are:

$$\max_{P_t(f)} \mathbf{E}_t \sum_{j=0}^{\infty} \phi_p^j \Lambda_{t,t+j}^R \left\{ P_t(f)^{1-\epsilon_p} P_{t+j}^{\epsilon_p - 1} Y_{t+j} - P_{w,t+j} P_t(f)^{-\epsilon_p} P_{t+j}^{\epsilon_p - 1} Y_{t+j} \right\}$$

The solution to this problem is the reset inflation rate, which is typical in New Keynesian model with Calvo (1983)'s staggered prices, and is in the same spirit as the reset wage rate set by labor unions.

Wholesale Firm

A representative wholesale firm hires two types of labor: (1)the regular type of labor sold by a labor packer, and (2)the non-regular type of labor hired through the competitive labor market. The production function of wholesale output is:

$$Y_{W,t} = A_t \left[\omega \left(A_t^n L_{d,t}^n \right)^{\mu} + (1-\omega) \left(A_t^R L_{d,t}^R \right)^{\mu} \right]^{\frac{1}{\mu}},$$

where A_t is stochastic TFP to be specified later. A_t^n and A_t^R are meant to capture the quality of labor input for each type, and μ governs the substitutability of the two types of labor. We also assume that labor demand for regular type of workers is subject to a quadratic adjustment cost of the form:

$$\theta (L_{d,t}^R - L_{d,t-1}^R)^2.$$

This term is meant to capture the sluggish adjustment in labor demand in the regular type of workers resulting from difficulties in firing. The resulting profit maximizing problem of the firm is set up as:

$$\max_{L_{d,t}^n, L_{d,t}^R} \pi_{W,t} = P_{w,t} Y_{W,t} - W_t^n L_t^n - W_t^R L_t^R - \theta P_{w,t} (L_{d,t}^R - L_{d,t-1}^R)^2.$$

Table 6—List of Model Parameters and Calibrated Values

	Description	Value	Origin
β	discount factor	0.99	standard
χ	Frisch elasticity of labor supply	1.83	our estimate
χ^n	Frisch elasticity of labor supply	1.10	our estimate
σ	inverse of inter-temporal elasticity of substitution (CRRA parameter)	1.12	our estimate
ε_p	price elasticity of demand	10.0	Muto and Shintani (2017)
ε_w	price elasticity of labor demand	6.23	Muto and Shintani (2017)
ϕ_p	probability that retail firms fail to change the price	0.49	Iwasaki, Muto, and Shintani (2021)
ϕ_w	probability that labor unions fail to change the wage	0.81	Iwasaki et al. (2021)
μ	production substitutability of regular and non-regular type of workers	0.75	our estimate
ω	proportion of non-egular type of workers	0.37	Labor Force Survey (Ministry of Internal Affairs and Communications)
κ	adjustment cost of bond holding	10	Inui et al. (2017)

D. Stochastic Processes and Aggregation

We assume that the gross nominal interest rate, R_t, is set according to a Taylor type rule:

$$\ln R_t = (1-\rho_R)\ln R + \rho_R \ln R_{t-1} + (1-\rho_R)\,\theta_\pi\,(\ln \Pi_t - \ln \Pi) + s_R \varepsilon_{R,t} \tag{2}$$

Variables without time subscripts, R and Π, denote non-stochastic steady state values.

The only exogenous variable is productivity A_t. We assume that it follows an AR(1) in log with non-stochastic mean normalized to unity:

$$\ln A_t = \rho_A \ln A_{t-1} + s_A \varepsilon_{A,t} \tag{3}$$

We assume that there is a mass of ω of non-regular workers, and $1-\omega$ of regular workers in the economy. We assume zero net supply of bonds.

IV. Calibration

This section details the calibration of the model described in the previous section. Table 6 summarizes the figures and sources for each.

While some parameters (β, κ, $\varepsilon_p, \varepsilon_w, \phi_p$, and ϕ_w) are chosen from previous work, we calibrate χ, χ^I, σ and μ using our own estimates, as described below. .

A. Frisch labor supply elasticity: χ and χ^n

We define the Frisch labor supply elasticity as the wage elasticity of hours supplied holding consumption constant. Thus it captures the substitution effects, but not the income effects from the wage change. It is typically estimated based on the intra-temporal optimality condition of consumption and labor, which is derived as below in our model:

$$\psi L_t^{\chi} = C_t^{-\sigma} W_t.$$

Taking logarithms, first differencing, and adding unobserved disturbances ε_t:

$$\Delta \log L_t = const. + \frac{1}{\chi} \Delta \log W_t + \alpha \Delta \log C_t + \varepsilon_t.$$

One of the challenges for this estimation is that we need to measure the response of labor to predictable wage changes, not actual wage changes, which may include unpredictable movements in wages. Thus the literature starting from MaCurdy (1981) uses instruments to obtain predictable wages, examples of which are (workers' own or their parents') education, age, and where they live. In earlier work for the case of Japan, Kuroda, Yamamoto et al. (2007) use panel data of young women in the Japanese Panel Surveys of Consumers to estimate the Frisch parameter to be 0.306 for households with regular workers, and 0.305 for non-regular workers.

We use our JHPS/KHPS data to estimate this parameter. One of the advantages of our dataset is that it not only includes the record of hours worked and wages but also collects the type of jobs they are engaged in, which allows us to obtain estimates for the regular type of workers and the non-regular type of workers separately.

Table 7 summarizes the estimation results using education, age, sex, city size dummy (living in (a) a city holding over 1 million of population, (b) other cities, and (c) towns or villages), and 8 region block dummy variables as instrumental variables. Columns (1) and (2) give OLS estimates, while (3) and (4) give IV estimates, which are our preferred specifications. The estimate for non-regular workers is higher than that for regular workers, and that for all workers lies in between. All estimates are higher in IV cases, suggesting that IV overcomes the downward bias. Although the estimate for regular workers is not significant, and thus the test for the difference in the estimates between the effects on regular workers and those on non-regular workers do not reject the null, we take these results as suggestive that the labor supply of non-regular workers is more elastic than that of regular workers.

Table 7—estimation of Frisch labor supply elasticity

	(1)	(2)	(3)	(4)
All workers	0.222***		0.731***	
	(9.79)		(6.24)	
Regular workers		0.148***		0.331
		(5.20)		(0.88)
Non-regular workers		0.285***		1.330**
		(8.54)		(2.59)
control	yes	yes	yes	yes
IV	no	no	yes	yes
p-val. of Regular - Irregular		0.002		0.241
Number of Observations	31824	31824	31824	31824

Notes: for this analysis we treat working husbands and working wives in a given household as distinct observations, and cluster standard errors at household levels. The coefficient "All workers" are obtained from a regression of pooling both types of workers and running log hours changes on log wages changes, whereas "Regular workers" and "Non-regular workers" are obtained from a regression of running log hours changes on interaction of dummy variables indicating regular type and non-regular type and log wages changes. For regression (2) and (4) the difference of coefficients are tested with lincom (linear combination) in Stata, and the p-values are shown.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

B. Intertemporal elasticity of substitution: σ

The Intertemporal elasticity of substitution (IES) is estimated using the Euler equation:

$$C_t^{-\sigma} = \beta R_t E_t \left[\pi_{t+1}^{-1} C_{t+1}^{-\sigma}\right],$$

which is transformed into log differences (growth rates):

$$\Delta \log C_t = const. + \frac{1}{-\sigma}\left(\pi_t + \Delta r_t\right) + \varepsilon_t.$$

Traditionally this equation is estimated using aggregate time series data, seminal work of which are Hall (1988) and Campbell and Mankiw (1989). The challenge here is to find instruments to control the endogeneity of the real interest rate. [8]. We overcome this challenge by using an exogenous policy shift as an instrument and use micro data.

