Essays on Labor Market Frictions and Macroeconomics

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Dedication

To my wonderful family. Completing this journey would not have been possible without their love and unwavering support over the years.

Abstract

This dissertation investigates the macroeconomic consequences of frictional labor markets in the United States and in Europe. It consists of three essays.

In Chapter 2, Jiwoon Kim and I develop a model with both frictional labor markets and financial frictions to explore how the dynamics of real and financial variables are affected by 'financial shocks'. We evaluate how important the inclusion of financial shocks is in accounting for labor market fluctuations by using a standard real business cycle model with search and matching as a benchmark. We find that the inclusion of financial frictions and financial shocks improves a standard matching model's ability to account for the observed dynamics of labor market variables. Financial frictions are able to generate more volatile hours per worker, labor shares, and employment relative to our benchmark matching model, bringing simulated moments closer to observed fluctuations.

Chapter 3 documents the cyclical properties of labor market flows in the United States and in Europe at business cycle frequencies. I create comparable quarterly estimates of the hazard rates across 19 European countries and the United States using the methodology pioneered by Shimer (2012). I then quantitatively assess the contribution of the job-finding and separation rates to the variability of unemployment over the business cycle in each country. In the United States, the job-finding hazard rate accounted for over three-quarters of the variation in unemployment while the separation rate accounted for the remainder. Most European labor markets have a 60:40 split between the job-finding rate and the separation rate, respectively.

Chapter 4 studies policy issues related to precarious forms of employment over a worker's life-cycle. A search and matching model with dual labor markets, overlapping generations of workers, and general and match-specific skills is presented in order to quantify and evaluate the effects of loosening restrictions on temporary forms of employment. Despite the increased likelihood of being employed, workers will be worse off due to a greater share of workers starting their careers in low-paying temporary positions, limiting young workers' ability to upgrade their skill level early in the life-cycle.

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Chapter 1

Introduction

This dissertation is a theoretical and quantitative investigation of frictional labor markets and macroeconomic outcomes.

- Chapter 2, "Labor Market Fluctuations and the Role of Financial Shocks," develops a model with both frictional labor markets and financial frictions to explore how the dynamics of real and financial variables are affected by 'financial shocks'. It evaluates how important the inclusion of financial shocks is in accounting for labor market fluctuations by using a standard real business cycle model with search and matching as a benchmark fo comparison.

- Chapter 3, "Unemployment Dynamics in Europe: The Roles of the Ins and Outs," documents the cyclical properties of labor market flows in Europe and compares them to flows in the United States at business cycle frequencies. It first creates comparable quarterly estimates of the hazard rates across 19 European countries and the United States. It then quantitatively assesses the contribution of the job-finding and separation rates to the variability of unemployment over the business cycle in each country.

- Chapter 4, "Dual Labor Markets and Life-Cycle Unemployment," studies policy issues related to precarious forms of employment over a worker's life-cycle. A search and matching model with dual labor markets, overlapping generations of workers, and general and match-specific skills is presented in order to quantify and evaluate the effects of labor market reforms.

Chapter 2

Labor Market Fluctuations and the Role of Financial Shocks

2.1 Introduction

The financial turmoil that began with the subprime mortgage crisis in 2007 brought about not only one of the largest decreases in real GDP in the US since the Great Depression, but also a substantial increase in the rate of unemployment. The unemployment rate jumped from 4.7% in 2007:Q4 to 9.9% in 2009:Q4 while real GDP decreased at an astonishing -1.7% annualized rate over the same time period. High unemployment has persisted and continues to be a challenge today, even after real GDP has recovered to pre-recession levels. It seems natural to assess the role credit markets have played in the sharp decrease in employment and its sluggish recovery to pre-recession levels.

The financial crisis and resulting Great Recession have fostered renewed interest in the incorporation of financial frictions in macroeconomic models. Many recent studies have emphasized the importance of employing such frictions to account for macroeconomic fluctuations in key variables over the business cycle. In particular, so called 'financial shocks' have been deemed significant contributing factors for the observed dynamics of real and financial variables over the business cycle. Financial shocks directly affect the financial sector of the economy as opposed to standard productivity shocks that are merely propagated through the financial sector. However, applicable studies have been silent about how unemployment and job postings interact with the deterioration of credit market conditions. In order to address this shortcoming, we evaluate just how important financial shocks are in accounting for movements in key labor market variables by using a standard real business cycle (RBC) matching model which incorporates financial frictions via an enforcement constraint. We assess the importance of incorporating financial shocks into our model by comparing our results to those of a standard matching model without financial frictions. We take our benchmark matching model without financial frictions to be the model developed by Andolfatto (1996) (simply Andolfatto hereafter). We refer to this as the standard matching model throughout.

While analyzing the role of the financial sector over the business cycle is not a new topic, most previous studies utilized the credit channels formalized by Bernanke and Gertler (1989), Kiyotaki and Moore (1997), and Bernanke, Gertler, and Gilchrist (1999) and treated the financial sector as an accelerator of productivity shocks. This standard credit channel differs from those developed more recently by Perri and Quadrini (2011) and Jermann and Quadrini (2012) (JQ hereafter), which incorporate financial shocks that directly affect the financial sector's ability to lend. That is, the financial sector not only propagates productivity shocks originating from other sectors of the economy, but it also acts as a source of the business cycle itself via financial shocks. The latter studies have emphasized the impact of financial shocks in their explanations for labor market fluctuations but offer no means for analyzing the extensive margin of employment in their framework.

Some authors have already highlighted the need for addressing the role of financial frictions on unemployment. Petrosky-Nadeau (2011) uses asymmetric information and costly state verification between financial intermediaries and borrowers which increases both the magnitude and persistence of unemployment fluctuations relative to a standard neoclassical growth model. Chugh (2009) uses a similar credit channel but builds a model with capital accumulation. Monacelli, Trigari, and Quadrini (2011) use a model with linear utility and no capital accumulation and show that borrowing more from financial intermediaries shifts bargaining weight from the worker to the firm which can explain why firms cut hiring after a negative financial shock even in the absence of a liquidity shortage. Our study departs from previous approaches and employs the credit channel used in JQ in order to compare the gains of adding financial frictions over a standard matching model as developed by Merz (1995) and Andolfatto (1996). Our model framework is somewhat related to that of Garin (2012), but his study neither utilizes the intensive margin nor compares the results to a standard RBC matching model. This distinction is important since the response along the intensive margin to financial frictions and shocks in our model is quite different from that along the extensive margin.

We start by documenting the cyclical properties of key variables for the US economy over the period 1984:Q1-2012:Q1 in Table 2.1. We chose this period for our analysis since JQ have argued that 1984 corresponds to a break in the volatility in many business cycle variables and that this time period also saw the stabilization of structural change in US financial markets compared to previous periods. All variables are deflated by population, logged (except debt repurchases and equity payouts), and HP-filtered. Debt repurchases and equity payouts statistics are computed after detrending with a band-pass filter that preserves cycles of 1.5-8 years (Christiano and Fitzgerald, 2003). Wages are defined as real labor compensation per labor-hour. A detailed description of the data used in Table 2.1 and throughout our study can be found in the Appendix.

Variable (x)	$\sigma_x\%$	$\rho\,(x, Output)$	$\rho\,(x_t, x_{t-1})$
Output	1.12	–	0.87
Total Hours	1.26	0.85	0.89
Employment	0.88	0.82	0.93
Hours per Worker	0.45	0.77	0.61
Wages	0.91	-0.18	0.77
Labor Productivity	0.66	0.07	0.59
Labor Share	0.73	-0.28	0.78
Vacancies	11.26	0.86	0.91
Equity Payouts/GDP	1.39	0.69	0.91
Debt Repurchases/GDP	2.23	-0.84	0.93

Table 2.1: Business Cycle Statistics, 1984:Q1-2012:Q1

A few elements in Table 2.1 deserve some discussion. First, employment is much more volatile than hours worked per worker. While total hours fluctuate more than output itself, most of the volatility is due to adjustments along the extensive margin. The relative contribution of variance in hours per worker to total hours worked is 32%. Thus, the intensive margin is one that should be incorporated into any model seeking to understand fluctuations in total hours worked in the US economy. Employment and total hours tend to lag output by one quarter while hours worked and vacancies are coincident variables which suggests firms are able to adjust the intensive margin and post vacancies quicker than they can adjust the stock of employees. We will incorporate this fact into our model. Second, real wages are almost as volatile as output, but are surprisingly countercyclical over our sample period. Third, the labor share is countercyclical, implying that during periods of expansion, labor is allocated relatively less of the gains. Finally, note that equity payouts are strongly procyclical while debt repurchases are strongly countercyclical. As JQ pointed out, there seems to be substitutability between equity payouts and debt repurchases over the business cycle. It is our goal to discover what gains can be made in accounting for the fluctuations in the variables reported in Table 2.1 once financial shocks are incorporated into a standard matching model.

The paper is structured as follows. Section 2.2 proposes a model with labor market frictions, financial frictions, and financial shocks. Section 2.3 discusses the calibration of the models. Section 2.4 studies the quantitative properties of our proposed model and studies the importance of financial shocks by comparing our model's results to those of a standard matching model. Section 2.5 concludes.

2.2 Model

Our model framework follows closely the models developed by JQ and Andolfatto. Since the Andolfatto model has a matching framework but no financial frictions, we take this to be our benchmark model to compare our results to. We will refer to the benchmark model as the Andolfatto model, the standard matching model, or simply Andolfatto. Note that the equations characterizing the solution to our model with financial frictions can quickly be mapped into the Andolfatto model by shutting down both the financial shock processes and the Lagrange multipliers on the enforcement constraint. For this reason, we do not lay out the Andolfatto model explicitly but choose to develop our model with financial frictions first.

2.2.1 Matching

Time is discrete and goes on forever. The timing of our model is as follows: (i) shocks are realized, (ii) wages and hours are bargained over, (iii) firms take our intra-period loans, (iv) production takes place and vacancies are posted, and then (v) separations and matches occur.

Labor markets are frictional and the law of motion of total employment, N, depends on the number of matches that occur at the end of each period. We take one model period to be one quarter. We assume that the number of matches is dictated by a constant returns-to-scale matching technology which depends on the total number of unemployed, $U \equiv 1 - N$, and on the total number of vacancies, V, posted by firms: $M(V, 1-N)$. Defining $V/(1-N) \equiv \theta$ as labor market tightness, we then define the job-finding rate as $\Psi(\theta) = M(\theta, 1)$ and the job-filling rate as $\Phi(\theta) = M(1, 1/\theta)$. Assuming that jobs are destroyed at the exogenous rate $\chi \in (0,1)$, it follows that employment evolves according to:

$$N' = (1-\chi)N + \Psi(\theta)(1-N)$$

2.2.2 Households

There is a continuum of identical and infinitely lived households each of measure one. Each household is endowed with a unit of time to split between working hours and leisure hours and each household derives utility from consumption and leisure. Households discount the future by the factor $\beta \in (0,1)$. We model a representative household similar to Merz (1995) and Andolfatto (1996), which allows for perfect unemployment insure across households. This, along with the assumption that there are no search costs, implies that every unemployed household will always be searching for a job. Households trade uncontingent bonds, a_H, and shares in firms, s. Unemployed households receive the unemployment benefit $b \geq 0$ from the government and each household pays the lump-sum tax T. We can then write the program of the representative household as:

$$V(S, s_H) = \max_{c, s', a'_H} \{u(c) + n\nu(1-h) + (1-n)\nu(1) + \beta E[V(S', s'_H)]\}$$

$$\text{s.t.}$$

$$\begin{aligned} c+\frac{a_H'}{1+r\left(S\right)}+p\left(S\right)s' &= w\left(S,s_H\right)nh\left(S,s_H\right)+(1-n)b \\ &\quad +a_H+\left[p\left(S\right)+d\left(S\right)\right]s-T\left(S\right) \\ n' &= (1-\chi)n+\Psi\left(S\right)\left(1-n\right) \\ S' &= G(S),\ c\geq 0,\ \text{No-Ponzi condition} \end{aligned}$$

The aggregate state of the economy is given by $S=\{z,\xi;K,B,N,D_-\}$, where z is total factor productivity and ξ is the financial shock which both evolve stochastically. K is the aggregate capital stock, B is total bond holdings of the household sector, N is total employment, and D_- is the amount of dividends paid out last period. $s_H=\{s,a_H,n\}$ is the individual state, and G is the law of motion for aggregate state variables. d is the dividend paid to shareholders, and p is the share price of the representative firm.

Wages and hours are the result of a Nash-bargaining problem between workers and the firm at the beginning of each period, so from the household's perspective $w\left(S,s_H\right)nh\left(S,s_H\right)$ is given before any consumption or savings decisions take place. Since we have assumed separable utility between consumption and leisure, the intra-household consumption level doesn't depend on employment status as noted in Merz (1995) and Andolfatto (1996). Note that this has the implication that unemployed households are better off than those that are employed since they receive the same consumption level as those that are employed but enjoy all the leisure. This implication is discussed in detail in Cheron and Langot (2004). The first order conditions (dropping the dependence on states) from the household's problem give:

$$\begin{aligned} 1 &= E\left[m'\left(1+r\right)\right] \\ 1 &= E\left[m'\left(\frac{p'+d'}{p}\right)\right] \end{aligned}$$

where $m'=\beta u_c\left(c'\right)/u_c\left(c\right)$ is the stochastic discount factor. These equations taken together simply give us the no-arbitrage condition between shares and bonds. All derivations of first order conditions for all agents can be found in the Appendix B.

2.2.3 Firms

We model the firm and derive an enforcement constraint similar to JQ. There exists a representative firm with gross revenue $F(z,k,nh)$, where z is the stochastic level of aggregate productivity. Capital evolves according to the standard law of motion $k' = (1-\delta)\,k + i$, where i is investment and $\delta \in [0,1]$ is the rate of depreciation. Firms discount the future via the stochastic discount factor m' and pay the fixed cost $c_v > 0$ to post a vacancy. The firm also pays the equity payout cost $\varphi(d, d_-)$ to pay dividends to shareholders. We impose this dividend adjust cost to capture the observation that firms tend to smooth dividends as well as to formalize the financial friction. Firms use equity and debt with debt preferred to equity due to the subsidy $\tau \in (0,1)$. Therefore, the *effective* gross interest rate that the representative firm faces every period is given by $R = 1 + r\,(1-\tau)$.

After negotiating wages and hours, firms take out the intra-period loan l_t to finance working capital. Before receiving any revenue from production, the firm pays the wage bill wnh, chooses investment, chooses the equity payout d and the associated adjustment cost, the number of vacancies v to post, and new intertemporal debt a'_F. Since all payments are done before the realization of revenues, the firm must take out the intra-period loan:

$$l = wnh + i + c_v v + \varphi(d, d_-) + a_F - \frac{a'_F}{R}$$

The firm's budget constraint every period is

$$i + a_F + \varphi(d, d_-) = F(z,k,nh) - wnh - c_v v + \frac{a'_F}{R}$$

It follows that the intra-period loan is simply total expected revenue, $l = F(z,k,nh)$.

The firm has the option to default after total revenues are realized but before the working capital loan l is paid back. At this moment in time, the firm holds liquidity l and total liabilities $l + a'_F/\,(1+r)$. Since firms can easily abscond with the liquidity l, the lender can only recover the firm's physical capital stock k' with probability ξ, which is stochastic. With probability $(1-\xi)$, the lender's recovery value is zero. One can interpret this probability as the probability of finding a buyer of the firm's capital stock.

In the case of default, the lender and the firm can negotiate a payment after the liquidation value of the capital stock is realized. We assume that the firm has all the bargaining power in this negotiation process and the lender will only get the threat value.

If the liquidation value is zero, the lender will not shutdown the firm because it is better off waiting for the intertemporal loan a'_F to come due. The firm keeps the liquidity l in this case. Therefore, the total ex-post value of default in the case when the liquidation value is zero is:

$$l + E\left[m'J'\right]$$

where m' is the stochastic discount factor and J' is the value of the firm tomorrow. That is, $E\left[m'J'\right]$ is the expected present value of the firm if the firm continues to operate.

If the liquidation value is k', the firm will negotiate the payment P to prevent the lender liquidating the firm. The net surplus to the firm of avoiding liquidation is:

$$l + E\left[m'J'\right] - P$$

The lender's net surplus of reaching an agreement is:

$$P + \frac{a'_F}{1+r} - k'$$

Assuming the firm holds all the bargaining power, the firm must pay $P = k' - a'_F/\left(1+r\right)$ to avoid liquidation. It follows that the total net surplus of reaching an agreement is:

$$l + E\left[m'J'\right] + \frac{a'_F}{1+r} - k'$$

Since the liquidation value is not known until after the default takes place, when the intra-period loan is contracted, the expected total net surplus to the firm (since it has all the bargaining power) is

$$\begin{aligned} & \xi\left(l + E\left[m'J'\right] + \frac{a'_F}{1+r} - k'\right) + (1-\xi)\left(l + E\left[m'J'\right]\right) \\ = \; & \xi\left(\frac{a'_F}{1+r} - k'\right) + l + E\left[m'J'\right] \end{aligned}$$

Incentive compatibility requires that the expected surplus of defaulting not exceed the value of not defaulting. This requires that

$$\begin{aligned} E\left[m'J'\right] \; &\geq \; \xi\left(\frac{a'_F}{1+r} - k'\right) + l + E\left[m'J'\right] \\ \xi\left(k' - \frac{a'_F}{1+r}\right) \; &\geq \; l = F(z,k,nh) \end{aligned}$$

The firm's ability to borrow is limited by the enforcement constraint derived above. Higher debt in the form of either intertemporal or intratemporal loans is associated with a tighter enforcement constraint while a higher capital stock loosens the enforcement constraint. Since employment (due to the lack of endogenous separations), productivity, the probability ξ, and the capital stock are given, the firm only has control over k', a'_F, and the intensive margin h. We refer to innovations in ξ as 'financial shocks' since they directly affect the firm's capacity to borrow from lenders. Negative innovations can be viewed as a deterioration in credit market conditions.

We can then write the program of the representative firm as:

$$J(S, s_F) = \max_{d,k',a'_F,v,n'} \left\{ d + E[m' J(S', s'_F)] \right\}$$

$$\text{s.t.}$$

$$\begin{aligned} k' + a_F + \varphi(d, d_-) &= F(z, k, nh\,(S, s_F)) + (1-\delta)k \\ &\quad - w\,(S, s_F)\, nh\,(S, s_F) - c_v v + \frac{a'_F}{R\,(S)} \\ \xi \left(k' - \frac{a'_F}{1 + r\,(S)} \right) &\geq F(z, k, nh\,(S, s_F)) \\ n' &= (1-\chi)n + \Phi\,(S)\, v \\ S' &= G(S),\ k', v \geq 0 \end{aligned}$$

where $s_F = \{k, a_F, n, d_-\}$ is the individual state, $R = 1 + r(1-\tau)$, and the firm's equity payout cost is $\varphi(d, d_-)$. Once again note that wages and hours are bargained at the beginning of the period and are treated as given in the program described above.

The first order conditions, dropping state dependencies, for the firm's problem gives:

$$\begin{aligned} 1 &= \lambda \varphi_d + E[m' \lambda' \varphi'_{d_-}] \\ \lambda c_v &= \Phi E\left[m' J'_n \right] \\ \lambda - \gamma \xi &= E\left[m' \left[\left(\lambda' - \gamma' \right) F'_k + (1-\delta)\, \lambda' \right] \right] \\ \lambda\,(1+r) - \gamma R &= R\,(1+r)\, E\left[m' \lambda' \right] \end{aligned}$$

where λ and $\gamma \geq 0$ are the Lagrange multipliers on the budget constraint and enforcement constraint, respectively. To see how these equations relate to the Andolfatto model, set $R = 1 + r, \lambda = 1$, and $\gamma = 0$.

