The Increase in Duration of Unemployment Benefits: Confronting Data and the Predictions of an Equilibrium Search Model*

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Abstract

We confront data and the predictions of an equilibrium search model on the effects of an increase in the duration of unemployment benefits. We focus on the Portuguese reform of 1999: a quasi-natural experiment. The reform increased the duration of benefits for some age groups and maintained all features of the unemployment insurance system fixed for other age groups. Data and predictions agree on the unemployment rate, labor market participation and on the levels of employment and unemployment. Data and predictions differ on the average duration of unemployment. For all cases, the differences between data and predictions are small.

Keywords: unemployment duration, unemployment benefits, equilibrium search, labor reforms, quasi-natural experiment.

JEL Codes: E24, J23, J64, J65.

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1 INTRODUCTION

In 1999, the Portuguese government extended the duration of unemployment insurance benefits for certain age groups. We use this event, a quasi-natural experiment, to estimate the impact on subsidized unemployment, and to evaluate whether the predictions of an equilibrium search model of unemployment match the impact of the reform. We compare predictions and data on the unemployment rate, average unemployment duration, labor force participation, and the level of employment and unemployment. We use the model of Alvarez and Veracierto (2000).

It is typically difficult to evaluate a model because ideally we would have to compare the economy with and without the reform. The solution developed by the causal inference econometric literature is to find a control group—those not exposed to the reform—to proxy what would have happened in the absence of the reform. Usually, however, a control group is not available either because there is no data or because the reform affects the whole economy indistinctively. This does not happen in the 1999 reform. We have a rich dataset—administrative data covering the entire population of unemployment insurance recipients, both before 1999 and afterwards—and the reform affected some groups but let others with similar characteristics unchanged.

The characteristics of the reform imply a privileged quasi-natural experiment: (1) in Portugal, the duration of benefits depends exclusively on the age of the recipient; and (2) the reform increased the maximum benefit period for six age groups and maintained it constant for two age groups. Moreover, reforms usually combine many changes, but the 1999 reform changed only the potential benefit duration. The characteristics of the reform allow us to use the difference-in-differences estimator to obtain the impact of longer benefits on the unemployment duration of subsidized unemployed. To our knowledge, this is the first paper to use a quasi-natural experiment on the increase in the benefit duration to recalibrate a search equilibrium model and compare its predictions with the data after the reform[1].

We use the difference-in-differences analysis to increase the precision of the model. While usually the predictions of a model are obtained by recalibrating a parameter with data before and after the reform, we improve the recalibration by taking into account only the direct impact of the reform on the parameter of interest. Our estimation procedure, under the identification assumptions, accounts only for the direct impact since we correct for common trends such as the macroeconomic cycle.

A prominent use of models is to run counterfactual experiments: what would happen if a particular policy parameter changed? This is interesting for policy makers. Following the argument in Lucas (1981), we have confidence in the model to answer these questions if the model reproduces the effects of simpler policies. Policies for which we have more certainty about the effects. We have to be careful, however, when comparing the predictions of the model with data. We have to remove from the empirical estimation elements that affect the economy but that are not related to the reforms. This is the reason to use a quasi-natural experiment.

In Alvarez and Veracierto (2000), there are different production sectors with different productivity shocks and number of workers. Agents decide whether to enter the labor force, and whether to accept a job offer or to search for another offer. Unemployment insurance affects the duration of unemployment and other variables such as production, consumption, and the number of employed and unemployed workers. We calibrate the model for the economy before the reform and analyze how equilibrium changes once the duration of unemployment benefits increases. We use the difference-in-differences estimator to determine how the duration of unemployment increased for the recipients of unemployment benefits.

[1] The empirical literature on the effects of labor market reforms is extensive. It includes, among others, Card and Levine (2000), Lalive et al. (2006) and Van Ours and Vodopivec (2006). Our contribution is to use a natural experiment to calibrate a model and compare its predictions with the data.

The model better predicts the effects on the unemployment rate, labor force participation, and on the levels of employment and unemployment. The predictions on labor force participation, employment and unemployment are closer to the data in the case of a smaller degree of substitution between domestic and market goods. However, the observed average duration of unemployment decreased after the reform, even for some groups of individuals with longer benefits, while the model predicts an increase in the average duration of unemployment.

The sections in the remainder of the paper are (2) description of the reform; (3) empirical estimation; (4) the search model; (5) calibration, data and predictions; and (6) conclusions.

2 THE REFORM OF THE UNEMPLOYMENT INSURANCE SYSTEM

The main feature of the Portuguese unemployment insurance reform of July 1999 is the increase of the maximum benefit duration for particular age groups. The economy was growing fast and the labor market was in good condition. In 1998, real GDP was growing at 4.7 percent per year and employment at 2.3 percent per year. Table 1 has data for GDP growth and the labor market variables from 1997 to 2002. The effects of an increase in the benefit duration may be overstated if the increase is endogenous, that is, induced by recessions (Card and Levine 2000, Lalive et al. 2006, and Lalive and Zweimüller 2004). We have the opposite in the 1999 reform. Favorable to our estimation, the good condition of the economy indicates that the reform was exogenous.

The reform favors causal inference with the difference-in-differences estimator: (1) the reform did not change the eligibility criterion: a minimum of 18 months of social contributions in the last 24 months before unemployment; (2) the reform did not change the way that the benefit is based, only on age at the beginning of the unemployment spell; (3) the value of the unemployment benefit did not change; and

(4) the reform increased the maximum benefit duration for some age groups while maintained it constant for contiguous age groups. The unemployment insurance system did not change for some individuals—they will serve as control groups—while it changed only the maximum benefit duration for other individuals—they will serve as treatment groups.

Table 1. The Portuguese economy before and after July 1999

	Real GDP Growth	**Employment Growth**	**Unemployment Rate**	**Long-Term Unemployment (%)**
1997	4.2	1.9	5.8	43.6
1998	4.7	2.3	5.0	45.4
1999	3.9	1.9	4.4	41.2
2000	3.9	2.3	3.9	43.8
2001	2.0	1.5	4.0	40.0
2002	0.8	0.5	5.0	37.3

Sources: National Accounts and Employment Survey from INE.

