Explaining the Gender Gaps in Unemployment Across OECD Countries

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Abstract

There is substantial heterogeneity in the gender gaps in unemployment across OECD countries. We incorporate labor market conditions, moral hazard and home production into a quantitative model of unemployment. The model can explain most of the gender gaps in unemployment across the OECD countries. We find that each component is quantitatively important to match the gender gaps in unemployment.

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Keywords: Unemployment, gender gap, home production.

1 Introduction

In this paper, we analyze the gender gaps in unemployment across OECD countries. To illustrate the data, we plot the gender gaps in unemployment across countries in Figure 1. As can be seen from the figure, there is a large variation across countries (between -1.4% (United Kingdom) and 10.5% (Spain)). The gender gaps in unemployment are

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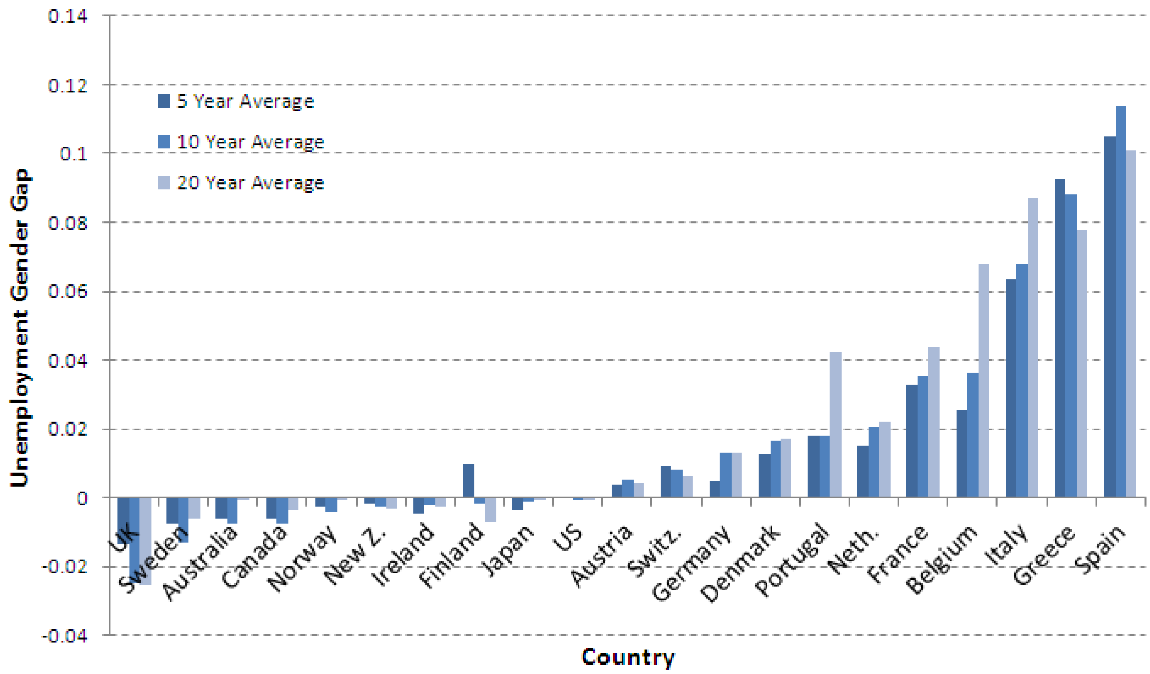
also very persistent. To give just one example, the gender gap in unemployment in Spain has been around 10 % for the last 20 years (see Figure 1 for the other countries). In the literature, while closely related questions such as gender gaps in wages and labor force participation have been studied extensively, gender gaps in unemployment have not been studied that much.[1] One of the aims of this study is to fill this gap.

Motivated by the high level of persistence over time and the high degree of variation in the gender gaps in unemployment across countries we postulate that the heterogeneity and the persistence of labor market conditions are potential candidates for explaining the observations. We build on the model developed in Hansen and Imrohoroglu (1992) and we incorporate labor market conditions into a quantitative search model to study the employment-unemployment decisions of workers and the interactions of these decisions with labor market conditions. We refer to earning tax rates, unemployment benefit levels and durations, average hours of work, average earnings and gender wage gap by "labor market conditions." In our model, the population consists of two types of infinitely lived agents, men and women. The only difference between men and women is their pay levels (which we get from the data for each country) when they are employed. Agents get job offers from an exogenous process and they choose to be employed or unemployed. Unemployed agents are able to partially smooth their consumption by doing home production. They may also have unemployment benefits depending on eligibility and government monitoring. The level of monitoring is costly and is determined by how much the government chooses to maximize average utility in the society.

For the numerical exercise, we solve the model for 21 OECD countries for which we have data on labor market conditions. In addition to the standard parameters that we borrow from the literature; tax rates, unemployment insurance replacement rates,

[1] Some studies on wage gender gap: Gunderson 1989, Blau and Kahn 1992,2003, and Black and Spitz-Oener 2010. Some studies on labor force participation of females: Blundell et al. 2007, Fogli and Veldkamp 2011, and Olivetti 2006.

Figure 1: Gender Gaps in Unemployment Across OECD Countries



average hours of work, gender pay gaps and GDP per capita values are country sğecific and we take them from the data. We assume that the level of home production is the same for both genders and across countries.[2] The model is successful in matching most of the gender gaps across countries (Figure 2). The coefficient of variation in the gender gaps is 1.96 and 1.72 in the data and the model, respectively. Other than for France, the calibrated versions of the model for the high and moderate gender gap countries match the empirical data closely. In the data, the gender gap in France is around 3%; however, the model generates a gender gap below 1%. Among the zero and negative gender gap countries, the model's performance is remarkable except for New Zealand and the United Kingdom. Empirical gender gaps in these countries are -0.14% and -1.4%; however the model generates 1.4% and 1%, respectively. This may be due to the fact that in the model we use only a limited number of economic factors that would affect gender gaps

[2] Note that without this assumption it would be possible to better match the data.

in unemployment. Imposing more country-specific factors would probably improve the results for the aforementioned countries. We perform additional quantitative exercises to see the effects of specific factors on the rate of the gender gap in unemployment. The results indicate that high taxes, high replacement rates, high pay gaps and low productivity levels are associated with high unemployment rates and gender gaps.

We make two important assumptions in the model. First, we do not include out of the labor force as an employment status in the model (i.e., individuals are either employed or unemployed). The findings of Azmat et al. (2006) provide empirical support for this assumption. Using micro data from OECD countries, they find that transitions into and out of inactivity are not important in explaining the rate of unemployment. The second assumption is the imperfect monitoring of the unemployment insurance qualification. Both the existence of imperfect monitoring and the significant effects of imperfect monitoring on the unemployment levels have empirical support. Lalive et al. (2002) show that the enforcement of the rules and the unemployment levels are negatively related. Johnson and Klepinger (1994) find strong evidence that more stringent search requirements reduce the unemployment spell. Dolton and O'Neil (1996) study the effect of search requirements on unemployment using the Restart experiment performed in the UK. They find that the notification of monitoring had a statistically significant positive effect on the transition from unemployment to employment.

This paper is closely related to Azmat, Guell and Manning (2006), who empirically study the effects of the following factors that can potentially explain observed gender gaps across countries: (i) differences in characteristics of the labor force, (ii) differences in transition rates in employment, unemployment and inactivity, (iii) prejudice or discrimination, (iv) lower labor market experience of women, (v) hiring-firing costs (employers prefer males as they are more likely to stick to their jobs), (vi) mismatch (the jobs women want and the jobs available are different), (vii) maternity leave provisions, and (viii) pay gap. For all these scenarios either they find some counter evidence or they find small effects of these conditions on gender gaps in unemployment. In contrast to their empirical exercise on labor market conditions, we jointly model labor market conditions and home production to explain gender gaps in unemployment across countries. As a result we are able to study the interactions of several key components of the labor market at the same time, which provides an explanation to the gender gaps in unemployment.

The rest of the paper is organized as follows: Section 2 gives brief information about the data. We provide a static model and some theoretical results in Section 3. We specify a dynamic model economy in Section 4. and explain the calibration in Section 5. In Section 6 we present the results. In Section 7 we propose some extensions for future work and conclude.

2 Data

In this section we present cross-country data on labor market conditions and gender gaps in unemployment. We obtain unemployment series from the OECD database. Unemployment series are comparable across countries, because we use the harmonized unemployment data, which provide unemployment series using the definition of the International Labor Organization. We calculate 5-, 10- and 20-year averages of gender gaps in unemployment and report them in Table 2. The table shows that there is substantial heterogeneity in gender gaps in unemployment across countries. The gender gap in unemployment varies between -1.36% (United Kingdom) and 10.50% (Spain) across countries. The coefficient of variation in gender gaps in unemployment across OECD countries is 1.96.