2.2.4 Nash Bargaining

Wages and hours are bargained over at the beginning of each period via a Nash bargaining problem between the representative household and the representative firm. Employing the notation from above, the value of an additional worker, in terms of consumption units, to the representative household is

$$\frac{V_n}{u_c} = \frac{\nu(1-h) - \nu(1)}{u_c} + wh - b + (1-\chi-\Psi)\beta\left[\frac{V_n'}{u_c}\right]$$

The value to the representative firm of an additional worker is:

$$J_n = (\lambda - \gamma) F_{nh} h - \lambda w h + (1-\chi) E\left[m' J_n'\right]$$

where λ and γ are, again, the Lagrange multipliers on the firm's budget constraint and enforcement constraint, respectively. Following Andolfatto (1996), it is assumed that the each worker is so small such that $F_{nh} \equiv \partial F / \partial (nh)$ is taken as given by both the household and the firm during the bargaining process. Given the worker's bargaining weight $\mu \in (0,1)$, the wage and hours are the result of the Nash bargaining problem:

$$(w,h) = \arg\max_{w,h} \left(\frac{V_n}{u_c}\right)^{\mu} (J_n)^{1-\mu}$$

Taking the derivatives with respect to wages and hours gives us the sharing rule of the production surplus and the static condition determining the number of hours.

$$\begin{aligned} \mu J_n &= \lambda(1-\mu)\left(\frac{V_n}{u_c}\right) \\ \frac{\nu_{(1-h)}(1-h)}{u_c} &= \left(1 - \frac{\gamma}{\lambda}\right) F_{nh} \end{aligned}$$

Using the sharing rule, $\mu J_n = \lambda(1-\mu)(V_n/u_c)$, along with the definition of V_n/u_c and J_n, gives the wage bill per worker:

$$\begin{aligned} wh &= \mu\left(\left(1-\frac{\gamma}{\lambda}\right) F_n + (1-\chi) E\left[m'\frac{J_n'}{\lambda}\right] + \frac{V}{1-N}\Phi E\left[m'\frac{J_n'}{\lambda'}\right]\right) \\ &\quad + (1-\mu)\left(\frac{\nu(1) - \nu(1-h)}{u_c} + b - (1-\chi) E\left[\beta\frac{V_n'}{u_c}\right]\right) \end{aligned} \tag{2.1}$$

This is simply a weighted average of (i) the effective marginal productivity of a worker plus the expected future value of maintaining the match plus the average discounted savings to the firm of not having to post a vacancy next period and (ii) the endogenous outside option of the worker which is simply the forfeited leisure in terms of consumption units as well as the unemployment benefit b minus the future value of maintaining the match. The marginal productivity of each worker F_n is driven down by the effective tightness of the enforcement constraint γ/λ. This is the key equation driving our results.

According to Hagedorn and Manovskii (2008) (HM hereafter), in order to increase the volatility of vacancies and employment, we need to increase the volatility of the firm's surplus per worker. In order to achieve this, they calibrate a low bargaining weight and a high value of the outside option for workers. The low value of the bargaining weight of workers makes the wage bill per worker less volatile in response to the marginal productivity of each worker F_n. The workers' higher outside option makes the firm's surplus small. These two properties taken together makes the firm's surplus per worker more sensitive to the marginal productivity of each worker F_n, which means firms have a greater incentive to post vacancies. Financial frictions have a similar effect by generating an additional wedge between the wage bill per worker and the marginal productivity of each worker F_n. When financial frictions are present, capital is more 'valuable' to the firm than an additional worker since capital has the added benefit of loosening the enforcement constraint in this model.

In our setup, positive financial shocks and negative productivity shocks will increase the outside option of workers endogenously. For these shocks, firms will choose to increase hours per worker since both shocks will relax the enforcement constraint and hours can be increased instantly unlike the stock of employees or capital. Since workers will work more on average, the outside option of not working increases. As a result, the firm's surplus per worker becomes more sensitive to the marginal productivity of each additional worker F_n, which gives the firm more of an incentive to change vacancy postings in response to shocks.

To see the effect of the enforcement constraint on the wage bill more clearly, consider the case in which the equity payout is simply $\varphi(d, d_{-}) = d$. In this case, there are no costs associated with adjusting the dividend and $\varphi_d = 1/\lambda = 1$. It follows that we can write the wage bill in Equation 2.1 as

$$\begin{aligned} wh &= \mu\left[(1-\gamma)F_n + \left(\frac{V}{1-N}\right)c_v\right] \\ &\quad + (1-\mu)\left[\frac{\nu(1)-\nu(1-h)}{u_c} + b\right] \end{aligned}$$

Since $\gamma \geq 0$, the tighter the enforcement constraint, the lower the effective marginal productivity of each worker to the firm becomes. That is to say, in situations in which the shadow price of the enforcement constraint increases, the bargaining weight shifts away from workers to the firm due to the fact that the firm would like to decrease the number of employees in order to loosen the enforcement constraint. However, since there are no endogenous separations, the firm is inhibited from decreasing either the capital stock or the stock of workers and must do so along the intensive margin. The shadow price of our enforcement constraint will increase during positive shocks to total factor productivity and in situation in which the credit market conditions deteriorate.

If there were no credit market frictions in our environment or during situations in which our enforcement constraint becomes nonbinding ($\gamma = 0$), our wage bill would collapse to the standard matching model sharing rule:

$$\begin{aligned} wh &= \mu\left[F_n + \left(\frac{V}{1-N}\right)c_v\right] \\ &\quad + (1-\mu)\left[\frac{\nu(1)-\nu(1-h)}{u_c} + b\right] \end{aligned}$$

This last equation will correspond to the wage bill in the Andolfatto benchmark model. The derivation of the equations above is detailed in the Appendix B.

2.2.5 Government

The government in this model simply raises revenue in order to subsidize firm's borrowing and to pay out the unemployment benefits b to the mass of unemployed households. Therefore, the government's budget constraint is:

$$T(S) = \left(\frac{1}{R(S)} - \frac{1}{1+r(S)}\right)a'_F(S, s_F) + (1-N)\,b$$

where S once again denotes the aggregate state of the economy.

2.2.6 Equilibrium

A *recursive competitive equilibrium* is defined as a set of functions for (i) the household's policies $c(S, s_H), s'(S, s_H)$, and $a'_H(S, s_H)$; (ii) the household's value function $V(S, s_H)$; (iii) the firm's policies $d(S, s_F), k'(S, s_F), a'_F(S, s_F)$, and $v(S, s_F)$; (iv) the firm's value function $J(S, s_F)$; (v) aggregate prices $r(S), R(S), p(S)$, and $m'(S, S')$; (vi) taxes $T(S)$; (vii) the law of motion for aggregate states $S' = G(S)$. Such that: (i) the household's policies are optimal and $V(S, s_H)$ satisfies the Bellman's equation (2.1); (ii) the firm's policies are optimal and $J(S, s_F)$ satisfies the Bellman's equation (2.4); (iii) $m' = \beta u_c(c')/u_c(c)$; (iv) the government's budget is balanced; (v) wages and hours $(w(S, s_H, s_F), h(S, s_H, s_F))$ is the solution to the bilateral Nash bargaining problem given by equation (2.9); (vi) markets clear, $s' = 1, a'_F = a'_H$; (vii) the law of motion $G(S)$ is consistent with individual decisions and the stochastic processes for z and ξ.

2.3 Calibration of the Model

We must now specify some functional forms in order to evaluate our model's quantitative results. We define the matching technology, the aggregate production technology and the equity payout cost to be:

$$\begin{aligned} M(V, 1-N) &= \omega V^{\psi}(1-N)^{1-\psi} \\ F(z, K, Nh) &= zK^{\alpha}(Nh)^{1-\alpha} \\ \varphi(d, d_{-}) &= d + \kappa(d - d_{-})^2 \end{aligned}$$

where $\psi \in (0,1), \alpha \in (0,1)$ and $\kappa \geq 0$. The representative household's preferences take the form:

$$u(c) = \log(c)$$

$$\nu(\ell) = \begin{cases} \phi \frac{\ell^{1-\eta}}{1-\eta} & \text{if } \ell \in [0,1) \\ \phi_u & \text{if } \ell = 1 \end{cases}$$

and the stochastic processes follow an autoregressive system:

$$\begin{pmatrix} z' \\ \xi' \end{pmatrix} = \mathbf{A}\begin{pmatrix} z \\ \xi \end{pmatrix} + \begin{pmatrix} \varepsilon_z \\ \varepsilon_\xi \end{pmatrix}$$

$$\begin{pmatrix} \varepsilon_z \\ \varepsilon_\xi \end{pmatrix} \sim N(0, \Sigma)$$

where ε_z and ε_ξ are normally distributed innovations with variance-covariance matrix Σ. We now left to determine twenty-one parameters in the model.

Our parameters can be categorized into three groups based on the way we chose to calibrate them. The first set of parameters are predetermined outside model. The second group is a set of parameters for the shock processes which are estimated from the constructed Solow residual and financial shock series. The last group of parameters consists of parameters determined endogenously in the model. We calibrate these parameters using simulated method of moments with a number of targets to be matched. To jointly choose this group of parameters, we minimize the distance between seven moments in the data and the in the model.

2.3.1 Predetermined Parameters

We set the unemployment benefit $b = 0$, so this plays no role in our analysis. We basically follow Andolfatto (1996) for the discount factor $\beta = 0.99$, the depreciation rate $\delta = 0.025$, the separation rate $\chi = 0.15$ and the matching elasticity $\psi = 0.60$. Since we focus on an economy where the wage in the labor market is determined in a non-competitive fashion, we cannot use labor share data to pin down α. Rather, we choose a value for $\alpha = 0.64$, which is common across the macroeconomic literature and it is also the same as Andolfatto (1996). We choose the tax benefit of debt in a similar to JQ, $\tau = 0.35$. Finally, we set the bargaining weight of workers $\mu = 0.35$, which is a middle of HM (2008) and Shimer (2005). The predetermined parameters are summarized in Table 2.2. All these parameters, with the exception of τ, will also be used within the Andolfatto model.

2.3.2 Parameters for the Shock Processes

We construct our TFP series, z_t, using our specification of the aggregate production function. In order to construct a series of the measured Solow residual, we must first

Parameter	*Description*	*Value*	*Remarks*
β	Discount factor	0.99	annual rate of return 4%
δ	Depreciation rate	0.025	Andolfatto (1996)
χ	Job-separation rate	0.15	Andolfatto (1996)
ψ	Matching elasticity	0.60	Andolfatto (1996)
α	CD parameter for capital	0.36	Andolfatto (1996)
τ	Tax benefit (subsidy)	0.35	JQ (2012)
μ	Bargaining weight	0.35	middle of HM and Shimer

Table 2.2: Predetermined Parameters

construct a time series for Y_t, K_t, N_t, and h_t. We use Current Population Survey (CPS) data on the level of employment (N_t) and the average weekly hours worked (h_t). Y_t is simply real GDP taken from the Bureau of Economic Analysis. We construct our capital stock using Flow of Funds data for the nonfinancial business sector and deflate the level of investment each period by the business GDP price index taken from the Bureau of Economic Analysis. Depreciation is taken to be the consumption of fixed capital of nonfinancial business Since we only have flows of net capital expenditures and not a level, we pick K_0 in 1952 such that the capital-output ratio displays no trend. Since we begin the recursion in 1952 and our analysis begins in 1984:Q1, it is not relevant for our results based on the time period for our analysis. Log-linearizing our aggregate production function gives:

$$\hat{z}_t = \hat{y}_t - \alpha \hat{k}_t - (1-\alpha)\hat{N}_t - (1-\alpha)\hat{h}_t$$

where hats denote log-deviations from a linear trend for each variable estimated over the period 1984:Q1-2012:Q1. We normalize $\bar{z} = 1$.

For the construction of our financial shocks, we make the assumption that the enforcement constraint is *always* binding. Of course, the validity of this assumption is critical for the construction of our financial shock series. We verify ex-post: after constructing the series for the shocks and feeding them into the model to verify that the Lagrange multiplier is always strictly greater than zero. This assumption is strong and open for debate. However, we feel that viewing the nonfinancial business sector in the aggregate as always being constrained is not an outrageous assumption to make.

Log-linearizing the enforcement constraint (equation (2.4)), gives us:

$$\hat{\xi}_t = \frac{\bar{\xi}\bar{b}^e}{\bar{y}}\hat{b}^e_{t+1} - \frac{\bar{\xi}\bar{k}}{\bar{y}}\hat{k}_{t+1} + \hat{y}_t$$

where we construct $\hat{b}^e_{t+1}$ using Flow of Funds data for net borrowing in credit market instruments in the nonfinancial business sector deflated by the business GDP price index. $\hat{y}_t$ in this case is not total GDP but real business GDP. Details of the data can be found in the Appendix B. The capital stock is as defined previously. We fix $\bar{b}^e/\bar{y} = 3.37$ to match the liabilities-output ratio over our sample period. This, in turn, gives us $\bar{\xi}\bar{k}/\bar{y} = 1.4362$ and $\bar{\xi}\bar{b}^e/\bar{y} = 0.4361$. We then use the constructed series for $\hat{z}_t$ and $\hat{\xi}_t$ and estimate a vector-autoregressive process over the time period 1984:Q1-2012:Q1. This gives us the matrix of coefficients and the variance-covariance matrix:

$$\begin{aligned} \mathbf{A}\binom{z}{\xi} &= \begin{pmatrix} 0.9910 & -0.0351 \\ 0.2403 & 0.8978 \end{pmatrix}\binom{z}{\xi} \\ \Sigma &= \begin{pmatrix} 0.0050^2 & 0.000027 \\ 0.000027 & 0.0079^2 \end{pmatrix} \end{aligned}$$

For our Andolfatto benchmark model without financial frictions, we simply have a AR(1) process for the productivity given by:

$$\begin{aligned} \rho_z &= 0.9426 \\ Var(\varepsilon_z) &= 0.0051^2 \end{aligned}$$

2.3.3 Parameters Determined Using Targets

For our remaining seven parameters, we use the simulated method of moments to minimize the distance between seven moments from the data and from the model. Our seven targets are:

1. Frisch elasticity of hours for those employed: 0.5
2. Steady-state employment to population ratio: 62%
3. Steady-state hours per worker: 0.39 (weekly potential hours assumed to be 100)
4. Steady-state job-filling rate: 90%

5. Vacancy expenditures-output ratio: 2.18%

6. Debt to GDP ratio: 3.37

7. Standard deviation of the equity payout-GDP ratio: 1.39

Parameter	*Description*	*KS*	*Andolfatto*
η	Curvature parameter for leisure	3.1166	3.1166
ϕ	Scale parameter for leisure	0.7814	0.7797
ϕ_u	Leisure for unemployed	0.2525	0.2554
c_v	Cost of posting a vacancy	0.1960	0.1875
ω	Matching efficiency	0.5349	0.5349
$\bar{\xi}$	Mean of credit process	0.1294	–
κ	Equity payout cost	0.1460	–

Table 2.3: Calibrated Parameters

According to Silva and Toledo (2009), the average cost of time spent hiring an additional worker is approximately 3.6%-4.3% of total labor costs. We target the median, 3.9%, of these estimates. In terms of our model, this implies $\frac{c_v v}{\Phi w n h} = 0.039$, which in turn gives $\frac{c_v v}{y} = 0.218$ given our targets for the job-filling rate $\Phi = 0.9$ and the labor share = 0.62, which is the average labor share over our sample period. κ is chosen to have a standard deviation of the equity payout-GDP ratio generated by the model equal to that of data.

For the calibration of the Andolfatto model, we omit the last two targets listed above from the calibration since κ and $\bar{\xi}$ are not present in that model environment. These targets result in the set of parameters reported in Table 2.3 for both our model (KS model, which stands for Kim and Seliski) and the Andolfatto model.

2.4 Results & Discussion

We solve both the KS and Andolfatto models using second order approximation around the steady-state. The derivation of the nonlinear equations characterizing both models' equilibriums can be found in the Appendix. We first show the resulting impulse response functions resulting from a one standard deviation shock to TFP for the KS model in order to develop some intuition underlying our results. This is shown in Figure 2.1.

2.4.1 Innovations to Productivity

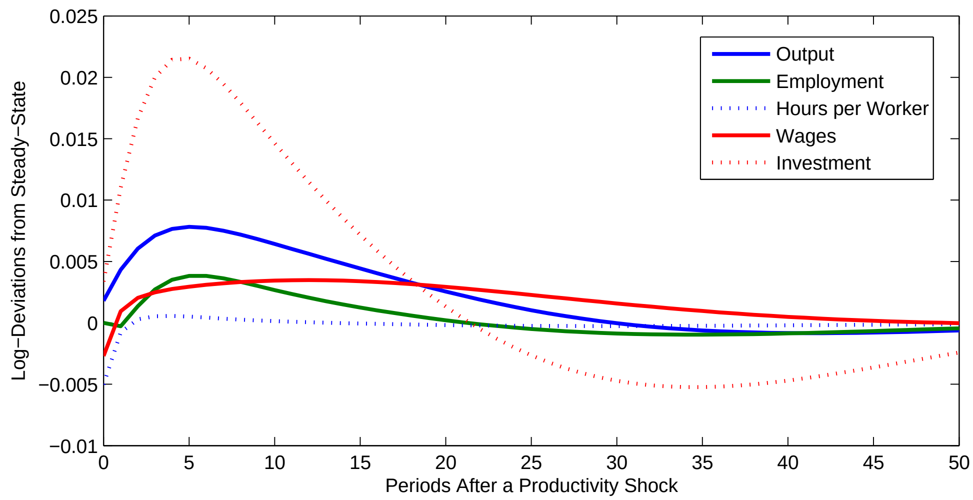

Figure 2.1: IRFs to a one standard deviation shock to TFP

When a productivity shock hits the KS model economy, the enforcement constraint instantly tightens. Since the stock of employees and capital are fixed, firms can only loosen the constraint via hours per worker and investing in a higher k_{t+1}. Hours in the model respond immediately because they can substitute for bodies that cannot be increased due to the nature of the hiring process. Once employees are separated exogenously, hours per worker quickly recovers back to its steady-state level.

In response to a positive productivity shock, the firm allocates resources away from labor input by decreasing both wages and hours and allocating the savings towards investment. This is consistent with the countercyclical nature of the labor share reported earlier. The shift in bargaining power is due to the shock increasing the ratio of the Lagrange multipliers, effectively lowering the marginal product of each worker to the firm. The reason for the firm allocating more resources to capital is as follows. After a tightening of the enforcement constraint, capital is deemed more 'valuable' to the firm because investment in capital tomorrow loosens the constraint. That is, labor and capital are imperfect substitutes not only due to their role in the production process, but also due to the added benefit of the higher capital stock loosening the enforcement constraint. The firm wishes to build up capital initially to loosen the constraint for future periods in order to take advantage of the persistence in the positive productivity shock. After employment begins to move (since it cannot move immediately), both wages and hours recover after the firm has effectively loosened the enforcement constraint by accumulating a higher capital stock.

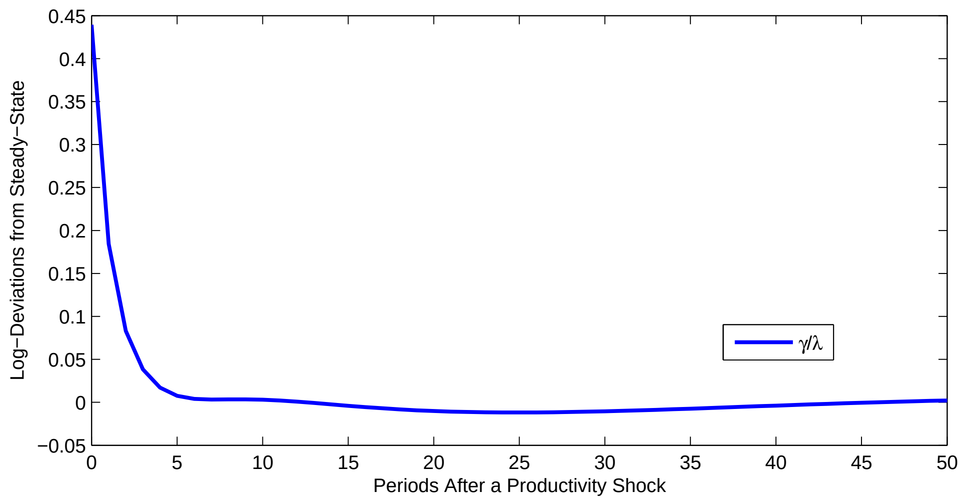

Figure 2.2: Shadow price response to a TFP shock

To gain some insight of the effects on the effective marginal product per worker, recall from the wage bargaining solution that $(1 - \gamma/\lambda)\, F_n$ is the effective benefit to the firm of employing an additional worker. The interpretation of γ/λ is the shadow price of the enforcement constraint discounted by the firm's marginal cost of financing operations via equity. The deviations of the effective shadow price are shown in Figure 2.2.

