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MORAL HAZARD VERSUS LIQUIDITY AND THE OPTIMAL TIMING OF UNEMPLOYMENT BENEFITS*

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We develop a novel way of identifying the liquidity and moral hazard effects of unemployment insurance exclusively from how job-finding rates respond to unemployment benefits that vary over an unemployment spell. We derive a sufficient statistics formula for the dynamically optimal level of unemployment benefits based on these two effects. Using a regression kink design (RKD) that simultaneously exploits two kinks in the schedule of unemployment benefits, we apply our method to Spain for the years 1992–2012 and find that moral hazard effects dominated liquidity effects, suggesting that Spanish unemployment benefits exceeded the optimal level in that period.

Unemployment insurance allows unemployed workers to smooth their consumption while unemployed, but also distorts the relative price of leisure and consumption, thus reducing the marginal incentive to search for a new job. Optimal unemployment insurance therefore needs to trade off the consumption-smoothing benefits with the moral hazard costs induced by the provision of insurance. Moral hazard is not easy to capture empirically: Chetty (2008) shows that moral hazard is not the only reason why unemployed workers reduce their job search intensity when they receive unemployment benefits. Part of their response is explained by a 'liquidity effect'; if financial markets are incomplete and unemployed workers are unable to borrow, then the unemployed will search for a job with an intensity that exceeds what would be optimal in an environment with complete markets. Raising the level of unemployment benefits in such a situation alleviates the incompleteness of financial markets by providing additional liquidity to unemployed workers. Therefore, in part, the reduction of search effort is not because of moral hazard, but because the environment moves in the direction of complete markets. As shown by

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Chetty (2008), in the presence of incomplete financial markets, the relative sizes of the moral hazard and liquidity effects determine the optimal level of unemployment insurance.

The analysis by Chetty (2008) focuses only on unemployment benefits that are constant during the unemployment spell. However, in many real-world unemployment insurance schemes benefits do not remain constant during the unemployment spell. This is the case in Spain where benefits decrease after an initial six-month period. Moreover, a broad theoretical literature (e.g., Hopenhayn and Nicolini, 1997) shows that time-varying unemployment benefits are usually optimal.[1]

In this paper, we empirically address the optimality of unemployment benefits that vary over time. We use economic theory and the institutional details of unemployment insurance in Spain and show how the liquidity and moral hazard effects of unemployment benefits can be identified given appropriate data. We then empirically estimate liquidity and moral hazard effects using a regression kink design (RKD) that exploits kinks in the schedule of unemployment benefits with respect to prior labour income. Armed with the resulting estimates, we calculate optimal unemployment insurance levels for Spain using a sufficient statistics formula that generalises that of Chetty (2008) to an environment in which unemployment benefits are allowed to vary over the unemployment spell.

The work closest to the objective of this paper is that of Kolsrud *et al.* (2018), who study the dynamic aspect of unemployment insurance and the optimal timing of unemployment benefits both theoretically and empirically, using administrative data for Sweden. However, their paper does not attempt to separate moral hazard and liquidity effects à la Chetty (2008), they identify the dynamic welfare benefits of unemployment insurance using consumption data (which they calculate as a residual). From a theoretical standpoint, the paper by Kolsrud *et al.* (2018) follows the line of Chetty (2006), who uses consumption expenditure data, rather than Chetty (2008), who uses labour market data exclusively. One of the drawbacks of using consumption expenditure is the need to assume a functional form for the utility function, including the level of risk aversion, and to restrict the ways in which utility differs between employed and unemployed workers.[2]

The main theoretical contribution of our paper is to provide a novel identification result of the moral hazard and liquidity effects of unemployment insurance which relies exclusively on variation of unemployment benefits during an unemployment spell. This differs from the identification of the effects by Chetty (2008) and Landais (2015) whose applications are tailored to the United States where unemployment benefits are flat during the unemployment spell. With flat benefits the response of hazard rates to unemployment benefits does not contain enough information to separate moral hazard and liquidity effects. Chetty (2008) resorts to the use of lump sum severance payments to approximate the liquidity effect and calculates the moral hazard effect as a residual whereas Landais (2015) uses changes in the length of the unemployment coverage periods as an approximation to changes in benefit levels in order to disentangle moral hazard and liquidity effects.

In contrast, in this paper we prove that when unemployment benefits vary over the unemployment spell, then moral hazard and liquidity effects can be identified directly from how the

[1] In contrast, in more recent work, Shimer and Werning (2008) show that when workers can borrow and save then economic theory implies that a constant or nearly constant scheme is optimal.

[2] Another issue that arises when relying on consumption is that the theoretical model from which the sufficient statistics optimality result is derived is formulated for an individual agent whereas consumption expenditure is usually measured at the household level and is difficult to assign to a particular household member.

hazard rate in the initial period of the unemployment spell responds to unemployment benefits. Starting from the environment modelled by Kolsrud *et al.* (2018), in which benefits change over time and exploiting intratemporal and intertemporal first-order conditions, we show that moral hazard and liquidity effects respond differently to payments that occur at different times during an unemployment spell. The intuition behind this result is that, as time progresses, it becomes more likely that a worker will have exited unemployment and, therefore, at the start of an unemployment spell, the moral hazard effect of unemployment insurance payments further in the future diminishes with respect to the liquidity effect. Benefits that vary over the unemployment spell are therefore composed of differing shares of moral hazard and liquidity components, and this different composition can be used to back out the unobservable moral hazard and liquidity effects that lead to an agent's optimal behaviour at the start of an unemployment spell.

The moral hazard and liquidity effects of unemployment insurance are identified from two estimates: the effect on the beginning-of-spell hazard rate of raising benefits in the first six months of the spell and the effect on this same beginning-of-spell hazard rate of raising benefits in the following 18 months.[3] An ideal experimental setting would have benefits increase in each of the two sub-periods for a random sample of the population and identify the effect by comparing treated with untreated workers. In lieu of this experimental design, we use a regression kink design (RKD). In Spain, unemployment benefits are tied to labour income over the 180 working days prior to the onset of unemployment but are capped above and below at an amount that is a multiple of an index called IPREM. These caps induce kinks in the relationship between income and benefits. Using these kinks, and the methodology described by Nielsen *et al.* (2010) and Card *et al.* (2015), and also used by Landais (2015), we estimate the parameters of interest using a sample of Spanish administrative social security data (*Muestra Continua de Vidas laborales*, MCVL).

Our estimates imply that the moral hazard effect is stronger than the liquidity effect in both periods. In our preferred specification, the response of the probability of finding a job to an increase in unemployment benefits in the first six-month period is composed of 87% moral hazard effect and 13% liquidity effect. For the subsequent 18 months in which unemployment benefits are at a lower level, the moral hazard effect amounts to 75% and the liquidity effect to 25% of the impact on the hazard rate. When these numbers are compared to the cost of providing additional insurance according to the sufficient statistics formula, our estimates imply that benefits are too high in both periods.

The paper proceeds as follows. In Section 1 we set up the model and derive our main identification result and the formula for optimal benefits. All proofs are relegated to the Online Appendix. In Section 2 we describe our empirical strategy and describe the context and the data used for our estimations. In Section 3 we report estimation results and apply our formula for optimal unemployment insurance for Spain. We conclude in Section 4.

1. Theory

The environment of our model is essentially that of Kolsrud *et al.* (2018) and differs from the model by Chetty (2008) and Landais (2015) because unemployment benefits are allowed to vary over time.

[3] The model assumes that agents behave in a forward-looking manner. Forward-looking behaviour has been documented for various optimal choices by Spanish households by Campos and Reggio (2015) and Barceló and Villanueva (2016), and by Rebollo-Sanz and Rodríguez-Planas (2020) for unemployment durations.

1.1. *Environment*

1.1.1. *Choices, constraints and preferences*

In the model, time is discrete and indexed by $t = 0, 1, \ldots, T$. There is a continuum (mass 1) of agents indexed by i. In each period t, an agent i can be in one of two mutually exclusive states: employed or unemployed. At $t = 0$ the agent is initially unemployed. Starting at $t = 0$, the worker transitions into employment in the next period with a probability $h_{i,t+1} \in [0, 1]$ that depends on an individual choice of search effort $s_{i,t+1} \geq 0$. We assume that the function that maps search effort to the probability of becoming employed satisfies $h'_{i,t+1}(s) > 0$ and $h''_{i,t+1}(s) \leq 0$. Employment is an absorbing state, so that—once employed—the probability of transitioning back into unemployment is zero. For later use, we denote the probability of being unemployed (the individual survival rate) at date $t \geq 1$ by $S_{i,t} = \prod_{j=1}^{t}(1 - h_{i,j}(s_{i,j}))$. The population survival rate is given by $S_t = \int S_{i,t}\, di$. Because all agents start out unemployed, $S_0 = S_{i,0} = 1$.

Agents have time-separable preferences with a common discount factor $\beta \in (0, 1]$. They choose consumption (in the employed and in the unemployed state) and search effort (in the unemployed state). A random variable $\omega_{i,t}$ collects the history up to time t of all information relevant for the agent's decision problem. The initial condition $\omega_{i,0}$ is taken as given by agents in their optimisation problem and may, in principle, differ across agents.[4] We use the notation $\mathbb{E}_t$ to denote the expectation of variables over possible values taken by the random variable ω_{t+1} conditional on all information available at time t.

Unemployed agents have a period utility function given by $v_i^u(c, s)$, which depends positively on the level of consumption c and negatively on search effort s. We assume that this function is strictly concave in consumption and strictly convex in search effort. Like Chetty (2008), we assume that this function is separable in consumption and search effort, although not all the results that we report depend on that.[5] Employed agents have a period utility function $v_i^e(c)$ that is increasing and concave in consumption.[6]

Agents receive a wage w_t and pay a lump sum tax τ in periods in which they are employed. When unemployed, agents do not earn a wage and receive unemployment benefits $b_t \geq 0$ instead. Unemployment benefits depend on the length of the unemployment spell and are equal to zero once unemployment benefits are exhausted. Agents, both employed or unemployed, borrow or save using assets $a_{i,t}$ that yield a net return r in the next period, which is constant and known beforehand. They face a borrowing limit: $a_{i,t} \geq \bar{a}$ and may also receive non-labour income y_t, which is independent of the employment state of the agent. The possibility of receiving non-labour income allows for a clean way of expressing the moral hazard and liquidity effects, disentangling them from intertemporal consumption smoothing. At the cost of including an additional variable, we will show that the decomposition into liquidity and moral hazard effects holds in a more general environment than the one considered by Chetty (2008).[7]

[4] For some of our results (Proposition 2) we will assume an *ex ante* homogeneous population, with $\omega_{i,0} = \omega_0$.

[5] The result in Lemma 1, for example, does not require this assumption.

[6] Notice that our set-up allows for the case in which the period utility function when employed is the same function as when unemployed, when evaluated at $s = 0$, but also the case where they are completely different functions.

[7] Notice that the model does not impose any particular value for y_t, or even that it is different from zero. The model just adds the *possibility* of receiving unconditional payments to the environment of Chetty (2008).

