The Rise of Part-time Employment in the Great Recession: Its Causes and Macroeconomic Effects

Hyunju Kang*
Korea Capital Market Institute
Jaevin Park†
Department of Economics, University of Mississippi
Hyunduk Suh‡
Department of Economics, Inha University

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Abstract

During the Great Recession, the U.S. economy witnessed a substantial rise in part-time employment for a sustained period. We extend the New Keynesian unemployment model by Galí et al. (2012) to allow substitutions between full-time and part-time labor, and estimate the model’s parameters by using the Bayesian method. In our model, households and firms can optimally allocate full-time and part-time labor, and disturbances exist in part-time labor supply (household disutility from part-time labor) and part-time labor demand (firms’ efficiency to use part-time labor). As for the Great Recession, the initial increase in part-time employment at the outset of the financial crisis is mostly explained by the rise of the risk premia; the persistently high level of part-time employment in the later period is mainly explained by an exogenous increase in part-time labor supply. A part-time labor supply shock also explains a significant portion of slow recovery in the gross wage during the recession, as the shock lowers the part-time wage and the proportion of full-time workers in total employment. Notably, the results from our model suggest that though the transition from full-time to part-time jobs contributed to mitigating the sharp contraction in total employment and labor force during the Great Recession, it played only a limited role in relieving recessionary pressure.

Keywords: Part-time labor, Great Recession, Unemployment, New Keynesian model

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*Email: hjkang326@gmail.com
†Email: jpark21@olemiss.edu
‡Email: hsuh@inha.ac.kr
1 Introduction

During the Great Recession, the U.S. economy experienced a substantial rise in part-time employment\(^1\) for a sustained period. Historically, this is not new, because, in the U.S., the part-time share of employment increases during recessions, but decreases during expansions, as shown in Figure 1 (a). This counter-cyclical movement in part-time jobs has remained unnoticed despite its non-negligible size.\(^2\) Yet, recently, policymakers have paid attention to the rise of part-time jobs, as this phenomenon may indicate an additional slackness in the labor market. For example, Yellen (2014) claims that the current unemployment rate may not fully capture the extent of the slackness in the labor market, considering the high percentage of involuntary part-time jobs. As Figure 1 (b) shows, the proportion of part-time workers in the labor force increased during this recession and has only slowly declined, even though the unemployment rate has come down to its pre-crisis level. This could signal that the economy fails to employ at full capacity even with the low unemployment rates.

In addition, the prevalence of part-time jobs during the Great Recession can be related to another recent puzzle in the U.S. labor market: the “flattening” of the wage Phillips curve (WPC hereafter), which refers to a situation wherein wages move up slowly despite the falling unemployment. Indeed, the unemployment rate in the U.S. decreased by a remarkable extent, that is, by 5.5 percentage points from 2010:1Q to 2017:2Q. However, during the same period, the median usual weekly nominal earning of full-time workers increased by only 1.9% annually and that of part-time workers increased by an even less degree, 1.8%.\(^3\) Considering that the wages in part-time jobs are lower than those in full-time jobs on average, the fact that the part-time share in total employment remains relatively high compared with previous recoveries could be associated with this flattening of WPC (a composition effect). Such complications call for a deeper understanding of what caused part-time jobs to rise and how it affected the overall economy during the recession and its recovery.

[Figure 1 here]

In this respect, our main research question can be summarized as follows: How does part-time employment react to economic shocks? Especially, what are the main causes of the transition to part-time employment during the Great Recession? Is it driven by household supply or firm demand? Why did part-time employment remain high until recently,

\(^1\)The U.S. Bureau of Labor Statistics defines part-time employment as those employees working fewer than 35 hours per week.

\(^2\)The share of part-time employment has been about one-sixth of the total on average since the 1990s in the U.S.

\(^3\)These two wage series, from the Current Population Survey (CPS), are currently the only publicly available wage series for full-time and part-time jobs in the U.S. We use these series as the full-time and part-time wages in our analysis.
whereas full-time jobs seem to have recovered? How do part-time jobs affect the labor force, unemployment, and the other macroeconomic variables such as output and inflation? Is there a connection between part-time jobs and the slow wage recovery?

To capture the dynamics of part-time jobs along the business cycle, we extend the New Keynesian dynamic stochastic general equilibrium (DSGE) model by Galí et al. (2012) (GSW hereafter), which incorporates the unemployment into the benchmark medium-sized DSGE model of Smets and Wouters (2007) (SW hereafter). Our extension of the model mainly involves introducing the additional building block of labor, in which agents work part time. Then we take a number of actual macroeconomic data series to identify the structural shocks, and explain the interaction between the macroeconomic variables and the labor type transitions. By maintaining the basic structure of SW and GSW, still considered as workhorse models by many central banks for forecast and policy analyses, we can practically focus on the dynamics of part-time jobs by using the standard analytical methods.

In our model, a large household has full-time and part-time available populations. It optimally determines consumption and the labor participation of each type, considering wage conditions in both types of jobs. The household can effectively substitute labor types by reducing one type of participation and increasing the other. We assume that a fraction of the part-time available population exhibits hand-to-mouth (HTM hereafter) behavior. These agents cannot access the financial markets for consumption smoothing, and thus their labor supply is likely to increase more aggressively during the recessions. Firms’ production technology includes both full-time and part-time labor; and the firms choose the level of employment in each type, given the wage conditions. Once the agents are employed—either full or part time—their labor is indivisible in the sense that the labor hour per person is constant (no change in the intensive margin for each labor type).4

We define “part-time labor supply shock” as a disturbance term that governs the relative disutility between full-time and part-time labor. This term reflects how each labor type has different utility implications in various aspects, arising from the differences in average working hour, degree of stress, and preference of demographic groups toward part-time jobs.5 In addition, it captures how the relative preference between the two labor types can change over time, either because the preference itself or a population share of certain demographic groups that favor part-time jobs can change. On the other hand, we define “part-time labor demand shock” as a disturbance that affects the firms’ relative productivity of

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4Previous studies estimate the Frisch elasticities of labor supply that consider the intensive margins along with the extensive margins. For example, Altonji and Paxson (1988), Altonji and Paxson (1992), French (2005), and Rogerson and Wallenius (2009) consider the models with continuous hours choice, whereas Chang et al. (2011) propose a model with a discrete hours choice. In this study, we model and interpret labor as the number of employments in order to match with the aggregate macroeconomic data.

5For example, Bardasi and Gornick (2000) show that the level of the spouse’s income and motherhood affect a household’s decision to work part time.
part-time labor. This term captures, as Valletta et al. (2015) suggest, the improvements in monitoring and scheduling technology that help schedule the part-time workers more efficiently, or the change in the share of certain industry groups that rely more heavily on part-time jobs. Moreover, it might reflect the firm’s cost concerns that are not captured in the usual concept of wages. Following GSW, the frictions in the labor market arise from a nominal wage rigidity and the monopolistic power of labor unions reflected in the wage markup. This wage markup leads to unemployment, that is, the household is willing to supply a certain level of labor at a given wage, but firms cannot hire all of them because of the wage markup.

Our estimated model does capture some key characteristics of the part-time variables in the data along the business cycle. For example, the model exhibits high volatilities of part-time employment and wage, a negative correlation between full-time and part-time employment, and a positive correlation between unemployment and part-time employment.

Shocks in the part-time labor supply, risk premium, monetary policy, and full-time wage markup mainly explain the rise of part-time employment during the Great Recession. They are able to cause substitutions between the labor types and were realized in ways to increase part-time employment during the Great Recession. The initial increase in part-time employment at the outset of the financial crisis is mostly explained by the rise of the risk premia. A large share of persistently high part-time employment in the later period is explained by an exogenous increase in the part-time labor supply. In addition, the contractionary monetary policy induced by the zero lower bound (ZLB), and a positive full-time wage markup, contribute to a lesser, but still significant proportion of the rise of part-time employment. On the other hand, a reduction in full-time employment is jointly attributable to the risk premium, investment technology, and monetary policy shocks. Increased supply of part-time labor also mitigates the sharp contraction of the labor force, and the long-lasting effect of this shock keeps the part-time employment at a high level even after the full-time employment recovers.

Although an exogenous increase in part-time labor supply and demand during the Great Recession functioned to mitigate the contraction of the output, its positive influence on the output is modest in quantitative terms. After removing the trend, the output in 2010–2014 is about 6% below the level at the end of 2007, but the combined positive effect of part-time shocks on the output is about 0.6%. Though there are also the endogenous reactions

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6 For example, Carrington et al. (2002) show that the cost for full-time employees’ health benefits is an element of the labor cost that may cause the use of part-time labor. Even and Macpherson (2015) determine that the mandate for providing health benefits in the Affordable Care Act induces an increase in involuntary part-time work.

7 We assume that a nominal rigidity and a wage markup exist in not only the full-time labor market, but also the part-time labor market. Later, we experiment on another specification that assumes that the part-time wage is completely flexible. The results are very similar in both specifications.
of firms and households to switch from full-time to part-time employment in our model, a counterfactual analysis suggests that these endogenous reactions do not play a significant role in relieving the recessionary pressure either.

Our estimated WPC for full-time jobs has the parameters similar to those estimated from GSW, whereas WPC for part-time jobs shows a higher wage flexibility. Regarding the recent flattening of the WPC, the part-time labor supply shock explains a significant proportion of slow recovery in the gross wage by lowering the part-time wage as well as the proportion of full-time workers in the total employment. The part-time labor demand shock has a significant positive effect on the part-time wage, but its effect on the gross wage is largely reduced, as the shock also lowers the proportion of the better-paid full-time workers.