The kinks are due to the frictional nature of employment (employment cannot adjust when the shock is initially realized). While the shadow price associated with the constraint is quite high initially, it quickly drops off as the firm accumulates capital in order to loosen the constraint. Once the constraint has been loosened, due to the higher capital stock k_{t+1}, the firm begins to accumulate employees once again by posting vacancies.

Figure 2.3 shows how the firms finance their operations and how much of their resources are devoted to hiring purposes following a productivity shock. Once again,

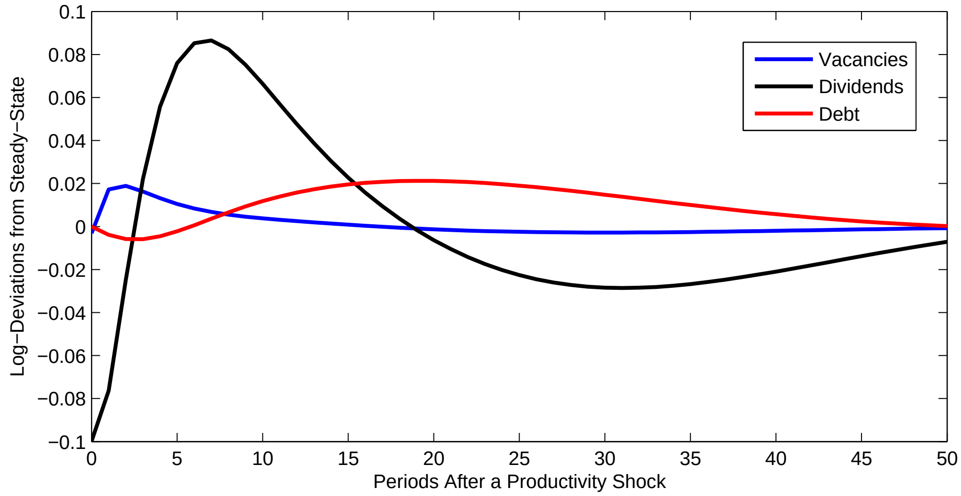

Figure 2.3: Firms' response to a TFP shock

the kink is the result of the lagged nature of employment. Initially, the firm finance their capital accumulation not only by reducing labor inputs and labor costs, but also via reductions in equity payouts. The firms use internal finances briefly to accumulate capital resources. It is noteworthy that equity payouts reach their peak over a year after the TFP innovation. This can be viewed as the firm paying out the highest dividends once it has adjusted both employment and capital to a situation in which the enforcement constraint's shadow price reaches its minimum deviation. Dividend payouts reach its peak around the same time that γ/λ reaches its minimum deviation. That is, the opportunity cost associated with diverting resources to dividend payments is at its lowest level.

2.4.2 Innovations to Credit Conditions

We now consider the situations in which our model economy is hit by a *negative* one standard deviation financial shock. The dynamics are shown in Figure 2.4. Similar to the productivity case, investment is hit hardest by an innovation to the financial process. As the firm faces a tighter enforcement constraint due to the negative financial shock, it immediately cuts hours, wages and investment. Since the firm cannot immediately adjust employment, employment does not drop until the period after the shock. One

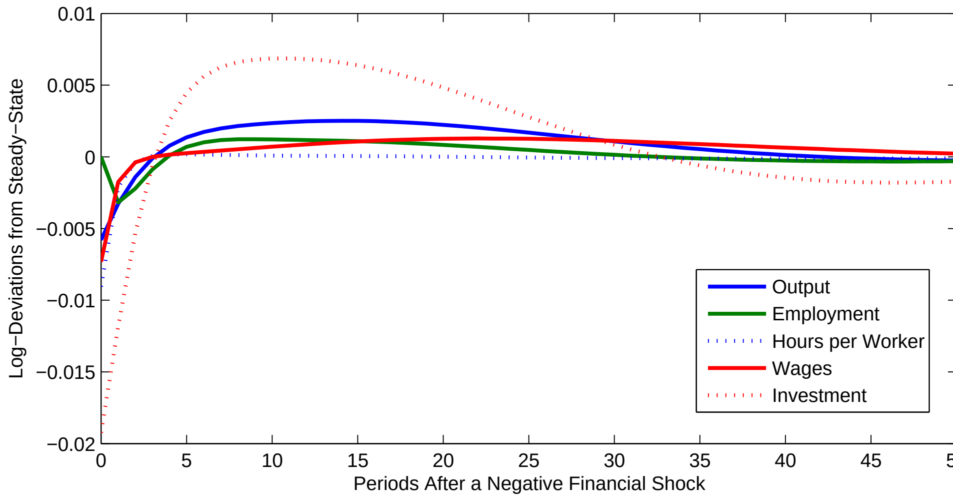

Figure 2.4: IRFs to a negative one standard deviation financial shock

of the key differences between the financial shock and the productivity shock, is the speed at which the economy recovers to its steady-state levels. This is in contrast to many findings that periods of financial distress lead to prolonged recessions. As in the positive productivity case, a negative financial shock shifts bargaining power away from the worker. Again, this is due to the tightness of the borrowing constraint driving down the effective marginal product of an additional worker to the firm.

The effective shadow price of the enforcement constraint, shown in Figure 2.5, displays a very similar pattern to the positive productivity shock case but drops off faster to return near to its steady-state ratio. Workers quickly recover their bargaining position as the ratio of the Lagrange multipliers recovers towards its steady-state level.

The most pronounced difference between the productivity and financial shock cases is the movement of financial variables, which one would expect. The firm decreases its debt position and continues to decrease it for some time after the financial shock. The firm also reduces its equity payouts but eventually increases them after some time. This is consistent with the observation that both equity payouts and debt positions are reduced during periods of financial turmoil as reported in JQ. To highlight the contributions of each shock to key variables, we report the variance decomposition of

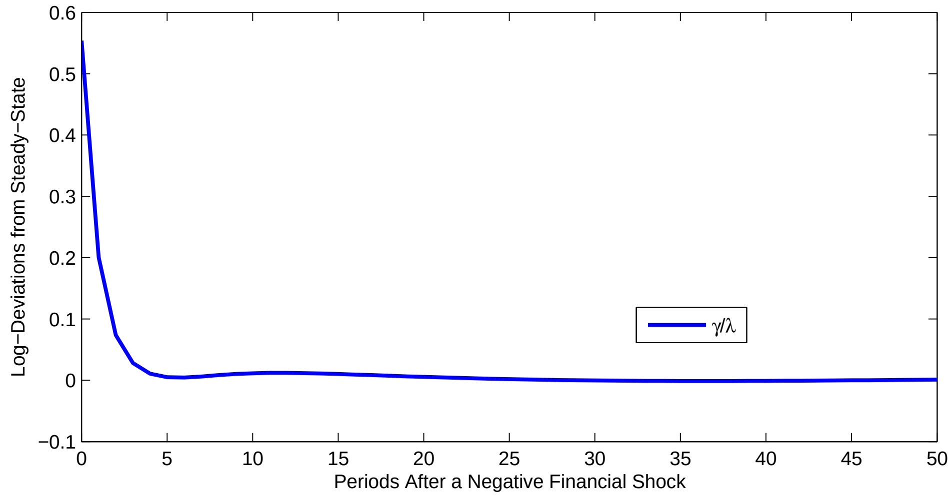

Figure 2.5: Shadow price response to a financial shock

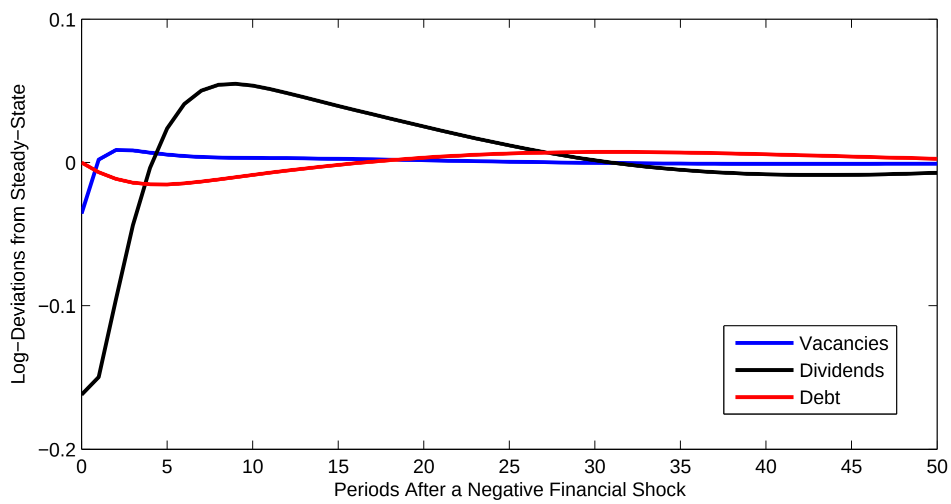

Figure 2.6: Firms' response to a negative financial shock

each shock in Table 2.4.

Variable	$\hat{z}$	$\hat{\xi}$
Output	86.20	13.80
Total Hours	63.99	36.01
Employment	83.36	16.64
Hours per Worker	8.44	91.56
Wages	76.38	23.62
Labor Productivity	85.73	14.27
Labor Share	19.15	80.85
Vacancies	61.09	38.91
Equity Payouts/GDP	45.74	54.26
Debt Repurchases/GDP	48.69	51.31

Table 2.4: Variance Decomposition (percent)

Financial shocks have a substantial impact on the volatility of both hours per worker and the labor share. The effects of financial shocks on the volatility of output and employment are relatively low. Despite equity and debt being financial variables, the impact of financial shocks on these is relatively similar to productivity shocks. While productivity shocks are still the main source of fluctuations along the extensive margin and seem to be the key driver in overall business cycle fluctuations, the impact of financial shocks is far from negligible on hours worked per worker. Financial shocks account for 36% of the volatility in total hours worked, mostly due to the impact of financial shocks on hours worked per worker. This, along with the fact that vacancies, hours, and the labor share are quite sensitive to financial shocks, provides evidence that incorporating financial shocks into a matching model results in a measurable improvement in the overall understanding of labor market fluctuations.

2.4.3 Comparing Results

We now compare our results to the Andolfatto model (model without financial frictions) to see what gains and what shortcomings the incorporation of financial frictions provides. Both the KS and Andolfatto models are simulated for 350 periods 500 times. Eighty-eight periods of data are burned in order to strip out the importance of initial values. All variables, except debt repurchases and equity payouts, are then logged and HP-filtered with a smoothing parameter of 1600. The main business cycle statistics for both models are reported in Table 2.5.

The addition of financial shocks into the matching model has a marked impact on key labor market variables. While the Andolfatto model generates high employment volatility, it is still orders of magnitude less than the data. The KS model improves the model's performance along this dimension. We are able to match the volatility of total hours and labor productivity quite well. However, our model performs poorly in replicating movements in wages and capturing the countercyclical nature of the labor share. Additionally, while the data has the intensive margin accounting for 32% of the variation in total hours worked, the KS model delivers 53%, overstating the importance of hours worked per worker while the Andolfatto model delivers only 14%.

Despite these shortcomings, our results comport to a greater extent with actual data than the Andolfatto model, indicating that the addition of financial frictions and financial shocks have a positive impact on matching moments from the data. This, taken together with the variance decomposition implies that financial shocks are an important dimension to incorporate into standard matching models. Our credit channel shows up through the multipliers associated with the enforcement constraint which drives down the marginal benefit of employees to firms. Financial frictions generate an additional wedge between the wage bill per worker and the marginal productivity of each worker F_n. Capital is more 'valuable' to the firm than an additional worker in this environment since capital has the additional benefit of loosening the enforcement constraint. This makes both investment and hours per worker sensitive to shocks originating in the financial sector or from TFP. Despite improving some labor market variables' volatilities via financial shocks, we are still quite far off from replicating the volatility displayed in the data, especially for vacancies.

2.5 Conclusion

Does the incorporation of financial shocks into a standard matching model better our understanding of fluctuations in hours, employment, and wages? Our analysis suggests that there are gains to be made by accounting for such shocks in a standard matching model. We proposed a model that uses Andolfatto as a our benchmark matching model and incorporate financial frictions and shocks into the environment similar to JQ. Within our model, we show that the credit channel has marked impacts on key labor variables via the shifting of bargaining power from workers to firms through the effective shadow price on the enforcement constraint.

Comparing our results to the Andolfatto model, calibrated to hit the same targets, demonstrates that our model can better replicate business cycle moments. Moreover, a variance decomposition of the shocks suggests that financial shocks play an important role in the fluctuation of both hours per worker and the labor share. While our results still support the notion that business cycle fluctuations are still largely due to productivity shocks, it also suggests that future research that employs a matching model framework should seriously consider the incorporation of financial shocks as well as the intensive margin to account for movements in key labor market variables. Without the incorporation of financial shocks, movements in employment, hours per worker, and the labor share are relatively muted over the business cycle.

	$\sigma_x\%$			$\rho\,(x, Output)$			$\rho\,(x_t, x_{t-1})$		
Variable (x)	Data	*KS*	*Andolfatto*	Data	*KS*	*Andolfatto*	Data	*KS*	*Andolfatto*
Output	1.12	1.15	0.94	–	–	–	0.97	0.78	0.81
Total Hours	1.26	0.94	0.50	0.85	0.86	0.93	0.89	0.66	0.90
Employment	0.88	0.60	0.45	0.82	0.77	0.81	0.93	0.83	0.86
Hours per Worker	0.45	0.64	0.14	0.77	0.54	0.72	0.61	0.15	0.48
Wages	0.91	0.62	0.41	-0.18	0.78	0.96	0.77	0.33	0.67
Labor Productivity	0.66	0.58	0.51	0.07	0.58	0.94	0.59	0.59	0.58
Labor Share	0.73	0.79	0.13	-0.28	0.18	-0.67	0.78	0.27	0.44
Vacancies	11.26	3.73	2.60	0.86	0.71	0.72	0.91	0.31	0.45
Equity Payouts/GDP	1.39	1.39	–	0.69	0.70	–	0.91	0.89	–
Debt Repurchases/GDP	2.23	2.07	–	-0.84	-0.78	–	0.93	0.88	–

Table 2.5: Business Cycle Moments

Chapter 3

Unemployment Dynamics in Europe: The Roles of the Ins and Outs

3.1 Introduction

The search and matching model of unemployment developed by Mortsensen and Pissarides (1994) has become the standard framework for studying unemployment in the macroeconomy. This model has two key variables driving flows into and out of the pool of unemployed: (i) the job-finding rate (outflow rate) and the (ii) separation rate (inflow rate). Just how important is the cyclicality of the job-finding rate versus the separation rate in understanding unemployment variability over a country's business cycle? Hall (2005) and Shimer (2012) have argued that unemployment fluctuations in the United States are almost entirely driven by variation in the job-finding rate. As a result, most macroeconomic models studying unemployment have assumed that the separation rate is acyclical, largely ignoring labor market models with a role for endogenous separations. Others have cautioned against this assumption (Elsby, Michaels, and Solon, 2009; Fujita and Ramey, 2009).

This paper studies labor market outcomes across a number of European countries and the US at business cycle frequencies. In particular, it constructs a quarterly measure of unemployment flows and evaluates the contribution of the job-finding and separation rates to the dynamics of the unemployment rate in each country. The methodology popularized by Shimer (2005, 2012) and Elsby, Hobijn, and Sahin (2013) is used to construct quarterly inflows and outflows from unemployment using publicly available labor force survey data.

Whereas the best comparable, cross-country estimates for the rates of inflow to and outflow from unemployment are annual, this study adds to the existing literature by creating *quarterly* estimates of the hazard rates across 19 European countries and the US using the methodology developed by Shimer (2012). This allows me to study the two key inputs of the search and matching model at business cycle frequencies. I then quantify the contribution of the job-finding and separation rates to the dynamics of unemployment in each country, which is the primary contribution of this paper. While fluctuations in the job-finding rate accounted for about 76% of the variability of the unemployment rate in the US, in the EU-15,[1] it accounted for roughly 61%, leaving a much larger role for the separation rate in European countries. This supports the findings of Hobijn and Sahin (2009) and Elsby *et al.* (2013) and reinforces the view that the US is the exception rather than the rule. Unlike the US, taking account of variations in the separation rate is critical for understanding unemployment variability in most European countries. Therefore, if one is interested in understanding how unemployment evolves across European countries, models with endogenous separations should be employed.

This paper is most closely related to Elsby *et al.* (2013), but their annual estimates of the job-finding and separation rates smooth out high frequency fluctuations in the separation rates, thereby understating the role of separation rates. Their study also ignores many breaks in the underlying unemployment duration data used in their sample. Since many of the European countries used in their analysis had substantial breaks in the labor force surveys prior to 2004, results reported in Elsby *et al.* (2013) may be biased due to breaks in the underlying time series. I avoid this issue by restricting my sample to cover only the periods after 2004.

The remainder of the paper is organized as follows. Section 3.2 describes the data

[1] Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the UK.

and methodology used for the construction of quarterly hazard rates across a sample of European countries and the US. Section 3.3 does a cross-country analysis of the estimated hazard rates and decomposes unemployment fluctuations in each country. Section 3.4 concludes.

3.2 Data and Analytical Framework

Data from the European Labor Force Survey (LFS) and from the Current Population Survey (CPS) for the US are used to produce quarterly estimates of flow hazard rates into and out of the pool of unemployed. In everything that follows, I restrict my analysis to the working age population, which I take to be those aged 15 to 64.[2] This study adopts the methodology pioneered by Shimer (2012) to construct implicit labor market flows. In order to employ this methodology and obtain simple measures of monthly hazard rates, two strong assumptions are made: (i) workers can only be in one of two states, unemployed or employed; (ii) all unemployed workers have the same job finding probability and all employed workers have the same exit probability. The first assumption rules out any movements into or out of the labor force while the second assumption rules out any heterogeneity among the employed or unemployed.

With regard to the first assumption, Shimer (2012) demonstrates that movements into and out of inactivity over the business cycle are dominated by movements between unemployment and employment, therefore accounting for the inactive state did not quantitatively change his main findings using US data. Elsby *et al.* (2013) also note that allowing for inactivity does not significantly change the results for their cross-country analysis in a quantitatively important way. However, ignoring the inactive state is not necessarily a benign assumption to make for European countries. In fact, as can be seen in Figure 3.1, almost 15% of those classified as inactive in the EU-8 [3] in 2006 transitioned into the labor force a year later. Since we cannot observe the flows into and out of the inactive state without having access to the relevant microdata, we cannot proceed with the analysis without making the first simplifying assumption.

As for the second assumption, estimating heterogenous hazard rates is not feasible

[2] 16 to 64 for the US.
[3] Belgium, Germany, Denmark, Greece, Spain, Italy, Portugal and the UK.

Status in 2006	Status in 2007		
	Employed	Unemployed	Inactive
Employed	94.7	2.5	2.8
Unemployed	32.5	54.2	13.3
Inactive	10.5	4.4	85.2

Table 3.1: Transition matrix, EU-8, 2006-2007 (%). *Source*: Table copied from European Commission (2009, p. 63).

without access to the appropriate microdata. Since unemployment duration data is the primary measure used to construct the job-finding rate, a cautionary consideration is the potential of duration dependence among the pool of unemployed. Elsby *et al.* (2013) use both quarterly and annual data and propose a means to test for duration dependence across a large set of OECD countries. It is worth emphasizing that the definition of duration dependence is a broad one and makes no distinction between duration dependence, which has a causal effect on the job-finding rate, and duration dependence that arises purely due to selection bias (i.e., the worst workers are left over). Elsby *et al.* (2013) find only weak evidence for duration dependence in the job-finding rate in Continental European countries and use an optimally weighted estimate to create a more 'precise' estimate of the job-finding rate using annual unemployment duration data. This paper uses quarterly unemployment duration data to construct quarterly measures of the hazard rates in each economy, so it is unnecessary to implement their optimal weighting procedure.