Cashin and Unayama (2016) earlier measured the IES using the consumption tax hike in Japan. This was a good natural experiment in three respects. Firstly,

[8] Early work such as Hall (1988) and Campbell and Mankiw (1989) used lagged variables as IV, but this is pointed out to be subject to a weak instruments problem by Yogo (2004)

consumption taxes in Japan are applied to almost all goods[9] at the same rate[10]. Thus a rise in the consumption tax rate can be regarded as a proportional change in the price level. Secondly, the tax hike is announced prior to implementation, so that households can engage in intertemporal optimization. Thirdly, given that interest rates in Japan have been near zero and stable for the last 20 years, we can attribute the change in real interest rates almost entirely to price changes.

While Cashin and Unayama (2016) use the Family Income and Expenditure Survey[11] and utilize the consumption tax hike in 1997, we apply the JHPS/KHPS data to the consumption tax hike in April 2014. Since our dataset has household expenditure data for only January, we regard data in January 2014 as the expenditure before the tax hike, and data in January 2015 as the expenditure after the tax hike. How was the policy announced and anticipated? The policy change was announced in June 2012 and was agreed to be implemented among the ruling Democratic Party at the time and the other two parties, the Liberal Democratic Party and the Komeito party. The two parties defeated the Democratic Party in the election at the end of the year, but maintained the earlier agreement; the consumption tax hike from 5% to 8% was implemented as scheduled. Thus we can regard the period between January 2013 and January 2014 as the announcement period, when households shifted their expenditures.

Table 8—estimation of intertemporal elasticity of substitution

	(1)	(2)
consumption tax hike	-0.00316	-0.00201
	(-0.46)	(-0.29)
announce		0.0110
		(1.63)
IES estimate (converted from estimate)	0.105	0.067
	(0.230)	(0.231)
Number of Observations	54507	54507

Note: "consumption tax hike" dummy takes 1 only in year 2015. "announce" dummy takes 1 in year 2013. IES estimate is negative of coefficients on "consumption tax hike" dummy divided by 0.03 (rate increase).

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 8 summarizes the estimation results. Each specification uses time dif-

[9] Examples of expenditure exemption are raised in Cashin and Unayama (2016).

[10] When rates were 3% (since April 1989), 5% (since April 1997) and 8% (since April 2014), there was almost no heterogeneity in applied rates. When rates were raised to 10% (since October 2019), some items including food and newspapers were under reduced rates (8%).

[11] This is one of the broadest surveys on household consumption and income. While it holds on average 8,000 households and their detailed information, each household is surveyed for only 6 months, thus this is a so-called rotating panel.

ferenced demographic data on the number of children and the number of family members as controls. Column (2) has lower estimates on the tax hike dummy (dummy taking 1 in 2015) than column (1), the only difference between the two columns being the inclusion of the announcement dummy which takes 1 only in 2013 and 2014. The resulting estimate of the IES parameter is 0.067 in column (2), which is a low estimate comparable to Hall (1988). Cashin and Unayama (2016) gives 0.21 as the most preferred estimate. The difference between their estimate and ours might be an interesting topic in itself, but we proceed with our estimate of 0.067[12].

C. Production Substitutability Parameter: μ

In the model we consider labor to be the only factor of production. There are two types of labor. One type is the regular type L_t^R, and the other is the non-regular type L_t^n, and both are imperfect substitutes. The production function for intermediate goods (wholesale output) $Y_{W,t}$ is (6):

$$Y_{W,t} = A_t \left[\omega \left(A_t^n L_{d,t}^n \right)^{\mu} + (1-\omega) \left(A_t^R L_{d,t}^R \right)^{\mu} \right]^{\frac{1}{\mu}}.$$

This μ governs the substitutability between the regular type and the non-regular type of workers, and we estimate this based on the "canonical model" by Katz and Murphy (1992):

$$\ln \left(\frac{w_t^R}{w_t^n} \right) = \mu \ln \left(\frac{A_t^R}{A_t^n} \right) + (\mu - 1) \ln \left(\frac{L_t^R}{L_t^n} \right) + const. + \varepsilon_t.$$

This $\mu - 1$ is estimated as -0.71, thus giving $\hat{\sigma} = \frac{1}{1-\hat{\mu}} = 1.41$ as in Katz and Murphy (1992) and is considered to be robust in the US regarding the substitutability between high-skilled and low-skilled workers.

We employ the specification of Katz and Murphy, and use wage and labor input data from the Monthly Labor Survey. The survey records data on workers in establishments including wages, hours, numbers and so on, for the regular type of workers and part-time workers. We use monthly wages exclusive of bonus payments to make seasonality as small as possible. We choose hours worked in a given month for variables L_t^R and L_t^n. Note that part-time workers are a narrower definition than the non-regular type of workers, which includes fixed-term workers.

As an IV to instrument for the ratio of labor inputs, we employ a policy change in Japan on the regulation of the Temporary Staffing Services Law. As mentioned in the Introduction, originally introduced in 1985, the law allowed several industries to use temporary workers who are non-regular workers. The 1999 amendment to the Law substantially expanded the range of industries in which

[12] While our estimate in Table 8 is not statistically significant, Cashin and Unayama (2016) also gives results not statistically significant.

the law is applicable[13]. Moreover, in the 2004 amendment, temporary workers were allowed to be used in the manufacturing industry, the second largest industry in terms of employees. These exogenous policy changes should have affected the ratio of regular workers to non-regular workers in most industries.

Table 9—estimation of substitutability of regular and irregular labor

	(1) average	(2) all industry	(3) all industry	(4) all industry
L^R/L^n	-0.165***	0.595***	0.922***	-0.735**
	(-3.75)	(54.50)	(64.48)	(-2.92)
A^R/A^n	-0.00000713	-0.00441***	-0.00475***	-0.00358***
	(-0.03)	(-16.58)	(-31.01)	(-9.79)
IV	no	no	no	yes
Number of Observations	352	4024	4024	4024

Notes: L^R/L^n is the log of the ratio of hours worked by regular type of workers divided by those by non-regular type of workers. A^R/A^n is treated as a yearly time trend. Each regression includes full set of month dummies to take care of seasonality. Specification "average" means the average across industry is used for regression. "all industry", on the other hand, include all industry averages into the estimation and form a panel.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Column (1) is a time series regression of the total industry average, and gives the estimate of -0.165, which corresponds to $\hat{\sigma} = 6.06$. While Katz and Murphy (1992) use a time series regression, we can increase the size of the sample by using industry level data. However, pooled OLS in column (2) and panel OLS in column (3) give positive estimates, which are difficult to interpret. Column (4) is the result utilizing IVs, and again gives a negative estimate of -0.735. This corresponds to $\hat{\sigma} = 1.36$, and happens to be very close to Katz and Murphy (1992)'s estimate on the substitution elasticity between high-skilled and low-skilled workers.

V. Model Simulation

We first show the steady state of the model introduced in section III, and the parameters calibrated in section IV. Then we show the impulse responses of the model in our monetary easing exercise. Finally, we compute and compare the welfare losses from the business cycles from the model, by varying the composition of the regular and non-regular workers.

[13]While the law used a positive list before the 1999 amendment, which specified types of professional jobs and industries in which temporary staffing service is allowed, including interpreters and secretary services, the 1999 amendment used a negative list, which specified the types of jobs and industries in which temporary staff servicing are not allowed, including manufacturing and medical industries.

Table 10—Steady State of the Quantitative Model

	Description	Value	(% of output)
Y	output	1.02	100%
C	aggregate consumption	0.74	68%
C^R	consumption of regular type	0.38	35%
C^n	consumption of non-regular type	0.35	32%
L^R	labor supply of regular type	0.62	-
L^n	labor supply of non-regular type	0.51	-
W	aggregate wage rate	0.34	-
W^R	wage rate of regular type	0.40	-
W^n	wage rate of non-regular type	0.23	-
π	price inflation	0.00	-
G	government expenditure	0.26	26%

A. Steady State

Table 10 summarizes the steady state of the variables in the model. Our model replicates well the wage difference between the regular type of workers and the non-regular type of workers, which we observe in Section I. The feature of the model which contributes to this is exactly the duality of the labor market; a competitive non-regular type labor market with flexible wage adjustment, and an unionized regular type labor market where the wage includes a markup and therefore is higher than the marginal product of the worker.