The results from our general equilibrium model suggest that the demand of firms for part-time jobs is less critical for the rise of part-time jobs than supply factors, which offers a different view from the hypothesis that Canon et al. (2014) and Borowczyk-martins and Lalé (2017) suggest. Meanwhile, the result that the transition to part-time jobs does not prevent well the contraction of output during the Great Recession is consistent with the analysis by Farber (2017), where the earnings of the full-time job losers significantly decrease due to the lower wage levels and fewer working hours. Moreover, the result that the effect of the part-time supply shock on part-time employment is persistent during the Great Recession contradicts the historical fact that the involuntary part-time duration is shorter than the unemployment spells, indicating that this persistence could be related to structural factors.8

1.1 Related literature

The study of part-time employment, specifically from a cyclical perspective, has been developed only recently. Valletta and Bengali (2013) and Robertson and Terry (2015) provide evidence from historical data that the recent rise of part-time employment during the Great Recession can be explained as a cyclical movement. Cajner et al. (2014) and Canon et al. (2014) contend that involuntary part-time employment was the main driving force for the increase in part-time jobs during the Great Recession. They do so by constructing transition probabilities with stock and flow data.9 Valletta et al. (2015) confirm that the movement of this involuntary part-time employment is affected by cyclical factors through state-level panel data regressions. Farber (2017) uses Displaced Workers Surveys data to show the flow from full-time jobs to involuntary part-time jobs and the change in earnings during the Recession. Borowczyk-martins and Lalé (2017) show that the cyclical behavior of part-time employment share is explained by individual transitions between part-time and full-time jobs within the same employer, as a process in which firms adjust the intensive margin

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8Valletta et al. (2015) note that the changes in the industry composition of employment might be a factor for the persistence in involuntary part-time jobs during the recovery.

9See also Borowczyk-martins and Lalé (2016).
in response to negative shocks. Additionally, there are other approaches for understanding part-time employment using search and matching frictions: Warren (2015) and Lariau (2016) suggest models that capture the counter-cyclicality of involuntary part-time employment in this perspective.\(^\text{10}\)

This study is also related to the literature analyzing macroeconomic dynamics using DSGE models with various frictions. Benchmark models such as that of Christiano et al. (2005) and SW, which include frictions such as nominal rigidity, habit formation, and investment adjustment costs, are widely used in both academia and central banks for policy analysis and forecasting purposes. Bayesian techniques we use to estimate the parameters of the model, summarized by An and Schorfheide (2007) and Herbst and Schorfheide (2016), have become a standard for empirical studies using these models. Developments in these models are made to better understand specific issues in labor market dynamics (for example, Gertler et al. (2008), Christiano et al. (2011), and GSW). Gertler et al. (2008) and Christiano et al. (2011) adopt search and matching frictions to explain extensive and intensive margins of labor along the business cycle. Christiano et al. (2016) also incorporate search and matching frictions in the model explicitly to capture the wage bargaining behavior in the labor market. Instead of considering search and matching frictions, our paper focuses on the wage markups, generated by nominal wage rigidities in the labor market, as shown in GSW. As mentioned earlier, GSW introduced unemployment to the SW model, enabling the model to exploit the information from the unemployment rate, which has long been regarded as one of the most important variables for policymakers. By extending this GSW framework with two labor sectors, our model can introduce a practical way of analyzing the effects of the transition between full-time (sticky wage) jobs and part-time (flexible wage) jobs on the macroeconomic variables within the standard New Keynesian DSGE framework. Lastly, introduction of HTM households in our paper is based on two-agent New Keynesian models such as Galí et al. (2007) and Bilbiie (2008).

2 Model: full-time and part-time labor

In this section, we introduce a model that can be used to analyze the transition between full-time and part-time jobs along the business cycle. The model can be seen as an extension of GSW, which incorporates the concept of unemployment into a benchmark medium-sized DSGE model of SW. The key departure of our model from GSW is that our model allows households and firms to allocate full-time and part-time labor optimally, whereas there is no such labor type distinction in GSW. Moreover, we introduce the consumer’s hand-to-mouth (HTM) behavior to reflect the lack of access to financial markets and borrowing constraints

\(^{10}\)Tavares (2015) uses a directed search model to identify the conditions for involuntary part-time employment.
Specifically, we assume that a fraction of the part-time available households only consume the current period’s income and are not able to smooth consumption, whereas the remaining part-time available households and all full-time available households can share their consumption risk to make an optimal intertemporal consumption choice. This way, we can differentiate full-time and part-time jobs regarding their financial situation and also reflect the feature of involuntary part-time jobs in the model.

2.1 Households

We assume \( \pi \) and \( 1 - \pi \) to be the fractions of the full-time and the part-time available population, respectively; \( \lambda \) denotes the proportion of HTM households in the part-time available population. Thus, the size of optimizing (forward-looking) part-time available population is \( (1 - \pi)(1 - \lambda) \). Given the widespread awareness of SW, we only describe the wage setting and unemployment block here and abstract from the rest of the model that resembles SW and GSW.\(^{12}\)

2.1.1 Optimizing households

An optimizing household is a large family with two types of members: full-time and part-time available groups. The two groups are indexed by \( (i, j) \in [0, 1] \times [0, 1] \) and \( (i, k) \in [0, 1] \times [0, 1] \), respectively. In each pair, the first dimension, indexed by \( i \), represents the type of specialized labor services. In the second dimension, \( j \) and \( k \) determine the disutility from the work for full-time and part-time labor, respectively. Although the family members cannot switch between the two types, the household can still reallocate labor between full time and part time by adjusting the level of employment in each type. To ensure this labor reallocation, it is also assumed that the population of each group is sufficiently large compared with the labor force, which prohibits the employment-population ratio of each type from reaching 1.

We also assume a perfect risk sharing of consumption among the optimizing household members, so that consumption is equalized between full-timers and part-timers. The optim-

\(^{11}\)HTM households are frequently used for understanding the effects of fiscal policy (Leeper et al. (2017)) and for considering credit-constrained agents (Debortoli and Galí (2017), Kaplan et al. (2018)). For further details, see Galí et al. (2007) and Galí (2018).

\(^{12}\)For a more detailed discussion on the remaining part of the model, refer to the full description in SW and the appendix in GSW. In addition, we provide the full set of log-linearized equations in our model in the Appendix.
mizing household’s utility is defined as integral over its members’ utilities,

$$E_0 \sum_{t=0}^{\infty} \beta^t U_t(C_t^o, \{N_{f,t}^o\}, \{N_{p,t}^o\})$$

$$= E_0 \sum_{t=0}^{\infty} \beta^t \left[ \log \tilde{C}_t^o - \chi_t \Theta_t \int_{0}^{1} \left( \omega \int_{0}^{N_{f,t}^o(i)} dj + (1 - \omega) \int_{0}^{N_{p,t}^o(i)} \Theta_{p,t} \Omega_t k^0 dk \right) \right]$$

$$= E_0 \sum_{t=0}^{\infty} \beta^t \left[ \log \tilde{C}_t^o - \chi_t \Theta_t \int_{0}^{1} \left( \omega \frac{N_{f,t}^o(i)^{1+\varphi_f}}{1 + \varphi_f} + (1 - \omega) \Theta_{p,t} \Omega_t \frac{N_{p,t}^o(i)^{1+\varphi_p}}{1 + \varphi_p} \right) \right],$$

where the superscript $o$ denotes the optimizing household, $\tilde{C}_t^o \equiv C_t^o - hC_{t-1}^o$ denotes consumption with habit, $h \in (0, 1]$ and $\omega = \frac{\pi}{\pi + (1 - \pi)(1 - \lambda)}$. $N_{f,t}^o$ and $N_{p,t}^o$ denote the full-time and part-time labor by the optimizing household, respectively. The above expression implies that the labor disutilities of the $j$th full-time member and the $k$th part-time member are given by $\chi_t \Theta_t^j j^\varphi_f$ and $\chi_t \Theta_t^k j^\varphi_f \Theta_{p,t} \Omega_t$, respectively. $\chi_t$ is an exogenous labor preference shock that applies to all types of labor, and $\Theta_t^o$ is the endogenous labor preference shock, adopted by GSW to reduce the wealth effect on labor supply. It is defined by

$$\Theta_t^o \equiv \frac{Z_t^o}{C_t^o - hC_{t-1}^o},$$

where $Z_t^o = (Z_{t-1}^o)^{1-\nu}(C_t^o - hC_{t-1}^o)^\nu$. Thus $\Theta_t^o$ can be interpreted as the “consumption externality factor,” lowering the marginal disutility of labor when the current consumption is higher than the “trend consumption” $Z_t^o$. $\Omega_t$ is a part-time labor supply shock, namely, an exogenous shock that captures a time-varying disutility difference between full-time and part-time work. This difference can arise from factors such as differences in labor hours, required efforts, and social status. $\Theta_{p,t}$ is an endogenous part-time labor preference shock, defined by $\Theta_{p,t} \equiv (1/u_{f,t})^\Theta$. This shock captures how households’ part-time preferences can be responsive to economic and job market conditions, especially difficulties in finding full-time jobs, as represented by the full-time unemployment rate.

Under the given preference, the marginal rate of substitution (MRS) between consumption is

$$MRS_{f,t}(i) \equiv -\frac{U_{N_{f,t}^o(i)}}{U_{C_t^o}} = \chi_t \Theta_t^o C_t^o N_{f,t}^o(i)^{\varphi_f} = \chi_t Z_t^o N_{f,t}^o(i)^{\varphi_f},$$

for $\omega$ fraction of the full-time available households, and

$$MRS_{p,t}^o(i) \equiv -\frac{U_{N_{p,t}^o(i)}}{U_{C_t^o}} = \chi_t \Theta_t^o C_t^o N_{p,t}^o(i)^{\varphi_p} \Theta_{p,t} \Omega_t = \chi_t Z_t^o N_{p,t}^o(i)^{\varphi_p} \Theta_{p,t} \Omega_t,$$

13We test alternative specifications in which an endogenous part-time labor preference shock responds to consumption, or to both consumption and full-time unemployment, but our main result does not change.
for \((1 - \omega)\) fraction of the optimizing part-time available households. In equation (3), we drop the superscript \(o\) in \(MRS_{f,t}\) and \(N_{f,t}\) because the full-time workers consist of the optimizing households only. By combining (3) and (4), we have

\[
\frac{MRS_{f,t}(i)}{MRS_p(t)} = \frac{N_{f,t}(i)^{\theta_f}}{N_{p,t}(i)^{\theta_p} \Theta_p \Omega_t}.
\]

Note that in a frictionless world, this MRS differential is equivalent to the wage differential ratio between the full-time and part-time labor of the optimizing household. By using lowercase letters to denote the natural logarithms of original variables, we can derive the average MRS in the log-linearized form by integrating over all labor types \(i\) as follows:

\[
mrs_{f,t} = \psi_t + z_t^o + \varphi_f n_{f,t},
\]

\[
mrs_{p,t} = \psi_t + z_t^o + \varphi_p n_{p,t} + \zeta_p + \eta_t,
\]

where \(n_{f,t} \equiv \int_0^1 n_{f,t}(i) \text{di}, n_{p,t} \equiv \int_0^1 n_{p,t}(i) \text{di}, \psi_t \equiv \log \chi_t, z_t^o \equiv \log Z_t^o, \zeta_p \equiv \log \Theta_p, \eta_t \equiv \log \Omega_t.