Another helpful feature of the reform is the following: the new rules applied exclusively to those entering unemployment after the reform. This, together with the characteristics above, allows us to use individuals before and after the reform to control for macroeconomic effects and for non-observed heterogeneity among individuals.

Table 2. Entitlement periods (in months) before and after July 1999

Before		**After**	
Age (years)*	Entitlement Period	Age (years)*	Entitlement Period
15-24	10	15-29	12
25-29	12		
30-34	15	30-39	18
35-39	18		
40-44	21	40-44	24
45-49	24	45-64	30 (+8)**
50-54	27		
55-64	30		

*: Age at the beginning of the unemployment spell. **: For those aged 45 or older, the entitlement period increases 2 months for each 5 years of social contributions during the previous 20 calendar years.

Table 2 summarizes the reform. It shows the maximum benefit duration of unemployment insurance before and after the reform. Before July 1999, there were eight age groups, each with a maximum benefit duration. After July 1999, there were only four age groups and their corresponding four maximum benefit durations. Two age groups are particularly important for the difference in differences estimation: the group 15-24 and the group 30-34.

For the age group 15-24, the maximum benefit duration increased from 10 to 12 months, increasing to the maximum benefit duration of the next older age group 25-29. This is the first set of treatment and control groups that we use to identify the impact of higher maximum benefit periods on the duration of subsidized unemployment. 15-24 is the treatment group and 25-29 is the control group. For the group 30-34, the maximum benefit duration increased from 15 to 18 months. Again, the new maximum duration coincides with the maximum benefit duration of the next older group, 35-39. This is our second set of treatment and control groups.

For those aged 40 to 44, the maximum benefit duration increased from 21 to 24 months. This group, however, does not have a control with the same maximum benefit duration. We will use the younger group 35-39 as the control group for the group 40-44.

The groups with individuals aged 45 or more will not be analyzed because we cannot determine the increase in the maximum benefit duration for these groups. For them, the maximum benefit duration became a function of the years with social security contributions. From a base benefit period of 30 months, the reform added 2 months of benefits for each 5 years of contributions. The data, however, does not have the complete record of social contributions or the actual maximum benefit duration. For the oldest age group, 55-64, moreover, the reform allowed early retirement with little or no penalties after a period of unemployment. Early retirement incentives individuals to remain with unemployment benefits beyond the increase of the maximum benefit duration. As we want to study the effects of the increase in the maximum duration of unemployment, we chose to analyze only the first three treatment groups.

For the first three treatment groups, we can determine the increase in the maximum benefit duration, and this was the only change with the reform.

Another useful characteristic of the Portuguese reform is the considerable increase in the maximum benefit duration: 20 percent for the 15-24 and 30-34 groups (2 months in 10, and 3 months in 15), and almost 15 percent for the 40-44 group. The size of the increase helps identification.

3 ESTIMATION WITH A QUASI-NATURAL EXPERIMENT

We start our identification of the impact of the increase in the potential benefit duration by exploring the quasi-natural experiment settings that results from the legislative change. In this section, we describe the construction of the treatment and control groups, briefly review the econometric methodology, present the data, and estimate the impact on subsidized unemployment duration with the difference-in-differences procedure.

3.1 Treatment and Control Groups

We have three pairs of treatment and control groups: (i) the treatment group 15-24, which has as control group individuals aged 25-29; (ii) similarly for the groups 30-34 and 35-39; (iii) and 40-44 and 35-39. As described in Table 2, the maximum benefit periods increased for those aged 15-24 and 30-34, set to the maximum periods in the next older age groups, 25-29 and 35-39. We cannot use the contiguous older group 45-49 as control group for the 40-44 because the benefit period increased for both groups. We use a younger group, 35-39, as a control for the group 40-44. The only groups that the reform did not increase the maximum benefit period were the control groups 25-29 and 35-39.

3.2 Methodology: Difference-in-Differences

Let Y_{it}^{D} be the potential outcome of interest for individual i at time t in state D, where $D = 1$ if exposed to the reform and 0 otherwise. Let treatment take place at time t. The fundamental identification problem is that we do not observe, at time t, individual i in both states. We cannot compute the individual treatment effect, $Y_{it}^1 - Y_{it}^0$. One can, however, if provided with a control group, estimate the average effect of the treatment on the treated.

Nonetheless, there may be unobservable differences between treatment and control that make the identification difficult. The unobservable differences may be overcome by the difference-in-differences estimator. The idea is to use an untreated comparison group to identify temporal variation in the outcome that is not due to the treatment. In order to achieve identification of the general difference-in-differences estimator we need to assume

$$E[Y_{it}^0 - Y_{it'}^0 \mid D = 1] = E[Y_{it}^0 - Y_{it'}^0 \mid D = 0], \tag{1}$$

where t' is a time period before the program implementation. The assumption states that the outcome of treated individuals ($D = 1$), if they had not been exposed to the treatment, would have evolved in the same way as for the individuals not exposed to the treatment ($D = 0$). This assumption is known as the time invariance principle.

If (1) holds, the difference-in-differences estimates of the average treatment effect on the treated can be obtained by the sample analogs of

$$\widehat{\alpha}_{\text{D-in-D}} = \{E[Y_{it} \mid D = 1] - E[Y_{it} \mid D = 0]\} - \{E[Y_{it'} \mid D = 1] - E[Y_{it'} \mid D = 0]\}. \tag{2}$$

The time invariance assumption can be too stringent if the treated and control groups are not balanced in covariates that are believed to be associated with the outcome variable (a problem known as the Ashenfelter's dip, after Ashenfelter 1978). The setup can be extended to accommodate a set of covariates, usually linearly, taking into account eligibility-specific effects, and time or aggregate effects. In the following model, $\widehat{\alpha}_D$ corresponds to the difference-in-differences estimate obtained on a sample of treatment and control units

$$Y_{it} = \lambda D + \tau_t + \theta' Z_{it} + \alpha_D D \tau_t + \varepsilon_{it}, \tag{3}$$

where D represents the eligibility-specific intercept, defined over age and gender according to treatment rules, τ_t captures time or aggregate effects and equals 0 for the before period and 1 for the after period, and Z is a vector of covariates to correct for differences in observed characteristics between individuals in treatment and control groups.