Since the regular type of worker exerts monopolistic power on the wage setting in their industry, the regular worker secures higher wages than non-regular workers. This wage difference is reflected in the consumption levels for each type of worker.

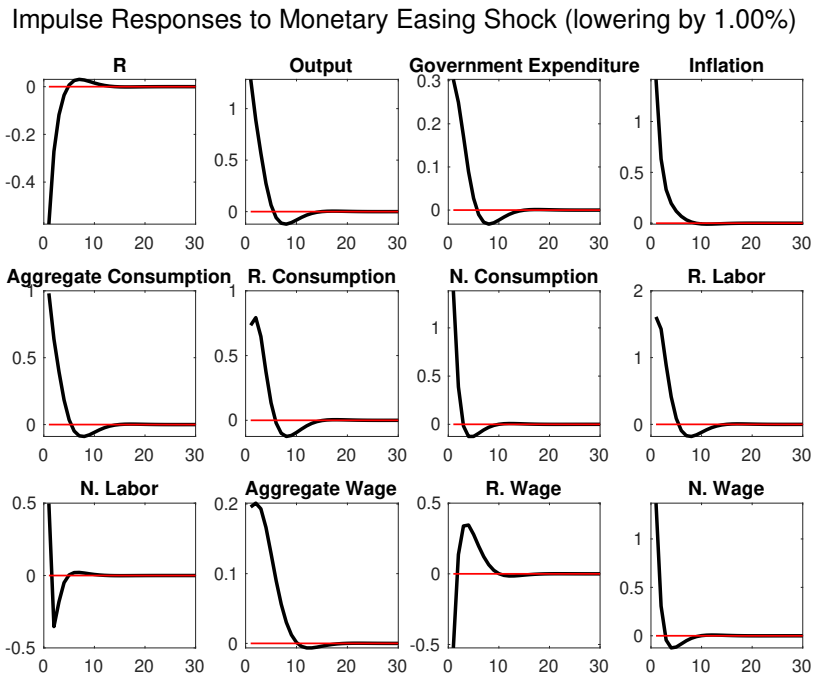
Government expenditures are set at 26 percent of GDP, as a result of taxes on labor and capital income. Note that government expenditures are endogeneized in this model through flat-rate income taxation. This share in GDP of government expenditures is comparable to the fraction of actual Japanese government outlays.

B. Benchmark Results

Figure 5 depicts the impulse responses of expansionary monetary policies. We impose a 1% monetary shock according to the Taylor rule (Equation 2 in our model). First, the consumption response of the non-regular type of workers is higher than that of the regular type of workers. This agrees with what is seen in Section II with the household panel data. Aggregate prices rise by more than nominal wages, and the real wage of regular workers goes *down* upon the impact of the monetary easing. Second, the labor supply of the non-regular workers

fluctuates while that of the regular type of workers moves smoothly. The monetary easing in this exercise is a temporary one, and the regular type of labor input is costly to adjust. Firms adjust the labor demand for the regular type of workers smoothly and adjust the labor demand for the non-regular type of workers from time to time; on impact of monetary easing it is raised to meet the increase in demand for final goods, but then it is reduced quickly since the regular type of workers' labor continues to be used.

FIGURE 5. IMPULSE RESPONSE TO A MONETARY EASING SHOCK



Note: Numbers in the vertical axis are percentage deviations from steady state values.

C. *Experiments*

In our first experiment, we answer the main question; had it not been for an expansion in the use of non-regular workers, what would be the consumption response to the monetary policy shocks? We study the impulse responses with differing compositions of regular workers and non-regular workers. This corresponds to a comparison of consumption responses to the monetary policy shocks in the 1980-1990 period, when the use of non-regular workers was not so prevalent ($\omega = 0.20$), with the consumption response in 2017, when non-regular worker use was more prevalent ($\omega = 0.37$). Specifically, we compare the impulse responses in Figure 5 with $\omega = 0.37$ to be the benchmark, and we newly compute alternative impulse responses with $\omega = 0.20$. In Figure 6 the former is depicted in solid lines, and the latter in dotted lines. We observe that the reaction of aggregate consumption to monetary easing is lower in its peak of 1.5% when $\omega = 0.20$ to 1% when $\omega = 0.37$.

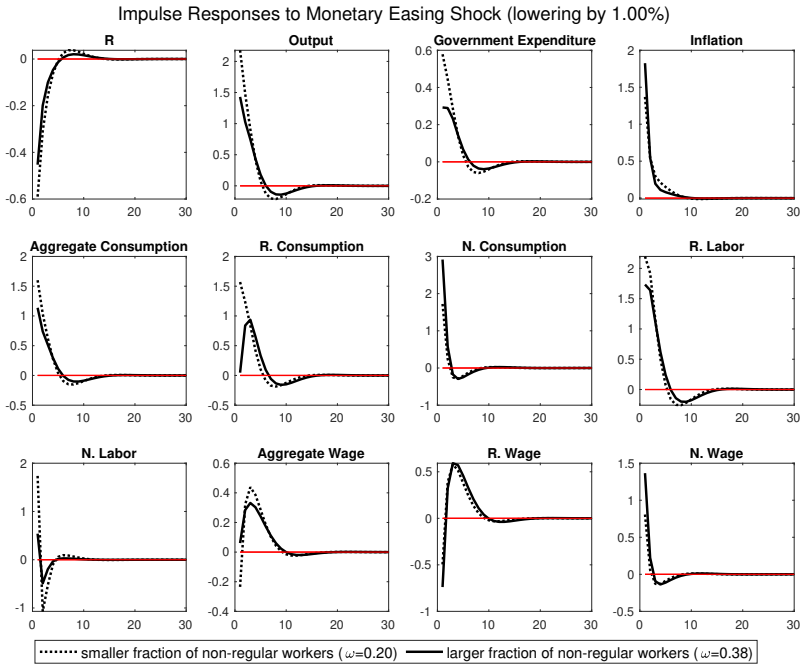
When non-regular worker households are more prevalent (high ω), firms can adjust their labor inputs more easily by the use of non-regular workers. This makes the wages of non-regular workers respond more to the monetary easing. Their response of the wages of regular workers, however, does not differ much from the wages in the low ω case. Since the adjustment of the regular workers' wage is slow due to the limited chance of wage revision, it cannot move differently at the beginning of the adjustment.

Since this wage response of non-regular workers has more influence on the aggregate wage response in the case with a large fraction of non-regular workers, the aggregate wage response is higher on impact of the monetary easing but weaker thereafter. At the same time, the response of the labor supply of regular household workers is weakened when the fraction of non-regular workers is large because firms can use the non-regular workers more and reduce the adjustment of the labor of the regular workers, which entails an adjustment cost. However, given their high wages and numbers (Figure 3), the high weight of regular worker wages in aggregate wages dominates and dampens the aggregate wage and consumption responses to monetary shocks.

In our second experiment, we vary the relative productivity of non-regular workers. Given that the wages of non-regular workers are much lower than that of regular workers, there may be productivity differences between these two types of workers. We take the impulse responses in Figure 5 with $A^n = 1$, no difference in the productivity of labor between regular and non-regular workers to be the benchmark. As our experiment, we take $A^n = 0.5$, that non-regular workers have a lower quality of labor than regular workers. In Figure 7 the former is depicted in dotted lines, and the latter in solid lines.