We obtained the values in Table 3 from the OECD database, which presents the rate and potential duration of unemployment benefits, average hours of work, taxes on earnings, and the mean and standard deviation of these variables across OECD countries.[3] The standard deviation of these variables implies significant dispersion in labor market conditions across these countries.

Benefit systems, which are summarized by the replacement rate and the duration, vary quite dramatically across countries. Most of the European countries have benefit systems more generous than that of the US. The countries that have low replacement rates tend to have longer duration of benefits. Australia, the UK, New Zealand, and Ireland have the longest potential durations and the lowest replacement rates. On the other hand, the countries with generous replacement rates tend to limit the duration. Sweden, Portugal, Denmark, Norway, and some others, limit benefits to shorter durations.

In Table 4, we report the gender pay gap and earning distribution of female and male workers.[4] The gender pay gap is defined as the ratio of female average earnings over male average earnings; the lower this value is the higher the gender pay gap is. We combine these empirical facts in a quantitative model and explain most of the gender gaps in unemployment across OECD countries.

3 Theoretical Analysis

In this section we present a static model and obtain theoretical results to develop an intuition and to highlight the mechanisms of the dynamic model. The agents in this economy choose whether to accept or reject a job offer. If an agent accepts a job offer, he or she earns a market wage rate of y but he or she has to pay a τ percent earning tax. Labor is indivisible and each worker has to work h hours. If agents choose to reject job offers (a moral hazard problem), they will not earn any market wage but they can

[3] The unemployment benefits are paid as a fraction of lost earnings which is called the "replacement rate."

[4] The calculation of the distribution is explained in detail in the Appendix.

produce at home. We denote home production with φ and asset level with m. There is an unemployment insurance system to support the involuntarily unemployed agents. The unemployed agents who are entitled will receive unemployment insurance benefits, which are $\theta\%$ of the after-tax market wage. We assume that the government cannot perfectly monitor the agents: π percent of the agents who reject the job offers still get the unemployment insurance benefit (a moral hazard problem).

The maximization problem is

$$Max\{V_{reject}, V_{accept}\}$$

where

$$V_{reject} = \pi U(\theta(1-\tau)y + m + \varphi, 0) + (1-\pi)U(m + \varphi, 0)$$

$$V_{accept} = U((1-\tau)y + m, 1 - l).$$

In the above equations, $U(.,.)$ is the utility function where the first argument is consumption and the second argument is leisure. We assume that the utility function is additively separable in consumption and labor and it is logarithmic.

$$U((c, h) = \log(c) + \log(1 - l)$$

where l is the level of the labor supply. The agents who reject the job offers will get the unemployment insurance benefits with probability π and consume $\theta(1-\tau)y + m + \varphi$ (we assume that home production and the market good are additive) if they receive the benefits. With probability $(1-\pi)$ they will not receive unemployment benefits and consume $m + \varphi$. Since they reject job offers, they will not be supplying any labor which implies $h = 0$. If an agent accepts a job offer, his or her or his consumption will be $(1-\tau)y + m$ and his or her labor supply will be h.

Agents will reject job offers if $V_{reject} > V_{accept}$. Imposing the functional form of the utility function into the above condition, we get:

$$\pi \log(\theta(1-\tau)y + m + \varphi) + (1-\pi)\log(m+\varphi) > \log((1-\tau)y + m) + \log(1-l). \quad (1)$$

After some simple algebra the condition simplifies to:

$$[\theta(1-\tau)y + m + \varphi]^{\pi}[m+\varphi]^{1-\pi} > [(1-\tau)y + m](1-l). \quad (2)$$

We use conditions 1 and 2 to derive the theoretical results of this section. We first start with the effect of the unemployment insurance benefit level (replacement rate) on accepting or rejecting a job offer.

Proposition 1 *Given other parameters, there exists a replacement rate θ^* such that if $\theta > \theta^*$ the agents will reject the job offers. Otherwise the agents will accept the job offers. The critical level of benefit, θ^*, is*

$$\theta^* = \frac{\left(\frac{[(1-\tau)y+m](1-l)}{[m+\varphi]^{1-\pi}}\right)^{\frac{1}{\pi}} - m - \varphi}{(1-\tau)y}. \quad (3)$$

Proof. Observe that the value of rejecting a job offer is increasing with the replacement rate θ, whereas the value of accepting a job offer does not depend on the benefit level. Next, we equate the value of rejecting to the value of accepting a job offer to obtain a closed-form solution shown in equation 3. ■

Proposition 2 θ^* *decreases if home production, φ, increases.*

Proof. This is easily seen from equation 3. If φ increases, the numerator deceases, which decreases θ^*. ■

Suppose that there are two kinds of economies, one with home production, φ, and one with no home production. Keeping everything constant, agents in the first economy would have a lower θ^* value. Therefore, a home production sector in an economy tends to increase the fraction of agents who would reject job offers. Moreover, interaction of home production - as a mechanism that increases the value of being unemployed - with labor market conditions would affect the labor supply decision of workers even further. Therefore, having a home production in our full model is quantitatively important.

Proposition 3 *If $(y+m)h > \theta y + m + \varphi$, then there exists a tax level τ^* such that $1 > \tau^* > 0$, and if $\tau > \tau^*$, the agents will reject the job offers. Otherwise they will not.*

Proof. If $\tau = 1$, then the value of rejecting will be higher than the value of accepting, since φ is positive and h is between 0 and 1.

$$m + \varphi > mh$$

If $\tau = 0$, then using the assumption that $(y+m)h > \theta y + m + \varphi$, we obtain that the value of accepting is larger than the value of rejecting. To see this, observe that $(y+m)h$ is the value of accepting a job offer when the tax rate is 0. The value of rejecting a job offer in this case is $[\theta y + m + \varphi]^\pi [m + \varphi]^{1-\pi}$. The fact that $\theta y + m + \varphi > m + \varphi$ implies $\theta y + m + \varphi > [\theta y + m + \varphi]^\pi [m + \varphi]^{1-\pi}$. Since both values of rejecting and accepting are continuous functions of τ, then there should exist a $\tau^* \in (0, 1)$ such that both functions intersect. Since both functions are monotonic, they intersect only once, which implies that if $\tau > \tau^*$, the agents will reject the job offers; otherwise, they will not. ■

The condition $(y+m)h > \theta y + m + \varphi$ is imposed to guarantee that τ^* is positive. If we remove the condition, then it is possible that τ^* will be negative. In such a case, for all values of possible taxes, the agents will reject the job offers. The next proposition shows how τ^* changes with home productivity φ.

Proposition 4 *If $h > \theta\pi$, then τ^* decreases if home production, φ, increases.*

Proof. The critical value of the tax, τ^*, can be obtained by equating the value of rejecting to the value of accepting.

$$\pi \log(\theta(1-\tau^*)y + m + \varphi) + (1-\pi)\log(m+\varphi) = \log((1-\tau^*)y + m) + \log(h) \tag{4}$$

Implicitly differentiating equation 4 gives

$$\frac{\pi(-\frac{\partial\tau^*}{\partial\varphi}\theta y + m + 1)}{\theta(1-\tau^*)y + m + \varphi} + \frac{1-\pi}{m+\varphi} + \frac{\frac{\partial\tau^*}{\partial\varphi}y}{(1-\tau^*)y+m} = 0.$$

Solving for $\frac{\partial\tau^*}{\partial\varphi}$ gives

$$\frac{\partial\tau^*}{\partial\varphi} = \frac{\frac{1-\pi}{m+\varphi} + \frac{\pi(m+1)}{\theta(1-\tau^*)y+m+\varphi}}{\frac{\pi\theta y}{\theta(1-\tau^*)y+m+\varphi} - \frac{y}{(1-\tau^*)y+m}}. \tag{5}$$

The numerator of equation 5 is positive. The denominator of equation 5 is negative if $\frac{\theta}{\theta(1-\tau^*)y+m+\varphi} - \frac{1}{(1-\tau^*)y+m}$ is negative (since π is smaller than 1). Dividing both the numerator and the denominator of $\frac{\theta}{\theta(1-\tau^*)y+m+\varphi}$ with θ gives the result that if $\frac{m+\varphi}{\theta} > m$, then $\frac{\theta}{\theta(1-\tau^*)y+m+\varphi} - \frac{1}{(1-\tau^*)y+m}$ will be negative. Since we assumed that home productivity, φ, is positive and the replacement rate, θ, is smaller than 1, $\frac{m+\varphi}{\theta} > m$ will always be true. As a result, equation 5 implies that $\frac{\partial\tau^*}{\partial\varphi}$ is negative. ■

We now turn to the importance of asset level for the agents' accepting or rejecting decisions.