Formally, the agent's problem can be expressed as a recursive problem using two value functions: one for the unemployed state,

$$\begin{aligned} V^u_{i,t}(\omega_{i,t}) = \max\ & v^u_i(c^u_{i,t}(\omega_{i,t}), s_{i,t+1}(\omega_{i,t})) \\ & + h_{i,t+1}(s_{i,t+1}(\omega_{i,t}))\beta \mathbb{E}_t V^e_{i,t+1}(\omega_{i,t+1}) \\ & + (1 - h_{i,t+1}(s_{i,t+1}(\omega_{i,t})))\beta \mathbb{E}_t V^u_{i,t+1}(\omega_{i,t+1}), \end{aligned} \tag{1}$$

subject to

$$a_{i,t+1}(\omega_{i,t}) = (1+r)a_{i,t}(\omega_{i,t-1}) + b_t - c^u_{i,t}(\omega_{i,t}) + y_t \tag{2}$$

$$a_{i,t+1}(\omega_{i,t}) \geq \bar{a}, \tag{3}$$

and one for the employed state,

$$V^e_{i,t}(\omega_{i,t}) = \max v^e_i(c^e_{i,t}(\omega_{i,t})) + \beta \mathbb{E}_t V^e_{i,t+1}(\omega_{i,t+1}), \tag{4}$$

subject to

$$a_{i,t+1}(\omega_{i,t}) = (1+r)a_{i,t}(\omega_{i,t-1}) + w_t - \tau - c^e_{i,t}(\omega_{i,t}) + y_t \tag{5}$$

$$a_{i,t+1}(\omega_{i,t}) \geq \bar{a}. \tag{6}$$

Each agent i solves the problem in equations (1) through (6) by choosing the sequences $\{c^u_{i,t}(\omega_{i,t}), c^e_{i,t}(\omega_{i,t}), s_{i,t+1}(\omega_{i,t}), a_{i,t+1}(\omega_{i,t})\}$, with initial conditions $\omega_{i,0}$ and $a_{i,0}$, taking as given the parameters $\{w_t, b_t, y_t\}, \tau, r, \bar{a}$.

1.1.2. *The unemployment insurance scheme and the planner's problem*

Unemployed agents receive benefits starting at $t = 1$.[8] They are set at $\bar{b}_1 > 0$ for the first B_1 periods in which the worker is unemployed and at $\bar{b}_2 > 0$ for the next B_2 periods; after that they revert to zero.[9] Therefore, unemployment insurance payments last potentially for $B \equiv B_1 + B_2$ periods and the stream of duration-dependent unemployment benefits is described by the following T-dimensional vector:

$$\mathbf{b} = (\underbrace{\bar{b}_1, \ldots, \bar{b}_1}_{1,\ldots,B_1}, \underbrace{\bar{b}_2, \ldots, \bar{b}_2}_{B_1+1,\ldots,B_1+B_2}, \underbrace{0, \ldots, 0}_{B_1+B_2+1,\ldots,T}). \tag{7}$$

Following Kolsrud *et al.* (2018), and given the two-part benefit structure, the planner's budget constraint can be expressed in terms of population survival rates and the exogenous interest rate r as follows:

$$G(\mathbf{b}, \tau) \equiv \tau \sum_{t=1}^{T}(1+r)^{-t}(1 - S_t) - \bar{b}_1 \sum_{t=1}^{B_1}(1+r)^{-t} S_t - \bar{b}_2 \sum_{t=B_1+1}^{B_1+B_2}(1+r)^{-t} S_t = \bar{G}, \tag{8}$$

where $\bar{G}$ is an exogenous budget target.

The planner chooses unemployment insurance parameters $(\mathbf{b}, \tau)$ to maximise the integral in (9) over expected utilities of agents at date 0 subject to the intertemporal budget constraint (8).

[8] Agents start out unemployed at $t = 0$ and it takes at least a period to become employed. Therefore, benefits obtained at $t = 0$ would not have any incentive effect on search behaviour in that period, which is why we assume that unemployment benefits start at $t = 1$.

[9] The model can be easily extended to benefits that take more than two possible positive values.

Formally, the objective function of the planner is given by:

$$V^P(\mathbf{b}, \tau) = \int V^u_{i,0}(\omega_{i,0})\, di + \lambda \left(G(\mathbf{b}, \tau) - \bar{G} \right). \tag{9}$$

1.2. *Liquidity and Moral Hazard*

The response of agents to changes in the level of unemployment benefits in any future period can be decomposed into a liquidity and a moral hazard component. The following lemma proves that the standard decomposition by Chetty (2008, eq.8) holds in our model.

LEMMA 1. *The effect of increasing current or future unemployment benefits on the probability of exiting unemployment at date $t = 1$ can be decomposed into a liquidity effect and a moral hazard component:*

$$\frac{\partial h_{i,1}(s_{i,1})}{\partial b_j} = \frac{\partial h_{i,1}(s_{i,1})}{\partial y_j} - \frac{\partial h_{i,1}(s_{i,1})}{\partial w_j}, \quad j \geq 1. \tag{10}$$

An increase in the unemployment benefit level in any (current or future) period lowers *current* search intensity through two channels. The first channel is the liquidity component. Raising b_j raises income and relaxes the budget constraint. This allows the agent to maintain a higher level of consumption while unemployed and therefore reduces the urgency of finding a new job. Hence, the agent rationally lowers search effort and the likelihood of finding a job decreases. The liquidity component is captured in (10) by the expression $\partial h_{i,1}/\partial y_j \leq 0$, which measures the effect of an unconditional payment y_j on the probability of exiting unemployment. The second component, $-\partial h_{i,1}/\partial w_j < 0$, is due to a standard moral hazard response; a higher benefit reduces the incentive to search for a job because it raises the value of being unemployed relative to that of working.

The decomposition in Lemma 1 does not require the assumption that utility is separable in consumption and search effort. An intuitive way of seeing why this must happen, is to take a perspective that is usual in the finance literature. Consider the question of how an agent responds to receiving an extra dollar j periods in the future when this dollar can be paid through instruments that pay off in different states of the world. Non-labour income y_j pays off in all possible states of the world; the unemployment benefit b_j pays off only in the unemployed state and the wage w_j pays off only in the employed state. Because employment and unemployment exhaust all possibilities, increasing b_j by one dollar is equivalent to increasing y_j by one dollar while simultaneously reducing w_j by one dollar. Therefore, a forward-looking agent responds by choosing a search effort in the same way when faced with either of these two alternatives.

In our formula, we express the liquidity component in terms of changes in the flow variable y instead of assets a. This shows that the decomposition is essentially an intratemporal relationship, in the sense that it is not directly affected by details on how consumption can be smoothed intertemporally. For example, it does not depend directly on the value of the interest rate r or the discount factor β. However, as the time horizon under consideration varies, an agent's optimal intertemporal choices imply that the magnitudes of the liquidity and moral hazard components follow a certain pattern. Indeed, as shown in the next lemma, an agent's optimal behaviour at the start of an unemployment spell implies that the moral hazard component wears off more rapidly than the liquidity component. This is a direct consequence of the fact that survival rates are decreasing. Lemma 2 proves that a result derived in the Online Appendix of Landais (2015) for the environment of Chetty (2008) also holds in our model.

LEMMA 2. *If the borrowing constraint is slack in periods $t = 1, \ldots, 1 + j$, then*

$$\frac{\partial h_{i,1}}{\partial y_{j+1}} = \frac{\partial h_{i,1}}{\partial y_1}(1+r)^{-j}, \quad j \geq 0, \tag{11}$$

and

$$\frac{\partial h_{i,1}}{\partial w_{j+1}} = \frac{\partial h_{i,1}}{\partial w_1}\frac{S_{i,j+1}}{S_{i,1}}(1+r)^{-j}, \quad j \geq 0. \tag{12}$$

The result in (11) states that, if the borrowing constraint does not bind, then raising non-labour income y now, or j periods from now, impacts optimal search behaviour in exactly the same way if this income has the same present value. The agent's ability to smooth consumption intertemporally implies that the agent's choices cannot be improved upon by reallocating resources purely across periods. A key fact behind the result in (11) is that the payment of y is unconditional, i.e., it does not depend on the realisation of a particular state of the world.

In contrast, the relationship in (12) depends on survival rates because wages are not an unconditional payment. An extra dollar in wages leads to a payment only in the states of the world in which the agent is employed. Therefore, the receipt of this dollar earlier or later is not a purely intertemporal reallocation. Raising the wage after j periods distorts the consumption-search choice only to the extent that the agent expects to still be unemployed. Because the probability of being unemployed decreases with the horizon j, as the agent has had more opportunities to reach the employed state, the moral hazard component weakens for periods that lie further in the future. The rate at which it weakens is given by $S_{i,j+1}/S_{i,1}$. This ratio equals period j's probability of being unemployed in the future conditional on being unemployed in the present (Period 1 in our case), as measured by the individual survival rates.

Whereas Lemma 1 decomposes the full impact of a change in benefits into liquidity and moral hazard components for a single period, in a two-level unemployment scheme, like (7), benefits change in multiple periods simultaneously. By summing (10) over several periods, the liquidity and moral hazard *effects* of changes in $\overline{b}_1$ and $\overline{b}_2$ can therefore be expressed as sums of the per-period liquidity and moral hazard components:[10]

$$\frac{\partial h_{i,1}}{\partial \overline{b}_1} = \sum_{t=1}^{B_1} \frac{\partial h_{i,1}}{\partial b_t} = \underbrace{\sum_{t=1}^{B_1} \frac{\partial h_{i,1}}{\partial y_t}}_{LIQ_{i,1}} - \underbrace{\sum_{t=1}^{B_1} \frac{\partial h_{i,1}}{\partial w_t}}_{MH_{i,1}} \tag{13}$$

$$\frac{\partial h_{i,1}}{\partial \overline{b}_2} = \sum_{t=B_1+1}^{B_1+B_2} \frac{\partial h_{i,1}}{\partial b_t} = \underbrace{\sum_{t=B_1+1}^{B_1+B_2} \frac{\partial h_{i,1}}{\partial y_t}}_{LIQ_{i,2}} - \underbrace{\sum_{t=B_1+1}^{B_1+B_2} \frac{\partial h_{i,1}}{\partial w_t}}_{MH_{i,2}}. \tag{14}$$

Lemma 2, which states that the moral hazard component wears off more rapidly than the liquidity component, implies that the relative importance of the moral hazard effect will be larger when considering a raise in benefits at the start of the unemployment spell ($\overline{b}_1$), rather than later

[10] We distinguish liquidity and moral hazard *components*, which refer to a single period, from liquidity and moral hazard *effects*, which refer to the decomposition related to changes in $\overline{b}_1$ and $\overline{b}_2$, affecting various periods simultaneously.