We observe that, compared with the baseline (dotted line) where non-regular workers have the same productivity ($A^R = A^n = 1$), aggregate consumption reacts less strongly to monetary easing when the productivity of non-regular workers is lower $A^R > A^n = 0.5$ (solid line). Because of the CES production function, a

FIGURE 6. IMPULSE RESPONSE TO A MONETARY EASING SHOCK WITH VARYING FRACTION OF NON-REGULAR WOKERS

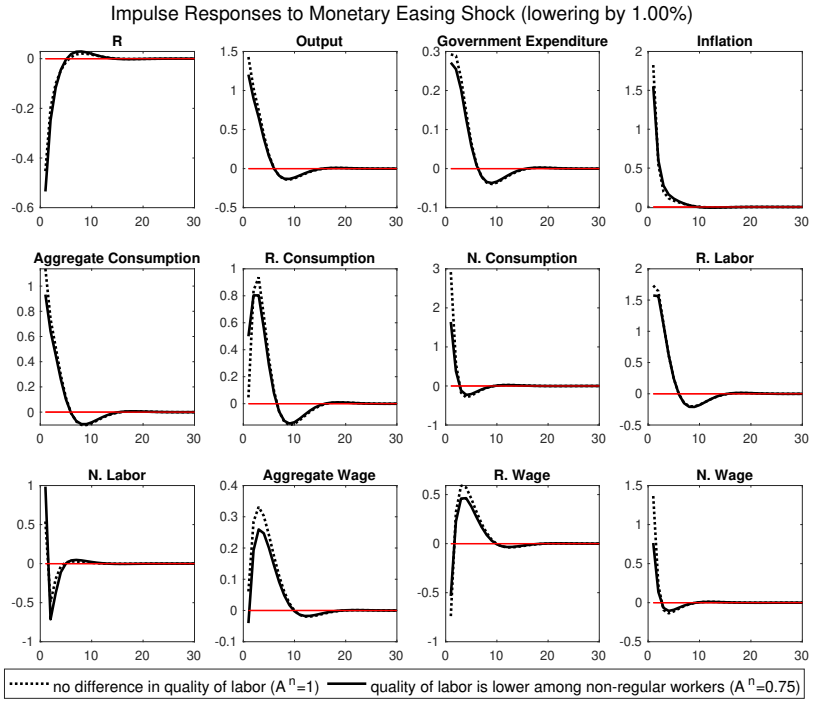


Note: Numbers in the vertical axis are percentage deviations from steady state values.

lower A^n has two effects; it decreases both the share of the non-regular workers and their productivity. This lowers aggregate productivity and the responses of aggregate wages and consumption to positive monetary shocks. The decreased share of the non-regular labor input will be $\frac{A^n{}^{\mu}\omega}{A^n{}^{\mu}\omega+1-\omega}$, while the associated overall productivity will be $A\left[\ A^n{}^{\mu}\omega+1\right]^{1/\mu}$, which will be lower than the aggregate productivity A if $A^{n\mu}$ is lower than the benchmark. This decline in aggregate productivity lowers the marginal productivities of both regular and non-regular workers, which in turn lowers the wage response to the monetary easing of both types of workers.

In our third experiment, we allow differing compositions of regular workers to non-regular workers just like in the first experiment, but this time we let the quality of labor of the non-regular type to be lower ($A^n = 0.5$) than that of the regular type ($A^R = 1$). In Figure 8 the case with a lower proportion of the non-regular type of workers is depicted in dotted lines, and the case with a higher proportion is depicted in solid lines. We observe that the reaction of aggregate consumption to monetary easing continues to be lower in its peak from about 1.5% when $\omega = 0.20$ to about 1% when $\omega = 0.37$, as in Figure 6. We can see,

FIGURE 7. IMPULSE RESPONSE TO A MONETARY EASING SHOCK WITH VARYING QUALITY OF NON-REGULAR WORKERS

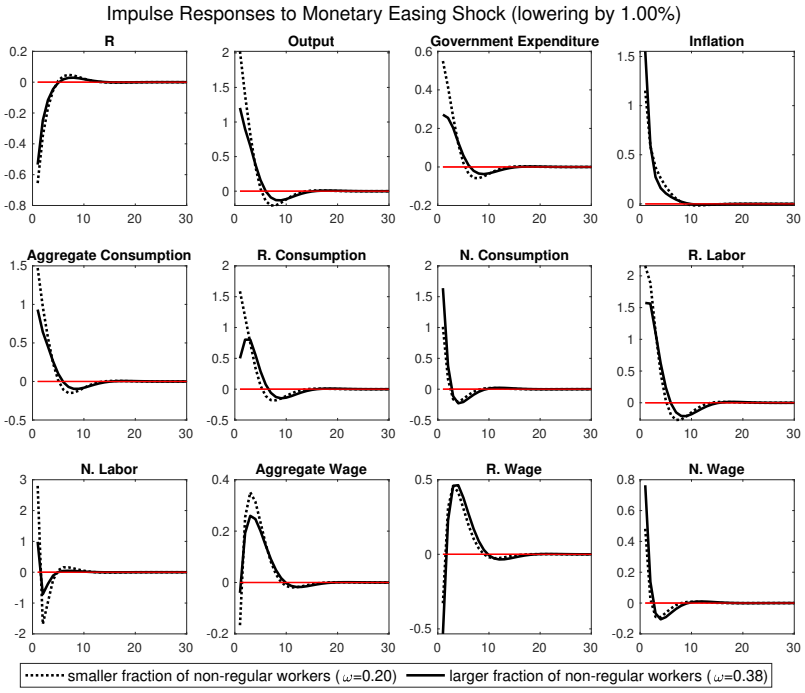


Note: Numbers in vertical axis are percentage deviation from steady state values.

however, that all the responses in this low quality of labor for non-regular type case have a smaller magnitude than that in the same quality of labor case. As explained in the second experiment, a lower quality of labor effectively lowers the composition of that type of labor as a production input and also lowers overall productivity even in the baseline case. This lowered overall productivity in the baseline case is responsible for the smaller magnitude of responses in Figure 8 than those in Figure 6.

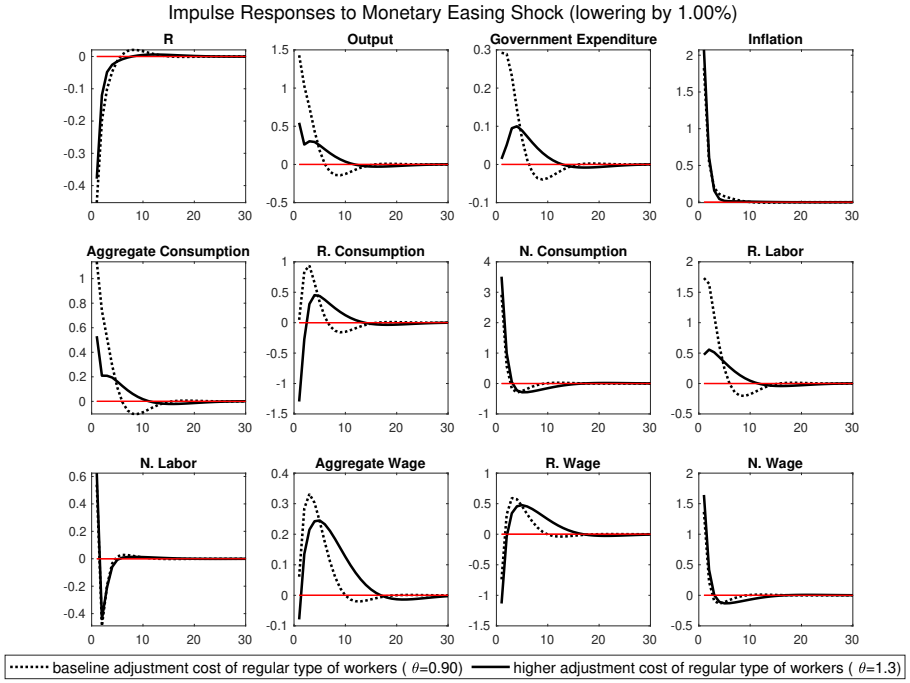
In our fourth experiment, we study impulse responses with varying adjustment costs of labor of the regular type of workers (θ). We take $\theta = 2.0$ to be the benchmark (as in Figure 5). We compare the benchmark with $\theta = 5.0$,which means that adjusting regular labor has becomes more expensive. We observe that compared with the baseline (dotted line), the case with higher adjustment costs yields a weaker response of aggregate consumption to the monetary easing shock. Institutionally, the protection of the regular type of workers has increased in Japan over time. For example, starting in the early 2000s, the rights of employers to dismiss regular workers has been enshrined by law, not only by case law. Later

FIGURE 8. IMPULSE RESPONSE TO A MONETARY EASING SHOCK WITH VARYING FRACTION OF NON-REGULAR WOKERS



Note: Numbers in vertical axis are percentage deviation from steady state values.

