# An Evaluation of Optimal Unemployment Insurance Using Two Natural Experiments

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**Abstract**

This paper identifies the liquidity and moral hazard effects of unemployment insurance (UI) using two policy changes in Taiwan: the introduction of a reemployment bonus program and a benefit extension for workers aged at least 45. The reemployment bonus counteracts the moral hazard effect of unemployment insurance without providing additional liquidity during unemployment. The benefits extension, however, increases workers' ability to smooth consumption when unemployed at the cost of distortion to search. Using the variation in the bonus offer around the time the bonus was introduced and the age discontinuity in the eligibility for extended benefits, we separately identify the moral hazard effect and the liquidity effect of UI. We estimate that the liquidity effect accounts for 65% of the duration response to extended benefits for workers aged around 45, and it is welfare enhancing to increase the potential benefit duration.

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# 1 Introduction

Unemployment insurance (UI) protects individuals against the risk of earnings loss during unemployment, but it also distorts incentives to search for jobs. The disincentive effect of UI, measured by the elasticity of unemployment duration to unemployment benefits, has been estimated across a wide variety of UI contexts.[1] The consumption smoothing benefits, however, are difficult to estimate due to the quality of data on consumption. Chetty (2008) addresses this by showing that more generous UI decreases workers' search effort through two distinct channels: a moral hazard effect and a liquidity effect. On the one hand, the moral hazard effect increases the opportunity cost of being employed and distorts workers' incentive to find a job. On the other hand, the liquidity effect increases workers' ability to smooth consumption during unemployment and allows them more time to search for a job. Empirically, however, only a few papers (Chetty, 2008; Card et al., 2007; Landais, 2015) distinguish the liquidity effect from the moral hazard effect of UI because the variation in unemployment benefits confounds these two sources of variation.

Our approach to evaluating optimal UI exploits two distinct policy changes in Taiwan, the 2003 introduction of a reemployment bonus program and the 2009 UI extension for older workers. In 2003, Taiwan introduced reemployment bonuses, in which people would be paid 50% of their remaining unemployment benefits after they were reemployed. Additionally, starting in 2009, workers aged 45 or more became eligible for 9 months of UI instead of the 6 months for those under age 45. Following Chetty (2008), we use a search model with borrowing constraints to demonstrate that the effect of extended benefits on job finding rate is a combination of a liquidity effect and a moral hazard effect. By contrast, the effect of a reemployment bonus identifies the moral hazard effect of extended benefits because the bonus increases the opportunity cost of being unemployed without increasing workers' income during unemployment. Therefore, we can recover the liquidity effect as long as we are able to provide credible estimates of the labor supply responses to the UI extension and

[1] Schmieder and von Wachter (2016) provides an excellent survey of the literature on the effects of unemployment benefits on unemployment duration, reemployment wages, and welfare.

reemployment bonus.

To estimate the effects of extended benefits, we exploit the discontinuous function of the eligibility rule for extended benefits—workers aged at least 45 at job loss are eligible for 9 months of benefits, rather than 6 months for those under 45. Since the eligibility rule in Taiwan depends on the age at job loss instead of the age when claiming benefits, it is unlikely workers can manipulate the age cutoff. Indeed, we observe that workers around age 45 at job loss are similar to each other in terms of their predetermined characteristics, so we can isolate the effect of extended benefits by comparing workers aged just below and above 45 at job loss. Our estimates using the regression discontinuity (RD) design show that a three-month increase in potential duration increases insured duration by 57 days, nonemployment duration by 41 dyas, and reduced monthly reemployment hazard by 1.7 percentage points for UI recipients aged around 45 at job loss.

The RD estimates, while internal valid, are a combination of a liquidity and a moral hazard effects. To understand the relative importance of these two effects, we estimate the effect of reemployment bonuses. Since the reemployment bonus program reached back to UI recipients who were receiving benefits when the program took effect in 2003, it results in two kinks in the bonus offer that workers are eligible for as a function of the date UI spells started. Our estimates using the regression kink (RK) design (Nielsen et al., 2010; Card et al., 2015) show that eligibility for the bonus program increase the monthly reemployment hazard by about 2 percentage points for UI recipients aged between 35 and 50 at job loss.

The decomposition formula, together with the reduced-form estimates, suggests that, for workers aged around 45, the liquidity effect accounts for 65% of the increased unemployment duration caused by the benefit extension. Based on Baily (1978) and Chetty (2008), we derive the welfare effects of the benefits extension—the optimal potential duration depends on the tradeoff of expected consumption smoothing benefits at the exhaustion point and the utility loss when employed due to the increased tax payment. Our estimated consumption smoothing benefits of extended benefits are larger than the cost of extended benefits, suggesting it is welfare enhancing to increase potential duration.

The outline of this paper is as follows. In Section 2, we review the related literature. In Section 3, we present our theoretical framework for welfare analysis. In Section 4, we describe the Taiwanese UI system and the administrative data. In Section 5 and Section 6, we estimate the effects of extended benefits and the effects of reemployment bonus on labor market outcomes. In Section 7, we plug the reduced-form estimates into the model to obtain the welfare effects of extended benefits. Section 8 summarizes the findings and discuss possible extension to this paper.

## 2 Literature Review

Our study closely relates to the literature on optimal UI design. There are two approaches in the literature: the structural approach and the sufficient statistic approach. The structural approach estimates or calibrates all model parameters and simulate the effects of changes in UI policies. However, it is hard to identify all the parameters in the models without making strong assumptions. The sufficient statistic approach boils down the welfare effects of UI to two parameters: the consumption smoothing benefits of UI and the elasticity of unemployment duration to UI generosity.[2]

There have been many convincing studies estimating the effects of UI on unemployment duration, but the empirical evidence on consumption smoothing benefits of UI is much less due to the availability and quality of consumption data. Gruber (1998) used panel data from Panel Study of Income Dynamics and state variation in UI replacement rate. Gruber (1998)'s estimates suggests a 10% increase in the replacement rate reduce the consumption drop during unemployment by 2.8%. However, Gruber (1998)'s estimates are imprecise and the estimated consumption smoothing benefits are sensitive to risk aversion coefficient.

[2]See Chetty (2009) and Chetty and Finkelstein (2013) for comparisons of the structural approach to the sufficient statistic approach.

Chetty (2008) and Landais (2015) circumvent issues with estimation of risk aversion coefficient using the sufficient statistic approach—the consumption smoothing benefits equals the ratio of the liquidity effect to the moral hazard effect of UI.[3] Chetty (2008) estimates the liquidity effect by estimating the behavioral response to severance pay. Landais (2015) uses the difference in the behavioral response to extended benefits and an increases in benefit level to identify the moral hazard, which identifies the liquidity effect indirectly. Their estimates suggest the liquidity effects explains about half of the effect of UI on unemployment duration can be attributed to the liquidity effect, suggesting significant consumption smoothing benefits of UI.

As Schmieder et al. (2016) pointed out, although there is some evidence on the consumption smoothing benefits of increasing benefit replacement rate, empirical evidence on the consumption smoothing benefits of extended benefits. An exception is Ganong and Noel (2017) who used bank account data to investigate the consumer spending during the course of unemployment. Ganong and Noel (2017)'s estimates suggest the consumption smoothing benefits from a benefits extension is at least three times larger than that from from an increased replacement rate.[4] This paper complements Ganong and Noel (2017)'s estimates using sufficient statistic approach. We explain our approach in the next section.

# 3 Theoretical Framework

In this Section, we use a simple search model to show that the effect of extended benefits on the timing of reemployment can be decomposed into a liquidity effect and a moral hazard effect, which can be identified using the effect of the reemployment bonus. Then, we show the labor supply response to extended benefits and that to the bonus are sufficient to identify the welfare effect of UI extension. Here, we focus on the intuition and leave the derivations

[3]Another approach is to use the reservation wage response to infer the welfare effects of UI (Shimer and Werning (2007)).

[4]Landais (2015) estimates the welfare effects of increasing benefit level and potential duration by assuming the consumption smoothing gain of these two policies are the same.

to the Appendix 11.1.

### 3.1 Moral Hazard versus Liquidity Effects of Extended Benefits

The discrete-time search model with borrowing constraints we use in this paper comes from Chetty (2008). Since we focus on the effects of extended benefits rather than the effects of increasing benefit level analyzed in Chetty (2008), we also consider Landais (2015)'s extension to Chetty (2008)'s model when deriving the effects of extended benefits.

The only difference between our model and the model in Chetty (2008) and Landais (2015) is that we incorporate Taiwan's reemployment bonus into the model. A worker reemployed before running out of benefits receives a reemployment bonus, $r_t$, equal to $\theta$ percent of the remaining benefits; otherwise, $r_t = 0$. Formally,

$$r_t = \theta \cdot \sum_{k=t}^{P-1} b_k, 0 < \theta < 1$$

For $t \leq P$, the effect of extended benefits on search intensity at time $t$ can be written as

$$\frac{\partial s_t}{\partial P} = b\frac{\partial s_t}{\partial A_t} - b(1-\theta)S_{t+1}(P)\frac{\partial s_t}{\partial w_t}; \forall t \leq P \tag{1}$$

where $S_{t+1}(P) = (1 - s_{t+1})..(1 - s_P)$ is the survival rate in period $P$ conditional on being unemployed in period $t+1$. The effect of extended benefits on search intensity is a combination of the liquidity effect ($\frac{\partial s_t}{\partial A_t}$) and the moral hazard effect ($-\frac{\partial s_t}{\partial w_t}$). On the one hand, the liquidity effect of UI increases workers' ability to smooth consumption during unemployment, allowing them more time to search for a job, so the liquidity effect is welfare increasing. On the other hand, the moral hazard effect is distortionary because it decreases workers' net wages, which decreases the incentive to search. Therefore, the relative importance of the liquidity effect and the moral hazard effect identifies the consumption smoothing benefits of a benefit extension.[5]

[5]The formula also shows the reemployment bonus counteracts the moral hazard effect by offering $\theta$ remaining benefits for workers reemployed before exhaustion point, suggesting the benefit extension in the UI with the reemployment bonus will not increases unemployment duration as much as extending potential

Empirically, to separate the effect of the liquidity effect from the moral hazard effect, we have to estimate at least any two of $\frac{\partial s_t}{\partial P}$, $\frac{\partial s_t}{\partial w_t}$, and $\frac{\partial s_t}{\partial A_t}$. We can identify the total effect of extended benefits by exploiting the age discontinuity in the eligibility rule, but we neither have information on the asset amount nor exogenous variation in wage offer.

To address this, we recognize that the variation in the wage rate and that in the bonus offer affect the search intensity in the same way, so that $\frac{\partial s_t}{\partial w_t} = \frac{\partial s_t}{\partial r_t}$. Since the introduction of the bonus program provides credible exogenous variation for identifying $\frac{\partial s_t}{\partial r_t}$, we can recover $\frac{\partial s_t}{\partial A_t}$ indirectly.

## 3.2 Welfare Effect of Extended Benefits

The social planner chooses the potential benefit duration ($P$) to maximize the expected utility of a job loser at the beginning of period 0 subject to the worker's optimal search behavior and government budget constraint, $Bb + (P - B)\theta b = (T - D)\tau$, where $B$ and $D$ are insured duration and nonemployment duration, respectively. The welfare effect of a balanced-budget increase in unemployment benefits at time $P$ is

$$\frac{dW_0^*}{db_P} = \frac{dW_0}{db_P}/u'(c_P^e) = S_0(P)R_P - \{(1-\theta)\sum_{t=0}^{P-1}\frac{dS_0(t)}{dP} + \tau \cdot \frac{dD}{dP}\} \tag{2}$$

where $\sum_{t=0}^{P-1}\frac{dS_0(t)}{dP}$ is the increase in duration due to reduced search effort before the exhaustion point and $R_P = -\frac{\partial s_P}{\partial A_P}/\frac{\partial s_P}{\partial r_P}$ is the ratio of liquidity effect to moral hazard effect at time $P$. The welfare effect of UI extension balances the utility gain from the increased ability to maintain consumption during unemployment, and the utility loss due to higher taxes levied on employment. On the one hand, the benefits of extended benefits are determined by the product of the exhaustion rate and the marginal utility gain of redistributing income from when workers are employed to income when unemployed. This product will be large for individuals who are liquidity constrained at the exhaustion point and for individuals

without the bonus. This prediction is consistent with Davidson and Woodbury (1991)'s findings that bonus reduce insured duration more for workers eligible for longer potential duration.

whose unemployment duration is long. On the other hand, the tax rate rises because the UI extension increases the insured and nonemployment durations of unemployment, implying a shorter employment duration with which to finance increased benefits.