in the unemployment spell ($\overline{b}_2$). Because of this, it is reasonable to expect that liquidity and moral hazard effects can be disentangled in unemployment insurance schemes where unemployment benefits vary over time. We formally prove this result and derive the formulas for liquidity and moral hazard effects in Proposition 1. The proof is in the Online Appendix. Following Chetty (2008) and Kolsrud *et al.* (2018) from now on, for simplicity, we focus on the special case in which $r = 0$ and denote durations $D_i = \sum_{t=1}^{T} S_{i,t}$, $D_{i,1} = \sum_{t=1}^{B_1} S_{i,t}$, $D_{i,2} = \sum_{t=B_1+1}^{B_1+B2} S_{i,t}$.[11]

PROPOSITION 1. *If the borrowing constraint does not bind, then the expressions for the liquidity and moral hazard effects defined in (13) and (14) are given by:*

$$\begin{aligned}
LIQ_{i,1} &= \sum_{t=1}^{B_1} \frac{\partial h_{i,1}}{\partial y_t} = \frac{B_1}{B_2 D_{i,1} - B_1 D_{i,2}} \left(D_{i,1} \frac{\partial h_{i,1}}{\partial \overline{b}_2} - D_{i,2} \frac{\partial h_{i,1}}{\partial \overline{b}_1} \right)\\
MH_{i,1} &= \sum_{t=1}^{B_1} \frac{\partial h_{i,1}}{\partial w_t} = \frac{D_{i,1}}{B_2 D_{i,1} - B_1 D_{i,2}} \left(B_1 \frac{\partial h_{i,1}}{\partial \overline{b}_2} - B_2 \frac{\partial h_{i,1}}{\partial \overline{b}_1} \right)\\
LIQ_{i,2} &= \sum_{t=B_1+1}^{B_1+B_2} \frac{\partial h_{i,1}}{\partial y_t} = \frac{B_2}{B_2 D_{i,1} - B_1 D_{i,2}} \left(D_{i,1} \frac{\partial h_{i,1}}{\partial \overline{b}_2} - D_{i,2} \frac{\partial h_{i,1}}{\partial \overline{b}_1} \right)\\
MH_{i,2} &= \sum_{t=B_1+1}^{B_1+B_2} \frac{\partial h_{i,1}}{\partial w_t} = \frac{D_{i,2}}{B_2 D_{i,1} - B_1 D_{i,2}} \left(B_1 \frac{\partial h_{i,1}}{\partial \overline{b}_2} - B_2 \frac{\partial h_{i,1}}{\partial \overline{b}_1} \right).
\end{aligned} \tag{15}$$

Proposition 1 proves that with just two levels of unemployment insurance the unobservable liquidity and moral hazard effects can be identified solely from data on unemployment spells.[12] Given estimates of $\partial h_1/\partial \overline{b}_1$ and $\partial h_1/\partial \overline{b}_2$, an agent's liquidity and moral hazard effect can be computed from observable durations $D_{i,1}$ and $D_{i,2}$ and the known entitlement periods B_1 and B_2 using the equations in (15). We will describe how to estimate $\partial h_1/\partial \overline{b}_1$ and $\partial h_1/\partial \overline{b}_2$ in Section 2, but first we show how liquidity and moral hazard effects characterise optimal unemployment benefit levels.

1.3. *Optimal Unemployment Benefits*

We now turn to the normative implications of the model and derive a sufficient statistics formula that determines optimal unemployment insurance. In the spirit of the model by Chetty (2008), we assume that agents are *ex ante* homogeneous; they are homogeneous (also in their preferences) at date $t = 0$, but experience idiosyncratic realisations of the individual random variable $\{\omega_{i,t}\}_{t=1}^{T}$. Because liquidity and moral hazard effects refer to choices at the start of an unemployment spell (they decompose the impact of future variables on the job-finding rate at the start of the unemployment spell), when all agents are identical, *ex ante* homogeneity implies that liquidity and moral hazard effects are equal across agents. We therefore express liquidity and moral hazard

[11] The expressions for the general case with $r > 0$ are derived in the proof of the proposition as well.

[12] As pointed out by an anonymous referee, almost all countries can be thought of as having a dual system of unemployment insurance once welfare programmes, often called unemployment assistance supporting long-term unemployed who exhausted their benefits, are taken into account. Therefore, another way of reading the paper is that it offers a way of jointly designing the unemployment insurance and assistance programmes.

effects as LIQ_1 and MH_1, and LIQ_2 and MH_2, removing the subscript i. Population averages of individual durations are computed as $D = \int D_i \, di$, $D_1 = \int D_{1,i} \, di$, and $D_2 = \int D_{i,2} \, di$.[13]

With this notation, the following proposition states our normative theoretical result on the optimality of unemployment benefits.

PROPOSITION 2. *If agents are ex ante homogeneous and $r = 0$, then optimality of $\overline{b}_1$ and $\overline{b}_2$ requires*

$$R_1 \equiv -\frac{LIQ_1}{MH_1} = \varepsilon_{D_1,\overline{b}_1} + \frac{\overline{b}_2 D_2}{\overline{b}_1 D_1}\varepsilon_{D_2,\overline{b}_1} + \frac{\tau D}{\overline{b}_1 D_1}\varepsilon_{D,\overline{b}_1} \tag{16}$$

$$R_2 \equiv -\frac{LIQ_2}{MH_2} = \varepsilon_{D_2,\overline{b}_2} + \frac{\overline{b}_1 D_1}{\overline{b}_2 D_2}\varepsilon_{D_1,\overline{b}_2} + \frac{\tau D}{\overline{b}_2 D_2}\varepsilon_{D,\overline{b}_2}, \tag{17}$$

where $\varepsilon_{x,b}$ denotes the elasticity of a variable x with respect to b.

The formula in Proposition 2 combines the liquidity and moral hazard effects with high-level elasticities and can be used to empirically assess whether unemployment benefits are at their optimal levels in a sufficient statistics framework.[14] The liquidity and moral hazard effects are identified from the beginning-of-spell hazard rates using Proposition 1 whereas the elasticities can be estimated from unemployment durations. The ratios $R_k = -LIQ_k/MH_k$, for $k = 1, 2$, on the left-hand side of the optimality conditions, capture the social marginal benefit of increasing unemployment insurance. If liquidity effects predominate, then insurance is more valuable. The right-hand side captures social marginal costs of raising the level of unemployment insurance because of the ensuing increase in unemployment durations.[15] At the optimum, marginal benefits and marginal costs coincide.

The formula generalises the result that Chetty (2008) derived for the case of a constant benefit level and a balanced budget. A constant benefit level is obtained in our environment by setting $\overline{b}_1 = \overline{b}$ and $\overline{b}_2 = 0$. A balanced budget implies that $G(\mathbf{b}, \tau) = \bar{G} = 0$. Imposing these two conditions simplifies the condition for optimality to

$$R = -\frac{LIQ}{MH} = \varepsilon_{D_B,\overline{b}} + \frac{D}{T - D}\varepsilon_{D,\overline{b}}. \tag{18}$$

Chetty further assumes for simplicity that $\varepsilon_{D_B,\overline{b}} = \varepsilon_{D,\overline{b}}$. Imposing this additional equality in (18) leads to (19), and coincides with the result by Chetty (2008, eq.14), according to which benefits are at their optimal level if and only if

$$R = -\frac{LIQ}{MH} = \frac{T}{T - D}\varepsilon_{D,\overline{b}}. \tag{19}$$

1.4. *Discussion of Assumptions*

1.4.1. *Heterogeneity*

The theoretical decomposition in Proposition 1 applies to each individual agent i and therefore holds for arbitrary degrees of heterogeneity in the population. Proposition 2, however, allows

[13] Notice that *ex ante* homogeneity also implies that all agents share the same *ex ante* expected durations D_i, $D_{i,1}$, and $D_{i,2}$.

[14] The conditions in the proposition are necessary for an optimum. Sufficiency is obtained by requiring that the budget constraint $G(\mathbf{b}, \tau) = \bar{G}$ holds.

[15] As shown by Kolsrud *et al.* (2018), when there are multiple levels of unemployment benefits, the costs of raising unemployment benefits contain cross-period elasticities of the form $\frac{\overline{b}_{k'} D_{k'}}{\overline{b}_k D_k}\varepsilon_{D_{k'},\overline{b}_k}$ ($k' \neq k$), as is the case here.

only for *ex post* heterogeneity, because it assumes that agents are homogeneous from an *ex ante* perspective. The assumption of *ex ante* homogeneity may not seem too strong at first sight, as it allows for widely different final outcomes across the population, and also that the agents' dislike for search effort differs in all but the initial period. However, it does impose requirements that may not be immediately obvious and which may not hold in practice; for example, the requirement that all agents start from the same initial conditions implies that they start with the same level of initial assets. This leads to the question of whether the assumption of *ex ante* homogeneity can be relaxed in certain special cases.

An interesting special case in which the *ex ante* homogeneity assumption can be dispensed with is an environment like that of Chetty (2008), with preferences that are separable in consumption and search effort and where search effort determines the probability of finding a job in a linear way. In such an environment, as we state in the following proposition, a quadratic specification of the disutility of search effort yields the same optimality conditions as Proposition 2 without requiring that all agents start out with the same initial conditions.

PROPOSITION 3. *Assume that liquidity and moral hazard effects* $\{LIQ_k, MH_k\}_{k\in\{1,2\}}$ *are known,* $r = 0$, *and that* $\forall i\colon h_{i,t}(s) = s$, $v_i^e(c) = \hat{v}^e(c)$, $v_i^u(c, s) = \hat{v}^u(c) - \frac{1}{2}\psi s^2$, $\psi > 0$. *Then, as in Proposition 2, optimality of* $\overline{b}_1$ *and* $\overline{b}_2$ *implies (16) and (17).*

There may also be other configurations of the environment and preferences that lead to the same optimality conditions, or configurations involving more heterogeneity that lead to different but still tractable expressions. For example, if agents differ in first-period job search disutility or have different search effort productivities, then the population-wide liquidity and moral hazard terms that are required for Proposition 2 would be calculated as the weighted average over their individual counterparts, where the weights would reflect the cross-sectional distribution of the parameters that govern this additional heterogeneity. Because the details depend on the type of heterogeneity that is assumed, we do not pursue this further as it is beyond the scope of this paper.

The takeaway from this discussion is that our normative theoretical result concerning the characterisation of optimal unemployment insurance is less general, as it depends on a certain degree of homogeneity in the population, than the positive result regarding the decomposition of benefit changes into liquidity and moral hazard effects.

1.4.2. *Endogenous ex ante behaviour*

We do not model behaviour before the onset of unemployment. The extension of the model to *ex ante* behaviour is analysed by Chetty (2008) and his results carry over to our setting. If behaviour prior to job loss is invariant with respect to unemployment benefit levels, then all results in the paper remain unchanged. If this is not the case, and agents' pre-unemployment behaviour responds to benefit levels, then initial conditions $\omega_{i,0}$ and $a_{i,0}$ become functions of $\overline{b}_1$ and $\overline{b}_2$ in our model. However, as noted by Chetty (2008), the theoretical formulas derived without *ex ante* behaviour generalise to the case with *ex ante* behaviour provided that the derivatives and elasticities with respect to $\overline{b}_1$ and $\overline{b}_2$ are calculated conditioning on fixed values of $\omega_{i,0}$ and $a_{i,0}$.

