Firing Cost in the Lifecycle Labor Search Model with Job-to-Job Transition

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1 Introduction

Firing cost induced by government-mandated employment protection is seen by economists as one of the primary determinants of labor market equilibrium, and has been intensely studied in the context of labor search models. The large body of the literature, however, has focused on the environment without job-to-job transition or life-cycle structure. The literature thus has failed to account for how job-to-job transition is affected by firing cost, how other labor market outcomes are affected by firing cost in the presence of job-to-job transition, and how different age groups of workers are affected by firing cost. For the sake of complete evaluation of the impact of firing cost on the labor market equilibrium, it is essential to take job-to-job transition into account, since it constitutes the substantial part of labor turnover and has a strong impact on other labor market outcomes such as vacancy creation. Also, accounting for life-cycle structure is important, because some of employment protection policies are applied to a particular age or tenure group of workers and even uniformly applied policies may have different impacts across ages.

In this study, I incorporate on-the-job search and a life-cycle structure into a Mortensen and Pissarides (1994)-type search model and analyze the impact of firing cost on the labor market equilibrium. I estimate the structural parameters of the model to replicate the U.S. labor market by matching the age-tenure profile of wages and transition probabilities in the model to those in the 1996 panel of SIPP. By shifting the parameter of firing cost in the model, I quantitatively analyze the counterfactual impact of firing cost. In the model, the firm and the worker match gradually learn their match quality through noisy signals as in Jovanovic (1979). Given their belief on match quality, they set wages by period-by-period Nash bargaining with no ex post response to outside offers. In such environment, firing cost affects job-to-job transition mainly through two opposing channels. First, firing cost discourages job-to-job transition by the workers by giving them better bargaining position only in ongoing jobs. Wages in ongoing jobs increse in response to better bargaining position, but initial wages in new jobs do not due to the absense of firing cost at the time of initial wage negotiation. Initial wages rather decrease, in order to offset subsequent wage increase. Second, low quality matches that have higher job-to-job transition probability survive without being resolved by firing, which causes more job-to-job transition. The first effect appears immediately after the once-and-for-all increase of firing cost, while the second becomes pronounced as the distribution of workers evolves into the new steady state distribution. In the estimated model the first effect dominates the second, so that firing cost reduces job-to-job transition. Although the first effect hinges on the wage setting rule in which the workers can exploit firing cost but not outside offers[1] to raise their wages, it provides a possible explanation for the negative correlation between strictness of employment protection legislation and job-to-job transition among OECD countries, which is suggested by Sousa-Poza and Henneberger (2004) and Gielen and Tatsiramos (2012).[2]

In an environment without job-to-job transition, Garibaldi (1998), Pries and Rogerson (2005), and Zanetti (2011) suggest that firing cost discourages job creation by causing inefficient firing decisions. In the presence of job-to-job transition, however, this negative impact could be mitigated or even be reversed. Both of two channels suggested above, through which firing cost affect job-to-job transition, involve positive impacts on the the firm's profit from new hires. In particular, the first channel deters the worker from being poached by another firm, and the second channel mitigates the burden of firing cost since low quality matches are resolved by job-to-job transition, which is not subject to firing cost. In fact, firing cost has a small negative impact on vacancy creation in the calibrated model, while it has a larger negative impact in the labor market with smaller efficiency of on-the-job search. This result emphasizes the importance of taking job-to-job transition into account to evaluate the impact of firing cost on vacancy creation.

Incorporating a life-cycle structure into the model enables me to analyze how the welfare of different age groups of workers is affected by the increase of firing cost. I show that the welfare impact is uneven across age groups and employment status even with the uniform increase of firing cost. The welfare of lder employed workers are affected more by a temporary wage gain associated with the change of the firm-worker bargaining position. On the other hand, unemployed workers and younger employed workers are affected more by a permanent wage gain or loss associated with the change of joint surplus of the firm-worker match.

Firing cost in this model is a tax paid by the firm upon an incidence of job loss caused by breakdown of wage negotiation. Without causing firing cost, the firm-worker match can be destroyed without causing firing cost in two ways: job-to-job transition or a random destruction. The random desctrucation represents a voluntary quit unrelated to wages or a bankrupt, and happens at a probability independent of match

[1]If the worker can exploit outside offers as in Postel-Vinay and Robin (2002), job-to-job transition is merely governed by efficiency and is not affected by firing cost.

[2]On the other hand, Boeri (1999) reports that job-to-job transition rate inferred by the tenure distribution in 1992 is high in Spain and Portugal, which have strict employment protection legislation, though he suggests in Spain it could be attributed to the prevalence of fixed-term contract.

quality. These assumptions on firing cost are standard in the literature, but a careful consideration is needed to associate firing cost in the model with firing cost induced by employment protection legislation in reality. According to OECD (2013b), employment protection legislation in OECD countries mainly regulates: i) severance payment and advance notice; ii) notification procedure for dismissal; and iii) requirements of just cause for dismissal. In addition to these types of legislation, the experience-rated unemployment insurance (UI hereafter) tax, which is peculiar to the United States, also works as mandated employment protection. The mandatory severance payment is one of the most relevant source of firing cost in OECD countries, but Garibaldi and Violante (2005) show that it has no effect on job creation and job destruction in a Mortensen and Pissarides (1994)-type search model without job-to-job transition. A similar result holds even in the model of this study; the mandatory severance payment has no effect on job-to-job transition as well as job creation and job destruction. Thus this study does not analyze the impact of the mandatory severance payment. Requirements on notification procedure and just cause induce firing cost as a red-tape cost or a legal cost,[3] which works similarly to a tax, and the experience-rated UI tax is a tax itself. Therefore, firing cost in this model represents these pieces of legislation rather than the mandatory severance payment.

Another inssue on associating firing cost in the model with employment protection legeslation in reality is about the distinction between firing and quit. In reality employment protection legislation only penalizes firing but not quit. The model, on the other hand, does not distinguish whether wage negotiation breaks down by firing or quit.[4] With no penalty on quit, the firm could evade firing cost by inducing the worker to quit by offering a severance package, and such practice is indeed common in reality. However, I believe this scheme cannot completely undo firing cost. The firm cannot profitably evade the experience rated UI tax because the firm has to offer severance package that is more attractive than the UI benefit. Also, requirements on notification procedure and just cause can only be partially undone by the agreement on quitting in exchange for a severance package, in the presense of negotiation costs and incomplete information on how much these requirements would actually cost for the firm.[5]

[3]Some part of just cause requirement is motivated by human right or covenant of good faith and fair dealing and can hardly be interpreted as firing cost. However, some countries have economic requirement on just cause. According to OECD (2013a), Finland, France, Germany, Japan, Netherlands, Norway, and Sweden require the employers to show "serious" business needs that make dismissal unavoidable and to attempt redeployment or retraining prior to dismissal.

[4]The Nash bargaining, which was originally axiomatic, is characterized by Rubinstein (1982) as the solution to a sequential game. In his bargaining game, the breakdown of the negotiation stochastically happens rather than being initiated by one party.

[5]Another issue is how the outcome of wage bargaining change if assymetric consequenses of firing and quit are accounted for. If the firm has 100% bargaining power, firing cost has no effect because the firm can induce worker to quit by offering substantially low wage. If the worker has 100% bargaining power, the presense of firing cost affects outcomes because because the worker offers the wage level at which the firm is indifferent between firing and keeping employment. Unfortunately, no wage bargaining model can predict what happens if both sides have some bargaining power.

The existing studies suggest that employment protection has a variety of impacts on the labor market. Bentolila and Bertola (1990) and Hopenhayn and Rogerson (1993) develop the model of heterogeneous firms with the idiosyncratic shock and the labor adjustment cost. They show that the adjustment cost, in which they embody employment protection, reduces both job finding rate and job destruction rate. More recent studies build on the framework of Mortensen and Pissarides (1994) and Mortensen and Pissarides (1999) to study the impact of employment protection. Garibaldi (1998) shows that employment protection, which he models as the duration until firing permission, reduces the level and the cyclical volatility of the job finding rate and the job destruction rate. Zanetti (2011) finds that firing cost has a similar effect. Wasmer (2006) shows that workers invest more in specific human capital under larger firing cost while they invest more in general human capital with smaller firing cost. As the most closely related papers to this study, Kugler and Saint-Paul (2004) and Postel-Vinay and Turon (2014) investigate the impact of firing cost in the presence of on-the-job search. They emphasize the positive impact of firing cost on job-to-job transition due to survival of low quality matches,[6] while this study emphasizes the negative impact of firing cost on job-to-job transition due to the worker's reinforced bargaining position in existing matches.

The rest of the paper is organized as follows: Section 2 describes the model; Section 3 explains the data and the calibration procedure; Section 4 presents the findings from the counterfactual experiments; and Section 5 concludes.

2 The Model of Labor Market with Employment Protection

In the following, I describe the model to analyze the impact of firing cost on the labor market equilibrium.