# 4 Institutional Backgraound and Data

## 4.1 Unemployment Insurance in Taiwan

Unemployment benefits in Taiwan form one part of the overall employment insurance program, which is a mandatory national program that offers unemployment benefits, reemployment bonuses, vocational training living allowances, parental leave allowances and national health insurance premium subsidies. It covers all Taiwanese workers, excluding civil servants and the self-employed. It is financed by 1% of the monthly insured wage: 20% is imposed on workers, 70% on employers, and the government pays the remaining 10%.

To be eligible for unemployment benefits, individuals aged 15 to 65 who lose their jobs must have at least one year of employment history in the three years prior to the job loss.[6] To receive the first month's benefits, a claimant must register with the government employment service and complete a 14-day waiting period. If the worker does not find a job by the end of the waiting period, the insured period begins (up to the maximum duration of benefits the claimant is entitled to). Since 2009, the maximum duration of benefits has been 6 months for workers aged below 45 at the time of job loss, and 9 months for those aged 45 or older when they lost their job.[7]

[6]Only workers losing their jobs involuntarily or due to the ending of a fixed term contract are eligible. According to Employment Insurance Act and Labor Standard Act, involuntary separation from employment refers to separation from employment because the insured unit has closed down, relocated, suspended business, dissolved, filed bankruptcy, or business cycle induced layoff and downsizing. Employment history is the number of days for which a worker has been enrolled in the employment insurance. Since part-time workers must be insured according to the Employment Insurance Act, history as a part-time worker is included when determining eligibility.

[7]There is only one exception: UI recipients who hold disability cards are eligible for nine months of benefits regardless of their age at the time of job loss. However, few UI recipients are disability card holders; our data showed that only 0.8% of workers younger than 45 received unemployment benefits for longer than six months during our study period.

Unlike in the United States, where benefits are paid weekly, unemployed workers in Taiwan claim benefits on a monthly basis. The Bureau of Labor Insurance treats one month as a period of 30 days. If a worker is reemployed before the end of a given 30-day interval, the amount of benefits paid in that month is prorated. The monthly UI benefits replace 60% of the average insured wage during the six months prior to job loss[8] for those without non-working dependents. For UI recipients with non-working dependents the replacement rate is increased, and can reach as high as 80% depending on the number of dependents.

Workers are required to actively search for a job while receiving benefits. Specifically, they have to list at least two job contacts for each continued claim. In general, this work search test plays the role of the stick, promoting rapid employment via undesirable consequences. The other strategy is the carrot: Taiwan's UI program offers a generous financial incentive to workers who return to work quickly. This incentive, which takes the form of a reemployment bonus, offers 50% of any remaining unemployment benefits to UI recipients who find jobs before the end of their eligibility period, and who then accumulate at least three months of employment history after reemployment. The three months of reemployment does not have to be continuous, or with a single employer. A person who worked for multiple employers for three months after reemployment would also qualify for the bonus.[9]

## 4.2 Data and Sample

We use two sources of data from the Taiwanese Bureau of Labor Insurance: the administrative unemployment benefits files and the employment insurance enrollee file (earnings records) dating from January 1999 to December 2013. Each entry in the unemployment benefits file represents one beneficiary case, and contains each UI recipient's date of birth, date of job loss, first and last date of benefit receipt, average previous insured earnings in

[8] This refers to the last six months for which a worker was enrolled in employment insurance prior to their job loss.

[9] The three months reemployment period does not include recalls (the work experience in the firm prior to layoff).

the six months prior to layoff (hereafter, previous earnings), an individual identifier, and some demographic information, including gender, number of dependents, place of birth, and a four-digit code indicating the recipient's previous occupation. Using the unemployment benefits file alone, we can create a dataset in which each observation represents one UI spell, containing information on the UI recipient's exact age at job loss and the insured duration of each period of unemployment, which is the total number of days for which a worker received unemployment benefits while unemployed.

We match the unemployment benefits records to the earnings records corresponding to each UI spell to construct a dataset of reemployment outcomes. In the earnings records, each entry represents a change in the employment record, such as new enrollments in employment insurance, cancellations of employment insurance (job separation), or wage changes. Using the matched dataset, we define the nonemployment duration as the total number of days from the start of receiving unemployment benefits to the next registered date of employment. UI recipients not observed to have been reemployed during our sample period were deemed to have either failed to find a job, become self-employed, or dropped out of the labor force altogether. We capped nonemployment duration at 730 days.

We impose three sample restrictions on our extended benefits sample. First, since the benefits extension took effect on May 1, 2009, we drop any UI spell starting before that date. Second, we exclude UI spells starting after January 1, 2012; since our data ends in December 2013, any nonemployment periods for those UI spells would have a maximum potential duration shorter than 730 days. Third, we focus on workers around the age 45 cutoff. Column 1 of Table 1 reports the summary statistics for the UI recipients aged 25-65 during the study period. This is the sample we use to choose the optimal bandwidths in the RD design. The baseline RD sample is comprised of workers aged 43-46 at time of job loss, shown in Column 2 of Table 1. The exhaustion rate for workers around age 45 is high, and their nonemployment duration is on average longer than 180 days, suggesting a substantial amount of workers do not find employment after exhausting their benefits.

The reemployment bonus sample contains 228,095 UI spells initiated between January 1, 2001 and December 31, 2004. Table 2 reports the summary statistics. We break the sample into three samples separated by two dates, July 5, 2002 and January 1, 2003. The insured duration and nonemployment duration both decrease over calendar time, which might be partly because the labor market conditions improved over time and partly because the bonus program was introduced in the beginning of 2003.

# 5 Effects of Extended Benefits

## 5.1 Regression Discontinuity Design

To estimate the effects of extended benefits, consider the following RD design in a regression framework:

$$y_i = \alpha + \beta_{EB} Age45_i + f(a_i) + v_i, \tag{3}$$

where $y_i$ is an outcome variable that includes insured duration, nonemployment duration, and reemployment hazard. $Age45_i$ indicates that a UI recipient was at least 45 years old at the time of job loss, and $a_i$ is the worker's age at job loss. $\beta_{EB}$ is the coefficient of interest, capturing the effects of a three-month increase in potential duration. The key identification assumption here is that the outcome variables should evolve smoothly over the cutoff in the absence of extended benefits. Note that $Age45_i$ depends solely on $a_i$. If the effects of age at job loss are adequately controlled by $f(a_i)$, such that $E(v_i|a_i) = 0$, $\beta_{EB}$ will identify the effects of the extended benefits. For our baseline results, we estimate the equation using a sample of workers aged 43-46 at time of job loss, and consider $f(a_i)$ to be a linear function interacting with the extended benefits dummy. Specifically,

$$f(a_i) = (1 - Age45_i)[\pi_0(a_i - 45)] + Age45_i[\pi_1(a_i - 45)]. \tag{4}$$

Using UI recipients aged 43-46 at time of layoff as the estimation sample was an arbitrary choice, so we also calculate RD estimates using the optimal bandwidth proposed by Calonico et al. (2014). The optimal bandwidth minimizes the mean square error (MSE) of the RD estimator (Imbens and Kalyanaraman (2012)). However, Calonico et al. (2014) points out that the MSE optimal bandwidth selector chooses a bandwidth that is too large to ensure an unbiased estimate. Although conventional bias correction method removes the bias, it introduces additional variability when estimating the bias. Calonico et al. (2014)'s robust standard error take this added variability into accounts. We therefore report the robust standard errors when using bias-correction estimates.

To estimate the effect on the reemployment hazard, we follow each spell from the date of initial claim to the next registered date of formal employment. Let $d$ represents day $d$ in the nonemployment spell. We group the data into 30-day intervals and define the monthly hazard rate as the probability of being reemployed during the 30-day interval $(d, d+30]$, given that an individual has not been reemployed at the start of $d$. Let $D$ represents nonemployment duration. The hazard rate of reemployment, $h_d$, is

$$h_d = P(D \leq d + 30 | D > d).$$

We specify the reemployment hazard as a linear function of the eligibility for extended benefits:

$$h_{id} = \alpha + \beta_{EB} Age45_i + f(a_i), \tag{5}$$

where $h_{id}$ is the job finding rate on day $d$ for worker $i$ given that she has not yet been reemployed. $\beta_{EB}$ captures the effect of the extended benefits on monthly job finding rate in a nonemployment spell.

## 5.2 Identifying Assumptions

The validity of the RD design depends on whether the UI recipients around the age-45 cutoff are similar except for their eligibility for extended benefits. Under Taiwan's UI program, it is unlikely that workers will be able to manipulate the eligibility rule for extended benefits because it is based on their age at the time of job loss rather than their age when claiming benefits.[10] It seems possible, however, that some firms might be willing to delay laying off workers for a certain period of time, so that they would qualify for extended benefits. If many firms were doing this, we would likely see a larger-than-expected number of workers just above age 45 claiming UI benefits. Furthermore, if these workers or employers fell into certain types or industries, then this sorting would not be random, and would need to be addressed. We investigate the validity of our RD design by examining the frequency of UI recipients over different ages, and the means of the observables around the cutoff, as Imbens and Lemieux (2008) and Lee and Lemieux (2010) suggest.

Figure 2 shows the number of UI recipients of each age, from 40 to 50, at layoff. Each age bin represents the total number of new claimants in a 30-day interval. Below the age 45 cutoff, there are roughly 450 new claimants within each age interval, and the number of new claimants decreases with age at job loss. Consistent with Schmieder et al. (2012), we find that there are about 150 more workers losing their jobs within the first 30 days past age 45 than just before that cutoff, and that the number of new claimants within a few months past age 45 is still slightly higher than that just before age 45. This increase in the number of UI recipients at and just above the cutoff is significant at the 5% level using the density test proposed by Cattaneo et al. (2016). However, it accounts for less than 1% of workers aged 43-46 at the time of job loss, and is thus unlikely to invalidate our RD design. To alleviate the concern that this small discontinuity in bin size at the cutoff might bias the RD estimator, we implement the donut RD strategy suggested by Barreca et al. (2016). We exclude observations within 180 days around the cutoff to examine how selective layoff around the cutoff affects the results. Our results are robust to this removal of observations.

[10] The eligibility rules for extended benefits in Germany and Austria are based on an applicant's age when claiming unemployment benefits. Schmieder et al. (2012) found a slight increase in the number of new claimants on the right of each age cutoff, and addressed this concern using a variety of methods, including adding covariates, a donut RD, and bounding.

To check for the possibility of non-random sorting, we look for any discontinuities in the means of workers' characteristics around the cutoff. Figure 7 plots the number of days between losing one's job and claiming benefits, whether workers previously worked in the manufacturing industry, their average log wage in the six months prior to layoff, whether workers were female, workers' number of dependents, and workers' predicted nonemployment duration. The means either evolved smoothly or showed economically small discontinuities around the cutoff. To make sure the small discontinuities at the cutoff did not invalidate our RD design, we estimate the average nonemployment duration by regressing nonemployment duration on available observables, excluding the treatment indicator as suggested by Card et al. (2007). Figure 7 shows that the predicted nonemployment duration is smooth around the age 45 cutoff. In Table 3, we estimate a local linear regression using the pre-determined observables as dependent variables of equation 3. The estimates are either insignificant or small. In particular, the estimated effect of extended benefits on the predicted nonemployment duration is insignificantly different from zero, suggesting the workers near the cutoff are comparable to each other.

### 5.3 Estimation Results

The eligibility rule for extended benefits in Taiwan generates clear discontinuities in the relationship between age and duration outcomes. Figure 3 plots our average outcomes against age at job loss using a [40, 50] window. Each bin indicates the conditional means within a width of 30 days. As shown in Figure 3 (a) and (b), at ages over 45, the average number of days of benefits receipt shifts up by about 60 days, while the average nonemployment duration shifts up by roughly 40 days. In Figure 3 (c), consistent with the duration outcomes, the average reemployment hazard in the first six months in an UI spell shows a discernible drop at the cutoff by about two percentage points. Moreover, there are no comparable discontinuities at other age points. Overall, the RD graphs for duration outcomes imply that extending potential duration lowers search intensity even in a UI system with a variable reemployment bonus.

