Internal Migration in Dual Labor Markets

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This paper uses a large panel assembled from Spanish administrative data for over one million individuals assembled from tax, welfare and employment records over a period spanning 30 years to estimate a dynamic model of individual optimization that explains transitions and spell lengths between permanent positions, temporary positions, unemployment and exits from the workforce. We seek to explain the sequence of job spells in temporary contracts and unemployment transitions as new entrants in the workforce gradually acquire experience and, ultimately, transition into permanent contracts. The career mobility of young workers is jointly determined with geographical and occupational mobility. Thus we investigate how different types of labor market experience and welfare entitlements affect job search behavior, employment duration, and migration patterns over the life cycle.

I. Introduction

This paper develops and estimates an equilibrium model of job search, on the job human capital accumulation, and mobility both between occupations and geographic locations. At any given point in time, workers can be unemployed, out of the labor force, in temporary work contracts, and permanent work contracts. Choices between jobs and the opportunity to migrate arrive at a Poisson rate in continuous time. The choices are over different types of jobs, and wages in each type of job depend on education and employment history. In our model, firm-worker matches produce specific human capital over time, longer matches providing greater benefits. Workers also have private information about their heterogeneous preferences over geographical regions. Workers cannot borrow against future labor income, and this creates a demand for unemployment benefits and severance pay. In equilibrium, the type of contract the firm offers a worker (including whether it is temporary or permanent) maximizes firm's wealth subject to the alternative opportunities, accumulated skills, and private information the worker has, facilitating hiring workers who are not likely to quit. We estimate a discrete choice dynamic contracting model in order to explain transitions and spell lengths between permanent positions, temporary positions, unemployment and exits from the workforce, as well as their associated occupation and location decisions.

The dataset for our empirical work is assembled from a large panel of Spanish administrative data for over one million individuals assembled from tax, welfare and employment records over a period spanning 30 years. The Spanish economy is ideal to handle the question that we are addressing in this paper, because of its high duality.[1] In our data, 84% of employment contracts signed between 1991 and 2012, and 22% of ongoing spells by the end of the sample, are temporary contracts. This makes Spain the OECD country with a highest duality rate, together with Poland (Boeri, 2011).

Our model is motivated by several stylized facts which come from our preliminary analysis of the administrative dataset we have developed to explain Spanish employment and unemployment. The first fact is that less geographically mobile workers have a higher probability of working under permanent contracts, and, while working in temporary contracts, a higher hazard rate to a permanent contract. The second fact is that, after controlling for observable skills, personal characteristics, plant characteristics, and job characteristics, workers in permanent contracts are paid less than temporary workers. And third, at the beginning of a temporary work spell, the (conditional) hazard of experiencing an unemployment spell over the subsequent working years is larger than at the beginning of a permanent spell. A simple model with two types of workers, movers, that search over geographical regions, and stayers, who do not, in which stayers are willing to pay an insurance premium for accepting permanent offers goes a long way in explaining these three stylized facts. In our model, movers and stayers are defined endogenously by the dynamic life cycle profiles they pursue.

Macroeconomic models of search in the labor market provide a convincing explanation of why unemployment exists. Information about the creation of new jobs is not instantaneously transmitted to the whole population, so when workers lose an existing job they expend time and energy in job search, possibly refusing several unacceptable offers before taking a new employment position. In such models, the identity of workers, their positions, and employment spells are essentially in-

[1] A country is said to have a highly dual labor market whenever very protected permanent contracts coexist with virtually unprotected temporary contracts. Duality rate is defined as the number of temporary contracts as a fraction of all contracts alive in a given time period.

terchangeable. Worker heterogeneity is typically modeled as a productivity draw for each job match, identically and independently distributed across all individuals, all unemployment spells and all sectors, there is essentially no scope for the experience to a role in determining either the unemployment rate across different groups, across the life cycle of an individual, or how evolving demographics help the aggregate unemployment rate. It is hard to reconcile the volatility of the unemployment rate when compared to the relatively rigid wages over the business cycle within search models populated with representative worker agents (Shimer, 2005). Rigid wages (Hall, 2005), starting wages that are flexible that are followed by stable wages (Pissarides, 2009), private information about the match productivity (Kennan, 2010) are three embellishments that have been added to the standard prototype to explain this puzzle.

Representative models of search in the labor market cannot explain why the level of unemployment, derived the probability of losing a job and the hazard rate to regaining another, is distributed unevenly across different groups within the total population, for example by age, education, gender, ethnic background, and labor market experience. Yet a common presumption is that a whole cohort can suffer long term consequences from poor labor conditions experienced early in their careers would suggest that human capital acquired from labor market experience actually propogates the cycle.

Our paper is related to several bodies of literature. First of all, our analysis is based on search models. The empirical literature on structural estimation of search models dates back to Lancaster (1979), Kiefer and Neumann (1979), and Flinn and Heckman (1982) (see Eckstein and van den Berg (2007) for a recent survey of the literature). Initially, this work was exclusively focused on the workers' dynamic optimization job search, and on modeling the reservation wage. An important development of this framework was to explicitly incorporate the firm side. Eckstein and Wolpin (1990), van den Berg and Ridder (1998), and Postel-Vinay and Robin (2002) estimate equilibrium models of search behavior in which firms form matches with workers. An implication of these models is that the wage distribution tails off to low wages and tends to put more mass on higher wages in equilibrium conditional on observed characteristics of the firm and the worker. Because of this feature, these models have hard to fit empirical wage distributions.

Second, the paper relates to the macro search literature, surveyed in Mortensen and Pissarides (1999) and Rogerson and Shimer (2011). Third, it is related to the literature of estimation of structural models of human capital accumulation from working on the job (e.g. Altuğ and Miller, 1998; Adda, Dustmann, Meghir and Robin, 2010; Gayle and Golan, 2012; Llull, 2014; Gayle, Golan and Miller, 2014). Fourth, the paper is also connected to the literature estimating structural models of migration and immigration (e.g. Kennan and Walker, 2011; Gemici, 2011; Lessem, 2013; Llull, 2014). Fifth, it is linked with the literature on labor market duality, surveyed in Boeri (2011). And, finally, it is connected to the literature that uses administrative data from different countries to estimate structural models (e.g. Abowd, Kramarz and Margolis (1999) and Postel-Vinay and Robin (2002) use data for France, and Adda, Dustmann, Meghir and Robin (2010) use German data).

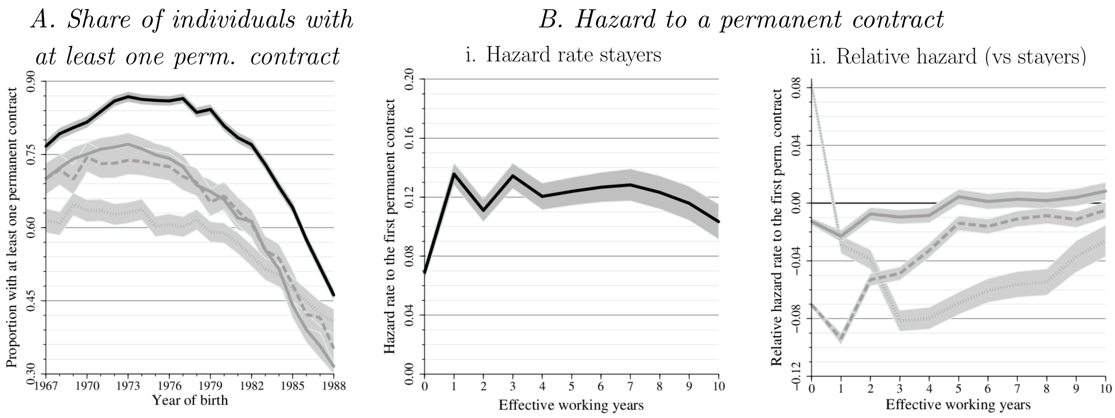
In a standard search model with homogeneous workers and employment offers drawn from a homogeneous distribution, no quitting and firing, infinite horizon, no aggregate shock, where wages are observed but not unemployment benefits, there is a well known observational equivalence between high job arrival rates and low unobserved unemployment benefits (Flinn and Heckman, 1982). Our model is a generalized Roy model with human capital, and apart from wages workers also receive non-pecuniary benefits, extended to continuous time. Even if the unobserved heterogeneity is parametrically specified, this model inherits the observational equivalence of the simple search model. Non-pecuniary benefits from unemployment are normalized to one. Non-pecuniary benefits of employment in a particular job vs unemployment are freely parameterized, and non-parametrically identified.

When a contract expires, there is a probability that the worker receives a new temporary contract with the firm, and a probability he or she receives a permanent contract offer. Conditional on worker type and history, and current job, we observe in the data the rate at which workers accept new offers. The systematic part/loading depends on workers' history up until the start of the current spell, and time invariant characteristics of the spell. This allows us to identify the job offer set, because a strictly positive proportion of people receiving each given wage/contract offer will accept it. Associated with each job offer there is an unobserved component independent and identically distributed.

II. Data and Facts

The data used in this paper is assembled from Spanish administrative records for over a million of individuals. The dataset is a 4% random sample of a population that consists of all individuals having any relationship with the Spanish Social Security Administration (SSSA) the year prior to each wage (2004-2012), including all private sector and selected public sector employees, self-employed

Figure 1. Permanent Contracts and Mobility



Note: Different lines indicate mover types: stayers (black), itinerant (dashed gray), permanent movers (solid gray), and international migrants (dotted gray). Gray areas are ± 2 robust standard error confidence bands. Left figure plots the probability of facing at least one permanent contract spell within the sample period (1991-2001) by cohort of birth and mobility type. Center and right figures plot (linear probability) hazard rates to the first permanent contract for stayers and relative hazard rates for movers (with respect to stayers) at different years of accumulated working experience. The sample is restricted to individuals born between 1967 and 1988. All estimates are (non-parametrically) conditional on education, the interaction of gender and number of cohabiters, province/country of birth and birth cohort. Figures plot baseline probabilities for Spanish secondary educated male born in Madrid (in 1967 in center and right figures) living with two cohabiters (e.g. spouse and one child).

workers, unemployed workers receiving unemployment insurance benefits or unemployment subsidies, and recipients of welfare benefits and retirement pensions. Complete working and payroll histories are provided for these workers, linked to personal information from population registries and income tax records for years 2004 to 2012. Plant identifier and a few plant characteristics are also observed (number of workers, city, 3-digit industry, and year in which first worker was hired). We select a sample of individuals born between 1967 and 1988, which are aged 24 at some point between 1991 and 2012.[2] Appendix B provides more detailed sample selection criteria and variable descriptions and definitions.

A nice feature of the data is that we can track people over their careers, and the human capital accumulated on the job can be analyzed easily. Another advantage of this data is that we precisely see spell duration (at a daily precision) for each contract and unemployment spell. We also have an institutional measure of quitting, which allows us to identify whether a match is ended voluntarily or involuntarily by the worker. And we have very detailed information unemployment benefits, and also on severance pay rules.

One of the motivating facts for our analysis is that there are substantial differences in the probability of observing a permanent contract working spell depending on whether the individual is geographically *mobile* or not. Figure 1 provides some

[2] Filling in contract type in SSSA forms was not mandatory until 1991.

evidence in that respect. The figure plots the probability that an individual of a given cohort have experienced at least one permanent contract spell by the end of the sample (Figure 1A), and the hazard to the first permanent spell (Figure 1B) for different mobility types. For the sake of the exploration analysis, individuals are classified according to their migration behavior prior to the first permanent spell. Individuals that never worked out of their province of birth are *stayers*; individuals that at some point worked out of their province of birth but find the first permanent contract at their birth province are *itinerants*; individuals finding a permanent job out of their province of birth are *permanent movers*; and finally, there are *international migrants*.