Proposition 5 *There exists a critical asset level m^* such that if $m > m^*$, agents will reject the job offers. Otherwise they will accept.*

Proof. If the asset level goes to $-\varphi$, the agents will accept the job offers. In this case consumption will go to zero, which pushes utility to $-\infty$ as we used log utility. If the asset level goes to infinity, the slope of V_{reject} goes to 1, whereas the slope of V_{accept} is h (it is constant and smaller than 1). As a result V_{reject} and V_{accept} should intersect at some m. The intersection point is m^*. As the slope of V_{reject} is larger than the slope of V_{accept} for the asset levels $m > m^*$, V_{reject} will be larger than V_{accept} for $m > m^*$. ■

Proposition 5 implies that households with higher asset levels, keeping the other factors constant, are more likely to reject the offers and become unemployed. The reason is that the richer households can use their assets to insure against the possibility that they do not get insurance after rejecting.

4 Dynamic Model

We consider labor market conditions, moral hazard, and home production as potential determinants of gender gaps in unemployment and incorporate them into a quantitative model of unemployment to explain gender gaps across countries. The model is built on Hansen and Imrohoroglu (1992) and extended with home production, endogenous government monitoring over job offers, and wage dispersion.

Ex-ante Heterogeneity in the Population The population consists of a continuum of infinitely lived agents that are heterogeneous regarding their earnings. Women have lower average earnings than men.[5] Ex-ante, we have three groups in the society, namely, $\{(y^{ij})\}$, where $i \in \{f, m\}$, and $j \in \{L, M, H\}$. Each gender has three earning groups, low(L), medium(M), and high(H).[6]

[5] The pay gap between males and females is a well established result in the empirical literature. See Kunze 2000 for a detailed survey.

[6] Here, the reason for emphasizing genders is that they have different fractions in income groups and different average earnings.

We allow for earning heterogeneity to embed progressive earning taxes (higher earners pay higher taxes) and unemployment benefits (in most countries, replacement rates are higher for lower earning groups).

Employment Process There is wage heterogeneity in the model economy; however, there is no transition between the income groups. Therefore, each individual faces income risk only through unemployment shocks. In each period, agents receive job offers according to a stochastic process that is specified by a two-state Markov chain, χ. If an agent receives a job offer, he/she has the *opportunity* to work for $\hat{h}$ hours (this means labor is indivisible) and earn wage y^{ij}, depending on her/his gender and earning group. If an agent does not receive a job offer or refuses a job offer, then he/she will be unemployed for that period.

Household Preferences Agents enjoy utility from a consumption good, leisure and a public good, and maximize their expected lifetime utility:

$$E\sum_{t=0}^{\infty}\beta^t U(c_t^{ij}, l_t^{ij}, G) \tag{6}$$

where β is the discount factor, c_t^{ij} is total consumption, and l_t^{ij} is the amount of time devoted to leisure by an agent with gender i, and earning j at time t. The third factor in the utility function is a public good, denoted by G, and provided by the government.[7] The total consumption of an agent with gender i and earning j in period t equals:

$$c_t^{ij} = \left\{ \begin{array}{l} c_{m,t}^{ij} + \varphi, \text{ if the agent is unemployed} \\ c_{m,t}^{ij}, \text{ if the agent is employed} \end{array} \right\}$$

where φ is home production and $c_{m,t}^{ij}$ is consumption of the market good for an agent with gender i and earning j at time t. We assume that total consumption is the sum of market

[7] We include a public good to have a balanced government budget.

consumption and home production. For simplicity, we assume that home production is only possible when the agents are not working in the market.[8] The home-produced goods are assumed to be consumed within the period of production.[9]

The utility function follows:

$$U(c,l,G) = \frac{(c^{1-\sigma}l^{\sigma})^{1-\rho} - 1}{1-\rho} + \psi \log(G) \tag{7}$$

The first term in the utility function gives the utility from consumption and leisure. This functional form is quite standard in the literature. The utility from the public good is assumed to be logarithmic and separate from private consumption.

Agents do not have any private insurance besides a storage technology, which is a non-interest bearing asset and accumulates as follows:

$$m_{t+1}^{ij} = m_t^{ij} + y_t^{d,ij} - c_{m,t}^{ij} \tag{8}$$

where m_t^{ij} is the asset holdings, $y_t^{d,ij}$ is the disposable income of an agent with gender i and earning j at time t. The disposable income will be different from earning y_t^j, because of the earning tax, τ_y, and unemployment benefit eligibility. The disposable income of individuals and the unemployment benefit system are explained later on.

Unemployment Benefits All agents who do not receive a job offer will receive unemployment benefits. Agents who refuse job offers will receive unemployment benefits with probability π, which shows the level of monitoring in the model ($1-\pi$ is the monitoring level). The level of monitoring is optimally chosen by the government to

[8] This is a simplifying assumption; however, allowing the working agents to do home production would not change the result, because the important point is the difference in home production during unemployment and employment spells. Burda and Hamermesh 2010 show that, in the U.S., unemployed agents do 10 hours per week more home production than employed agents do.

[9] Here, c_t^m can be interpreted as the consumption good that agents buy from the market and φ_i can be interpreted as the home production that agents do at home, such as cooking, cleaning, repairing, child care, etc. The sum of the two components gives total consumption.

maximize social welfare. Although better monitoring decreases the moral hazard problem, it is costly. We assume that the cost of monitoring is linearly increasing in the monitoring level. The cost of monitoring is defined as:

$$\xi(\pi) = \delta(1-\pi) \tag{9}$$

where δ is a positive constant.

The unemployment insurance program can be summarized as the following scheme, where μ is an indicator that takes a value of 1 if the agent receives benefits, and 0 if he/she does not receive benefits:

$$\begin{array}{lll} \text{No job offer} & \Rightarrow & \mu = 1\text{, gets benefits} \\ \text{Gets an offer, accepts} & \Rightarrow & \mu = 0,\ \text{no benefits} \\ \text{Gets an offer, rejects} & \Rightarrow & \mu = 1 \text{ gets benefits with probability } \pi \\ & & \mu = 0 \text{ does not get benefits with probability } 1-\pi \end{array} \tag{10}$$

Upon qualifying for unemployment benefits, an agent with previous earnings y^{ij} receives an amount of $\theta_{y^{ij}}(1-\tau_{y^{ij}})y^{ij}$, where $\theta_{y^{ij}}$ is the net replacement rate for earning y^{ij}.[10]

Earning Tax and Disposable Income The government taxes earnings progressively; that is, the rate of linear tax, τ_y, decreases as the level of earnings increases. The earning tax system of each country is taken from the data and imposed on the model exogenously. The government uses the tax revenues to finance the unemployment insurance program and to provide a public good.

The disposable income of an agent is determined by employment status, level of

[10] Note that the replacement rate depends on the level of lost earnings; therefore, we have θ_y, instead of θ.

earnings, and qualification for unemployment benefits, and can be summarized as follows:

$$\text{gets no offer } (s = u), \text{ gets benefit } (\mu = 1) \Rightarrow \quad y_t^{d,ij} = b \tag{11}$$

$$\text{gets no offer } (s = u), \text{ no benefit } (\mu = 0) \Rightarrow \quad y_t^{d,ij} = 0 \tag{12}$$

$$\text{gets offer } (s = e), \text{ accepts } \Rightarrow \quad y_t^{d,ij} = (1 - \tau_{y^{ij}})y^{ij} \tag{13}$$

$$\text{gets offer}(s = e), \text{ rejects , gets benefit } (\mu = 1) \Rightarrow \quad y_t^{d,ij} = b \tag{14}$$

$$\text{gets offer } (s = e), \text{ rejects , no benefit } (\mu = 0) \Rightarrow \quad y_t^{d,ij} = 0 \tag{15}$$

where $y_t^{d,ij}$ represents the disposable income of an agent in gender group i, and earning group j at time t. An agent with no job offer receives unemployment insurance benefits, $b = \theta_{y^{ij}}(1-\tau_{y^{ij}})y^{ij}$, if α, the number of consecutive periods of benefits received, is smaller or equal to $\alpha_{\max}$, the maximum potential duration. He or she has 0 disposable income after the maximum duration of benefits is exhausted.

An employed agent has a disposable income that equals the after-tax earnings $(1 - \tau_{y^{ij}})y^{ij}$. An agent who qualifies for benefits (that is he or she is not monitored by the government) upon refusing a job offer receives unemployment benefits b if α is smaller than or equal to α_{max}. If he or she does not qualify for the benefits (that is he or she is monitored) upon refusing a job offer, then he or she has 0 disposable income in that period.

Recursive Formulations We formulate the problem of agents in a recursive form to compute equilibrium numerically. To make the dynamic planning problem more understandable we analyze the problem in two cases.