Column 1 of Table 4 reports our baseline estimates for the effect of extended benefits on insured duration of unemployment, nonemployment duration and the reemployment hazard in the first six months of a UI spell. A three-month increase in potential benefits duration is estimated to increase the insured duration of unemployment by about 57.96 days, a 39% increase in the average insured duration and an elasticity with respect to potential duration equal to 0.78. The estimated effect of extended benefits on nonemployment duration is about 41.14 days, a 15% increase in nonemployment duration and an elasticity of 0.3. [11] Including covariates affects the estimates and precision little, suggesting the estimated effect is not driven by the observed difference between eligible and ineligible workers. Panel C in Table 4 reports the estimates for the hazard rate response to extended benefits. These estimates indicate that a three month increase in potential duration reduces the monthly reemployment rate by 7 percentage points between the 7th and 9th months of a nonemployment spell, which is equivalent to an 50% decline in the average reemployment hazard between the 7th and 9th months of a nonemployment spell.

In column 3 of Table 4, we estimate equation 3 using a triangular kernel and the optimal bandwidth algorithm proposed by Calonico et al. (2014). Column 4 reports the bias corrected estimates and standard errors adjusted for bias correction. Column 5 specifies a quadratic regression on either side of the cutoff, rather than a linear regression. The optimal bandwidth is in the range of three to five years. Overall, the point estimates in columns 3-5 are slightly smaller but statistically indistinguishable from the estimates in columns 1 and 2.

As a placebo test for our RD estimates, we plot the average outcomes conditional on age at layoff, for observations before the reform, in Figure 4. There are no discernible discontinuities at the cutoff. The estimates in Table 6 also suggest there are no permanent differences

[11] The insured duration elasticity equals percentage change of insured duration divided by percentage change of potential duration, which is $\frac{57.96/147.32}{(9-6)/6}$. Similarly, the nonemployment duration elasticity is $\frac{41.14/276.39}{(9-6)/6}$.

between workers laid off on either side of the age threshold. The smooth relationship of workers' age at layoff with the observed covariates after the reform and the outcomes before the reform raises our confidence in the validity of the RD design.

The RD estimates, while internally valid for the total effect of extended benefits, demonstrates the combination of a liquidity effect and a moral hazard effect. In the next section, we estimate the effect of reemployment bonus on the hazard rate of reemployment, which captures the moral hazard effect of UI.

# 6 Effects of Reemployment Bonuses

## 6.1 Regression Kink Design

The reemployment bonus program in Taiwan offers 50% of remaining benefits to UI recipients reemployed before exhaustion point and holding jobs for at least three months. The program was announced by the government on May 15, 2002, before it officially began on Januray 1, 2003. Importantly, it not only applies to workers starting their UI spells after Januray 1, 2003, but also workers having UI spells span across Januray 1, 2003. Therefore, as the program phased in, in effect, the potential duration of benefits as a bonus increases. Figure 5 plots the bonus offer that workers are potentially eligible for with respect to the date individuals starting UI spells. There are three segments distinguished by two cutoffs. The first cutoff is July 5, 2002: any workers starting their spells before this date would not be eligible for bonus, while the bonus increased linearly as the date approaches Januray 1, 2003. Since any workers starting to receive benefits after Januray 1, 2003 is eligible for 3 months of benefits as bonuses, Januray 1, 2003 becomes the second cutoff. For example, an UI recipient lost his job on August 1, 2002 was eligible for a half month of benefits as a reemployment bonus if finding a job in the beginning of 2003, while an UI recipient losing his job on Januray 1, 2003 was eligible for up to three months of benefits as a bonus. Therefore, the slope of the duration of benefits as a bonus is zero before the first cutoff, 0.5 between the two cutoffs and zero again after the second cutoffs.

To estimate effects of reemployment bonuses, we look for induced kinks in the relationship between the date UI spells start and outcomes around the cutoffs, and compare the magnitude of the kinks at the cutoffs in the outcomes to that of the bonus amount. The idea is that we can attribute the slope change in the reduced from to that in the first stage if workers are similar around the kinks. Following Nielsen et al. (2010) and Card et al. (2015), the effect of one day increases in benefits as a bonus that workers are potentially eligible for can be expressed as

$$E(\frac{\partial y}{\partial RB(t)}|t=c) = \frac{\lim\limits_{t\to c^+} \frac{dE(y|t)}{dt} - \lim\limits_{t\to c^-} \frac{dE(y|t)}{dt}}{\lim\limits_{t\to c^+} \frac{dRB(t)}{dt} - \lim\limits_{t\to c^-} \frac{dRB(t)}{dt}}$$

where $y$ represents an outcome variable, reemployment hazard. $t$ is the UI starting date and $c$ is the date where the kinks located at. $RB(t)$ is the duration of unemployment benefits as a bonus individuals are potentially eligible for, which is an increasing and kinked function of the first date of receiving benefits. The denominator is straightforward to calculate, since the slope change at these two kinks are deterministic. Specifically, the slope change is 0.5 for the first kink and $-0.5$ for the second one. To estimate the effect on average reemployment hazard in an UI spell, we estimate the following regression:

$$y_{im} = \alpha + \gamma(t_i - c) + \beta_{RB}(t_i - c) \cdot D_c + u_{im}. \tag{6}$$

where $y_{im}$ is equal to 1 if UI recipient $i$ in month $m$ finds a job in month $m+1$. $\beta_{RB}$ divided by the first stage coefficient captures $E(\frac{\partial y}{\partial RB(t)}|t=c)$. Multiply by 180 then gives effects of eligibility for the bonus program since the bonus program offers three months benefits as a bonus if workers are reemployed in the beginning of UI spells. We first present graphical evidence and RK estimates, then check the validity of RK design by examining whether there is any kink or discontinuity in mean predetermined variables and the density function of running variable.

## 6.2 Graphical Evidence

Figure 6a presents the relationship between average monthly reemeployment hazard and starting date of UI benefits for the benefit recipients who were age 35 to 50 during 2002-2003. Each bin represents the total number of UI spells starting within 20 days interval. We find that the monthly reemeployment hazard of the benefit recipients who started their UI spells between July 5, 2002 and Januray 1, 2003 (i.e. partially eligible for reemployment bonus) increased as their UI starting date approaches Januray 1, 2003. On average, the monthly reemeployment hazard increased substantially from 0.06 (those who started UI around July 5, 2002) to 0.08 (those who started UI around Januray 1, 2003). For those who started their UI spells before July 5th, 2002 (i.e. ineligible for reemployment bonus) or after Januray 1, 2003 (i.e. fully eligible for reemployment bonus), we find that their monthly reemeployment hazard did not change with their UI starting date. In other words, there are two changes in slope of average reemployment hazard against workers' UI starting date, which is consistent with the relationship of potential bonus offer and UI starting date depicted in Figure 5.

Figure 6a displays the relationship between average monthly reemeployment hazard and starting date of UI benefits for the benefit recipients who were age 35 to 50 during 2001-2002. We use it as placebo test to show the above graphical evidence is not due to seasonality of labor market conditions. In contrast to Figure 6a, we find that the monthly reemeployment hazard of the benefit recipients who started their UI spells during 2001-2002 (i.e. unaffected by reemployment bonus reform) was constantly around 0.06.

## 6.3 Estimation Results

Table 5 show the RK estimates for the effect of reemployment bonuses on average reemployment hazard in an UI spell. For kink 1 (kink 2), we multiply $\beta_{RB}$ by 180 (-180) directly to represent the effect of a reemployment bonus equivalent to 90-day of UI benefits on monthly reemployment hazard. The estimates in column (1) to column (3) using kink 1 (kink 2) suggests reemployment bonus significantly increased the average job finding rate in the UI spells by roughly 2 (1.8) percentage points. The estimates using optimal bandwidth in column 4 and column 5 are also similar.

# 7 Welfare Implications

To back out the liquidity effect, we first define each period as an interval of three months such that the regular six months of potential duration is equal to two periods. With this timing definition, increasing the potential duration from six months to nine months is equivalent to a one-period increase in potential duration.[12] According to Table 4, a three-month increase in potential duration $\frac{\partial s_t}{\partial P}$ is estimated to decrease the monthly reemployment hazard by 1.7 percentage points. On the other hand, based on Table 5, the eligibility for the bonus $b\frac{\partial s_t}{\partial r_t}$ is estimated to increase the monthly reemployment hazard by 2 percentage points for workers aged between 35 and 50. Plugging the reduced form estimates into equation 1 yields

$$\begin{aligned} b\frac{\partial s_P}{\partial A_P} &= \frac{\partial s_P}{\partial P} + 0.5b\frac{\partial s_P}{\partial r_P} \\ &= -0.017 + 0.5 \cdot 0.6 \cdot 0.020 \\ &= -0.011. \end{aligned}$$

The above result suggests the liquidity effect accounts for 65% ($\frac{0.011}{0.017} \cdot 100\%$) of the effect of extending potential duration on the reemployment hazard for workers aged around 45. Also, the ratio of the liquidity effect to the moral hazard effect of extending potential duration is

$$\begin{aligned} R_P &= -\frac{\partial s_t}{\partial A_t} / \frac{\partial s_t}{\partial r_t} \\ &= 0.011/0.012 \\ &= 0.91 \end{aligned}$$

[12] This definition is similar to that of Card et al. (2007). They define ten weeks in a UI spell as one period. Therefore, extending unemployment benefits from 20 weeks to 30 weeks is equivalent to a one-period increase in potential duration under their timing definition.

Plugging our reduced form estimates into the welfare formula 2, we get

$$\begin{aligned}\frac{dW_0^*}{db_P} &= S_0(P)R_P - \{(1-\theta)\sum_{t=0}^{P-1}\frac{dS_0(t)}{dP} + \frac{(1-\theta)B+\theta P}{T-D}\cdot\frac{dD}{dP}\} \\ &= 0.61\cdot 0.91 - \{0.5\cdot(\frac{58.29}{90} - 0.61) + (0.5\cdot 0.15 + 1.38\cdot 0.5\cdot 0.15)\cdot\frac{43.02}{90}\} \\ &> 0\end{aligned}$$

This means increasing potential duration is estimated to be welfare enhancing for workers aged around 45, because the expected consumption smoothing benefits at exhaustion point are larger than the increased welfare cost arising from lengthened insured and nonemployment durations.

# 8 Summary and Discussion

This paper has exploited the introduction of a reemployment bonus program and a UI extension to older workers to evaluate optimal potential duration of unemployment benefits. The duration response to the reemployment bonus is linked to the moral hazard effect of UI, because the bonus offer increases workers' incentive to search, while it does not increase workers' ability to maintain consumption during unemployment. On the other hand, the duration response to extended benefits is composed of a liquidity effect and a moral hazard effect, since it not only increases income during unemployment but also distorts the incentive to search. Using a search model with borrowing constraint and the RD (RK) design, we separately identify the liquidity and moral hazard effects of UI. Our estimates show that, for workers aged around 45, the liquidity effect explains 65% of the effect of extended benefits on reemployment hazard, and increasing potential duration is welfare enhancing for them.

Note that our welfare calculation is based on at least two assumptions. First, our model assume a flat labor demand and every unemployed worker is eligible for unemployment benefits. However, in the search model including reservation wage, when the government increase the generosity of unemployment benefits, workers will raise their selectivity, so the firms might be less willing to open vacancies. Second, since workers eligible for more generous benefits will decrease the search effort, those ineligible will have better chance to be employed and become more willing to exert search effort. Recent evidence from Lalive et al. (2015) suggests the latter dominates the former.

We have also assumed the effects of reemployment bonuses on hazard rate in each period before exhaustion point is constant. However, it is possible that workers in different timing of unemployment spell respond differently for reemployment bonuses. Figure 11 and Figure 12 suggest there might be a significant heterogeneity in the hazard rate response to both extended benefits and reemployment bonuses over a nonemployment spell. Future studies on how the ration of a liquidity and a moral hazard effect varies over unemployment duration will provide insights on optimal time profile of unemployment benefits (Kolsrud et al. (2016)).