FIGURE 9. IMPULSE RESPONSE TO A MONETARY EASING SHOCK WITH VARYING ADJUSTMENT COST OF REGULAR WORKERS



Note: Numbers in vertical axis are percentage deviation from steady state values.

these rights were written in one of the labor laws so that the regular type of workers' rights is now properly secured.

In Figure 9 the benchmark is depicted in dotted lines, and the result with $\theta = 5.0$ in solid lines. We observe that compared with the baseline (dotted line), the case with higher adjustment costs (solid line) yields a weaker response of aggregate consumption to monetary easing shock. While the labor supply and wage of the non-regular type of workers are essentially unchanged, the rise in the labor supply of regular workers is suppressed due to the high adjustment costs imposed on the wholesale firm.

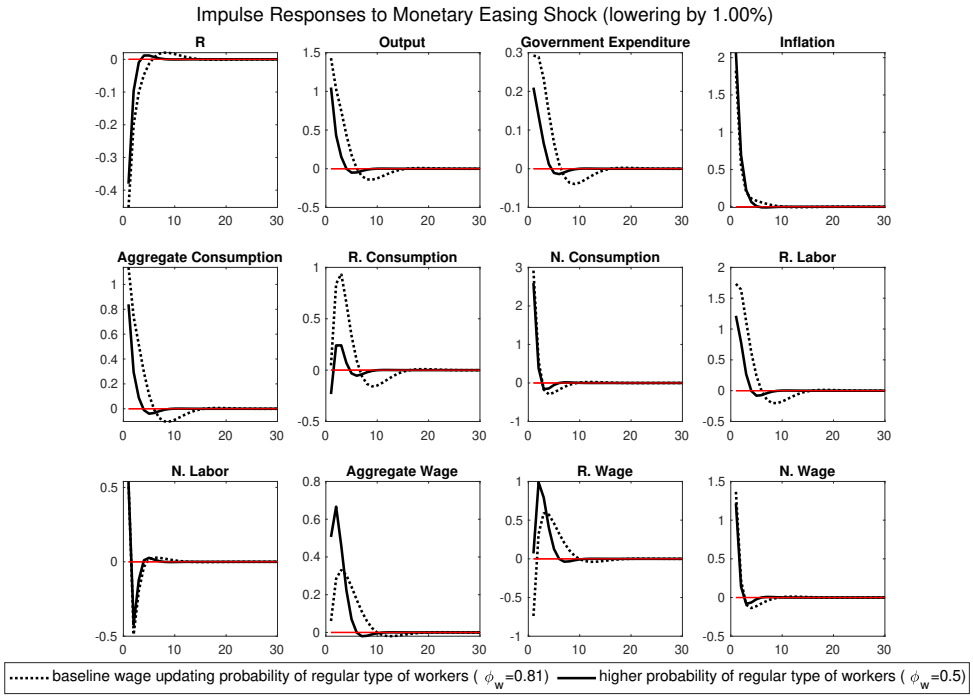
The response in the wages of the regular type of workers is slightly more persistent with higher adjustment costs. The slower adjustment of the regular type of workers' wage and labor also corresponds to a longer expansion of consumption of the regular type of workers (after plunging on impact). Thus, their consumption does not rise so much and this drags down aggregate consumption.

In our last experiment, we study the impulse responses with varying wage reset probabilities of the regular workers ϕ_w. We take the impulse responses in Figure 5 with $\phi_w = 0.81$ to be the benchmark. We compare the benchmark with

alternative impulse responses with $\phi_w = 0.50$, implying that the labor unions have more opportunities to reset the wage rate. Institutionally, at the start of the Abe administration, the government emphasized wage increases as a key to overcoming deflation, and the government moved aggressively to push the business commuity to raise wages and to introduce tax At the start of the Abenomics, the government emphasized wage increases as a key to overcoming deflation, and the government moved aggressively to ask the business community to raise wages and to introduce tax breaks to encourage this. Notably, the prime minister repeatedly called for a 3% wage increase to the business community. Such an initiative has a possibility for the wage negotiation of the labor unions to have more chances to revise their wages to encourage this reflation. Notably, the Prime Minister repeatedly called for a 3 percent wage increase to businesses.

In Figure 10 the former is depicted in dotted lines, and the latter in solid lines. We observe that the wage rate of the regular type of workers in fact responds more to a monetary easing shock, which raises the aggregate wage response as well. The response of aggregate consumption, however, is weakened. While the wage rate of the regular type of workers is raised more in response to the monetary stimulus, the wholesale firm reduces the labor demand compared with the benchmark because now the regular type of workers are more costly to hire. This leads to a reduced response of the labor income of the regular type of workers despite the upward revision of their wage rate. Hiring of non-regular labor does not respond sufficiently to raise the total labor response. To sum up, while a more flexible adjustment of the regular worker's wage seems to lead to expansion of labor income and consumption, it in fact leads to a lower aggregate consumption response to an expansionary monetary policy shock.

FIGURE 10. IMPULSE RESPONSE TO A MONETARY EASING SHOCK WITH VARYING WAGE STICKINESS OF REGULAR WORKER



Note: Numbers in vertical axis are percentage deviation from steady state values.

Table 11—Welfare Loss depending on the Composition of Workers ω

	Regular HH		Non-regular HH	
ω	0.20	0.38	0.20	0.38
Φ	0.22	0.14	0.65	0.71

D. Welfare Implications

We finally consider the welfare of each type of worker when they are hit by monetary policy shocks. We conduct second order Taylor expansions to the utility functions of each type of worker, and compute a certainty consumption equivalence. Applying second order Taylor expansions to $U\left(C_t^i, L_t^i\right)$ and taking the expectation operator, we compare this with the steady state utility from certainty equivalence Φ^i (which we define as a 'welfare loss'):

$$U\left((1-\Phi^i)C^i, L^i\right) = E(U\left(C_t^i, L_t^i\right)) \simeq U\left(C^i, L^i\right) - \frac{1}{2}\left[\sigma C^{i1-\sigma} Var(\hat{C}_t^i) + \chi^i L^{i1+\chi^i} Var(\hat{L}_t^i)\right],$$

where variables with hats $\hat{C}_t^i, \hat{L}_t^i$ means percentage deviation from the steady state values. This Φ^i measures the welfare loss due to the business cycle in second order; as a household is faced with higher volatility in their quantities, they are less happy compared with non-stochastic stationary welfare U. In Table 11, we calculate these welfare losses for each type of household under two different parameters; $\omega = 0.20$, which corresponds to the proportion of the non-regular type of households in the 1990s, and $\omega = 0.37$, which corresponds to the current proportion. We observe, comparing two ωs, that while the regular type of households are enjoying lower Φ ($0.22 \to 0.14$) as the proportion of non-regular workers widen, non-regular workers are worse off ($0.65 \to 0.71$) as ω gets higher. This is because firms are better able to adjust the amount of labor depending on the business cycle since they do not have to rely so much on the costly-adjustment regular type of workers. All the fluctuations in the adjustment of the labor supply go to non-regular workers, and this is why non-regular workers are worse off when ω increases.

VI. Conclusion

The weak response of aggregate consumption to expansionary monetary policy shocks during the recent period has been a puzzle. Based on Japanese household panel data that the consumption response of non-regular worker households is stronger than that of regular worker households, we construct a New Keynesian model with dual labor markets. Our model has two types of workers, one unionized and monopolistically competitive (regular workers), and the other in a perfectly competitive market (non-regular workers). We calibrate our model with

Japanese household level panel data. We find that our model well replicates the weak rise of aggregate consumption to monetary policy easing, and the widening use of non-regular type of workers is aligned with the weakening of consumption response. Moreover, since non-regular workers are more affected by business cycles, the increased proportion of non-regular type of jobs in the economy has led to a reduction in welfare.