2.1 Environment

Basic Setting The economic agents consist of infinitely lived firms and overlapping generations of finitely lived workers. Both firms and workers are risk neutral with discount factor $\beta \in (0, 1)$. Each worker has T periods of working life, and each cohort of workers has a unit population. Following the convention I refer to the worker's age as the number of periods since entry in the labor market, instead of biological age. The worker is either employed at the firm or unemployed. The output y_n of the employed worker with age a_n and tenure n is given by

$$y_n = f_{a_n,n} + x_n, \tag{1}$$

[6]In Kugler and Saint-Paul (2004), the positive impact of firing cost on job-to-job transition is also caused by the adverse selection in favor of already employed workers, who are less likely to be "lemons".

where x_n is the match quality. The match quality follows AR(1) process with

$$x_{n+1}|x_n, \ldots, x_0 \sim N\left(\rho x_n, \sigma_x^2(1-\rho^2)\right), \tag{2}$$

with the initial value $x_0 \sim N(0, \sigma_x^2)$. Neither the firm nor the worker can observe the match quality, but they form a belief about it through an observation of a noisy signal

$$\epsilon_n|x_n, \ldots, x_0 \sim N(x_n, \sigma_\epsilon^2) \tag{3}$$

in each period. Unemployed workers with age a produce as much as b_a at home.

Labor Market Institution At the beginning of each period, the firm-worker match negotiates a wage in the period. At negotiation both the firm and the worker have an alternative to break up the match, which causes the firm to pay firing cost $c_{a,n}$ regardless of which side initiates the break-up. Firing cost is imposed by the government as a tax and the tax revenue is given back to workers period-by-period as a lump-sum transfer. There is no firing cost at the initial wage negotiation: $c_{a,0} = 0$, as in Mortensen and Pissarides (1999). The negotiated wage solves a Nash bargaining problem in which the disagreement points are $-c_{a,n}$ for the firm and the value of unemployment for the worker, as characterized in the next subsection. The wage cannot be renegotiated at any other timings during the period, which rules out the firm's any ex post response to a poaching.

The labor market is segmented according to the worker's age.[7] After the production in the period takes place, continuing matches are exogenously destroyed with probability $d_{a,n}$. Also, the firm can post the vacancy in any submarket at cost η, and the worker searches for a new job if and only if there is a strictly positive gain from searching.[8] Given a tightness θ_a of the submarket for age a workers, a matching probability is $q(\theta_a)$ for the firms, $p(\theta_a)$ for the unemployed workers, and $\lambda p(\theta_a)$ for the employed workers who decide to search, where $p(\theta) = \theta q(\theta)$ and $0 \leq \lambda \leq 1$. The unemployed workers who have just become unemployed due to the exogenous job destruction have no chance of finding new jobs in the same period. Newly formed matches start their employment relationship in the next period. When meeting the new employer, the worker can neither renegotiate wages with the current employer nor pre-negotiate with the new employer. Beginning of the period is the only timing at which wage negotiation takes place. Having already left the previous employer, the unemployment is an outside option for the worker to negotiate the initial wage with the new employer. Figure 1 summarizes the timeline of events in each period.

[7] Segregating the market by age may not be realistic, since the U.S. labor market, which I take my model to, has anti-age-discrimination laws. Nevertheless, I maintain this assumption for tractability. It would not significantly affect the result whether the market is segmented or pooled, since the job finding rates of unemployment workers are almost constant between age 25 and 55.

[8] Since there is no search cost for the worker, the worker's any search decision can be justified when there is no gain from searching. I focus on the equilibrium in which the worker does not search if there is no gain from doing so. The other equilibria are intractable because the firm's vacancy creation decision depends on the worker's distribution due to the possibility of unsuccessful matches.

Learning of Match Quality In order to recursively solve for the lifetime value of the workers and the firms, I characterize the evolution of the belief about the match quality as a first-order Markov process. Using Bayes' rule it can be shown that $x_n|\epsilon_0, \dots \epsilon_{n-1}$ is normally distributed, so the conditional distribution of the match quality is summarized by the conditional mean $m_n := \mathbb{E}[x_n|\epsilon_0, \dots \epsilon_{n-1}]$ and the conditional variance $\gamma_n^2 := Var[x_n|\epsilon_0, \dots \epsilon_{n-1}]$ that follow a Markov process

$$\begin{cases} m_{n+1}|m_n & \sim N\left(\rho m_n, \frac{(\rho\gamma_n)^2}{1+(\sigma_\epsilon/\gamma_n)^2}\right) \\ \gamma_{n+1}^2 & = \sigma_x^2(1-\rho^2) + \frac{\rho^2}{1/\sigma_\epsilon^2 + 1/\gamma_n^2} \end{cases} \tag{4}$$

, with initial values $m_0 = 0$ and $\gamma_0^2 = \sigma_x^2$.

2.2 Lifetime Values, Wages, and Vacancy Creation

Lifetime Value of Workers and Firms The worker's lifetime value is the sum of the lifetime labor income from wages and home production and the lifetime non-labor income from the lump-sum transfer. This subsection focuses on describing the lifetime labor income, leaving the description of the lifetime non-labor income to the next subsection. Let $E_{a,n}(m)$ be the lifetime labor income of the employed worker and $J_{a,n}(m)$ be the lifetime profit of the firm, given the worker's age a, tenure n, and the conditional mean quality m. Also, let U_a be the lifetime labor income of the unemployed worker with age a. Due to retirement, $E_{T,n}(m) = J_{T,n}(m) = U_T = 0$. The lifetime labor income of the unemployed worker of age $a = 0, \dots, T-1$ is recursively given by

$$U_a = b_a + \beta\left[U_{a+1} + p(\theta_a)\max\left\{E_{a+1,0}(0) - U_{a+1},\, 0\right\}\right]. \tag{5}$$

If the match were to continue and the wage w were to be paid in the period, the employed worker would achieve the value

$$\begin{aligned} \widehat{E}_{a,n}(m,w) &= w + \beta d_{a,n} U_{a+1} + \beta(1-d_{a,n}) \\ &\times \mathbb{E}\left[E_{a+1,n+1}(m_{n+1}) + \lambda p(\theta_a)\max\left\{E_{a+1,0}(0) - E_{a+1,n+1}(m_{n+1}),\, 0\right\}|m_n = m\right], \end{aligned} \tag{6}$$

while the firm would achieve the value

$$\begin{aligned} \widehat{J}_{a,n}(m,w) &= (f_{a,n} + m - w) + \beta\,(1-d_{a,n}) \\ &\times \mathbb{E}\left[(1 - \lambda p(\theta_a)\mathbb{I}\{E_{a+1,0}(0) > E_{a+1,n+1}(m_{n+1})\})\, J_{a+1,n+1}(m_{n+1})|m_n = m\right]. \end{aligned} \tag{7}$$

The wage is determined by a Nash bargaining in which disagreement point payoffs are U_a for the worker and $-c_{a,n}$ for the firm as in Mortensen and Pissarides (1999), and is characterized as the solution to

$$\begin{aligned} &\max_{w\in\mathbb{R}} \left(\widehat{E}_{a,n}(m,w) - U_a\right)^\phi \left(\widehat{J}_{a,n}(m,w) + c_{a,n}\right)^{1-\phi} \\ &s.t.\ \widehat{E}_{a,n}(m,w) \geq U_a,\ \ \widehat{J}_{a,n}(m,w) \geq -c_{a,n}, \end{aligned} \tag{8}$$

where $\phi \in (0,1)$ is the bargaining power of the worker. The solution $w^*_{a,n}(m)$ exists as long as the joint surplus $S_{a,n}(m) := \left(\widehat{E}_{a,n}(m,w) - U_a\right) + \widehat{J}_{a,n}(m,w)$ is greater than $-c_{a,n}$. In that case, the lifetime values are given by $E_{a,n}(m) = \widehat{E}_{a,n}(m, w^*_{a,n}(m))$ and $J_{a,n}(m) = \widehat{J}_{a,n}(m, w^*_{a,n}(m))$. If the solution does not exist, then the match breaks up: $E_{a,n}(m) = U_a$ and $J_{a,n}(m) = -c_{a,n}$. In both cases, the relationship among the worker's surplus and the firm's surplus, and the joint surplus is given by

$$(1-\phi)\left(E_{a,n}(m) - U_a\right) = \phi\left(J_{a,n}(m) + c_{a,n}\right), \tag{9}$$

$$E_{a,n}(m) - U_a = \phi \max\{S_{a,n}(m), -c_{a,n}\} + \phi c_{a,n}, \tag{10}$$

$$J_{a,n}(m) = (1-\phi)\max\left\{S_{a,n}(m),\, -c_{a,n}\right\} - \phi c_{a,n}. \tag{11}$$

Combining (5), (6), (7), and (9), the joint surplus $S_{a,n}(m)$ and the value of unemployment U_a are given by

$$\begin{aligned} S_{a,n}(m) = {} & (f_{a,n} + m - b_a) - \beta p(\theta_a)\max\left\{\phi S_{a+1,0}(0),\, 0\right\} + \beta\left(1 - d_{a,n}\right) \\ & \times \mathbb{E}\Bigg[(1 - \lambda p(\theta_a)\mathbb{I}\{E_{a+1,0}(0) > E_{a+1,n+1}(m_{n+1})\})\max\{S_{a+1,n+1}(m_{n+1}), -c_{a+1,n+1}\} \\ & + \lambda p(\theta_a)\mathbb{I}\{E_{a+1,0}(0) > E_{a+1,n+1}(m_{n+1})\}\phi S_{a+1,0}(0) | m_n = m\Bigg] \end{aligned} \tag{12}$$

$$U_a = b_a + \beta\left[U_{a+1} + p(\theta_a)\max\left\{\phi S_{a+1,0}(0),\, 0\right\}\right]. \tag{13}$$