Figure 1A shows that, conditional on observable characteristics, stayers have a very persistent 10-15 percentage points higher probability of experiencing their first permanent contract spell by the end of the sample (when they are aged 24-45 years, depending on the birth cohort) compared to itinerants and permanent movers. This gap is even larger when comparing to international migrants. Figure 1B.i presents the baseline hazard rate to the first permanent contract spell for a stayer Spanish secondary educated male born in Madrid in 1967 living with two cohabiters (e.g. spouse and one child). This baseline hazard is relatively constant at around a 12% probability of exiting to a permanent contract for individuals remaining without experiencing a permanent contract spell after each working year, slightly decreasing after seven years. The exceptions are the low probability of starting in a permanent contract straight off (7%), and two spikes after one and three years working, consistent with the findings in Güell and Petrongolo (2007). Figure 1B.ii presents the relative hazards of each type of movers with respect to the stayers' baseline hazard. Permanent movers sustain a 1-2 percentage points lower hazard of exiting to a permanent contract until the fifth year of working experience, when the gap disappears. Itinerant movers, instead, have a permanently lower hazard to a permanent contract, averaging around 5 percentage points during the first five years, and still sustaining a 1 percentage point difference at their tenth year of working. International migrants, have a higher chance to hit a permanent spell straight off, but conditional on not doing so, they have a 4-8 percentage points lower hazard throughout the first ten years of working experience.

The advantage that a permanent contract offers to a worker (compared to a sequence of temporary contracts) is job protection. If the employee wants to fire a worker that holds a permanent contract has to compensate her with a severance payment increasing in tenure under the current contract spell, whereas temporary

Table 1—Wage Gap between Fixed-Term and Permanent Contracts

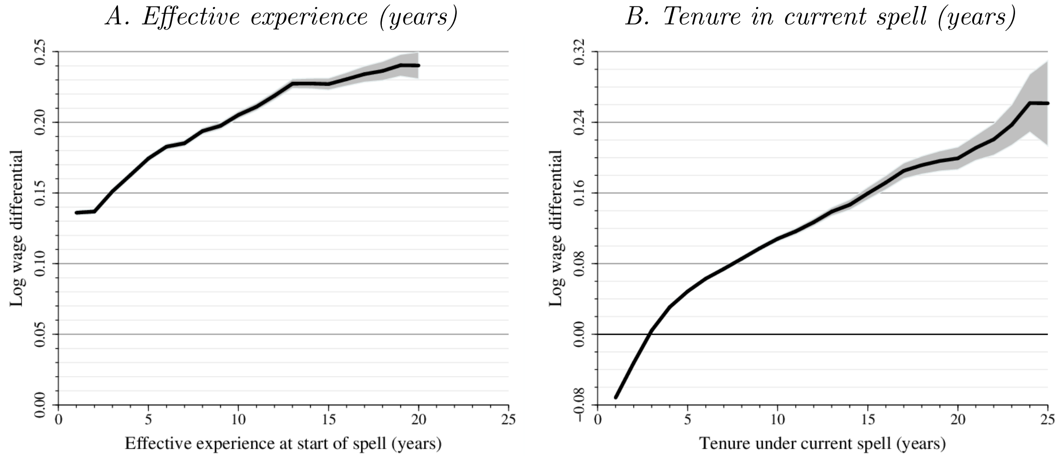
	(1)	(2)	(3)	(4)	(5)
Permanent contract	0.040	-0.025	-0.026	-0.026	-0.025
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Female		-0.064	-0.055	-0.057	-0.056
		(0.000)	(0.000)	(0.000)	(0.000)
Education: *(baseline: Primary)*					
Secondary		0.087	0.036	0.036	0.035
		(0.000)	(0.000)	(0.000)	(0.000)
University		0.357	0.117	0.115	0.111
		(0.001)	(0.001)	(0.001)	(0.001)
Selected professional categories: *(baseline: High level managers/engineers/B.A.'s)*					
Qualified staff			-0.096	-0.096	-0.096
			(0.001)	(0.001)	(0.001)
Administr. officer			-0.345	-0.345	-0.336
			(0.001)	(0.001)	(0.001)
Clerk			-0.480	-0.479	-0.465
			(0.001)	(0.001)	(0.001)
1st or 2nd officer			-0.426	-0.426	-0.407
			(0.001)	(0.001)	(0.001)
3rd officer			-0.468	-0.468	-0.452
			(0.001)	(0.001)	(0.001)
Laborer			-0.562	-0.562	-0.542
			(0.001)	(0.001)	(0.001)
Other controls (dummies):					
Year and province	Yes	Yes	Yes	Yes	Yes
Exper. and tenure		Yes	Yes	Yes	Yes
Industry (3-digit)			Yes	Yes	Yes
Year & place birth				Yes	Yes
Plant age and size					Yes
Observations	6,128,767	6,128,767	5,939,010	5,939,010	5,938,964
R-squared	0.19	0.27	0.39	0.43	0.40

Note: The table presents selected coefficients of a regression of log full-time equivalent daily wages on different sets of dummies for different variables, as indicated. The unit of observation is spell-year. Robust standard errors are in parenthesis.

workers can be fired at a very reduced cost. A mover-type worker will typically attach a lower value to this severance pay, because she has a higher probability of voluntarily quitting the job if an interesting opportunity in a different geographical labor market appears. In order to sustain in equilibrium a lower probability of working in a permanent contract for an individual that, everything else equal, is of a mover type, some wedge is needed to generate a trade-off.

Table 1 analyzes whether this wedge is observed in the data. The table presents

Figure 2. Wage Returns to Experience and Tenure



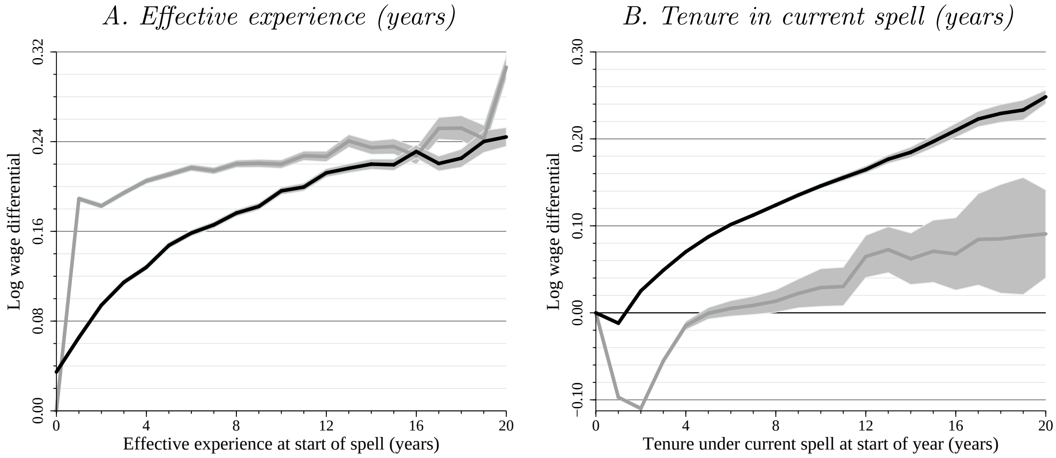
Note: Figures present returns to the experience accumulated at the beginning of the spell and to tenure in the spell. Point estimates and ±2 robust standard error bands are from experience and tenure dummies from the regression in column (5) in Table 1. In both cases, returns are relative to the baseline of zero experience/tenure.

non-parametric estimates of a conditional wage function. In column (1), log full-time equivalent daily wage in a given spell-year is regressed on time and province dummies, and on a dummy that indicates whether the spell is on a permanent contract. Point estimates suggest a 4% wage gap in favor of permanent contracts. This unconditional gap can be substantially driven by the different composition of the two groups. Indeed, once one starts controlling for skills (2), type of job (3), year and place of birth (4), and plant characteristics (5), the wedge turns into 2.5% gap in favor of temporary contracts. In other words, in equilibrium, workers require a 2.5% wage premium to be indifferent between accepting a temporary or a permanent employment contract. This result suggests a potential explanation for the results in Figure 1.

The remaining rows of Table 1 provide several dimensions of wage heterogeneity. A 5.5% gender wage gap is sustained even after controlling for personal, job, and plant characteristics. The return to university education is of 36%, but a big fraction is captured by industry and professional category dummies, as it reduces to 11% once they are controlled for. And the differential wages in the selected professional categories seem to smoothly capture the different roles within the firm. Finally, as the model presented below is one of on the job human capital accumulation, the coefficients for experience and tenure dummies in column (5) of Table 1 are graphed in Figure 2. The figure shows clear evidence of on the job human capital accumulation.

Given the compensating wage differential required by workers to accept temporary employment contracts documented in Table 1, a relevant question is what do

Figure 3. Wage Returns to Experience and Tenure by Contract Type



Note: Figures present returns to the experience accumulated at the beginning of the spell and to tenure in the spell by type of contract, this is permanent (black) or temporary (gray). Point estimates and ±2 robust standard error bands are from experience and tenure dummies interacted with a contract type dummy from a regression that, for everything else, is similar to the one in column (5) in Table 1. In both cases, returns are relative to the baseline of zero experience and tenure in a temporary contract.

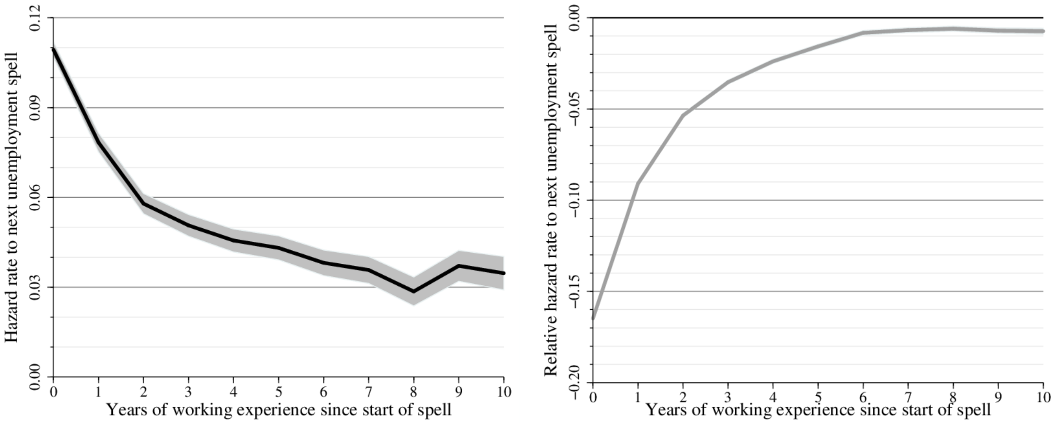
workers get in exchange to this wedge. Figure 4 explores a potential candidate: job security. The figure explores the hazard of reaching unemployment at each time after the beginning of a temporary or permanent spell. Figure 4A plots the baseline hazard for a Spanish primary educated male born in Barcelona in 1967 with zero years of experience starting a temporary spell in Barcelona. The hazard is clearly decreasing, indicating that as the individual spends time continuously working, the probability of reaching unemployment is reduced. After eight years of accumulated working experience since the beginning of a temporary spell without experience any unemployment spell, the probability of experiencing an unemployment spell in the following period stabilizes at around a 3%. Figure 4B plots the relative hazard when starting from a permanent contract spell. The gap is initially very substantial (15 percentage points) and then progressively decreases, converging to a 1 percentage point differential after six years. This indicates that starting from a permanent contract spell is associated with a lower probability of experiencing unemployment over at least the following ten years. This suggests that individuals may be buying unemployment insurance in exchange to the aforementioned wage premium.

III. Model

In this dynamic model of job and location choice, workers sequentially sort themselves into jobs that are interrupted by nonemployment spells throughout their working lives. Employment spells end in three ways: involuntary termi-

Figure 4. Hazard to Unemployment after Start of a Spell by Type of Contract

A. Baseline hazard (temporary contract) *B. Differential hazard (permanent)*



Note: Point estimates (lines) and ±2 robust standard error confidence bands (areas) are obtained from a linear probability hazard model that also (non-parametrically) conditions on education, gender, experience at the beginning of the spell, professional category, year of start of the spell, birth province/country, and plant province. The baseline hazard plotted in the left figure is computed for a Spanish primary educated male born in Barcelona in 1967 with zero years of experience starting a temporary spell in Barcelona.

nation, quitting, and beginning a new contract (either with the same firm or with another). Jobs vary according to their location (home versus away), contract type (temporary or permanent), wage and benefit package (including the severance pay), nonpecuniary characteristics (that directly affect utility), and human capital (accumulated through the number of spells and total experience on the job).

Employment opportunities arise from the potential for new productive job matches that are created exogenously. Firms post vacancies when new employment opportunities are created. These vacancies are for heterogeneous jobs defined by the characteristics. There is randomized matching between workers and firms. This generates a stochastic arrival rate of new employment opportunities to workers that depend on the characteristics of the workers and the jobs. Offers are defined by characteristics. (The firm could offer permanent and temporary contracts. They could be either permanent or temporary contracts, and specify the wage.) Whether employed or unemployed, workers receive at most one offer at each point in time. The job arrival rate depends on workers characteristics, and in particular, on whether they are employed or unemployed. If a currently employed worker receives an offer, with some probability, the employer has the opportunity to respond with a counter offer. Three different outcomes are possible: worker remains with the current employer, the worker quits his current job and accepts an offer from another firm, or the existing job match is destroyed, the worker is fired, and ends in unemployment.