Finally, this paper can be extended to study design optimal age-dependent UI. Intuitively, optimal UI should consider heterogeneity in consumption smoothing benefits and heterogeneity in moral hazard costs, offering a longer potential duration or a higher replacement rate for workers suffering greater losses and having smaller duration responses. However, in the literature, it is unclear how the liquidity effect and moral hazard effect vary over age. On the one hand, in the early years of the life cycle, workers are likely to be more liquidity constrained due to low income, and want jobs that build up a high return of human capital (Michelacci and Ruffo (2015)). On the other hand, young workers might return to live at home when unemployed, operating as an alternative form of insurance (Kaplan (2012)). Estimating how the effects of extended benefits and reemployment bonuses vary over ages will be useful for optimal UI design over life-cycle.

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# 9 Tables

Table 1: Descriptive Statistics for Extended Benfits Sample

| | All (1) | 43-46 (2) | 15-30 (3) | 30-45 (4) | 45-65 (5) |
|---|---|---|---|---|---|
| age (years) | 36.90 | 44.99 | 26.67 | 36.65 | 50.24 |
| female | 0.52 | 0.49 | 0.59 | 0.52 | 0.46 |
| number of dependants | .63 | 1.13 | 0.16 | 0.82 | 0.80 |
| previous wage (NTD) | 29,316 | 30,853 | 25,675 | 30,516 | 31,134 |
| insured duration (days) | 143.68 | 175.04 | 113.09 | 129.83 | 213.30 |
| nonemployment duration (days) | 252.84 | 294.97 | 198.44 | 236.04 | 358.83 |
| right censored at 730 days | 0.11 | 0.14 | 0.05 | 0.09 | 0.21 |
| exhaustion rate | 0.51 | 0.65 | 0.37 | 0.50 | 0.73 |
| recall rate | 0.13 | 0.12 | 0.11 | 0.12 | 0.18 |
| reemployment wage (NTD) | 25,231 | 25,907 | 23,102 | 25,902 | 26,367 |
| observations | 199,500 | 20,893 | 55,092 | 100,242 | 44,166 |

Note: This table shows the means of our main variables from the extended benefits sample. The sample in Column 1 consists of all UI recipients starting UI spells between May, 1, 2009 and Jan. 1, 2012. Columns 2-5 report the results for UI recipients in the same sample period for workers from four different age groups. Nonemployment duration is censored at 730 days. Average reemployment hazard denotes the average monthly reemployment rate in the first six months of the UI spells. We define exhaustion rate as the ratio of workers whose insured duration is longer than 180 days.

Table 2: Descriptive Statistics for Reemployment Bonus Sample

| | 01/2002-06/2002<br>(1) | 07/2002-12/2002<br>(2) | 01/2003-12/2003<br>(3) |
|---|---|---|---|
| age (years) | 36.06 | 36.27 | 36.88 |
| female | 0.53 | 0.56 | 0.56 |
| previous wage (NTD) | 26,994 | 26,773 | 27,177 |
| insured duration | 151.68 | 144.87 | 134.44 |
| nonemployment duration | 368.08 | 334.77 | 306.48 |
| right censored | 0.11 | 0.09 | 0.08 |
| exhaustion rate | 0.69 | 0.62 | 0.55 |
| recall rate | 0.11 | 0.10 | 0.11 |
| reemployment wage | 23,402 | 23,113 | 22,983 |
| observations | 38,429 | 29,044 | 24,426 |

Note: This table shows the means of our main variables from the reemployment bonus sample. The sample in Column (1) consists of all UI recipients starting UI spells between Jan, 1, 2002 and Jun. 30, 2002. Column (2) reports the results for all UI recipients starting UI spells between Jul, 1, 2002 and Dec. 31, 2002, Column (3) between Jul, 1, 2002 and Dec. 31, 2002. Nonemployment duration is censored at 730 days. Average reemployment hazard denotes the average monthly reemployment rate in the first six months of the UI spells. We define exhaustion rate as the ratio of workers whose insured duration is longer than 180 days.

Table 3: RD: Estimates of Smoothness of Predetermined Covariates

| | (1) Delay Days | (2) Female | (3) Manu. Sector | (4) # of Dependents | (5) Log previous Wage | (6) Predicted Reemp. hazard |
|---|---|---|---|---|---|---|
| $\beta_{EB}$ | -0.70 | -0.00 | 0.01* | 0.01 | 0.01* | -0.0000 |
| | (2.06) | (0.10) | (0.00) | (0.01) | (0.00) | (0.0000) |
| Sample size | 46,916 | 43,035 | 42,036 | 37,961 | 50,903 | 5,973,289 |
| Poly. model | linear | linear | linear | linear | linear | linear |
| Bandwidth (days) | CCT | CCT | CCT | CCT | CCT | CCT |

Note: This table checks for smoothness of mean predetermined variables by estimating a local linear regression using the optimal bandwidth by Calonico et al. (2014) and triangular kernel. The sample are workers aged within the bandwidth and starting UI spells between May 1, 2009 and Jan. 1, 2012. The predictors for average reemployment hazard in the first six months are previous wage, squared previous wage, previous industry, gender, place of birth, number of dependants, month/year at job loss and the number of days between job loss and initial claim. Standard errors in parentheses are clustered by age in days. *** significant at the 1 percent level, ** significant at the 5 percent level, and * significant at the 10 percent level.

Table 4: The Effect of Extended Benefits on Unemployment Duration and Monthly Reemployment Hazard

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| *Insured Duration* | | | | | |
| $\beta_{EB}$ | 57.96*** | 58.29*** | 56.55*** | 56.12*** | 57.09*** |
| | (1.97) | (1.95) | (1.50) | (1.74) | (2.25) |
| Baseline mean | | | 147.32 | | |
| Sample size | 20,906 | 20,893 | 40,507 | 40,507 | 37,785 |
| *Nonemployment Duration* | | | | | |
| $\beta_{EB}$ | 41.14*** | 43.02*** | 36.23*** | 37.76*** | 40.41*** |
| | (6.90) | (6.90) | (5.18) | (6.01) | (7.96) |
| Baseline mean | | | 276.39 | | |
| Sample size | 20,906 | 20,893 | 40,987 | 40,987 | 36,589 |
| *Monthly Reemployment Hazard* | | | | | |
| $\beta_{EB}$ | -0.017*** | -0.018*** | -0.016*** | -0.017*** | -0.017*** |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) |
| Baseline mean | | | 0.084 | | |
| Sample size | 119,802 | 119,753 | 213,478 | 213,478 | 278,748 |
| Bias-corrected | – | – | – | Yes | Yes |
| Covariates | – | Yes | – | – | – |
| Poly. model | linear | linear | linear | linear | quadratic |
| Bandwidth (days) | 730 | 730 | CCT | CCT | CCT |

Note: This table shows the estimates of the effect of increasing potential duration from 6 months to 9 months on insured duration, nonemployment duration and the reemployment hazard between the 1st and 6th month of nonemployment. Column 1 estimates a linear regression on either side of the cutoff using sample from workers aged 43-46 at job loss, and starting UI spells between May 1, 2009 and Jan. 1, 2012. Column 2 includes the following covariates: previous wage, squared previous wage, previous industry, gender, place of birth, number of dependants, month/year at job loss, number of job loss and number of days between job loss and initial claim. Columns 3 reports the estimates using optimal bandwidth algorithm from Calonico et al. (2014). The optimal bandwidths vary with the outcome variables, in the range of 3 to 6 years. The bias correction estimates and the corresponding robust standard errors are presented in the Column 4. In Column 5, we report the bias correction estimates and robust standard error using a local quadratic regression. Standard errors in parentheses are all clustered by age in days. Columns 1 and 2 use rectangular kernel. Columns 3-5 use triangular kernel. *** significant at the 1 percent level, ** significant at the 5 percent level, and * significant at the 10 percent level.

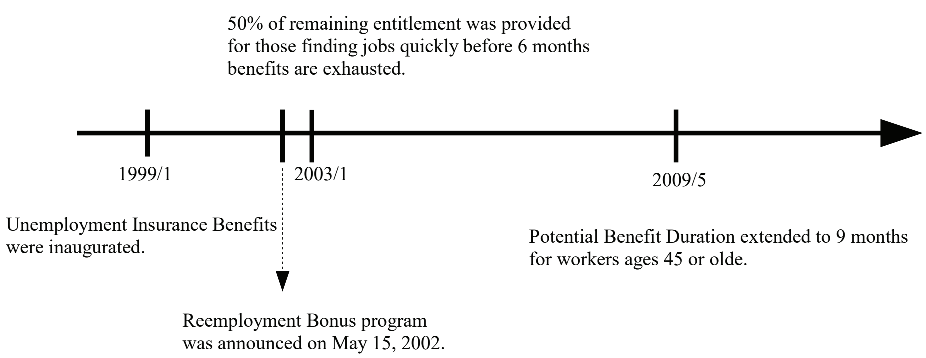
Table 5: The Effect of Reemployment Bonus on Monthly Reemployment Hazard

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| *Kink 1: Monthly Reemployment Hazard* | | | | | |
| $180 \times \beta_{RB}$ | 0.021*** | 0.024*** | 0.019*** | 0.016*** | 0.020*** |
| | (0.006) | (0.006) | (0.006) | (0.005) | (0.005) |
| Baseline mean | | | 0.053 | | |
| Sample size | 120,045 | 120,045 | 120,045 | 159,191 | 159,191 |
| *Kink 2: Monthly Reemployment Hazard* | | | | | |
| $-180 \times \beta_{RB}$ | 0.014** | 0.015** | 0.014** | 0.016** | 0.018** |
| | (0.007) | (0.007) | (0.007) | (0.008) | (0.008) |
| Baseline mean | | | 0.064 | | |
| Sample size | 100,557 | 100,557 | 100,557 | 108,009 | 108,009 |
| Bias-corrected | – | – | – | – | Yes |
| Covariates | – | Yes | – | – | – |
| Discontinuity | – | – | Yes | – | – |
| Poly. model | linear | linear | linear | linear | linear |
| Bandwidth (days) | 150 | 150 | 150 | CCT | CCT |

Note: This table shows the estimates of the effect of eligible for reemployment bonus on the reemployment hazard between the 1st and 6th month of nonemployment. *** significant at the 1 percent level, ** significant at the 5 percent level, and * significant at the 10 percent level.

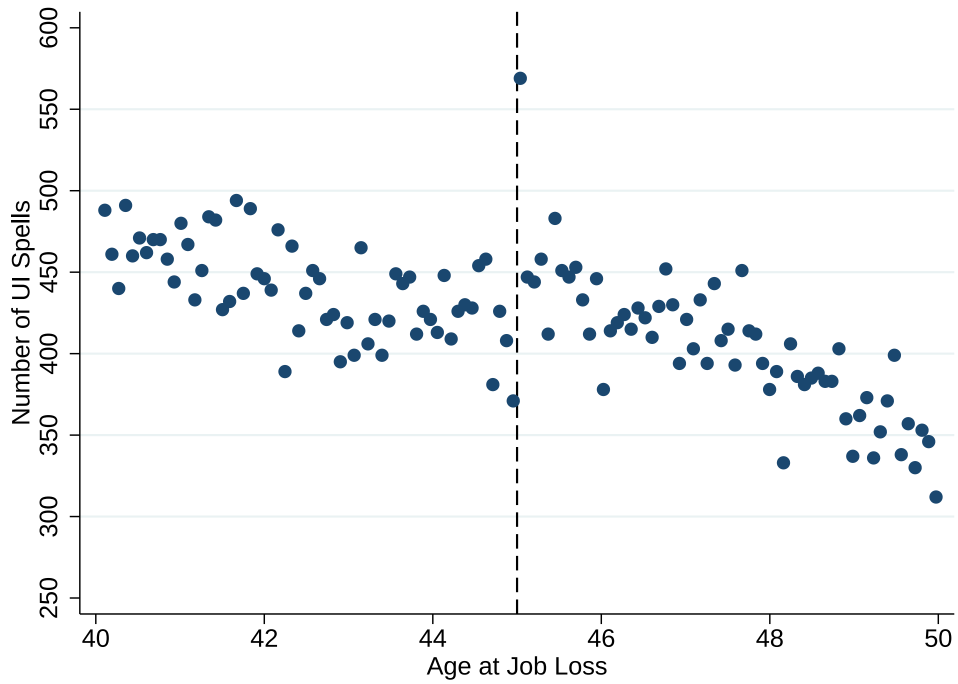
# 10 Figures

Figure 1: UI Timeline




Notes: This figure summarizes the evolution of Taiwan's UI. UI in Taiwan was inaugurated in Jan 1999. On May 15, 2002, the reemployment bonus program was announced. On January 1, 2003, a bonus, equal to 50% of remaining benefits, began to offer for UI recipients who find jobs before exhausting benefits. The potential duration for the worker aged 45 or older has extended from 6 months to 9 months since May 1, 2009.