3.3 Data

We use administrative data by the Portuguese social security bureau *Instituto de Informática da Segurança Social* (IISS). The dataset has *all* subsidized unemployment spells initiated between 1998 and 2002. It has detailed and reliable information on previous wages, and on the type, amount and duration of benefits. An important statistical feature of the data is that all spells are complete: the recipients are followed from the moment they register until they exit the system. In other words, the unemployment spells correspond to a single-cycle/flow sampling scheme as defined in Lancaster (1992). Table 3 contains summary statistics by age group and period.

For data on nonrecipients of benefits, labor force participation and other labor statistics, we use the Portuguese quarterly employment survey, *Inquérito ao Emprego*, conducted by the national statistics agency *Instituto Nacional de Estatística*. We use data for 1999:3-2002:4 and, therefore, we can track transitions from inactivity, unemployment, and employment, and compute the duration of unemployment spells.

For the age groups studied, we have a total of 130,788 subsidized unemployment spells, of which 104,686 correspond to spells initiated under the new legislation. These are divided in 17,962 units in the younger treatment group 15-24, and 30,254 units in the corresponding control group 25-29; the remaining observations are divided into

24,479 and 14,165 individuals for the 30-34 and 40-44 treatment groups, and 17,827 in the corresponding control group 35-39. Observations in the before period average over 5,000 observations per pair period-group. Table 3 contains summary statistics of the key variables by age group and period.

Table 3. Summary statistics and unconditional difference-in-differences

	Treatment 15-24		**Control 25-29**		**Treatment 30-34**		**Control 35-39**		**Treatment 40-44**	
	Before	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**
Unemployment (days)	146.2	179.0	203.0	187.9	206.5	269.3	301.5	288.3	266.9	368.6
Differences	32.8		-15.1		62.9		-13.2		101.7	
	(1.8)		(1.7)		(2.8)		(3.0)		(4.8)	
Difference-in-differences	47.9				76.1				114.9	
	(2.5)				(4.1)				(5.4)	
Female (proportion)	0.49	0.57	0.48	0.60	0.43	0.56	0.41	0.52	0.35	0.47
Pre-unemployment wages										
Average	401.14	443.47	512.96	599.35	581.22	645.11	662.28	659.98	689.50	679.40
Median	385.77	416.12	458.75	525.60	472.70	537.29	502.33	514.82	495.50	517.90
Age	22.0	22.2	27.0	27.0	31.9	31.8	36.9	36.9	41.8	41.9
No. of observations	5,149	17,962	7,084	30,254	5,075	24,478	5,358	17,827	3,436	14,165

Authors' calculations based on IIES administrative data. Mean values unless otherwise noted. The dataset includes data on region and date (month and year) of unemployment insurance claim, also used in the estimation. Standard deviations in parentheses.

Average unemployment duration before the new legislation was 146 days for the treatment group 15-24 and 203 days for the corresponding control group 25-29. After the reform, the average durations changed, respectively, to 179 and 188 days. As expected, the subsidized unemployment durations of the two groups differed substantially when the groups had different maximum benefit durations, but the difference between durations decreased after the reform equalized the maximum benefit duration. For the group 30-34, the difference to the control group before the reform was close to 100 days. After reform, the difference reduced to less than 20 days. If we use this information to compute a simple unconditional difference-in-differences estimate, then the average treatment impact on the duration of subsidized unemployment is 48 days for the 15-24 group, 76 days for the 30-34 group and 115 days for the 40-44 age group; all estimates are statistically significant (see Table 3).

In terms of the observable characteristics, there are no ex-ante noticeable gender-composition differences between the treatment groups and the respective control groups. For instance, women represent 57 percent of the subsidized individuals aged 15-24 after the reform and 60 percent of the subsidized individuals aged 25-29. Larger differences are observed for average age, as expected, and pre-unemployment wages. The effect of age is the result of the definition of treatment and control groups, which yields control units older than the treatment units. For the pre-unemployment wages, the control group average is always larger than the respective treatment group. Again, this an expected result given the well-documented Mincerian age and tenure profile of wages (Mincer 1974). Despite of the differences, the inclusion of the age variable in the conditional difference-in-differences estimator corrects for the observed heterogeneity.

3.4 Causal Inference: The Impact on Unemployment Duration for Recipients of Unemployment Benefits

Table 4 presents the estimates with the difference-in-differences of the average treatment effect on the treated. That is, the impact of the increase in the maximum benefit duration on the duration of unemployment for those that receive the benefit. The estimations do not change much with the inclusion of control variables: columns (1) vs. (2), (3) vs. (4), and (5) vs. (6). We interpret this finding as a sign of the quality of our quasi-natural experiment. The inclusion of control variables, nonetheless, yields a slightly lower impact: from 48 to 43 days for subsidized unemployed aged 15-24, from 76 to 74 days for the group 30-34, and from 115 to 110 days for the group 40-44.

Our estimation of the impact is not particular to the difference-in-differences estimator. The estimation agrees with Centeno and Novo (2007), which use the same quasi-natural experiment but focus on the unemployed aged 30-39 with gross replacement rates of 65 percent. Centeno and Novo (2007) estimate the impact using the non-parametric Kaplan-Meyer method, but also with quantile treatment effects, with results in line with our average treatment effects.