A. Timing

We model the stationary equilibrium of a continuous time infinite horizon economy, where s denotes time, production flow is continuous, and the timing of decisions is determined by discrete events that occur at intervals of varying length.[3] These events are outcomes of the job arrival process, quitting opportunities, and of marginal productivity adjustments. The acceptance of new employment opportunities and the updating of human capital determine a sequence of individual-specific cycles that characterize the career of each worker. A new cycle begins when employment status changes, job turnover occurs, or after human capital accumulates for a fixed amount of time, whichever comes first.

During a cycle, new employment opportunities and the chance to quit arise according to a Poisson process. Workers are randomly matched to labor markets. When a worker has the opportunity to form a new match in a given market several firms in that labor market compete to attract her. They simultaneously make ultimatum wage offers. Upon receiving the job offers, or a chance to quit, the worker accepts at most one of them. If she declines, then no further opportunities arrive until human capital is updated at the end of the cycle. Another Poisson process determines job destruction, in which case the firm dismisses the worker. When a worker completes a cycle with a given employer, the firm makes some decisions about the worker's future with the firm.

In the model, workers are employed on temporary or permanent contracts. They are initially hired on a temporary contract. If a worker finishes the first cycle with the current firm, then her employer decides between not renewing the contract, renewing the temporary contract, or replacing it with a permanent contract. The employer faces the same three choices for the first $\tilde{n}$ cycles. However, if the firm has renewed the worker's temporary contract $\tilde{n}$ times, it must decide between offering a permanent contract or letting the worker go. Once the worker is on a permanent contract, the firm makes no further decisions about renewal.

The marginal productivity of labor depends on a set of state variables that are updated at the end of each cycle. The state variables characterize the employment experience of the worker, both general and specific to the employer and the occupation, the worker's employment history, along with some other individual characteristics. All location changes occur occur at the end of the cycle. Wage offers only occur at the beginning of each cycle. Thus, current employers cannot

[3] We assume very experienced (older) workers are replenished with younger workers in this steady state population.

respond immediately to outside offers.

B. Worker employment choices

There are a finite number of job types in the labor market are indexed by $k \in \{1, \ldots, K-1\}$. We let $k = 0$ denote involuntary unemployment, and $k = K$ denote voluntary nonemployment. Thus the set of possible job types consists of finely partitioned classifications, including occupations and regions (which might include region of birth and current region). Workers are infinitely lived. Each worker is characterized by a vector h, which includes human capital and her current employment status, as described in Section III.C.

There are two features that distinguish jobs that come from migration that jobs that emerge locally. First, migration is costly. Second, there are different job arrival rates across regions. Therefore, changing location affects the rate at which new employment opportunities arrive.

New employment opportunities and involuntary terminations arise continuously, and the flow rates for these events depend on a worker's history.[4] For example, job arrivals might occur more frequently in the region where the worker currently resides, more likely if a worker is unemployed rather than employed, and if employed, more likely if she is currently engaged on a temporary contract. Let $\lambda_k(h)$ denote the flow rate of labor market opportunities in type k jobs to a worker with a given history h (which includes her current position). Similarly, let $\lambda_0(h)$ denote the flow rate of involuntary job terminations and $\lambda_K(h)$ denote the flow rate of quitting opportunities. Thus, employment events to a worker with history h arrive at the rate $\sum_{k=0}^{K} \lambda_k(h)$.[5]

Let l_k denote an indicator variable signaling the arrival of a new employment opportunity in a type k position. Also let $d \in \{0, 1\}$ denote the indicator variable for accepting a new employment or quitting opportunity conditional on its arrival, where $d = 1$ means the worker moves and $d = 0$ means she stays. Setting $l \equiv \sum_{k=0}^{K} l_k$, it follows that $ld = 1$ indicates the event of the worker moving.

C. Production factors

In our model workers receive wage income when employed, and subject to their eligibility, unemployment and severance pay when unemployed. Wages and entitlements ultimately depend on work history, including job spell length and the

[4] Hereafter we refer to quitting opportunities as new employment opportunities, and we refer to new employment opportunities as well as involuntary terminations as employment events.

[5] For notational convenience, we normalize $\lambda_0(h) \equiv 0$ and $\lambda_K(h) \equiv 0$ when the worker is either voluntarily nonemployed or involuntarily nonemployed.

contract form of successive jobs, personal traits and the administrative rules determining the disbursement of entitlement income.

The (marginal) productivity of a worker depends on her state h, a multidimensional vector that includes fixed demographic characteristics, age, and indexes work experience, as well as the job type where she works. We define $h \equiv (x, j, m, n)$ where x denotes the worker characteristics, her human capital, and her employment history, $j \in \{0, ..., K\}$ denotes current position, $m \in \{\mathcal{T}, \mathcal{P}\}$ denotes whether her current contract is temporary ($\mathcal{T}$) or permanent ($\mathcal{P}$), and $n \leq \tilde{n}$ is the number of times the current temporary contract has been renewed, and $n = \infty$ if the worker is already in a permanent contract.

The productivity of the worker also depends on a cycle-specific component denoted by ξ. The value of ξ is revealed after the new cycle begins when production takes place. We assume that ξ is independent and identically distributed with $\mathbb{E}[\xi|h] = 0$.[6]

The duration of the current spell contributes to labor productivity, differentially affecting productivity in the current job relative to others. Thus general work experience measured by a weighted sum of past general work experience; this variable increases by a unit each instant that the worker is employed, and the stock declines from disuse. Another component is occupational-specific work experience. It follows a similar law of motion, even though the accumulation occurs only while working in a specific specialized occupation. The depreciation rate is occupational-specific. We assume the whole stock of specialized capital is destroyed by changing to another specialized occupation, but not by spells of unemployment or general work. A third component is firm-specific human capital. We distinguish between firm-specific human capital accumulated on a temporary contract from capital accumulated on a permanent contract. Aside from work experience in its various forms, individual heterogeneity, a vector of time-invariant characteristics and skills, that the background of the worker, such as gender, education and place of birth (for example in the case of migrants).

State transitions occur at the end of the cycle. If the worker switches to position k her state updates to $H_k(h) \equiv (X_k(x), k, \mathcal{T}, 0)$, where $X_k(x)$ denotes how x is updated in this case. Similarly, if she remains with her current employer, her human capital updates to $H_{\mathcal{T}}(h) \equiv (X_{\mathcal{T}}(x), j, \mathcal{T}, n+1)$ if she stays in a temporary contract, and to $H(h) \equiv (X(x), j, \mathcal{P}, \infty)$ if she is on a permanent contract next cycle.

[6] Nonemployed workers receiving unemployment benefits are paid the sum of two components, one which depends on h, and an idiosyncratic disturbance denoted by ξ.

D. Entitlements

In our model, workers are entitled to unemployment benefits and severance pay. While the individual is unemployed, she might or might not receive unemployment benefits from the government. To be entitled to them, she cannot leave her job voluntarily. The amount perceived depends on recent employment history. In addition, workers whose labor relations are involuntarily terminated receive from the firm, as severance pay, an amount that depends on tenure on the job and wage. When upgraded to a permanent contract, workers are entitled to severance pay, and their seniority entitlements to future severance pay are restarted.

We assume actual severance pay in permanent contracts depends of which of three institutional rules applies, whereas in temporary contracts it depends on a single institutional rule. In the case of a permanent contract, let ς_i denote the probability that rule i applies, and $S_i(h, \xi, s)$ denote the corresponding severance pay. Also let $S_{\mathcal{T}}(h, \xi, s)$ denote the severance pay for temporary contracts. Then the expected severance pay for a worker contracted for a wage w (that is net of ξ), denoted by $S(h, w, s)$, is defined as:

$$S(h, w, s) \equiv \begin{cases} S_{\mathcal{T}}(h, w, s) & \text{if } h = (x, j, \mathcal{T}, n) \\ \sum_{i=1}^{3} \varsigma_i S_i(h, w, s) & \text{if } h = (x, j, \mathcal{P}, \infty) \end{cases} \tag{1}$$

for all (x, j), and $n \leq \tilde{n}$. We assume that $S_{\mathcal{T}}(h, w, s)$ and $S_i(h, w, s)$ are linear in s.[7]

E. Firms

Firms are expected value maximizers. In their production, firms use a technology with constant returns to scale in employment. Consequently, the value of each job match is not affected by other firm's activities, including the values of other matches that the firm makes. Each job match is affected by an idiosyncratic component, specific to each worker, firm, and cycle. Production is realized and wages are paid at the end of each cycle. A firm is liable to severance pay if it fires a worker, either because the job match is destroyed or because a temporary contract is not renewed or replaced by a permanent contract.

Let $\zeta(h)$ denote the match-specific idiosyncratic productivity. We assume that in the first cycle of employment $\zeta(h)$ absorbs and hence is net of all hiring and training costs faced by the firm. Let $\pi(h, w, \xi, s)$ denote the probability density

[7] In Spain, workers accumulate credits in proportion to the amount of time they have accumulated on the job, and severance pay is the product of credited time and their current wage rate when they are laid off.

function of the worker leaving the firm at time s, and let $\psi_0(h, w, \xi, s)$ denote the probability density function of an exogenous job match destruction. We can now recursively define the value of a job match to the firm as:

$$V(h) = \max_{w \in \mathcal{W}(h)} \mathbb{E} \left\{ \begin{array}{l} [\zeta(h) - w] \left[\dfrac{1 - e^{-r}}{r} - \displaystyle\int_0^1 \pi(h, w, \xi, s) \dfrac{e^{-rs} - e^{-r}}{r} ds \right] \\ - \displaystyle\int_0^1 \psi_0(h, w, \xi, s) e^{-rs} S(h, w, s) ds \\ + \left[1 - \displaystyle\int_0^1 \pi(h, w, \xi, s) ds \right] e^{-r} W(h, w) \end{array} \middle| \, h \right\}, \tag{2}$$

where $\mathcal{W}(h)$ is the set feasible wages given h, and $W(h, w)$, defined below, denotes the value function at the end of the cycle. Three lines comprise the maximand in Equation (2). The expression in the top line is derived from:

$$\int_0^1 [\zeta(h) - w] \, e^{-rs} ds - \int_0^1 \int_s^1 \pi(h, w, \xi, s) \, [\zeta(h) - w] \, e^{-rz} dz ds. \tag{3}$$

The first expression in Equation (3) is the firm's surplus if the worker remains with the firm until the firm revises the worker's employment contract, while second accounts for the possibility that the worker might leave before the firm has the opportunity to revise her contract. The second line in Equation (2) is the expected discounted firing cost, and the third is the firm's expected continuation value. In the third expression, $W(h, w)$ is defined as:

$$W(h, w) \equiv \begin{cases} \max \{\epsilon_0 - S_{\mathcal{T}}(h, w), V(H_{\mathcal{T}}(h)) + \epsilon_1, V(H(h)) + \epsilon_2\} & \\ \qquad\qquad\qquad\qquad\qquad \text{if } h = (x, j, \mathcal{T}, n) \text{ and } n < \tilde{n} & \\ \max \{\epsilon_0 - S_{\mathcal{T}}(h, w), V(H(h)) + \epsilon_2\} & \\ \qquad\qquad\qquad\qquad\qquad \text{if } h = (x, j, \mathcal{T}, n) \text{ and } n = \tilde{n} & \\ V(H(h)) \qquad\qquad\qquad\qquad \text{if } h = (x, j, \mathcal{P}, \infty) & \end{cases} \tag{4}$$

where ϵ_0 is the idiosyncratic benefit associated with letting the worker go, ϵ_1 is associated with renewing a temporary contract with another one, and ϵ_2 with promoting the worker to a permanent contract.

F. Home production and amenities

We also include production by the worker outside of the firm and amenities including those within the firm, denoted by $\alpha(h)$. In this way, we allow for non-wage income, nonpecuniary benefits, and home production, which accrue at the end of the cycle.