3.2.1 Labor Flow Accounting

This section closely follows Shimer (2012). Time is continuous but data is only collected at discrete dates $t \in \{0, d, 2d, \dots\}$ where $d > 0$ is an integer and represents the distance in time units between data collection dates. The labor force is constant and normalized to one, $l_t \equiv e_t + u_t = 1,\ \forall t$, where e_t and u_t denote the stock of employed and unemployed at time t, respectively. Within the period, defined as the interval $[t, t+d)$, all unemployed workers find a job according to a Poisson process with constant arrival rate $f_t \geq 0$ and all employed workers separate from their current job according to a Poisson process with constant arrival rate $s_t \geq 0$. These hazard rates are assumed to be constant *within* each interval $[t, t+d)$. I refer to f_t as the job-finding rate or outflow rate and s_t as the separation rate[4] or inflow rate throughout the remainder of this paper.

Fix t and let $j \in [0, d]$ be the time that has elapsed since our last discrete time observation. Define $u_t^s(j)$ as the stock of short-term unemployed between observations. They are the workers that were unemployed at time $(t+j)$, but were employed at some point within the interval $[t, t+j]$. By construction, $u_t^s(0) = 0$ for all t. Thus, the evolution of the stock of unemployed and short-term unemployed between observations is governed by the following system of equations:

$$\dot{u}_{t+j} = s_t e_{t+j} - f_t u_{t+j} \tag{3.1}$$

$$\dot{u}_t^s(j) = s_t e_{t+j} - f_t u_t^s(j) \tag{3.2}$$

Modeling flows in a continuous time environment such as this allows me to ignore any time aggregation bias that may result in my measure of the rates. Workers can potentially switch between states multiple times between observations when flows are modeled in this manner and is reflected in the above system of equations. Issues arising from time aggregation bias are discussed at length in Elsby *et al.* (2009) and Shimer (2012). Substituting for $s_t e_{t+j}$ in Equation 3.1 above and solving the differential equation with initial condition u_t gives:

$$[\dot{u}_{t+j} - \dot{u}_t^s(j)] + f_t[u_{t+j} - u_t^s(j)] = 0$$

By definition, $u_t^s(0) = 0$. Therefore, given the the observations u_t and u_{t+d}, the solution to this differential equation is:

$$u_{t+d} = e^{-f_t d} u_t + u_t^s(d) \tag{3.3}$$

where $u_t^s(d)$ is the stock of unemployed workers who have been unemployed for no more than d units of time. Shimer (2012) uses monthly unemployment duration data from the Current Population Survey (CPS) to back out the hazard rate f_t each month. In the context of his study, $u_t^s(1)$ would represent the stock of those who have been unemployed for four weeks or less. Therefore, using Equation 3.3, the probability that a worker that

[4] Elsby et al. (2013) stress that this is a bit of a misnomer since a separation is typically defined as a layoff or quit. When workers flow from inactivity to being unemployed it would be incorrect to label these transitions as ‘separations’.

was unemployed in period t, i.e. at the beginning of the interval $[t, t+d)$, finds *at least* one job by period $(t+d)$ can be written as:

$$F_t(d) \equiv \frac{u_t - e^{-f_t d} u_t}{u_t} = 1 - \frac{u_{t+d} - u_t^s(d)}{u_t} \tag{3.4}$$

It is worth stressing that this is not the probability that an unemployed person is employed at the beginning of period $(t+d)$, but is the probability a person that was unemployed had at least one spell of employment within the interval between observations. The monthly job-finding rate is related to the probability of finding a job within the interval $[t, t+d)$ through the mapping $f_t = -\ln(1 - F_t)/d$. Since I have assumed that the labor force is constant and normalized to one, we can write the differential Equation 3.1 d time units forward as:

$$\dot{u}_{t+d} + (s_t + f_t) u_{t+d} = s_t$$

The solution to this linear first order differential equation with initial condition u_t is:

$$u_{t+d} = \left(1 - e^{-(s_t + f_t)d}\right) \frac{s_t}{s_t + f_t} + u_t e^{-(s_t + f_t)d} \tag{3.5}$$

Once I estimate f_t, I can obtain estimates of s_t by solving this nonlinear equation, given data for u_t and u_{t+d}. This equation also characterizes the out of steady-state dynamics of the unemployment rate for a given initial unemployment rate and the inflow and outflow rates, s_t and f_t. The current unemployment is a convex combination of the previous unemployment rate and the within period steady-state:

$$u_{t+d} = \lambda_t u_t^* + (1 - \lambda_t) u_t \tag{3.6}$$

where the rate of convergence λ_t and the steady-state within the period are defined as,

$$\lambda_t \equiv 1 - e^{-(s_t + f_t)d}$$
$$u_t^* \equiv \frac{s_t}{s_t + f_t}$$

The higher the rate of turnover in an economy, $(s_t + f_t)$, the faster the economy will adjust to its steady-state unemployment rate within the period $[t, t+d)$. Thus, if a shock hits either of the flow hazard rates, not only will it change the new steady-state unemployment rate, it will also affect the rate at which the economy will converge to this new steady-state. If job turnover is low, or equivalently, if λ_t is small, then the unemployment rate from last period will persist into the current period because the labor market will only slowly adjust towards its new steady-state unemployment rate. Equation 3.6 provides one with a useful analytical framework in which we can decompose fluctuations in a country's unemployment rate and attribute it to variations in the job-finding rate and to variations in the separation rate. This equation provides the cornerstone of my analysis of the cross-country differences in quarterly unemployment dynamics.

3.2.2 Data

While Shimer (2012) was able to exploit unemployment duration data at monthly frequencies for his study of the US labor market, publicly available unemployment duration data from the European LFS are only available at quarterly frequencies. Elsby *et al.* (2013) use both annual and quarterly data on unemployment to estimate their hazard rates. For my analysis, I will use quarterly European LFS and CPS data from 2004:Q1-2015:Q1. I will now briefly describe the data used and the adjustments made for this paper as well as discuss some of the limitations when using European LFS data.

Prior to 1997, the European LFS was only conducted once in the spring each year.[5] Since 1998, EU countries gradually moved to a quarterly continuous survey with reference weeks spread uniformly throughout each quarter. By 2004, most countries had already adopted the continuous survey with the exception of Germany. In an effort to derive the most comparable hazard rates for cross-country analysis, I only use data after most countries had already adopted the quarterly continuous survey. One limitation of employing the methodology described in Elsby *et al.* (2013) is that the unemployment rate and unemployment duration data are not those observed at end of a quarter, due to the continuous nature of the survey. Households are uniformly sampled throughout the quarter and without access to the appropriate microdata, we cannot say that the data reported is in fact the observation at the end of the quarter. Instead, these time series should be viewed as quarterly averages and not end of quarter observations. While this is a rather fine detail, it is worth mentioning since it is necessary to treat the data as

[5] Data were typically collected in the 2nd quarter. France and Poland conducted their spring surveys in the 1st quarter.

an 'end of quarter' observation in order to apply the methodology of Shimer (2012) and Elsby *et al.* (2013). For this very reason, I also avoid using those unemployed for less than one month as my primary metric for estimating the job-finding rate. Instead, I use data representing those unemployed for less than three months.

When using unemployment duration data from the European LFS, two adjustments must be made. First, the European LFS counts individuals who have already found jobs and will start working within a period of at most 3 months as unemployed. This shows up in the unemployment duration data as 'Not Started', which is normally lumped in with those who have been unemployed for less than 1 month, as is done in the OECD dataset. This is problematic in the sense that it provides no information about how long those unemployed workers were searching prior to securing a job. In most countries, the share of the unemployed classified as 'Not Started' is negligible. However, the share of unemployed in Italy classified in this manner averaged 2% since 2004. I address this problem by omitting this group of unemployed when calculating the incidence of unemployment by duration.

Additionally, I must take stock of unemployed individuals who did not respond to the duration question. This is potentially a more serious problem than the 'Not Started' one as a number of countries have classified a non-negligible share of their unemployed as 'No Response' as can be seen in Table 3.2. Again, I deal with this problem by omitting this group of unemployed when calculating the incidence of unemployment by duration, but it is useful to be aware of the shortcomings that could potentially lead towards biased estimates of the hazard rates.

Using Equation 3.4 from above and taking a period to be a month, we can write the probability that an unemployed worker exits unemployment by the end of the quarter as:

$$F_t(3) = 1 - \frac{u_{t+3} - u_t^s(3)}{u_t}$$

where $u_t^s(3)$ denotes the stock of short-term unemployed workers with duration less than

Country	$d < 1$	$1 \leq d$ < 3	$3 \leq d$ < 6	$6 \leq d$ < 12	$d \geq 12$	Not Started	No Response
Austria	9.5	23.9	20.1	19.4	27.2	–	–
Belgium	3.6	15.0	15.2	16.2	49.9	–	–
Czech Republic	7.6	14.2	15.4	19.3	43.6	–	–
Denmark	16.5	21.9	19.2	15.6	25.1	1.5	–
Finland	16.3	26.3	19.2	14.2	22.1	–	1.1
France	4.6	15.9	16.4	18.6	43.9	–	0.7
Germany	9.8	16.1	14.1	15.2	44.0	–	0.8
Greece	2.1	6.2	7.6	10.3	73.4	0.4	–
Hungary	11.4	9.3	12.4	19.5	47.4	–	–
Ireland	4.4	10.5	10.9	14.2	58.2	–	1.7
Italy	2.7	9.9	11.8	12.2	60.7	1.6	1.1
Netherlands	6.1	17.3	16.7	19.2	38.6	–	2.0
Norway	15.5	27.7	16.8	13.5	21.7	–	4.7
Poland	9.9	10.0	17.6	19.8	42.7	–	–
Portugal	3.8	11.7	10.7	14.3	59.5	–	–
Slovakia	2.3	6.6	7.5	13.4	70.3	–	–
Slovenia	2.2	12.3	14.0	17.0	54.5	–	–
Spain	5.9	13.4	12.8	15.0	52.8	–	–
UK	11.8	19.7	15.6	16.2	35.6	0.9	0.2
US	25.8	25.5	15.7	10.5	22.6	–	–
EU-15	6.4	14.2	13.7	15.2	49.6	0.4	0.6

Table 3.2: Incidence of Unemployment by Duration (%), 2014. Annual average. The duration d is measured in months and the population are those aged 15-64 except for the US, which is 16-64. *Source*: Eurostat, BLS

three months. I estimate the hazards rates with the following two equations:

$$f_t = -\frac{1}{3}\ln\left((1 - \text{share}^{<3}_{t+3})\frac{u_{t+3}}{u_t}\right) \tag{3.7}$$

$$u_{t+3} = \left(1 - e^{-3(s_t+f_t)}\right)\frac{s_t}{s_t + f_t} + e^{-3(s_t+f_t)}u_t \tag{3.8}$$

where $\text{share}^{<3}_{t+3} = u^s_t(3)/u_{t+3}$, denotes the proportion of those unemployed at time $(t+3)$, i.e. the next quarter, who have been unemployed for less than three months. Since the raw data displays a large degree of seasonality, the unemployment rates and the share of short-term unemployed are both seasonally adjusted[6] prior to estimating the monthly hazard rates f_t and s_t. The job-finding hazard rate is then estimated using the seasonally adjusted unemployment duration data for those unemployed for less than three months and the seasonally adjusted time series of the unemployment rates. Once f_t is obtained, one can then pin down the separation hazard rate, s_t, by solving the nonlinear equation above. I create measures using this procedure for 19 European countries as well as the EU-15.

To create the most comparable estimates, I use the same procedure to generate estimates for the US using CPS data. I do not adjust the pool of short-term unemployed as is done in Shimer (2012) and Elsby *et al.* (2013) to account for the 1994 CPS redesign. This results in an overall lower job-finding estimate for the US in my analysis compared to their estimates.

3.3 Labor Market Flows

A summary of the average values of f_t, s_t, steady-state unemployment estimates u_t^*, and actual unemployment rates for those aged 15-64[7] in my sample of 19 European countries, the US, and the EU-15 are shown in Table 3.3.

Over the period 2005:Q2-2015:Q1, the average probability of an unemployed worker in the EU-15 flowing into employment within a month was 9.5% and the probability of an employed worker flowing into unemployment within a month was 1%. The median monthly unemployment outflow rate across my sample of 19 European countries was 8.1% and the median inflow rate was 0.8%, with the Nordic countries displaying the highest inflow rates. This comports with Elsby *et al.* (2013)'s set of annual results.

European countries' labor markets are, relative to the US, less dynamic. The rate of total job turnover, $(s_t + f_t)$, ranges from an average high of 22.7% in Norway to a low of 3.9% in Slovakia. The rate of total job turnover in the US is roughly 30%. This indicates that the half-life of a deviation from steady-state unemployment would be close to 3 months in Norway, 18 months in Slovakia, and close to 2 months in the US. Out of steady-state unemployment rates are quite persistent in Europe. Steady-state

[6] This is achieved using the Census X-13 seasonal adjustment method in Eviews 9.
[7] 16-64 for the US.

Country	Outflow Rate (f_t)	Inflow Rate (s_t)	Turnover ($s_t + f_t$)	$u_t^* = \frac{s_t}{f_t+s_t}$	Unemployment Rate (u_t)
Austria	14.6	0.8	15.4	5.2	5.1
Belgium	8.1	0.7	8.8	8.5	8.0
Czech Republic	7.3	0.5	7.8	6.6	6.7
Denmark	18.6	1.1	19.7	5.9	5.9
Finland	19.4	1.7	21.1	8.0	8.0
France	10.9	1.1	12.0	9.2	9.1
Germany*	9.2	0.7	9.8	6.9	7.3
Greece	5.2	1.0	6.2	17.8	15.5
Hungary	6.3	0.6	6.9	9.5	8.9
Ireland	7.7	0.8	8.5	10.4	9.8
Italy	6.6	0.6	7.3	9.8	8.9
Netherlands	10.9	0.6	11.5	5.1	4.9
Norway	21.9	0.8	22.7	3.4	3.4
Poland	7.8	0.8	8.6	10.3	11.2
Portugal	6.4	0.9	7.2	12.2	11.3
Slovakia	3.4	0.5	3.9	14.5	13.5
Slovenia	7.0	0.5	7.5	8.1	7.3
Spain	12.6	2.2	14.8	17.6	17.0
UK	14.9	1.0	15.9	6.6	6.6
US	27.3	1.9	29.2	6.9	6.9
EU-15*	9.9	1.0	10.9	9.4	9.2

Table 3.3: Sample Average Hazard Rates (%), 2004:Q2-2015:Q1. *Note*: The population are those aged 15-64 except for the US, which is 16-64; *Germany and EU-15 start in 2005:Q2. *Source*: Eurostat, BLS, author's calculations

unemployment will not be a good approximation to the actual unemployment rate for many European countries since the quarterly rate of convergence is substantially lower than one.

3.3.1 Decomposition of Unemployment Dynamics

Since most European countries will not converge quickly to their within quarter steady-state unemployment rate, conventional techniques to decompose unemployment fluctuations into fluctuations in the job-finding rate and fluctuations in the separation rate are not appropriate. Elsby *et al.* (2013) devise a convenient way to decompose these fluctuations even when the unemployment rate is out of its steady-state. The out of steady-state dynamics within a quarter can we written as:

$$u_{t+3} = \left(1 - e^{-3(s_t+f_t)}\right)\frac{s_t}{s_t+f_t} + e^{-3(s_t+f_t)}u_t \tag{3.9}$$

$$= \lambda_t u_t^* + (1-\lambda_t)u_t \tag{3.10}$$

We can log-linearize this equation around the trend values $s_t = \bar{s}_t$, $f_t = \bar{f}_t$, and $u_t = \bar{u}_t$, which yields

$$\ln u_{t+3} \simeq \ln \bar{u}_{t+3} + \bar{\lambda}_t(1-\bar{u}_{t+3})\left[\ln\left(\frac{s_t}{\bar{s}_t}\right) - \ln\left(\frac{f_t}{\bar{f}_t}\right)\right] + (1-\bar{\lambda}_t)\ln\left(\frac{u_t}{\bar{u}_t}\right) \tag{3.11}$$

where the trend rate of convergence is defined as $\bar{\lambda}_t = 1 - e^{-(\bar{s}_t+\bar{f}_t)}$. We can rewrite this in terms of log-deviations, $\hat{x} = \ln x - \ln \bar{x}$, from trend

$$\hat{u}_{t+3} \simeq \bar{\lambda}_t(1-\bar{u}_{t+3})\left[\hat{s}_t - \hat{f}_t\right] + (1-\bar{\lambda}_t)\hat{u}_t \tag{3.12}$$

Deviations from trend unemployment are a convex combination of current log-deviations in the both the separation and job-finding rates as well as past log-deviations from trend unemployment. If an economy's trend turnover $(\bar{s}_t + \bar{f}_t)$ is high, then $\bar{\lambda}_t \simeq 1$ and Equation 3.12 reduces to the standard steady-state decomposition for unemployment fluctuations and fluctuations in unemployment will only depend on contemporaneous deviations in the hazard rates. Since turnover is quite low in most of Europe, past deviations in unemployment will persist into the current period, so we need to take account of 'spillovers' in deviations from previous periods into the current unemployment deviation. We are primarily interested in the flow hazard rates' contributions, so we can write Equation 3.12 recursively as

$$\hat{u}_{t+3} = C_t^s + C_t^f + C_t^0 + \varepsilon_t \tag{3.13}$$

where C_{ft}, C_{st}, and C_{0t} denote the *cumulative* contributions at time t of contemporaneous and past variation in the hazard rates as well as the initial deviation from trend at some arbitrary initial period $t = 0$ and a residual, ε_{t+3}. These cumulative contributions are written recursively as

$$C_t^s = (1-\bar{\lambda}_t)C_{t-3}^s + \bar{\lambda}_t(1-\bar{u}_{t+3})\hat{s}_t \tag{3.14}$$

$$C_t^f = (1-\bar{\lambda}_t)C_{t-3}^f - \bar{\lambda}_t(1-\bar{u}_{t+3})\hat{f}_t \tag{3.15}$$

$$C_t^0 = (1-\bar{\lambda}_t)C_{t-3}^0 \tag{3.16}$$

with initial conditions $C_0^s = C_0^f = 0$ and $C_0^0 = \hat{u}_3$. Written this way, variation in the unemployment rate depends on the contemporaneous fluctuation in the hazards rates as well as lagged variation in the hazard rates. It will also depend on the initial deviation $\hat{u}_3$ and the residual term.

As in Fujita and Ramey (2009), this linear representation of deviations in the unemployment rate allows me to attribute variability in unemployment to variability in the separate components on the right-hand side of Equation 3.13. The variation in unemployment is

$$Var\big(\hat{u}_{t+3}\big) = Cov\big(C_t^s, \hat{u}_{t+3}\big) + Cov\big(C_t^f, \hat{u}_{t+3}\big) + Cov\big(C_t^0, \hat{u}_{t+3}\big) + Cov\big(\varepsilon_t, \hat{u}_{t+3}\big) \quad (3.17)$$

Dividing both sides by the variance in unemployment deviations allows me to write the decomposition in terms of each term's share:

$$1 = \beta^s + \beta^f + \beta^0 + \beta^\varepsilon$$

where

$$\beta^x = \frac{Cov\big(C_t^x, \hat{u}_{t+3}\big)}{Var\big(\hat{u}_{t+3}\big)}$$

for each series $x \in \{s, f, 0\}$ as well as the residual term. The β's capture the amount of variation that can be attributed to each underlying series through its direct correlation with unemployment deviations and its cross correlations with other series.

The series for s_t and f_t are HP filtered with a standard smoothing parameter of 1600. What remains to be determined is the initial deviation in the unemployment rate, $\hat{u}_3$. I set this to be the initial deviation of the HP filtered unemployment rate series but use Equation 3.13 to construct deviations in unemployment thereafter. In an effort to reduce endpoint bias in the HP filtered series and reduce the impact of the assumed initial deviation in unemployment, I omit the first four observations and the last four observations when calculating the contributions and summary statistics. The main results for the period 2005:Q1-2014:Q1 are reported in Table 3.4.

As previously noted in the literature, fluctuations in unemployment at business cycle frequencies in the US are primarily driven by deviations in the job-finding rate. The job-finding rate accounted for about 76% of the variation in unemployment. Compared to most European countries, the US lies at the high end, with only Spain and Slovenia having higher contributions from the job-finding rate. Most European countries' tend to have a 60:40 split between contributions from the job-finding rate and contributions from the separation rate. The median contribution from the job-finding rate for my sample of European countries was 60.9% while the median contribution from the separation rate was 40.6%. These numbers are quite similar for the EU-15 taken as a whole, which were 61.3% and 37.6%, respectively. The job-finding rate is the primary driver of unemployment fluctuations in all countries except the Czech Republic and the Netherlands. These results affirm those reported[8] by Elsby *et al.* (2013) and lends even more support to their assertion that one should seriously consider the role of the separation rate if one seeks to understand variation in unemployment rates outside of the US.