Vacancy Posting and Wage Equation

Maintaining a vacancy for age a workers gives $\beta q(\theta_a) J_{a+1,0}(0) - \eta$. Note that the firm's gain from meeting does not depend on the worker's employment status because every worker negotiates the initial wage with the unemployment as an outside option. Also, note that every meeting results in a new employment relationship because only the worker who gains from being matched with the new firm decides to search. The firm posts the vacancy until the surplus is exhausted, so the equilibrium market tightness is given by

$$\theta_a = \begin{cases} q^{-1}\left(\dfrac{\eta}{\beta J_{a+1,0}(0)}\right) & \text{if } \beta J_{a+1,0}(0) > \eta \\ 0 & \text{otherwise} \end{cases}. \tag{14}$$

Combining (5), (6), (7), (9), and (14) yields the wage equation

$$\begin{aligned} & w^*_{a,n}(m) = \phi(f_{a,n} + m) + (1-\phi)b_a \\ & + \phi\eta\theta_a\left(\mathbb{I}\{E_{a+1,0}(0) > U_{a+1}\} - \lambda(1 - d_{a,n})Pr[E_{a+1,0}(0) > E_{a+1,n+1}(m_{n+1}) | m_n = m]\right) \\ & + \phi\left(c_{a,n} - \beta(1 - d_{a,n})\left(1 - \lambda p(\theta_a)Pr[E_{a+1,0}(0) > E_{a+1,n+1}(m_{n+1}) | m_n = m]\right) c_{a+1,n+1}\right). \end{aligned} \tag{15}$$

2.3 Flows of Workers

Let $u_{a,t}$ be the measure of unemployed workers with age a in period t. Also, let $e_{a,n,t}(\mathcal{M})$ be the measure of employed workers with age a, tenure n, and the belief about the match quality $m \in \mathcal{M}$ in period t. As the population of each cohort is 1, $u_{a,t} + \sum_{n=0}^{a} \int x_{a,n,t}(dm) = 1$.

The number of unemployed workers evolves as

$$u_{a+1,t+1} = (1 - p(\theta_a))\, u_{a,t} + \sum_{n=0}^{a} \Bigg[d_{a,n} + (1 - d_{a,n}) \times \\ (1 - \lambda p(\theta_a)) \int Pr[S_{a+1,n+1}(m_{n+1}) < -c_{a+1,n+1} | m_n = m] e_{a,n,t}(dm) \Bigg]. \quad (16)$$

The tax revenue per capita in period t, which is given back lump-sum to the workers, is

$$\ell_t = \frac{1}{T} \sum_{a=1}^{T-1} \sum_{n=1}^{a} (1 - d_{a,n})\, (1 - \lambda p(\theta_a)) \int Pr[S_{a,n}(m_n) < -c_{a,n} | m_{n-1} = m] e_{a-1,n-1,t-1}(dm), \quad (17)$$

and thus the lifetime non-labor income for the worker with age a is $L_{a,t} = \sum_{s=0}^{T-a-1} \beta^s \ell_{t+s}$.

The number of newly employed workers evolves as

$$e_{a+1,0,t+1}(\mathcal{M}) = \mathbb{I}\{0 \in \mathcal{M}\} \Bigg[p(\theta_a) u_{a,t} \\ + \lambda p(\theta_a)(1 - d_{a,n}) \int Pr[E_{a+1,0}(0) > E_{a+1,n+1}(m_{n+1}) | m_n = m] e_{a,n,t}(dm) \Bigg]. \quad (18)$$

Finally, the number of employed workers with tenure $n = 1, 2, \ldots, a$ is given by

$$e_{a+1,n+1,t+1}(\mathcal{M}) = (1 - d_{a,n}) \int \mathbb{E} \left[\mathbb{I} \left\{ S_{a+1,n+1}(m_{n+1}) < -c_{a+1,n+1} \right\} \right. \\ \left. \times (1 - \lambda p(\theta_a) \mathbb{I}\{E_{a+1,0}(0) > E_{a+1,n+1}(m_{n+1})\})\, \mathbb{I} \left\{ m_{n+1} \in \mathcal{M} \right\} | m_n = m \right] e_{a,n,t}(dm). \quad (19)$$

2.4 Discussion: Impact of Firing Cost on Firing, On-the-job Search, and Welfare

This subsection analyzes the determinants of firing decision by the firm and on-the-job search decision by the worker, in order to draw implications about the impact of firing cost on job-to-job transition, job-to-unemployment transition, and welfare. These implications are confirmed in Section 4 by the quantitative analysis of the calibrated model.

The firm fires the worker if the match quality is lower than the cutoff m_F with

$$S_{a+1,n+1}(m_F) = -c_{a+1,n+1},$$

which is a jointly optimal decision given the firm-worker match has no way of evading firing cost. The worker does on-the-job search if the match quality is lower than the cutoff m_S with

$$\begin{aligned} & E_{a+1,0}(0) && = E_{a+1,n}(m_S) \\ \Leftrightarrow\quad & S_{a+1,0}(0) && = S_{a+1,n+1}(m_S) + c_{a+1,n+1}, \end{aligned}$$

while the jointly optimal cutoff m_S^* for on-the-job search is given by

$$E_{a+1,0}(0) = S_{a+1,n}(m_S^*),$$

which is higher than the actual cutoff m_S if $c_{a+1,n+1} = 0$.

Job-to-job and job-to-unemployment transition probability depend on the level of cutoffs m_F and m_S as well as the measure of workers below cutoffs. As the firing cost increases, both cutoffs decrease, which results in the immediate decline of both job-to-job and job-to-unemployment transition. The decline of cutoff for firing is simply because it becomes more costly to fire workers, while that for on-the-job search is because workers can leverage higher firing cost to extract more surplus in the existing matches but not in the new matches. The decline of cutoffs eventually causes a downward shift of the match quality distribution, which results in the rebound of transition probabilities. These results imply that there is an immediate decline of both job-to-unemployment and job-to-job transition probability right after the increase of firing cost, while the decline is mitigated in the long run.

With no firing cost, the worker's on-the-job search decision is jointly suboptimal ($m_S > m_S^*$) for the firm-worker match. Since the cutoff m_S is decreasing in firing cost, sufficiently small firing cost brings m_S closer to the optimal level, which increases the joint surplus. On the other hand, firing cost reduces the joint surplus through its payment and the distortion of the cutoff m_F. The positive impact on the joint surplus through job-to-job transition and the negative impact through firing jointly imply ambiguous impact of the firing cost on the vacancy creation, which depends on $J_{a,0}(0) = \phi S_{a,0}(0)$.

According to (10) and (11), the increase of firing cost by $\Delta c_{a,n}$ increases the worker's lifetime labor income by $\phi \Delta c_{a,n}$, while decreasing the firm's lifetime value by the same amount. This effect is due to the change of the firm's threat point in the Nash bargaining, and it can be interpreted as the bargaining effect of the firing cost increase. Firing cost affects the joint surplus $\max\{S_{a,n}(m), -c_{a,n}\}$ as well, and the employed worker takes ϕ fraction of the change and the firm takes $1-\phi$ fraction of the change. Firing cost also affects the value of unemployment through the joint surplus of the new match $\max\{S_{a+1,0}(0), 0\}$,as in (13). These effects, which are associated with the change of the joint surplus of the firm-worker match, can be interpreted as the surplus effect of the firing cost increase.

3 Calibration of the Model

3.1 Data and Basic Strategy

To calibrate the model, I use the 1996 panel of Survey of Income and Program Participation (SIPP) provided by the US Census Bureau. I construct a panel data in which every individual i in period t has the observation of the employment status dummy D_{it} and the age a_{it}. If the individual is employed ($D_{it} = 1$), the observation also contains tenure n_{it}, the wage w_{it}, the job-destruction dummy EU_{it}, endogenous separation dummy N_{it}, and job-to-job transition dummy JJ_{it}. If the individual is unemployed, the observation contains the job-finding dummy UE_{it}.

The 1996 panel of SIPP is a 48-month panel with 4 rotation groups. The first group was surveyed from December 1995 to November 1999, while the last group was surveyed from March 1996 to February 2000. I restrict my sample to men who have high school degree and no further education at their first observations after their 20th birth-months, and do not enroll in school and own any business during the whole sample period. For each individual, I use the monthly observations in which he is between age 20 and 60, has a valid record of tenure if working, and has a job or is looking for work for at least one week in a month. As a result, I end up with 2,740 individuals and 116,410 person-month observations.