G. Preferences

The worker's preferences depend on her consumption and utility cost of switching positions. Preferences are characterized by the discounted flow of utility, which we assume is a constant absolute risk aversion (CARA) utility function. Let γ denote the coefficient of risk aversion, and δ the continuously compounded subjective discount factor.

When the worker relocates and/or voluntarily changes her employment status, she experiences a random utility loss from moving denoted by ε drawn from a distribution that depends on h. The worker's lifetime utility can be summarized as:

$$-\int_0^\infty \{\exp(-\rho s - \gamma c(s)) \left[\delta(l(s)d(s)) + \delta(1 - l(s)d(s)) \exp(\varepsilon(s))\right]\} \, ds, \tag{5}$$

where $\delta(.)$ is the Dirac delta function, $d(s)$ and $l(s)$ are d and l respectively evaluated at time s, and similarly $\varepsilon(s)$ is ε evaluated as s when $l(s) = 1$.

H. Intertemporal consumption and employment choices

Following Margiotta and Miller (2000), we assume that workers cannot borrow against future income and entitlements, but do have sufficient access to financial markets to smooth their accumulated wealth without using their firm as a bank. In our model this means there exists a complete contingent-claims market for consumption. Let b denote the price of a bond that provides a flow rate of consumption from now into perpetuity, and let r denote the continuous real interest rate.

Workers have two forms of capital: accumulated wealth, and their human capital stock, included in h. The value of the human capital depends of the choices the worker makes in the future. Given stationarity, we set $s = 0$ at the beginning of a new cycle, and we let $s = 1$ denote the fixed interval of time that determines when human capital is updated if the worker remains with her current employer.

The equilibrium probability of accepting offer k if it arrives at time $s \in (0, 1)$ is denoted by $p_k(h, \xi, s)$. Let $\psi_k(h, s)$ denote the probability density that the next employment opportunity is $k \in \{1, ..., K\}$ and arrives at time $s \in (0, 1)$:

$$\psi_k(h, s) \equiv \exp\left(-s \sum_{k'=0}^{K} \lambda_{k'}(h)\right) \lambda_k(h). \tag{6}$$

Also denote by $\psi_0(h,\xi,s)$ the probability density of being fired at time s:

$$\psi_0(h,\xi,s) \equiv \exp\left(-s\left[\lambda_0(h) + \sum_{k=1}^{K}\lambda_k(h)p_k(h,\xi,s)\right]\right)\lambda_0(h) \tag{7}$$

Let $\Upsilon_k(h,\xi,s)$ denote the expected value of the exponentiated idiosyncratic disturbance associated with accepting a new employment opportunity $k \in \{1,...,K\}$ at time $s \in (0,1]$, defined as:

$$\Upsilon_k(h,\xi,s) \equiv \mathbb{E}\left[\exp\left(\frac{\varepsilon}{b}\right)\middle| d,h,\xi,s,l_k = 1\right]. \tag{8}$$

Set $S_i(h,s) \equiv S_i(h,w(h),s)$ and $S_{\mathcal{T}}(h,s) \equiv S_{\mathcal{T}}(h,w(h),s)$, and let $\Upsilon_0(h,s)$ denote the expected utility flow from severance if the worker is fired, defined as:

$$\Upsilon_0(h,s) \equiv \begin{cases} \exp\left[-\frac{\gamma S_{\mathcal{T}}(h,s)}{b}\right] & \text{if } h = (x,j,\mathcal{T},n) \\ \sum_{i=1}^{3}\varsigma_i \exp\left[-\frac{\gamma S_i(h,s)}{b}\right] & \text{if } h = (x,j,\mathcal{P},\infty). \end{cases} \tag{9}$$

Let $y(h,\xi,s)$ denote the discounted utility obtained from the flow rate of wages and nonpecuniary benefits to time $s \in (0,1]$, defined as:

$$y(h,\xi,s) \equiv \exp\left\{-\frac{\gamma\left(\alpha(h) + w(h) + \xi\right)s}{b}\right\}. \tag{10}$$

We now define $U(h)$ as:

$$U(h) \equiv \mathbb{E}\left[e^{-\frac{r}{b}}y(h,\xi,1)\left\{1 - \int_0^1\left[\psi_0(h,\xi,s) + \sum_{k=1}^{K}\psi_k(h,s)p_k(h,\xi,s)\right]ds\right\}\right], \tag{11}$$

$U_k(h)$ as:

$$U_k(h) \equiv \mathbb{E}\left[\int_0^1 e^{-\frac{rs}{b}}\psi_k(h,s)p_k(h,\xi,s)\Upsilon_k(h,\xi,s)y(h,\xi,s)ds\middle| h\right], \tag{12}$$

for $k \in \{1,...,K\}$ and:

$$U_0(h) \equiv \mathbb{E}\left[\int_0^1 e^{-\frac{rs}{b}}\psi_0(h,\xi,s)\Upsilon_0(h,s)y(h,\xi,s)ds\middle| h\right]. \tag{13}$$

Let $\mu_0(h)$ denote the probability that the worker is not renewed at the end of the cycle when she is on a temporary contract, $\mu_1(h)$ the probability that the firm offers another temporary contract at the end of the cycle, and $\mu_2(h)$ the probability that she is promoted to a permanent contract. Thus $\mu_1(h) \equiv 0$ when the firm does not have the option of renewing the worker into another temporary contract, that is when $h = (x, j, \mathcal{T}, \tilde{n})$ or $h = (x, j, \mathcal{P}, \infty)$. Also, $\mu_0(h) \equiv 0$ and hence $\mu_2(h) \equiv 1$ when the worker is in a permanent contract, that is when $h = (x, j, \mathcal{P}, \infty)$.

Let $A(h)$ and $B(h)$ denote an indexes of human capital for a worker in state h. Using the definitions in Equations (6) through (13), we recursively define these mappings as as:

$$A(h) \equiv U(h)B(h) + \sum_{k=0}^{K} U_k(h)A(H_k(h))^{\frac{1}{b}}, \tag{14}$$

and:

$$B(h) \equiv \mu_0(h)\Upsilon_0(h,1)A(H_0(h))^{\frac{1}{b}} + \mu_1(h)A(H_{\mathcal{T}}(h))^{\frac{1}{b}} + \mu_2(h)A(H(h))^{\frac{1}{b}} \tag{15}$$

Note that the first expression in Equation (14) is associated with staying in the current position after the end of the cycle, while the second expression is associated with changing the current position. The first expression in Equation (15) is associated with not being renewed, the middle expression with continuing with the firm in a temporary contract, and the third applies to continuing with the firm in a permanent contract.

For a given h, the index $A(h)$ measures the future accumulation of discounted utility obtained from the flow rate of wages and amenities plus the utility benefit associated with the choice-based disturbances. By inspection, the index is strictly positive, and lower values of it are associated with higher values of human capital. Thus, increasing expected compensation reduces $A(h)$. Similarly, $A(h)$ is monotonically increasing in $\alpha(h)$. Theorem 1 provides the basis of identification and estimation as described in Sections IV.B and V.D.

Theorem 1 *Conditional on having the opportunity to switch to k at time s, the worker chooses d to maximize:*

$$d\left\{\varepsilon - \frac{1}{b}\ln A(H_k(h))\right\} \tag{16}$$
$$-(1-d)\left\{\ln\left[\begin{array}{l} A(H_0(h))^{\frac{1}{b}}\lambda_0(h)\displaystyle\int_0^{1-s}\exp\left[-z\left(\lambda_0(h)+\frac{r}{b}\right)\right]\Upsilon_0(h,z+s)y(h,\xi,z)dz \\ +B(h)\exp\left[-(1-s)\left(\lambda_0(h)+\frac{r}{b}\right)\right]y(h,\xi,1-s)\end{array}\right]\right\}.$$

I. Equilibrium

Firms solve Equations (2) and (4). We assume a free entry condition into each labor market drives the expected value of a new match to each employer to zero.

Thus firms make initial wage offers by selecting w to solve:

$$\mathbb{E}\left\{\begin{array}{l}[\zeta(h)-w]\left[\dfrac{1-e^{-r}}{r}-\displaystyle\int_0^1 \pi(h,w,\xi,s)\dfrac{e^{-rs}-e^{-r}}{r}ds\right] \\ -\displaystyle\int_0^1 \psi_0(h,w,\xi,s)e^{-rs}S(h,w,s)ds \\ +\left[1-\displaystyle\int_0^1 \pi(h,w,\xi,s)ds\right]e^{-r}W(h,w)\end{array}\middle|\, h\right\}=0, \tag{17}$$

where h is the state of the worker conditional on accepting the firm's offer. Similarly, workers maximize Equation (16) solving Equations (14) and (15).

Equilibrium in our model is defined by the following three sets of conditions. First, $w(h)$, the wage contract appearing in Equation (10) which enters the worker's decision problem is the solution to the firm's problem defined in Equations (2) and (17). Second, $\mu_0(h)$, $\mu_1(h)$, and $\mu_2(h)$ used in Equation (15) of the worker's problem are the conditional choice probabilities for the firms solving the retention and promotion problem in Equation (4). Third, $\pi(h,w,\xi,s)$, the transition probability density of the worker leaving the firm, satisfies:

$$\pi(h,w(h),\xi,s)\equiv\psi_0(h,\xi,s)+\sum_{k=1}^{K}\psi_k(h,s)p_k(h,\xi,s) \tag{18}$$

where $p_k(h,\xi,s)$ is the conditional choice probabilities of the worker's employment choice problem obtained from the maximization of Equation (16), and $\psi_k(h,s)$ and $\psi_0(h,\xi,s)$ are defined in Equations (6) and (7), and $\psi_0(h,w,\xi,s)$ satisfies $\psi_0(h,w(h),\xi,s)=\psi_0(h,\xi,s)$.

IV. Identification

The data set contains information on all the components of the state variable h. We assume the updating transition functions for human capital, H_k, $H_{\mathcal{T}}$, and H, are known. Wages $\tilde{w}$, and unemployment benefits are observed. Thus, $w(h)$, the optimal wage contract, is identified as the nonlinear conditional expectation of on h. Consequently, $\xi=\tilde{w}-\mathbb{E}[\tilde{w}|h]$ is also identified. The function defining unemployment benefits is identified the same way. The rules for severance pay, $S_1(h,s)$, $S_2(h,s)$, $S_3(h,s)$, and $S_{\mathcal{T}}(h,s)$, depend on the type of separation. They are known, but we do not observe which rule applies when workers on permanent contracts are fired. The interest rate and bond price are set to the average of the period.

The decision to leave the firm is observed, but the decision to stay is not. Thus, all job transitions are observed, and so are quitting and firing. Thus $\pi_k(h,\xi,s)\equiv$

$\psi_k(h,s)p_k(h,\xi,s)$, the probability density function for accepting offers in $k \in \{1,...,K\}$, is identified in our data. Similarly, the hazard rate of firing, $\lambda_0(h)$, is identified. Consequently, $\psi_0(h,\xi,s)$ defined in Equation (6) is identified, as is $\pi(h,\xi,s)$.

The primitives of the model comprise match parameters, the distribution of severance pay rules, production parameters, amenities, and worker preference parameters. The match parameters are job arrival rates $\lambda_1(h)$ through $\lambda_K(h)$ and firing rates $\lambda_0(h)$. The probability distribution of rules for severance pay applying to permanent contracts is defined by ς_1, ς_2, and ς_3. Production is measured by $\zeta(h)$. Finally, $\alpha(h)$ characterizes amenity values for different positions, γ is the risk aversion parameter, and δ is the subjective discount factor.