### 2.1.2 Hand-to-mouth households

HTM households are subject to the same endogenous and exogenous labor preference shocks, including the part-time specific shocks. For simplicity, we assume that the elasticity of labor substitution of the HTM household is the same as that of the part-time population of the optimizing household. Thus, the HTM household’s preference can be written as

\[
E_0 \sum_{t=0}^{\infty} \beta_t U_t(\tilde{C}_t^h, \tilde{N}_{p,t}^h)
\]

\[
= E_0 \sum_{t=0}^{\infty} \beta_t \left[ \log \tilde{C}_t^h - \chi_t \Theta_t^h \int_0^1 \left( \int_0^{N_{p,t}^h(i)} \Theta_{p,t} \Omega_t q^{\theta_p} dq \right) di \right],
\]

where the superscript \(h\) denotes the HTM household; \(\tilde{C}_t^h\) and \(\tilde{N}_{p,t}^h\) denote consumption with habit and part-time labor by the HTM household, respectively. \(\Theta_t^h\) is the endogenous labor preference shock defined by \(\Theta_t^h \equiv Z_t^h / \tilde{C}_t^h, Z_t^h = (Z_{t-1}^h)^{1-\omega} (\tilde{C}_t^h)^{\omega}\). The HTM households can only consume their current incomes that consist of a labor income plus a transfer from the optimizing households:

\[
P_t \tilde{C}_t^h = W_{p,t} \tilde{N}_{p,t}^h + P_t T.
\]
We set the transfer $T$ to equalize the steady state consumption between the optimizing and HTM households, which can simplify the log-linearization as shown in Galí et al. (2007). Then, we can solve for the HTM household’s MRS in a log-linearized form as

$$mrs^h_{p,t} = \psi_t + z^h_t + \varphi_p h_{p,t} + \zeta_{p,t} + \eta_t. \tag{10}$$

The total part-time employment can be obtained by aggregating the part-time employments in the optimizing and HTM households as $N_{p,t} = \lambda N^h_{p,t} + (1 - \lambda) N^o_{p,t}$. Similarly, total consumption can be calculated by aggregating the optimizing and HTM households’ consumption as $C_t = (1 - \pi) N^h_t + [1 - (1 - \pi) \lambda] C^o_t$.

### 2.2 Goods production

On the production side, the production technology of intermediate goods producers is given by

$$Y_t = A_t(K_s^\gamma)^\alpha \left\{ \left( N_{f,t} \right)^{\frac{\alpha - 1}{\epsilon_n}} + (\nu_t (1 - \pi) N_{p,t})^{\frac{\alpha - 1}{\epsilon_n}} \right\}^{\frac{\epsilon_n - 1}{\epsilon_n - 1 - \alpha}} - \gamma^\Phi, \tag{11}$$

where $A_t$ is total factor productivity (TFP), $K^\gamma$ is the capital service, $\gamma$ is the deterministic growth trend, $\Phi$ is the fixed cost, $\epsilon_n$ is a parameter that governs the elasticity of substitution between full-time and part-time labor, and $\nu_t$ is a disturbance that affects the relative productivity of part-time workers, possibly capturing the scheduling and monitoring technology involving part-time workers. We consider $\nu_t$ as the part-time labor demand shock, and its steady-state value is assumed to be less than 1. The total cost function of this firm is defined by $W_{f,t} \cdot \pi N_{f,t} + W_{p,t} \cdot (1 - \pi) N_{p,t} + R^K_t K_t$, where $W_{f,t}$ and $W_{p,t}$ are nominal wages for full-time and part-time labor, respectively; $R^K_t$ is the rental rate of capital; and $K_t$ is the physical capital. Then, a cost minimization yields the equilibrium labor demand,

$$\frac{W_{N_{f,t}}}{W_{N_{p,t}}} = \left( \frac{\pi}{1 - \pi} \right)^{\frac{1}{\epsilon_n}} \left( N_{p,t} \right)^{\frac{1}{\epsilon_n}} \left( 1 \right)^{\frac{\epsilon_n - 1}{\epsilon_n}}. \tag{12}$$

### 2.3 Labor market

Workers in each labor type, $\ell = f, p$, are assumed to be represented by a labor union. Following Galí et al. (2007), we assume that the part-time labor union allocates the labor

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14 Note that Ricardian equivalence does not hold in our model with HTM households, whereas it does hold in SW and GSW. However, no government debt is introduced, and the transfer is not time-varying in our model. Hence, this transfer does not matter for model dynamics. See Galí et al. (2007) and Cogan et al. (2010a) for more details.

15 In reality, only a small fraction of part-time workers have union membership. However, we apply labor union assumption to introduce nominal rigidity in a symmetric way with the full-time labor. In fact, the role of this assumption is muted in our result, as the posteriors suggest that the part-time wage is largely flexible.
demand uniformly across the optimizing and HTM households, that is, \( N_{p,t} = N_{p,t}^o = N_{p,t}^h \) for all \( t \). Another assumption is that only a fraction, \( 1 - \theta_{w,t} \), of each type labor union reoptimizes its nominal wages. Workers, who do not have the chance to set wages with probabilities \( \theta_{w,t} \), adopt the following wage indexation scheme:

\[
W_{\ell,t+k|t} = W_{\ell,t+k-1|t} \Pi^x (\Pi^{p}_{t-1})^\gamma_W p (\Pi^p)^{1-\gamma_W p},
\]

where \( W_{\ell,t+k|t} \) is the nominal wage at time \( t+k \) for each labor type, \( \ell = f, p \), worker who last reoptimized at time \( t \). \( \Pi^x \) is the steady state (gross) growth rate of productivity. \( \Pi^p \equiv \frac{P_t}{P_{t-1}} \) denotes the (gross) price inflation rate and \( \Pi^p \) is its steady state value.

Each type of labor union chooses the optimal wages \( W^f_{\ell,t|t} = (1 - \theta_{w,t}) \) with the probabilities \( (1 - \theta_{w,f}) \), respectively. The full-time labor union’s problem can be stated as maximizing the following expressions:

\[
\max \sum_{k=0}^{\infty} (\beta \theta_{w,f})^k E_t \left( \left( \frac{N_{f,t+k|t}}{C^0_{t+k}} \right) \left( \frac{W^f_{f,t+k|t}}{P_{t+k}} \right) - \chi_{t+k} \Theta_{f,k+1} \frac{N_{f,t+k|t}^{1+\phi_f}}{1+\phi_f} \right),
\]

subject to the demand schedule of

\[
N_{f,t+k|t} = \left( \frac{W_{f,t+k|t}}{W_{f,t+k}} \right)^{-\varepsilon_{w,f}} N_{f,t+k},
\]

where \( N_{f,t+k|t} \) denotes the time \( t+k \) employment of the full-time workers whose wages were last reoptimized in \( t \). The optimality condition is given by

\[
\sum_{k=0}^{\infty} (\beta \theta_{w,f})^k E_t \left( \left( \frac{N_{f,t+k|t}}{C^0_{t+k}} \right) \left( \frac{W^f_{f,t+k|t}}{P_{t+k}} - MU^n_{w,f,t+k} MRS_{f,t+k|t} \right) \right) = 0,
\]

where \( MU^n_{w,f,t+k} \equiv \varepsilon_{w,f,t} / (\varepsilon_{w,f,t} - 1) \) is the natural wage markup for full-time labor, namely, the markup that can be obtained under flexible wages and is allowed to exogenously fluctuate over time. As is clear from the expression, it is driven by the elasticity of substitution, \( \varepsilon_{w,f,t} \), and is also related to the degree of the market power of specialized labor. \( MRS_{f,t+k|t} \equiv N_{f,t+k|t} N_{f,t+k|t} \varepsilon_{f,t+k} N_{f,t+k|t} \varepsilon_{f,t+k} \) is the MRS between the consumption and the employment at time \( t+k \).

The part-time labor union solves a similar problem, except that the objective function considers the weights from the optimizing and HTM households:

\[
16 Erceg et al. (2008) also assume that the employment is equal across the optimizing and HTM households. However, in their model the employment of HTM households is determined passively by following the choice of the optimizing households. In our model the part-time labor union decides the employment by considering both the optimizing and HTM households.
Given the assumption of symmetric part-time employment ($N_{p,t} = N_{p,t}^o = N_{p,t}^h$), the equilibrium condition of the part-time labor union is given by,

$$\max \sum_{k=0}^{\infty} (\beta \theta_{w,f})^k E_t \left[ (1 - \lambda) \left\{ \left( \frac{N_{p,t+k|t}}{C^o_{t+k}} \right) \left( \frac{W^*_{p,t+k|t}}{P_{t+k}} \right) - X_{t+k}^o \Theta_{t+k}^o \frac{N_{p,t+k|t}^{1+\varphi_p}}{1 + \varphi_p} \Theta_{p,t+k}^o \Omega_{t+k}^o \right\} \right] + \lambda \left\{ \left( \frac{N_{p,t+k|t}}{C^h_{t+k}} \right) \left( \frac{W^*_{p,t+k|t}}{P_{t+k}} \right) - X_{t+k}^h \Theta_{t+k}^h \frac{N_{p,t+k|t}^{1+\varphi_p}}{1 + \varphi_p} \Theta_{p,t+k}^h \Omega_{t+k}^h \right\} \right],$$

(17)

Under the given assumptions, we can define the aggregate wage index as

$$W_{t,\ell} = \int_0^1 W_{t,\ell}(i)^{1-\epsilon_{w,\ell}} \frac{1}{1-\epsilon_{w,\ell}} di$$

$$= \left[ \theta_{w,\ell} (W_{t,\ell-1} \Pi^p (\Pi^p_{t-1} \gamma_{w,\ell} (\Pi^p_{t-1} \gamma_{w,\ell})^{1-\epsilon_{w,\ell}}} \right)^{1-\epsilon_{w,\ell}}} \right]^{1-\epsilon_{w,\ell}}$$