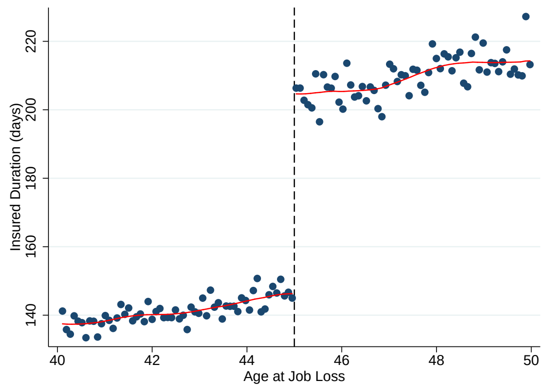
Figure 2: Validity of RDD: Density Test



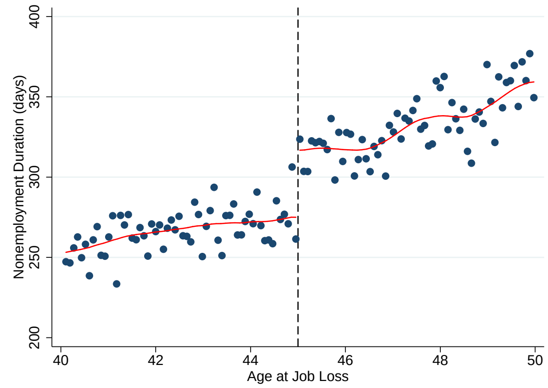

Notes: This figure plots the number of workers starting UI spells between May 1, 2009 and Jan. 1, 2012, conditional on age at job loss. Each bin corresponds to the total number of workers starting UI spells within a 30 days interval.

Figure 3: Effects of Extended UI Benefits

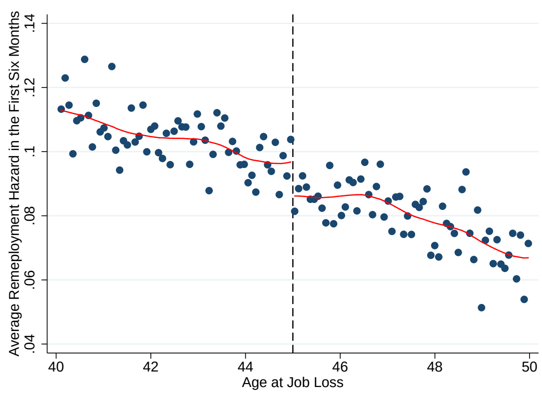
(a) Insured Duration



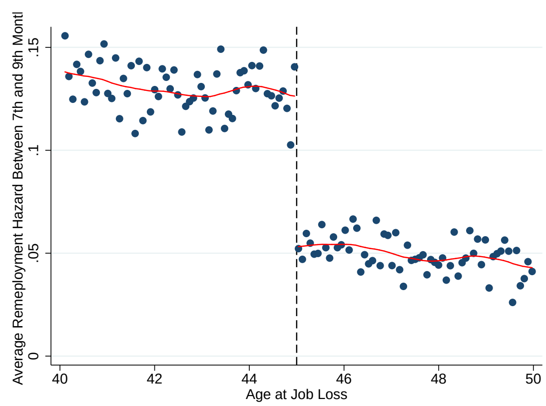

(b) Nonemployment Duration




(c) Monthly Reemployment Hazard in the First 6 Months



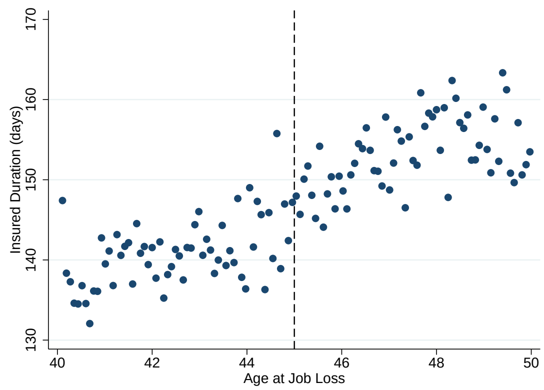

(d) Monthly Reemployment Hazard Between 7th and 9th Month



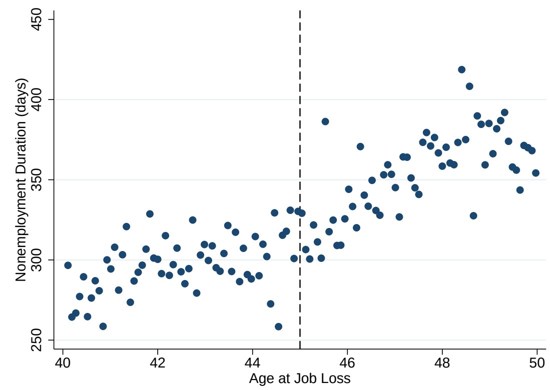

Notes: This figure plots the average outcomes for UI recipients aged 40 to 50 at job loss and starting UI spells between May 1, 2009 and Jan. 1, 2012, conditional on age at job loss. Each bin represents the average number of UI recipients within 30 days interval. The solid lines are fitted values from a local linear regression on either side of the cutoff using edge kernel, with a bandwidth of one year.

Figure 4: Test RDD Assumption: Placebo Test

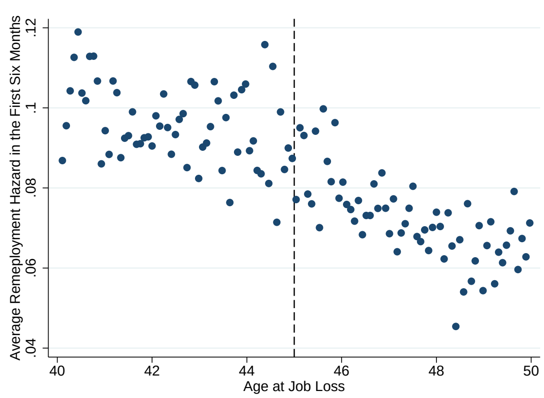
(a) Insured Duration Prior to UI Extension



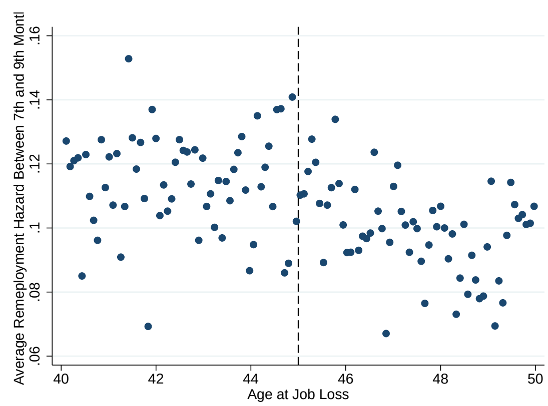

(b) Nonemployment Duration Prior to UI Extension




(c) Monthly Reemployment Hazard (1th-6th)

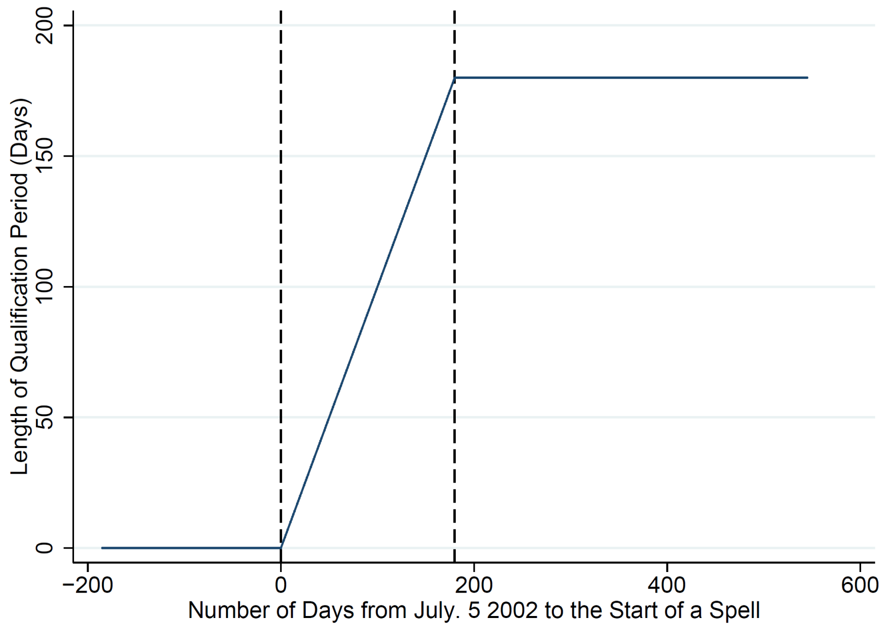



(d) Monthly Reemployment Hazard (7th-9th)




Notes: This Figure plots the average outcomes for UI recipients age 40 to 50 at job loss and start UI spells before Nov. 1, 2008, conditional on age at job loss. Each bin represents the average number of UI recipients within 30 days interval.

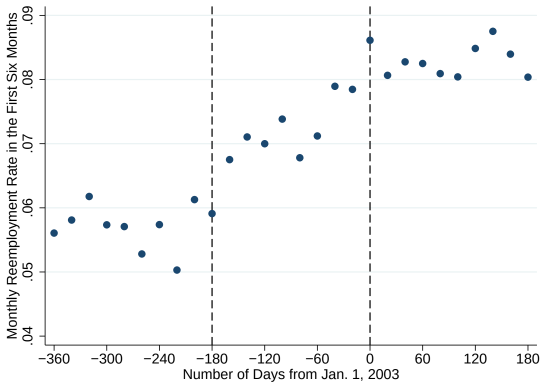
Figure 5: RKD's First Stage



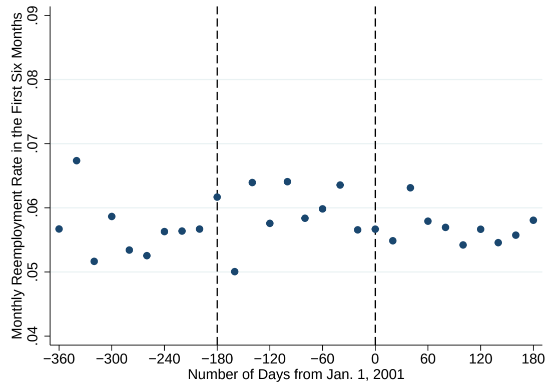

Notes: This figure demonstrates the relationship between the length of qualification period and the date UI spells started. UI recipients starting receiving benefits before July 1, 2002 are not eligible for any reemployment bonus. As the program phased in, UI recipients are potentially eligible for a more generous bonus offer, while the potential reemployment bonus is constant for UI recipients start receiving benefits after Januray 1, 2003.

Figure 6: Effects of Reemployment Bonus

(a) Average Monthly Reemployment Hazard within 6 months:2002-2003




(b) Average Monthly Reemployment Hazard within 6 months:2001-2002




Notes: Figure 6a plots the average monthly reemployment hazard over the number of days between Jan. 1, 2003 and the date UI spells started. The sample include every UI spell started within 360 days from Jan 1, 2003. Each bin represents the average number of UI recipients within 20 days interval. The first dash line indicates Jul. 5, 2002, 6 months before the bonus program began. The second line indicates Jan. 1, 2003, the date bonus program began. Figure 6b is for a placebo test. It plots the average monthly reemployment hazard over the number of days between Jan. 1, 2002 and the date UI spells started. The sample include every UI spell started within 360 days from Jan 1, 2002. The first dash line indicates Jul. 5, 2001, 6 months before the bonus program began. The second line indicates Jan. 1, 2002.