A. Productivity and severance pay

In a stationary economy, the value from holding a permanent contract is the unique solution to a fixed point problem defined below. Given parameter values $\zeta(h)$ and $\varsigma \equiv (\varsigma_1, \varsigma_2, \varsigma_3)$, for the subset of the state space taking the form $\tilde{h} \equiv (x, j, \mathcal{P}, \infty)$, let $\Psi\left[\tilde{V}; \zeta, \varsigma\right]$ denote an operator defined from the space of functions of $\tilde{h}$ to itself as:

$$\Psi\left[\tilde{V};\zeta,\varsigma\right]\left(\tilde{h}\right) \equiv \mathbb{E}\left\{\begin{array}{l} \left[\zeta\left(\tilde{h}\right) - w\left(\tilde{h}\right)\right]\left[\dfrac{1-e^{-r}}{r} - \displaystyle\int_0^1 \pi\left(\tilde{h},\xi,s\right)\dfrac{e^{-rs}-e^{-r}}{r}ds\right] \\ -\displaystyle\sum_{i=1}^{3}\varsigma_i \int_0^1 \psi_0\left(\tilde{h},\xi,s\right)e^{-rs}S_i\left(\tilde{h},s\right)ds \\ +\left[1-\displaystyle\int_0^1 \pi\left(\tilde{h},\xi,s\right)ds\right]e^{-r}\tilde{V}\left(H\left(\tilde{h}\right)\right) \end{array}\right| \tilde{h}\left.\vphantom{\begin{array}{l}1\\1\\1\end{array}}\right\}, \tag{19}$$

It is straightforward to show that $\Psi\left[\tilde{V}; \zeta, \varsigma\right]$ is a contraction. Hence $V(h) = \Psi^{\infty}[0; \zeta, \varsigma](h)$ when h takes the form $(x, j, \mathcal{P}, \infty)$, that is in a permanent contract. Furthermore, $\Psi\left[V; \zeta, \varsigma\right]$ is monotone increasing in ζ. Also, noting that $\varsigma_3 = 1-\varsigma_1-\varsigma_2$, $\Psi\left[V; \zeta, \varsigma\right]$ is monotone in ς_1 and ς_2. Appealing to Equation (4), and rewriting $W(h) \equiv W(h, w(h))$, we obtain:

$$W(h) \equiv \begin{cases} \max\left\{\epsilon_0 - S_{\mathcal{T}}(h,1), V(H_{\mathcal{T}}(h)) + \epsilon_1, \Psi^{\infty}[0;\zeta,\varsigma](H(h)) + \epsilon_2\right\} & \\ \qquad\qquad\qquad\qquad \text{if } h = (x,j,\mathcal{T},n) \text{ and } n < \tilde{n} & \\ \max\left\{\epsilon_0 - S_{\mathcal{T}}(h,1), \Psi^{\infty}[0;\zeta,\varsigma](H(h)) + \epsilon_2\right\} & \\ \qquad\qquad\qquad\qquad \text{if } h = (x,j,\mathcal{T},n) \text{ and } n = \tilde{n} & \\ \Psi^{\infty}[0;\zeta,\varsigma](H(h)) \qquad\qquad \text{if } h = (x,j,\mathcal{P},\infty) & \end{cases} \tag{20}$$

Replacing $V(H_{\mathcal{T}}(h))$ by its definition in Equation (2), we obtain a finite recursion in $V(h)$ for $h = (x, j, \mathcal{T}, n)$ where $n \leq \tilde{n}$.

We assume the distribution of $\epsilon \equiv (\epsilon_0, \epsilon_1, \epsilon_2)'$ is known. Since we assume $S_1(h, s)$, $S_2(h, s)$, $S_3(h, s)$, and $S_{\mathcal{T}}(h, s)$ are known, the only unknowns in the system of equations given by (2), (19), and (20) are the function $\zeta(h)$ and the parameters ς. Because decisions are only taken at discrete intervals, the results in Arcidiacono and Miller (2014) for discrete time models apply, which implies that ς is identified off firm's conditional choice probabilities $\mu_0(h)$, $\mu_1(h)$, and $\mu_2(h)$, as is $\zeta(h)$ from the first renewal decision onwards ($n \geq 1$).

To establish $\zeta(h)$ is identified for the first cycle of the worker with the firm, that is where $h = (x, j, \mathcal{T}, 0)$, we appeal to Equation (17). Note that $W(h)$ is identified because the parameters in Equation (20) are identified by the arguments above. Rewriting Equation (17) to make $\zeta(h)$ the subject of the equation, and substituting $w(h)$ into the resulting expression, proves $\zeta(h)$ is a known function of identified parameters.

B. *Worker preferences and arrival rates*

Worker preferences are identified off the conditional choice probabilities, job arrivals, firing probabilities, and wages, which characterize the worker's lifecycle choices in equilibrium. Appealing to Proposition 1 of Hotz and Miller (1993), there exists a mapping $q(p_k(h, s)) : \Delta \rightarrow \mathcal{R}$ between conditional choice probabilities and the primitives of the model.

Lemma 1

$$q(p_k(h, \xi, s)) = \frac{1}{b} \ln A(H_k(h)) \tag{21}$$
$$- \ln \left[\begin{array}{c} A(H_0(h))^{\frac{1}{b}} \lambda_0(h) \displaystyle\int_0^{1-s} \exp\left[-z\left(\lambda_0(h) + \frac{r}{b}\right)\right] \Upsilon_0(h, z+s) y(h, \xi, z) dz \\ +B(h) \exp\left[-(1-s)\left(\lambda_0(h) + \frac{r}{b}\right)\right] y(h, \xi, 1-s) \end{array} \right].$$

If rejected employment opportunities were observed, then the conditional choice probabilities would be identified, and, given an assumption for the distribution for the utility loss from moving ε, $\alpha(h)$, and γ would be identified from Equation (21). In our framework, rejection rates are not observed, and we identify the conditional choice probabilities along with the job arrival rates from the structure of the model as described below.

We assume involuntary terminations are observed in the data. We also assume that job acceptance rates and job quit rates are also observed, but rejected opportunities are not observed. We now show that the other two arrival processes and the conditional choice probabilities are identified. Let $\pi_k(h,\xi,s) \equiv \psi_k(h,s)p_k(h,\xi,s)$ denote the probability density function for accepted offers in $k \in \{1,...,K\}$, which is identified in our data. Similarly, denote by $\varphi(h,\xi,s)$ the survival function for continuing in the same status, defined by:

$$\varphi(h,\xi,s) \equiv \exp\left(-s\left[\lambda_0(h) + \sum_{k'=1}^{K} \lambda_{k'}(h)p_{k'}(h,\xi,s)\right]\right), \tag{22}$$

which is also identified. Additionally, the hazard rate of firing, $\lambda_0(h)$, is identified from the data.[8] Using the definition $\psi_k(h,s)$ in Equation (6), Lemma 2 shows that if $\lambda_k(h)$ are identified for $k \in \{1,...,K\}$, then the conditional choice probabilities are identified.

Lemma 2

$$p_k(h,\xi,s) = \frac{1}{\lambda_k(h)} \frac{\pi_k(h,\xi,s)}{\sum_{k'=1}^{K} \pi_{k'}(h,\xi,s)} \left(-\lambda_0(h) - \frac{1}{s}\ln\varphi(h,\xi,s)\right). \tag{23}$$

By Hotz and Miller (1993) there exists $\tilde{\Upsilon}_k(p_k(h,\xi,s))$ defined on the simplex on to the real line for $k \in \{1,...,K\}$ such that $\Upsilon_k(h,\xi,s) = \tilde{\Upsilon}_k(p_k(h,\xi,s))$. Given a distributional assumption on idiosyncratic disturbances, and hence a functional form for the mapping $q(p_k(h,\xi,s))$, the theorem below shows that γ and $\alpha(h)$ are known functions of conditional choice probabilities.

Lemma 3

Theorem 2 *For any k, $s \in (0,1)$, ξ', and ξ, such that $\xi' \neq \xi$:*

$$\gamma = \frac{b^2}{(\xi'-\xi)(1-s)(b-1)}\left[q(p_k(h,\xi',s)) - q(p_k(h,\xi,s))\right]. \tag{24}$$

Also, for any k, ξ, $s' \in (0,1)$, and $s \in (0,1)$, such that $s' \neq s$:

$$\delta + \alpha(h) = \frac{b^2}{(s-s')(b-1)}\left[q(p_k(h,\xi,s')) - q(p_k(h,\xi,s))\right] - r - \gamma\tilde{w}. \tag{25}$$

To identify the system it only remains to show that $(\lambda_1(h),...,\lambda_K(h))$ is identified. To prove that this is the case, the Lemma 4 shows that $U(h,\xi)$ and $U_k(h)$ can be expressed as functionals of $(\lambda_1(h),...,\lambda_K(h))$ and identified functions.

[8] Given $\varphi(h,\xi,s)$ and λ_0, $\psi_0(h,\xi,s)$ is identified. Given $\pi_k(h,\xi,s)$, λ_0, and $\psi_0(h,\xi,s)$, $\pi(h,\xi,s) \equiv \psi_0(h,\xi,s) + \sum_{k=1}^{K} \pi_k(h,\xi,s)$ is identified.

Lemma 4 *Define $D_U(h,\xi,s)$ and $D_{U_k}(h,\xi,s)$ by the Equations (A17) and (A18) in Appendix A. These functions are identified, and:*

$$U(h,\xi) = \exp\left(-\frac{b-1}{b^2}\left(r+\delta+\alpha(h)+\gamma\tilde{w}\right)\right) D_U(h,\xi) \tag{26}$$

$$U_k(h) = \mathbb{E}\left[\int_0^1 D_{U_k}(h,\xi,s)\tilde{\Upsilon}_k(p_k(h,\xi,s))\exp\left[-\frac{b-1}{b^2}\left(r+\delta+\alpha(h)+\gamma\tilde{w}\right)s\right]ds\middle|h\right], \tag{27}$$

We now show that $A(h)$ and $B(h,\xi)$ depend on $(\lambda_1(h),...,\lambda_K(h))$ and identified functions. First, we substitute Equation (23) into Equations (24) and (25), and substitute the resulting expression from (25) into Equation (9). This shows that the parameter γ as well as the functions $\delta+\alpha(h)$ and $\Upsilon_0(h,\xi,s)$ can be expressed as functions $(\lambda_1(h),...,\lambda_K(h))$. Substituting Equation (23) and the resulting expressions from Equations (24) and (25) into Equations (26) and (27), all the components of $A(h)$ and $B(h,\xi)$ as defined in Equations (11) and (13) are defined as functions $(\lambda_1(h),...,\lambda_K(h))$. Substituting Equation (23) into Equation (21), $(\lambda_1(h),...,\lambda_K(h))$ are identified subject to invertibility conditions.

V. Estimation

This section describes the elements of h and how they are updated, and outlines the stepwise estimation procedure. The first step is to estimate the optimal wage contract $w(h)$, along with $\xi = \tilde{w} - w(h)$, and the unemployment benefits function. Then we estimate the firm's conditional choice probabilities $\mu_1(h,\xi)$, $\mu_2(h,\xi)$, and $\mu_3(h,\xi)$, and the density function of exiting the firm $\pi(h,\xi,s)$. Next, we estimate the productivity process $\zeta(h)$ and the probability distribution of severance pay rules ς from the solution of the firm's problem. Finally, appealing to the solution worker's problem, we estimate the worker's conditional choice probabilities $p_k(h,\xi,s)$ along with the arrival rates $\lambda_k(h)$ for $k \in \{1,...,K\}$, and, thence the remaining primitives $\alpha(h)$, δ, and γ.

A. Human capital

In our application the observed state variables, $h \equiv (x,j,m,n)$, are formed from the worker's characteristics, her human capital and her employment history captured by x, her current position j, the form of her current contract (temporary versus permanent) m, and if she is on a temporary contract, the number of times it has been renewed, n. We now describe the elements defining x, how they transition, and the set of positions in the labor market $\{0,...,K\}$. Further details are provided in Appendix B.

Labor market positions: Positions are characterized by location, employment status, industry, and occupational category. We partition Spain into 18 states, which correspond to the Spanish *Comunidades Autónomas* plus Ceuta and Melilla. Workers are classified by whether they are employed by a firm, self-employed in the agricultural sector, self-employed in another sector, involuntarily unemployed, or voluntarily nonemployed. The positions of workers employed by firms are characterized by industry (11), and occupational category (skilled, staff, officers, and laborers).[9] In sum, there are 864 separate positions.[10] Finally, we assume the maximal cycle length is one year for employed workers, and one month for nonemployed workers.

Fixed characteristics of workers: For each worker we include her birth place (province for Spanish born, country for foreign born), gender, age when and province where she entered the workforce, as well as a measure of education.[11] These permanent characteristics identify 1,059,968 different types of workers. We also exploit data on detailed (three-digit) industry, number of workers and date of first hire by the plant, and type of incorporation of the firm by spell to construct a time-invariant worker-specific index to indicate proclivity towards certain types of work.

Employment and migration histories: A complete employment and migration history is a list of the amount of time a worker with a given set of fixed characteristics spends in each of the labor market positions defined above. We define a set of state variables to represent this list as follows. We group human capital into four categories: general, and capital that is specific to location, occupation, and firm.