While our two agent model shows how the increase in the proportion of low wage, non-regular workers can lower the aggregate consumption response to monetary policy, there are several possible extentions. First, we do not consider the extensive margin of labor supply but incorporate only the intensive margin. The composition of the two types of labor is treated as exogenous. Monetary policy, however, could affect this composition. This consideration of the extensive margin naturally extends the household's problem to the choice of which labor markets to enter. For this decision, human capital accumulation or the distribution of skills across agents are among the features that need to be added. Moreover, since our model does not have capital accumulation just like the textbook New Keynesian model, the movement of income and consumption is tough to decouple. Although our model tries at least to make a level difference by introducing income taxes, the introduction of saving for some of the agents, as in Kaplan, Moll, and Violante (2018), would enrich the agents' response to monetary policy shocks.

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Appendix: Data

A1. Data on Labor Force

The main data source is Labor Force Survey (LFS) by Ministry of Internal Affairs and Communication. This is a monthly survey on status of employment and unemployment for randomly selected households. While data on number of employed workers is available on monthly basis since 1953, what comes in each employment status (regular workers and non-regular workers) dates back to 1984. Seasonally adjusted data is, however, available only from 2013. Below is the classification rule listed in the website:[14]

Type of employment
Employees, excluding Executive of company or corporation are classified into seven categories of "Regular employee", "Part-time worker", "Arbeit (temporary worker)", "Dispatched worker from temporary labour agency", "Contract employee", "Entrusted employee" and "Other" according to how they are called at their workplaces. Six categories except "Regular employee" are classified into "Non-regular employee".

Another source is Monthly Labor Survey (MLS) by Ministry of Health, Labor and Welfare (MHLW). This is a monthly survey for establishments and collects records of number of days and hours worked, number of workers, and wages paid. Number of workers data comes in two broad category of 'regular workers' and 'part-time workers'. We cite the definition of each as below from the website:[15]

Number of Regular Employees : Regular Employees are workers who satisfy one of the following conditions:
(1) persons hired for an indefinite period or for longer than one month
(2) persons hired by the day or for less than one month and who were hired for 18 days or more in each of the two preceding months
Note : If the board-directors of corporations satisfy above mentioned condition, work regularly and are paid a salary based on the same salary rules as normal workers, they are regarded as regular workers. If family members of the owner of a business satisfy above mentioned condition, work regularly and are paid a salary based on the same salary rules as normal workers, they are regarded as regular employees.

Definition of Part-time workers
Part-time workers are the persons who satisfy either of the following : a.whose scheduled working hours per day is shorter than ordinary workers, b.whose scheduled working hours per day is the same as ordinary workers, but whose number

[14] Page 3 of https://www.stat.go.jp/english/data/roudou/pdf/definite.pdf
[15] Page 4 of https://www.mhlw.go.jp/english/database/db-slms/dl/slms-01.pdf

of scheduled working days per week is fewer than ordinary workers.
Full-time employees are regular employees who are not a part-time worker.

Careful consideration is needed regarding some of the employment status categories. The notable one is 'part-time.' While LFS classifies a worker into 'part time' just because workers are referred to as "part-time" or "part-san" in the work place, MLS classifies a worker as 'part-time' if the scheduled work hours or scheduled number of work days are shorter than normal workers (roughly corresponding to regular workers).

A2. Wage Data

MLS collects various scopes of wages.

Contractual cash earnings : earnings paid according to method and conditions previously determined by labor contracts, collective agreements, or wage regulations of establishments.

Scheduled cash earnings : contractual cash earnings other than non-scheduled cash earnings. Non-scheduled cash earnings are the wages paid for work performed outside scheduled working hours, and on days off or night work, that is allowances for working outside work hours, night work, early morning work, and overnight duty.

Special cash earnings : amount actually paid to the employee during the survey period for temporary or unforeseen reasons not based on any previous agreement, contract, or rule. Also included in this category are retroactive payment of wages as a result of a new agreement, and payments such as summer and year end bonuses which, though terms and amounts are fixed by collective agreements, are calculated over a period exceeding three months, and such as allowances (e. g., marriage allowance) paid with respect to unforeseen events.

Total cash earnings : total for 'contractual cash earnings' and 'special cash earnings'

As explained in the previous section, definition of 'part-time' workers in MLS may not be appealing to every researcher. Wage data for more minute subsets of workers can be obtained in Basic Survey of Wage Structure (BSWS) by MHLW. The survey is conducted annually and survey the result in June. It should be noted, however, that the current classification of regular and non-regular workers (each come both in normal and shorter hours) starts from 2005 only.

A3. Labor Data

MLS reports working hours of several definition.

Scheduled hours worked : actual number of hours worked between starting and ending hours of employment determined by the work regulations of the establishment.

Non-scheduled hours worked : actual number of hours worked (ex. early morning work, overtime work, or work on a day off).

Total hours worked : total for 'scheduled hours worked' and 'non-scheduled hours worked.'

Appendix: Detail of the Model

B1. Household

Regular Workers

Flow utility is given by:

$$U\left(C_t^R, L_t^R\right) = \frac{{C_t^R}^{1-\sigma}}{1-\sigma} - \psi \frac{{L_t^R}^{1+\chi^R}}{1+\chi^R}$$

Flow utility is discounted by β. The budget constraint facing the household, written in nominal terms, is:

$$P_t C_t^R + B_t^R \leq W_t^R L_t^R + R_{t-1} B_{t-1}^R - \kappa {B_t^R}^2 + DIV_t \tag{B1}$$

The household can save via a one period bond (B_t^R) with gross nominal interest rate R_t, but selling and buying them incurs costs ($\kappa {B_t^R}^2$). W_t^R is the nominal wage earned by regular type of workers. Here regular type of households are assumed to have full ownership of the firms in the economy (DIV_t), but this is easily relaxed and some of the share can just be passed to non-regular workers.

While regular type of households are homogeneous and supply the same amount of labour, they supply labour to continuum of monopolistically competitive markets, where wage is set by the unions, which are not an independent decision maker but belong to households. Unions sell the labour to wholesale firm (to be defined later), and the industry j is faced with a labor demand function of:

$$L_t^j = \left(\frac{W_t^j}{W_t}\right)^{-\varepsilon_w} L_{d,t}^R.$$

Households make a decision not just on consumption C_t^R and hours L_t^R, but also, as a labor union, on the wage W_t^j where $j \in [0,1]$. However, they cannot set

the wages every period: they have a probability ϕ_w with which they are stacked with current prices.

The Lagrangian of the household looks like as follows:

$$\begin{aligned}\mathcal{L} =& E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{C_t^{R1-\sigma}}{1-\sigma} - \psi \frac{L_t^{R1+\chi^R}}{1+\chi^R} + \frac{\lambda_t w_t}{\tilde{\mu}_t} \left[h_t - h_t^d \int_0^1 \left(\frac{w_t^i}{w_t} \right)^{-\tilde{\eta}} di \right] \right. \\ & \left. + \lambda_t \left[L_{d,t} \int_0^1 W_t^i \left(\frac{W_t^i}{W_t} \right)^{-\varepsilon_w} di - P_t C_t^R - B_t^R + R_{t-1} B_{t-1}^R - \kappa B_t^{R2} + DIV_t \right] \right\}\end{aligned}$$

The first order conditions with respect to C_t^R, L_t^R, and B_t^R are:

$$\begin{aligned} C_t^{R-\sigma} &= \mu_t P_t \\ \psi L_t^{R\chi^R} &= \mu_t MRS_t \\ \mu_t(1+2\kappa B_t^R) &= \beta R_t \mathbf{E}_t \mu_{t+1} \end{aligned}$$

Re-written in real terms, where $\Pi_t = P_t/P_{t-1}$, we have:

$$\psi L_t^{R\chi^R} = C_t^{R-\sigma} mrs_t \tag{B2}$$

$$1 + 2\kappa B_t^R = R_t \mathbf{E}_t \Lambda_{t,t+1}^R \Pi_{t+1}^{-1} \tag{B3}$$

$$\Lambda_{t,t+1}^R = \beta \left(\frac{C_{t+1}^R}{C_t^R} \right)^{-\sigma} \tag{B4}$$

where $\Lambda_{t,t+1}^R$ is the real stochastic discount factor.