# 11 Appendix

## 11.1 Decomposition of the Effect of Extended Benefits

Consider a discrete time search model based on Chetty (2008) and Landais (2015). An unemployed worker becomes unemployed at time 0 and holds an initial asset $A_0$. She lives for $T$ periods and determines the probability of finding a job in period $t$ by varying search intensity, $s_t$, at a cost of $g(s_t)$, which is strictly increasing and convex. If she is unemployed at time $t$, she receives an unemployment benefit, $b_t$, with a potential duration, $P$, that is

$$b_t = \begin{matrix} b, & \text{if } 0 \leq t < P \\ 0, & \text{if } t \geq P \end{matrix}$$

If she is employed at time $t$, she earns a wage rate $w_t$, pays a tax rate, , and keeps the job forever. Moreover, if she is reemployed before running out of benefits, she receives a reemployment bonus, $r_t$, equal to $\theta$ percent of remaining benefits; otherwise, $r_t = 0$. Formally,

$$r_t = \theta \cdot \sum_{k=t}^{P-1} b_k, 0 < \theta < 1$$

The worker's consumption at time $t$ equals the difference in income and saving. The income depends on her employment status, while the change in asset, $A_{t+1} - A_t$ reflects her saving. When employed, she earns wage rate, $w_t$, bonus, $r_t$, and pays a tax, $\tau$. The flow utility when employed at time $t$ equals $u(c_t^e) = u(A_t - A_{t+1} + w_t + r_t - \tau)$, where $c_t^e$ indicates the consumption when employed at time $t$. Assuming the interest rate and the time discount rate are zero, the value of being employed in period $t$ is

$$V_t = \max_{A_{t+1}} u(A_t - A_{t+1} + w_t + r_t - \tau) + V_{t+1}(A_{t+1})$$

If an unemployed worker cannot find a job at time $t$, her flow utility is equal to $u(c_t^u) = u(A_t - A_{t+1} + b_t)$. The value of being unemployed in period $t$ is

$$U_t = \max_{A_{t+1}} u(A_t - A_{t+1} + b_t) + J_{t+1}(A_{t+1}),$$

where $J_{t+1}(A_{t+1})$ is the value of entering period $t+1$ unemployed with asset $A_{t+1}$. The worker without a job in the beginning of period $t$ maximizes

$$J_t(A_t) = \max_{s_t} \; s_t V_t(A_t) + (1 - s_t)U_t(A_t) - g(s_t),$$

In the model, since workers face no uncertainty after they are employed, the marginal utility of consumption when workers are employed at time $t$ equals the marginal utility of consumption at time $t+1$ when employed if the liquidity constraint does not bind. Otherwise, workers set consumption at time $t$ equal to after tax wage rate. Formally, we can write the intertemporal first order condition when employed as follows:

$$u'(c_t^e) = \begin{array}{c} u'(c_{t+1}^e);\; \text{if } A_t > L \\ u'(w - \tau);\; \text{if } A_t = L \end{array}$$

Similarly, if workers are unemployed at time $t$, they smooth consumption such that the marginal utility of consumption when unemployed at time $t$ equals the expected marginal utility of consumption at time $t+1$. That is, the intertemporal first order condition when unemployed is

$$u'(c_t^u) = \begin{array}{c} s_{t+1}u'(c_{t+1}^e) + (1 - s_{t+1})u'(c_{t+1}^u);\; \text{if } A_t > L \\ u'(b_t);\; \text{if } A_t = L \end{array}$$

If liquidity constraint is not binding yet at exhaustion point, $P-1$,

$$u'(c_t^e) = u'(c_P^e);$$

$$u'(c_t^u) = [1 - S_{t+1}(P)]u'(c_P^e) + S_{t+1}(P)u'(c_P^u).$$

The intratemporal first order condition balances the marginal cost of search and the difference between the value of being employed and unemployed at time $t$.

$$g'(s_t) = V_t(A_t) - U_t(A_t)$$

The effect of one dollar increase in unemployment benefits in period $P$ on search intensity in period $t$ is dependent on the effect on the value of employment in period $t$ and the value of unemployment in period $t$, respectively.

$$g''(s_t)\frac{\partial s_t}{\partial b_P} = \frac{\partial V_t(A_t)}{\partial b_P} - \frac{\partial U_t(A_t)}{\partial b_P}$$

For $t \leq P$, one dollar increase in $b_P$ raises $r_t$ by $\theta$ dollar, and increases the value of employment in period $t$ by $\theta u'(c_t^e)$.

$$\frac{\partial V_t(A_t)}{\partial b_P} = \theta u'(c_t^e)$$

One dollar increase in $b_P$ increases the value of unemployment in period $t$ through two channels. On one hand, it increases the value of unemployment in period $t$ because it increases the utility of being unemployed in period $P$. On the other hand, it also increases the utility of finding a job in any period before exhaustion point.

$$\begin{aligned}\frac{\partial U_t(A_t)}{\partial b_P} &= (1-s_{t+1})..(1-s_P)u'(c_P^u) + s_{t+1}\theta u'(c_{t+1}^e) + .. + (1-s_{t+1})..s_P\theta u'(c_P^e) \\ &= S_{t+1}(P)u'(c_P^u) + [1-S_{t+1}(P)]\theta u'(c_t^e)\end{aligned}$$

Hence, we can write the effect of one dollar increase in unemployment benefits at time $P$ on search effort at time $t$ as below

$$\begin{aligned}\frac{\partial s_t}{\partial b_P} &= \frac{\theta u'(c_t^e) - \{S_{t+1}(P)u'(c_P^u) + \theta u'(c_t^e)[1-S_{t+1}(P)]\}}{g''(s_t)} \\ &= \frac{-S_{t+1}(P)u'(c_P^u) - \theta u'(c_t^e)S_{t+1}(P)}{g''(s_t)}; \forall t \leq P\end{aligned}$$

The liquidity effect and the moral hazard effect of one dollar increase in unemployment benefits at time $P$ on search effort at time $t$ is captured by $\frac{\partial s_t}{\partial A_t}$ and $\frac{\partial s_t}{\partial w_t}$, respectively.

$$\frac{\partial s_t}{\partial A_t} = \frac{u'(c_t^e) - u'(c_t^u)}{g''(s_t)};$$

$$\frac{\partial s_t}{\partial w_t} = \frac{u'(c_t^e)}{g''(s_t)}.$$

Using intertemporal first order conditions and assuming liquidity constraint is not yet binding at time $P-1$, we decompose the effect of an increases in $b_P$ on search intensity into a liquidity and a moral hazard effect.

$$
\begin{aligned}
\frac{\partial s_t}{\partial b_P} &= \frac{[1 - S_{t+1}(P)]u'(c_t^e) - u'(c_t^u) + \theta S_{t+1}(P)u'(c_t^e)}{g''(s_t)} \\
&= \frac{u'(c_t^e) - u'(c_t^u) - (1-\theta)S_{t+1}(P)u'(c_t^e)}{g''(s_t)} \\
&= \frac{\partial s_t}{\partial A_t} - (1-\theta)S_{t+1}(P)\frac{\partial s_t}{\partial w_t}; \forall t \leq P
\end{aligned}
$$

## 11.2 Welfare Effects of Extending Potential Duration

Given the level of benefits, $b$, and the generosity of bonuses, $\theta$, the social planner chooses the potential duration $P$ to maximize the agents expected utility in the beginning of period 0 subject to the agent's optimization and the government's budget constraint.

$$W_0 = \max_{s_0} s_0 V(A_0) + (1-s_0)U(A_0) - g(s_0)$$

$$s.t. Bb + (P-B)\theta b = (T-D)\tau;$$

Differentiating $W_0$ with respect to $P$ yields

$$\begin{aligned} \frac{dW_0}{db_P} &= (1-s_0)[\frac{\partial U_0}{\partial b_P} - \frac{\partial U_0}{\partial w}\frac{d\tau}{db_P}] + s_0[\frac{\partial V_0}{\partial b_P} - \frac{\partial V_0}{\partial w}\frac{d\tau}{db_P}] \\ &= (1-s_0)\frac{\partial U_0}{\partial b_P} + s_0\frac{\partial V_0}{\partial b_P} - [(1-s_0)\frac{\partial U_0}{\partial w} + s_0\frac{\partial V_0}{\partial w}]\frac{d\tau}{db_P} \end{aligned}$$

Using envelope theorem and Euler equations,

$$\begin{aligned} \frac{\partial U_0}{\partial b_P} &= S_1(P)u'(c^u_p) + s_1\theta u'(c^e_1) + .. + (1-s_1)..(1-s_{P-1})s_P\theta u'(c^e_P) \\ &= S_1(P)u'(c^u_p) + [1-S_1(P)]\theta u'(c^e_P) \end{aligned}$$

$$\frac{\partial V_0}{\partial b_P} = \theta u'(c^e_0)$$

$$\frac{\partial U_0}{\partial w} = \sum_{t=1}^{T-1}[\prod_{i=1}^{t-1}(1-s_i)]s_t(T-t)u'(c^e_t)$$

$$\frac{\partial V_0}{\partial w} = Tu'(c^e_0)$$

Define $\mathbb{E}_{0,T-1}u'(c^e_t)$ as the average marginal utility of consumption when employed, that is

$$(T-D)\mathbb{E}_{0,T-1}u'(c^e_t) = (1-s_0)\sum_{t=1}^{T-1}[\prod_{i=1}^{t-1}(1-s_i)]s_t(T-t)u'(c^e_t) + s_0Tu'(c^e_0)$$

Plug in into $\frac{dW_0}{db_P}$,

$$\begin{aligned}\frac{dW_0}{db_P} &= S_0(P)u'(c_p^u) + (1-s_0)[1-S_1(P)]\theta u'(c_P^e) + s_0\theta u'(c_0^e) - (T-D)\mathbb{E}_{0,T-1}u'(c_t^e)\frac{d\tau}{db_P} \\ &= S_0(P)u'(c_p^u) + (1-s_0)[1-S_1(P)]\theta u'(c_p^e) + s_0\theta u'(c_p^e) - (T-D)u'(c_p^e)\frac{d\tau}{db_P} \\ &= S_0(P)u'(c_p^u) + [1-S_0(P)]\theta u'(c_p^e) - (T-D)u'(c_p^e)\frac{d\tau}{db_P}\end{aligned}$$

An increase in benefits in period $P$ increases the tax rate by

$$\frac{d\tau}{db_P} = \frac{d\tau}{dP}\frac{1}{b} = \frac{1}{T-D}[(1-\theta)\frac{dB}{dP} + \theta + \frac{dD}{dP}],$$

where

$$\frac{dB}{dP} = S_0(P) + \sum_{t=0}^{P-1}\frac{dS_0(t)}{dP}$$

In other words, the tax rate, , increases because a longer potential duration increases the benefits and bonus payment in a shorter period of employment. Using the decomposition of $\frac{dB}{dP}$ and $= \frac{(1-\theta)B+\theta P}{T-D}$, $\frac{dW_0}{db_P}$ can be written

$$\begin{aligned}\frac{dW_0}{db_P} &= S_0(P)u'(c_p^u) + [1-S_0(P)]\theta u'(c_p^e) - u'(c_p^e)[(1-\theta)\frac{dB}{dP} + \theta + \frac{(1-\theta)B+\theta P}{T-D}\frac{dD}{dP}] \\ &= S_0(P)[u'(c_p^u) - u'(c_P^e)] - u'(c_P^e)\{(1-\theta)\sum_{t=0}^{P-1}\frac{dS_0(t)}{dP} + \frac{(1-\theta)B+\theta P}{T-D}\frac{dD}{dP}\}\end{aligned}$$

$$\frac{dW_0}{db_P}/u'(c_P^e) = S_0(P)R_P - \{(1-\theta)\sum_{t=0}^{P-1}\frac{dS_0(t)}{dP} + \frac{(1-\theta)B+\theta P}{T-D}\frac{dD}{dP}\},$$

where we define $R_P = -\frac{\partial s_p/\partial A_p}{\partial s_p/\partial w_p}$.