Table 4. Difference-in-differences estimates of the impact of longer UI entitlement periods on the duration of subsidized unemployment, per age group

	Treatment Groups					
	15-24		**30-34**		**40-44**	
	Unrestricted	Restricted	Unrestricted	Restricted	Unrestricted	Restricted
	(1)	(2)	(3)	(4)	(5)	(6)
After	-15.1	16.8	-13.2	34.4	-13.2	21.2
	(1.6)	(3.0)	(2.9)	(5.0)	(3.4)	(6.4)
Treat	-56.8	-38.9	-95.1	-66.7	-34.6	-53.7
	(2.2)	(2.7)	(3.7)	(4.6)	(4.8)	(6.1)
After × Treat	**47.9**	**42.8**	**76.1**	**74.4**	**114.9**	**110.2**
	(2.5)	**(2.5)**	**(4.1)**	**(4.1)**	**(5.4)**	**(5.3)**
Log of previous wage		1.8		34.3		57.2
		(1.2)		(1.6)		(2.1)
Female		0.4		14.4		34.5
		(1.0)		(1.7)		(2.3)
Age		-0.1		31.0		-9.3
		(2.9)		(7.6)		(11.7)
Age^2		0.1		-0.4		0.2
		(0.1)		(0.1)		(0.1)
Dummies:						
Regional	No	Yes	No	Yes	No	Yes
Month of unemployment	No	Yes	No	Yes	No	Yes
Year of unemployment	No	Yes	No	Yes	No	Yes
No. of observations	60,449	60,449	52,738	52,738	40,786	40,786

The age group 25-29 is the control group for the treatment group 15-24; similarly, the age group 35-39 is the control group for the treatment group 30-34. These control groups are the age groups who maintained the entitlement period, respectively, 12 and 18 months. Coincidentally, these entitlement periods correspond to the new duration of benefits for the treatment groups. The age group 35-39 is also the control group for the treatment group 40-44. The difference-in-differences estimate of the impact of the UI entitlement extension on subsidized unemployment duration is the coefficient on "After × Treat." See Table 2 for the UI entitlement periods before and after the new legislation. Standard error in parentheses.

Another indication of the quality of the experiment is the reduction in the duration of only 2 weeks for the control groups (see Table 3). This reduction is compatible with the strong economic growth around the period of the reform, and the negative correlation of unemployment duration and economic growth. The quality of the experiment, we argue, allows us to identify the impact of the increase in the maximum benefit duration.

The increase of 43, 74, and 110 days in the unemployment duration for the groups

15-24, 30-34, and 40-44 show in practice how the reform changed the behavior of individuals with benefits. We will use these estimates to change the parameter of the model responsible for the duration of unemployment benefits (ψ, as we will see). This change implies new equilibrium variables: our model predictions after the reform. We will compare the new equilibrium variables with the data after the reform.

4 AN EQUILIBRIUM SEARCH MODEL

We use the search model with unemployment insurance of Alvarez and Veracierto (2000). We briefly describe the model and then concentrate on its calibration and predictions about the increase in the maximum benefit duration of the 1999 reform[2].

There are many production sectors and a constant population of agents with measure one. The productivity in each sector changes according to a stochastic shock. According to the current shock, agents in the sector decide to stay, move to another sector, or exit from the labor market. If they move to another sector, they search for one period, as unemployed workers, and are assigned randomly to another sector in the following period. If they exit from the labor market, they engage in home production and produce a domestic good. Agents in home production have to search for one period to re-enter the labor market. The model is an equilibrium search model because wages and the number of agents employed, unemployed and at home are compatible with preferences, production, and the unemployment insurance system.

Agents have infinite lives. They have preferences

$$E\sum_{t=0}^{\infty}\beta^t\left(\frac{c_t^{1-\gamma}-1}{1-\gamma}+h_t\right), \tag{4}$$

where c_t is consumption of market goods, h_t is consumption of domestic goods, $\gamma \geq 0$ and $0 < \beta < 1$. Each agent supplies one unit of labor in each period.

[2] We direct readers interested in a detailed analysis of the model to Alvarez and Veracierto (2000).

The production technology in each sector is $y_t = z_t g_t^{\alpha}$, $0 < \alpha < 1$, where y_t is production of market goods, g_t is the number of employed agents in the sector, z_t is the productivity shock. The productivity shock evolves according to the AR(1) process $\log z_{t+1} = \rho \log z_t + \varepsilon_{t+1}$, where $0 < \rho < 1$ and ε_{t+1} has Normal distribution with mean zero and variance σ^2, independent across sectors. The process for z implies a transition function $Q(z, Z')$, which gives the probability of z being an element of Z' in the following period. The labor market is competitive and so wages are equal to the marginal productivity of labor, $f(z_t, g_t)$. Domestic production produces w^h goods with one unit of labor.

Let x denote the number of agents in a sector at the beginning of a period. Index each sector by its beginning number of agents and shock, (x, z). Let U denote the number of unemployed agents, uniformly assigned to each sector. The number of agents in a sector in the following period is $x' = g(x, z) + U$.

The productivity shock process and the movement of agents across sectors imply a stationary distribution $\mu(x, z)$ for the number of sectors with x agents and productivity z. With μ, we can calculate the number of employed and unemployed workers, the average duration of unemployment and other equilibrium variables.

To describe the equilibrium conditions, consider first the case with no unemployment insurance. Assume for now perfect substitution of market and domestic goods, $\gamma = 0$. γ affects the substitution between market and domestic goods but it does not affect equilibrium values that involve rates, such as the duration of unemployment and the unemployment rate.

Let $v(x, z)$ denote the value for an employed agent in the beginning of a period in sector (x, z). If the agent stays in the sector, he receives wages $f(g(x, z), z)$ and begins the following period in the same sector as a worker. If he leaves, he obtains a value θ, to be determined in equilibrium.

The value function v is increasing in the productivity shock z and decreasing in the population of the sector x, until v reaches its minimum value, θ. In this case, some agents prefer to leave the sector and obtain θ. There is a threshold employment value $\bar{g}(z)$ such that all agents stay in the sector if $x < \bar{g}(z)$, and some agents leave the sector if $x \geq \bar{g}(z)$. Employment in sector (x, z) is, therefore, $g(x, z) = x$ if $x < \bar{g}(z)$ and $g(x, z) = x$ if $x \geq \bar{g}(z)$. As a result, the Bellman equation of an employed agent in sector (x, z) is

$$v(x, z) = \max\left\{ f(x, z) + \beta \int v(x + U, z') Q(z, dz'), \theta \right\}. \tag{5}$$

Agents that leave the sector may search during the current period or leave the labor force and produce w^h domestic goods. As θ is the value of an agent who leaves a sector, it satisfies

$$\theta = \max\left\{ \beta \int v(x, z) \mu(dx \times dz), w^h + \beta\theta \right\}. \tag{6}$$

That is, θ is equal to the maximum between staying in the labor force as an unemployed agent (the term in the left in the max), or leaving the labor force (the term in the right). In equilibrium, agents out of the labor force are indifferent between searching or staying out of the labor force and so the terms in the left and in the right in the max are equal. We have two equilibrium conditions: (1) $\theta = \dfrac{w^h}{1-\beta}$, and (2) $\theta = \beta \int v(x, z) \mu(dx \times dz)$. Condition (1) is the only one that changes when $\gamma > 0$. It has to be replaced by $\theta c^{-\gamma} = w^h / (1 - \beta)$, where c is aggregate consumption of the market good.