(19)

for each labor type, $\ell = f, p$. Following Galí (2011), under the symmetric steady state consumption assumption ($C^o = C^h$), it is possible to show the nominal wage inflation for each labor type, $\pi^w_{t,\ell} \equiv \bar{w}_{t,\ell} - w_{t,\ell-1}$, from log-linearizing (16), (18) around a perfect foresight steady state as follows:

$$\pi^w_{t,\ell} = \alpha_{w,\ell} + \gamma_{w,\ell} \pi^p_{t-1} + \beta E_t \{ \pi^w_{t+1} - \gamma_{w,\ell} \pi^p_{t} \} - \lambda_{w,\ell} (\mu_{w,\ell,t} - \mu^n_{w,\ell,t})$$

(20)

where

$$\alpha_{w,\ell} = (1 - \beta) [(1 - \gamma_{w,\ell}) \pi^p + \pi^\gamma],$$

$$\lambda_{w,\ell} = [(1 - \beta \theta_{w,\ell})(1 - \theta_{w,\ell})]/[\theta_{w,\ell}(1 + \epsilon_{w,\ell} \varphi_\ell)],$$

$$\mu_{w,\ell,t} \equiv (w_{t,\ell} - p_t) - m_{\ell,\ell,t},$$

$$\mu^n_{w,\ell,t} \equiv \log MU^a_{w,\ell,t}.$$

\footnote{Detailed derivation for this WPC can be also found in Attey (2016).}
for each labor type, $\ell = f, p$, and $mrs_{p,t} = (1 - \lambda)mrs_{p,t}^o + \lambda mrs_{p,t}^h$ holds from $MRS_{p,t} \equiv \chi t \left[ (1 - \lambda)Z_{t}^o + \lambda Z_{t}^h \right] N_{p,t}(i)^{q_{p,t}} \Theta_{p,t}\Omega_{t}$. An individual supplying type $i$ labor will participate in the full-time or part-time labor force in period $t$ if and only if

$$
\left(\frac{1}{C_{t}^f}\right) \left(\frac{W_{f,t}(i)}{P_t}\right) \geq \chi t \Theta_{t}^f \eta_{f,t},
$$

(21)

$$
\left(\frac{1}{C_{t}^p}\right) \left(\frac{W_{p,t}(i)}{P_t}\right) \geq \chi t \Theta_{t}^p \eta_{p,t} \Theta_{p,t}\Omega_{t},
$$

(22)

$$
\left(\frac{1}{C_{t}^h}\right) \left(\frac{W_{p,t}(i)}{P_t}\right) \geq \chi t \Theta_{t}^h \eta_{p,t} \Theta_{p,t}\Omega_{t}.
$$

(23)

If we denote the marginal supplier of type $i$ labor by $L_{f,t}(i)$, $L_{p,t}^o(i)$, and $L_{p,t}^h(i)$, then we have the following equality conditions:

$$
\frac{W_{f,t}(i)}{P_t} = \chi t Z_{t}^o L_{f,t}(i)^{q_{f,t}},
$$

(24)

$$
\frac{W_{p,t}(i)}{P_t} = \chi t Z_{t}^o L_{p,t}^o(i)^{q_{p,t}} \Theta_{p,t}\Omega_{t},
$$

(25)

$$
\frac{W_{p,t}(i)}{P_t} = \chi t Z_{t}^h L_{p,t}^h(i)^{q_{p,t}} \Theta_{p,t}\Omega_{t}.
$$

(26)

By taking natural logs and integrating over labor type $i$, we get

$$
w_{f,t} - p_t = \psi_t + z_{t}^o + \phi_{f,t} l_{f,t},
$$

(27)

$$
w_{p,t} - p_t = \psi_t + z_{t}^o + \phi_{p,t} l_{p,t} + \zeta_{p,t} + \eta_t,
$$

(28)

$$
w_{p,t} - p_t = \psi_t + z_{t}^h + \phi_{p,t} l_{p,t} + \zeta_{p,t} + \eta_t.
$$

(29)

where $l_{f,t} \equiv \int_0^1 l_{f,t}(i)di$, $l_{p,t}^o \equiv \int_0^1 l_{p,t}^o(i)di$, and $l_{p,t}^h \equiv \int_0^1 l_{p,t}^h(i)di$ can be interpreted as the log aggregate full-time, optimizing part-time and HTM part-time labor forces. Additionally, the log gross labor force $l_t$ can be defined as $l_t = \pi l_{f,t} + (1 - \pi) l_{p,t}$, where $l_f$ and $L_p$ are the steady state values of the full-time and part-time labor forces, respectively; and $l_{p,t}$ is the log part-time labor force obtained by aggregating the optimizing and HTM part-time labor forces.

Following Galí (2011), we define the unemployment rates for each labor force in the following way:

$$
u_{f,t} \equiv l_{f,t} - n_{f,t},
$$

(30)

$$
u_{p,t} \equiv l_{p,t} - n_{p,t}.
$$

(31)
Note that the gross unemployment rate can be also defined as the weighted average between the full-time and part-time unemployment rates as follows:

\[ u_t = \pi \frac{L_f}{L} u_{f,t} + (1 - \pi) \frac{L_p}{L} u_{p,t}. \]  

(32)

Notably, the above aggregation involves a normalizing assumption that \( \frac{N_f}{N_p} = \frac{L_f}{L_p} = 1 \) in the steady state. This assumption is discussed in more detail in the estimation section. By combining the definition of the (log) full-time wage markup, \( \mu_{w,f,t} \equiv (w_{f,t} - p_t) - mrs_{f,t} \), with (6), (27), and (30), and the (log) part-time wage markup, \( \mu_{w,p,t} \equiv (w_{p,t} - p_t) - mrs_{p,t} \), with (7), (10), (28), (29), and (31), the relationship between the average wage markup and the unemployment rate can be derived as

\[ \mu_{w,f,t} = \varphi_f u_{f,t}, \]  

(33)

\[ \mu_{w,p,t} = \varphi_p u_{p,t}. \]  

(34)

The natural rate of unemployment, \( u^n_t \), defined as the unemployment rate in the absence of nominal wage rigidities, can be similarly determined from

\[ \mu^n_{w,f,t} = \varphi_f u^n_{f,t}, \]  

(35)

\[ \mu^n_{w,p,t} = \varphi_p u^n_{p,t}. \]  

(36)

### 2.4 Rest of the model

The remaining equations describing the rest of the model are identical to SW; they are presented in the Appendix. The remaining model’s equations consists of the consumption and investment Euler equations, value of the capital stock, price-setting under nominal rigidities with indexation, capital accumulation, optimal input choice, monetary policy, and goods market clearing. In addition to the aforementioned wage markup shocks (\( \varepsilon_{w,f}^t, \varepsilon_{w,p}^t \)), the general labor preference shock (\( \varepsilon_{\psi}^t \)), and the part-time labor supply (\( \varepsilon_{\eta}^t \)) and demand (\( \varepsilon_{\nu}^t \)) shocks, the model includes a neutral productivity shock (\( \varepsilon_{a}^t \)), a risk premium shock (\( \varepsilon_{b}^t \)), a government spending shock (\( \varepsilon_{g}^t \)), a monetary policy shock (\( \varepsilon_{r}^t \)), a price markup shock (\( \varepsilon_{p}^t \)), and an investment-specific technology shock (\( \varepsilon_{q}^t \)). The shock processes are assumed to follow the autoregressive model of AR(1).

### 3 Estimation

The model is estimated with Bayesian estimation techniques by using 11 U.S. macroeconomic variables as observables. As in SW, the data series include GDP, consumption, in-
vestment, GDP deflator, and the federal funds rate. In addition, we use the median usual weekly nominal earnings, the employment to population ratio, and the unemployment rates for full-time and part-time labor from CPS statistics. We divide the wage series by the GDP deflator to convert them into the real terms. All data series are available from Federal Reserve Economic Data. The sample period runs from 2000:1Q to 2017:2Q. We cannot extend the sample to earlier periods due to the part-time wage data availability. However, because the estimated parameters are well-aligned with the standard estimates for the most part, as we will see later, the sample length may not be a significant issue in analyzing our main research questions.

The measurement equations consist of the log-differenced series, except for the federal funds rate and the employment/unemployment rates. For the federal funds rate, its level is used, whereas for the employment/unemployment rate, level difference is used in the measurement equations. GDP, consumption, investment, and the real wages share the common deterministic trend, \( \bar{\gamma} \).

\[
\begin{align*}
\Delta \ln Y^\text{data}_t &= \gamma + y_t - y_{t-1} \\
\Delta \ln C^\text{data}_t &= \gamma + c_t - c_{t-1} \\
\Delta \ln I^\text{data}_t &= \gamma + i_t - i_{t-1} \\
\pi^\text{data}_t &= \pi + p_t - p_{t-1} \\
\text{FFR}^\text{data}_t &= \bar{r} + r_t \\
\Delta \ln W^\text{data}_{f,t} &= \gamma + (w_{f,t} - p_t) - (w_{f,t-1} - p_{t-1}) \\
\Delta \ln W^\text{data}_{p,t} &= \gamma + (w_{p,t} - p_t) - (w_{p,t-1} - p_{t-1}) \\
\Delta \ln N^\text{data}_{f,t} &= \bar{n} + n_{f,t} - n_{f,t-1} \\
\Delta \ln N^\text{data}_{p,t} &= \bar{n} + n_{p,t} - n_{p,t-1} \\
\Delta \text{Unemp}^\text{data}_{f,t} &= u_{f,t} - u_{f,t-1} \\
\Delta \text{Unemp}^\text{data}_{p,t} &= u_{p,t} - u_{p,t-1}
\end{align*}
\]

In the estimation procedure, the population of each household group, the steady-state full-time wage to part-time wage ratio, a depreciation rate, the steady state government spending share in GDP, the curvature of Kimball aggregator in the goods market, the steady-state elasticity of substitution between the specialized labor, and the persistence of the exogenous labor supply shock are calibrated in the model. The other structural parameters and shock processes are estimated. In our model, the steady state full-time labor force
and employment are $\pi L_f$ and $\pi N_f$, respectively; those for part-time are $(1 - \pi) L_p$ and $(1 - \pi) N_p$, respectively. Moreover, the sample means for the full-time share in total labor force and total employment are almost identical at 0.82. That is, the full-time labor force to part-time labor force ratio ($\equiv \pi L_f / [(1 - \pi) L_p]$) is the same as the full-time employment to part-time employment ratio ($\equiv \pi N_f / [(1 - \pi) N_p]$) in the steady state. Now, we impose a normalizing assumption that $L_f / L_p = N_f / N_p = 1$, which pins down the value for $\pi$, the population of full-time available group, at 0.82. $\lambda$, the fraction of HTM in the part-time available population, is set as 0.5.\textsuperscript{18} The steady-state full-time wage to part-time wage ratio, which is taken as 3.28 from the sample mean, is necessary to determine the steady state values of part-time labor supply and demand shocks and the steady state labor income–consumption ratio for HTM.