Finally, the ratio of liquidity to moral hazard effect at time $P$ can be transformed to the ratio of liquidity to moral hazard effect at time $P$ using

$$\begin{aligned}
R_t &= \frac{u'(c_t^u) - u'(c_t^e)}{u'(c_t^e)} \\
&= \frac{S_{t+1}(P)u'(c_p^u) + [1 - S_{t+1}(P)]u'(c_p^e) - u'(c_t^e)}{u'(c_t^e)} \\
&= S_{t+1}(P)R_p.
\end{aligned}$$

This implies the ratio of liquidity to moral hazard effect increase over the UI spell.

## 11.3 Tables

Table 6: Placebo Test for RDD

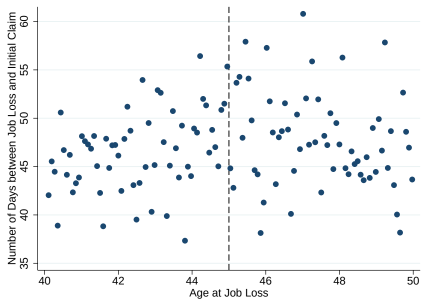
| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| *Panel A: Insured Duration* | | | | | |
| $\beta_{EB}$ | 1.49 | 1.34 | 2.09 | 1.48 | 1.19 |
| | (1.88) | (1.87) | (1.68) | (1.93) | (2.07) |
| Sample size | 14,023 | 14,023 | 18,531 | 18,531 | 26,690 |
| *Panel B: Nonemployment Duration* | | | | | |
| $\beta_{EB}$ | 2.28 | 2.18 | 4.50 | 2.63 | 0.08 |
| | (9.18) | (9.15) | (7.85) | (9.30) | (9.40) |
| Sample size | 14,023 | 14,023 | 18,487 | 18,487 | 32,081 |
| *Panel C: Monthly Reemployment Hazard* | | | | | |
| $\beta_{EB}$ | -0.002 | -0.002 | -0.003 | -0.003 | -0.006 |
| | (0.009) | (0.009) | (0.007) | (0.008) | (0.010) |
| Sample size | 22,065 | 22,065 | 39,522 | 39,522 | 53,345 |
| Bias-corrected | – | – | – | Yes | Yes |
| Covariates | – | Yes | – | – | – |
| Poly. model | linear | linear | linear | linear | quadratic |
| Bandwidth (days) | 730 | 730 | CCT | CCT | CCT |

Note: This table conducts a placebo test using sample before UI extension. Column 1 estimate a linear regression on either side of the cutoff using sample from workers age 43-46 at job loss, and starting UI spells before Nov. 1, 2008. Column 2 includes the following covariates: previous wage, squared previous wage, previous industry, gender, place of birth, number of dependants, month/year at job loss, number of job loss and number of days between job loss and initial claim. Columns 3 reports the estimates using optimal bandwidth algorithm from Calonico et al. (2014). The optimal bandwidths vary with the outcome variables, in the range of 4 to 6 years. The bias correction estimates and the corresponding robust standard errors are presented in the Column 4. In Column 5, we report the bias correction estimates and robust standard error using local quadratic regression. Standard errors in parentheses are all clustered by age in days. Column 1 and 2 use rectangular kernel. Columns 3-5 use triangular kernel. *** significant at the 1 percent level, ** significant at the 5 percent level, and * significant at the 10 percent level.

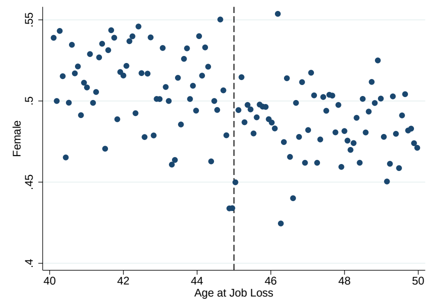
## 11.4 Figures

Figure 7: RD: Smoothness of Covariates

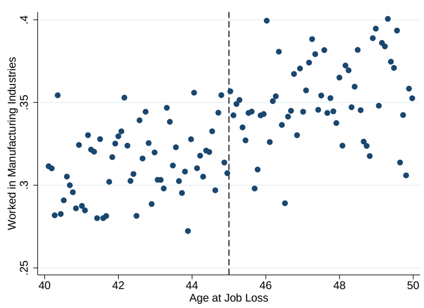
(a) Number of Days Between Job Loss and Initial Claim



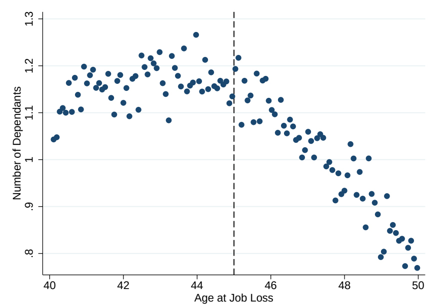

(b) Female



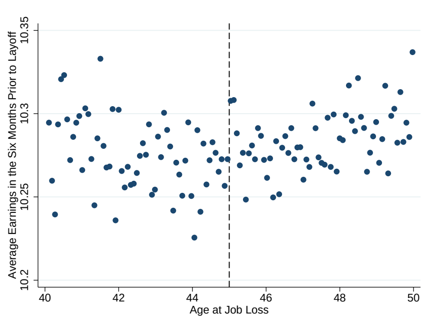

(c) Worked in Manufacturing Sector (Last Job)



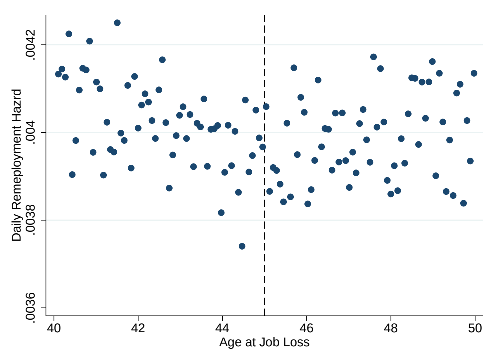

(d) Number of Dependents




(e) Log Average Monthly Wage Prior to Layoff



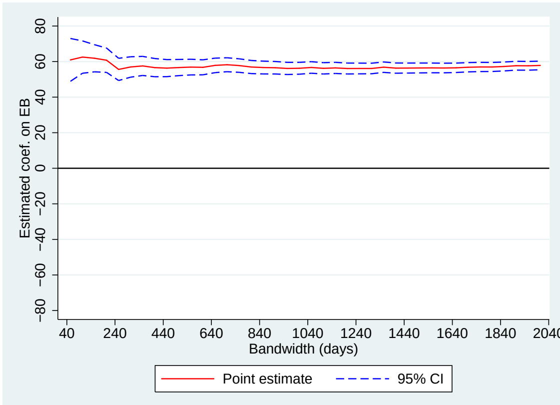

(f) Predicted Average Reemployment Hazard in the First Six Months



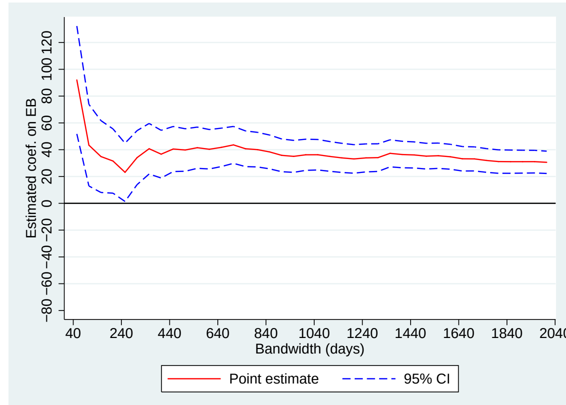

Notes: This figure plots the averages workers' characteristics for those starting UI spells between May 1, 2009 and Jan. 1, 2012, conditional on age at job loss. The predictors for average reemployment hazard before exiting UI are previous wage, squared previous wage, previous industry, gender, place of birth, number of dependants, month/year at job loss and the number of days between job loss and claiming benefits. Each bin represents the average number of UI recipients within 20 days interval.

Figure 8: RD Estimates with Varying bandwidths

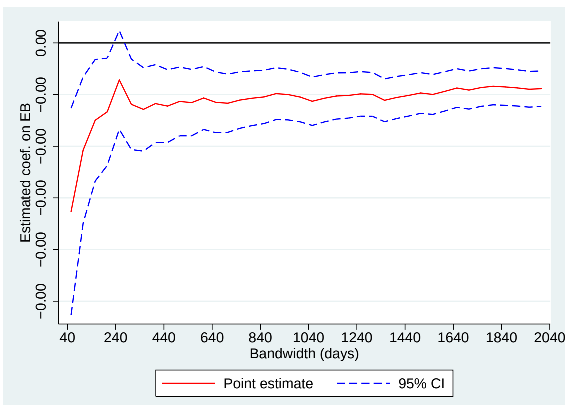
(a) Insured Duration



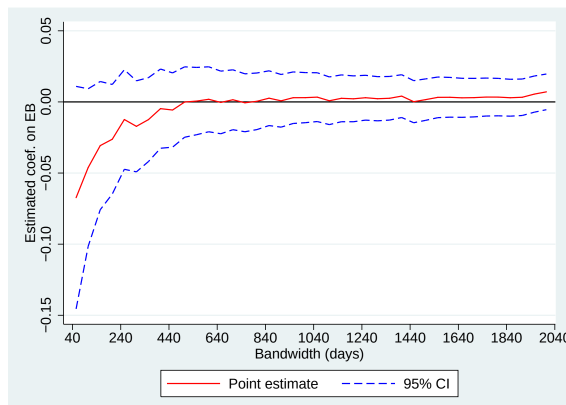

(b) Nonemployment Duration




(c) Average Monthly Reemployment Hazard in UI Spells



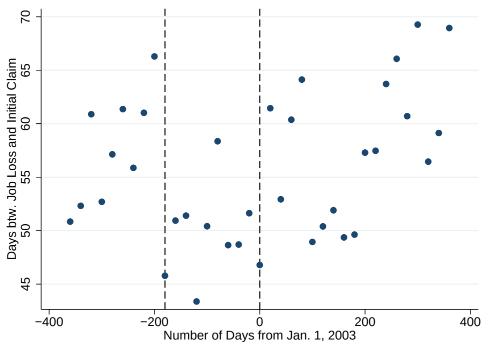

(d) Difference in Log Reemployment Wage and Log Previous Wage



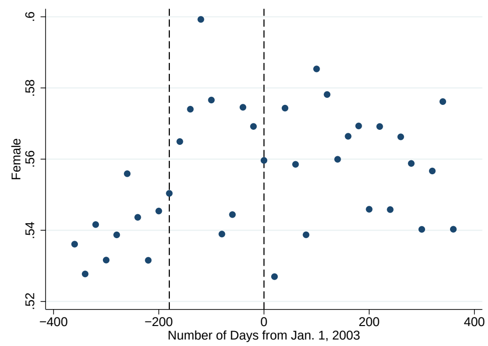

Notes: This figure test for the sensitivity to bandwidth choice for our RD estimates. We estimate a local linear regression using a bandwidth ranging from 40 to 2000 days. The solid line indicates the point estimates, and the dash lines are corresponding confidence intervals.