General human capital is formed from the unemployed spells, and the lengths of both unemployed and employed spells. Location specific human capital is defined by six elements: current location, place of birth, and place of first employment (all

[9] The industries are: 1) agriculture and extraction; 2) manufacturing, energy, and water/waste; 3) construction; 4) sales and vehicle repairs; 5) transportation and storage; 6) tourism; 7) information technologies, communication, finance, professional, scientific, and technology; 8) services; 9) public administration; 10) education, health, and social services; 11) artistic and entertainment activities.

[10] Positions can also be classified according to whether they are part time or full time. In our data, 88 percent of employment spells are full time, and about 7 percent of spells require less than 20 hours per week.

[11] The educational categories are: uncompleted primary or no education (11.4 percent), primary education or elementary high school —8th to 10th grade— (35.8 percent), elementary vocational training (5.3 percent), high school diploma (23.6 percent), advanced vocational training (8 percent), university diploma —three year degree— (6 percent), and bachelor degree or above (10 percent).

of which are defined above), plus number of spells in the current location, the time accumulated there, and number of moves in location. Occupation specific human capital is defined by the time accumulated in the current and previous occupations (defined by industry and occupational category). Firm specific human capital is defined by the length of the current spell.

B. Wages and unemployment benefits

The assumptions of the model imply that the difference between observed wages $\tilde{w}$ and the optimally contracted wage $w(h)$ is the independently distributed disturbance ξ. Thus, our estimates are obtained from a nonparametric regression function based on the sample analog of:

$$\mathbb{E}[\tilde{w} - w(h)|h] = 0. \tag{28}$$

Unemployment benefits are estimated nonparametrically as a function of the state variables in the model in a similar way.

We measure wages three different ways. The first measure is to define ξ as a difference between wages and a regression of wages on the characteristics included in h. The other two methods require us to first construct an additional measure of wages augmenting the regressors with the additional variables described above, as well as time dummies to reflect aggregate effects. In one case, we define $\tilde{w}$ as the effect of h on wages plus the residuals of the regression, and, in the other case, we add in a summary measure of the other regressors.

C. Productivity and severance pay

We assume $S_{\mathcal{T}}(h, \xi, s)$ is a uniform rule that applies to workers released from temporary contracts, accruing at a rate of 9 days per year worked. Circumstances surrounding firing determine which of three rules apply to workers involuntarily terminated from permanent contracts. If there is just cause (*despido procedente*) then the firm is not liable for any severance pay, and $S_1(h, \xi, s) = 0$. If the worker is let go because the firm is in economic distress (*despido por causas objetivas*) then severance pay, denoted by $S_2(h, \xi, s)$ in this case, accumulates at the rate of 20 days per year employed. Workers fired without just cause (*despido improcedente*) are due $S_3(h, \xi, s)$, calculated on the basis of 45 days' wages per year worked. Since we do not observe which of the three rules applies, we treat the proportion of layoffs associated with each rule, $(\varsigma_1, \varsigma_2, \varsigma_3)$, as parameters to be estimated within the model.

In estimation, we assume the distribution of ϵ is Type-I Extreme Value. To estimate the primitives of this model, we first estimate several components of Equation (19), leaving only $\zeta(h^*)$ and ς to estimate from this equation. Let $H^{n+1}(h^*) \equiv H^n(h^*)$ denote the composite function of successively updating human capital when the worker stays remains with a firm in a permanent contract, with $H^0(h^*) \equiv h^*$. The following lemma defines the representation that we use in estimation of these primitives. It shows that $\Psi^\infty[0; \zeta, \varsigma](h^*)$ is a linear combination of the primitives, where the coefficients are formed from nonparametrically estimated functions.

Lemma 5 *There exist mappings $v_0(h^*)$ through $v_3(h^*)$ plus $v_{4n}(h^*)$ for all n defined in Appendix A6, identified, and consistently estimated from density estimates and nonparametric regressions, satisfying the representation:*

$$\Psi^\infty[0; \zeta, \varsigma](h^*) = v_0(h^*) - \sum_{i=1}^{3} \varsigma_i v_i(h^*) + \sum_{n=0}^{\infty} v_{4n}(h^*)\zeta\left(H^n(h^*)\right). \tag{29}$$

Substituting Equation (29) into Equation (20), we exploiting the fact that not renewing a contract is a terminal action, and proceed using standard CCP methods. We first estimate the conditional choice probabilities $\mu_0(h, \xi)$, $\mu_1(h, \xi)$, and $\mu_2(h, \xi)$. In the second stage we recover the primitives $\zeta(h)$ and $(\varsigma_1, \varsigma_2, \varsigma_3)$.

D. Worker preferences

In our empirical framework we assume that idiosyncratic taste shock ε is Exponentially distributed with parameter κ. Lemma 6 gives the functional form for $q(p_k(h, \xi, s))$ and $\tilde{\Upsilon}_k(p_k(h, \xi, s))$ in this case.

Lemma 6

$$q(p_k(h, \xi, s)) = -\frac{1}{\kappa} \ln p_k(h, \xi, s) \tag{30}$$

$$\tilde{\Upsilon}_k(p_k(h, \xi, s)) = \frac{\kappa}{\kappa + b^{-1}} p_k(h, \xi, s)^{\frac{\kappa + b^{-1}}{\kappa}} \tag{31}$$

To estimate $\delta + \alpha(h)$ and γ we rewrite Equation (**??**) as a function of $\lambda_k(h)$ for $k \in \{0, ..., K\}$ and $\pi_k(h, \xi, s)$, and substitute the resulting expression into Equations (24) and (25).

For example, if $\kappa = 1$, we obtain the following simplifications:

$$q(p_k(h, \xi, s)) = -\ln p_k(h, \xi, s) \tag{32}$$

$$\tilde{\Upsilon}_k(p_k(h, \xi, s)) = \frac{b}{b+1} p_k(h, \xi, s)^{\frac{1+b}{b}} \tag{33}$$

and establish that γ and $\delta + \alpha(h)$ have the following closed forms:

$$\gamma = \frac{b^2}{(\xi' - \xi)(1-s)(b-1)} \ln \frac{D_{\psi k}(h, \xi, s)}{D_{\psi k}(h, \xi', s)}. \tag{34}$$

$$\delta + \alpha(h) = \frac{b^2}{(s - s')(b-1)} \ln \frac{D_{\psi k}(h, \xi, s)}{D_{\psi k}(h, \xi, s')} - r - \gamma \tilde{w}. \tag{35}$$

We also establish that:

$$U(h, \xi) = D_U(h, \xi) \tag{36}$$

$$U_k(h, \xi) = \lambda_k(h)^{-\frac{1+b}{b}} D_{Uk}(h) \tag{37}$$

$$A(h) = \mathbb{E}\left[D_U(h, \xi) B(h, \xi)^{1-\frac{1}{b}} \middle| h \right] + \sum_{k=0}^{K} \lambda_k(h)^{-\frac{1+b}{b}} D_{Uk}(h) A(H_k(h))^{1-\frac{1}{b}} \tag{38}$$

To do list

2) With regards of young workers, especially those joining the workforce, we assume finite dependence is achieved by mixing sequences of temporary jobs with non-employment spells. We will assume a similar profile applies to permanent job offers for young workers.

VI. Results

(TO BE PRESENTED AT THE CONFERENCE)

VII. Simulations

To determine the optimal permanent contract, the firm chooses wages to optimize equation (**??**), subject to the constraint that wages are rigid downwards. Appealing to Bellman's principle, the first order condition for an interior solution of a permanent contract is:

$$\begin{aligned} \frac{1-e^{-r}}{r} = & \int_0^1 \left[\pi(h, w, s) - [\zeta(h) - w] \frac{\partial \pi(h, w, s)}{\partial w} \right] \frac{e^{-rs} - e^{-r}}{r} ds \\ & - \int_0^1 \psi_0(h, s) e^{-rs} \frac{\partial S(h, w, s)}{\partial w} ds \\ & - e^{-r} \int_0^1 \frac{\partial \pi(h, w, s)}{\partial w} ds \mathcal{W}(H(h), w) + e^{-r} \left[1 - \int_0^1 \pi(h, w, s) ds \right] \frac{\partial \mathcal{W}(H(h), w)}{\partial w} \end{aligned} \tag{39}$$

An analogous condition applies for the temporary contract by replacing $\mathcal{W}(H(h), w)$ with $\mathbb{E}[\mathcal{U}(H(h), w)]$ in equation (39). Otherwise a boundary condition holds at

$w = w_0$, and:

$$\mathcal{W}(h, w_0) = \left\{ \begin{array}{l} [\zeta(h) - w] \left[\frac{1 - e^{-r}}{r} - \int_0^1 \pi(h, w, s) \frac{e^{-rs} - e^{-r}}{r} ds \right] \\ - \int_0^1 \psi_0(h, s) e^{-rs} S(h, w, s) ds \\ + \left[1 - \int_0^1 \pi(h, w, s) ds \right] \mathcal{W}(H(h), w_0) \end{array} \right\}, \tag{40}$$

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Appendix A: Proofs of Theorems and Lemmas

A1. Proof of Lemma 1

From Proposition 1 in Hotz and Miller (1993) we can define $q(p_k(h,s))$ as:

$$q(p_k(h,\xi,s)) \equiv \frac{1}{b}\ln A(H_k(h)) - \ln\left[\begin{array}{l} A(H_0(h))^{\frac{1}{b}}\lambda_0(h)\displaystyle\int_0^{1-s}\exp\left[-z\left(\lambda_0(h)+\frac{r}{b}\right)\right]\Upsilon_0(h,z+s)y(h,\xi,z)dz \\ +B(h)\exp\left[-(1-s)\left(\lambda_0(h)+\frac{r}{b}\right)\right]y(h,\xi,1-s)\end{array}\right]. \tag{A1}$$

where $A(h)$ is defined in Equation (14), $B(h)$ is defined in Equation (15), and $y(h,\xi,s)$ is defined in Equation (10). As noted in footnote 7, $S_{\mathcal{T}}(h,s)$ is linear in s, so it can be expressed as:

$$S_{\mathcal{T}}(h,s) \equiv S_{\mathcal{T}0}(h) + S_{\mathcal{T}1}(h)s. \tag{A2}$$

$$q(p_k(h,\xi,s)) \equiv \frac{1}{b}\ln A(H_k(h)) - \ln\left[\begin{array}{l} A(H_0(h))^{\frac{1}{b}}\lambda_0(h)\displaystyle\int_0^{1-s}\exp\left[-z\left(\lambda_0(h)+\frac{r}{b}\right)\right]\exp\left[-\frac{\gamma S_{\mathcal{T}}(h,z+s)}{b}\right]\exp\left\{-\frac{\gamma\left(\alpha(h)+w(h)+\xi\right)}{b}\right. \\ +B(h)\exp\left[-(1-s)\left(\lambda_0(h)+\frac{r}{b}\right)\right]y(h,\xi,1-s)\end{array}\right. \tag{A3}$$

$$q(p_k(h,\xi,s)) \equiv \frac{1}{b}\ln A(H_k(h)) - \ln\left[\begin{array}{l} A(H_0(h))^{\frac{1}{b}}\lambda_0(h)\displaystyle\int_0^{1-s}\exp\left[-z\left(\lambda_0(h)+\frac{r}{b}\right)-\frac{\gamma S_{\mathcal{T}}(h,z+s)}{b}-\frac{\gamma\left(\alpha(h)+w(h)+\xi\right)z}{b}\right]dz \\ +B(h)\exp\left[-(1-s)\left(\lambda_0(h)+\frac{r}{b}\right)\right]y(h,\xi,1-s)\end{array}\right] \tag{A4}$$

A2. Proof of Lemma 2

Using the definition of $\pi_k(h,\xi,s)$ and substituting the definition of $\psi_k(h,s)$ from Equation (6) we obtain:

$$\pi_k(h,\xi,s) \equiv \exp\left(-s\sum_{k'=0}^{K}\lambda_{k'}(h)\right)\lambda_k(h)p_k(h,\xi,s). \tag{A5}$$

Summing over k from 1 to K and rearranging yields:

$$\exp\left(-s\sum_{k=0}^{K}\lambda_k(h)\right) = \frac{\sum_{k=1}^{K}\pi_k(h,\xi,s)}{\sum_{k=1}^{K}\lambda_k(h)p_k(h,\xi,s)}. \tag{A6}$$