The quarterly depreciation rate is chosen as 0.025. The government spending-output ratio in the steady state is set as 0.18 by matching the national account expenditure ratio. As in SW, the curvature parameter of the Kimball aggregator in the goods market is set as 10. The steady-state elasticity of substitution of full-time specialized labor is calibrated to 5, consistent with the steady state markup estimate in GSW. The same parameter for part-time labor is set as 10. The persistence parameter of the general exogenous labor supply shock is fixed at 0.99, following GSW.

The prior distributions of structural parameters and shock processes are chosen based on the standard specification in the previous literature. The parameters for the price and wage rigidities, inflation indexation, monetary policy rigidity, and habit formation follow a beta distribution. The capital share in production, elasticity of labor substitution in the production function, sensitivity of the endogenous part-time labor supply shock to the full-time unemployment, inverse Frisch labor elasticity and monetary policy reaction to inflation, GDP gap, and trend growth rate follow a normal distribution. The steady state inflation rate and detrended real interest rate ($\beta^{-1}\lambda$) with a positive sign follow a gamma distribution. Their posterior distributions are obtained by the Markov Chain Monte Carlo method. We simulate 400,000 sets of the posterior parameters by using the Metropolis–Hastings algorithm; we use the last 240,000 draws to formulate the posterior distributions.

We compare the results from our baseline model (KPS hereafter) with the model that does not distinguish between the two labor types, which is identical to GSW. However, for consistency with the KPS models, we use the employment-weighted average of median weekly earnings of the two labor types, instead of the original wage data series used in

\textsuperscript{18}This parameter is not identified as we do not have separate consumption data for part-timers. As for the fraction of HTM in total population, Campbell and Mankiw (1989) estimated for the fraction of liquidity-constrained households around 0.5, and Coenen and Straub (2005), Cogan et al. (2010b) suggest DSGE estimates around 0.25–0.30. In section 5, we discuss the role of this parameter and the implications when three alternative values ($\lambda = 0, 0.5, 1.0$) are used. We choose 0.5 as the baseline value as it maximizes the marginal likelihood of the model.
GSW. Also, we compare the estimation result with the model that assumes the part-time wage is fully flexible (KPS-FLEX) in the appendix. In the baseline KPS model, as will be discussed more in the next paragraph, the part-time wage rigidity is estimated to be close to zero. Thus, we consider this flexible part-time wage specification to check the robustness of the model. In this specification, we eliminate the part-time wage markup shock and replace the sectoral unemployment data with the gross unemployment data in the set of observable variables. As shown in the appendix, the parameter estimates as well as the model properties are very similar in KPS and KPS-FLEX.

Tables 1 and 2 report the estimated structural parameters in KPS and GSW: First, the Calvo probability of the part-time wage changes, $1 - \theta_{w,p}$, is estimated at 0.99 in KPS. This suggests that the part-time wage is almost as flexible as that assumed in KPS-FLEX. The actual data process for the part-time unemployment rate is stable over time, yet its wage movement is more volatile than the full-time wage. This implies that the part-time Wage Phillips Curve is close to vertical, yielding a low value of the price rigidity parameter. Second, the estimated parameters are mostly in line with the results from SW and the original GSW articles, despite the difference in the sample period. The inverse Frisch labor elasticity for full-time and part-time agents are estimated similarly around 3.7–3.9. The degrees of price and full-time wage stickiness are 0.88 and 0.70, and the degrees of price and full-time wage indexation are 0.23 and 0.17, respectively. The monetary policy reaction to the inflation, GDP gap, and GDP growth rate is 1.38, 0.14, 0.12, respectively. The exception is the parameter $\upsilon$ that governs the short-run wealth effects on labor supply. Though the original GSW reports $\upsilon$ as 0.02, it is estimated to be 0.86 in KPS and 0.49 in our GSW model. Third, the estimated value of $\epsilon_n$—elasticity of substitution between full-time and part-time labor in the production function—is around 5.3, which is somewhat greater than the commonly accepted estimates of the elasticity between skilled and unskilled labor (around 1.5 in Katz and Murphy (1992) and Ciccone and Peri (2005)). The difference may arise from the fact that the two elasticities are comparable but not exactly identical: Though the former is about the employment types, the latter is related to the level of human capital typically measured by the year of schooling. Moreover, recent studies on the elasticity between skilled and unskilled labor report that the industry-level estimates of elasticity are in excess of the consensus value in most industries. The estimated values of world elasticity are similar to our estimates of the elasticity between full-time and part-time labor (Mollick (2011) and Blanckenau and Cassou (2011)). Lastly, the estimated value of $\phi$, the sensitivity of endogenous part-time labor supply shock to full-time unemployment rate, is 4.38, which is far greater

---

19 The sample periods of SW and original GSW are 1966:Q1 to 2004:Q4 and 1966:Q1 to 2007:Q4, respectively.
20 When we choose alternative priors for $\gamma_\pi \sim N(1.8, 0.3)$, $\gamma_\gamma \sim N(0.3, 0.1)$, $\gamma_\Delta \sim N(0.3, 0.1)$, we obtain a posterior mean for $[\gamma_\pi, \gamma_\gamma, \gamma_\Delta] = [1.60, 0.18, 0.15]$. This experiment suggests that the identification of the monetary policy rule is not strong, probably because of the short sample period as well as a possible bias caused by the ZLB. However, it is still informative.
than the prior value of 2.0. This confirms the existence of endogenous preference change towards part-time labor, responding to economic and job market conditions.

These parameter estimates imply the steady-state capital/output ratio of 4.53, consumption/output ratio of 0.70, and investment/output ratio of 0.12 in our model. The steady state value of the part-time labor supply shock $\Omega$ is 0.30, and that of the part-time labor demand shock is 0.16. Both values imply that part-time jobs have the lower disutility and productivity per person than full-time jobs do. This is plausible when we consider the lower working hours and wages per person for part-time jobs.

[Table 1 - Table 2 here]

4 Findings

This section discusses in detail how our estimated model can be used to address the questions raised in the introduction section.

4.1 The model’s ability to capture key features of part-time jobs along the business cycle

The second moments generated by our estimated model show that the model can capture some, if not all, key characteristics of part-time jobs along the business cycle. Tables 3 and 4 report the sample standard deviations and correlations of key variables, along with the unconditional estimates of those moments from each model. In Table 3, the standard deviations of the key macroeconomic variables in KPS are very close to those in GSW, and they are quite in line with those in the sample data. Moreover, the table shows that the KPS model generates higher volatilities for part-time employment and wage compared with their full-time counterparts, consistent with the observations from the actual data.

Table 4 suggests that the KPS model can capture some key correlations associated with the part-time variables. For example, the model exhibits negative correlations between full-time and part-time employment, and between unemployment and full-time employment, as well as a positive correlation between unemployment and part-time employment. In addition, albeit small, the model produces a negative correlation between part-time employment and GDP that appears in the data. At the same time, regarding the non-part-time variables such as the comovements among output, consumption, investment, and total employment, the KPS and GSW models exhibit the similar values of correlations.

[Table 3 - Table 4 here]
4.2 Factors that caused the rise of part-time employment during the Great Recession

Figure 2 presents the historical decomposition of the part-time and full-time employment to population ratios. The figure suggests that there are four shocks that notably explain the rise of part-time employment during the great recession: part-time labor supply, risk premium, monetary policy, and full-time wage markup. The initial increase of the part-time employment, which occurred in the second half of 2008, is mainly caused by the risk premium shock. However, the part-time employment lingers at a high level even when the effect of the risk premium shock is somewhat mitigated after 2009. A large share of that phenomenon is explained by the part-time labor supply shock. In addition, the monetary policy and full-time wage markup shocks around 2009–2012 contributed significantly to the high part-time employment. Meanwhile, a reduction in full-time employment is jointly attributable to the risk premium, investment technology, and monetary policy shocks. It is also notable that the general labor supply shock has increased both the full-time and part-time employment since 2014.

The following analysis on impulse response functions and estimated shock processes can suggest how those shocks are able to explain the rise of part-time employment. Figure 3 presents the impulse response functions of the key variables from the KPS model upon one standard deviation part-time labor supply and demand shocks. It shows that a sudden increase in the part-time labor supply, or demand, causes the part-time employment to increase and the full-time employment to decrease, a substitution between the two types. An increase in the part-time labor supply generates a large increase in the part-time employment, but a relatively very small reduction in the full-time employment. Compared with this, the part-time labor demand shock brings a more balanced exchange between part-time and full-time employment. Interestingly, the part-time labor supply shock increases both the total employment and the unemployment rate, because this shock increases total labor participation. Meanwhile, both part-time labor shocks result in a higher GDP and a lower inflation by increasing the production input (part-time labor supply shock) and enhancing labor productivity (part-time labor demand shock). Regarding wages, as expected, the part-time wage falls after a part-time labor supply shock but rises after a part-time labor demand shock.