3.4 Concluding Remarks

There has been a recent debate among macroeconomists as to the importance of the separation rate in understanding labor market outcomes over the business cycle. Both Hall (2005) and Shimer (2012) have argued that the separation rate is acyclical in the US while Elsby and Solon (2009) and Fujita and Ramey (2009, 2012) have cautioned against ignoring the cyclicaltiy of the separation rate. This paper constructed labor market flows for a number of European countries and the US and found that most variation in the unemployment rate is driven by the cyclicality of the job-finding rate. However, the US is the exception rather than the rule. Most European labor markets have a 60:40 split between the job-finding rate and the separation rate in accounting for unemployment fluctuations at business cycle frequencies. Therefore, if one truly wants to understand unemployment's movements over the business cycle in Europe, one cannot assume the separation rate in most European countries is acyclical.

Can cross-country differences in hazard rate contributions be explained by employment protection (EPL) policies? Theoretically, more stringent EPL should lower both the number of separations and the number of new hires, resulting in an ambiguous net effect. Stricter EPL limits job destruction by making terminations more expensive and inhibits job creation by reducing the expected profitability of hiring a new worker as

[8] They found a 55:45 job-finding/separation split for their annual time series using first differences in the unemployment rate.

Country	std($\hat{u}_t$)	std($\hat{f}_t$)	std($\hat{s}_t$)	β^f	β^s	β^0	β^r
Austria	8.6	17.6	9.6	51.5	45.5	-0.1	3.0
Belgium	6.7	22.6	8.8	60.2	40.6	-0.1	-0.6
Czech Republic	14.0	16.0	20.1	33.6	64.6	0.1	1.6
Denmark	16.5	16.0	9.1	68.3	30.8	0.3	0.6
Finland	7.9	8.0	7.1	52.6	47.3	0.1	0.0
France	6.1	9.7	7.3	59.8	38.7	0.1	1.4
Germany*	5.0	11.2	5.8	51.9	49.0	-0.1	-0.8
Greece	14.4	22.8	15.7	56.9	48.5	2.1	-7.4
Hungary	7.9	19.7	12.8	63.7	36.1	0.0	0.2
Ireland	18.2	24.2	18.0	49.4	48.6	1.8	0.2
Italy	7.4	21.2	8.6	71.1	33.2	1.5	-5.7
Netherlands	12.2	13.5	9.6	47.2	54.9	-1.1	-1.0
Norway	12.0	14.0	11.7	60.9	41.1	-0.1	-2.0
Poland	11.8	19.9	10.9	63.9	37.8	0.4	-2.1
Portugal	8.8	17.8	11.4	64.6	35.3	-0.4	0.5
Slovakia	10.9	52.6	23.7	73.8	50.8	0.6	-25.2
Slovenia	12.3	33.2	12.4	82.1	27.5	0.1	-9.6
Spain	13.8	15.9	6.8	79.4	24.2	0.5	-4.1
UK	7.3	8.3	5.4	68.3	31.8	-0.2	0.1
US	14.4	13.3	6.3	76.4	25.4	0.0	-1.8
EU-15*	6.7	7.6	4.9	61.3	37.6	0.8	0.3

Table 3.4: Unemployment Volatility Decomposition (%), 2005:Q1-2014:Q1. *Germany and EU-15 start in 2006:Q1.

shown in Cahuc and Postel-Vinay (2002). A large volume of literature has affirmed that stronger EPL in the form of higher firing costs generally results in an ambiguous impact on the level of total employment, but reduces labor market flows (Bentolila and Bertola, 1990; Bentolila and Saint-Paul, 1992; Blanchard and Landier, 2000; Garibaldi, 1998; Hopenhayn and Rogerson, 1993; Messina and Vallanti (2007); Mortensen and Pissarides, 1994). A recent study by Perez and Yao (2015) concluded that stricter EPL tends to reduce separation rates. Future work should examine the role labor market institutions play in accounting for the observed differences in job-finding rates and separation rates across countries.

Chapter 4

Dual Labor Markets and Life-Cycle Unemployment

4.1 Introduction

Throughout the 1980s and 1990s, many European governments undertook labor market reforms in an attempt to increase labor market flexibility in the face of high unemployment. These reforms left employment protection legislation (EPL) on permanent (open-ended) contracts largely unchanged while loosening regulations on or increasing access to temporary forms of employment. This partial (two-tier) reform strategy has given rise to dual labor markets in a number of European economies. Dual labor markets comprise a juxtaposition of workers with highly protected, long-term employment relationships existing alongside workers with insecure, short-term forms of employment. Temporary contracts allow firms to employ workers for a relatively short duration and costlessly, or at dramatically reduced cost, separate from a worker once the contract has expired. Firms could potentially forego dismissal costs indefinitely by continually renewing temporary contracts with workers, although most European countries restrict the number and/or cumulative duration of successive temporary contract renewals. Since the unemployment rate and the incidence of temporary employment tend to decrease with age, regulatory changes that exclusively promote the use of temporary contracts will have disparate effects across age groups.

Such two-tiered reforms, according to Boeri and van Ours (2013), are intended to promote flexibility along the margin for new hires while keeping the high dismissal costs associated with permanent contracts in place. This effectively widens the protections granted to permanent employees relative to temporary workers. Theoretically, such asymmetric reforms should increase both the rate of job creation and job destruction, leading toward an ambiguous net effect on the level of unemployment. Job creation will increase as firms hire more temporary positions exempt from dismissal costs and job destruction will increase since firms will have less incentive to transform temporary contracts into permanent ones. Saint-Paul (2000) has argued extensively that this strategy was primarily the result of political influence exerted by incumbent employees rather than policymakers attempting to design the most efficient form of EPL. Naturally, all young, inexperienced workers must start as a new hire at some point before enjoying the protections afforded incumbent employees. Therefore, labor market reforms restricted to creating flexibility at the margin for new hires, should have a significant impact on young workers entering the labor market. Indeed, as noted by the European Commission (2010, p. 117), dual labor markets "can be a particularly serious problem for young people, as a precarious start in the world of work is likely to have a long-lasting negative impact on future employment and earnings prospects."

The primary goal of this paper is to examine the intergenerational impact of two-tier labor market reforms. In particular, the paper seeks to answer a number of pertinent questions: Will the use of temporary contracts increase or decrease unemployment? What are the welfare implications of partial labor market reforms? Will average wages be higher or lower after partial reforms? I present a life-cycle search and matching model in which temporary and permanent contracts coexist in order to address these questions. The model economy is calibrated to match a set of facts from the Italian economy prior to the implementation of the 1997 Treu reforms, the first in a set of reforms that loosened restrictions on temporary forms of employment. The key result is that increasing access to temporary contracts will decrease the unemployment rate for all age groups but will have a negative impact on the average welfare of younger workers. The model is successful at matching a number of key facts: (i) the decreasing age-profile of unemployment, (ii) the decreasing age-profile of the incidence of temporary employment, (iii) the earnings distribution, and (iv) the wage-gap between temporary and permanent positions.

While it is widely discussed in the literature that temporary positions are disproportionately held by younger workers, few have tried to explicitly account for age in their model environments. The model presented in this paper extends the life-cycle search and matching environment developed by Esteban-Pretel and Fujimoto (2014) and Chéron *et al.* (2013). Unlike the model of age-directed search presented in Menzio *et al.* (2012), this class of models assumes labor markets are not segmented by age. The key departure from the baseline framework of these models is the possibility for firms to offer temporary and permanent positions and the assumption that human capital can only be upgraded while working in a permanent position. The model embeds the hypothesis that temporary contracts are used as screening devices in a number of European countries, as advocated by Faccini (2014), and assumes that matches differ in match-specific quality that is learned over time in the style of Pries (2004) and Pries and Rogerson (2005). Workers will only be hired, conditional on age and contract type, if the prior probability that the match is good exceeds a certain threshold. As in Faccini (2014) and Cahuc and Postel-Vinay (2002), firms can offer new hires a temporary contract with an exogenous probability, which is a reduced form way of capturing the strictness of labor market regulations on temporary contracts. My focus in this paper will be on the effects of this parameter on labor market outcomes over the life-cycle.

Temporary forms of employment differ from permanent positions in three important respects in the model environment presented in this paper. First, firing costs are only incurred when a worker with an existing permanent contract separates from the firm. Second, some temporary contracts must be upgraded, at which point the firm can dismiss the worker cost-free or upgrade the contract to a permanent one. Third, permanent contracts have the added benefit of accumulating on-the-job human capital. Since all workers in the model are homogenous upon entering the labor market, workers who are determined to be of the highest match quality early in the life-cycle will enjoy the benefits of being in permanent positions with higher pay and with a greater possibility to upgrade their level of human capital. Young temporary workers who are not matched well early in the life-cycle will suffer the most because of their inability to increase their human capital level and because firms will be more reluctant offer older workers permanent positions. Firms are more stringent in their screening of older workers for new permanent contracts due to the horizon effect. That is, the older a worker is, the fewer the number of periods in which the firm is able to profit from the match and recover any expected dismissal costs associated with the permanent position.

My paper relates to two strands of literature: the extensive literature evaluating the macroeconomic implications of temporary contracts and the literature analyzing life-cycle unemployment. Many important studies incorporating temporary contracts into search and matching models, including Bentolila and Saint-Paul (1992), Alonso-Borrego *et al.* (2005), Boeri and Garibaldi (2007), and Boeri (2011), assume that the market for temporary contracts and permanent contracts are segmented. In these frameworks, temporary employees cannot be converted into permanent positions and act as a buffer against economic shocks. They all share the common feature that increasing labor flexibility increases worker turnover.

The models of Cahuc and Postel-Vinay (2002) and Blanchard and Landier (2002) analyze the steady-state implications of temporary positions and allow for the conversion of temporary contracts to permanent positions. Blanchard and Landier (2002) discuss how two-tier reforms have negatively affected youth in France, but their theoretical model does not incorporate a life-cycle component. Both studies conclude that increasing access to temporary contracts would have the perverse effect of increasing the unemployment rate in addition to lowering the welfare of workers. The intuition that informs this result is that, when firing costs are large, allowing the creation of more temporary jobs will increase both job creation and job destruction simultaneously. The latter effect will dominate since firms will choose not to transform temporary jobs into permanent positions when dismissal costs are prohibitive.

In the model of Faccini (2014), which bears the most similarity to my model along the temporary contracting dimension, if temporary positions are used as a screening mechanism, we should observe a permanent decrease in the unemployment rate and large welfare gains after the enactment of policies permitting more temporary jobs. This is in stark contrast to the majority of the literature that has raised serious concerns on the efficacy of using temporary contracts as a tool to combat high unemployment. Faccini (2014) supports his claims empirically and demonstrates that looser regulations on temporary contracts are associated with a reduction in unemployment rates in Europe.

My paper also contributes to the existing life-cycle equilibrium unemployment literature. In particular, it extends the recent work of Chéron *et al.* (2013) and Esteban-Pretel and Fujimoto (2014) to allow for temporary and permanent positions. The latter study employs a search and matching model of the labor market that incorporates a life-cycle structure with human capital accumulation to account for the fact that, in the United States, the unemployment, job finding, and separation rates are all decreasing with age. Another study that attempts to account for these three key phenomena with one-sided search over the life-cycle is Gorry (2011). These findings are not unique to the United States and, as is shown in the European Commission's report (2010), are characteristic of almost all European countries. While accounting for this set of facts is not the primary purpose of my study, I am able to replicate all these features in my own model with the exception of the decreasing separation rate. Hahn (2009) uses a continuous time, overlapping generations, matching model and concludes that labor market institutions have a differential impact for different age groups when a worker is only active in the labor market up to a certain age. Young workers and older workers will be particularly sensitive to policy measures. Though Hahn (2009) discusses the implications and interactions of labor market policies over the life-cycle, he does not allow for the existence of dual labor markets in his model environment.

4.2 Two-Tier Reforms: The Italian Experience

Most of the literature analyzing the macroeconomic effects of temporary employment have focused on the cases of France and Spain. However, the case of Italy in the late 1990s serves as a particularly good laboratory to evaluate the impact of liberalizing the use of temporary contracts. As pointed out by Boeri (2011) and the European Commission (2010), Italy seems to be the country characterized by the most asymmetric set of reforms, liberalizing temporary forms of employment drastically while keeping EPL on permanent contracts untouched. Figure 4.1 shows the OECD's EPL Indicator on temporary forms of employment for both the 1990s and 2000s. The index measures the regulation of temporary contracts and ranges from 0-6, with higher values representing stricter regulations. Any observation below the 45 degree line indicates that regulations on temporary forms of employment were liberalized between the 1990s and 2000s. In terms of differences, Italy had the largest drop in the EPL indicator on temporary employment. I discuss some of the laws governing permanent contracts in Italy and the set of major labor market reforms that were passed in 1997, 2001, and 2003 below.

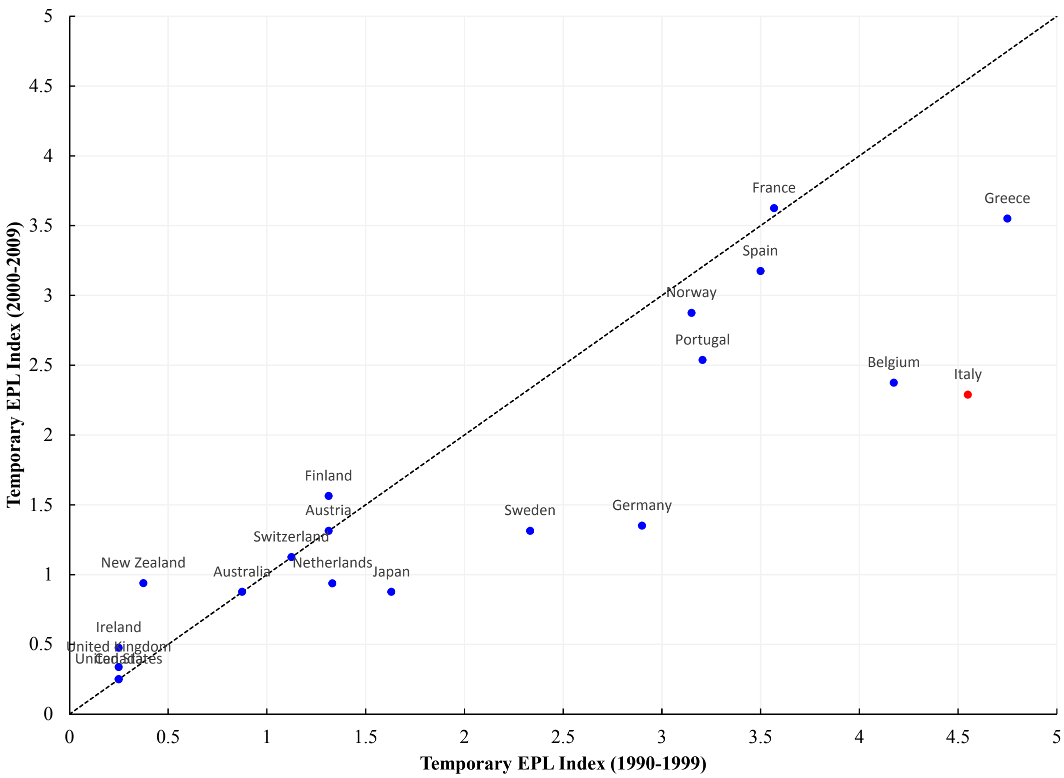

Figure 4.1: Evolution of the EPL temporary employment indicator. *Source*: OECD

Italy has some of the strictest regulations in Europe pertaining to the dismissal of permanent employees. In Italy, workers on permanent contracts enjoy the protections granted to them under Article 18 of the Italian Workers' Statute (Act No. 300 of 1970). Article 18 of the Workers' Statute, a piece of legislation passed in 1970 that establishes a set of workers' rights, protects employees from 'unfair' dismissals by firms that employ 15 or more workers. If a judge rules that a worker was dismissed unfairly by an employer, the employee has the right to be fully reinstated by the firm or be given 15 months of pay plus any foregone wages from the time of the initial dismissal up to the point of the court ruling. Workers opt for the severance payments in over 95 percent of the cases ruled in the worker's favor (Garibaldi and Taddei, 2013). The reforms of 2012 (the so called Fornero reforms) shifted this choice of a severance payment or reinstatement to the court. Garibaldi and Violante (2005) study the firing costs in Italy in great detail and conclude that the majority of the dismissal costs are transfers to the worker rather than a tax paid to a third-party. They estimate the *ex ante* firing cost in Italy to be 18.75 months of average wages, of which only 3.5 months are the tax component. The model presented in this paper only focuses on the tax component of the firing costs.

Temporary forms of employment were substantially liberalized in 1997 through the Treu reforms (Act No. 196 of 1997). The Treu reforms allowed, for the first time, the establishment of temporary help agencies and reduced the penalties associated with using fixed-term contracts illegally. It also eased regulation of new apprenticeships and work-training contracts and ended the automatic conversion of fixed-term contracts into permanent employment (Tealdi, 2011).

In 2001, another reform was undertaken (Legislative Decree No. 368 of 2001) that widened the categories of jobs in which fixed-term contracts could be used, based on a 1999 EU Directive. Prior to the reform, fixed-term employment could only be used in limited situations. The reform significantly expanded the conditions under which a fixed-term contract could be used and only required that the motivation for the limited duration of employment be written into the contract. There is no maximum duration on a single fixed-term contract, but fixed-term contracts longer than three years cannot be renewed upon expiration.

The last major reform on the use of temporary employment was the Biagi reforms of 2003 (Act No. 30 of 2003). The Biagi reforms allowed more flexibility for jobs on call, staff leasing, and new probationary contracts. The effect each reform had on the OECD's synthetic indicator is shown in Figure 4.2, as well as the unemployment rate for those aged 15-64. A similar graph is also shown and discussed in Faccini (2014) which led him to report the stylized fact that, in Italy, the liberalization of temporary contracts closely coincided with a reduction in the unemployment rate.

Throughout my analysis, I define youth to be the 20-29 age group. The OECD (2008) reports that the age at which 50 percent of the young people in Italy have finished their initial education is 19.9 and the median age in Italy when full-time education was stopped as 19.5. Similarly, Eurostat reports that the average age for individuals leaving formal education in Italy is 21. Therefore, I believe it is reasonable to take age 20 to

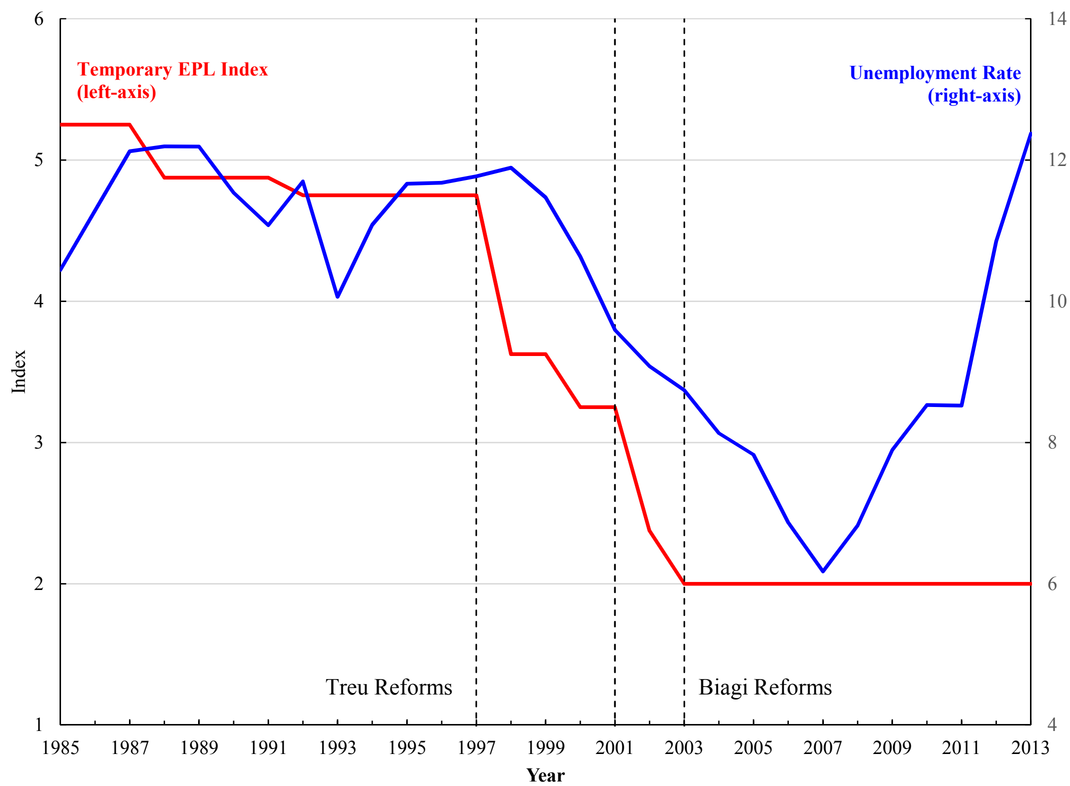

Figure 4.2: Unemployment rate and EPL temporary employment indicator. *Source*: OECD

roughly be the age of entry for young workers in Italy. For the sake of this analysis, it is therefore more appropriate to adopt 20 as the approximate age of entry for young workers in Italy. I define prime to be those aged 30-54 and overall to be those aged 15-64.