With this interpretation of the theory, the possibility of endogenous *ex ante* behaviour makes the estimation of the parameters of interest for the model more demanding. For example, cross-sectional comparisons between agents with different benefit levels, or estimations exploiting anticipated changes in benefits, might be driven by the characteristics in $\omega_{i,0}$ that are unobservable to the econometrician. In our application, we use an RKD to attempt to overcome the problem posed by unobserved heterogeneity.

1.4.3. *Hand-to-mouth consumers*

In the model, agents are forward-looking and they choose their actions expecting to be able to smooth consumption during the unemployment spell. Our results, except for Lemma 1, require that at the start of an unemployment spell agents expect that they will not hit the borrowing constraint and will be able to smooth consumption in the future. If agents expect to reach the borrowing limit in any future period, then their search behaviour will not be responsive to payments received from that period onward.

The magnitude of the liquidity effect is likely to be underestimated relative to the moral hazard effect for agents who expect to reach the borrowing limit during the unemployment spell because they will exhibit a weaker response of search effort to future benefit levels. This muted response is more important for changes in $\overline{b}_2$ because these benefits lie further in the future. Through the lens of the model, a weaker response to $\overline{b}_2$ (whose moral hazard effect is more diluted than $\overline{b}_1$) translates into a lower estimate of the liquidity effect, both in the first and the second period.[16] In practical terms, the estimate of the liquidity effect from Proposition 1 is therefore a lower bound of the true value in a population in which agents expect to become hand-to-mouth consumers during the unemployment spell.

2. Empirical Implementation: Strategy, Context and Data

2.1. *Empirical Objects of Interest*

We estimate the effect of variation in unemployment benefit levels on a number of outcome variables. To separate liquidity from moral hazard effects (Proposition 1), the variables of interest are $\partial h_1/\partial \overline{b}_1$ and $\partial h_1/\partial \overline{b}_2$: the effect of changing unemployment benefit levels in each period on the hazard of exiting unemployment at the beginning of an unemployment spell. To evaluate the normative theoretical result (Proposition 2), it is necessary to obtain estimates of the effect of $\overline{b}_1$ and $\overline{b}_2$ on D_1, D_2, and D: the expected unemployment duration while on benefits $\overline{b}_1$ and $\overline{b}_2$ and the total expected unemployment duration.

2.2. *Empirical Strategy*

To estimate the effect of benefit levels on the variables of interest we exploit the piece-wise linear kinked relationship between pre-unemployment labour income and the level of unemployment benefits. We exploit two kinks that arise due to a change in replacement rates during the unemployment spell. This strategy, termed the regression kink design (RKD), is a close relative of a regression discontinuity design, and has been used in the context of unemployment benefits by Landais (2015) for the United States, and by Card *et al.* (2015) for Austria. One of the advantages of the RKD is that the source of variation in unemployment benefits is time-invariant. In

[16] This can be shown formally by starting from the expressions in Proposition 1 and realising that the partial derivatives of $R_1 = -LIQ_1/MH_1$ and $R_2 = -LIQ_2/MH_2$ with respect to the magnitude of $\partial h_{i,1}/\partial \overline{b}_2$ are positive. Therefore, a muted response of search effort to changes in $\overline{b}_2$ (holding constant the response to $\overline{b}_1$) decreases the relative importance of the liquidity effect in both periods.

contrast, empirical strategies that use changes in legislation over time, face the potential pitfall that changes in legislation might be endogenous to labour market conditions.

2.2.1. *Regression kink design in the presence of one kink*

In the standard RKD, Y is an outcome of interest, V is an observed 'running variable' (labour income prior to the unemployment spell in our case) that affects Y through a smooth function $g(V)$ and $b(V)$ is the observed variable of interest (unemployment benefits), which is a deterministic and continuous function of V with a kink at $V = \bar{v}$. The relationship between these variables is described by a constant-effect additive model:

$$Y = \theta b(V) + g(V) + \epsilon. \tag{20}$$

The logic of the RKD is that, given smoothness of $g(V)$ and the kink in $b(V)$ if $b(V)$ affects Y, then there ought to be a kink in the relationship between V and Y at the point $V = \bar{v}$. As shown by Card *et al.* (2015), the coefficient of interest θ in (20) can then be calculated from

$$\theta = \frac{\lim\limits_{v_0 \to \bar{v}^+} \left.\dfrac{dE[Y|V = v]}{dv}\right|_{v=v_0} - \lim\limits_{v_0 \to \bar{v}^-} \left.\dfrac{dE[Y|V = v]}{dv}\right|_{v=v_0}}{\lim\limits_{v_0 \to \bar{v}^+} b'(v_0) - \lim\limits_{v_0 \to \bar{v}^-} b'(v_0)}. \tag{21}$$

The expressions $v_0 \to \bar{v}^+$ and $v_0 \to \bar{v}^-$ respectively indicate that right-hand side and left-hand side limits are taken.

The numerator in (21) is the change in the slope in the conditional expectation function at the location of the kink and the denominator is the change in the slope of the deterministic function $b(V)$ at the kink. The value of the denominator does not need to be estimated; it is determined by the known administrative rule for calculating unemployment benefits as a function of prior labour income. The numerator, however, is estimated using a specification of the form:

$$E[Y|V = v] = \alpha + \eta' X + \sum_{p=1}^{P} \gamma_p (v - \bar{v})^p + \sum_{p=1}^{P} \beta_p W (v - \bar{v})^p, \tag{22}$$

where Y and V are, as before, the outcome of interest and the running variable (always pre-unemployment labour income in our case), X stands for additional covariates, $\bar{v}$ is the level of the running variable at which the kink takes place and W is a dummy variable that takes the value one for observations above the kink and zero otherwise. This specification is estimated for observations with $|v - \bar{v}| \leq h$, where h is the bandwidth size. The numerator in (21) is captured by the coefficient β_1 in (22).

2.2.2. *Unemployment benefits in Spain*

In Spain, access to unemployment benefits requires that a worker has worked for at least 360 working days in the six-year period prior to becoming unemployed. Once unemployed, the worker is entitled to unemployment benefits for a period that ranges from 120 to 720 days, depending on the length of the worker's prior employment spells. To obtain the maximum entitlement of 720 days the worker must have worked during at least 2,160 days. These days are equivalent to six years in employment and they do not need to be consecutive. The level of benefits is based on labour earnings in the 180 working days (registered at the Social Security Administration) prior to the onset of unemployment. For the period we analyse, the level of benefits is set at

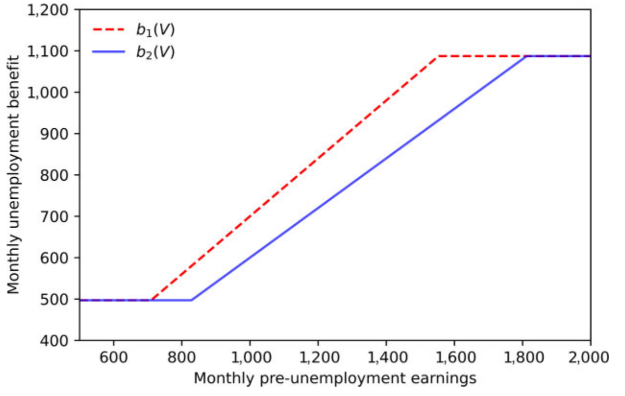


Fig. 1. *Unemployment Benefits as a Function of Pre-unemployment Earnings in Spain. We calculate unemployment benefits for an individual with no dependants using the value of the IPREM in 2011. The dashed line corresponds to the level of unemployment benefits in the first six months of unemployment. The solid line corresponds to unemployment benefits in the remainder of the unemployment spell. Both unemployment benefits and pre-unemployment earnings are expressed in euros.*

70% of prior labour income during the first six months in unemployment, and at 60% during the remainder of the period in which the worker is entitled to unemployment benefits.

Benefits are capped below and above by values b_{min} and b_{max} that depend on an index called IPREM, whose values are set by the government on a yearly basis. Minimum and maximum benefits are a function of IPREM and also of the worker having zero, one, or two or more dependants. A dependant is defined as someone who receives no income, lives with the person claiming unemployment and is less than 26 years old, or older than 26 but with a disability degree greater than 33%. The level of unemployment benefits depends on prior labour income V according to:

$$b_k(V) = \begin{cases} b_{min} & \text{if } V \times r_k \leq b_{min} \\ V \times r_k & \text{if } b_{min} < V \times r_k \leq b_{max} \\ b_{max} & \text{if } V \times r_k > b_{max} \end{cases}, \qquad k = 1, 2, \tag{23}$$

where b_{min} and b_{max} depend on the calendar year and the number of dependants, and $r_1 = 70\%$ and $r_2 = 60\%$ are the replacement rates. As an example, in Figure 1 we plot unemployment benefits as a function of prior labour income V, as in (23), for an individual without dependants using the value of the IPREM in 2011.

Figure 1 shows that the horizontal difference at b_{max} is larger than at b_{min}. Also, the number of workers in the sample at or close to the maximum kink is larger than at the minimum kink. For these reasons, in our estimations we will focus only on the kink at b_{max}.

2.2.3. *Regression kink design in the presence of two kinks*

Our application differs from a classical RKD design with just one kink. In our application, there are two variables of interest, $b_1(V)$ and $b_2(V)$, with kinks at two different points, $\bar{v}_1 = b_{max}/0.7$ and $\bar{v}_2 = b_{max}/0.6$, and therefore two parameters to be estimated, θ_1 and θ_2. The relation between these variables and the outcome Y is described by

$$Y = \theta_1 b_1(V) + \theta_2 b_2(V) + g(V) + \epsilon. \tag{24}$$

An observation in (24) is defined as an unemployment spell. Unemployment spells belong to one of three mutually exclusive groups. The first group contains unemployment spells with pre-unemployment earnings below the first kink, the second group contains those with pre-unemployment earnings above the first kink but below the second kink and the third group contains those with pre-unemployment earnings above the second kink. Formally:

$$Y = \begin{cases} \theta_1 r_1 V + \theta_2 r_2 V + g(V) + \epsilon & \text{if } V \leq \frac{b_{max}}{r_1} \\ \theta_1 b_{max} + \theta_2 r_2 V + g(V) + \epsilon & \text{if } \frac{b_{max}}{r_1} < V \leq \frac{b_{max}}{r_2} \\ \theta_1 b_{max} + \theta_2 b_{max} + g(V) + \epsilon & \text{if } V > \frac{b_{max}}{r_2} \end{cases}. \tag{25}$$

The parameters θ_1 and θ_2 can be recovered from comparing the slopes for different groups of unemployment spells. The derivative of the outcome variable with respect to the running variable for each group is:

$$\frac{\partial Y}{\partial V} = \begin{cases} \theta_1 r_1 + \theta_2 r_2 + g'(V) & \text{if } V \leq \frac{b_{max}}{r_1} \\ \theta_2 r_2 + g'(V) & \text{if } \frac{b_{max}}{r_1} < V \leq \frac{b_{max}}{r_2} \\ g'(V) & \text{if } V > \frac{b_{max}}{r_2} \end{cases}. \tag{26}$$

Subtracting the expression for the slopes for neighbouring groups in (26) leads to expressions composed of each of the parameters of interest θ_k multiplied by the corresponding replacement rate r_k:

$$\begin{aligned} \left.\frac{\partial Y}{\partial V}\right|_{\text{below kink 1}} - \left.\frac{\partial Y}{\partial V}\right|_{\text{above kink 1, below kink 2}} &= \theta_1 r_1 \\ \left.\frac{\partial Y}{\partial V}\right|_{\text{above kink 1, below kink 2}} - \left.\frac{\partial Y}{\partial V}\right|_{\text{above kink 2}} &= \theta_2 r_2. \end{aligned} \tag{27}$$

The specification adapted for our application with two kinks is

$$E[Y|V = v] = \alpha + \eta' X + \sum_{p=1}^{P} \gamma_p (v - k_1)^p + \sum_{j=1}^{2} \sum_{p=1}^{P} \beta_{jp} W_j (v - k_j)^p, \tag{28}$$

where Y and V are, as before, the outcome of interest and the running variable (pre-unemployment labour income), P is the order of the polynomial, X stands for additional covariates and W_j is equal to 1 if pre-unemployment income is above kink j ($v \geq k_j$). The numerator in (21) corresponds to the coefficients β_{j1}.