Figures 4-5 display the impulse response functions of another group of shocks that substantially cause the rise of part-time employment: the risk premium, monetary policy, and full-time wage markup shocks. The figures suggest that a substitution between the full-time and part-time employment arises in response to those shocks. There are three possible chan-
nels to explain this: First, the risk premium, monetary policy, and full-time wage markup shocks directly affect the production cost of firms by raising either the interest rate or the wage of full-time labor. This, in turn, forces the firms to react by substituting the labor types. Second, these shocks affect the full-time unemployment rate, which changes the household’s preference for part-time employment through an endogenous part-time labor supply shock. Third, when the risk premium or the policy interest rate rises, a recessionary pressure in the economy lowers the household’s labor income. In response, the HTM households may supply part-time labor more aggressively than optimizing households because the former agents cannot access financial markets to smooth consumption. Thus, their consumption and MRS between labor and consumption are likely to reduce further.

The responses from the risk premium and policy interest rate shocks are quite similar. When an economy experiences a recession, both the full-time and part-time wages fall, but the latter falls more deeply. The full-time employment decreases, but the part-time employment increases. Thus, to some degree, firms switch from full-time to part-time labor, which is now cheaper. Meanwhile, a rise in the full-time wage markup lowers the GDP, raises the inflation rate, and triggers a similar transition from full-time to part-time labor. However, the interest rate shocks and full-time wage markup shock have different implications regarding the part-time wage because the latter shock causes the part-time wage to rise.

Figure 6 plots the time series of the structural shocks in the KPS model, estimated and smoothed by using the Kalman filter. Recent studies in the New Keynesian DSGE literature, such as Brzoza-Brzezina and Kolasa (2013), Negro and Schorfheide (2013), Lindé et al. (2016), and Suh and Walker (2016), suggest that those models can only interpret the Great Recession as a joint outcome of large shocks hitting the economy at the same time. Figure 6 reveals a similar finding in our model. Also, all the four shocks—part-time labor supply, risk premium, monetary, full-time wage markup shocks—moved in a direction that caused a transition to part-time jobs. A sharp rise in the risk premium around 2008–2009 triggered the recession. Monetary policy shock is very accommodative during the early crisis, but soon becomes contractionary, due to the existence of a ZLB in the policy rate, as suggested by GSW, Negro and Schorfheide (2013), and Lindé et al. (2016). The full-time wage markup remains high until around 2012—again consistent with GSW—because the nominal wage rigidity hinders a large drop in the full-time wages despite the strong recessionary pressure. Regarding the labor market shocks, there is a sharp rise in the household’s general labor disutility, which reduces the total labor supply during the early crisis. On the other hand, the shock in the household’s part-time labor disutility (part-time labor supply shock) falls, and hence the part-time labor supply increases. Combining these two patterns strongly suggests that the households switch their supply of labor from full time to part time at the outset of the crisis. In addition, a shock to the firm’s technology to use part-time labor (part-time labor demand shock) also increases during the crisis, but the historical decomposition sug-
gests that the contribution of this shock to the increase in part-time employment is relatively small.

[Figure 3 - Figure 6 here]

The variance decomposition\(^{21}\) in Table 5 confirms the importance of the part-time labor supply shock to the part-time employment fluctuation. The shock explains about 60% of the part-time employment variation, whereas the other 40% is explained by the shocks in the risk premium, general labor supply and part-time labor demand. On the other hand, the fluctuation in full-time employment is explained by various factors, such as the risk premium shock (30%), TFP shock (25%), government spending shock (13%), general labor supply and monetary policy shock (about 10% per each shock).

[Table 5 here]

4.3 Explanations on why the part-time employment remains high while the full-time employment seems to recover

Figure 2 suggests that the part-time employment remains high for a sustained period from the outset of the great recession until the end of the estimation period (2017:2Q), whereas the full-time employment recovers at a steady pace. The estimated risk premium and part-time labor supply shock processes are highly persistent with the AR(1) parameters being greater than 0.9. Therefore, as Figure 6 suggests, positive realizations in the risk premium shock in 2008–2009 and several negative realizations in the part-time labor supply shock since 2008 kept the part-time employment at a high level. In contrast, the full-time employment shows a steady recovery since 2012. Even though the risk premium shock has a lingering negative effect, the recovery is led by the increase in the general labor supply and the weakening of the negative effects from monetary policy and TFP shocks.

4.4 Effects of part-time jobs on total employment, labor forces, and unemployment rates

Figures 7-8 present the historical decompositions for total employment, labor participations, and unemployment rates. Because full-time jobs account for the majority of total employment, the shocks that reduce the full-time employment during the recession similarly drag down total employment. However, the decomposition also shows that the part-time labor supply shock, by increasing the part-time employment, plays a significant role in preventing total employment from declining further. On the other hand, the effect of the part-time

\(^{21}\)Forecast error variance decomposition informs how each structural shock contributes to the forecast error variances of variables.
labor demand shock on total employment seems negligible. The figure also shows that there is a strong offsetting effect between the general labor supply shock and the part-time labor supply shock in the early crisis, implying a strong force within the household sector driving the transition from full-time to part-time employment.

Total labor participation also fell during the recession. The difference between the total employment and the labor participation is that the former variable decreased sharply to reach the lowest point in 2010, whereas the latter variable declined slowly and gradually until 2014. There is an even stronger offsetting effect in the early crisis between the general labor supply shock and the part-time labor supply shock, causing a transition from full-time to part-time participation as well. One conjecture is that this transition is related to the baby boom generation’s retirement or resignation from full-time jobs and their re-entry into the part-time labor force. In fact, the U.S. civilian participation rate during the recession fell in all age groups, except for those aged 55 years and over. This conjecture is also consistent with the micro evidence in Valletta et al. (2015), who break down the employment status in CPS. According to this study, the share of the part-time employment in the total employment rose from 17.3% in 2003 to 17.9% in 2014, and the age group of 55 years and over explains most of the increase; the ratio of this age group’s part-time employment to all-age total employment rose from 2.9% to 3.9%. Notably, the full-time wage markup shock has a positive effect on the total participation. This is because it contributes positively to both the full-time and part-time wages, thus increasing the participation of both types. After 2014, the participation rate displays clear signs of a recovery, mainly because the effect from the general labor supply shock turns from negative to largely positive whereas the positive effect of the part-time labor supply shock still remains.

Regarding the unemployment, its significant rise during the recession is jointly explained by a high risk premium, low investment efficiency, contractionary monetary policy due to ZLB, and high full-time wage markup. Among these shocks, the risk premium shock displays the largest impact. Although the general labor supply shock plays an important role for the total employment and participation, its role is limited for the unemployment dynamics. It is worthwhile to note that the increased part-time labor supply and demand commonly increase the unemployment rate rather than decrease it. Still, this observation is consistent with the impulse response functions shown in Figure 3. The unemployment rate has continued to decline since 2010, moving opposite to the total employment rate. This decline is, for the most part, explained by the weakening of factors that led to the initial rise, including the risk premium, full-time wage markup, and monetary policy constraint caused by ZLB.

22 According to the U.S. Bureau of Labor Statistics, participation rate changed from 59.2% at the end of 2007 to 54.9% at the end of 2014 for ages 16–24, from 83.1% to 81.3% for ages 25–34, from 83.9% to 81.9% for ages 35–44, from 82.2% to 79.5% for ages 45–54, and from 38.9% to 39.9% for ages 55 and over.
4.5 Macroeconomic consequences of the increase in part-time employment

Along with investigating how the macroeconomic conditions affected the rise of part-time employment, we also wish to investigate the opposite direction of this interaction, that is, how the part-time employment affected the macroeconomic outcomes. From our previous discussion, four key channels can explain the rise of part-time employment. The first is the exogenous increases in both the part-time labor supply and demand. The second is the firm’s endogenous decision to change the labor types. The third is the endogenous response of the household’s willingness to work part-time, represented by the endogenous part-time labor supply shock. The fourth is the active part-time labor participation by the HTM household whose labor income becomes more valuable during the crisis. We discuss the role of HTM households in the later section and focus on the first three channels here. We use a historical decomposition and counterfactual analysis to examine how these channels affected the macroeconomic outcomes during the Great Recession.

Figure 9 presents the historical decomposition of output and consumption. The part-time labor supply and demand shocks seem to work such that they mitigate the contraction of the output during the Great Recession, but the quantitative effect is not large. After removing the trend, the output in 2010–2014 is about 6% below the level at the end of 2007. During this period, the combined positive effect of the part-time shocks on output is about 0.6%. These shocks also contribute positively to consumption by partially offsetting the labor income loss from the recession, as the combined positive effect of the part-time shocks on consumption is also about 0.7%. Regarding the inflation rate, whose decomposition plot is omitted, both the part-time shocks generated a small deflationary pressure during the recession. The reason can be found from the impulse responses in Figure 3, as the increases in both the part-time labor supply and demand are interpreted as a downward shift of the aggregate supply, therefore lowering the inflation rate.

To examine the second and the third channels, we compare the outcomes in our baseline model with the outcomes from a hypothetical economy in which the production firm’s labor type substitution or the endogenous response of the part-time labor supply is not active. This can be done by lowering the elasticity of substitution between full-time and part-time labor in the production function ($\epsilon_n = 0.5$), or the responsiveness of the part-time labor supply to the full-time unemployment rate ($\phi=0$). The result in Figure 10 compares the impulse response functions from each economy given the risk premium shock and the full-time wage markup shock. The result of monetary policy shock is similar to the risk premium shock thus omitted. The figure suggests that, in response to a rise in the risk premia, or the full-time wage markup, an active transition to the part-time employment in our baseline...
model mitigates the reduction in total employment, output, and consumption. Especially, the difference becomes larger when we mute both channels ($\epsilon_n = 0.5$ and $\phi = 0$). However, the mitigating effect on output and consumption is less distinguishable than the effect on total employment.

To summarize, active switching from full-time to part-time employment during the Great Recession was able to soften the deterioration in total employment (but not the unemployment rate), and it functioned as a buffer against the contraction of output, but its quantitative effect on output seems to be modest.