I assign the employment status to each individual based on the reported status of the first week of each month. I classify a person as employed ($D_{it} = 1$) if he reports having a job, either working, absent without pay, or on layoff without pay. If the person reports being without job, I classify him as unemployed ($D_{it} = 0$). I assign $JJ_{it} = 1$ when the person is continuously employed ($D_{it} = D_{i,t+1} = 1$) and changes his dominant employer between month t and $t+1$.[9] Following Menzio, Telyukova, and Visschers (2016), I identify the dominant employer of the person based on his monthly earning from the employers. I determine the tenure by the reported starting month of employment for the dominant employer. I use monthly earned income as the measure of wages. If the reported reason for separation of those who become unemployed ($D_{it} = 1$ and $D_{i,t+1} = 1$) is layoff, firing, slack work, or unsatisfactory work arrangements, which are likely to be driven by productivity shock and to be subject to firing cost associated

[9] Due to the well-known "seam bias" of SIPP, the transition rate is overstated across waves and understated within waves. I treat the data as repeated cross section except for identifying the transitions, so I essentially use 48-month averages of transition rates. As long as two biases cancel each other out, the seam bias would not affect my result.

with the experience-rated UI tax, I assign $N_{it} = 1$ and otherwise $N_{it} = 0$.[10] Tables 1 and 2 provide the descriptive statistics of the sample.

Given a parameter vector φ of the model, I solve for the steady state of the model and compute the job finding probability $g_{UE}(a;\varphi)$ of an unemployed worker with each age a in the model. I also compute a mean log wage $g_W(a,n;\varphi)$, an endogenous job destruction probability $g_N(a,n;\varphi)$, an exogenous job destruction probability $g_X(a,n;\varphi)$, a job-to-job transition probability $g_{JJ}(a,n;\varphi)$, and a staying probability $g_S(a,n;\varphi)$ for an employed worker with age a and tenure n. To estimate the parameter vector, I match the age-tenure profiles of the wage and the transition probabilities of the model with those of the sample. In particular, I assume the identification condition:

> *There exists a unique parameter vector φ_0 such that the conditional mean log wage is identical across the model and the population of the data up to location, i.e.*
>
> $$g_W(a,n;\varphi_0) + \nu = E[\log w_{it} | D_{it} = 1, a_{it} = a, n_{it} = n] \text{ for some } \nu,$$
>
> *and the conditional transition probabilities are identical across the model and the population of the data, i.e.*
>
> $$\begin{aligned} g_{JJ}(a,n;\varphi_0) &= Pr[D_{i,t+1} = 1,\ JJ_{it} = 1 | D_{it} = 1, a_{it} = a, n_{it} = n], \\ g_{JJ}(a,n;\varphi_0) &= Pr[D_{i,t+1} = 1,\ JJ_{it} = 0 | D_{it} = 1, a_{it} = a, n_{it} = n], \\ g_N(a,n;\varphi_0) &= Pr[D_{i,t+1} = 0,\ N_{it} = 1 | D_{it} = 1, a_{it} = a, n_{it} = n], \\ g_X(a,n;\varphi_0) &= Pr[D_{i,t+1} = 0,\ N_{it} = 0 | D_{it} = 1, a_{it} = a, n_{it} = n], \text{ and} \\ g_{UE}(a;\varphi_0) &= Pr[D_{i,t+1} = 0 | D_{it} = 0, a_{it} = a]. \end{aligned}$$

This identification condition does not exploit the age-tenure distribution and the unemployment rate, because the model is not rich enough to account for the demographic structure of the labor force.

The estimator for φ_0 maximizes the quasi-likelihood

$$\hat{\varphi} = \arg\max_{\varphi} \Bigg\{ \max_{(\nu,\xi)} \sum_{i,t} \omega_{it} \Big[D_{it} \log \ell^W(w_{it} | a_{it}, n_{it}; \varphi, \nu, \xi) \\ + D_{it} \log \ell^E(D_{i,t+1}, JJ_{it}, N_{it} | a_{it}, n_{it}; \varphi) + (1 - D_{it}) \log \ell^U(D_{i,t+1} | a_{it}; \varphi) \Big] \Bigg\},$$

[10] To be precise, endogenous separation includes layoff (24.8%), firing (9.7%), unsatisfactory work arrangements (9.3%), and slack work / business conditions (6.5%), and exogenous separation includes quit for other reasons (16.5%), quit to take another job (11.0%), temporary job (7.8%), illness/injury (5.5%), retirement (4.6%), bankrupt/acquisition (3.3%), and family obligations (1.0%).

where (ν, ξ) is the auxiliary parameter and ω_{it} is the population weight provided by the SIPP data. ℓ^W is the likelihood associated with the wage:

$$\ell(w_{it}|a_{it}, n_{it}; \varphi, \nu, \xi) = \begin{cases} \frac{1}{\sqrt{2\pi\xi^2}} \exp\left[-\frac{1}{2\xi^2}\left(\log w_{it} - g_W(a_{it}, n_{it}; \varphi) - \nu\right)^2\right] & \text{if } w_{it} \text{ is not missing} \\ 0 & \text{otherwise.} \end{cases}$$

ℓ^E is the likelihood associated with the transition of the employed workers:

$$\ell^E(D_{i,t+1}, JJ_{it}, N_{it}|a_{it}, n_{it}; \varphi) = \begin{cases} g_{JJ}(a_{it}, n_{it}; \varphi) & \text{if } D_{i,t+1} = 1 \text{ and } JJ_{it} = 1 \\ g_S(a_{it}, n_{it}; \varphi) & \text{if } D_{i,t+1} = 1 \text{ and } JJ_{it} = 1 \\ g_N(a_{it}, n_{it}; \varphi) & \text{if } D_{i,t+1} = 0 \text{ and } N_{it} = 1 \\ g_X(a_{it}, n_{it}; \varphi) & \text{if } D_{i,t+1} = 0 \text{ and } N_{it} = 0 \\ g_X(a_{it}, n_{it}; \varphi) + g_N(a_{it}, n_{it}; \varphi) & \text{if } D_{i,t+1} = 0 \text{ and } N_{it} \text{ is missing} \\ 0 & \text{if } D_{i,t+1} \text{ is missing.} \end{cases}$$

Finally, ℓ^U is the likelihood associated with the transition of the unemployed workers:

$$\ell^U(D_{i,t+1}|a_{it}; \varphi) = \begin{cases} g_{UE}(a_{it}; \varphi) & \text{if } D_{i,t+1} = 1 \\ 1 - g_{UE}(a_{it}; \varphi) & \text{if } D_{i,t+1} = 0 \\ 0 & \text{if } D_{i,t+1} \text{ is missing.} \end{cases}$$

Even though the identification condition only specifies the conditional mean function, it yields a consistent estimator for φ_0 given by the identification condition,[11] as long as the variables are missing completely at random.

3.2 Parameterization

Some parameters are determined outside of the estimation procedure. Table 3 summarizes those parameters. A unit period in the model is a month, and the number of periods in a worklife is $T = 44 \times 12$, assuming that the worker starts his worklife at age 18 and retires at age 62. The discount rate is $\beta = 0.996$, which corresponds to the annual interest rate of 5%. The payoff during unemployment is constant fraction of an output of a newly-employed worker at each age: $b_a = \tau f_{a,0}$, where I set $\tau = 0.71$ following Hall and Milgrom (2008). The matching function is $q(\theta) = (1 + \theta^\alpha)^{-1/\alpha}$ and $p(\theta) = \theta q(\theta)$, as suggested by den Haan, Ramey, and Watson (2000). I set $\alpha = 0.484$ to get the elasticity $\frac{d \log p(\theta)}{d \log \theta} = 0.5$ as in Hall and Milgrom (2008), when the monthly job

[11] The quasi-likelihood function specified here is the true likelihood if the sample is drawn from repeated cross section, and the log wage follows normal distribution and is independent from state transition given age and tenure. None of these assumptions is true, but I expect that this method gives the estimator of decent level of efficiency as long as quasi-likelihood is close to true likelihood.

finding probability of unemployed workers is 23.87% as in the data. The bargaining power of the worker is $\phi = 0.5$.[12]

Finally, I choose the firing cost profile $c_{a,n}$ accounting for the experience-rated UI tax. In the United States there are other sources of firing cost such as wrongful discharge laws, but they are difficult to quantify. Thus I consider the UI tax as the only source of firing cost. In most US states the government maintains an individual account for each employer from which the unemployment benefit is paid to its former employees. The balance of the account determines the unemployment insurance tax rate for the employer. The method to determine the tax rate varies by state, but its essential function is the same; the employer has to pay for a certain fraction of the unemployment benefit when it lays off its employees. The average duration of insured unemployment in 1996-2000 is around 14.5 weeks. Card and Levine (1994) estimates that in average a marginal dollar charged to the employer's account results in 68 cents loss for the employer in present value. Following Hall and Milgrom (2008), I assume the monthly benefit is 25% of an output of a newly-employed worker at each age. Given these, I conclude that the impact of the benefit claim to the employer is worth $\frac{14.5}{(30/7)} \cdot 0.68 \cdot 0.25 \approx 0.58$ months of an output of a newly-employed worker at each age. In the case of the short-term employment, the benefit charged to the employer's account is typically proportional to the earnings during the first four of the last five calendar quarters before the benefit claim. Accounting for these institutional features, I set

$$c_{a,n} = \begin{cases} 0 & n = 0, 1, 2 \\ \frac{n-3}{12} \cdot 0.58 f_{a,0} & n = 3, \ldots, 14 \\ 0.58 f_{a,0} & n = 15, \ldots, T. \end{cases} \tag{20}$$

The other parameters are estimated by the procedure suggested in the previous subsection using the 1996 panel of SIPP. I assume the functional form of

$$f_{a,n} = 1 + \mu_{a1}(a/T) + \mu_{a2}(a/T)^2 + \mu_{n1}(n/T) + \mu_{n2}(n/T)^2$$

for the age and tenure premium to the productivity and

$$d_{a,n} = \Phi\left(\delta_0 + \delta_1(a/T) + \delta_2(n/T)\right)$$

for the exogenous separation probability, where Φ is the cdf of the standard normal distribution. As a result, a vector of 12 parameters $\varphi = (\lambda, \eta, \rho, \sigma_x, \sigma_\epsilon, \mu_{a1}, \mu_{a2}, \mu_{n1}, \mu_{n2}, \delta_0, \delta_1, \delta_2)$ is estimated from the 1996 panel of SIPP. Table 4 reports the parameter estimates and the standard errors.