From the period prior to the reforms to the period after the Biagi reforms, the unemployment rate in Italy dropped from an average of 11.3% between 1993 and 1997 to 7.2% between 2004 and 2007. For those aged 20-29, the age group that I have labeled youth, the unemployment rate dropped from an elevated 22.2% to 14.7%. For those aged 30-54, the unemployment rate dropped from 6.5% to 5.2%. Over these same time periods, the incidence of temporary employment increased from 5.1% to 9.5%. I take the incidence of temporary employment to be temporary employment as a share of *total* employment, rather than the typically used dependent employees. This rate surged from 9.7% to 22% for youth and rose from 3.5% to 6.9% for prime aged workers. The summary statistics before and after the Italian reforms are shown in Table 4.1. Although it would be extremely reductive to attribute the drop in the unemployment rate to the labor market reforms alone, Faccini (2014) has demonstrated empirically that looser regulations on temporary contracts are associated with reductions in the unemployment rate in Europe. Therefore, I hypothesize that the labor market reforms were at least partially responsible for the drop in the unemployment rate in Italy.

Unemployment Rate (percent)	Overall	Youth	Prime
Pre-reform (1993-1997)	11.3	22.2	6.5
Post-reform (2004-2008)	7.2	14.7	5.2
Percentage point difference	-4.1	-7.5	-1.3
Incidence of Temp. Employment (percent)	Overall	Youth	Prime
Pre-reform (1993-1997)	5.1	9.7	3.5
Post-reform (2004-2008)	9.5	22.0	6.9
Percentage point difference	4.4	12.3	3.4

Table 4.1: Italy pre and post-reform. *Source*: Eurostat, OECD.

4.3 Model

The model is a version of Esteban-Pretel and Fujimoto's (2014) overlapping generations search model extended to include both temporary and permanent contracts in a similar manner as Cahuc and Postel-Vinay (2002) and Faccini (2014).

4.3.1 Environment

Time is discrete and continues forever. Two types of agents participate in the economy, workers and firms. There are N overlapping generations of workers and a continuum of firms with positive measure. Workers are either employed and producing or unemployed and searching for jobs. There is no on-the-job search. At each point in time, a continuum of new workers (normalized to unity) enter the labor market as unemployed and are active for N periods, where $N \geq 2$ is an integer. Firms have one job, are *ex ante* homogenous, and post vacancies in order to be matched with an unemployed worker. A unit of production in the economy is a matched firm-worker pair. Both workers and firms are risk-neutral and discount the future by the factor $\beta \in (0, 1)$. There is no aggregate uncertainty in the economy.

Workers differ in age and in their level of general human capital. All workers start at the lowest skill level, $z_1 > 0$, and have the potential to accumulate it up to z_H, where $z_1 \leq \ldots \leq z_H$ and $H \geq 1$ is an integer. It is assumed that workers can only accumulate human capital while working under a permanent contract and will upgrade to the next level with probability $\rho \in [0, 1]$ each period. This can be thought of as educational benefits or on-the-job training and captures the notion that firms are more likely to train workers with whom they expect to maintain long employment relations. Empirically, the OECD (2002) and European Commission (2010) have found that temporary workers receive considerably less formal employer-provided training and less on-the-job training than permanent workers, which serves as motivation for this assumption. A worker's level of human capital does not decay and stays with the worker until she exits the labor market.

Matching Technology

Labor markets are frictional in the sense that unemployed workers and vacant jobs are paired through an imperfect matching process each period. Unemployed workers are heterogenous along two dimensions, in their age and along their level of human capital. It is assumed that firms cannot direct their search. Therefore, workers of all ages and skill compete for the same vacancy postings. That is, the labor market is not segmented by age or human capital. Despite not being able to *ex ante* discriminate, once the firm meets a worker, the worker's age and level of human capital are revealed and the firm can choose not to engage in production with the worker. Let $u_{a,h}$ be the number of unemployed workers of age $a \in \{1, \ldots, N\}$ with human capital level $h \in \{1, \ldots, H\}$ and v be the number vacancies. The *total* number of unemployed workers in the economy is: $\sum_{a=1}^{N} \sum_{h=1}^{H} u_{a,h}$. However, due to the timing assumption that it takes one period for a match to become productive, the oldest generation of unemployed workers will not actively search for a vacancy (those aged N). Therefore, the measure of job-seekers is $u = \sum_{a=1}^{N-1} \sum_{h=1}^{H} u_{a,h}$. The number of new matches each period is given by $M(v, u)$. The matching function M is increasing and concave in both arguments and exhibits constant returns-to-scale. The latter assumption allows the per-period probability of a vacant job (unemployed worker) being matched with an unemployed worker (a vacant job) to be expressed as a function of market tightness, $\theta = v/u$. The probability that a vacant job meets an unemployed worker is $M(u, v)/v = q(\theta)$ and the probability that an unemployed worker meets an unemployed worker is $M(u, v)/u = \theta q(\theta) = p(\theta)$. It is important to note that not all matches will necessarily result in an employment relationship.

Production Technology and Learning

There are two types of match-specific qualities: good ($\bar{y} = y_g$) and bad ($\bar{y} = y_b \leq y_g$). Match quality is persistent and lasts for the entire duration of an employment relationship. Output at time t is observed at the end of a period and is given by $y_t = z_h \bar{y} + \varepsilon_t$ where $\bar{y}$ is the true match-specific productivity component, z_h is the worker-specific level of human capital, and ε_t is a mean-zero idiosyncratic productivity shock which is i.i.d. across time and matches. The 'noise' term, ε_t, is assumed to be uniformly distributed over the interval $[-\bar{\varepsilon}, \bar{\varepsilon}]$ where $\bar{\varepsilon} \geq 0$. Under these assumptions, the learning process takes an all-or-nothing form, as in Pries and Rogeron (2005).

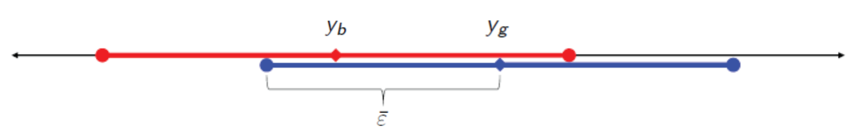

Figure 4.3: Potential Output and Match-Specific Types

When a worker and firm are initially matched with one another, the worker and firm know the worker's age, a, and human capital, z_h, but the true match-specific quality, $\bar{y}$, is unknown to both. The worker and firm observe the prior $\pi \in [0, 1]$ which corresponds to the probability that the match is of good quality. It is assumed that π is drawn from the distribution $F(\pi)$ when a worker and firm first meet. The firm and worker will learn that the true quality of the match is good whenever $y_t \in [z_h y_b + \bar{\varepsilon}, z_h y_g + \bar{\varepsilon}]$ and will learn that the quality of the match is bad whenever $y_t \in [z_h y_b - \bar{\varepsilon}, z_h y_g - \bar{\varepsilon}]$.

If the observed output lies in the range $[z_h y_g - \bar{\varepsilon}, z_h y_b + \bar{\varepsilon}]$, nothing is learned and the posterior probability will equal the prior, π. Therefore, given the assumptions about the noisy component of output, ε_t, the probability the true quality of the match is revealed at the end of the period is $\alpha_h = (y_g - y_b)z_h/2\bar{\varepsilon}$ and the probability that nothing is learned about match quality is simply its complement, $(1 - \alpha_h)$. The probability that the match is revealed, α_h, is independent of the worker's age and of the match's actual quality but is strictly increasing in the worker's human capital, z_h. In order to ensure that $\alpha_h \leq 1$, it is assumed that $(y_g - y_b)z_H \leq 2\bar{\varepsilon}$. Since both good and bad matches have the same probability of being revealed, the proportion of good quality matches that have not been revealed remains π. It follows that the the probability that a match is revealed to be of the good type is $\alpha_h \pi$ and the probability that the match is revealed to be of the bad type is $\alpha_h(1 - \pi)$.

Separations between a firm and a worker occur for three different reasons. First, a firm and a worker may choose to endogenously separate if the joint surplus is too low to justify the continuation of the employment relationship. Second, matches are exogenously destroyed with probability $\lambda \in [0, 1]$. Third, matches are destroyed whenever the worker exits the labor force at age $(N + 1)$.

Temporary and Permanent Contracts

Two types of labor contracts co-exist in the economy: temporary and permanent. Temporary contracts differ from permanent contracts along three dimensions. First, temporary contracts can be dismissed costlessly. Second, temporary contracts can be upgraded to permanent contracts whenever the non-renewal clause is activated, but permanent contracts cannot be downgraded to temporary ones. Third, permanent contracts have the added benefit of potentially increasing the worker's human capital stock.

Whenever an existing permanent contract is terminated, for endogenous or exogenous reasons, the firm incurs the dismissal cost $d \geq 0$. Only continuing matches are subject to these dismissal costs. That is, upon first meeting, the firm and worker can choose to dissolve the match without having to pay any dismissal costs. This cost is a pure resource waste. Dismissal costs are an an exogenous 'tax' and should not be viewed as transfers to workers, such as severance pay, but as transfers from the firm to a third-party outside of the match. As noted in Pries and Rogerson (2005), referring to these as dismissal costs is somewhat of a misnomer, since it is effectively a separation tax levied on employers. Temporary contracts cannot be renewed with probability $\eta \in [0, 1]$. If the non-renewal clause is activated, the firm and worker have the option to convert the contract into a permanent one or to dissolve the match altogether.

When matched with a firm and employed under a permanent contract, the worker will upgrade her human capital stock with probability $\rho \in [0, 1]$. In this sense, a permanent contract is a different technology than that of a temporary contract. The upgrade does not cost the worker or firm any resources in this framework and is simply an added benefit of a permanent contract. Following the modeling framework of Cahuc and Postel-Vinay (2002) and Faccini (2014), when a firm and worker first meet, the firm can initially offer the worker a temporary contract with probability $\phi \in [0, 1]$. This is a policy instrument that captures the ease with which a firm can offer temporary contracts in the economy.

The timing of the model is as follows. Separations occur at the beginning of each period, allowing workers (unless exiting) and firms to begin searching and posting again within the period. Wages are then negotiated and new matches formed. Matches that are formed in period t become productive in period $t + 1$. Matches of unknown quality in period t will observe output at the end of the period and update their beliefs at the beginning of period $t + 1$. Human capital accumulation is realized at the very end of each period following production.

4.3.2 The Problem of the Agents

I now characterize the steady-state behavior of firms and workers in the economy. I adopt the following notation:

- $J_{i,a,h}$: Value to the firm with a worked aged a, human capital level h, and contract type i;
- $W_{i,a,h}$: Value to the worker aged a with human capital level h and contract type i;
- $U_{a,h}$: Value of being unemployed when aged a and with human capital level h;
- V: Value to the firm of a vacant job slot.

where $i \in \{T, P_0, P\}$. T denotes a temporary contract, P_0 a new permanent contract, and P a continuing permanent contract. There needs to be a distinction between a new permanent contract and one that has been active for at least one period because new permanent contracts are exempt from the firing costs d.

Firms

Firms are free to open a vacancy and search for unemployed workers. The resource cost of posting a vacancy is each period is $\kappa > 0$. Letting V be the expected value of a vacancy, the value of posting a vacancy can be written as:

$$\begin{aligned} V &= -\kappa + \beta\big(1 - q(\theta)\big)V \\ &+ \beta q(\theta) \sum_{a=1}^{N-1} \sum_{h=1}^{H} \frac{u_{a,h}}{u} \left[\phi \int_0^1 J_{T,a+1,h}(\pi) dF(\pi) + (1-\phi) \int_0^1 J_{P_0,a+1,h}(\pi) dF(\pi) \right] \end{aligned} \tag{4.1}$$

The value of posting a vacancy has the following interpretation: A firm pays κ to post a vacancy and, with probability $(1 - q(\theta))$, the firm does not meet a worker and the firm enters the next period with a vacant job. With probability $q(\theta)$, the firm meets a worker. Since the search process is undirected, the firm is randomly allocated a worker of age a with skill level z_h. The probability of meeting such a worker is simply $u_{a,h}/u$. With probability ϕ, the firm can initially offer a temporary contract. Matches produce at the end of the following period, so firms must make an expectation about being in a good quality match. The prior probability of it being of the good type is π and is drawn from the distribution $F(\pi)$.

After being matched, the firm decides at the beginning of the next period whether to hire the worker and produce this period or to dissolve the match. Once a firm employs a worker, wages are negotiated and production takes place. The value to the firm of a temporary contract being matched with a worker type (a, h) with the prior π that the match is good at the beginning of a period is:

$$J_{T,a,h}(\pi) = \max\{J^c_{T,a,h}(\pi), V\}$$

The continuation value is given by:

$$\begin{aligned} J^c_{T,a,h}(\pi) = {} & \pi z_h y_g + (1-\pi) z_h y_b - w_{T,a,h}(\pi) + \beta\lambda V \\ & + \beta(1-\lambda)\alpha_h \pi \big[\eta J_{P_0,a+1,h}(1) + (1-\eta) J_{T,a+1,h}(1)\big] \\ & + \beta(1-\lambda)\alpha_h (1-\pi) \big[\eta J_{P_0,a+1,h}(0) + (1-\eta) J_{T,a+1,h}(0)\big] \\ & + \beta(1-\lambda)(1-\alpha_h) \big[\eta J_{P_0,a+1,h}(\pi) + (1-\eta) J_{T,a+1,h}(\pi)\big] \end{aligned}$$

where $w_{T,a,h}(\pi)$ is the wage paid to the worker. The first three terms on the right-hand side are expected current-period profits. The expected output is independent of the noise term because ε is assumed to have mean zero. The fourth term is the expected value of the match being destroyed exogenously and having a vacant job the following period. Conditional on the match surviving in the following period, the firm's expected value will depend on whether the match quality is revealed and if the non-renewal clause is activated. With probability ρ, the non-renewal clause is activated and the firm is forced to either upgrade the contract to a permanent one or dismiss the worker. Match-specific quality is revealed to be good with probability $\alpha_h \pi$, revealed to be bad with probability $\alpha_h(1-\pi)$, and with probability $(1-\alpha_h)$ nothing is learned about match quality.

The value to the firm of a new permanent contract with a worker type (a, h) with the prior π that the match is good at the beginning of a period is:

$$J_{P_0,a,h}(\pi) = \max\{J^c_{P_0,a,h}(\pi), V\}$$

where the continuation value is given by:

$$\begin{aligned} J^c_{P_0,a,h}(\pi) = {} & \pi z_h y_g + (1-\pi) z_h y_b - w_{P_0,a,h}(\pi) + \beta\lambda (V - d) \\ & + \beta(1-\lambda)\alpha_h \pi \big[\rho J_{P,a+1,h'}(1) + (1-\rho) J_{P,a+1,h}(1)\big] \\ & + \beta(1-\lambda)\alpha_h (1-\pi) \big[\rho J_{P,a+1,h'}(0) + (1-\rho) J_{P,a+1,h}(0)\big] \\ & + \beta(1-\lambda)(1-\alpha_h) \big[\rho J_{P,a+1,h'}(\pi) + (1-\rho) J_{P,a+1,h}(\pi)\big] \end{aligned}$$

where $h' \equiv \min\{h+1, H\}$ indexes the accumulation of human capital to the next level. Recall that a permanent contract cannot be downgraded to a temporary one, so a permanent contract will remain permanent until it is dissolved. The revelation about match quality has the same interpretation as it did with the temporary contracts.

Finally, the value to the firm of a continuing permanent contract is:

$$J_{P,a,h}(\pi) = \max\{J^c_{P,a,h}(\pi), V - d\}$$

where the continuation value is given by:

$$\begin{aligned} J^c_{P,a,h}(\pi) = \pi z_h y_g + (1-\pi) z_h y_b - w_{P,a,h}(\pi) + \beta\lambda(V-d) \\ + \beta(1-\lambda)\alpha_h \pi\big[\rho J_{P,a+1,h'}(1) + (1-\rho) J_{P,a+1,h}(1)\big] \\ + \beta(1-\lambda)\alpha_h(1-\pi)\big[\rho J_{P,a+1,h'}(0) + (1-\rho) J_{P,a+1,h}(0)\big] \\ + \beta(1-\lambda)(1-\alpha_h)\big[\rho J_{P,a+1,h'}(\pi) + (1-\rho) J_{P,a+1,h}(\pi)\big] \end{aligned}$$

The only difference between a new and a continuing permanent contract is the wage and the inability to avoid the firing cost after being together after one period. The value to the firm with an exiting worker is:

$$\begin{aligned} J_{T,N+1,h}(\pi) = J_{P_0,N+1,h}(\pi) = V \\ J_{P,N+1,h}(\pi) = V - d \end{aligned}$$

for all $\pi \in [0,1]$ and $h \in \{1,\dots,H\}$.

Workers

As is standard in search and matching models, wages are assumed to be the result of generalized Nash bargaining with workers having the bargaining parameter $\mu \in [0,1]$. However, I make the additional assumption that there is a minimum wage $\bar{w}$ present in the economy. As in Pries and Rogerson (2005) and Faccini (2014), the wage is the result of generalized Nash bargaining whenever the minimum wage is non-binding and require that the worker receives *at least* the fraction μ of the match surplus. Thus, the worker receives exactly the fraction μ of the match surplus whenever the minimum wage is non-binding and possibly more whenever it is binding. When the wage is the result of generalized Nash bargaining, firms and workers never disagree about match formation and split the surplus whenever the match surplus is positive. However, in the presence of a minimum wage, this is no longer the case. It is now possible for the worker to prefer to be hired at the minimum wage $\bar{w}$ but the firm may not if the surplus generated by the match is sufficiently low. To put it another way, the surplus of a pair may be positive, but if the worker is being allocated *more* than the entire match surplus, the firm would be better off not hiring the worker at all. Since the hiring decision requires the consent of both the worker and the firm, it is sufficient to only consider the firm's decision. Therefore, in what follows, the workers simply take the firms' hiring decisions as given.

Unemployed workers search for jobs each period. The value of being unemployed for a worker aged a with skill level z_h, $U_{a,h}$, is

$$\begin{aligned} U_{a,h} &= b + \beta\big(1 - p(\theta)\big)U_{a+1,h} \\ &\quad + \beta p(\theta)\left[\phi \int_0^1 W_{T,a+1,h}(\pi)dF(\pi) + (1-\phi)\int_0^1 W_{P_0,a+1,h}(\pi)dF(\pi)\right] \end{aligned} \tag{4.2}$$

where b is the per-period value of being unemployed which can be viewed as the combination of unemployment benefits and the value of leisure. This flow value is independent of age or human capital.