Using the specification in (28), the parameters of interest are recovered from the coefficients β_{11} and β_{21} by first computing the differences between the slopes and then equating the results to the expressions in (27).

Comparing the slopes leads to:

$$\left.\frac{\partial Y}{\partial V}\right|_{\text{below kink 1}} - \left.\frac{\partial Y}{\partial V}\right|_{\text{above kink 1, below kink 2}} = -\beta_{11}$$
$$\left.\frac{\partial Y}{\partial V}\right|_{\text{above kink 1, below kink 2}} - \left.\frac{\partial Y}{\partial V}\right|_{\text{above kink 2}} = -\beta_{21}. \tag{29}$$

The parameters of interest can then be found by combining (27) and (29):

$$\theta_1 r_1 = -\beta_{11}$$
$$\theta_2 r_2 = -\beta_{21}, \tag{30}$$

and solving these equations for known values $r_1 = 0.7$ and $r_2 = 0.6$.

As shown in (28) we estimate a single equation with two kinks whereas all the empirical RKD literature that we are aware of applies the methodology to a single kink. In a Monte Carlo exercise contained in the Online Appendix, we study whether estimating each kink separately would also have been a valid strategy. Our results imply that estimating one RKD per kink in an environment with two kinks, or simultaneously estimating both kinks, as we do, leads to equally precise estimates for the parameters of interest.

2.3. *Data*

We use data from the Continuous Sample of Working Histories (Muestra Continua de Vidas Laborales, MCVL). This is a dataset based on administrative records made available by the Spanish Social Security Administration (Ministerio de Inclusión, Seguridad Social y Migraciones, 2018). Each wave contains a random sample of 4% of all individuals who had some type of contact with the Social Security Administration, either by working or by receiving a contributory benefit (such as unemployment insurance, permanent disability insurance, old-age subsidies, etc.) during at least one day in the year from which the sample is selected.

The MCVL reconstructs the labour market histories of individuals in the sample back to 1967 (although data on earnings are available only starting in 1980). Moreover, this dataset has a yearly longitudinal structure, meaning that an individual who is present in any wave and remains registered at the Social Security Administration (registration is required to receive unemployment benefits) stays in the sample in subsequent waves. In addition, in each wave the sample is refreshed with new entrants to guarantee that the sample is representative of the population. We use 11 waves (2005–2015) in our estimations. Starting in 2005 ensures that only workers who were never registered with the Social Security Administration in the period 2005–2015 are excluded from this sample by design.

Information is available on the entire employment, non-employment and pension history of workers, including the exact duration of each spell of employment, non-employment and of periods with a disability or retirement pension. The data contain several variables that describe the characteristics of the job, such as the sector of activity, type of contract, number of hours and qualification requirements. The data also contain information on personal characteristics, such as age, sex, nationality and level of education. Periods of non-employment are identified using information on the dates in which the firm does not pay social security contributions for the worker. Non-employment spells during which the worker receives unemployment benefits

Table 1. *Descriptive Statistics: Spells in Regression Sample.*

	Mean	SD
Duration		
Entitlement	662.84	(60.51)
Total NE duration	299.12	(257.46)
Duration Period 1	129.92	(63.48)
Duration Period 2	162.08	(203.71)
Exhaustion	0.25	(0.43)
Exit during Period 1	0.46	(0.50)
Earnings		
UB Period 1	1,138.17	(133.07)
UB Period 2	1,039.52	(161.81)
Pre-unemployment earnings	1,818.94	(382.39)
Covariates		
Age	38.46	(5.87)
Male	0.69	(0.46)
Highest job qualification	0.10	(0.30)
Lowest job qualification	0.22	(0.41)
Permanent contract	0.52	(0.50)
Observations	61,827	

Notes: Entitlement is the number of days that a worker is entitled to receive unemployment benefits. Total NE duration is the number of days in non-employment. Duration Period 1 corresponds to the first six months of the unemployment spell, and Duration Period 2 to the subsequent 18 months. Exhaustion is a dummy variable that takes the value one if the worker exhausts unemployment benefits. Exit during Period 1 is a dummy variable that takes the value one if the unemployment spell ends during the first six months. UB denotes unemployment benefits. Pre-unemployment earnings are defined as average monthly earnings in the previous 180 working days. Age is computed at the beginning of the unemployment spell. All monetary values are expressed in real terms in constant 2011 euros.

are clearly identified as unemployment spells. Because the dataset contains all social security payments made by firms for each worker, we are able to compute the exact entitlement to unemployment benefits for each unemployment spell and the level of unemployment benefits, also for workers who switched jobs before becoming unemployed.

In our estimations we restrict the sample to unemployment spells starting between 1 January 1992 and 14 July 2012, because the calculation of unemployment benefits changed after that period. For unemployment spells in this period, the institutional framework for calculating unemployment benefits remained constant with a replacement rate of 70% in the first six months and 60% during the subsequent 18 months of an unemployment spell. We restrict our attention to complete unemployment spells after full-time employment and to individuals who had most jobs in the general regime. We further restrict the sample to individuals who are aged between 30 and 50.[17]

Table 1 contains descriptive statistics of the unemployment spells used in the estimation. There are 61,827 unemployment spells in our base sample. The table shows the mean and standard deviation of duration-related variables, earnings and additional variables used as covariates in the estimations. On average, non-employment spells in the sample last about 299 days, 130 days in the first six-month period of unemployment and an extra 162 days in the second 18-month

[17] We exclude workers older than 50 because in Spain they are eligible for subsidies that provide incentives to stay out of the labour force until they can legally retire.

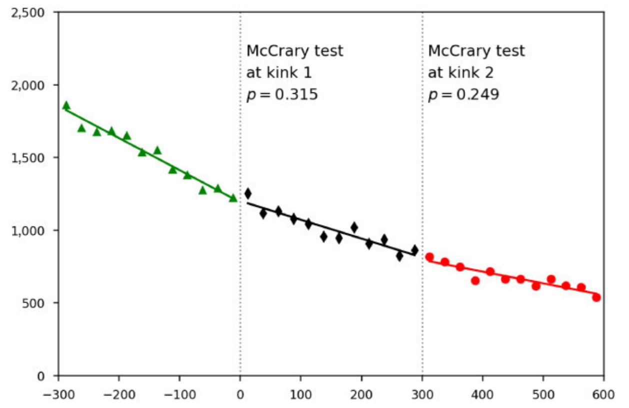


Fig. 2. *Frequency Distribution of Pre-Unemployment Earnings Around the Kinks. The figure shows the frequency distribution of pre-unemployment earnings in the vicinity of both kinks as an indication of the smoothness of the distribution of the running variable. The running variable is measured in constant 2011 euros and the first kink is normalised to zero. We include the p-values for a McCrary test at each kink. The null hypothesis of no discontinuity is not rejected at the usual confidence levels.*

period. In addition to observing long durations of unemployment, we detect that an important fraction of unemployed individuals exhausts their benefits (25% of the spells reach the maximum possible duration). Around 46% of the unemployed exit unemployment in the first six months. Average pre-unemployment earnings are EUR 1,819 and average unemployment benefits hover around 1,138 in the first period and 1,040 in the second period.[18] The average age is 39 years, 69% of the sample consists of males, and in 52% of the unemployment spells workers had a permanent contract in their prior job.

3. Results

3.1. *Assumptions of the RKD and Tests*

3.1.1. *Assumptions of the RKD*

The RKD estimates a local average response parameter that is a weighted average of the treatment effects across the population, where individuals receive higher weights for having a higher likelihood of being at the threshold (Card *et al.*, 2016). The two key assumptions for identification in the RKD are that the direct effect of the running variable (pre-unemployment earnings) on the outcome of interest is smooth and that unobserved heterogeneity does not change discontinuously at the kink in the running variable. None of these assumptions is directly testable, but lack of smoothness of the running variable and covariates at the kinks would raise concerns that they do not hold.

3.1.2. *Smoothness of the running variable*

The first key identifying assumption in an RKD is the existence of a smooth relationship between the running variable and the dependent variable. This assumption is less likely to hold if there is a discontinuity in the density of the running variable around the kink locations. In Figure 2

[18] All monetary values are expressed in 2011 constant euros.