[Figure 9 - Figure 10 here]

### 4.6 Role of part-time employment in the WPC, and explanation of slow wage recovery

One virtue of Galí (2011) and GSW model setup is that they allow us to estimate WPC consistent with the wage dynamics in the model. Equations (37)–(38) provide the estimated WPCs for the full-time and part-time wages by combining equations (20) and (33)–(36) and plugging in the KPS posterior mean parameter values. Equation (39) presents the estimated WPC for the aggregate wage using the posterior mean of GSW. Note that constant terms are omitted from equations (37)–(39) as they are very close to zero.

$$
\pi_{f,t}^w = 0.1738 \pi_{t-1}^p + 0.9982 \{ E_t \pi_{f,t+1}^w - 0.1738 \pi_t^p \} - 0.0065 (u_{f,t} - u_{f,t}^n),
$$

(37)

$$
\pi_{p,t}^w = 0.2061 \pi_{t-1}^p + 0.9982 \{ E_t \pi_{p,t+1}^w - 0.2061 \pi_t^p \} - 7.6256 (u_{p,t} - u_{p,t}^n),
$$

(38)

$$
\pi_t^w = 0.1662 \pi_{t-1}^p + 0.9984 \{ E_t \pi_{t+1}^w - 0.1662 \pi_t^p \} - 0.0082 (u_t - u_t^n).
$$

(39)

The above estimates indicate that the aggregate WPC dynamics are mainly dominated by the full-time wage determination. The full-time wages and aggregate wages have similar values for the response to the unemployment gap (the gap between the actual unemployment and the natural unemployment) and to the previous inflation.

On the other hand, the part-time WPC exhibits a great sensitivity of the wage inflation to the unemployment gap (7.6256 in equation (38)). This is also related to high wage flexibility in part-time jobs in our posterior.\(^{23}\) Despite this high flexibility, the effect of the part-time wage determination on the aggregate wage determination seems to be limited during the sample period.

\(^{23}\)The posterior mean for $\theta_{w,p}$ is 0.01.
However, the above result does not mean that the part-time shocks were irrelevant for explaining why the wage growth has remained stagnant while the unemployment rate fully recovered from the Great Recession. Figure 11 presents the historical decompositions of these gross and part-time wages. Although the long-lasting effect of the risk premium shock explains the most of the sluggish wage recovery, the increased part-time labor supply shock also explains a significant portion of the slow growth in the gross and part-time wages. Interestingly, the part-time labor demand shock has a positive effect on the part-time wage, which is quite similar to the negative effect of the part-time labor supply shock in terms of absolute magnitude. However, the former shock’s effect on the gross wage is largely reduced, whereas the latter shock’s effect remains significant. This difference comes from the composition effect. Consistent with the model, the gross wage $W_t$ is defined as $W_t \equiv \pi(N_{ft,t}/N_t)W_{ft,t} + (1-\pi)(N_{pt,t}/N_t)W_{pt,t}$. Obviously, this gross wage is affected by not only the wages of both types, but also the composition of total employment $(\pi N_{ft,t}/N_t, (1-\pi) N_{pt,t}/N_t)$. Both shocks can lower the gross wage by reducing the share of the full-time employment, as full-timers receive higher wages than part-timers. This composition effect offsets the positive effect from the part-time labor demand shock but adds to the negative effect from the part-time labor supply shock. This different impact of the part-time labor supply and demand shocks on wage might also play a key role in the estimation results, as observational data suggests a rise in employment and a fall in the wage in the part-time labor, favoring the labor supply shock.

Except for the risk premium and the part-time labor supply shocks, the full-time wage markup shock also contributes to the sluggish wage increase during the recovery. It seems that the nominal rigidity in wages plays a role here: During the early recession the positive wage markup delayed a decline of the wage at the cost of high unemployment rate, but during the recovery the negative wage markup suppressed the wage rise. As pointed out by Daly and Hobijn (2014), a wage rigidity can cause WPC to flatten through “pent-up wage deflation” during a recession. In addition to the full-time wage markup shock, the ZLB of the policy rate and the investment-specific shock also drag down the wage recovery. This indicates that the flattening of the WPC may be structural and the wage growth may remain in stall for the time being. In contrast to employment, the general labor supply shock does not have any visible effect on the wages. This observation is consistent with the variance decomposition in Table 5, wherein the shock makes little contribution to the forecast error variance of the wages.

Although historical decomposition of full-time wage is not presented in this study, the contributions of both part-time shocks to full-time wage are very small.
5 Further analysis

5.1 Role of the HTM households in model dynamics

As mentioned, the HTM households, because of the restriction on the financial access, need to supply part-time labor more aggressively than the optimizing households when a contractionary shock hits the economy. If this channel is strong, then the key recessionary shocks (e.g., the risk premium shock in our model) must exercise a stronger influence to the part-time labor dynamics when the economy has a higher HTM population. Also, the contribution from the part-time labor supply shock could decrease accordingly. In this subsection, we analyze how the size of HTM households affects the model dynamics regarding the part-time labor supply. Specifically, we consider three models in which the HTM proportion in the part-time available population are different ($\lambda = 0, 0.5, 1$), and thus estimate the posterior distribution for each model.

Figure 12 shows the relative contributions of the risk premium shock and part-time labor supply shock on the part-time employment during the Great Recession. The ratio in the figure is each shock's relative contribution to the part-time employment, measured by $[(\text{contribution of risk premium shock at time } t - \text{contribution of risk premium shock at 2007:4Q})/(\text{contribution of PT labor supply shock at } t - \text{contribution of PT labor supply shock at 2007:4Q})]$. The result is consistent with the logic explained above: For most periods of the recession, with a strong shock in the risk premium, the contribution from the risk premium shock to the part-time employment becomes stronger as the size of the HTM households becomes larger. The gaps between the relative contribution ratios across different HTM populations narrow only after 2012.

However, model comparison and variance decomposition results are less favorable to the model with a large HTM population. Marginal likelihood evaluated by the Laplace approximation around the posterior mode is -679.38 when $\lambda = 1$, but the baseline model of $\lambda = 0.5$ has the best value among three models with -678.10. Table 6 summarizes the standard deviations and the correlations of the key variables: The volatility of the key variables seem similar across the models. However, the correlations of the key variables tend to move away from the sample values as the HTM proportion increases, including the correlation between output and unemployment, output and total employment, and output and part-time employment. Regarding the variance decomposition in Table 7, even though the contribution of the part-time labor supply shock to the part-time employment decreases as the HTM proportion increases, this is more attributable to the general labor supply shock rather than other business cycle shocks. Especially, the contribution of the risk premium shock is the smallest when the HTM proportion is the largest.

[Figure 12 here]
5.2 Model comparison: out-of-sample forecast

To evaluate the model’s performance, we compare the forecasting power of the KPS model with that of the GSW model. Table 8 compares the root mean squared error (RMSE) of the out-of-sample forecast from each model. The out-of-sample period for total employment and unemployment rates is set as 2014:1Q-2019:2Q. For the other variables, we use a shorter out-of-sample period of 2014:1Q-2017:2Q because of data discontinuity caused by the base year change in the national income product account variables. The period of 2000:2Q-2013:4Q is used for the in-sample estimation. Each model is assumed to be re-estimated every quarter during the forecasting period.

In general, forecasting power of KPS is quite comparable to that of GSW. For some variables, such as investment, inflation, and total employment, forecasting power of KPS improves over GSW across almost all forecast horizons. Regarding total unemployment, the KPS’s RMSE is generally higher than the GSW’s except in the 8-step forecast. This is understandable given that GSW uses the total unemployment rate as an observable variable, whereas KPS uses the full-time/part-time unemployment rates as observables. In this respect, an RMSE reduction in the KPS model for the total employment is remarkable because it does not use the total employment as a direct observable variable, whereas GSW does.

5.3 Zero lower bound of the interest rate

As a caveat to our analysis, it should be noted that the nonlinear features in the data, such as the ZLB on the nominal interest rate, are not explicitly considered. Because a standard Taylor rule without the ZLB fails to explain the federal funds rate set near zero percent during and after the Great Recession, the parameter estimates may be subject to the possible bias by neglecting the effect of the ZLB (Fernandez-Villaverde et al. (2015) and Hirose and Inoue (2016)). In addition, the estimation of the model without the ZLB may bring about the bias in the structural shocks, even though the bias in the estimated parameter is not significant. Especially, though this paper aims to explain the dynamics of the part-time employment during the crisis, the absence of the ZLB may lead to overestimating the impact of the part-time labor supply shock.

To address this issue, Figure 13 compares the three cases of the impulse responses to the risk premium shock large enough to hit the ZLB under the same parameter estimates from the baseline model. The first impulse response (“Piecewise Linear (OccBin)”) is obtained by employing OccBin, the quasi-linear method of Guerrieri and Iacoviello (2015) to solve the
baseline model with the ZLB. The second response (“Linear (ignores ZLB”) assumes the baseline model without the ZLB, letting the policy interest rate fall below zero. In the third case (“Linear (ignores ZLB + MP shock”) , the ZLB is not binding, but the interest rate path matches the ZLB by adding positive shocks in the monetary policy equation. This captures the effect of positive monetary policy shocks estimated in our model during the ZLB period. As expected, the part-time employment increases greater with the ZLB than without it, when the constraint binds. However, the third case shows that, when we have the observationally equivalent interest rate path generated by imposing contractionary monetary shocks, the part-time employment dynamics become closer to the ZLB model.25 Thus, even though the models that neglect the ZLB, do understate the role of recessionary shocks to explain the dynamics of the part-time employment, the contractionary monetary policy shocks induced by the observed zero interest rate in our estimation can alleviate this concern. It is also worth mentioning that the severity of ZLB on real economic activity was at least partially mitigated by the Federal Reserve’s asset purchases and forward guidance, as pointed by Chung et al. (2012), Gambacorta et al. (2014) and Eberly et al. (2020). Considering these two offsetting factors, the bias in the result might be smaller than it seems.