No Job Offer Case: Agents with no job offer, $s = u$, receive unemployment insurance benefits unless, α, the number of consecutive periods of benefits received is greater than

$\alpha_{\max}$, the maximum number of consecutive periods of benefits allowed. The generosity of unemployment benefits, θ^y, is changing with the level of income. The problem of an agent in gender group i, and earning group j who receives no job offer is to choose the optimal amount of assets for the next period. As they do not work, their leisure time will be equal to the total time endowment of 1:

$$V^{ij}(m,s,\alpha) =$$
$$\max_{m'}\{U(m+(1-\tau_{y^{ij}})\theta_{y^{ij}}y^{ij}-m'+\varphi,1)+\beta E[\chi(u,s'^{ij}(m',s',\alpha')]\}$$
$$\text{subject to } 0 \leq m'$$
$$\alpha' = \alpha+1 \text{ if } \alpha \leq \alpha_{\max}$$
$$\alpha' = 0 \text{ if } \alpha = \alpha_{\max}$$

In the above equation, m denotes asset accumulation. Agents receive job offers from a two-state Markov process, which is denoted with $\chi(.,.)$. In this case, where an agent has no job offer, the relevant transition probabilities should be the ones from the unemployment state to the others, $\chi(u,s')$. E denotes the expectation operator.

Job Offer Case: Agents who receive employment opportunities have the choice of rejecting the job offer. This is where moral hazard comes in. As the government does not monitor job offers perfectly, agents may find it optimal to reject the job offers and receive benefits afterwards. The ones who reject the job offer will know whether they receive benefits or not upon refusing the job offer. Afterward, they make their consumption/saving decisions. The ones who accept the job offer receive a constant wage and do not have any further uncertainty, so they directly make their consumption/saving decisions.

$$V^{ij}(m,s,\alpha) =$$

$$\max\{\max_{m'} U(m + (1-\tau_{y^{ij}})y^{ij} - m', 1 - \hat{h}) + \beta E[\chi(e, s'^{ij}(m', s', 0)],$$

$$\pi \max_{m'} U(m + (1-\tau_{y^{ij}})\theta_{y^{ij}} y^{ij} - m' + \varphi, 1) + \beta E[\chi(e, s'^{ij}(m', s', \alpha')] +$$

$$(1-\pi)\max_{m'} U(m - m' + \varphi, 1) + \beta E[\chi(e, s'^{ij}(m', s', \alpha')]\}$$

$$\text{subject to } 0 \leq m'$$

$$\alpha' = \alpha + 1 \text{ if } \alpha \leq \alpha_{\max}$$

$$\alpha' = 0 \text{ if } \alpha = \alpha_{\max}$$

Equilibrium An individual state is denoted with $x = (i, j, m, s, \alpha)$. Let $\lambda(x)$ be the invariant distribution of the agents, $c(x)$ the consumption decision, $m(x)$ the saving decision, and $\eta(x)$ the employment decision. In the stationary competitive equilibrium, the agent's decision rules $c(x)$ and $m(x)$ solve the dynamic planning problem. The good market clears,

$$\sum_x \lambda(x)c(x) + G = \sum \lambda(x)\eta(x)y^{ij}. \tag{16}$$

The government has a balanced budget constraint. It collects taxes from all workers and from the unemployed who get insurance and uses them to finance the unemployment insurance payments and the remaining balance is used to provide a public good.

$$\begin{aligned}
&\underbrace{\sum \lambda(i,j,m,1,\alpha)\eta(i,j,m,1,\alpha)y^{ij}\tau_{y^{ij}}}_{tax\ return\ from\ the\ workers} \\
&\underbrace{+\sum \pi\lambda(i,j,m,1,\alpha)(1-\eta(i,j,m,1,\alpha))\tau_{y^{ij}}\theta_{y^{ij}} + \sum \lambda(i,j,m,0,\alpha)\tau_{y^{ij}}\theta_{y^{ij}}}_{tax\ return\ from\ the\ insured} \\
&\underbrace{-\sum \{\lambda(i,j,m,0,\alpha)\theta_{y^{ij}}y^{ij} + (1-\pi)\lambda(i,j,m,1,\alpha)(1-\eta(i,j,m,1,\alpha))\theta_{y^{ij}}y^{ij}\}}_{insurance\ expenditure} \\
&- \underbrace{G}_{public\ good\ expenditure} = 0
\end{aligned} \tag{17}$$

The invariant distribution should satisfy the following functional equation:

$$\lambda(i,j,m,s,\alpha) =$$

$$\begin{cases}
\sum_{s'}\sum_{m\in\Omega} \chi(s',u)\lambda(i,j,m,u,\alpha-1) & \text{if } s=u,\ \alpha \leq \alpha_{\max} \text{ and } \alpha > 0 \\
\sum_{s'}\sum_{m\in\Omega} \chi(s',e)(1-\eta(i,j,m,e,\alpha-1))\lambda(i,j,m,e,\alpha-1) & \text{if } s=e,\ \alpha \leq \alpha_{\max} \text{ and } \alpha > 0 \\
\sum_{s'}\sum_{m\in\Omega} \chi(s',e)\eta(i,j,m,e,\alpha)\lambda(i,j,m,e,\alpha) + \lambda(i,j,m,e,\alpha_{\max}) & \text{if } s=e,\ \alpha = 0 \\
\sum_{s'}\sum_{m\in\Omega} \lambda(i,j,m,u,\alpha_{\max}) & \text{if } s=u,\ \alpha = 0
\end{cases} \tag{18}$$

where Ω is defined as the set of state space that will give the optimal asset level m from the model.

The government maximizes the total welfare subject to its budget constraint and cost function.

$$\underset{\pi}{Max}\sum_{x}\lambda(x)E[U(c(x),\eta(x)] \qquad (19)$$
$$subject\ to\ equations\ 9\ and\ 17$$

5 Calibration

We calibrate the model parameters in three steps. In the first step, we borrow the values of some parameters from the literature and these parameters are assumed to be the same for each country. We set β to 0.995, which corresponds to an annual discount rate of 4 %, and σ to 0.67, both are standard in the literature. The value of parameter ρ is set to 5, which corresponds to a risk aversion of 2.3, which is within the standard range of 1.5-4.0 in the literature. We choose the values of the transition probability matrix similar to those in Hansen and Imrohoroglu (1992). The chosen transition matrix gives an involuntary unemployment level of 5.66 %,[11] and an average duration of 12 weeks (two periods) without job offers. The corresponding transition matrix is as follows:

$$\begin{bmatrix} .97 & .03 \\ .5 & .5 \end{bmatrix}$$

In the second step of the calibration, we obtain the country-specific values of the parameters that represent labor market conditions from the OECD database. The average hours of work, denoted by $\hat{h}$, is set to the empirical average working hours of the corresponding country. We normalize this value by dividing working hours by total hours. The values of parameters $\theta_{y^{ij}}$, α, and $\tau_{y^{ij}}$ are set to replacement rate, potential duration of unemployment benefits and earning tax of the corresponding country. Note that tax and replacement rates depend on earnings and features progressiveness. The

[11] The fraction of agents who do not receive a job offer.

Table 1: Benchmark Parameters

Parameter	Explanation	Value
β	Discount factor	0.99
σ	Utility function	3
ρ	Utility function	.67
ψ	Utility function	0.057
$\chi(e,e)$	Employment process	.97
$\chi(u,e)$	Employment process	.5
φ	Home production	0.067
δ	Monitoring cost	0.012

Notes: These parameters are common in calibration of the model for each country. The country specific parameters are reported in Table 3 and Table 4.

chosen parameter values are reported in Table 3.

The values of parameters y^{ij} and κ_i^j are calculated from the data for each country and imposed on the model. The calculation method is explained in detail in the Appendix and the calculated values are reported in Table 4.

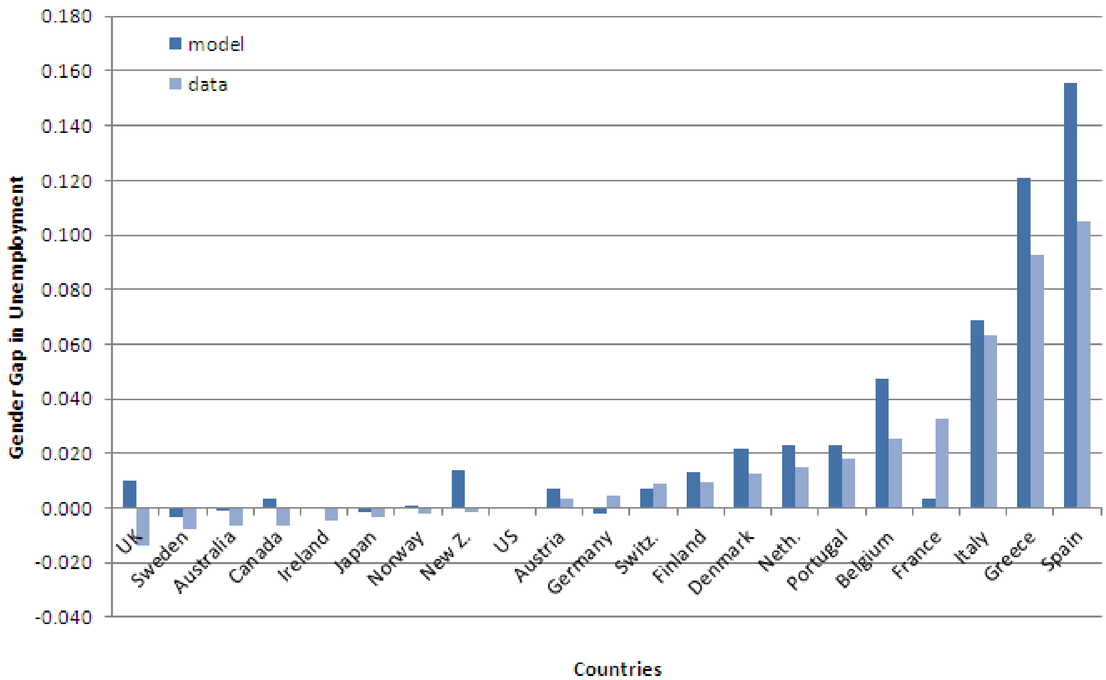
Finally we calibrate the values of parameters φ and δ to match the gender gaps across countries. We do not calibrate these parameters separately for each country, but we use the same values for each country to match the whole set of countries. The corresponding values for the selected parameter are reported in Table 1.