Now let's study the determination of w_t^R (the real wage, $w_t^R = W_t^R/P_t$). The first observation is that while wage is set so as to maximise the discounted flow of profit if possible; otherwise it is just preserved and the value is exposed to the inflation:

$$w_t^i = \begin{cases} \tilde{w}_t & \text{if } w_t^i \text{ is set optimally in } t \\ w_{t-1}^i/\pi_t & \text{otherwise} \end{cases}$$

Next, we determine the optimal reset wage $\tilde{w}_t$. The determination of $\tilde{w}_t$ takes into account not just the period t but also the further period than $t+1$ in which households are stacked with the period determined at period t. So we can write $w_{t+s=}\tilde{w}_t/(\Pi_{k=1}^s \pi_{t+k})$ in this calculation. Below is the Lagrangean set up before in which terms relevant to the determination of $\tilde{w}_t$ is extracted:

$$\mathcal{L}^w = E_t \sum_{s=0}^{\infty} (\phi_w \beta)^s \lambda_{t+s} \left(\frac{\prod_{k=1}^s \left(\frac{1}{\pi_{t+k}} \right)}{w_{t+s}} \right)^{-\tilde{\eta}} L_{d,t+s} \left[\tilde{w}_t^{1-\varepsilon_w} \prod_{k=1}^s \left(\frac{1}{\pi_{t+k}} \right) - \tilde{w}_t^{-\varepsilon_w} \frac{w_{t+s}}{\tilde{\mu}_{t+s}} \right].$$

the FOC is:

$$E_t \sum_{s=0}^{\infty} (\tilde{\alpha}\beta)^s \lambda_{t+s} \left(\frac{\tilde{w}_t \prod_{k=1}^{s} \left(\frac{\mu_{z^*} \pi_{t+k-1}}{\pi_{t+k}} \right)}{w_{t+s}} \right)^{-\tilde{\eta}} h_{t+s}^d \left[\frac{(\tilde{\eta}-1)}{\tilde{\eta}} \tilde{w}_t \prod_{k=1}^{s} \left(\frac{\mu_{z^*} \pi_{t+k-1}}{\pi_{t+k}} \right) - \frac{-U_h(t+s)}{\lambda_{t+s}} \right] = 0$$

Let's define the following f_t^1 and f_t^2:

$$f_t^1 = \left(\frac{\tilde{\eta}-1}{\tilde{\eta}} \right) \tilde{w}_t E_t \sum_{s=0}^{\infty} (\beta\tilde{\alpha})^s \lambda_{t+s} \left(\frac{w_{t+s}}{\tilde{w}_t} \right)^{\tilde{\eta}} h_{t+s}^d \prod_{k=1}^{s} \left(\frac{\pi_{t+k}}{\mu_{z^*} \pi_{t+k-1}} \right)^{\tilde{\eta}-1}$$

$$f_t^2 = -\tilde{w}_t^{-\tilde{\eta}} E_t \sum_{s=0}^{\infty} (\beta\tilde{\alpha})^s w_{t+s}^{\tilde{\eta}} h_{t+s}^d U_h \left(c_{t+s} - b c_{t+s-1}, h_{t+s} \right) \prod_{k=1}^{s} \left(\frac{\pi_{t+k}}{\mu_{z^*} \pi_{t+k-1}} \right)^{\tilde{\eta}}$$

These can be rewritten in recursive forms:

$$f_t^1 = \left(\frac{\tilde{\eta}-1}{\tilde{\eta}} \right) \tilde{w}_t \lambda_t \left(\frac{w_t}{\tilde{w}_t} \right)^{\tilde{\eta}} h_t^d + \tilde{\alpha}\beta E_t \left(\frac{\pi_{t+1}}{\mu_{z^*} \pi_t} \right)^{\tilde{\eta}-1} \left(\frac{\tilde{w}_{t+1}}{\tilde{w}_t} \right)^{\tilde{\eta}-1} f_{t+1}^1,$$

$$f_t^2 = -U_h \left(c_t - b c_{t-1}, h_t \right) \left(\frac{\tilde{w}_t}{w_t} \right)^{-\tilde{\eta}} h_t^d + \tilde{\alpha}\beta E_t \left(\frac{\tilde{w}_{t+1} \pi_{t+1}}{\mu_{z^*} \tilde{w}_t \pi_t} \right)^{\tilde{\eta}} f_{t+1}^2.$$

The FOCs correspond to the following holds for each period:

$$f_t^1 = f_t^2$$

Non-regular Workers

Basically the problem faced by non-regular workers is the same as that by regular workers. The flow utility is

$$U \left(C_t^n, L_t^n \right) = \frac{C_t^{n\,1-\sigma}}{1-\sigma} - \psi \frac{L_t^{n\,1+\chi^n}}{1+\chi^n}$$

The budget constraint facing the household, written in nominal terms, is:

$$P_t C_t^n + B_t^n \leq W_t^n L_t^n + R_{t-1} B_{t-1}^n - \kappa {B_t^n}^2. \tag{B5}$$

Note that they are paid at W_t^n, which is the competitive market wage in non-regular labor market. The optimality conditions are listed below:

$$\psi L_t^{n\chi^n} = C_t^{n-\sigma} W_t^n \tag{B6}$$

$$1 + 2\kappa B_t^n = R_t \mathbf{E}_t \Lambda_{t,t+1}^n \Pi_{t+1}^{-1} \tag{B7}$$

$$\Lambda_{t,t+1}^n = \beta \left(\frac{C_{t+1}^n}{C_t^n} \right)^{-\sigma} \tag{B8}$$

B2. Labor Market Players

We need labor packers to combine the differentiated labor into a single labor which can be sold to the wholesale firm.

Labor Packer

There are a continuum of labor unions indexed by $l \in [0, 1]$. They hire regular type of labor from the household at MRS_t and sell to a labor packer at $W_t^R(l)$. The labor packer combines union labor into a final labor input available to wholesale firms via a CES technology. In particular:

$$L_{d,t}^R = \left[\int_0^1 L_t^R(l)^{\frac{\epsilon_w - 1}{\epsilon_w}} dl \right]^{\frac{\epsilon_w}{\epsilon_w - 1}}$$

Profit maximization yields a demand curve for each union's labor and an aggregate wage index of regular workers:

$$L_t^R(l) = \left(\frac{W_t(l)}{W_t} \right)^{-\epsilon_w} L_{d,t}$$

$$W_t^{R1-\epsilon_w} = \int_0^1 W_t^R(l)^{1-\epsilon_w} dl$$

B3. Firms in Goods Markets

Final Goods Firm

The final goods firm combines retail output into a final output good. Retail output is transformed into final output via:

$$Y_t = \left[\int_0^1 Y_t(f)^{\frac{\epsilon_p - 1}{\epsilon_p}} df \right]^{\frac{\epsilon_p}{\epsilon_p - 1}}$$

Profit maximization by the final goods firm yields a demand for each retail output and a price index.

$$Y_t(f) = \left(\frac{P_t(f)}{P_t}\right)^{-\epsilon_p} Y_t$$

$$P_t^{1-\epsilon_p} = \int_0^1 P_t(f)^{1-\epsilon_p} df$$

Retail Firms

The retail firms purchase wholesale output at $P_{w,t}$ costlessly repackage it, and sell it to a competitive final goods firm at $P_t(f)$, where retailers are indexed by $f \in [0,1]$. Their nominal dividend is:

$$DIV_{r,t}(f) = P_t(f)Y_t(f) - P_{w,t}Y_t(f)$$

Using the demand function, this is:

$$DIV_{r,t}(f) = P_t(f)^{1-\epsilon_p} P_t^{\epsilon_p} Y_t - P_{w,t} P_t(f)^{-\epsilon_p} P_t^{\epsilon_p} Y_t$$