Substituting Equation (A6) into Equation (A5), and rearranging to make $p_k(h, \xi, s)$ the subject of the equation we obtain:

$$p_k(h, \xi, s) = \frac{1}{\lambda_k(h)} \frac{\pi_k(h, \xi, s)}{\sum_{k'=1}^{K} \pi_{k'}(h, \xi, s)} \left(\sum_{k'=1}^{K} \lambda_{k'}(h) p_{k'}(h, \xi, s) \right). \tag{A7}$$

Similarly, rearranging terms in Equation (22) we note that:

$$\sum_{k=1}^{K} \lambda_k(h) p_k(h, \xi, s) = -\lambda_0(h) - \frac{1}{s} \ln \varphi(h, \xi, s). \tag{A8}$$

Substituting Equation (A8) into Equation (A7) delivers the result. ■

A3. Proof of Lemma 3

We evaluate the mapping $q(p_k(h, \xi, s))$ at two distinct points in time in the same cycle, s' and s''. Subtracting one from the other and exponentiating the difference we obtain:

$$\exp\left[q(p_k(h, \xi, s'')) - q(p_k(h, \xi, s'))\right] = \tag{A9}$$
$$\frac{\left[\begin{array}{l} A(H_0(h))^{\frac{1}{b}} \lambda_0 \int_0^{1-s'} \exp\left[-z\left(\lambda_0 + \frac{r}{b}\right)\right] \Upsilon_0(h, \xi, z + s') y(h, \xi, z) dz \\ + \exp\left[-(1 - s')\left(\lambda_0 + \frac{r}{b}\right)\right] y(h, \xi, 1 - s') B(h, \xi) \end{array}\right]}{\left[\begin{array}{l} A(H_0(h))^{\frac{1}{b}} \lambda_0 \int_0^{1-s''} \exp\left[-z\left(\lambda_0 + \frac{r}{b}\right)\right] \Upsilon_0(h, \xi, z + s'') y(h, \xi, z) dz \\ + \exp\left[-(1 - s'')\left(\lambda_0 + \frac{r}{b}\right)\right] y(h, \xi, 1 - s'') B(h, \xi) \end{array}\right]}$$

A4. Proof of Theorem 2

Equation (24) is derived by exploiting differences in ξ that are reflected in the choice probabilities. Differencing the log of Equation (10), the definition of $y(h, \xi, s)$, for two distinct values ξ' and ξ yields:

$$\ln y(h, \xi', 1 - s) - \ln y(h, \xi, 1 - s) = -\frac{b - 1}{b^2} \gamma(\xi' - \xi)(1 - s). \tag{A10}$$

Similarly, taking the difference of Equation (21) evaluated at ξ and the same equation evaluated at ξ', we obtain:

$$q(p_k(h, \xi, s)) - q(p_k(h, \xi', s)) = \ln y(h, \xi', 1 - s) - \ln y(h, \xi, 1 - s). \tag{A11}$$

Substituting Equation (A10) into Equation (A11) and rearranging, we obtain Equation (24).

To prove Equation (25), we evaluate the mapping $q(p_k(h,\xi,s))$ at two distinct points in time in the same cycle, s' and s''. Subtracting one from the other, and using the definition of y in Equation (10), it follows that:

$$q(p_k(h,\xi,s'')) - q(p_k(h,\xi,s')) = \ln y(h,\xi,1-s') - \ln y(h,\xi,1-s''). \tag{A12}$$

Note that:

$$\ln y(h,\xi,1-s) = \ln y(h,\xi,1) - \ln y(h,\xi,s), \tag{A13}$$

which implies (A12) can be expressed as:

$$q(p_k(h,\xi,s'')) - q(p_k(h,\xi,s')) = \ln y(h,\xi,s'') - \ln y(h,\xi,s'). \tag{A14}$$

Also, taking logs in Equation (10), dividing the result by s, and performing a similar operation for s', we can equate the two expressions to obtain, upon rearrangement:

$$\ln y(h,\xi,s') = \frac{s'}{s} \ln y(h,\xi,s). \tag{A15}$$

Substituting Equation (A15) and an equivalent expression for s'' into Equation (A14), we rearrange to obtain:

$$\ln y(h,\xi,s) = \frac{s}{s''-s'} \left[q(p_k(h,\xi,s'')) - q(p_k(h,\xi,s')) \right]. \tag{A16}$$

Replacing $y(h,\xi,s)$ by its definition in Equation (10) and rearranging terms completes the proof. ■

A5. Proof of Lemma 4

Substituting Equation (10) into Equation (11), and using the definition of $\pi_k(h,\xi,s)$, $U(h,\xi)$ can be expressed as:

$$\begin{aligned} U(h,\xi) &= \exp\left(-\frac{b-1}{b^2}\left(r+\delta+\alpha(h)+\gamma\tilde{w}\right)\right)\left(1-\sum_{k=0}^{K}\int_0^1 \pi_k(h,\xi,s)ds\right) \\ &\equiv \exp\left(-\frac{b-1}{b^2}\left(r+\delta+\alpha(h)+\gamma\tilde{w}\right)\right) D_U(h,\xi), \end{aligned} \tag{A17}$$

where $D_U(h,\xi)$ is identified as an integral of the identified functions $\pi_k(h,\xi,s)$. Similarly, to obtain Equation (27), define:

$$D_{U_k}(h,\xi,s) \equiv \begin{cases} \pi_k(h,\xi,s)\exp\left(-\frac{rs}{b}\right) & \text{if } k \neq 0 \\ \pi_0(h,\xi,s)\Upsilon_0(h,\xi,s) & \text{if } k = 0 \end{cases}, \tag{A18}$$

Substituting Equations (A18), (10) and (**??**), into Equation (13), and defining $\tilde{\Upsilon}_0(p_0(h,\xi,s)) \equiv 1$, the result follows. ■

A6. *Proof of Lemma 5*

Define:

$$\tilde{v}_i(h^*) \equiv \int_0^1 \psi_0(h^*, \xi, s) e^{-rs} S_i(h^*, \xi, s) ds \quad i = 1, 2, 3, \tag{A19}$$

$$\tilde{v}_4(h^*) \equiv \frac{1 - e^{-r}}{r} - \int_0^1 \pi(h^*, \xi, s) \frac{e^{-rs} - e^{-r}}{r} ds, \tag{A20}$$

and:

$$\tilde{v}_{5n}(h^*) \equiv \begin{cases} 1 & \text{if } n = 0 \\ \prod_{n'=0}^{n-1} \left[1 - \int_0^1 \pi(H^{n'}(h^*), \xi, s) ds\right] & \text{if } n > 0 \end{cases} \tag{A21}$$

Telescoping $V^*(H(h^*))$, Equation (19) can be expressed as the infinite sum:

$$\Psi^\infty[0; \zeta, \varsigma](h^*) = \sum_{n=0}^{\infty} \tilde{v}_{5n}(h^*) e^{-nr} \left\{ [\zeta(H^n(h^*)) - w(H^n(h^*)) - \xi] \tilde{v}_4(H^n(h^*)) - \sum_{i=1}^{3} \varsigma_i \tilde{v}_i(H^n(h^*)) \right\}. \tag{A22}$$

Thus:

$$\Psi^\infty[0; \zeta, \varsigma](h^*) = v_0(h^*) - \sum_{i=1}^{3} \varsigma_i v_i(h^*) + \sum_{n=0}^{\infty} v_{4n}(h^*) \zeta(H^n(h^*)), \tag{A23}$$

where:

$$v_0(h^*) \equiv -\sum_{n=0}^{\infty} \tilde{v}_4(H^n(h^*)) \tilde{v}_{5n}(h^*) e^{-nr} [w(H^n(h^*)) + \xi], \tag{A24}$$

$$v_i(h^*) \equiv \sum_{n=0}^{\infty} \tilde{v}_i(H^n(h^*)) \tilde{v}_{5n}(h^*) e^{-nr} \quad i = 1, 2, 3, \tag{A25}$$

and:

$$v_{4n}(h^*) \equiv \tilde{v}_4(H^n(h^*)) \tilde{v}_{5n}(h^*) e^{-nr}. \tag{A26}$$

Note that $v_0(h^*)$ through $v_3(h^*)$ plus $v_{4n}(h^*)$ for all n can be estimated nonparametrically. ■

A7. *Proof of Lemma 6*

Since ε is Exponentially distributed, the probability of $\varepsilon \geq q$ is:

$$\Pr(\varepsilon \geq q) = \exp(-\kappa q). \tag{A27}$$

Solving for q yields Equation (30). In this case, $\tilde{\Upsilon}_k(p_k(h, \xi, s)$ equals to:

$$\begin{aligned} \tilde{\Upsilon}_k(p_k(h, \xi, s) &= \int_q^\infty \exp\left(\frac{-\varepsilon}{b}\right) \kappa \exp(-\kappa\varepsilon) d\varepsilon \\ &= \frac{\kappa}{\kappa + b^{-1}} \exp\left[-\left(\kappa + b^{-1}\right) q\right]. \end{aligned} \tag{A28}$$

Substituting for q we obtain Equation (31). ■

A8. Proof of Theorem ??

From replacing Equation (??) into Equation (26) we note that:

$$\sum_{k=0}^{K}\int_0^1 D_{1U}(h,\xi,s)\lambda_k(h)\tilde{\Upsilon}_{0k}(p_k(h,\xi,s))ds \tag{A29}$$
$$= \sum_{k=0}^{K}\int_0^1 D_{1U}(h,\xi,s)\left(\lambda_k(h)^b - \lambda_k(h)^{b-1}\frac{\pi_k(h,\xi,s)}{D_\psi(h,\xi,s)}\right)^{\frac{1}{b}}\Gamma\left(\frac{b+1}{b}\right)ds,$$

and:

$$\sum_{k=0}^{K}\int_0^1 D_{2U_k}(h,\xi,s)\tilde{\Upsilon}_{0k}(p_k(h,\xi,s))ds \tag{A30}$$
$$= \sum_{k=0}^{K}\int_0^1 D_{2U_k}(h,\xi,s)\left(1 - \lambda_k(h)^{-1}\frac{\pi_k(h,\xi,s)}{D_\psi(h,\xi,s)}\right)^{\frac{1}{b}} ds,$$

and by replacing Similarly, replacing Equation (??) into Equation (27) we note that:

$$\tilde{\Upsilon}_{dk}(p_k(h,\xi,s)) = \begin{cases} p_k(h,\xi,s)^{\frac{1}{b}}\Gamma\left(\frac{b+1}{b}\right) & \text{if } d=1 \\ (1-p_k(h,\xi,s))^{\frac{1}{b}}\Gamma\left(\frac{b+1}{b}\right) & \text{if } d=0. \end{cases} \tag{A31}$$

$$U_k(h) = \mathbb{E}\left[\int_0^1 D_{2U_k}(h,\xi,s)\tilde{\Upsilon}_{1k}(p_k(h,\xi,s))\exp\left[\frac{1-b}{b^2}(r+\delta+\alpha(h)+\gamma\tilde{w})\,s\right]ds\bigg| h\right], \tag{A32}$$

A9. Proof of blah

Differencing the mapping $q(p_k(h,\xi,s))$ for two distinct offers k and k' and rearranging terms yields:

$$A(H_k(h))^{1-\frac{1}{b}} = \exp\left[q(p_k(h,\xi,s)) - q(p_{k'}(h,\xi,s))\right]A(H_{k'}(h))^{1-\frac{1}{b}}. \tag{A33}$$

Similarly, rearranging terms in Equation (21) we can write, for any $k \in \{1, ..., K\}$:

$$B(h,\xi)^{1-\frac{1}{b}} = \frac{A(H_k(h))^{1-\frac{1}{b}}}{\exp\left(q(p_k(h,\xi,s))\right)y(h,\xi,1-s)}. \tag{A34}$$

Thus, substituting Equations (A33) and (A34) in Equation (14) we obtain:

$$A(h) = A(H_k(h))^{1-\frac{1}{b}}\times \tag{A35}$$
$$\left\{\mathbb{E}\left[\frac{U(h,\xi)}{\exp\left(q(p_k(h,\xi,s))\right)y(h,\xi,1-s)}\bigg| h\right] + \sum_{k'=0}^{K}U_{k'}(h)\exp\left[q(p_{k'}(h,\xi,s)) - q(p_k(h,\xi,s))\right]\right\}.$$