6 Results

6.1 Model Predictions

To obtain the gender gaps in unemployment for each country, we solve the model for each country separately. The model predictions are compared with the data in Figure 2. One should keep in mind that we do not include some variables in the model that could

Figure 2: Gender Gaps: Data vs Model



potentially improve our results.[12] Among others, these additional variables could be educational differences across countries and different marriage and fertility rates across countries. In fact, some of these factors are considered by Azmat et al. (2006), and they are found to generate small gender gaps. So the small deviations from the data can be attributed to these factors.

The heterogeneity in labor market conditions together with home production generates most of the heterogeneity in gender gaps across countries (Figure 2). The coefficient of variation in gender gaps is 1.96 and 1.72 in the empirical data and model, respectively. The calibrated versions of the model for the high and moderate gender gap countries match the empirical data quantitatvely. Among the moderate gender gap countries, the only exception is France. The empirical level of the gender gap in France is around 3%;

[12] We can include only a certain number of factors in the model due to computational limitations.

however, the model generates a gender gap below 1%. Among the zero and negative gender gap countries, the model's performance is quite well except for New Zealand and the United Kingdom. Empirical gender gaps in these countries are -0.14% and -1.4%, however the model generates 1.4% and 1%, respectively. This is a result of the fact that the model we use contains only a limited number of economic factors that would affect the gender gap in unemployment. Imposing more country-specific factors would probably improve the results for the aforementioned countries. We perform additional quantitative exercises to see the effect of specific factors on the rate of the gender gap in unemployment. The results indicate that high taxes, high replacement rates, high pay gaps and low productivity levels are associated with high unemployment rates and gender gaps.

The rate of unemployment is determined by two dynamics: the first is the exogenous process that generates employment opportunities, and the other is the accept/reject decisions of individuals. Since the exogenous process of employment opportunities is the same for each country and gender, the heterogeneity in the unemployment rate across genders and countries is created by the accept/reject decisions of individuals. This decision is affected by the key ingredients of the model, which are labor market conditions, home production, and imperfect monitoring of job offers (moral hazard).

In countries where there is no gender gap or small gender gaps, both women and men tend to accept all job offers. For the other countries, the decomposition shows some heterogeneity. For example, gender gaps in Belgium, Germany, the Netherlands, Norway, Canada, and Switzerland mostly arise coming from the decisions of women. In these countries, men mostly tend to accept job offers, while some women turn them down. For Denmark, Finland, France, and Portugal the gender gap is affected by both female and male tendencies to refuse job offers. In general, due to the interaction of labor market conditions, gender pay gap and home production in these countries, women tend to refuse job offers more than men, and that generates the gender gap in unemployment in the model.

6.2 Contributions of Specific Factors to Gender Gaps in Unemployment

In this section, we analyze the effects of specific factors on the quantitative results.[13] We solve the model with various values of the pay gap, tax rate and replacement rate parameters. At each exercise, we change one parameter and keep the rest fixed to see the effect of the given parameter on the quantitative results.

In this exercise, we limit our attention to four countries: France, Italy, Norway and the U.S. We choose these countries because they represent different kinds of economies. The U.S. has comparatively low taxes on labor, low replacement rates, and comparatively high working hours. France has high taxes, high replacement rate, and comparatively low hours of work. Norway has high taxes, moderate replacement rate, and very low hours of work. Italy has high taxes, low replacement rates and the moderate hours of work. Due to this heterogeneity, the countries show various responses to the factors.[14]

6.2.1 Role of Replacement Rate

The effect of unemployment benefits on the rate of unemployment has always been an important discussion in both Europe and the U.S. Economic theory suggests that unemployment rates increase in response to increased unemployment benefits by discouraging

[13] Taking taxes, replacement rate, and hours of work as state variables, and solving the unemployment rates as a function of these variables would be ideal for this kind of analysis. Since this is computationally infeasible, we do not solve the model across all possible combinations of these variables. Instead, we take these variables from the data for each country and solve the model at those points only.

[14] In most of the figures in the following parts, we see some discontinuous behavior. The main reason is the level of heterogeneity in the model. There are only three levels of earnings. So there are many similar agents, who change their decisions at the same time, which causes the observed jumps in the figures.

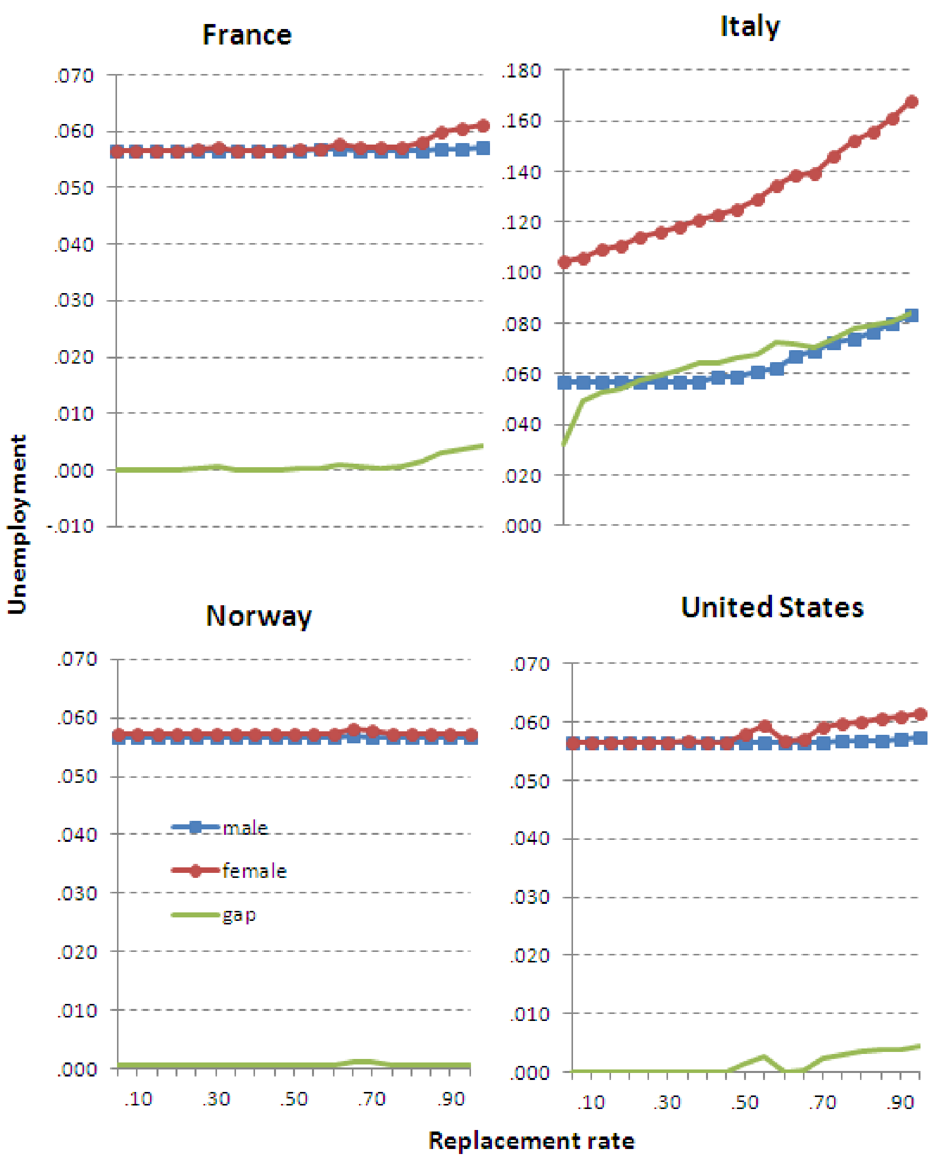
job search intensity. The empirical literature reports weak positive relationship between unemployment benefits and unemployment rates.[15] Our findings suggest that the small coefficients might be due to nonlinearity of the relationship between the unemployment rate and the benefit levels. Our model implies that low levels of replacement rates do not affect the unemployment rates. However, after some threshold level it starts to cause higher unemployment rates in our quantitative exercises.