Unemployment Insurance

Agents receive the unemployment benefit when they leave a sector in which they were workers to search for employment. Three parameters model the unemployment insurance system: (1) the value of the benefit, b, in consumption goods, (2) the probability of eligibility, κ, and (3) the probability of maintaining eligibility, ψ. An increase in the maximum duration of benefits goes into the model as an increase in ψ. The unemployment insurance is financed with lump-sum taxes.

Unemployment insurance increases the value of becoming employed because previously employed agents may receive the benefits when unemployed. As an increase in κ or ψ increases the probability of receiving unemployment benefits, the value of becoming employed increases with these parameters.

There are now two threshold levels of employment such that employed and ineligible agents are indifferent between staying or leaving the sector for a given productivity shock, $\bar{g}_1(z)$ and $\bar{g}_0(z)$. Eligible agents are the first to leave a sector as they have a higher search value, $\bar{g}_1(z) < \bar{g}_0(z)$. We may consider the threshold level of eligible agents, however, in equilibrium the number of eligible agents that decide to search is equal to zero.

The Bellman equation now takes into account the cases in which new arrivals, U, are smaller or higher than $\bar{g}_1(z)$. For low productivity shocks, $U > \bar{g}_1(z)$, the number of arrivals in the sector is too high relative to its productivity. In this case, all employed workers leave and a few agents stay. At the most, U agents stay if the shock is high enough to imply $U \leq \bar{g}_0(z)$. In this case, $g(x,z) = U$. The shock, however, may be so low that even some ineligible leave: $\bar{g}_0(z) < U$ and so $g(x,z) = \bar{g}_0(z)$. Denote by θ_1 and θ_0 the value of search of eligible and ineligible agents. The value function when productivity shocks are low is then

$$v_0(x,z) = \max\left\{ f(U,z) + \beta \int v(U+U,z')\, Q(z,dz'),\, \theta_0 \right\}. \tag{7}$$

For high productivity shocks, we have $U \leq \bar{g}_1(z)$. If there are few agents in the sector, $x \leq \bar{g}_1(z)$, then all agents stay and $g(x,z) = x$. Otherwise, the currently employed workers stay until they are indifferent between staying and leaving, $g(x,z) = \bar{g}_1(z)$. Therefore, the value function for agents that begin in sector (x,z) with high productivity shocks is

$$v_1(x,z) = \max\left\{ f(x,z) + \beta \int v(x+U, z') \, Q(z, dz'), \, \kappa\theta_1 + (1-\kappa)\theta_0 \right\}. \tag{8}$$

Combining the cases with high and low productivity shocks, the Bellman equation with unemployment insurance is

$$v(x,z) = \min\{v_1(x,z), \, v_0(x,z)\}. \tag{9}$$

The values of θ_1 and θ_0 are equal to the maximum value obtained staying out of the labor force or searching, according to the eligibility. We have

$$\begin{aligned} \theta_1 = {} & b + \max\Big\{ w^h + \beta\left[\psi\theta_1 + (1-\psi)\theta_0\right], \\ & \beta\left(\psi \int \max\{v(x,z), \theta_1\} \, d\mu + (1-\psi) \int \max\{v(x,z), \theta_0\} \, d\mu\right)\Big\}, \end{aligned} \tag{10}$$

$$\theta_0 = \max\left\{ w^h + \beta\theta_0, \, \beta \int \max\{v(x,z), \theta_0\} \, d\mu \right\}. \tag{11}$$

Eligible agents must take into account the probability ψ of maintaining eligibility, as stated in (10). Equation (10) considers the case in which the government cannot monitor the effort of unemployment insurance recipients: they receive the unemployment benefit whether they search or stay out of the labor force.

Agents out of the labor force must be indifferent between staying out or searching. Analogously to the equilibrium conditions for the case with no insurance, we have $\theta_0 = w^h / (1-\beta)$ and $\theta_0 = \beta \int \max\{v(x,z), \theta_0\}$.

5 CALIBRATION, DATA AND PREDICTIONS

The parameters to calibrate are b, ψ and κ for the unemployment insurance system; α and w^h for the production function; ρ and σ^2 for the productivity process; and β and γ for the utility function. We use the calibrated model to compare the predictions of the model on the increase in the maximum benefit duration with the data after the reform. The dataset has substantial detail for each age group. It has, for example, the unemployment rate, average duration of unemployment, and labor force participation for each age group. Because of the availability of data, we calibrate the parameters for each age group separately: 15-24, 30-34, and 40-44. This allows us to compare the predictions of the model for each age group instead of just comparing the predictions for the whole economy.

The three treatment groups behave differently, particularly when the age difference increases. For instance, the unemployment rate for the 40-44 group before the reform was 3.8 percent, less than half the unemployment rate of the 15-24 group, of 10 percent. If we treated all groups as a single agent, the predictions of the model would be more imprecise. Implicitly, we assume that workers in each group have common characteristics among themselves, such as skills and position in the life cycle, but that they are sufficiently different from the workers in the other treatment groups. The common characteristics allow workers to be treated as homogeneous agents within groups. The different characteristics separate the effects of the increase in the benefit duration for each group: more agents aged 30-34 searching for a job do not affect the search results of agents aged 15-24. Notice that the control groups are contiguous in age to the treatment groups, and therefore should have enough common characteristics to allow us to use of the difference-in-differences estimators.

We follow the calibration procedure in the literature (among others, Alvarez and Veracierto 2000, 2001, Gomes, Greenwood, and Rebelo 2001, and Ljungqvist and

Sargent 2007, 2008). We indicate when our procedure is different. The calibrated parameters are in Table 5.