Let:

$$B_k(h,\xi,s) \equiv \mathbb{E}\left[\frac{U(h,\xi)}{\exp\left(q(p_k(h,\xi,s))\right) y(h,\xi,1-s)}\middle| h\right] + \sum_{k'=0}^{K} U_{k'}(h) \exp\left[q(p_{k'}(h,\xi,s)) - q(p_k(h,\xi,s))\right]. \tag{A36}$$

We define:

$$B_{0k}(h,\xi,s) \equiv \mu_0(h,\xi)\Upsilon_{10}(h,\xi,1)B_k(H_0(h),\xi,s) \tag{A37}$$

$$B_{1k}(h,\xi,s) \equiv \mu_1(h,\xi)B_k(H(h),\xi,s) \tag{A38}$$

$$B_{2k}(h,\xi,s) \equiv \mu_2(h,\xi)B_k(H_{\mathcal{T}}(h),\xi,s). \tag{A39}$$

Substituting Equation (A35) in the top row of Equation (15) yields:

$$\begin{aligned}
&\mu_0(h,\xi)\Upsilon_{10}(h,\xi,1)A(H_0(h))^{1-\frac{1}{b}} + \mu_1(h,\xi)A(H(h))^{1-\frac{1}{b}} + \mu_2(h,\xi)A(H_{\mathcal{T}}(h))^{1-\frac{1}{b}} \\
&\quad = B_{0k}(h,\xi,s)^{1-\frac{1}{b}}A(H_k(H_0(h)))^{\frac{(b-1)^2}{b^2}} + B_{1k}(h,\xi,s)^{1-\frac{1}{b}}A(H_k(H(h)))^{\frac{(b-1)^2}{b^2}} + B_{2k}(h,\xi,s)^{1-\frac{1}{b}}A(H_k(H
\end{aligned} \tag{A40}$$

A10. Proof of blah blah

Successively substituting (A8) into (A6), and the result into the top line of Equation (6) yields:

$$\begin{aligned}
\psi_k(h,\xi,s) &= \frac{\sum_{k'=1}^{K}\pi_{k'}(h,\xi,s)}{-\lambda_0(h) - \frac{1}{s}\ln\frac{\psi_0(h,\xi,s)}{\lambda_0(h)}}\lambda_k(h) \\
&\equiv D_\psi(h,\xi,s)\lambda_k(h),
\end{aligned} \tag{A41}$$

for $k \in \{1,...,K\}$, where $D_\psi(h,\xi,s)$ is identified by inspection. Thus, Equation (23) simplifies to:

$$p_k(h,\xi,s) = \lambda_k(h)^{-1}\frac{\pi_k(h,\xi,s)}{D_\psi(h,\xi,s)}. \tag{A42}$$

Similarly, from Equations (**??**) and (**??**):

$$\Upsilon_{dk}(h,\xi,s) \equiv \begin{cases} \exp\left(-\frac{rs}{b}\right)\lambda_k(h)^{-\frac{1}{b}}\left(\frac{\pi_k(h,\xi,s)}{D_\psi(h,\xi,s)}\right)^{\frac{1}{b}}\Gamma\left(\frac{b+1}{b}\right) & \text{if } d=1 \\ \exp\left(-\frac{rs}{b}\right)\left(1-\lambda_k(h)^{-1}\frac{\pi_k(h,\xi,s)}{D_\psi(h,\xi,s)}\right)^{\frac{1}{b}}\Gamma\left(\frac{b+1}{b}\right) & \text{if } d=0 \end{cases} \tag{A43}$$

A11. Proof of blah blah blah

Appealing to Equations (23) and (**??**):

$$q(p_k(h,\xi,s)) = -\ln\left[\lambda_k(h)\frac{D_\psi(h,\xi,s)}{\pi_k(h,\xi,s)} - 1\right]. \tag{A44}$$

Thus, for distinct ξ' and ξ, we can write:

$$\exp\left[q(p_k(h,\xi',s)) - q(p_k(h,\xi,s))\right] = \frac{\pi_k(h,\xi',s)}{\pi_k(h,\xi,s)} \frac{[\lambda_k(h)D_\psi(h,\xi,s) - \pi_k(h,\xi,s)]}{[\lambda_k(h)D_\psi(h,\xi',s) - \pi_k(h,\xi',s)]}. \tag{A45}$$

Substituting (A45) into Equation (24) and rearranging we obtain:

$$\frac{\lambda_k(h)D_\psi(h,\xi,s) - \pi_k(h,\xi,s)}{\lambda_k(h)D_\psi(h,\xi',s) - \pi_k(h,\xi',s)} = \frac{\pi_k(h,\xi,s)}{\pi_k(h,\xi',s)} \exp\left(\gamma \frac{(b-1)}{b^2}(\xi' - \xi)s\right). \tag{A46}$$

Appendix B: Data construction (TO BE COMPLETED)

B1. Muestra Continua de Vidas Laborales

The *Muestra Continua de Vidas Laborales* (MCVL) is a large micro-level panel data set assembled by the Spanish Social Security Administration (SSSA) that contains complete working histories for over one million individuals. The dataset also includes several socioeconomic characteristics, unemployment, retirement and welfare benefits, Social Security contributions, and labor income tax bases. This information is obtained from linking data from the SSSA (*Dirección General de Ordenación de la Seguridad Social*), population registries (*Padrón Municipal Continuo*), and tax declarations (*Agencia Tributaria*).

The MCVL draws a 4% random sample of all individuals that are (or have been at some point in the reference year) contributing to the Social Security, or receiving pensions or benefits from the SSSA. The MCVL has been ongoing since reference year 2004 (we use waves from 2004 to 2012). Working histories are available retrospectively. The 4% random sample is selected based on the Social Security Identifier, which ensures that the data are longitudinal, and refreshed to account for mortality, labor market detachment, and new labor market entries. The reference population includes individuals who worked at least a day during the reference year, including self-employment and excluding a subset of civil servants, unemployed workers who received unemployment insurance benefits, or unemployment subsidy, retirees, widows and orphans receiving benefits, and unentitled unemployed workers who voluntarily decide to contribute to the Social Security System.[12] In 2006, for example, the population of reference consisted of 29.3 millions of individuals.

B2. Sample selection and variable definitions (pilot estimation)

We draw our preliminary results from a subsample of individuals, which we call our pilot sample. The pilot sample is restricted to include male born in Spain between 1971 and 1975 (both included). This sample includes 62,628 individuals observed over 1,604,941 spells. Table B1 summarizes sample construction. Some inconsistent and overlapping spells are dropped, as described in Panel A. Similarly,

[12] The population of interest thus excludes individuals whose only connection to the SSSA is publicly provided health insurance or non-contributory subsidies, as well as individuals without any connection to the SSSA. In particular, the subset of civil servants that are affiliated to MUFACE —an alternative mutuality available to civil servants from the *Cuerpo de Funcionarios del Estado* who entered in that category before 2011— are excluded from the population of interest.

Table B1—Sample Selection and the Construction of Spells (pilot sample)

A. Sample selection

Description	Spells	Individuals
Initial sample (male born in Spain in 1971-1975)	**1,402,196**	**62,887**
− Individuals that during their working life experienced at least one calendar year with more than 60 working or paid unemployment spells	−86,977	−247
− Spells with zero or negative length. Most of them are zero-length spells that correspond to administrative adjustments	−115,281	
− Spells initially appeared for the individual in older waves, but disappeared in the most recent waves	−6,910	
− Spells of unemployment benefits that are collected because an ongoing contract is temporarily suspended —hence the unemployment spells are embedded in an employment contract (will be revised, R)	−28,844	−12
− Summer job spells defined as spells that occur before age 25 to individuals who never experienced non-summer job spells, and have the following characteristics: length below 100 days, and either start between June and September of a given calendar year and are not followed by any other spell in the given year, or the individual works less than 120 days in that year	−31,763	
− Spells of employment in agriculture that are duplicated due to firm's and worker's separate contributions to Social Security	−3,756	—
− Spells that exactly overlap with others (R)	−1,915	—
− Spells completely embedded in longer self-employment spells	−48,332	—
− Spells completely embedded in longer spells (R)	−46,129	—
− Spells completely embedded by two longer contiguous spells (R)	−1,548	—
+ Spells of unpaid nonemployment	+262,655	—
Final pilot sample	**1,293,396**	**62,628**

B. Adjustments of starting and ending dates of overlapping spells

Description	Start dates delayed	End dates advanced
Self-employment spells partially overlapping with other spells	4,710	6,257
End dates that coincide with the following starting date (delayed one day)	—	4,154
Unemployment benefits spells overlapping with (often part time) employment spells or other unemployment spells (R)	1,350	1,685
Voluntarily terminated employment spells that overlap by less than 15 days (mandatory notice period)	—	3,874
Overlapping employment spells in which at least one of them is part time (the one with fewer hours is shortened) (R)	2,228	2,885
Overlapping full time employment spells (R)	4,459	—
Total	**12,747**	**18,855**

starting and ending dates of partially overlapping spells are adjusted such that spells fit consecutively (12,747 starting dates are delayed, and 18,855 ending dates are advanced, as detailed in Panel B). Coexisting payments in simultaneous spells will be included in the estimation of wage equations with the final version, but they are omitted in the pilot sample.

The final number of spells is obtained from dropping a set of spells from the initial sample. These include: spells that have zero or negative length (115,281, most of them zero length, which often consist of administrative adjustments as opposed to real employment or unemployment spells); spells that appeared in older waves but disappeared from more recent ones (6,910); unemployment spells that were totally embedded in ongoing contracts due to a temporal suspension of the contract (28,844); summer job spells while still in school (31,763); agricultural worker contributions to Social Security that coexist with firm's contributions (3,756); spells that were exactly overlapping with others (1,915); spells that are completely embedded within a self-employment spell (48,332); spells that are completely embedded within a longer spell (46,129); and spells completely embedded within two longer spells (1,548). Similarly, starting and ending dates of partially overlapping spells are adjusted such that spells fit consecutively (12,747 starting dates are delayed, and 18,855 ending dates are advanced). Coexisting payments in simultaneous spells will be included in the estimation of wage equations with the final version, but they are omitted in the pilot sample.

Contract type A long list of types of contracts is included in the raw data, which we summarize in two general types: permanent and temporary. The classification of contracts into these two categories is based on contract description. Permanent contracts include regular permanent contracts (*fijos*), and seasonal permanent contracts (*fijos-discontinuos*). Temporary contracts include all fixed-term contracts, task-based contracts (*por obra o servicio*), and substitution contracts.

Job type The different types of jobs are defined geographically and by occupations. Geographically we distinguish between rural and urban labor markets for each of the 17 Spanish regions (*Comunidades Autónomas*), plus the two autonomous cities of Ceuta and Melilla, which are grouped in one urban category. Spells are assigned to locations based on the city where the plant is declared to operate.[13] Urban markets are identified as municipalities with more than 40,000

[13] For a small number of spells this information is not available (3.01%). In all these cases, all other spells for the worker are in the current region, so we impute this region to the spell with missing geographical information. Wether the worker is in an urban or rural area within the region is imputed sequentially. All spells with missing rural/urban status that are observed

inhabitants. Occupations are defined by the combination of industry and professional category. Eleven industries are considered: Agriculture and extraction; Manufacturing, energy, water and waste; Construction; Sales and vehicle repairs; Transportation and storage; Tourism; Information, communications, financial services, professionals, scientists, and technical; Services; Public administration; Education, health, and social services; and Artistic and entertainment activities. Four professional categories are included: skilled (including *Ingenieros, licenciados y alta dirección*; *Ingenieros técnicos, peritos y ayudantes*; and *Jefes administrativos y de taller*), staff (*Ayudantes no titulados*, *Oficiales administrativos*; and *auxiliares administrativos*), officers (*Oficiales de primera y segunda*; and *Oficiales de tercera y especialistas*), and laborers (*Mayores de 18 años no caulificados*; *Menores de 18 aos*; *Menores de 17 años*; and *Subalternos*).

in Ceuta and Melilla are considered urban (0.00%). If the rural/urban status is observed for the plant in other spells, it is imputed accordingly (0.55%). If the spell is ongoing, we impute the current residence rural/urban status (0.32%). The spell is imputed a rural/urban status if all other spells are in the same status, and so is the current residence (0.30%). We impute rural status if the worker is employed in agriculture (0.72%). We impute rural/urban status if previous and next spells were in the same rural/urban situation (0.32%). Most of the remaining spells with missing information are imputed according to the most frequent status in the other spells by the worker (0.80%). The residual is imputed to urban (0.04%).