There is no one-to-one relationship between each parameter and each feature of the conditional mean functions, except for the parameters $(\delta_0, \delta_1, \delta_2)$ of the exogenous

[12] The match surplus is not equal to the social surplus in this model due to the presence of job-to-job transition, so the firm's vacancy creation is not socially optimal even though this choice appears to be in line with the Hosios (1990) condition.

separation probability, which are directly identified. Nevertheless, I provide a heuristic argument for the identification. The vacancy creation cost η corresponds to the level of the job finding rate. The efficiency of on-the-job search λ corresponds to the level of the job-job transition probability. The standard deviation of the match quality σ_x corresponds to the level of the endogenous separation hazard, including job-to-job transition and endogensous job destruction. The standard deviation of the signal σ_ϵ captures how fast the endogenous separation hazard decays over tenure. The persistence of the match quality ρ captures the endogenous separation hazard of the workers with long tenure; if $\rho = 1$, then the match quality is eventually learned perfectly and endogenous separation rate converges to zero. The parameters of the age/tenure premium to the output $(\mu_{a1}, \mu_{a2}, \mu_{n1}, \mu_{n2})$ corresponds to the age/tenure premium to the wage.

3.3 Evaluating the Fit of the Model

In order to evaluate how well the model fits the data, I provide a comparison of age profiles (Figure 2) and tenure profiles (Figure 3) of transition probabilities and mean log wage, as well as the average transition probabilities (Table 5) between the model and the data. The age and tenure profiles of outcomes in the data are fitted by quadratic splines with 80% joint confidence bands, while those in the model are given by averaging the age-tenure profiles in the model according to the age-tenure distribution in the data. For example, the age profile of job-to-job transition probability in the model is computed by $\sum_{n=0}^{a-1} g_{JJ}(a, n; \hat{\varphi})\hat{h}_{N|A}(n|a)$ for each $a = 0, \ldots, T-1$, where $\hat{h}_{N|A}$ is the estimate of the distribution of tenure given age in the data. Such a way of averaging is needed to make relevant comparisons between the model and the data, because the age-tenure distribution in the model is not matched with that in the data. Except for three parameters $(\delta_0, \delta_1, \delta_2)$ that are reserved for matching the exogenous separation probability, the model has only 9 parameters to match the age-tenure profiles of mean log wage, job destruction rate, job-to-job transition rate, and job finding rate. Given that the model is not flexible enough, the profiles in the model is surprisingly close to those observed in the data.

4 Quantitative Analysis of the Impact of Firing Cost

This section presents a result of a quantitative analysis which evaluates the impact of firing cost on various labor market outcomes. I consider a counterfactual experiment in which firing cost unexpectedly increases once and for all at the steady state of the calibrated model. I evaluate how labor market outcomes respond to this change immediately after the increase as well as in the new steady state. Throughout the analysis, the increase of firing cost is proportional to the re-employment output at each age. If the increase is given by $\Delta c_{a,n} = C \cdot f_{a,n}$ for the workers with age a and tenure $n > 0$, for example, I refer to this increase as "the increase of firing cost by C

months of re-employment output". Zero firing cost for newly employed workers is still maintained (i.e. $c_{a,0} = 0$). To see how the presence of job-to-job transition affects the nature of the impact, I evaluate the impact of firing cost in the economies with two different values of the efficiency of on-the-job search: the calibrated value ($\lambda = 0.556$), and a half of the calibrated value ($\lambda = 0.278$).

4.1 Overall Impact

Figure 4 presents the changes of job-to-job transition rate and employment-to-unemployment transition rate in response to the increase of firing cost, immediately after the increase as well as in the new steady state. Regardless of the efficiency of on-the-job search, both job-to-job and employment-to-unemployment transition decline immediately after the increase of firing cost. The reason why employment-to-unemployment transition rate declines is trivial; firing cost deters firing. The reason why job-to-job transition rate declines is that firing cost enables workers to extract more surplus in the existing matches but not in the new matches, which in turn discourages job-to-job transition. Both transition rates rebound in the long run, although the new steady state levels of them are still lower than the old steady state levels. This is because the match quality distribution shifts downward in the long run, as workers with lower match quality are retained without being fired or being poached by other firms.

Table 6, which presents decomposition of the impact, supports the interpretation above. In order to provide decomposition, I sequentially shift the match quality cutoffs defined in subsection 2.4., the labor market tightness, the match quality distribution given age and tenure, the tenure distribution given age, and the age distribution given employment status, from the original steady state levels to the new steady state levels after the increase of firing cost by a month of re-employment output. The cutoffs and the labor market tightness immediately change, which jointly form the immediate impact of firing cost increase, while the distribution of the match quality, tenure, and age gradually evolves into the new steady state distribution. The table shows that the immediate decline of job-to-job transition is mostly explained by the decline of the match quality cutoff below which workers do on-the-job search. The labor market tightness has only a small impact, according to the table. Moreover, the long-run rebound of job-to-job and employment-to-unemployment transition is indeed explained by the change of the match quality distribution, although the rebound is weaken by the effect of longer tenure.

Figure 5 shows the changes of job finding rate of unemployed workers and the expected lifetime income of age 18 workers. With smaller efficiency of on-the-job search ($\lambda = 0.278$), firing cost has negative impact on job finding rate and the worker's income, because firing cost reduces the match surplus by preventing the destruction of inefficient matches. On the other hand, at the calibrated level of efficiency of on-the-job search ($\lambda = 0.556$), firing cost has smaller negative impact on job finding rate and ambiguous impact on the worker's lifetime income. This is because job-to-job can resolve inefficient matches that have survived due to firing cost and small enough firing cost induces more efficient job-to-job transition, as discussed in subsection 2.4. Though not presented in the figure, firing cost has positive impact on job finding rate of unemployed workers of almost all ages, when the efficiency of on-the-job search is at $\lambda = 0.834$, which is 1.5 times larger than the calibrated value.

4.2 Impact on Expected Lifetime Income across Difference Age and Tenure

Figure 6 presents the change of the average expected lifetime income of workers at different age, immediately after the increase of firing cost by a month of re-employment output. The figure plots the within-age average of the bargaining effect as defined in subsection 2.4., as well as the overall effect of the firing cost increase on the expected lifetime income. The difference between the overall effect and the bargaining effect comes from the surplus effect as discussed in subsection 2.4. and the change of the lifetime non-labor income from lump-sum transfer. Since the bargaining effect works only through the wage increase in the current match, the welfare change of older employed workers, whose incomes are affected less by prospective employment relationship, is mostly explained by the distributional effect. The lifetime income of unemployed workers is not affected by the bargaining effect at all, because they cannot make use of better bargaining position for workers. Even though they can receive higher wages after they are employed and become protected by firing cost, their initial wage is adjusted down to exactly offset the gain from higher future wage. According to the figure, even with the uniform increase of firing cost, the change of the expected lifetime income is different across employment status and age groups. In particular, with smaller efficiency of on-the-job search ($\lambda = 0.278$), unemployed workers of most ages lose from the firing cost increase, while employed workers, especially older employed workers, still gain from the increase.

5 Conclusion

This paper has analyzed the impact of firing cost on labor market outcomes in the Mortensen and Pissarides (1994)-type search model with job-to-job transition and a lifecycle structure. Firing cost affects job-to-job transition through two channels. As the first channel, it reinforces the worker's bargaining position in existing matches, which reduces job-to-job transition. As the second channel, it deters the firm from resolving low quality matches by firing, which increases job-to-job transition because such low quality matches are resolved instead by job-to-job transition. In the calibrated model the first channel is dominant and firing cost has negative effect on job-to-job transition. This result can explain the empirical results of Sousa-Poza and Henneberger (2004) and Gielen and Tatsiramos (2012), which suggest the negative correlation between strictness of employment protection legislation and job-to-job transition among OECD countries. Firing cost affects job creation, also through two channels. As the first channel, it discourages job creation due to a prospect of inefficient job destruction and payment of firing cost. The presence of job-to-job transition mitigates this negative impact, since low quality matches can be resolved by job-to-job transition instead of firing. As the second channel, it facilitates job creation, because firing cost reduces inefficient job-to-job transition. This positive impact becomes more pronounced in a labor market with more frequent job-to-job transition. Combining these two channels, negative impact of firing cost on job creation in a labor market with less frequent job-to-job transition can be mitigated or even be reversed in a labor market with more frequent job-to-job transition. Firing cost affect the worker's welfare through the change of bargaining position, which affects the worker's wage temporarily and the change of the match surplus, which affects the worker's wage permanently. A temporary gain from the change of the bargaining position has a stronger impact on older employed workers, while a permanent gain or loss from the change of the match surplus has a stronger impact on unemployed workers and younger employed workers. As a result, the welfare impact of firing cost is uneven across age groups and employement status.