For each selected country, we solve the model with various values of replacement rates to see its quantitative effect on results. The replacement rate of the median earner takes the value of each .05 increment in [.05,.95] interval. Recall that we have a progressive replacement rate profile (higher earnings in employment spells imply lower replacement rates in unemployment spells). Therefore, we adjust the replacement rate of low and high earning groups proportionately consistent with thedata.

Figure 3 reports the results. The values in the horizontal axis of the figure represent the median earner's replacement rate. The figure shows that in the calibrated model for the French economy, the unemployment rate does not increase in response to the changes in the replacement rate at moderate levels. This happens for two reasons: first, the high tax rates imply a high level of optimal monitoring for unemployment benefits qualification, because the cost of monitoring is financed with taxes; second, the average hours of work is low; therefore, the value of being unemployed (relative to being employed) is smaller compared to the countries where the average hours of work is high. That makes employment stable in the model economy when calibrated to French data. Moreover, female unemployment starts to increase when replacement rates are more than 80% of lost earnings due to the lower earnings of women in this economy. For Norway, unemployment responds similarly for the same reasons. However, female unemployment is stable even at very high replacement rates, because the pay gap is very small and

[15] See Krueger and Meyer 2002 for a detailed survey.

Figure 3: Replacement Rates vs Gender Gap in Unemployment



average earning is very high in this economy.

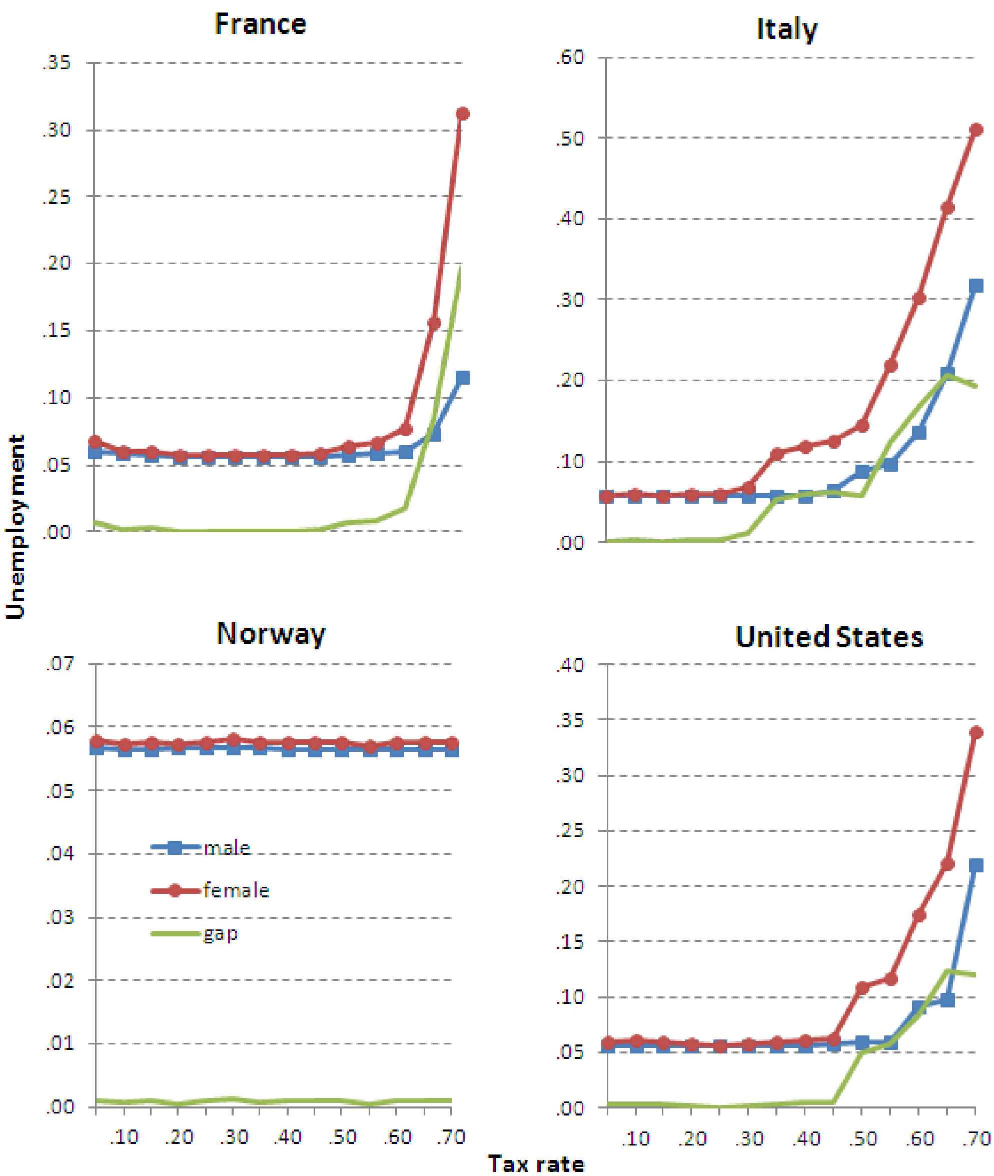
When we calibrate the model to the U.S. data, the model economy responds similar to France in terms of increasing unemployment rates with increased unemployment benefits. However, the reason for the increase in unemployment is high working hours rather than high earning taxes.

In the model economy for Italy, the unemployment rate for females increases even with low replacement rates. This is because of the very large pay gap in this economy. The male unemployment rate is stable until the 50% replacement rate and increases after then.

6.2.2 Role of Taxes

In the model, the tax rate is a determinant of the unemployment rate, since it affects the value of employment through earnings. Figure 4 shows the effect of taxes on the unemployment rates of females and males. We look at the effects of taxes from 5% to 70% with 5% increments, and we fix the values of the rest of the parameters. As depicted in the figure, the rate of tax is quantitatively important. As the rate of tax increases, agents tend to refuse job offers, because the value of employment decreases through reduced after-tax earnings. The responses of unemployment rates to an increase in tax rates differ across countries, because there is heterogeneity in their labor market conditions. For the U.S. and Italy, unemployment rates increase immediately above 30-40% of taxes on earnings. This is because of the high hours of work - which reduces the relative value of employment - in these countries. Note that Italy is more responsive to taxes, because average earnings are smaller in this country. We also observe an increase in the gender gap in unemployment in both countries. It increases more in Italy, because the pay gap is much larger compared to the U.S.

Figure 4: Earning Tax Rate vs Gender Gap in Unemployment



In the calibration of our model for France, unemployment increases after 60% of earnings tax. In France, the threshold level of taxes that creates high unemployment is higher compared to the U.S. and Italy due to the lower average hours of work in this economy. In the model economy for Norway, the unemployment rate does not increase, although the tax level increases up to 70%. This is due to the very high average earnings and very low average hours of work, which creates a high value for employment in this economy.