A worker aged a with human capital level z_h being offered a temporary contract has the lifetime utility value of

$$W_{T,a,h}(\pi) = X_{T,a,h}(\pi)W^c_{T,a,h}(\pi) + (1 - X_{T,a,h}(\pi))U_{a,h}$$

where $X_{T,a,h}(\pi)$ is the firm's hiring rule, which is defined as

$$X_{T,a,h}(\pi) = \begin{cases} 1, & \text{if } J^c_{T,a,h}(\pi) \geq V \\ 0, & \text{otherwise} \end{cases}$$

The firm's hiring rules are the only real economic decisions being made in this model economy. Workers simply take these as given and only play a role during the bargaining process. The continuation value is given by:

$$\begin{aligned} W^c_{T,a,h}(\pi) &= w_{T,a,h}(\pi) + \beta\lambda U_{a+1,h} \\ &\quad + \beta(1-\lambda)\alpha_h\pi\big[\eta W_{P_0,a+1,h}(1) + (1-\eta)W_{T,a+1,h}(1)\big] \\ &\quad + \beta(1-\lambda)\alpha_h(1-\pi)\big[\eta W_{P_0,a+1,h}(0) + (1-\eta)W_{T,a+1,h}(0)\big] \\ &\quad + \beta(1-\lambda)(1-\alpha_h)\big[\eta W_{P_0,a+1,h}(\pi) + (1-\eta)W_{T,a+1,h}(\pi)\big] \end{aligned}$$

where $w_{T,a,h}(\pi)$, as in the firm's problem, is the wage paid to the worker.

The value to the worker of a new permanent contract with age a and human capital level z_h and with the prior π that the match is of the good type at the beginning of a period is:

$$W_{P_0,a,h}(\pi) = X_{P_0,a,h} W^c_{P_0,a,h}(\pi) + (1 - X_{P_0,a,h}) U_{a,h}$$

where $X_{P_0,a,h}(\pi)$ is the firm's hiring rule, which is defined as

$$X_{P_0,a,h}(\pi) = \begin{cases} 1, & \text{if } J^c_{P_0,a,h}(\pi) \geq V \\ 0, & \text{otherwise} \end{cases}$$

and the continuation value is given by:

$$\begin{aligned} W^c_{P_0,a,h}(\pi) = w_{P_0,a,h}(\pi) &+ \beta\lambda\big[\rho U_{a+1,h'} + (1-\rho)U_{a+1,h}\big] \\ &+ \beta(1-\lambda)\alpha_h \pi \big[\rho W_{P,a+1,h'}(1) + (1-\rho)W_{P,a+1,h}(1)\big] \\ &+ \beta(1-\lambda)\alpha_h (1-\pi)\big[\rho W_{P,a+1,h'}(0) + (1-\rho)W_{P,a+1,h}(0)\big] \\ &+ \beta(1-\lambda)(1-\alpha_h)\big[\rho W_{P,a+1,h'}(\pi) + (1-\rho)W_{P,a+1,h}(\pi)\big] \end{aligned}$$

where $h' \equiv \min\{h+1, H\}$ indexes the accumulation of human capital to the next level. It is important to take note that even if the worker is terminated for exogenous reasons next period, she still receives the human capital appreciation with probability ρ within the period.

Finally, the lifetime value to a worker with a continuing permanent contract is:

$$W_{P,a,h}(\pi) = X_{P,a,h} W^c_{P,a,h}(\pi) + (1 - X_{P,a,h}) U_{a,h}$$

where $X_{P_0,a,h}(\pi)$ is the firm's hiring rule, which is defined as

$$X_{P,a,h}(\pi) = \begin{cases} 1, & \text{if } J^c_{P,a,h}(\pi) \geq V - d \\ 0, & \text{otherwise} \end{cases}$$

and the continuation value is given by:

$$\begin{aligned} W^c_{P,a,h}(\pi) = w_{P,a,h}(\pi) &+ \beta\lambda\big[\rho U_{a+1,h'} + (1-\rho)U_{a+1,h}\big] \\ &+ \beta(1-\lambda)\alpha_h \pi \big[\rho W_{P,a+1,h'}(1) + (1-\rho)W_{P,a+1,h}(1)\big] \\ &+ \beta(1-\lambda)\alpha_h (1-\pi)\big[\rho W_{P,a+1,h'}(0) + (1-\rho)W_{P,a+1,h}(0)\big] \\ &+ \beta(1-\lambda)(1-\alpha_h)\big[\rho W_{P,a+1,h'}(\pi) + (1-\rho)W_{P,a+1,h}(\pi)\big] \end{aligned}$$

The only difference between a new and a continuing permanent contract, from the worker's perspective, is the potentially differing current period wages. The terminal conditions for the workers at the end of the life-cycle are:

$$U_{N+1,h} = W_{T,N+1,h}(\pi) = W_{P_0,N+1,h}(\pi) = W_{P,N+1,h}(\pi) = 0$$

for all $\pi \in [0,1]$ and $h \in \{1, \dots, H\}$.

4.3.3 Surplus and Wage Bargaining

As previously discussed, wages are set via Nash bargaining whenever the minimum wage doesn't bind. The surplus of a match is defined as:

$$\begin{aligned} S_{T,a,h}(\pi) &= J_{T,a,h}(\pi) + W_{T,a,h}(\pi) - U_{a,h} - V \\ S_{P_0,a,h}(\pi) &= J_{P_0,a,h}(\pi) + W_{P_0,a,h}(\pi) - U_{a,h} - V \\ S_{P,a,h}(\pi) &= J_{P,a,h}(\pi) + W_{P,a,h}(\pi) - U_{a,h} - (V - d) \end{aligned}$$

Since the firm makes the hiring decision unilaterally and the worker simply takes the firm's decision as given, the surplus of each match is $S_{i,a,h}(\pi) = X_{i,a,h}(\pi) S^c_{i,a,h}(\pi) \geq 0$ for a contract type i. Again, it is sufficient only to consider the firm's problem since the worker would always receive *at least* a fraction μ of the surplus and would be willing to work whenever the surplus has positive value. It can be shown by starting from the terminal conditions and iterating backwards that the surplus is increasing in the prior π since π has no influence on either the firm or worker's outside option. However, the surplus will, in general, not be continuous in π. Thus, the firm's hiring decisions will display the usual cutoff rules for a given contract type, age, and human capital stock. Firms will hire any worker with a prior π above the cutoff rule. The value the worker receives from a match of contract type i is:

$$W_{i,a,h}(\pi) - U_{a,h} \geq \mu S_{i,a,h}(\pi)$$

which holds with equality any time the minimum wage is non-binding. The wage function is $w_{i,a,h}(\pi) = \max\{\bar{w}, w^n_{i,a,h}(\pi)\}$, where the second element in the max operator is the wage determined by generalized Nash bargaining. We can now define a steady-state equilibrium in this environment.

4.3.4 Equilibrium

Given the initial stocks of employed and unemployed and the terminal conditions of the value functions, a *steady-state equilibrium* in this economy is a set $\{W_{i,a,h}(\pi), U_{a,h}, J_{i,a,h}(\pi), V, X_{i,a,h}(\pi), w_{i,a,h}(\pi), e_{i,a,h}(\pi), u_{a,h}, \theta\}$ for all $i \in \{T, P_0, P\}$, $a \in \{1, \ldots, N\}$, $h \in \{1, \ldots, H\}$, and $\pi \in [0, 1]$, such that the following conditions hold:

1. Given $w_{i,a,h}$ and θ, the value functions satisfy the agents' problems above;
2. Given $w_{i,a,h}$ and θ, $X_{i,a,h}(\pi)$ is the firm's optimal decision rule;
3. $w_{i,a,h} = \max \left\{\bar{w}, w^n_{i,a,h}\right\}$, where $w^n_{i,a,h}$ is the result of Nash bargaining;
4. The free entry condition is satisfied, $V = 0$;
5. The probabilities of finding a worker/firm are consistent with the matching function;
6. The flows $e_{i,a,h}(\pi)$ and $u_{a,h}$ are consistent with the firm's hiring rules.

Since each entering cohort is normalized to unity, the measure of the employed and unemployed in each age group a is:

$$1 = \sum_{h=1}^{H} \left(u_{a,h} + \sum_{i \in \{T, P_0, P\}} \int_0^1 e_{i,a,h}(\pi) d\pi \right)$$

As noted in Esteban-Pretel and Fujimoto (2014), in life-cycle search models with a single labor market, one cannot generally prove that there is a unique equilibrium because the value of meeting a worker in the free-entry condition may not be monotonic in market-tightness, θ. However, Hahn (2009) has argued that multiple equilibria is unlikely for a sufficiently high bargaining power. I choose a high value for μ in the calibration below and verify numerically that the equilibrium is unique by checking the free-entry condition around reasonable ranges for θ.

4.4 Calibration

I calibrate the model economy to match a number of key facts about the Italian economy prior to the first major set of reforms to temporary contracts (Treu reforms) in 1997. I then explore what the effects of increasing access to temporary contracts via the policy parameter ϕ in Section 4.5.

A model period is taken to be a quarter. I assume that individuals enter the labor market one period before they turn 20 years old. This way, all workers who are initially matched after entry will be at least 20 years of age. Workers are active in the labor market until they turn 65, at which point, they exit the labor market exogenously. Therefore, the number of quarters (including those aged 19.75) a worker is active is $N = 181$. I assume an annual interest rate of 4%, which implies a quarterly discount factor of $\beta = 0.99$. To keep the model as parsimonious as possible, I assume that there are only two experience/human capital levels, $H = 2$.

I anchor all the production technologies around a match of the lowest quality with a worker having the initial level of human capital. That is, the bad match quality and the initial level of experience are each normalized to unity, $y_b = z_1 = 1$. I also make the assumption that a good quality match is twice as productive as a bad one, $y_g = 2$. The probability a match is revealed when the worker has experience level z_1 is then $\alpha_1 = (y_g - y_b)z_1/2\bar{\varepsilon} = 1/2\bar{\varepsilon}$. Assuming that the worst match combination is revealed, on average, after observing output for a year, we have $\alpha_1 = 0.25$ which implies that $\bar{\varepsilon} = 2$.

The firing costs d are taken to be a year's worth of expected output of the worst match combination (those with y_b and z_1), giving $d = 4$. It will be shown later that this level of d is consistent with the values estimated by Garibaldi and Violante (2005). While most studies are able to pin the unemployment benefits and leisure values to the elasticity of unemployment with respect to b theoretically, in this model we cannot determine what the average wage will be prior to simulating the model. However, to ensure that the worst combination matches which are revealed are destroyed in equilibrium on both temporary contracts and new permanent contracts, it is sufficient to assume that $b > z_1 y_b = 1$. I take a conservative value of the unemployment benefits/value of leisure to be $b = 1.05$. As will be shown later, after the model is calibrated, this implies a replacement ratio to the average wage of 0.36. Since Italy is characterized by one of the lowest net unemployment benefit ratios in the OECD, averaging 0.23 between 2001-2011, this value is not drastically different from what one might expect to observe.

There is no national minimum wage in Italy. However, there are minimum wages which are set in sectoral collective agreements within the economy that broadly apply to many outside the agreements themselves. Dolado *et al.* (1996) reports a ratio of 0.71 in 1991 for the minimum wage resulting from these collective agreements compared to the national average wage. Again, while I cannot pin down the average wage before simulating the model, I assume the minimum wage is close to the value of unemployment benefits and leisure and set $\bar{w} = 1.15$. After calibration, this implies a ratio of 0.39, far below the 0.71 reported by Dolado *et al.* (1996). Despite this number being off for the mean wage, compared to the median wage in the simulations, this ratio rises to 0.59. While the model comes up short along this dimension in relation to the average wage, a higher minimum wage will only serve to reinforce my main result.

I assume the matching function is Cobb-Douglas and takes the functional form: $M(u, v) = Au^{\delta}v^{(1-\delta)}$. I calibrate A to match the job-finding rate reported by Elsby *et al.* (2013), as is noted below, and take the worker's bargaining power to be the same as the elasticity of the matching function with respect to unemployment, $\mu = \delta = 0.8$, which seems relatively high compared to the findings reported in Petrongolo and Pissarides (2001). However, since not all matches will result in hires in this model, this is not inconsistent with their findings and the 0.8 assumed will in fact be an upper bound of the elasticity of *hires* with respect to unemployment.

The remaining eight parameters are determined endogenously from a set of targets taken from Italian data over the period 1993-1997. The coefficient of the matching function, A, and the exogenous destruction rate, λ, are calibrated to match the average quarterly job-finding rate and separation rate for Italy as reported by Elsby *et al.* (2013) over 1993-1997. The probability of initially being offered a temporary contract after being matched, ϕ, and the probability a temporary contract is not renewed, η, are calibrated to match the five year average incidence of temporary employment for the youth and for prime aged workers over the period 1993-1997. The highest experience level, z_2, and the probability of gaining experience while employed on a permanent contract, ρ, are calibrated to match the average net earnings ratios for both the 90-10 and the 50-10 deciles for Italy for 1993 and 1995. Similar to Pries and Rogerson (2005) and Faccini (2014), the distribution of priors, $F(\pi)$, is obtained from a normal with mean zero and standard deviation σ which is then truncated to the support $[0, 1]$ and rescaled to integrate to one. The parameter σ is calibrated to match the average youth unemployment rate and the prime unemployment rate over the period 1993-1997. I also attempt to match the raw wage gap between temporary and permanent workers in Italy in 1997 of 0.72 as reported by the OECD (2002). Normalizing $\theta = 1$ for the benchmark case allows us to pin down the vacancy posting cost κ from the free-entry condition once all the value functions are determined. To summarize, the targets and their resulting model outcomes are shown in Table 4.2.

Targets	**Source**	**Data**	**Model**
Youth unemployment rate	Eurostat	0.222	0.260
Prime unemployment rate	Eurostat	0.065	0.070
Youth incidence of temporary contracts	Eurostat	0.097	0.103
Prime incidence of temporary contracts	Eurostat	0.035	0.035
Job-finding rate	Elsby *et al.* (2013)	0.109	0.133
Separation rate	Elsby *et al.* (2013)	0.014	0.012
Wage gap	OECD	0.720	0.759
90-10 net earnings ratio	OECD	2.370	2.483
50-10 net earnings ratio	OECD	1.518	1.024

Table 4.2: Targets and Model Outcomes

It should be noted that it is difficult to generate the earnings ratio for both the 90-10 and the 50-10 simultaneously when there are only two human capital states, especially when the state is an absorbing one. The 90-10 ratio tempers the human capital accumulation. If people jump to the most experienced state too quickly in the life-cycle, there is virtually no earnings spread in the distribution of wages. Thus, I can have a much higher accumulation of human capital, but it will substantially miss the 90-10 earnings target. It is also difficult to match the youth unemployment rate while also matching the overall job-finding rate. Since everyone (at age 19.75) starts as unemployed, matching the youth rate of 22.2% observed in the data requires people to find jobs too quickly, so there is a trade-off when attempting to match both the youth unemployment rate and the overall job-finding rate. Despite these tensions, the baseline targets are matched reasonably well with the exception of the 50-10 ratio. The resulting baseline parameters are shown in Table 4.3.

Returning to the assumption regarding the dismissal cost, d, Garibaldi and Violante (2005) estimate an *ex ante* firing tax of 3.5 months of average wages for Italy. The

Exogenous Parameters		
Discount Factor	β	0.99
Productivity of low-skilled worker	z_1	1
Productivity of bad-quality match	y_b	1
Productivity of good-quality match	y_g	2
Uniform noise range	$\bar{\varepsilon}$	2
Worker's bargaining power	μ	0.8
Elasticity of matching function w.r.t. unemployment	δ	0.8
Value of leisure/Unemployment benefits	b	1.05
Minimum wage	$\bar{w}$	1.15
Dismissal cost	d	4
Endogenous Parameters		
Scale of matching function	A	0.431
Productivity of high-skilled worker	z_2	2.408
Standard deviation of the truncated normal	σ	1.546
Exogenous separation rate	λ	0.008
Probability of human capital accumulation	ρ	0.007
Probability of non-renewal	η	0.056
Probability of being offered a temporary contract	ϕ	0.138
Vacancy posting cost	κ	0.155

Table 4.3: Calibrated Parameter Values

dismissal costs relative to the model generated average wage is 1.37, which implies that the firing cost in the model is 4.1 months worth of the average wage, which is in line with their estimate, lending support for my assumption on the level of the dismissal cost.

4.5 Results

I now present the results of the calibration exercise and later show the implications of increasing access to temporary contracts through the policy parameter ϕ. Figure 4.4 shows the firm's hiring rules for the baseline results. The worker's age is on the x-axis and the prior probability, π, that the match is of the good type is on the y-axis. The firm will hire any worker with a prior above the lines shown for a particular age and contract type. That is $X_{i,a,h} = 1$, for all π's above the lines shown for a given contract type with a worker aged a and with human capital h. The high-skilled cutoffs are shown in the right panel.

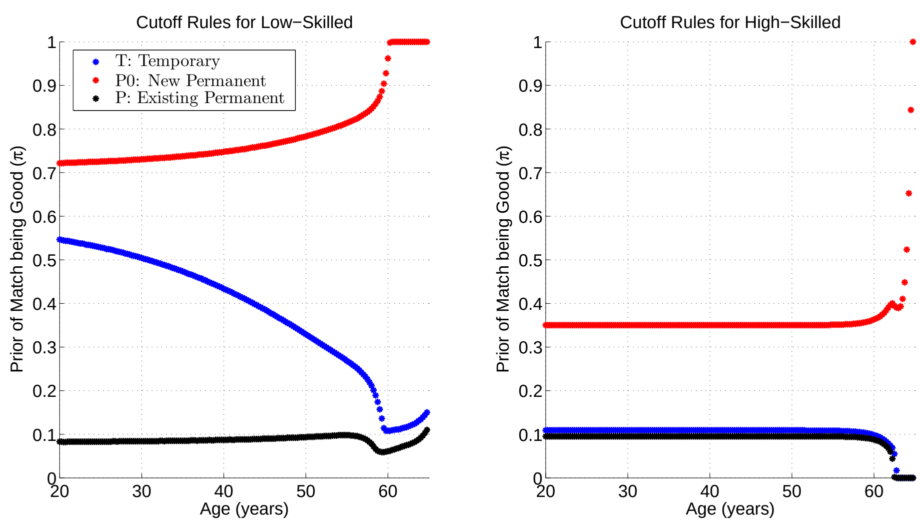

Figure 4.4: Firm's Cutoff Rules

The firm is most selective whenever it offers a new permanent contract (P_0) to a low-skilled worker. This is rather intuitive. Since the firm knows that it will incur the dismissal cost d at some point if it hires a worker on a permanent contract, it prefers to be fairly certain that the match is good. However, if the worker is high-skilled, the firm is much less selective and is more willing to play the odds because of the large benefits of being in a good match with the highest skilled worker. The cutoff rules for existing permanent contracts (P) merely indicate that firms will separate with workers that are revealed to be the bad type since the cutoff rules for the existing permanent contracts are always less than the cutoff rules for new permanent contracts. That is, since the prior π never changes as long as the match exists and is not revealed, if a π makes it through the filter of a new permanent contract, the match will continue unless it is destroyed for exogenous reasons or if the match is revealed to be bad. In this sense, the only interesting decision rules to consider are those for new permanent and temporary contracts.

With a temporary contract (T), a firm is less selective in its hiring practices because it can costlessly separate from the worker if the match turns out to be the bad type. This represents the screening motive for temporary positions. All matches that are not revealed and have priors between the cutoff rules for temporary and new permanent hires (those priors between the red and blue lines) will not be upgraded to new permanent contracts. The firm will endogenously separate from the worker in these instances. The difference between these cutoffs becomes larger as a worker progresses through the life-cycle. This phenomenon is due to the horizon effect as discussed in Chéron *et al.* (2013). As workers age, the value of being unemployed decreases monotonically since they have a shorter work horizon and fewer chances, if they are low-skilled, to be upgraded to the higher human capital level. Firms will be more willing to offer temporary contracts to older workers since workers' outside option, the value of being unemployed, is decreasing with age, giving the firm a stronger bargaining position.

Unlike the case with temporary positions, firms will be more selective when they have to offer a new permanent contract to older workers. Firms will not be able to be matched long enough with an older worker to offset any dismissal costs. The minimum wage prevents the firm from sharing this sunk cost with the worker upon meeting. Very late in the life-cycle, not even matches that have been revealed to be good will be hired in permanent positions because the minimum wage becomes higher than the match surplus itself. To summarize, firms are most willing to offer a new permanent contract to younger workers with relatively high priors π. Firms prefer younger workers on new permanent contracts because they have time to infer whether the match quality is good or not and have more periods to benefit from the relationship.