The assumptions on the labor market institution heavily affects the results of this study. In particular, the worker's ability to get higher wage by exploiting firing cost and the firm's inability to control the worker's on-the-job search are crucial assumptions for the negative impact of firing cost on job-to-job transition. If wage were not affected by firing cost, the worker's incentive for on-the-job search would not be affected by firing cost. If the firm were able to partially or completely control the worker's on-the-job search decision by offering a long-term contract or by responding to outside offers, the impact of firing cost on job-to-job transition would be weakened or eliminated. Questions such as what the economic theory predicts in other kinds of labor market institution, what kind of labor market institution can be empirically supported, and to what extent the prediction of the model of this study can be empirically supported, should be addressed by the future research.

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Table 1: Distribution of age, tenure, and log monthly wage

Variable	Obs.	Mean	St. Dev.	Min	1st Q	Median	3rd Q	Max
Age	116,410	39.05	10.06	20	32	39	47	59
Tenure (years)	112,657	9.08	9.08	0	1.83	5.83	13.92	41.83
Log Monthly Wage	112,657	7.65	0.69	0	7.34	7.71	8.06	12.49

Table 2: Employment status and state transition

Variable	Universe	Obs	Rate (%)
Unemployment	All	116,410	3.30
Job Finding	Unemployed	3,737	23.87
Job-to-Job Transition	Employed	110,283	1.99
Job Destruction	Employed	110,283	0.86
Endogenous Separation	Job Destruction	648	50.22

Table 3: Predetermined parameters

	Description	Value
T	# of months in worklife	528
β	discount factor	0.996
τ	unemployment payoff	0.710
α	shape of matching function	0.484
ϕ	bargaining power of workers	0.500
$c_{a,n}$	firing cost function	see eq. (20)

Table 4: Estimated parameters

	Description	Value	(s.e.)
λ	efficiency of on-the-job search	0.556	(0.092)
η	vacancy creation cost	0.916	(0.012)
ρ	persistence of match quality	0.987	(0.007)
σ_x	s.d. of match quality	0.916	(0.067)
σ_ϵ	s.d. of signal on quality	2.306	(0.020)
μ_{a1}	age coefficient for output	1.876	(0.037)
μ_{a2}	age^2 coefficient for output	-0.829	(0.101)
μ_{n1}	tenure coefficient for output	0.963	(0.015)
μ_{n2}	tenure^2 coefficient for output	-1.108	(0.011)
δ_0	exogenous separation level	-2.474	(0.046)
δ_1	age effect on separation	-0.362	(0.050)
δ_2	tenure effect on separation	-0.268	(0.111)

Note: The standard errors are misspecification-robust, clustered standard error of the maximum likelihood estimation.

Table 5: Average monthly transition rates (%)

Variable	Data (s.e.)	Model	
		(1)	(2)
Job Finding	23.87 (1.07)	22.71	22.02
Job-to-Job Transition	1.99 (0.06)	1.82	2.35
Job Destruction	0.86 (0.04)	0.95	1.39

Note: The column (1) of the "Model" section shows the average with respect to the empirical age-tenure distribution given by the data, while the column (2) shows the average with respect to the steady state age-tenure distribution derived from the model. Since transition rates given age and tenure is matched, the column (1) is supposed to fit the data. The standard errors are robust to within-individual correlation.

Table 6: Decomposition of impact of firing cost increase on transition probabilities (%)

	λ: calibrated value (0.556)			λ: 1/2 of calibrated value		
	JtoJ	EtoU	UtoE	JtoJ	EtoU	UtoE
Cutoff shift	-0.49	-0.49	-	-0.25	-0.51	-
Tightness change	-0.00	0.00	-0.09	-0.01	0.00	-0.25
Quality distribution	0.31	0.11	-	0.16	0.20	-
Tenure distribution	-0.14	-0.06	-	-0.06	-0.09	-
Age distribution	0.00	0.00	-0.11	0.00	0.00	-0.02
Total	-0.32	-0.43	-0.20	-0.16	-0.40	-0.28

Note: Increase of firing cost is equivalent to a month of re-employment productivity. The sum of (Cutoff shift) and (Tightness change) corresponds to the immediate impact.