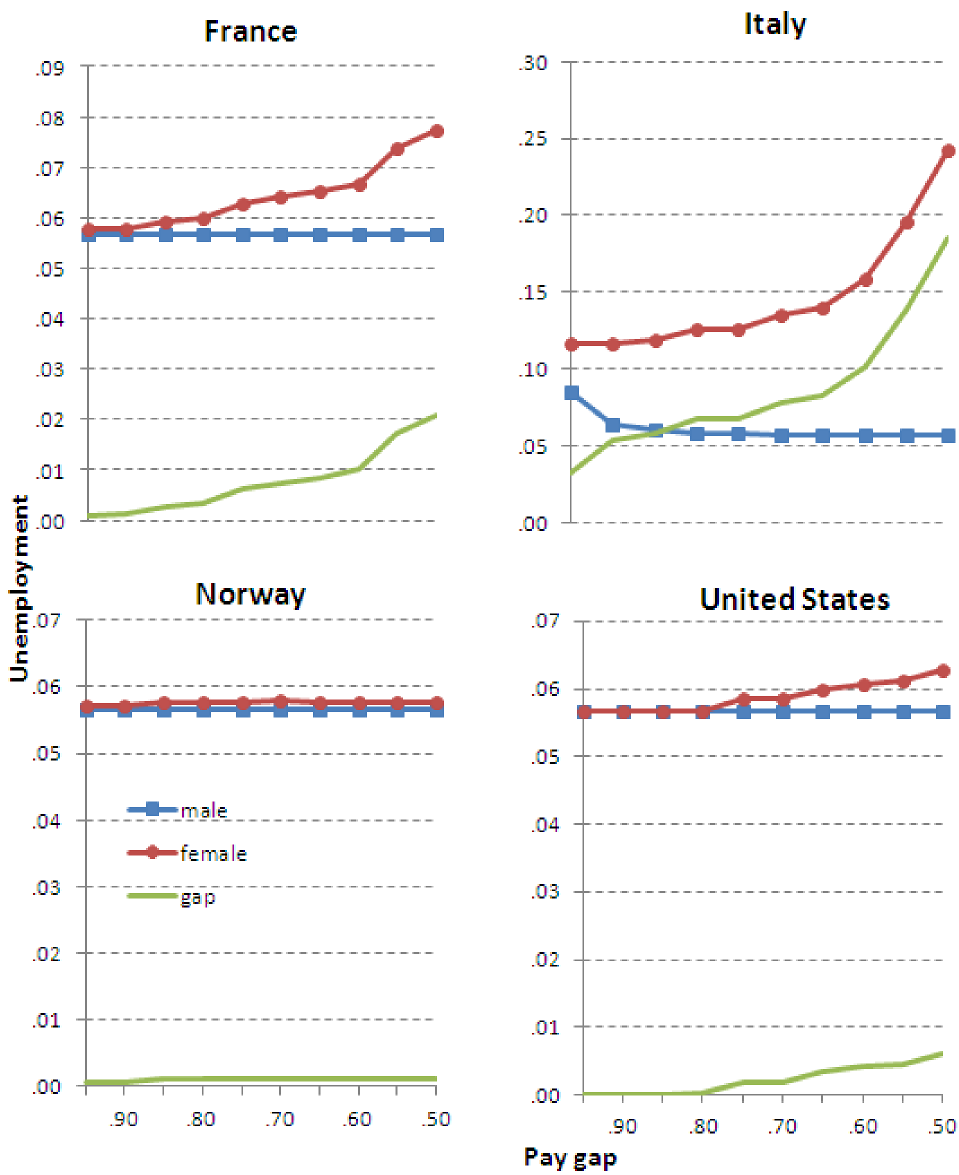
6.2.3 Role of Pay Gap

In this exercise the ratio of the average earnings of women to the average earnings of men takes values between 0.50 and 0.95 with 0.05 increments. The results show that in the calibrated versions of our model for France, Italy, and the U.S., the gender gap in unemployment is increasing with the increase in the pay gap between men and women. The rate of increase in the gender gap in unemployment depends on the labor market conditions in these economies. In Italy and France, even low levels of the pay gap create a gender gap in unemployment due to high earning taxes. In the U.S. economy, the gender gap in unemployment happens after moderate levels of pay gaps due to low earning taxes. In the model economy for Norway, even if the pay gap becomes very large, the gender gap in unemployment does not increase due to very low hours of work and high average earnings in this economy. The results are reported in Figure 5.

6.2.4 Role of Productivity

In this section, we analyze the effect of productivity levels on the rate of male and female unemployment. For each country, we consider productivity levels between .20 and 1.00. Figure 6 shows the response of each country to the changes in productivity

Figure 5: Pay Gender Gap vs Gender Gap in Unemployment



levels. The economies of France, Italy and the United States respond similarly: the gender gap in unemployment starts from about .40 and diminishes gradually and goes to 0 as productivity increases. However, in Norway, the gender gap in unemployment gets zero much earlier than in the other three economies. This is due to very low average hours of work in this economy. Low hours of work increase the value of employment and workers stop rejecting job offers right after the wage rate goes above .30.

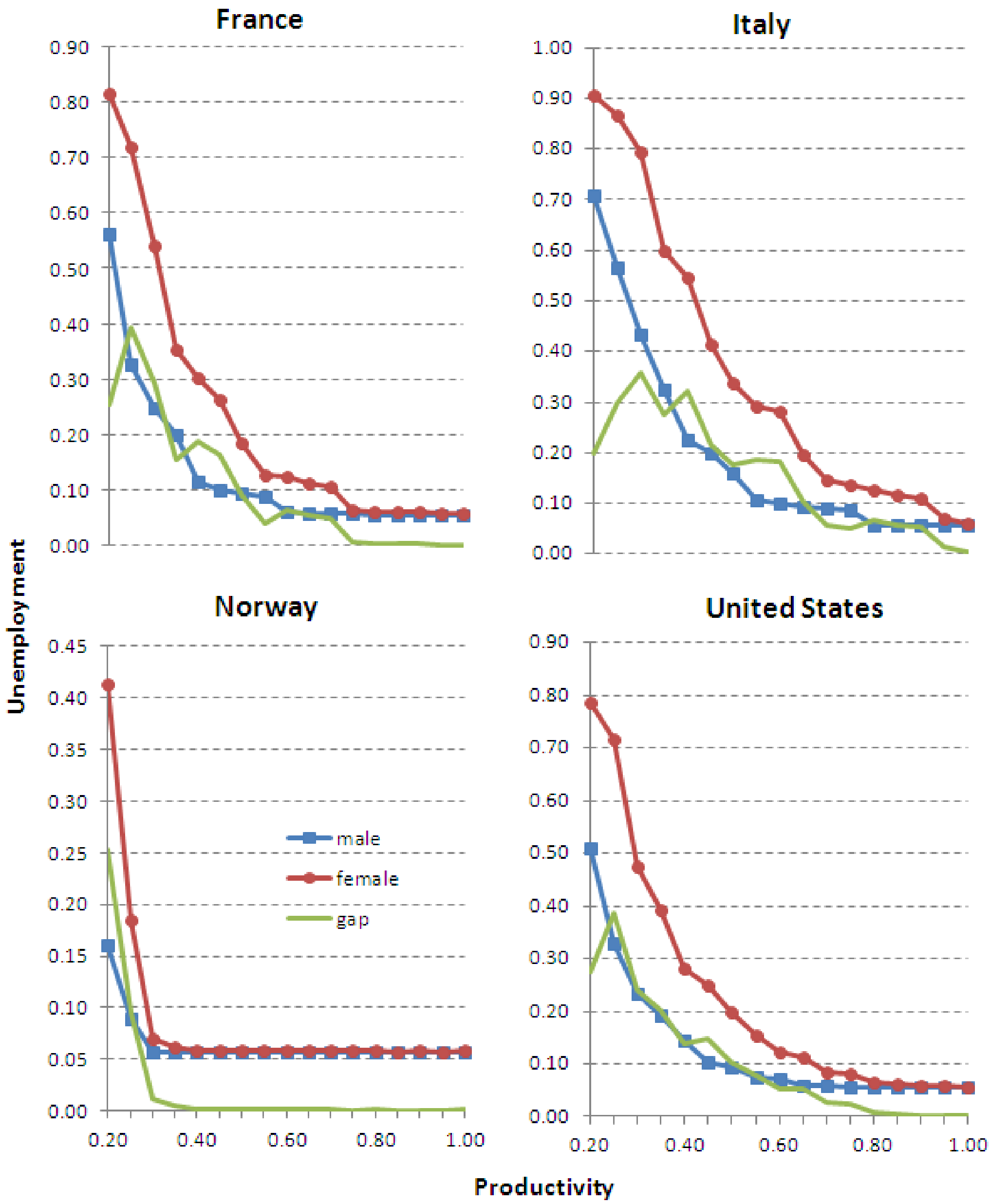
7 Discussion and Conclusion

We propose a mechanism that can generate most of the gender gaps in the unemployment rate observed in most of the OECD countries. The components of the mechanism are home production, pay gaps, unemployment benefits, earning taxes, hours of work and imperfect government monitoring of job offers. We further investigate the effect of specific factors on gender gaps in unemployment. All of the ingredients seem to have quantitative importance.

Our quantitative exercises also offer some explanation for the high unemployment rates in Europe. Our model implies that high replacement rates and high earning taxes reduce employment. Since earning taxes and replacement rates increased in Europe between 1960 and the 1980s, we guess that this might have contributed to the high unemployment rates in Europe.

In the model, we assume that governments choose the monitoring levels optimally. In a dynamic setting if the governments cannot adjust their monitoring levels spontaneously, we will see high unemployment levels. From the governments' perspective, while decreasing the level of unemployment insurance benefit will put political pressure on them, most people will agree on better monitoring levels. After the success story of the Danish economy in lowering their unemployment level, other countries made its

Figure 6: Productivity vs Gender Gap in Unemployment



unemployment insurance criteria stricter. This seems to work for them also.

Extending the model by adding a costly search decision is the next step. The model will have implications for labor force participation, which differs across countries, along with unemployment levels. Another extension is endogenizing the stochastic process in the model by adding the firm side of the search. With this model, it will be possible to see the effects of policies more broadly. The model will have the potential to propose a mechanism that can generate unemployment levels over time and across countries.