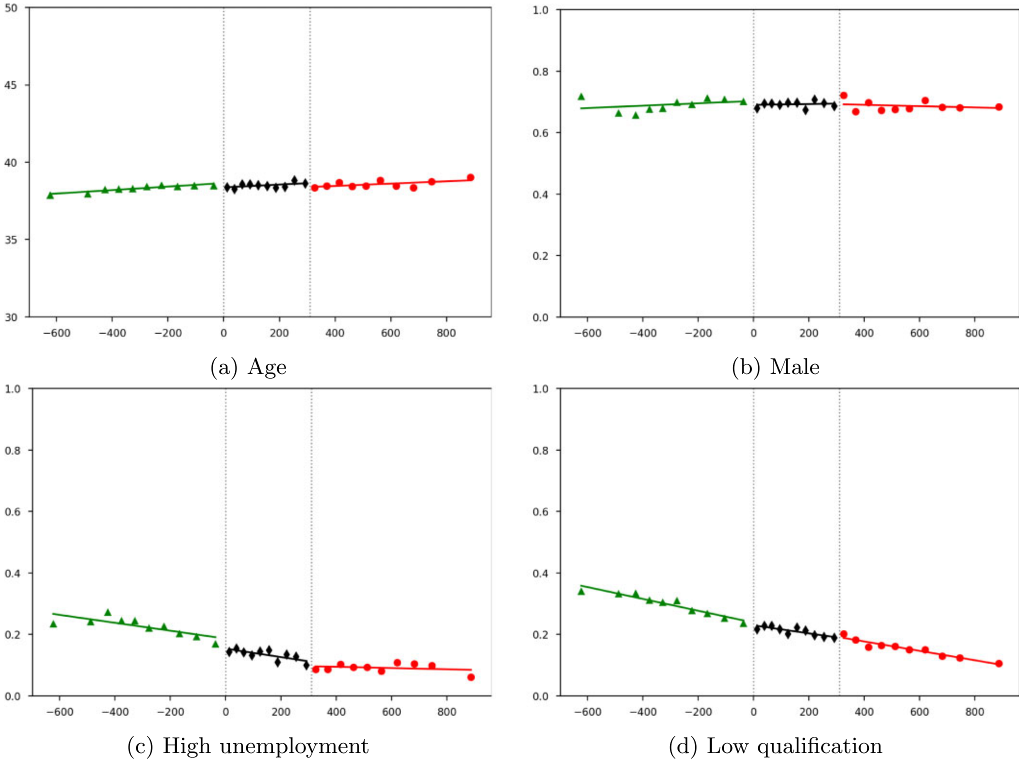


Fig. 3. *Pre-determined Variables and Pre-unemployment Earnings Around the Kinks. Figures show binned scatter plots of the average of each variable for bins of pre-unemployment earnings and a linear regression for each region. Pre-unemployment earnings are normalised to zero at the first kink. Ten bins are used for each region of the running variable.*

we plot the probability density function of normalised pre-unemployment earnings at both kink points (we normalise earnings so that the kink is located at one in both graphs). The plots show a smooth density and suggest that there is no manipulation of earnings at either kink point. We also include the p-values of the usual McCrary (2008) test for discontinuities. These p-values also show no evidence of manipulation of the running variable at the kinks.[19]

3.1.3. *Smoothness of pre-determined variables*

A second check concerns the smoothness of the conditional distribution function of pre-determined variables at the kinks. We plot the relationships between pre-unemployment earnings and a set of pre-determined variables: age at the time of unemployment, being male, living in a region with a high unemployment rate and having a job that requires low qualification. The graphs in Figure 3 show average values of each pre-determined characteristic for bins of the

[19] The implementation of this test is based on the tests of manipulation of the running variable for RD designs by McCrary (2008), which is implemented also for the case of the RKD by Landais (2015).

Table 2. *RKD Estimations on Several Pre-determined Variables.*

	Age	Male	Large regions	Low qualification	High qualification
Bandwidth 250					
Kink 1	0.717	0.060	0.410	0.548	0.929
Kink 2	0.746	0.957	0.398	0.460	0.522
Bandwidth 350					
Kink 1	0.401	0.250	0.222	0.338	0.527
Kink 2	0.159	0.294	0.406	0.615	0.723
Bandwidth 450					
Kink 1	0.524	0.134	0.712	0.583	0.796
Kink 2	0.085	0.579	0.661	0.818	0.465

Notes: Using each pre-determined variable as the dependent variable, and for different bandwidths, we estimate the baseline equation and test whether there is a change in the slope of the relationship between each variable and pre-unemployment earnings for both kinks. Each value in the table shows the *p*-value corresponding to the null hypothesis of no change in the slope.

running variable, and provide graphical evidence on the smoothness in the relationship between these covariates and pre-unemployment earnings, with no jumps at any of the kinks.[20]

We also formally test for changes in the slope of these relationships. The pre-determined variables on which we run tests are the following: age at time of unemployment, being male, living in a large province (with a population of more than 2 million), having a job that requires only low qualification and having a job that requires high qualification. In Table 2 we present the *p*-values for the null hypothesis that there is no change in the slopes around the kinks. There is no evidence of significant changes in the slope at the kinks for the relationships between pre-unemployment earnings and the pre-determined variables.

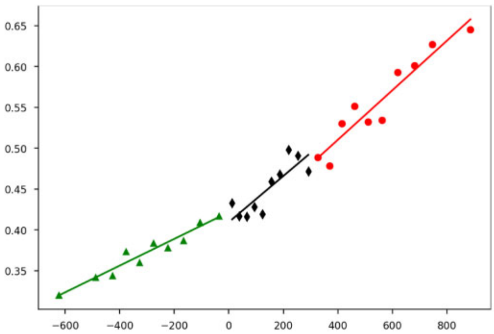
3.1.4. *Visual evidence of kinks*

Figure 4 presents visual evidence on the change in slopes in the relationship between outcome variables and pre-unemployment earnings. The figure contains a graph for each outcome of interest: the probability of leaving unemployment in the first period, unemployment duration in the first period, unemployment duration in the second period and total non-employment duration. We show binned scatter plots and the fit of a linear regression for residualised outcomes and pre-unemployment earnings. We use ten bins per region as defined in (25) for the running variable and do not force the linear regressions to meet at the kinks. The fit for each region seems adequate, and the endpoints of the regression lines are close, as expected if the relationship between earnings and the outcome variables is continuous. Moreover, the visual evidence suggests that the slopes in the relationship between earnings and each outcome variable change in the expected direction at the kinks.

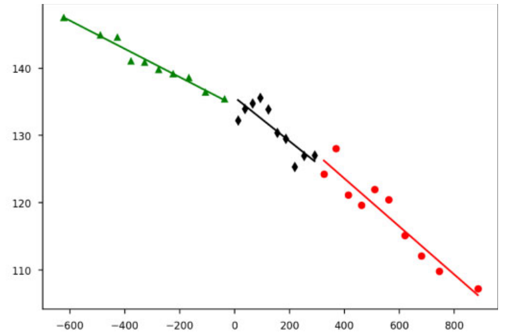
3.1.5. *Degree of the polynomial and bandwidth choice*

The implementation of the RKD depends on two practical details: the choice of the degree of the polynomial and the choice of the bandwidth. Based on the Akaike Criterion, we select a quadratic specification as the best alternative. However, in the Online Appendix we show that results do

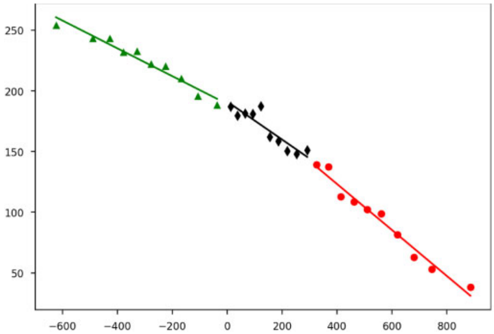
[20] The dataset is not very rich in terms of pre-determined variables. We graph only some variables for brevity, although the picture is similar when we use different geographical or qualification variables.



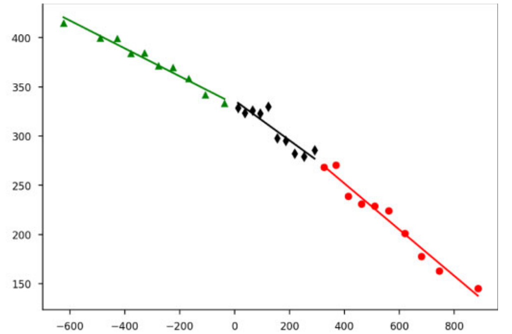
(a) Exit in the first period (h_1)



(b) Duration in the first period (D_1)



(c) Duration in the second period (D_2)



(d) Non-employment duration (D)

Fig. 4. *Outcome Variables and Pre-unemployment Earnings Around the Kinks. Figures show binned scatter plots and linear fitted values of each residualised outcome variable on pre-unemployment earnings. Pre-unemployment earnings are normalised to zero at the first kink. Ten bins are used for each region of the running variable.*

not depend qualitatively on the degree of the polynomial. We choose a bandwidth of $h = 450$. In the Online Appendix we show that point estimates vary little with bandwidth size. Estimates become less precise for smaller bandwidth sizes, especially for the second kink.[21]

3.2. *Estimation Results*

As discussed, we estimate the baseline specification in (28) using a quadratic choice of the polynomial $g(\cdot)$ and a bandwidth $h = 450$. Control variables consist of year and month dummy variables, age at the time of becoming unemployed, and this age squared, and dummy variables for being male, for having a permanent contract in the previous job, for the qualifications of the job, for the number of unemployment spells up to and including the current one and for regions. Results for the variables of interest are presented in Table 3. We transform the coefficients obtained in the regressions into the marginal impact of increasing benefits in each one of the two periods on each outcome according to the formula in (30). The estimate $\hat{\theta}_1$ represents the impact on any dependent variable of increasing benefits in the first six-months period, and is obtained as

[21] In the Online Appendix we also check the robustness of our main results to the exclusion of covariates and perform placebo and permutation tests.

Table 3. *RKD Estimates on Several Outcomes.*

	(1) Exit in Period 1 h_1	(2) Duration Period 1 D_1	(3) Duration Period 2 D_2	(4) Non-employment duration D	(5) MH	(6) Optimal
$\frac{\partial}{\partial \bar{b}_1}$	-0.014^{**}	0.014^{*}	0.095^{***}	0.120^{***}	86%	Too high
	(0.006)	(0.007)	(0.024)	(0.030)		
$\frac{\partial}{\partial \bar{b}_2}$	-0.021^{**}	0.022^{*}	0.142^{***}	0.168^{***}	74%	Too high
	(0.009)	(0.011)	(0.036)	(0.045)		
Observations	61,827	61,827	61,827	61,827		

Notes: All estimations include controls for year and month dummies, age (at the time of becoming unemployed) and age squared, and dummy variables for being male, for having a permanent contract in the previous job, for qualifications of the job, for the cumulative count of unemployment spells and for regions. In columns 1 through 4, the dependent variables are, respectively, a dummy variable for exiting unemployment in the first six months of a spell (h_1), duration in unemployment in the first six months of a spell (D_1), duration in unemployment after the initial six months (D_2) and total duration in non-employment (D). Duration in each period is measured in days. Coefficients are transformed according to the formula in (30) in order to obtain the values of interest. The coefficients and standard errors in the first column are multiplied by 100. The value for MH (in column 5) represents the relative importance of the moral hazard effect, and Optimal (in the last column) shows if unemployment benefits are too high or too low with respect to optimal levels. The period is 1992–2012 and workers are between 30 and 50 years old.

$\hat{\theta}_1 = -\hat{\beta}_{11}/r_1 = -\hat{\beta}_{11}/0.7$, and $\hat{\theta}_2 = -\hat{\beta}_{21}/r_2 = -\hat{\beta}_{21}/0.6$ is the impact of increasing benefits in the second period.[22]

The probability of exiting unemployment in the first six months (h_1) decreases with higher unemployment benefits. Coefficients in the first column are multiplied by 100, so that an EUR 100 increase in $\bar{b}_1$, the level of unemployment benefits in the first period, implies a decrease of around 1.4 percentage points in h_1. In turn, a EUR 100 increase in $\bar{b}_2$ implies a decrease of around 2.1 percentage points in h_1. The second column in Table 3 shows that unemployment duration in the first six months also increases with unemployment benefits: D_1 increases on average by 1.4 days per EUR 100 increase in $\bar{b}_1$ and by 2.2 days per EUR 100 increase in $\bar{b}_2$. Unemployment duration in the second period, D_2, increases on average by about 10 and 14 additional days per EUR 100 increase in $\bar{b}_1$ and $\bar{b}_2$. Finally, total non-employment duration D increases by around 12 and 17 additional days per EUR 100 increase in unemployment benefits in periods 1 and 2.