Figure 1: Timeline of events and decisions

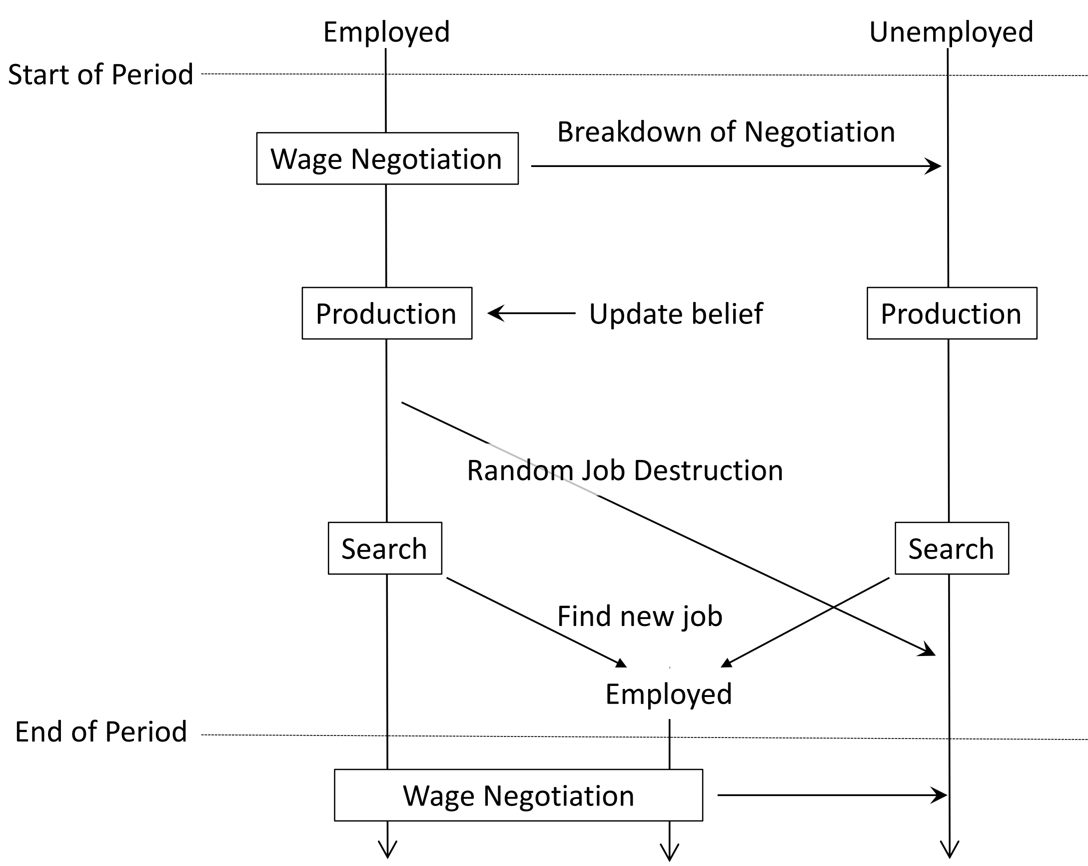
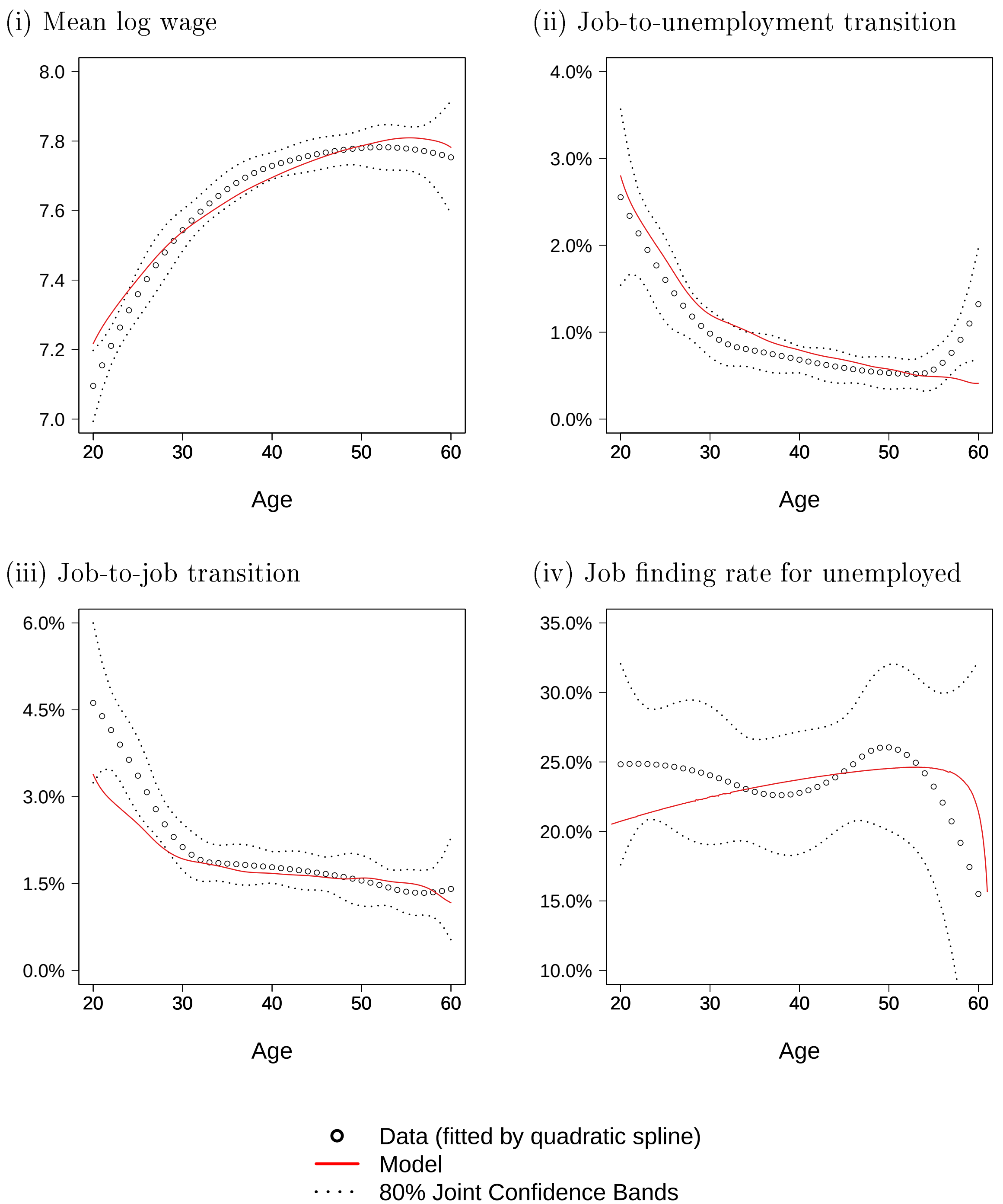
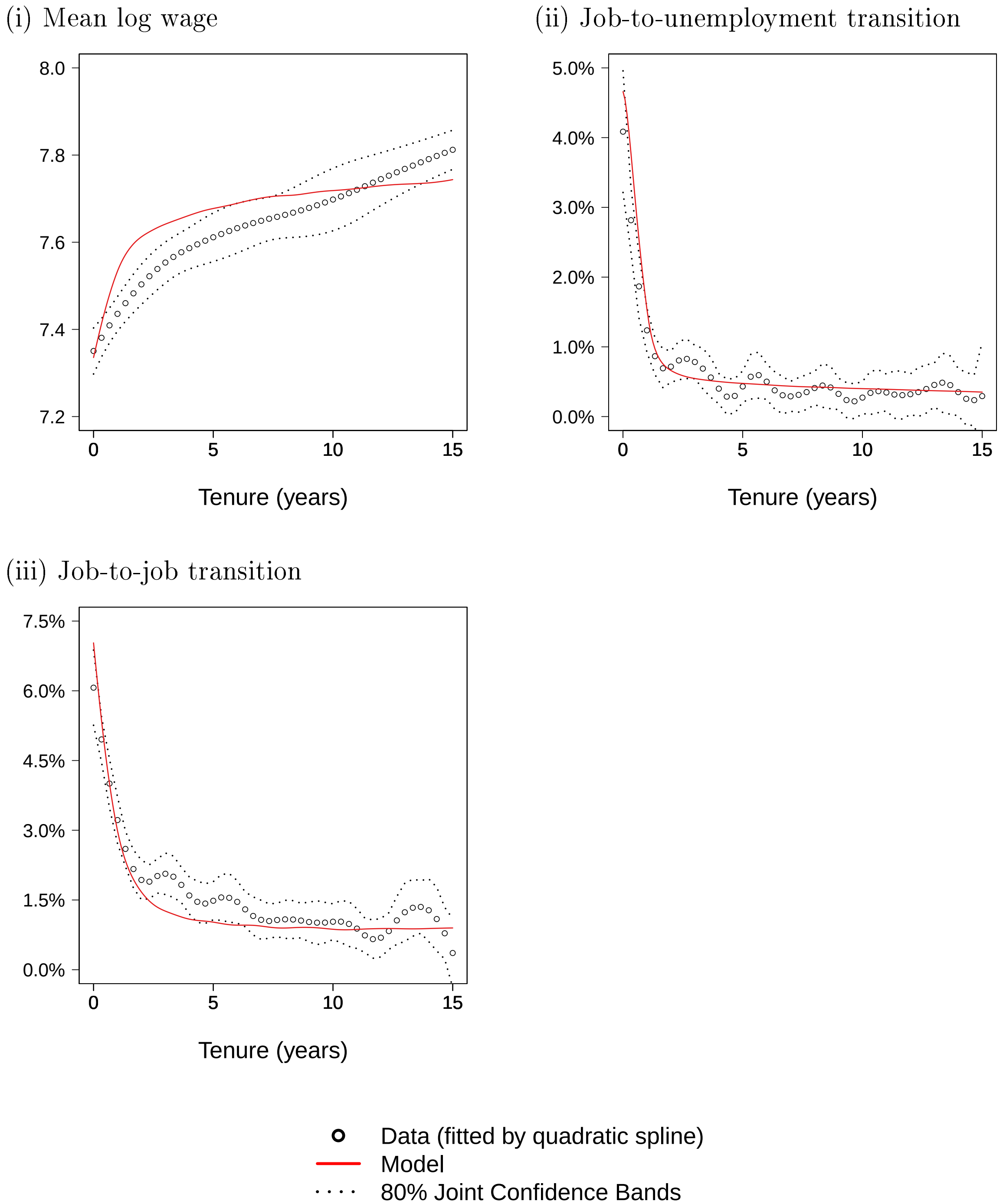


Figure 2: Monthly transition probabilities and log wage across age, tenure-averaged



Note: The age profiles of outcomes in the model is given by averaging the age-tenure profiles in the model using the distribution of tenure given age in the data. Such a way of averaging is needed to make relevant comparisons between the model and the data, because the age-tenure distribution in the model is not matched with that in the data. 80% joint confidence bands are constructed using the quadratic spline fits of the data.

Figure 3: Monthly transition probabilities and log wage across tenure, age-averaged

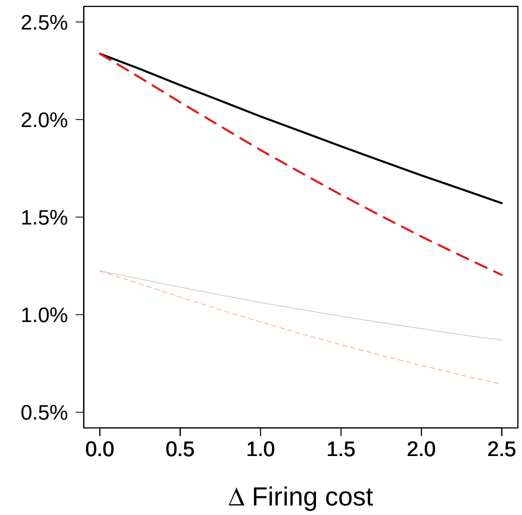


Note: The age profiles of outcomes of the model is given by averaging the age-tenure profile of the model using the empirical distribution of age given tenure. Such a way of averaging is needed to make relevant comparisons between the model and the data, because the age-tenure distribution in the model is not matched with that in the data. 80% joint confidence bands are constructed using the quadratic spline fits of the data.