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8 Tables

Table 2: Gender Gaps in Unemployment

	5 Year Average	10 Year Average	20 Year Average
Australia	-0.62	-0.77	-0.08
Austria	0.36	0.53	0.42
Belgium	2.54	3.63	6.78
Canada	-0.62	-0.75	-0.34
Denmark	1.26	1.66	1.69
Finland	0.96	-0.16	-0.72
France	3.28	3.53	4.39
Germany	0.48	1.32	1.3
Greece	9.26	8.81	7.78
Iceland	0.6	0.6	0.61
Ireland	-0.48	-0.21	-0.28
Italy	6.34	6.78	8.72
Japan	-0.36	-0.11	-0.02
Netherlands	1.5	2.07	2.18
New Zealand	-0.14	-0.25	-0.31
Norway	-0.24	-0.41	-0.07
Portugal	1.8	1.83	4.22
Spain	10.5	11.38	10.09
Sweden	-0.74	-1.32	-0.61
Switzerland	0.92	0.83	0.63
UK	-1.36	-2.47	-2.54
US	0.04	-0.05	-0.06
Mean	1.60	1.66	1.99
St. Dev.	3.16	3.39	3.47

Notes: 5-year averages are computed by averaging over gender gaps between years 1997-2002. The 10-year and 20-year averages are obtained similarly. The data is comparable across countries, because ILO definition of unemployment is used for each country. Source: World Development Indicators (2004).

Table 3: Labor Market Data

	θ_L %	θ_M %	θ_H %	α_{max} years	$\hat{h}$ hours	τ_L %	τ_M %	τ_H %
Australia	45	31	23	4	1870	39.4	35.6	45.0
Austria	55	55	55	2	1600	56.3	59.9	41.4
Belgium	83	63	46	4	1580	71.3	66.5	68.4
Canada	65	62	43	1	1740	34.2	40.7	35.9
Denmark	84	61	47	2.5	1510	42.1	43.5	62.8
Finland	73	60	48	2	1770	52.8	56.9	56.9
France	77	73	67	3	1650	63.2	52.0	59.7
Germany	62	61	62	4	1600	58.1	63.3	44.3
Greece	71	48	34	1	1900	50.8	50.8	57.4
Ireland	42	30	23	4	1750	35.9	54.8	54.8
Italy	50	54	46	0.5	1730	53.6	53.6	61.5
Japan	70	60	50	0.5	1960	29.9	34.2	33.6
Netherlands	81	71	59	2	1510	49.0	46.5	50.0
New Zealand	53	37	26	4	1830	21.0	34.0	38.0
Norway	65	66	53	1.5	1430	43.1	51.1	53.7
Portugal	81	78	84	0.8	2000	47.1	47.1	55.6
Spain	76	69	48	3.5	1820	45.2	48.1	37.0
Sweden	82	77	55	1.2	1510	46.3	47.9	66.9
Switzerland	80	70	71	1	1640	32.5	35.8	42.6
United Kingdom	63	45	31	4	1750	38.8	38.8	47.7
United States	62	62	45	0.5	1940	34.4	34.4	43.7
Mean	67.62	58.71	48.38	2.24	1718.57	45.00	47.40	50.33
St. Dev.	12.99	13.79	15.63	1.39	164.66	11.97	9.84	10.47

Notes: θ_L, θ_M, and θ_H denote the replacement rate for low, medium and high earning groups. It is defined as the ratio of unemployment benefit level to labor income prior to unemployment. α_{max} is the maximum potential length of benefit receipt. $\hat{h}$ is the average annual hours of worked per worker. τ_L, τ_M, and τ_H denote the tax rates for low, medium and high earning groups. Sources: Nickell (1997,2003), OECD Benefits and Wages (2002, 2004), OECD Employment Outlook (2005).

Table 4: Labor Market Data, Cont'd

	y^L	y^M	y^H	κ_f^L	κ_f^M	κ_f^H	κ_m^L	κ_m^M	κ_m^H
Australia	0.696	1.038	1.734	0.137	0.310	0.002	0.077	0.414	0.060
Austria	0.694	1.036	1.731	0.089	0.362	0.000	0.023	0.514	0.012
Belgium	0.592	0.884	1.476	0.230	0.213	0.000	0.037	0.432	0.088
Canada	0.655	0.977	1.632	0.191	0.264	0.012	0.122	0.277	0.134
Denmark	0.682	1.017	1.699	0.172	0.278	0.023	0.128	0.286	0.114
Finland	0.636	0.950	1.586	0.189	0.259	0.037	0.141	0.239	0.136
France	0.561	0.838	1.399	0.169	0.292	0.000	0.044	0.430	0.064
Germany	0.576	0.859	1.435	0.181	0.272	0.000	0.063	0.397	0.087
Greece	0.451	0.673	1.125	0.209	0.192	0.001	0.115	0.335	0.149
Ireland	0.699	1.044	1.743	0.199	0.217	0.008	0.142	0.271	0.164
Italy	0.541	0.807	1.348	0.216	0.174	0.007	0.170	0.228	0.205
Japan	0.539	0.805	1.344	0.251	0.164	0.000	0.096	0.330	0.160
Netherlands	0.677	1.010	1.687	0.177	0.267	0.006	0.111	0.321	0.117
New Zealand	0.521	0.777	1.298	0.141	0.310	0.002	0.075	0.410	0.062
Norway	0.896	1.337	2.233	0.123	0.352	0.003	0.072	0.407	0.044
Portugal	0.386	0.575	0.961	0.201	0.245	0.011	0.131	0.261	0.152
Spain	0.479	0.715	1.194	0.232	0.181	0.000	0.000	0.586	0.001
Sweden	0.732	1.093	1.825	0.160	0.283	0.041	0.136	0.284	0.096
Switzerland	0.714	1.065	1.779	0.168	0.286	0.002	0.084	0.370	0.091
United Kingdom	0.634	0.946	1.579	0.174	0.264	0.016	0.129	0.295	0.123
United States	0.799	1.192	1.991	0.197	0.238	0.023	0.146	0.238	0.158

Notes: y^L, y^M, and y^H denote 0.67, 1, and 1.67 times the average earnings in the corresponding country. We categorize the earnings in these three groups so that we can apply the progressive earning tax and replacement rates for these three groups. κ_i^L, κ_i^H, and κ_i^M denote the fraction of population with gender i and earning level less than or equal to y^L, more than y^H, and in between y^L and y^H in the corresponding country, where $i \in \{f, m\}$. Note that $\sum_i \sum_j \kappa_i^j = 1$, that is the measure of the population is normalized to 1. For the detailed explanation of the calculations, see Section 9. Data source: OECD Statistics.

9 Appendix

OECD Statistics provide data on tax rates and replacement rates for three earning groups in each country. Those earning groups are 0.67, 1, and 1.67 times average earnings in the corresponding country. We would like to reflect this fact in the model, because it is an important determinant of the value of employment and unemployment. In order to incorporate this fact into the model properly, we need to determine the distribution of population with respect to gender and earning groups. We approximate this distribution for each country by the following steps:

- Calculating average earnings (comparable across countries):
  - We obtain the ratio of average earnings of women over men for each country k, r^k, from OECD. We set $\tilde{y}_f^k = r$, and $\tilde{y}_m^k = 1$.
  - For each country k, we define $\bar{y}_f^k = \tilde{y}_f^k * gdp^k$, and $\bar{y}_m^k = \tilde{y}_m^k * gdp^k$, which are cross-country comparable average earnings of women and men for each country. gdp^i denotes GDP per capita for country i, comparable across countries, OECD average equals 1.
- Calculating fractions of earning-gender groups in each country k (κ_i^{jk}), where $i \in \{f, m\}$, and $j \in \{L, M, H\}$. L stands for low, M stands for medium and H stands for high earning group:
  - We assume earnings of women and men in country k are distributed normally: $y_i^k \sim N(\bar{y}_i^k, \sigma_{y_i^k})$, where $i \in \{f, m\}$.
  - We need to know $\sigma_{y_f^k}$ and $\sigma_{y_m^k}$ in order to figure out fractions κ_i^{jk}.
  - OECD provides coefficient of variation for the earnings of the whole working population. We assume that the coefficient of variation for women and men

equal to this reported value. Since, we assume the following equalities: $CV_f^k = CV_m^k = CV^k = \sigma_{y_f^k}/\bar{y}_f^k = \sigma_{y_m^k}/\bar{y}_m^k$.

- We extract $\sigma_{y_f^k}$, and $\sigma_{y_m^k}$ from the above equalities.
- Once we have $\bar{y}_f^k$, $\bar{y}_m^k$, $\sigma_{y_f^k}$, and $\sigma_{y_m^k}$, we can calculate $P_i^{Lk} = P(y_i^k < y^{Lk})$, $P_i^{Hk} = P(y_i^k > y^{Hk})$, and $P_i^{Mk} = P(y^{Lk} < y_i^k < y^{Hk})$ for each $i \in \{f, m\}$ under the assumption of normal distribution.
- The fractions for each country k, κ_i^{jk}, can be calculated by multiplying each P_i^{jk} by $L_i^k/(L_i^k + L_{-i}^k)$ which weights each gender by their labor force participation rates, and normalizes the measure of population to 1. (Note that we implicitly assume population have equal number of women and men.)