Or, in real terms:

$$div_{r,t}(f) = P_t(f)^{1-\epsilon_p} P_t^{\epsilon_p - 1} Y_t - P_{w,t} P_t(f)^{-\epsilon_p} P_t^{\epsilon_p - 1} Y_t$$

Retailers can only adjust their price with probability $1 - \phi_p$. This makes their price-setting problem dynamic, where future real dividends are discounted by the household's stochastic discount factor as well as the probability that a price chosen in period t remains in effect in the future. The price-setting problem is:

$$\max_{P_t(f)} \mathbf{E}_t \sum_{j=0}^{\infty} \phi_p^j \Lambda_{t,t+j}^R \left\{ P_t(f)^{1-\epsilon_p} P_{t+j}^{\epsilon_p - 1} Y_{t+j} - P_{w,t+j} P_t(f)^{-\epsilon_p} P_{t+j}^{\epsilon_p - 1} Y_{t+j} \right\}$$

Calculating this, we obtain the following reset inflation rate:

$$\Pi_t^{\#} = \frac{\epsilon_p}{\epsilon_p - 1} \frac{x_{1,t}}{x_{2,t}} \tag{B9}$$

$$x_{1,t} = p_{w,t} Y_t + \phi_p \mathbf{E}_t \Lambda_{t,t+1} \Pi_{t+1}^{\epsilon_p} x_{1,t+1} \tag{B10}$$

$$x_{2,t} = Y_t + \phi_p \mathbf{E}_t \Lambda_{t,t+1} \Pi_{t+1}^{\epsilon_p - 1} x_{2,t+1} \tag{B11}$$

Wholesale Firm

A representative wholesale firm hires two types of labor: (1) regular type of labor sold by a labor packer, and (2) non-regular type of labor which is directory hired through competitive labor markets at marginal cost. Production function

of wholesale output is:

$$Y_{W,t} = A_t L_{d,t} = A_t \left[\omega {L_{d,t}^n}^{\mu} + (1-\omega){L_{d,t}^R}^{\mu}\right]^{\frac{1}{\mu}}, \tag{B12}$$

where A_t is stochastic TFP to be specified later. μ governs the substitutability of two types of labor; $\frac{1}{1-\mu}$ is the elasticity of substitution. Cost minimization problem is:

$$\begin{aligned} \min_{L_{d,t}^n, L_{d,t}^R} \quad & W_t^n L_{d,t}^n + W_t^R L_{d,t}^R + \theta P_{w,t}(L_{d,t}^R - L_{d,t-1}^R)^2, \\ s.t. \quad & Y_{W,t} \leq A_t \left[\omega {L_{d,t}^n}^{\mu} + (1-\omega){L_{d,t}^R}^{\mu}\right]^{\frac{1}{\mu}}. \end{aligned}$$

Solving this, we obtain the following condition regarding labor demands:

$$\frac{1-\omega}{\omega}\left(\frac{L_{d,t}^R}{L_{d,t}^n}\right)^{\mu-1}\left(\frac{A^R}{A^n}\right)^{\mu} w_t^n = w_t^R + 2w_t^R\theta\left(L_{d,t}^R - L_{d,t-1}^R\right). \tag{B13}$$

Wholesale firm produces wholesale output and sells it to a continuum of retail firms at $P_{w,t}$. His dividend is expressed as follows using the redult from cost minimization: Its nominal dividend is:

$$DIV_{W,t} = P_{w,t}Y_{W,t} - W_t^n L_t^n - W_t^R L_t^R - \theta P_{w,t}(L_{d,t}^R - L_{d,t-1}^R)^2.$$

The optimality condition is:

$$W_t = P_{w,t}$$

Or, in real terms:

$$w_t = p_{w,t} \tag{B14}$$

B4. Stochastic Processes

Monetary Policy

Assuming the gross nominal rate, R_t, is set according to a Taylor type rule:

$$\ln R_t = (1-\rho_R)\ln R + \rho_R \ln R_{t-1} + (1-\rho_R)\,\theta_\pi\left(\ln \Pi_t - \ln \Pi\right) + s_R\varepsilon_{R,t} \tag{B15}$$

Variables without time subscripts denote non-stochastic steady state values.

Exogenous Process

A_t is the only exogenous variable. Assume it follows an AR(1) in the log with non-stochastic mean normalized to unity:

$$\ln A_t = \rho_A \ln A_{t-1} + s_A \varepsilon_{A,t} \tag{B16}$$

B5. Aggregation

The aggregate inflation rate and real wage evolve according to the following expressions, which can be derived using properties of Calvo pricing:

$$1 = \left(1-\phi_p\right)\left(\Pi_t^{\#}\right)^{1-\epsilon_p} + \phi_p \Pi^{\epsilon_p - 1} \tag{B17}$$

$$w_t^{R1-\epsilon_w} = \left(1-\phi_w\right)\left(w_t^{R\#}\right)^{1-\epsilon_w} + \phi_w \Pi_t^{\epsilon_w - 1} {w_{t-1}^R}^{1-\epsilon_w} \tag{B18}$$

Goods market-clearing requires that wholesale output by sold to unions in the aggregate, or:

$$Y_{W,t} = \int_0^1 Y_t(f) df$$

Given the demand function for each retailers output, this works out to:

$$Y_{W,t} = Y_t v_t^p \tag{B19}$$

Where v_t^p is a measure of price dispersion:

$$v_t^p = \left(1-\phi_p\right)\left(\Pi_t^{\#}\right)^{-\epsilon_p} + \phi_p \Pi_t^{\epsilon_p} v_{t-1}^p \tag{B20}$$

Labor supplied by the regular workers must equal labor used by the union:

$$L_t^R = \int_0^1 L_{u,t}^R(l) dl$$

Reminding that unions' labor demand is $L_t^R(l) = \left(\frac{W_t(l)}{W_t}\right)^{-\epsilon_w} L_{d,t}$, this reduces to:

$$L_t = L_{d,t} v_t^w, \tag{B21}$$

where v_t^w is a measure of wage dispersion:

$$v_t^w = \left(1-\phi_w\right)\left(\frac{w_t^{\#}}{w_t}\right)^{-\epsilon_w} + \phi_w \Pi_t^{\epsilon_w}\left(\frac{w_t}{w_{t-1}}\right)^{\epsilon_w} v_{t-1}^w \tag{B22}$$

Also, labor market for non-regular workers needs to clear:

$$L^n_{d,t} = L^n_t. \tag{B23}$$

We consider that there are mass of ω of non-regular workers, and $1-\omega$ of regular workers in the economy.[16] We assume zero net supply of bond, so bond market clearing is:

$$\omega B^n_t + (1-\omega) B^R_t = 0. \tag{B24}$$

Although redundant due to Warlas Law, goods market clearing is expressed as follows:

$$Y_t = \omega(C^n_t - \kappa B^{n2}_t) + (1-\omega)(C^R_t - \kappa B^{R2}_t)$$

Appendix: Derivation of Regression Equation in 4.3

FOCs are:

$$\begin{aligned}
\frac{\partial Y_{W,t}}{\partial L^n_t} &= Y^{1-\mu}_{W,t} A^\mu_t \omega A^{n\mu}_t L^{n\mu-1}_t = w^n_t \\
\frac{\partial Y_{W,t}}{\partial L^R_t} &= Y^{1-\mu}_{W,t} A^\mu_t (1-\omega) A^{R\mu}_t L^{R\mu-1}_t = w^R_t
\end{aligned}$$

Taking the ratio of the two equations,

$$\frac{w^R_t}{w^n_t} = \frac{1-\omega}{\omega} \left(\frac{A^R_t}{A^n_t}\right)^\mu \left(\frac{L^R_t}{L^n_t}\right)^{\mu-1}$$

The regression equation is obtained by taking logarithm of the both sides.

[16] This is the same weight as production function: $Y_{W,t} = A_t \left[\omega {L^n_{d,t}}^\mu + (1-\omega) {L^R_{d,t}}^\mu\right]^{\frac{1}{\mu}}$. I think we do not need to stick to this, and arbitrarily set the proportion of each worker.