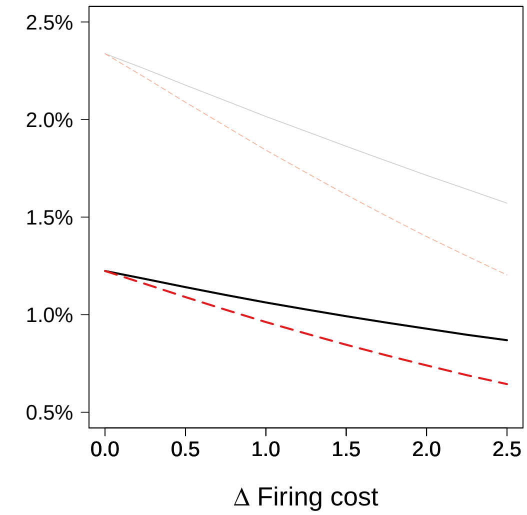
Figure 4: Impact of firing cost increase, with different efficiency (λ) of on-the-job search

(i) Job-to-job transition (monthly rate)

(a) λ: calibrated value (0.556)

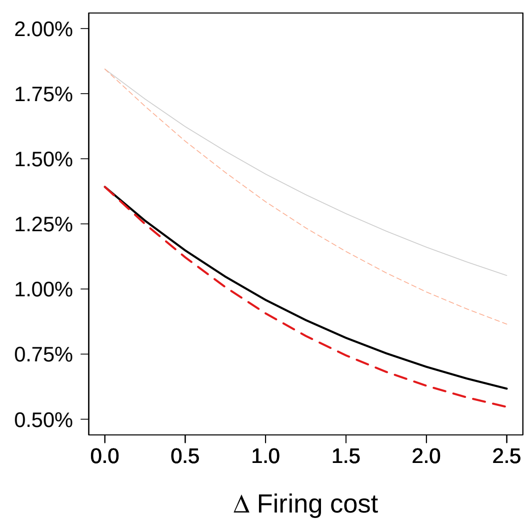


(b) λ: 1/2 of calibrated value (0.278)

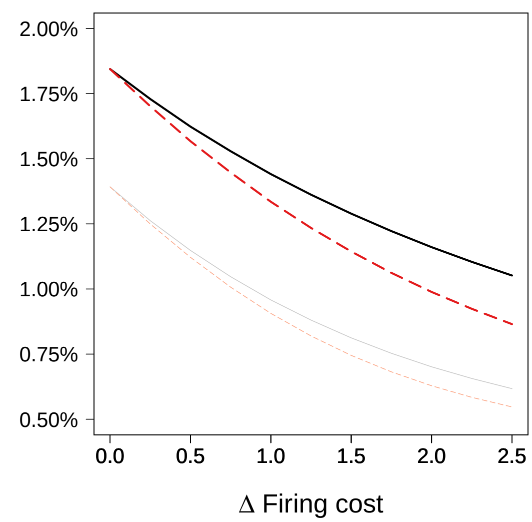


(ii) Job-to-unemployment transition (monthly rate)

(a) λ: calibrated value (0.556)



(b) λ: 1/2 of calibrated value (0.278)



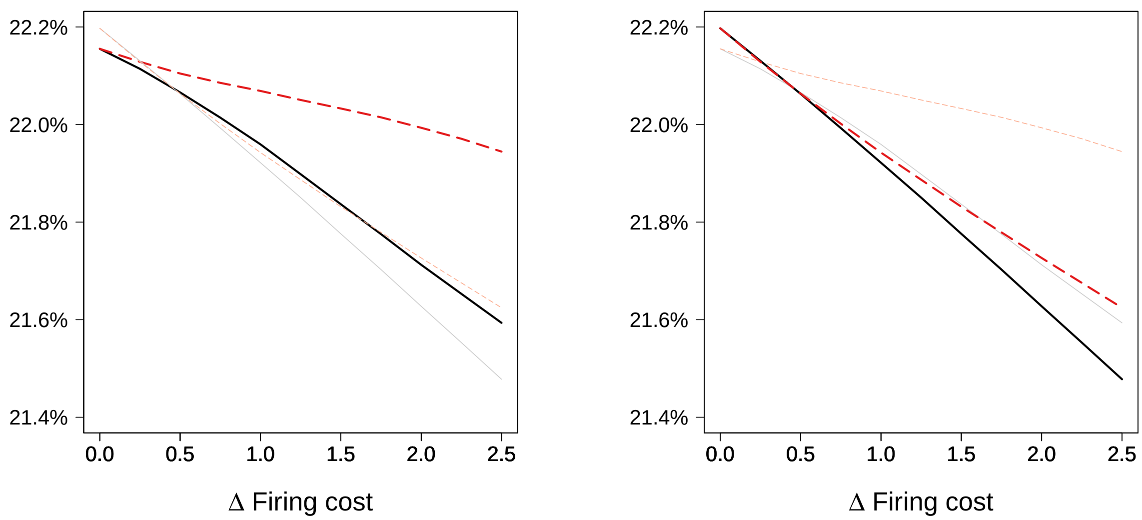
New steady state   Immediately after increase

Note: The increase of firing cost is measured in terms of monthly output of newly employed worker at each age.

Figure 5: Impact of firing cost increase, with different efficiency (λ) of on-the-job search

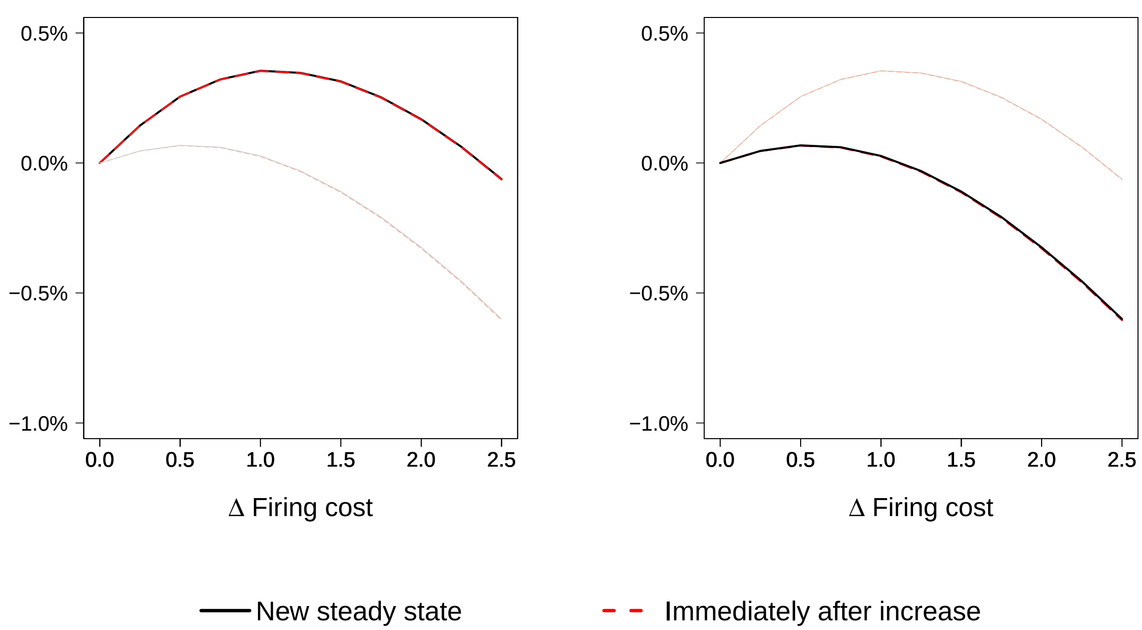
(iii) Monthly job finding rate of unemployed workers

(a) λ: calibrated value (0.556) (b) λ: 1/2 of calibrated value (0.278)



(iv) Expected lifetime income of age 18 workers (% change from original value)

(a) λ: calibrated value (0.556) (b) λ: 1/2 of calibrated value (0.278)

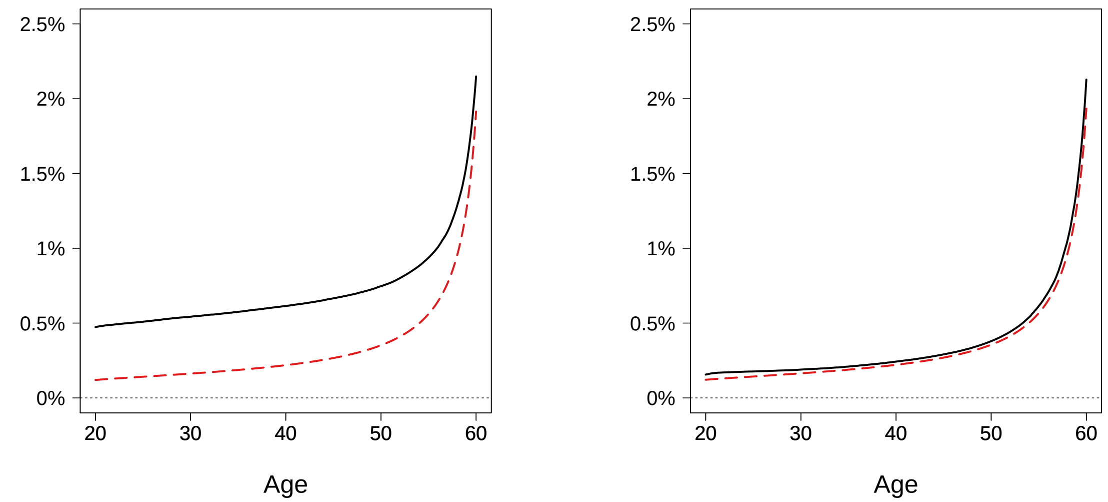


Note: The change of firing cost is measured in terms of monthly output of newly employed worker at each age.

Figure 6: Impact of firing cost increase on lifetime income, evaluated right after the increase (% change from the original level)

(i) Impact on employed workers with different ages

(a) λ: calibrated value (0.556) (b) λ: 1/2 of calibrated value (0.278)



(ii) Impact on unemployed workers with different ages

(a) λ: calibrated value (0.556) (b) λ: 1/2 of calibrated value (0.278)