[Figure 13 here]

6 Conclusion

This study analyzes the movement of part-time jobs and its implications along the business cycle through the lens of a New Keynesian DSGE model, especially focusing on the rise of part-time jobs during the Great Recession. Our results suggest that during the Great Recession, along with the substitution caused by the recessionary shocks, there was a large shift in the household preference to part-time labor. This increased the labor supply for part-time jobs. The shift played a vital role in the rise and persistence of part-time jobs as it mitigated the sharp contraction of total employment and total labor force. Also, this shock explains a significant portion of the slow wage recovery, as it lowered the part-time wage as well as the proportion of full-time jobs in total employment. However, although part-time jobs provide households and firms facing the contractionary economic conditions with an alternative way of working and hiring, their role to relieve a recessionary pressure is estimated to be, at most, moderate. This result indicates that the prevalence of part-time jobs

25 Nevertheless, the difference still remains, which seems to be in part caused by the fact that in the ZLB model agents consider the possibility of the ZLB before the realization of the shock, but they do not in the models without the ZLB. In this regard, Del Negro et al. (2017) employ anticipated monetary policy shocks to capture the effect of the ZLB by allowing forward-looking agents to factor the future ZLB. As pointed out by Wu (2017), however, their estimation method also seems to have some limitations on the proper treatment of the ZLB in a respect to their counterfactual estimates of natural interest rates.
can be an additional source of inefficiency in the labor market, and more caution should be
given when interpreting the employment-to-population ratio or the unemployment rates.

In our general equilibrium model, there are several channels that draw an endogenous
increase in part-time employment during a recession. If a fraction of part-timers exhibits
HTM behavior, then their labor supply might increase more aggressively, facing a down-
ward pressure in their wage incomes. Also, a household’s appetite to work part-time en-
dogenously increases when finding full-time jobs is difficult. Firms can switch to part-
time jobs where the wage is more flexible. These endogenous responses to the recessionary
shocks, such as contractionary risk premium and monetary policy shocks, initiated the in-
crease in part-time employment during the early stages of the Great Recession. Then, the
exogenous increase in part-time labor became more important during the latter part of the
recession. However, although our model specification tries to separate the two channels,
the estimated exogenous part-time labor supply shock may still capture an unidentified en-
dogenous household response. This identification issue can be a challenging, but interest-
ing, subject for future research. In this respect, alternative approaches to exploit theories of
search and matching friction, as in Gertler et al. (2008), Christiano et al. (2016), or on-the-job
search as in Van Zandweghe (2010), could be useful.

The framework used in our study is practical, as it maintains the basic structure of the
SW type model. It can be easily applied to the analysis of part-time jobs in countries other
than the U.S. However, to our knowledge, only a few countries currently compile and pub-
lish the quarterly wage statistics for full-time and part-time jobs separately. Therefore, we
believe improving the range and depth of the employment and wage statistics can be a key
to the development of this strand of research.

Possibly, understanding the behavior of part-time jobs will become more important for
business cycle analysis in the future if technological, or demographic, changes make part-
time work more prevalent. Several issues regarding part-time jobs need to be examined
more thoroughly, aside from their role in the business cycle addressed herein—the examples
include how to use the information on part-time jobs to measure an additional slackness in
the labor market, as well as welfare implications of part-time jobs, especially considering
jobs categorized as voluntary and involuntary. We leave it to future research to address
these issues.

References


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<table>
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<tr>
<th>Parameter</th>
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<th>Posterior (GSW) Mean</th>
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Table 2: Priors and posteriors of shock processes

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<td><strong>Part-time labor demand shock</strong></td>
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Table 3: Standard deviations of key variables

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<th>GSW</th>
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<td>0.71</td>
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<td>0.63</td>
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<tr>
<td>Interest rate</td>
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<tr>
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<td>Part-time employment</td>
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<td>Full-time wage</td>
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Note: The level of the interest rate is used to calculate the standard deviation. For the employment/unemployment rate, the level difference is used. For other variables, log differences are used. “Full-time wage” for GSW is the gross wage. Model moments are evaluated at the posterior mode.

Table 4: Correlation coefficients between key variables

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<th>GSW</th>
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<td>0.79</td>
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<td>Output-investment</td>
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<td>0.54</td>
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<tr>
<td>Output-unemployment rate</td>
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<tr>
<td>Output-total employment</td>
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<tr>
<td>Output-FT employment</td>
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<td>0.45</td>
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<tr>
<td>Output-PT employment</td>
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<td>-</td>
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Note: For the employment/unemployment rate, the level difference is used to calculate the correlation coefficient. For the other variables, the log differences are used. The model moments are evaluated at the posterior mode.
<table>
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<th>Unemp.</th>
<th>FT wage</th>
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<td>FT emp.</td>
<td>PT emp.</td>
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<td>4</td>
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Note: The numbers for each variable are from the KPS and GSW models in that order. “Full-time wage” for GSW is the gross wage. “Wage markup shock” for KPS is the full-time wage markup shock. The variance decompositions are evaluated at the posterior mode.
Table 6: Model moment comparison with different HTM household proportion (λ)

(a) Standard deviation of key variables

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<td>0.73</td>
<td>0.74</td>
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<td>0.63</td>
<td>0.63</td>
<td>0.65</td>
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<td>0.45</td>
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<tr>
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<td>0.48</td>
<td>0.49</td>
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<td>0.59</td>
<td>0.56</td>
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<td>0.58</td>
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<tr>
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<td>1.74</td>
<td>1.76</td>
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<tr>
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<td>0.72</td>
<td>0.72</td>
<td>0.72</td>
</tr>
<tr>
<td>Part-time wage</td>
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</table>

(b) Correlation coefficients between key variables

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<td>0.70</td>
<td>0.77</td>
<td>0.78</td>
<td>0.79</td>
</tr>
<tr>
<td>Output-investment</td>
<td>0.71</td>
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<td>0.56</td>
<td>0.56</td>
</tr>
<tr>
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<td>-0.38</td>
<td>-0.35</td>
<td>-0.33</td>
</tr>
<tr>
<td>Output-total employment</td>
<td>0.42</td>
<td>0.41</td>
<td>0.43</td>
<td>0.46</td>
</tr>
<tr>
<td>Output-FT employment</td>
<td>0.49</td>
<td>0.46</td>
<td>0.45</td>
<td>0.44</td>
</tr>
<tr>
<td>Output-PT employment</td>
<td>-0.37</td>
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<td>0.05</td>
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<tr>
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<td>-0.34</td>
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Note: λ stands for the fraction of HTM in the total part-time available population. The model moments are evaluated at the posterior mode.
Table 7: 10- and 40-quarter forecast error variance decomposition of part-time employment (%)

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<td>PT dem</td>
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Note: $\lambda$ stands for the fraction of HTM in total part-time available population. The variance decompositions are evaluated at the posterior mode.

Table 8: RMSE, out-of-sample forecast error

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<tr>
<th></th>
<th>KPS</th>
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<tr>
<td></td>
<td>Forecast horizon</td>
<td>1Q</td>
<td>2Q</td>
<td>4Q</td>
<td>6Q</td>
<td>8Q</td>
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<tr>
<td>Output</td>
<td>0.443</td>
<td>0.614</td>
<td>0.983</td>
<td>1.464</td>
<td>1.843</td>
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<tr>
<td>Consumption</td>
<td>0.272</td>
<td>0.515</td>
<td>0.936</td>
<td>1.181</td>
<td>1.458</td>
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<td>Investment</td>
<td>0.974</td>
<td>1.964</td>
<td>5.146</td>
<td>9.530</td>
<td>14.052</td>
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<td>Inflation</td>
<td>0.244</td>
<td>0.334</td>
<td>0.799</td>
<td>1.374</td>
<td>1.965</td>
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<td>Total employment</td>
<td>0.234</td>
<td>0.322</td>
<td>0.519</td>
<td>0.737</td>
<td>0.970</td>
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<td>Unemployment</td>
<td>0.139</td>
<td>0.187</td>
<td>0.381</td>
<td>0.561</td>
<td>0.682</td>
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<td>Forecast horizon</td>
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<td>2Q</td>
<td>4Q</td>
<td>6Q</td>
<td>8Q</td>
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<tr>
<td>Output</td>
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<td>0.968</td>
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<td>Consumption</td>
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<td>0.896</td>
<td>1.090</td>
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<td>Investment</td>
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<td>2.136</td>
<td>5.649</td>
<td>10.277</td>
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<td>Inflation</td>
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<td>0.820</td>
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<td>Total employment</td>
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<td>0.335</td>
<td>0.674</td>
<td>1.101</td>
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<td>Unemployment</td>
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<td>0.154</td>
<td>0.330</td>
<td>0.553</td>
<td>0.724</td>
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Note: The out-of-sample period is set as 2014:1Q-2019:2Q for the total employment to population ratio and unemployment ratio, and as 2014:1Q-2017:2Q for the other variables, due to data discontinuity in national income product account statistics caused by a base year change.
Figure 1: Unemployment and part-time jobs

(a) Unemployment rate and part-time share in total employment

(b) Unemployment rate and part-time employment to labor force rate
Figure 2: Shock decomposition: PT and FT employment

(a) Part-time employment

(b) Full-time employment
Figure 3: Impulse response functions: part-time shocks

(a) Part-time labor supply shock

(b) Part-time labor demand shock
Figure 4: Impulse response functions: risk and monetary policy shocks

(a) Risk premium shock

(b) Monetary policy shock
Figure 5: Impulse response functions: FT wage markup shock

Figure 6: Estimated shocks

Note: Shocks are estimated and smoothed using the Kalman filter from the KPS models.
Figure 7: Shock decomposition: total employment rate and labor participation rate

(a) Total employment

(b) Labor participation
Figure 8: Shock decomposition: unemployment rate
Figure 9: Shock decomposition: output and consumption

(a) Output

(b) Consumption
Figure 10: Impulse response functions: when part-time labor switching is difficult

(a) Risk premium shock

(b) Full-time wage markup shock
Figure 11: Shock decomposition: gross wage and part-time wage

(a) Gross wage

(b) Part-time wage
Figure 12: Shock contribution ratio: risk premium shock/PT labor supply shock

Note: This figure measures the risk premium shock/PT labor supply shock contribution ratio: \[
\frac{\text{contribution of risk premium shock on PT employment at time } t - \text{contribution of risk premium shock on PT employment at } 2007:4Q}{\text{contribution of PT labor supply shock on PT employment at } t - \text{contribution of PT labor supply shock on PT employment at } 2007:4Q}\].
Figure 13: Impulse response to risk premium shock with and without ZLB

1. Policy Interest Rate (percent at AR)

2. PT Employment

Note: The size of the risk premium shock is 2. In “Linear (ignores ZLB + MP shock),” monetary policy shock is introduced to match the interest rate path of “Piecewise Linear (OccBin)”.