Unemployment insurance system (b, κ and ψ). b is the unemployment benefit received in each period, in terms of average wages. We set b equal to the average replacement ratio in the period immediately before the reform—from the first quarter of 1998 to the second quarter of 1999[3]. The replacement ratio is the ratio between unemployment benefits and before-tax wages. Unemployment benefits are tax exempt in Portugal.

For the probability of eligibility, κ, we use the ratio of recipients to unemployed workers in each age group. As the reform did not change the eligibility criterion, we maintain the probability of eligibility for each group before and after the reform. We calculate separately the average ratios before and after the reform, and then set κ equal to the average of the two values. For the 30-34 group, for example, the ratio before and after the reform increased from 23 to 25 percent. We use the average of the two values, 24 percent. We use the same procedure for the other age groups.

The probability of maintaining eligibility, ψ, implies that the expected duration of unemployment benefits is $1/(1-\psi)$. We use administrative data on the duration of unemployment benefits for each age group from 1998:1 to 1999:2 to retrieve ψ before the reform. We do not use directly the benefit period set by the legislation to calibrate ψ. As common in the literature, we use data on the average duration of benefits and the implications of the model on the expected duration of benefits. We consider a model period of three months for the age group 15-24 and six months for the other age groups. We discuss further the choice of the model period in the calibration of the productivity process.

[3] Alvarez and Veracierto (2000) set the value of b to 40% of the replacement ratio in the U.S. to remove the effect of the experience-rated tax, which they consider a firing cost. There is not an experience-rated tax in Portugal or another tax that could confuse unemployment benefits with firing costs. Therefore, we use the data for the replacement ratio without corrections to set the value of b.

How to obtain ψ after the reform? To map legislation to parameters, the procedure requires the new duration of benefits for unemployment recipients after the reform. We obtain ψ after the reform with the calculations in section 3, which took advantage of the quasi-natural experiment For the 30-34 group, the reform increased the maximum benefit duration from 15 to 18 months. According to the calculations in section 3, in contrast, the average number of months of benefits for recipients in this group increased from 6.9 to 9.4 months.[4] The values of ψ before and after the reform are obtained from these two values: ψ is found so that the expected duration of unemployment benefits is equal to 6.9 months before and 9.4 months after the reform. We proceed in the same way for the other groups.

The equilibrium is a function of the expected present value of benefits, $p = \kappa b/(1-\beta\psi)$. As the policy only changed the duration of the benefit, keeping b and κ fixed, the increase in the present value of benefits is approximately given by the ratio between the duration after and before the change in policy. The increase, p_{after}/p_{before}, in particular, does not depend on the model period. For the groups 15-24, 30-34 and 40-44, the increase in the benefit duration increased the present value of benefits 31, 35, and 38 percent, respectively.

Production. For the labor share, we use the calculations in Gollin (2002), who estimates labor shares taking into account labor income of the self employed. He obtains three estimates for the labor share in Portugal: 0.602, 0.748 and 0.825, according to the method used to obtain income of the self employed. We set $\alpha = 0.7$, a little smaller than the mean of the three estimates, 0.725, as Gollin points out that the highest estimate can overstate the labor share. Traditionally, the labor shares for Portugal are assumed to be smaller, around 0.6 or lower, not taking into account labor income of the self employed.

[4] We add the difference-in-differences estimate, in Table 4, to the before reform subsidized unemployment duration $(206.5 + 74.4)/30 = 9.4$ months.

We set the domestic production of agents out of the labor force, w^h, so that the model matches the data for the labor force participation before the reform for each age group. w^h affects only labor participation, it does not affect the unemployment rate or the duration of unemployment.

Table 5. Parameters

		15-24	30-34	40-44
b	Unemployment benefit	0.77	0.70	0.68
κ	Probability of eligibility	0.08	0.24	0.36
ψ	Persistence of eligibility, before	0.38	0.13	0.33
ψ	Persistence of eligibility, after	0.53	0.36	0.52
ρ	Persistence of z	0.99095	0.99420	0.99524
σ^2	Variance of z	1.255E-02	5.65E-03	4.40E-03
w^h	Domestic productivity (for γ = 1)	1.403	0.737	0.775
α	Labor Share	0.7	0.7	0.7
β	Intertemporal discount	0.99024	0.98058	0.98058

The change in legislation is modeled as an increase in the persistence of eligibility, ψ. p in model period wages. The model period is three months for the group 15-24 and six months for the other groups. w^h for curvature γ = 1, the other parameters do not depend on the curvature parameter.

Productivity Process. We set ρ and σ^2—the persistence of $\ln z_{t+1}$ and the variance of the shock ε_{t+1}—to match the average duration of unemployment and the unemployment rate before the increase in the benefit duration. A characteristic of the labor market in Portugal is the high average duration of unemployment combined with a relatively low unemployment rate: for the age group 30-34, the unemployment duration before the policy change was 24 months while the unemployment rate was 4.9 percent. Blanchard and Portugal (2001) analyze in detail the combination of high average duration and low unemployment rate for Portugal. For the calibration, high unemployment duration and low unemployment rate demands a value of ρ close to one. With ρ close to one, the productivity process z approaches a random walk and the numerical algorithm cannot approximate precisely the theoretical distribution of z. To circumvent this problem, we use a model period of three months for the 15-24 age group and six months for the groups 30-34 and 40-44. We use a smaller model period for the 15-24 group because the benefit duration for this group is 4.9 months, smaller than six months.

Utility function. We set the time discount β so that it is equivalent to an interest rate of 4 percent per year. We consider three values for the curvature parameter, $\gamma = 0$, 1 and 8. As γ increases, it is harder to substitute consumption goods for leisure. However, γ does not affect steady state rates such as the unemployment rate and the average duration of unemployment (equal to the ratio of unemployed agents to the number of new hires in the steady state). With $\gamma = 0$ (linear utility) there is perfect substitution between consumption and leisure; $\gamma = 1$ (logarithmic utility) implies that wages do not affect labor supply; $\gamma = 8$ provides less substitution between consumption and leisure. Alvarez and Veracierto (2000) propose $\gamma = 8$ to match the evidence on the elasticity of the labor force with respect to a labor tax.

Data and Predictions

We model the increase in the maximum benefit duration as an increase in ψ. As stated above, we recalibrate ψ after the reform with the increase in the unemployment duration for recipients of unemployment benefits.