3.3. *Liquidity and Moral Hazard Effects in the Estimation Sample*

The results reported in Table 3 yield an estimate of $\partial h_1/\partial \bar{b}_1 = -0.014$ and $\partial h_1/\partial \bar{b}_2 = -0.021$. Using the formulas in Proposition 1, these effects can be separated into a liquidity effect and a moral hazard effect.[23] We define a period as lasting six months (180 days). With this convention,

[22] Note that the dependent variable in the first column in Table 3 is in both cases a dummy variable that takes the value one if the worker exits unemployment in the first six months (Period 1) and zero otherwise. Both estimations use all workers in the sample around each kink regardless the actual duration of the unemployment spell. Therefore, these estimates are not affected by selection bias.

[23] To test the assumption that the borrowing constraint is not binding, we conduct the slackness test proposed by Landais (2015). Using the RKD design, we estimate the effect of unemployment benefits in Period 2 on the probability of exiting unemployment in the 180 days after the exhaustion of unemployment benefits conditional on still being unemployed. The estimated coefficient on second-period benefits is of the expected sign and significantly different from zero: -0.009^{**} (0.004). This suggests that agents are not hand-to-mouth in the last period and that they can still transfer resources across periods.

$B_1 = 1$ (180 days) and $B_2 = 2.67$ (using a weighted average of entitlements in the sample).[24] We calculate the durations D_1 and D_2 for the sample of spells used in the main regression and set $D_1 = 130/180 = 0.72$ and $D_2 = 162/180 = 0.90$. Plugging these values into the formulas of Proposition 1, we find that

$$\frac{\partial h_1}{\partial \overline{b}_1} = -0.014 = \underbrace{-0.0020}_{LIQ_1} - \underbrace{0.0123}_{MH_1}, \tag{31}$$

and

$$\frac{\partial h_1}{\partial \overline{b}_2} = -0.021 = \underbrace{-0.005}_{LIQ_2} - \underbrace{0.015}_{MH_2}. \tag{32}$$

For unemployment benefits $\overline{b}_1$, the liquidity effect accounts for 14% of the total effect on h_1 whereas the moral hazard effect accounts for 86%. For benefits $\overline{b}_2$, liquidity and moral hazard effects respectively account for 26% and 74% of the total response of h_1. In consequence, the ratios of liquidity to moral hazard effects, which are needed for the normative results of Proposition 2, are estimated at $R_1 = 14\%/86\% = 0.16$ and $R_2 = 26\%/74\% = 0.34$.

In comparison, Chetty (2008) finds that the liquidity effect accounts for 60% of the total effect. His estimated ratio of liquidity to moral hazard effects is therefore $R = 60\%/40\% = 1.5$. Landais (2015) reports a lower ratio of liquidity to moral hazard effects of $R = 0.9$, implying that approximately 47% of the total effect corresponds to the liquidity effect. Our estimates imply larger moral hazard effects for the case of Spain than for the United States. Our estimates for R_1 and R_2 are very close to the consumption-based value of unemployment insurance estimated for Spain by Campos and Reggio (2020), who report values ranging from 0.163 to 0.237 for coefficients of relative risk aversion between 2 and 3.

The results in Table 3 also yield estimates that are useful to calculate the fiscal cost of raising unemployment benefits. Using these estimates, we calculate that the elasticities relevant for the fiscal externalities of raising $\overline{b}_1$ are $\varepsilon_{D_1,\overline{b}_1} = 0.13$, $\varepsilon_{D_2,\overline{b}_1} = 0.72$, and $\varepsilon_{D,\overline{b}_1} = 0.39$. In turn, the estimated elasticities related to the fiscal externalities of raising $\overline{b}_2$ are $\varepsilon_{D_1,\overline{b}_2} = 0.20$, $\varepsilon_{D_2,\overline{b}_2} = 1.08$, and $\varepsilon_{D,\overline{b}_2} = 0.55$. The elasticities that we obtain for total duration are in line with the value of $\varepsilon_{D,\overline{b}} = 0.5$ commonly assumed for the United States based on the survey by Krueger and Meyer (2002). For Spain, Rebollo-Sanz and Rodríguez-Planas (2020) find an elasticity of unemployment duration to the replacement rate ($\varepsilon_{D,r}$) of 0.86, although for a different period. For Sweden, Kolsrud *et al.* (2018) estimate $\varepsilon_{D,\overline{b}} = 1.53$, $\varepsilon_{D_1,\overline{b}} = 1.32$, and $\varepsilon_{D_2,\overline{b}} = 1.62$ for a joint increase in $\overline{b}_1$ and $\overline{b}_1$ and, using 2001 data, $\varepsilon_{D,\overline{b}_2} = 0.68$, $\varepsilon_{D_1,\overline{b}_2} = 0.60$, and $\varepsilon_{D_2,\overline{b}_2} = 0.59$. Although there are differences in context and time, the comparison with these other studies suggests that our estimates for the elasticities of durations are in a plausible range.

3.4. *Optimal Unemployment Insurance: Calibration for Spain*

Armed with our estimates we now attempt to shed light on whether $\overline{b}_1$ and $\overline{b}_2$ are set at their optimal levels. Results for hazard rates in (31) and (32) yielded the estimates required for R_1 and

[24] For a maximum entitlement of 720 days, $B_1 + B_2 = 180$ days/180 days + 540 days/180 days = 720 days/180 days = 3.

R_2. These numbers need to be compared to the right-hand side of the expression in Proposition 2. As also done by Chetty (2008), we consider the case in which the budget is balanced. Substituting $\tau D = \overline{b}_1 D_1 + \overline{b}_2 D_2$ into (16) and (17) yields the following expressions:

$$R_1 = -\frac{LIQ_1}{MH_1} = \varepsilon_{D_1,\overline{b}_1} + \frac{\overline{b}_2 D_2}{\overline{b}_1 D_1}\varepsilon_{D_2,\overline{b}_1} + \frac{D}{T-D}\left(1 + \frac{\overline{b}_2 D_2}{\overline{b}_1 D_1}\right)\varepsilon_{D,\overline{b}_1} \tag{33}$$

$$R_2 = -\frac{LIQ_2}{MH_2} = \varepsilon_{D_2,\overline{b}_2} + \frac{\overline{b}_1 D_1}{\overline{b}_2 D_2}\varepsilon_{D_1,\overline{b}_2} + \frac{D}{T-D}\left(1 + \frac{\overline{b}_1 D_1}{\overline{b}_2 D_2}\right)\varepsilon_{D,\overline{b}_2}. \tag{34}$$

Assuming that in the long term the ratio of time spent in unemployment to time spent working is $D/(T-D) = 0.10$, and given the estimated elasticities, the right-hand side for the first period is calculated at 1.04, of which 0.96 is due to the rise in expected benefit payments and, the remainder, 0.08 is the drop in expected revenue arising from an increase in $\overline{b}_1$. For the second period, the expected marginal cost of raising unemployment benefits is estimated at 1.36, of which 1.26 is due to the expected rise in payments and 0.10 is due to the fall in revenues:

$$R_1 = 0.16 < 1.04 = \underbrace{\varepsilon_{D_1,\overline{b}_1} + \frac{\overline{b}_2 D_2}{\overline{b}_1 D_1}\varepsilon_{D_2,\overline{b}_1}}_{0.96} + \underbrace{\frac{D}{T-D}\left(1 + \frac{\overline{b}_2 D_2}{\overline{b}_1 D_1}\right)\varepsilon_{D,\overline{b}_1}}_{0.08}, \tag{35}$$

and

$$R_2 = 0.34 < 1.36 = \underbrace{\varepsilon_{D_2,\overline{b}_2} + \frac{\overline{b}_1 D_1}{\overline{b}_2 D_2}\varepsilon_{D_1,\overline{b}_2}}_{1.26} + \underbrace{\frac{D}{T-D}\left(1 + \frac{\overline{b}_1 D_1}{\overline{b}_2 D_2}\right)\varepsilon_{D,\overline{b}_2}}_{0.10}. \tag{36}$$

Given these point estimates for Spain, marginal costs appear to clearly exceed the marginal benefit of raising unemployment benefits, both for $\overline{b}_1$ and $\overline{b}_2$.

The ratios used in our analysis in (35) and (36) are constructed using the point estimates in Table 3. In order to incorporate the uncertainty from those estimations, we bootstrap standard errors using 5,000 replications to obtain the empirical distribution for R_1 and R_2. Using these empirical distributions, we test the hypothesis that R_k is equal to the right-hand side of the expression in Proposition 2, against the alternative that R_k is lower (implying that optimal $\overline{b}_k$ is lower). After allowing for this uncertainty, our calibration for Spain implies that over the period 1992–2012 benefit levels were set too high for both periods and that a reduction would be welfare-improving. This finding agrees qualitatively with the consumption-based results for Spain reported by Campos and Reggio (2020).

3.4.1. *A statistical extrapolation*

To assess the approximate distance between actual and optimal unemployment benefits we perform a statistical extrapolation of the optimality conditions in (33) and (34) by assuming that the estimated parameters $\partial h_1/\partial\overline{b}_k$, $\partial D_1/\partial\overline{b}_k$, $\partial D_2/\partial\overline{b}_k$ remain constant over the range of possible benefit levels $\overline{b}_1$ and $\overline{b}_2$. In other words, the statistical extrapolation substitutes the possibly non-linear relationship between benefit levels the variables of interest (first-period hazard rates and unemployment durations) by a first-order (linear) approximation.