Figure 9: Test RKD Assumption: Smoothness of Covariates

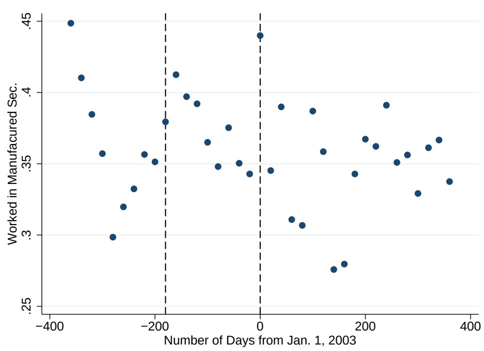
(a) Number of Days Between Job Loss and Initial Claim



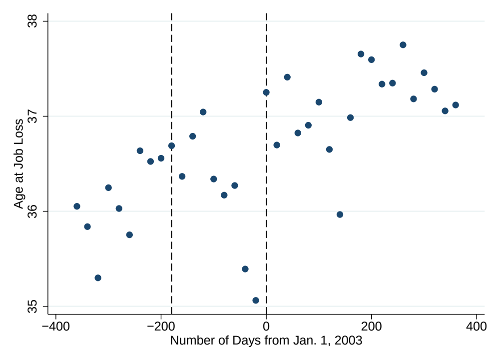

(b) Female



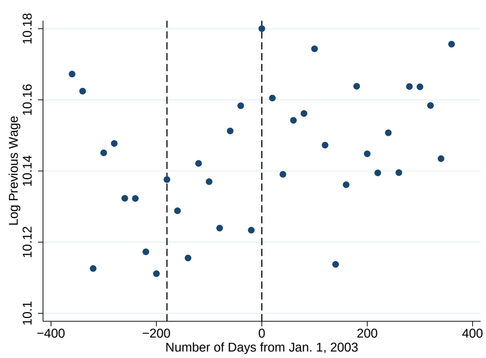

(c) Worked in Manufacturing Sector (Last Job)



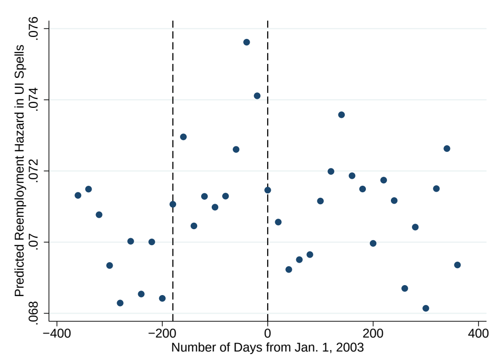

(d) Age at Job Loss




(e) Average Log Monthly Wage Prior to Layoff

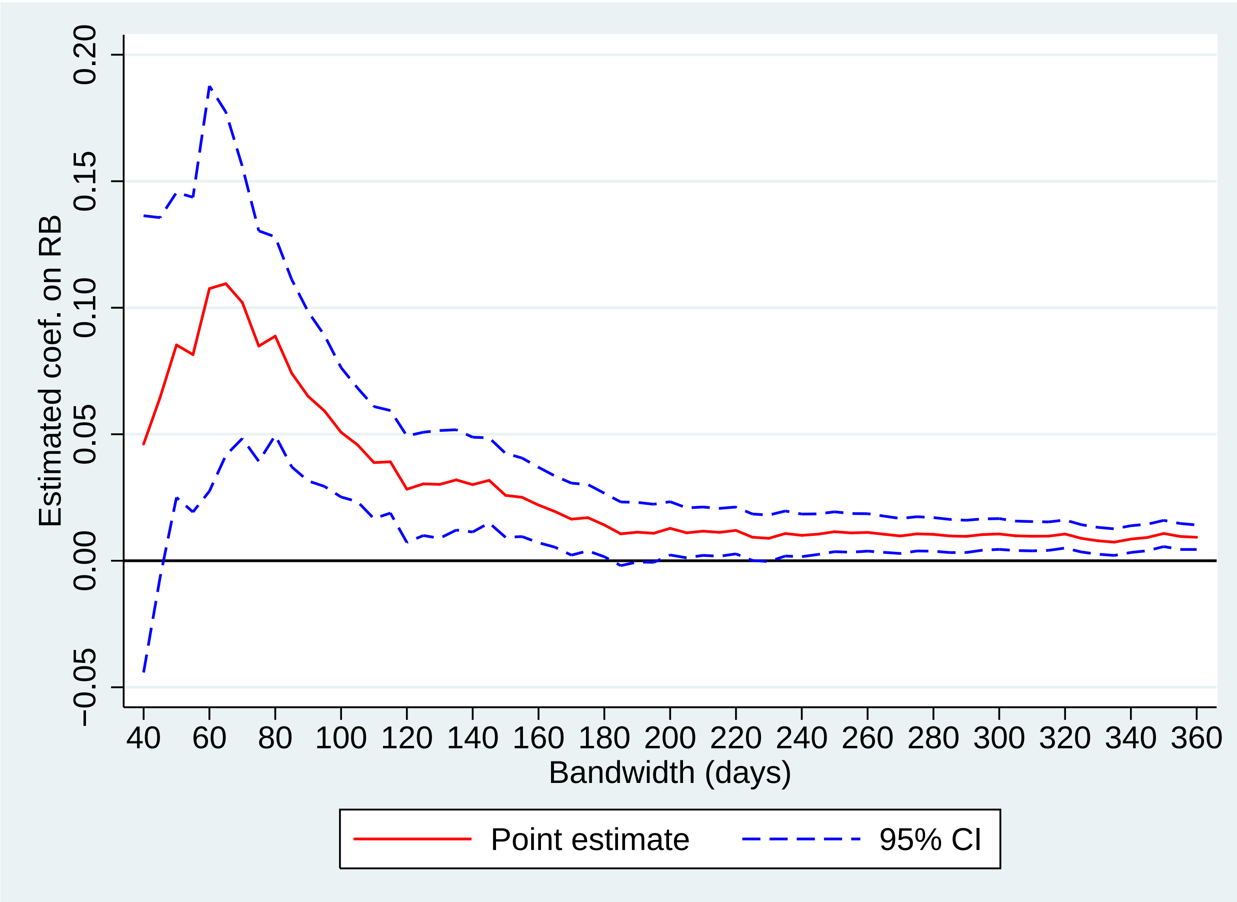



(f) Predicted Average Reemployment Hazard in the First 6 Months



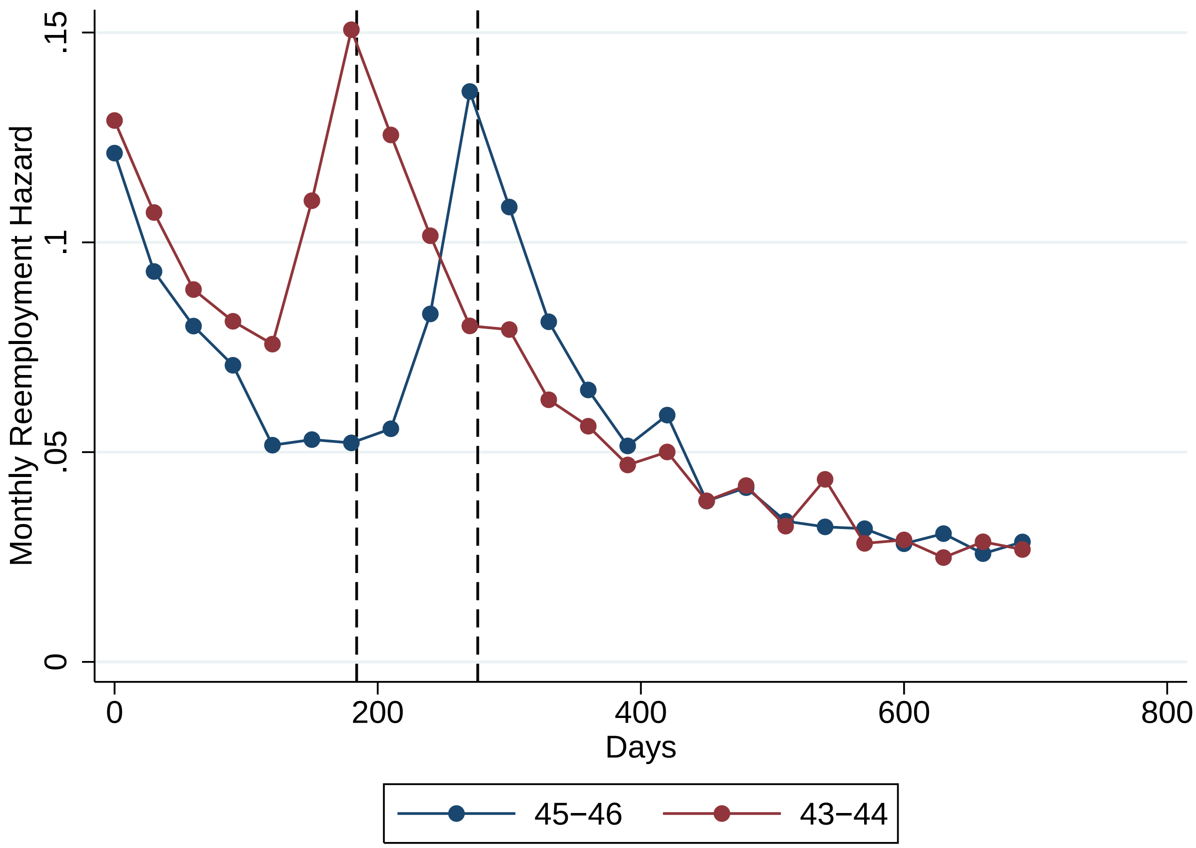

Notes: This graph plots the means of observables against the number of days between Jan. 1, 2003 and the date UI spells started. The sample include every UI spell started within 360 days from Jan. 1, 2003. Each bin corresponds to the total number of workers starting UI spells within a 30 days interval. The first dash line indicates June 1, 2002, 6 months before the bonus program began. The second line indicates Jan. 1, 2003, the date bonus program began.

Figure 10: RK Estimates with Varying Bandwidths Using Kink 1



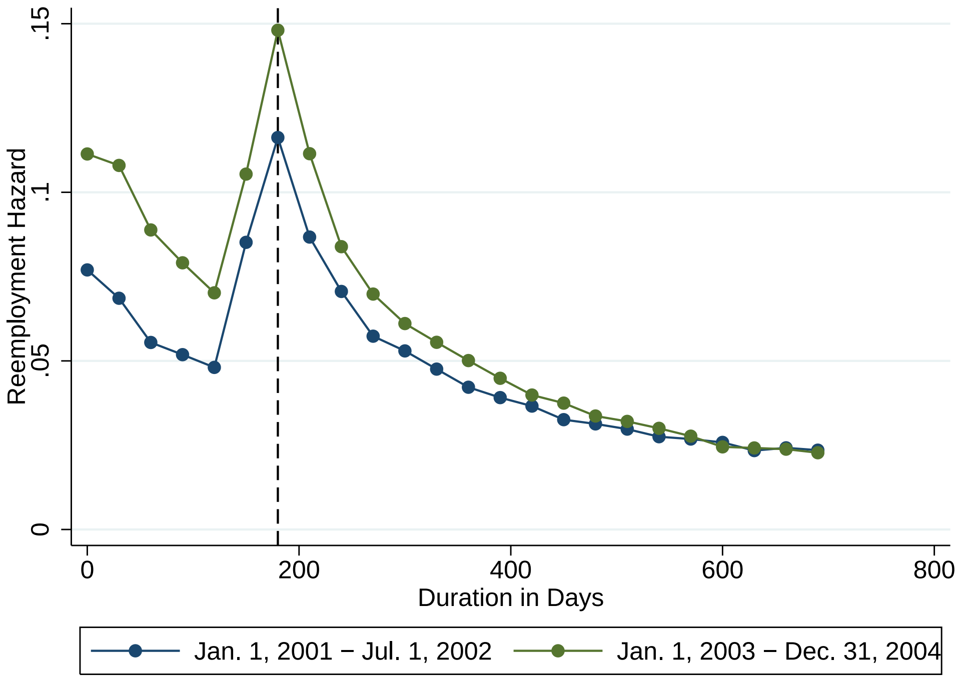

Notes: This figure test for the sensitivity to bandwidth choice for our RK estimates using kink 1. We estimate equation 6 using a bandwidth ranging from 40 to 170 days. The solid line indicates the point estimates, and the dash lines are corresponding confidence intervals.

Figure 11: Monthly Reemployment Hazard for Workers Aged 43-44 and 45-46




Notes: This figure plots the monthly reemployment hazard for workers aged 43-44 at job loss and those aged 45-46 at job loss. The sample are from workers staring nonemployment spell between May 1, 2009 and January 1, 2012. The first dash line indicates the end of 6th month in the spell, while the second dash line indicates the end of 9th month.

Figure 12: Reemployment Hazard over the Nonemployment Spell for Cohorts not Exposed, Partially Exposed, and Fully Exposed to the Bonus Program




Notes: This figure plots the reemployment hazard over the nonemployment spell for cohorts entering UI during three different time periods. The blue line is the hazard function for workers entering UI between January 1, 2001 and July 1, 2002. The red line is the hazard function for workers entering UI between July 1, 2002 and January 1, 2003. The green line uses is the hazard function for workers entering UI between January 1, 2003 and December 31, 2004. The dashed line indicates the 180th day of the nonemployment spell.