We focus on the impact on five variables: unemployment rate, unemployment duration, labor force, and the levels of employment and unemployment (normalized by the population aged 15 to 64). As the economy was growing fast in the period, and these variables have cyclical behavior, we treat the data to account for the economic cycle. For that purpose, we use the groups 25-29 and 35-39 as controls, as there was no change in the unemployment insurance system for these groups. We assume that all changes in the labor market for these groups were caused by changes in macroeconomic conditions and use the before-after estimator to compute the effects of the cycle. Table 6 shows the data before and after the reform, the correction factors obtained from the control groups, and the data after the cyclical correction.

Table 6. Treatment

Age Group		Before the Reform	After the Reform	After-Before	After, with Treatment
15-24	Unemployment Rate	10.0%	8.7%	-	10.0%
	Avg Duration of Unemployment	12.1	11.2	-	11.0
	Labor Force Participation	46.9%	46.4%	-	45.7%
	Employment/Population 15-64	42.2%	42.3%	-	40.8%
	Unemployment/Population 15-64	4.7%	4.4%	-	5.0%
25-29	Unemployment Rate	5.9%	4.6%	-1.3%	-
Control	Avg Duration of Unemployment	17.6	17.8	0.2	-
	Labor Force Participation	85.7%	86.4%	0.8%	-
	Employment/Population 15-64	80.6%	82.1%	1.5%	-
	Unemployment/Population 15-64	5.0%	4.5%	-0.5%	-
30-34	Unemployment Rate	4.9%	3.8%	-	4.6%
	Avg Duration of Unemployment	23.7	21.4	-	25.4
	Labor Force Participation	87.9%	88.4%	-	86.8%
	Employment/Population 15-64	83.7%	85.2%	-	83.2%
	Unemployment/Population 15-64	4.3%	3.6%	-	3.9%
35-39	Unemployment Rate	4.0%	3.2%	-0.8%	-
Control	Avg Duration of Unemployment	22.2	18.2	-4.0	-
	Labor Force Participation	86.2%	87.7%	1.6%	-
	Employment/Population 15-64	82.7%	84.6%	1.9%	-
	Unemployment/Population 15-64	3.4%	3.1%	-0.4%	-
40-44	Unemployment Rate	3.8%	3.3%	-	4.1%
	Avg Duration of Unemployment	28.0	23.4	-	27.4
	Labor Force Participation	86.1%	86.0%	-	84.5%
	Employment/Population 15-64	82.8%	83.2%	-	81.2%
	Unemployment/Population 15-64	3.3%	3.0%	-	3.3%

Before: 1998:1 to 1999:2. After: 1999:3 to 2002:4. Average duration in months. Example: for the unemployment rate of the group 15-24, 10.0% = 8.7% - (-1.3%). Treatment and control groups as for the difference-in-differences (table 4): group 15-24 treated with group 25-29; groups 30-34 and 40-44 treated with group 35-39.

Consider, for instance, the unemployment rate for the group 15-24, which decreased from 10.0 to 8.7 percent after the reform. However, the unemployment rate decreased from 5.9 to 4.6 percent for the group 25-29; a decrease of 1.3 percentage points. As the unemployment insurance system did not change for the age group 25-29, we say that the decrease of 1.3 percentage points was caused by changes unrelated to the reform. Correcting for these effects, the unemployment rate for the group 15-24 stays constant at $8.7 - (-1.3) = 10.0$ percent. We proceed in a similar way for the average duration of unemployment, the labor force participation and the levels of employment and unemployment. As we did for the difference-in-differences estimator, we use the group 25-29 to adjust the values the group 15-24, and the group 35-39 to adjust the variables of the groups 30-34 and 40-44.

The changes in the control groups are as expected for an economy in expansion. The unemployment rate and the unemployment level decreased, the labor force participation and the level of employment increased. The average duration of unemployment of the group 25-29 is an exception: it increased 0.2 months even with economic growth. For the group 35-39, in accordance with the expansion, the average duration of unemployment decreased substantially, 4 months.

We use only non-recipients of unemployment benefits to compute the average duration of unemployment. We do this because, in the model, agents with benefits do not search. As a result, the average duration of unemployment in the model refers to unemployed agents without benefits, and we should compare the predictions on this variable with data on agents without benefits[5].

We confront predictions and data in Table 7. The predictions are on average only 4 percent different from the data after the reform. The predictions, however, tend to exceed the data. The model with low substitution between market and domestic goods, $\gamma = 8$, best matches the data (the average 4 percent refers to this choice of γ). The labor force participation and the level of employment decreased for all groups; and, with the exception of the group 30-34, the level of unemployment increased for all groups (it was almost constant for the group 40-44). The model can reproduce these

[5] There is a potential problem with this procedure. As we use official data for the unemployment rate (with recipients and nonrecipients) and data with nonrecipients only for the average duration, we could be cherry-picking the variables to match data and predictions. However, the evolution of the unemployment rate for all unemployed agents and for only nonrecipients are paralell. Before and after the reform, the unemployment rate for all unemployed is 1.3 percentage points above the rate for only nonrecipients. Therefore, the conclusions of this paper would not change if we used the unemployment rate only for nonrecipients.

facts with $\gamma = 8$. The unemployment rate and the average duration of unemployment do not depend on the utility parameter γ.

The model predicts an increase in the unemployment rate and in the average duration of unemployment, as usual in search models. The data shows approximately constant unemployment rate after the reform: from a decrease of 0.3 percent for the 30-34 group to an increase of 0.3 for the 40-44 group. The unemployment rate decreased for the group 15-24, although it is approximately constant. The model better predicts the changes on the unemployment rate for the group 40-44. The average duration of unemployment decreased for the groups 15-24 and 40-44 while it increased for the group 30-34. Therefore, the model better predicts the average duration of unemployment for the group 30-34.

For the group 15-24, the model predicts small changes because only 8 percent of unemployed workers in this group received benefits. As changes in the model are solely caused by changes in the unemployment insurance system, the small number of recipients implies small changes in the equilibrium. The duration of unemployment decreased from 12.1 to 11.0 months, the model predicts an increase to 12.2 months. The unemployed rate stayed constant at 10.0 percent, while the model predicts an increase to 10.1 percent.