The sufficient statistics approach is specifically tailored to assessing whether certain policy is locally optimal, rather than to exploring the effects of counterfactual policy alternatives. Statistical extrapolations are sometimes used to give a rough indication of the distance that separates policies

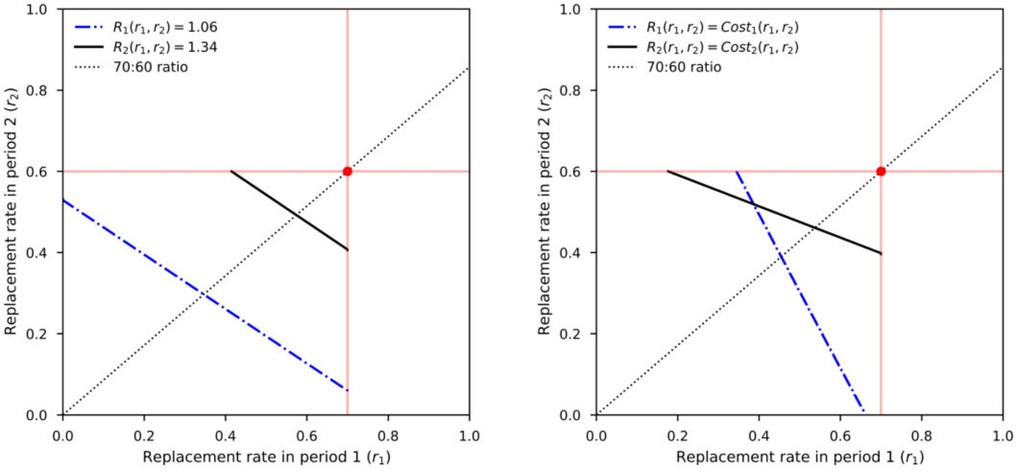


Fig. 5. *Optimality According to a Statistical Extrapolation. The dot situated at (0.7, 0.6) corresponds to current replacement rates. The locus of replacement rates that lead to an optimal value of R_1 is depicted by a solid line and the locus of replacement rates that lead to an optimal value of R_2 by a dot-dashed line. The dotted line indicates the set of replacement rates that satisfy the ratio $r_1/r_2 = 0.7/0.6$.*

in place from the optimal ones (e.g., Gruber, 1997). A major caveat of this type of exercise is that a statistical extrapolation is not immune to the Lucas Critique and is less reliable than methods that use an economic model to explicitly model how behaviour changes with policies.[25]

The results of our extrapolation exercise are shown in Figure 5.[26] To ease the interpretation, we express the figure in terms of replacement rates instead of benefit levels. The left panel shows an intermediate solution, in which we update only the left-hand side of the equation (the R_k terms) and the right panel shows the complete solution, where the right-hand side (the fiscal cost of unemployment benefits) is also updated.

Because there are two instruments, optimality for any given period can be achieved by a continuum of combinations of replacement rates. Globally optimal replacement rates are located at the intersection of the two lines in the graph on the right. There is a unique point at which both optimality conditions are satisfied simultaneously. It is essential for obtaining a unique optimum that changes in benefits induce changes in fiscal costs. This can be seen by comparing the graph on the left with the one on the right. In the graph on the left, which does not take into account changes in costs, the two lines depicting optimality are almost parallel and do not intersect. This is resolved by the rotation in opposite directions of the locus of replacement rates that are optimal for each period in the graph on the right, once the impact on costs is taken into account. This difference in slopes allows r_1 and r_2 to fulfil their separate roles in achieving optimality.[27]

[25] This point and the relative merits of statistical approximations and structural estimation is discussed in a review article by Chetty (2009).

[26] We perform a grid search over 1,000 equally spaced grid points in each interval $[0, \overline{b}_k]$. The total number of points in the two-dimensional grid is therefore $10^3 \times 10^3 = 10^6$ and the distance between contiguous grid points along any dimension implies differences in monthly benefit levels below EUR 1.50.

[27] Because $\overline{b}_1$ and $\overline{b}_2$ enter the right-hand side of (33) and (34) in opposing ways, the slopes of the right-hand side of the optimality equations are approximately reciprocal to each other. Moreover, because this difference in slopes is not directly tied to the linear approximation, it holds more generally.

At the optimal point, replacement rates are $r_1^* = 0.39$, $r_2^* = 0.52$. Compared to replacement rates that were in place in Spain in the period we study, the optimal replacement rate is 50% lower in the first period and 20% lower in the second period of an unemployment spell. Taking these results at face value, the change in benefits in the labour market reform in 2012, which made the benefit schedule steeper by decreasing replacement rates over the second period from 60% to 50% achieved the optimal level for that period.[28] The reform in 2012 kept the replacement rate for the first six months unchanged, which is too high according to the statistical extrapolation. Because of the elevated moral hazard effect in the first period, the benefits of maintaining such a high replacement rate are not enough to compensate the expected fiscal costs that arise in the first six months of an unemployment spell.

3.5. *Extension*

3.5.1. *Model-based liquidity and moral hazard effects of workers with different entitlements*

In our baseline estimation in Subsection 3.3, we restrict the sample to workers who are entitled to at least 540 days of unemployment benefits in an attempt to use a group of unemployed workers that is plausibly more homogeneous. In this subsection we use the model to obtain estimates of R_2 for a wider population by incorporating workers with shorter entitlement periods. In principle, the separation into liquidity and moral hazard effects using Proposition 1 can be performed for any homogeneous group of workers entitled to shorter periods of unemployment benefits, provided that $\partial h_1/\partial \overline{b}_1$ and $\partial h_1/\partial \overline{b}_2$ can be estimated. Unfortunately, in the case of Spain, sample sizes are too small to obtain precise estimates, except for the pool of workers who are entitled to long lengths of unemployment benefits.

However, it turns out that the model implies a relationship between liquidity and moral hazard effects across periods 1 and 2 that can be exploited. In Spain, entitlement periods increase by brackets of 60 days until reaching the maximum of 720 days. We index workers by their total entitlement period and define types $e = 240, 300, \dots 720$.[29]

The theory implies a specific relationship between liquidity effects and moral hazard effects across periods. Dividing first- and second-period liquidity and moral hazard effects, the expressions in Proposition 1 imply that for any entitlement type e:

$$LIQ_2^e = \frac{B_2^e}{B_1^e} LIQ_1^e, \tag{37}$$

and

$$MH_2^e = \frac{D_2^e}{D_1^e} MH_1^e. \tag{38}$$

Because durations are observable in the data, the second-period liquidity and moral hazard effects for any type of worker can be obtained from the first-period counterparts, if they are known.

We will use an approximation based on the fact that it is likely that types are more similar in terms of their first-period than in terms of their second-period liquidity and moral hazard effects. To use a concrete example, consider the two types with the highest entitlements: type $e = 720$ and $e = 660$. These two types share a first-period entitlement $B_1 = 180$, but the higher type has

[28] Unfortunately, the data currently available is not sufficient to test this result on the more recent post-reform period.

[29] The first type ($e = 240$) corresponds to $B_1 = 180/180$ and $B_2 = 60/180$, the second type ($e = 300$) to $B_1 = 180/180$ and $B_2 = 120/180$, and so on until type $e = 720$, for whom $B_1 = 180/180$ and $B_2 = 540/180$. These types are listed in the first column of Table 4.

Table 4. *Ratio of Liquidity to Moral Hazard Effects in Period 2 Implied by the model for Increasingly Larger Groups of the Population.*

Type e	B_1	B_2	Cumulative R_2
720	180/180	540/180	0.313
660	180/180	480/180	0.337
600	180/180	420/180	0.342
540	180/180	360/180	0.345
480	180/180	300/180	0.347
420	180/180	240/180	0.348
360	180/180	180/180	0.348
300	180/180	120/180	0.346
240	180/180	60/180	0.342

Notes: The table presents computations of R_2 for an increasingly larger subset of workers, ranging from entitlements of 720 days all the way down to 240 days. The cumulative R_2 column is our model-based estimate of R_2 when the population is defined for an increasingly larger range of types.

a B_2^{720} of 540 days and the lower type a B_2^{660} of 480 days, i.e., the two types differ only in that one of them is entitled to an additional 60 days of unemployment benefits in the second period. It is therefore likely that both types will behave similarly when facing the hypothetical question of how much search effort to exert at the start of an unemployment spell (h_1) in response to changes in the wage (w) or non-labour income (y) in the first period. In comparison, their response to a change in the wage or non-labour income in the second period will reasonably differ because the second period has a different length for each type. This implies that the two types in question will have liquidity and moral hazard effects that are approximately equal in Period 1, i.e., $LIQ_1^{660} \approx LIQ_1^{720}$ and $MH_1^{660} \approx MH_1^{720}$ but their Period 2 liquidity and moral hazard effects will differ.

Using this argument, and the relationships in (37) and (38) derived from Proposition 1, for any type e we approximate the second-period liquidity and moral hazard effects by

$$LIQ_2^e \approx \frac{B_2^e}{B_1^e} LIQ_1^*, \tag{39}$$

and

$$MH_2^e \approx \frac{D_2^e}{D_1^e} MH_1^*, \tag{40}$$

where LIQ_1^* and MH_1^* are the liquidity and moral hazard effects obtained in Subsection 3.3 for the sample with $e \in [540, 720]$. We expect the approximation to be increasingly worse as we move to lower values of e, because the similarity with the decision problem faced by types with long benefit entitlements decreases as we move to lower types and the different lengths of B_2^e may start to spill over into first-period decisions.[30]

In Table 4 we compute R_2 for an increasingly larger subset of workers, ranging from entitlements of 720 days down to 240 days. The approximation derived from the theory becomes less reliable as lower types are included. We do not impose a specific cut-off of when the approximation stops to be credible and, instead, present the evidence for all possible cut-offs, allowing each reader to decide when approximations start to fail. Results in the column denoted 'Cumulative

[30] Notice that because D_2^e and B_2^e are increasing in e, both the liquidity effect and the moral hazard effect necessarily become smaller for lower types.

R_2' are obtained in the following way: first, we calculate the liquidity effect (LIQ_2^e) and the moral hazard effect (MH_2^e) for each type using the approximations in (39) and (40). Second, we compute LIQ_2 and MH_2 as a weighted average of liquidity and moral hazard effects for all types 720 down to the type listed in Column 1. Third, we take the ratio of the average liquidity and moral hazard effects to obtain R_2. The cumulative R_2 is therefore our model-based estimate of a population-wide R_2 when the population is defined for an increasingly larger range of types.

The striking result from the model-based results in Table 4 is that R_2 is always close to the value obtained for the estimation sample and the moral hazard effect is always between 74.2% and 76.2%. Although the proportions of liquidity and moral hazard effects vary with the entitlement period, the moral hazard effect always dominates the liquidity effect and the ratio stays roughly constant. These findings should not be taken as precise estimates of the liquidity and moral hazard effects of the total population. Rather, they are an approximate measure of the relative importance of liquidity and moral hazard effects in the overall population based on the theory developed in Section 1. According to this theory and the approximations, it seems that the importance of the liquidity effect relative to the moral hazard effect may be common to a wider set of the population.

4. Conclusion

In this paper we study unemployment insurance schemes with time-varying benefits. We make two theoretical contributions. First, we show that an insurance scheme in which unemployment benefits vary during the unemployment spell, as is the case in Spain, provides the necessary variation in the data to separately identify the moral hazard and liquidity effects defined by Chetty (2008). Second, we derive a ‘sufficient statistics’ formula which, using the separation into liquidity and moral hazard effects, allows us to verify whether unemployment benefits are set at their optimal level.

We use administrative data from Spain (the MCVL) and a regression kink design to obtain the estimates needed to disentangle liquidity and moral hazard effects. We then feed these estimates into the formula for the optimal benefit level. Our findings indicate that moral hazard effects dominate and that the marginal benefits of unemployment insurance are low relative to the costs. This finding implies that unemployment benefits are above the optimal level, also in the second period of the unemployment spell, when the replacement rate in the Spanish system is a bit lower.

Our model is admittedly stylised, assumes a certain degree of homogeneity in the population and does not include general equilibrium effects. This calls for caution when using it for public policy. However, we hope that the ease of applying the formula using data just on unemployment spells and the novel identification of liquidity and moral hazard effects will earn it a place among the numerous tools in the arsenal of policymakers.

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Additional Supporting Information may be found in the online version of this article:

Online Appendix
Replication Package

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