For the group 30-34, the duration of unemployment increased from 23.7 to 25.4 months. The simulation predicts an increase to 24.3 months, one month below the data, an error of 4 percent. The unemployment rate decreased from 4.9 to 4.6 percent while the simulations predicts an increase to 5.1 percent, an upward error of 0.5 points or 11 percent.

For the group 40-44, the duration of unemployment decreased from 28.0 to 27.4 months, while the model predicts an increase to 30.0 months, an upward difference relatively to the data after the reform of 2.6 months, or 9 percent. The unemployment rate increased from 3.8 to 4.1 percent, and the model predicts an increase to 4.3

percent; an upward difference of 0.2 percentage points, or 4 percent.

For all groups, the model gets closer to the data for the labor force participation, employment and unemployment. The model best matches the data for $\gamma = 8$. In this case, the model matches the direction of change of nine out of fifteen variables studied after the change (five for each of the three groups).

Table 7. Data and the predictions of the model

Age Group		Before the Reform	After the Reform			
		Data and Model	Treated Data	Model		
15-24	Unemployment Rate	10.0%	10.0%	10.1%		
	Avg Duration of Unemployment	12.1	11.0	12.2		
				$\gamma = 0$	$\gamma = 1$	$\gamma = 8$
	Labor Force Participation	46.9%	45.7%	47.2%	47.0%	46.9%
	Employment/Population 15-64	42.2%	40.8%	42.4%	42.2%	42.1%
	Unemployment/Population 15-64	4.7%	5.0%	4.8%	4.8%	4.8%
30-34	Unemployment Rate	4.9%	4.6%	5.1%		
	Avg Duration of Unemployment	23.7	25.4	24.3		
				$\gamma = 0$	$\gamma = 1$	$\gamma = 8$
	Labor Force Participation	87.9%	86.8%	88.9%	88.4%	87.9%
	Employment/Population 15-64	83.7%	83.2%	84.4%	83.8%	83.4%
	Unemployment/Population 15-64	4.3%	3.9%	4.5%	4.6%	4.5%
40-44	Unemployment Rate	3.8%	4.1%	4.3%		
	Avg Duration of Unemployment	28.0	27.4	30.0		
				$\gamma = 0$	$\gamma = 1$	$\gamma = 8$
	Labor Force Participation	86.1%	84.5%	89.3%	86.6%	85.8%
	Employment/Population 15-64	82.8%	81.2%	85.5%	82.9%	82.1%
	Unemployment/Population 15-64	3.3%	3.3%	3.8%	3.7%	3.7%

Before: 1998:1 to 1999:2. After: 1999:3 to 2002:4. Average duration in months. The model is calibrated so that data and predictions before the 1999 reform are equal. See table 6 for the procedure to obtain the treated data.

We conclude that the model can predict the data satisfactorily for the three age groups. When the model cannot predict the changes, the differences are usually small. Another result that our simulation reveals is that the model works better with a small substitution between domestic and market goods (a larger preferences parameter, $\gamma = 8$).

It is surprising to find a decrease in the average duration of unemployment for groups 15-24 and 40-44 in the data. Can firing costs explain this behavior? The average duration of unemployment decreases if the number of hirings increases faster than the number of workers searching for a job (unemployed workers). Firing costs can make the job to job flow approximately constant, making the number of workers searching for a job approximately constant. Moreover, higher benefit durations increases the value of being a worker and so workers previously out of the labor force accept offers more quickly, increasing the number of hirings. That can be the case of economies with high firing costs, such as Portugal (OECD 2004).

The model lacks many factors present in the actual economies: borrowing constraints, directed search, ex-ante heterogeneity of agents, and human capital, for example. It is no surprise to find that in some cases the model misses the data. Moreover, Portugal was growing at a rather strong pace (even by historical standards) in the years before and after the reform. Possibly macroeconomic effects, different from the effects of the change in the unemployment insurance system, conditioned the most the data. We treated the data for macroeconomic effects using the quasi-natural experiment given by the reform. But we cannot expect to treat all effects.

Another limitation is the time for the transition. The before and after of the model refer to two steady states. We emulate the steady state after taking the average of a relatively long period after the change, from 1999:3 to 2002:4. The transition in Portugal may be long because the average duration of unemployment and the benefit duration are long, and because the benefit duration increased for only new recipients. As a consequence, probably part of the effects in the data refer to a transition period.

Lalive et al. (2006) show that unemployment duration in Austria increased after an increase in the replacement ratio and in the benefit duration. For Slovenia, Van Ours and Vodopivec (2006) showed that a decrease in the benefit duration had the opposite effect, an increase in the exit rates from unemployment. Both empirical findings are in accordance to search theory. We go one step further and confront the predictions of a calibrated search model and the data. Models are stylized by nature. To evaluate the model, we used a quasi-natural experiment, such as the 1999 reform in Portugal, a methodological innovation in the literature, setting a bridge between the literatures of econometric causal inference and search equilibrium models.

6 CONCLUSIONS

Economists usually have a theoretical model, but typically cannot use an experiment to evaluate it. Only in rare cases an unexpected change, resembling a natural phenomenon, substitutes a controlled experiment. The 1999 reform is one of these cases. We have shown that an equilibrium search model is able to reproduce most of the effects of an increase in the unemployment benefit period.

The model predictions are close to the data on the unemployment rate, the labor force participation, and on the levels of employment and unemployment. When the substitution between domestic and market goods is smaller (γ higher), the predictions for the labor force participation, employment and unemployment improve. The model is less able to predict the changes in the average duration of unemployment. Contrary to the predictions of the model, the observed average duration of unemployment decreased for the groups 15-24 and 40-44 after the increase in the benefit period. Nevertheless, the difference between predictions and data is small.

General equilibrium models are useful for policy evaluation. They complement empirical studies. As Meghir (2006) points out, we can use models to predict long run effects, isolate particular institutional changes, and run counterfactuals. This kind of analysis is usually impossible to be done solely with an empirical study. But we can only trust the predictions of a model if it reproduces the facts for simpler policy changes. We conclude that the model reproduces the facts in various dimensions. This finding increases our confidence to expose the model to more complex changes.

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