Figure 4.5 shows the job-finding and separation rates for each age group. While the separation rate delivers a reasonable profile, the job-finding rate is initially increasing in age, which is counterfactual. Older unemployed workers can find jobs easier because the cutoff rules for temporary contracts decreases faster than the cutoff rules increase on new permanent contracts. Additionally, older unemployed workers are more likely to have achieved a higher human capital level.

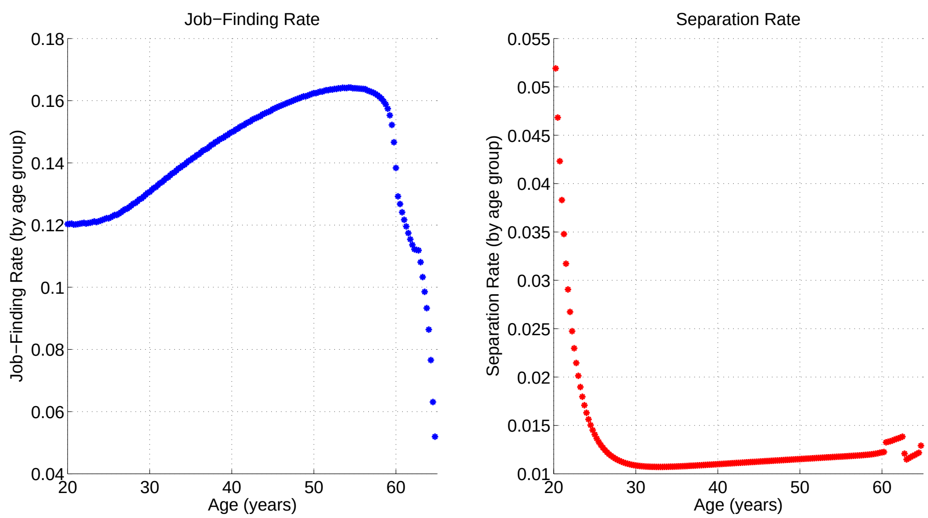

Figure 4.5: Job-Finding and Separation Rates

I now take the baseline parametrization and evaluate the implications of increasing access to temporary contracts in the model economy. The main policy instrument that changed in Italy between 1997 and 2004 were the restrictions imposed on temporary contracts. In the model, this reform is captured in a reduced form way by the parameter ϕ. For a given change in ϕ, the economy's market-tightness must adjust in order to satisfy the free-entry condition, which, in turn, will affect the value functions of firms and workers. The overall impact on each age group's unemployment rate is shown in Figure 4.6 and demonstrates that a reform increasing access to temporary forms of employment decreases the unemployment rates for all age groups. Figure 4.6 also shows the incidence of temporary employment, capturing the decreasing incidence of temporary contracts. There is a slight uptick for both near the end of the life-cycle when firms cease upgrading and hiring workers to permanent positions.

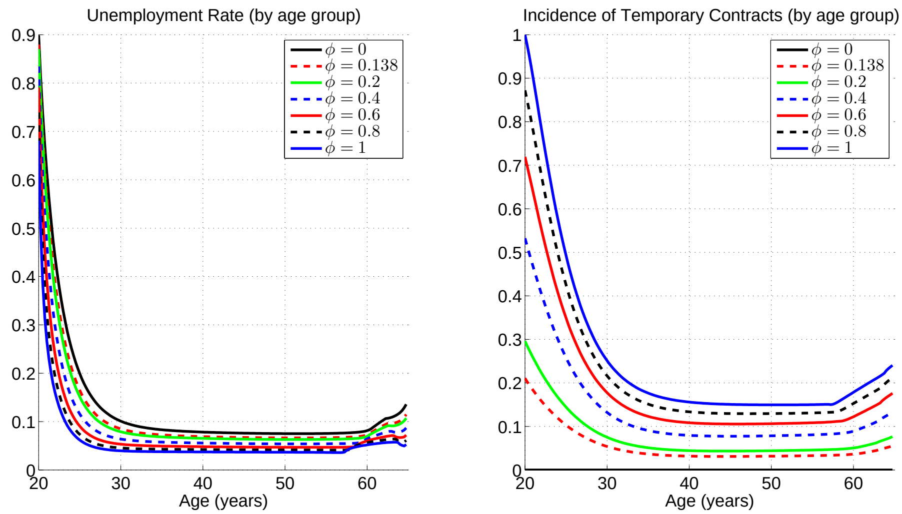

Figure 4.6: Unemployment and the Incidence of Temporary Employment

The primary focus of this paper is on how two-tier labor market reforms impact *workers'* welfare of different ages. I measure an age group's welfare as the sum of the value functions of each worker and of each unemployed worker within a cohort. This is:

$$\text{Welfare}_a = \sum_{h=1}^{H} u_{a,h} U_{a,h} +$$
$$\sum_{h=1}^{H} \int_0^1 \Big[e_{T,a,h}(\pi) W_{T,a,h}(\pi) + e_{P_0,a,h}(\pi) W_{P_0,a,h}(\pi) + e_{P,a,h}(\pi) W_{P,a,h}(\pi) \Big] d\pi$$

Since each cohort has measure one, the within cohort welfare is simply a weighted average of the expected net present value lifetime utilities of all workers and unemployed aged a.

A set of summary statistics comparing the steady-state outcomes is shown in Table 4.4. In the baseline parameterization, firms prefer to offer temporary contracts to low-skilled workers, so increasing firms' ability to offer such contracts will increase the value of a vacancy. As a result, the number of vacancies will increase up to the point in which the value of a vacancy returns to zero. Therefore, as ϕ increases, the job-meeting rate will increase as well. Since the job-meeting rate applies to workers of all ages, workers in all age groups are more likely to be interviewed by a firm. Compared to the baseline calibration, the cutoff rules for younger workers actually decrease for all contract types, pushing unemployment down for all ages.

Despite the lower unemployment rate for all age groups, workers are worse off relative to the benchmark economy when temporary contracting increases, as can be seen in Figure 4.7 and as reported is Table 4.4. Workers effectively become 'trapped' in temporary positions early in the life-cycle and cannot quickly upgrade their human capital. Indeed, since the probability a temporary contract must be upgraded, η is only 0.056, many young workers will not transition to permanent positions rapidly. The value of being unemployed at the lowest skill level is also lower, decreasing the bargaining positions of unskilled workers.

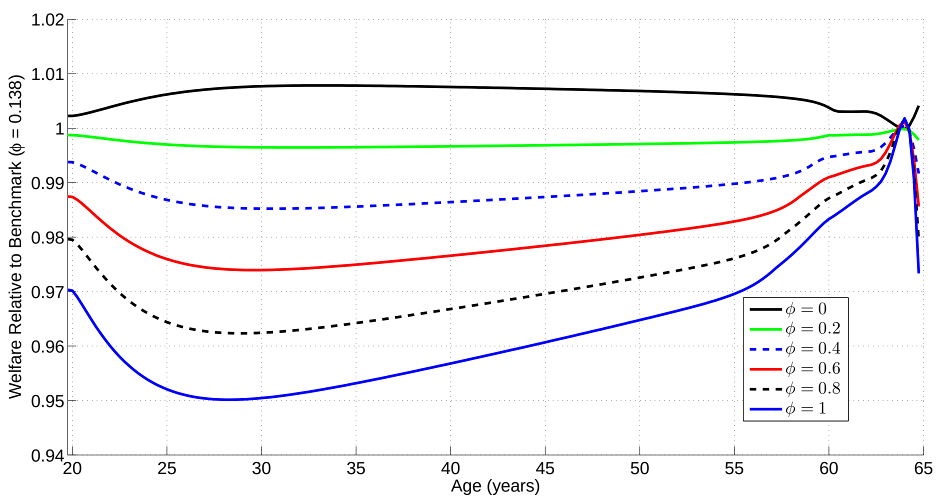

Figure 4.7: Welfare Relative to the Benchmark Economy

The amount of separations increases as ϕ increases. Even though the firm is less selective overall, more people will be separated endogenously because the cutoff rules for the temporary contracts decreases more than the cutoff rule for entry into permanent positions, increasing the total amount of separations within each age group. These results are in agreement with the argument put forward in Blanchard and Landier (2002) that the increased turnover in France seems to have had a negative impact on workers' welfare. In the model I have presented, this is due not only to turnover, but also to the opportunity cost of the inability to upgrade skill set early in the life-cycle. Workers' ability to enjoy the benefits of a long, productive career in a good permanent match are inhibited when they cannot quickly transition to permanent positions early in their careers.

4.6 Conclusion

In a number of European countries, the fraction of young people with temporary jobs and the youth unemployment rate are quite high. Many new labor market entrants in Europe pass through a spell of temporary employment before they transition to permanent positions that are protected by strict EPL. This paper's primary goal was to examine the role of dual labor markets and how two-tier labor market reforms affect the employment prospects for labor market entrants. To achieve this, the paper presented a search and matching model with dual labor markets, overlapping generations of workers, and general and match-specific skills. The model was calibrated to match the pre-reform economy of Italy. When access to temporary contracts increases, firms will be less selective in their hiring practices and the job-finding rate will increase, decreasing the unemployment rate for all age groups. Despite the increased likelihood of being employed, younger workers, as a group, will be worse off due to a greater share of workers starting their careers in low-paying temporary positions, limiting young workers' ability to upgrade their skill level early in the life-cycle. This complements the findings of Blanchard and Landier (2002) who have concluded that partial labor reforms may lead to higher turnover and lower welfare. Future work should take the life-cycle into account when examining two-tier labor market reforms since reforms may have a negative impact on worker's career prospects early in their life-cycle.

	Data	Benchmark $\phi = 0.138$	$\phi = 0.0$	$\phi = 0.2$	$\phi = 0.4$	$\phi = 0.6$	$\phi = 0.8$	$\phi = 1.0$
Youth unemployment rate	0.222	0.260	0.294	0.246	0.205	0.172	0.145	0.123
Prime unemployment rate	0.065	0.070	0.080	0.066	0.056	0.048	0.042	0.037
Youth incidence of temp	0.097	0.103	–	0.145	0.263	0.362	0.448	0.524
Prime incidence of temp	0.035	0.035	–	0.048	0.086	0.116	0.142	0.165
Job-finding rate	0.109	0.133	0.108	0.145	0.187	0.234	0.287	0.346
Separation rate	0.014	0.012	0.011	0.013	0.014	0.016	0.017	0.018
Wage gap	0.720	0.759	–	0.762	0.770	0.776	0.780	0.782
90-10 net earnings ratio	2.370	2.483	2.438	2.503	2.519	2.508	2.509	2.513
50-10 net earnings ratio	1.518	1.025	1.008	1.031	1.034	1.025	1.022	1.019
Relative to Benchmark								
Average wage	–	–	1.018	0.995	0.975	0.958	0.942	0.928
Workers' welfare gain (%)	–	–	0.66	-0.30	-1.24	-2.17	-3.12	-4.11
Youth welfare gain (%)	–	–	0.57	-0.27	-1.21	-2.22	-3.31	-4.50
Prime welfare gain (%)	–	–	0.74	-0.32	-1.32	-2.28	-3.23	-4.20

Table 4.4: Summary of Model Outcomes

Bibliography

[1] Alonso-Borrego, C., Fernandez-Villaverde, J. and Galdon-Sanchez, J. (2005). Evaluating labour market reforms: a general equilibrium approach. Working Paper No. 11519, NBER.

[2] Andolfatto, D. (1996). Business cycles and labor-market search. *American Economic Review*, 86(1), pp. 112-132.

[3] Barnichon, R. (2010). Building a composite help-wanted index. *Economics Letters*, 109(3), pp. 175-178.

[4] Bentolila, S. and Bertola, G. (1990). Firing costs and labour demand: how bad is Eurosclerosis?. *Review of Economic Studies*, 57(3), pp. 381-402.

[5] Bentolila, S. and Saint-Paul, G. (1992). The macroeconomic impact of flexible labour contracts, with an application to Spain. *European Economic Review*, 36(5), pp. 1013-1053.

[6] Bernanke, B. and Gertler, M. (1989). Agency costs, net worth, and business fluctuations. *American Economic Review*, 79(1), pp. 14-31.

[7] Blanchard, O. and Landier, A. (2002). The perverse effect of partial labour market reforms: fixed duration contracts in France. *Economic Journal*, 112(480), pp. F214-F244.

[8] Boeri, T. (2011). Institutional reforms and dualism in european labor markets. *Handbook of Labor Economics*, Elsevier.

[9] Boeri, T. and Garibaldi, P. (2007). Two tier reforms of employment protection: a honeymoon effect?. *Economic Journal*, 117(521), pp. 357-385.

[10] Boeri, T. and van Ours, J. (2013). *The Economics of Imperfect Labor Markets*, 2nd Edition,Princeton, NJ: Princeton University Press.

[11] Cahuc, P. and Postel-Vinay, F. (2002). Temporary jobs, employment protection and labour market performance. *Labour Economics*, 9(1), pp. 63-91.

[12] Chéron, A. and Langot, F. (2004). Labor market search and real business cycles: reconciling Nash bargaining with the real wage dynamics. *Review of Economic Dynamics*, 7(2), pp. 476-493.

[13] Chéron, A., Hairault, J. and Langot, F. (2013). Life-cycle equilibrium unemployment. *Journal of Labor Economics*, 31(4), pp. 843-882.

[14] Choi, S. and Rios-Rull, J. (2009). Understanding the dynamics of labor share: the role of noncompetitive factor prices. *Annales d'Economie et Statistique*, No. 95/96.

[15] Christiano, L. and Fitzgerald, T. (2003). The band pass filter. *International Economic Review*, 44(2), pp. 435-465.

[16] Chugh, S. (2009). Costly external finance and labor market dynamics. Working paper.

[17] Dolado, J., Kramarz, F., Machin, S., Manning, A., Margolis, D. and Teulings, C. (1996). The economic impact of minimum wages in Europe. *Economic Policy*, 11(23), pp. 317-372.

[18] Elsby, M., Hobijn, B. and Sahin, A. (2013). Unemployment dynamics in the OECD. *Review of Economics and Statistics*, 95(2), pp. 530-548.

[19] Elsby, M., Michaels, R. and Solon, G. (2009). The ins and outs of cyclical unemployment. *American Economic Journal: Macroeconomics*, 1(1), pp. 84-110.

[20] Esteban-Pretel, J. and Fujimoto, J. (2014). Life-cycle labor search with stochastic match quality. *International Economic Review*, 55(2), pp. 575-599.

[21] European Commission (2009). *Employment in Europe 2009*, Brussels.

[22] European Commission (2010). *Employment in Europe 2010*, Brussels.

[23] Faccini R. (2014). Reassessing labour market reforms: temporary contracts as a screening device. *Economic Journal*, 124(574), pp. F167-F200.

[24] Fujita, S. and Ramey, G. (2009). The cyclicality of separation and job finding rates. *International Economic Review*, 50(2), pp. 415-430.

[25] Fujita, S. and Ramey, G. (2012). Exogenous versus endogenous separation. *American Economic Journal: Macroeconomics*, 4(4), pp. 68-93.

[26] Garibaldi, P. (1998). Job flow dynamics and firing restrictions. *European Economic Review*, 42(2), pp. 245-275.

[27] Garibaldi, P. and Taddei, F. (2013). Italy: A dual labour market in transition. ILO Employment Working Paper No. 144.

[28] Garibaldi, P. and Violante, G. (2005). The employment effects of severance payments with wage rigidities. *Economic Journal*, 115(506), pp. 799-832.

[29] Garin, J. (2012). Borrowing constraints, collateral fluctuations, and the labor market. Working paper.

[30] Gorry, A. (2011). Experience and worker flows. Mimeo, University of California, Santa Cruz.

[31] Hagedorn, M. and Manovskii, I. (2008). The cyclical behavior of equilibrium unemployment and vacancies revisitied. *American Economic Review*, 98(4), pp. 1692-1706.

[32] Hahn, V. (2009). Search, unemployment, and age. *Journal of Economic Dynamics and Control*, 33(6), pp. 1361-1378.

[33] Hall, R. (2004). The labor market is key to understanding the business cycle. Stanford Mimeo, September 23.

[34] Hall, R. (2005). Employment efficiency and sticky wages: evidence from flows in the labor market. *Review of Economics and Statistics*, 87(3), pp. 397-407.

[35] Hobijn, B. and Sahin, A. (2009). Job-finding and separation rates in the OECD. *Economic Letters*, 104(3), pp. 107-111.

[36] Hopenhayn, H. and Rogerson, R. (1993). Job turnover and policy evaluation: a general equilibrium analysis. *Journal of Political Economy*, 101(5), pp. 915-938.

[37] Jermann, U. and Quadrini, V. (2012). Macroeconomic effects of financial shocks. *American Economic Review*, 102(1), pp. 238-271.

[38] Kiyotaki, N. and Moore, J. (1997). Credit cycles. *Journal or Political Economy*, 105(2), pp. 211-248.

[39] MaCurdy, T. (1981). An empirical model of labour supply in a life cycle setting. *Journal of Political Economy*, 89(61), pp. 1059-1085.

[40] Menzio, G., Telyukova, I. and Visschers, L. (2012). Directed search over the life cycle. PIER Working Paper Archive 12-002, Penn Institute for Economic Research, University of Pennsylvania.

[41] Merz, M. (1995). Search in the labor market and real business cycle. *Journal or Monetary Economics*, 36(2), pp. 269-300.

[42] Messina, J. and Vallanti, G. (2007). Job flow dynamics and firing restrictions: evidence from Europe. *Economic Journal*, 117(521), pp. F279-F301.

[43] Monacelli, T., Quadrini, V. and Trigari, A. (2012). Financial markets and unemployment. NBER Working Paper No. 17389.

[44] Mortensen, D. and Pissarides, C. (1994). Job creation and job destruction in the theory of unemployment. *Review of Economic Studies*. 61(3), pp. 397-415.

[45] Nakajima, M. (2012). Business cycles in the equilibrium model of labor market search and self-insurance. *International Economic Review*, 53(2), pp. 399-432.

[46] OECD (2002). *Employment Outlook*, Paris: OECD.

[47] OECD (2008). *Employment Outlook*, Paris: OECD.

[48] Perez, E. and Yao, Y. (2015). Can institutional reform reduce job destruction and unemployment duration? Yes it can. *Empirical Economics*. pp 1-23.

[49] Perri, F. and Quadrini, V. (2012). International recessions. NBER Working Paper No. 17201.

[50] Petrongolo, B. and Pissarides, C. (2001). Looking into the black box: a survey of the matching function. *Journal of Economic Literature*, 39(2), pp. 390-431.

[51] Petrosky-Nadeau, N. (2011). Credit, vacancies and unemployment fluctuations. GSIA Working Paper 2009-E27.

[52] Petrosky-Nadeau, N. and Wasmer, E. (2013). The cyclical volatility of labor markets under frictional financial markets. *American Economic Journal: Macroeconomics*, 5(1), pp. 193-221.

[53] Pissarides, C. (2000). *Equilibrium Unemployment Theory*, 2nd Edition, Cambridge, MA: MIT Press.

[54] Pries, M. (2004). Persistence of employment fluctuations: a model of recurring job loss. *Review of Economic Studies*, 71(1), pp. 193-215.

[55] Pries, M. and Rogerson, R. (2005). Hiring policies, labour market institutions, and labour market flows. *Journal of Political Economy*, 113(4), pp. 811-39.

[56] Saint-Paul, G. (2000). *The Political Economy of Labor Market Institutions*. Oxford: Oxford University Press.

[57] Shimer, R. (2005). The cyclical behavior of equilibrium unemployment and vacancies. *American Economic Review*, 95(1), pp. 25-49.

[58] Shimer, R. (2012). Reassessing the ins and outs of unemployment. *Review of Economic Dynamics*, 15(2), pp. 127-148.

[59] Silva, J. and Toledo, M. (2009). Labor turnover costs and the cyclical behavior of vacancies and unemployment. *Macroeconomic Dynamics*, 13(1), pp. 76-96.

[60] Tealdi, C. (2011). Typical and atypical employment contracts: the case of Italy. MPRA working paper no. 39456, University Library of Munich, Germany.

Appendix A

Appendix to Chapter 2

A.1 Derivation of the Equilibrium Conditions

Households solve following dynamic programming problem.

$$V(S, s_H) = \max_{c, s', a'_H} \{u(c) + n\nu(1-h) + (1-n)\nu(1) + \beta E[V(S', s'_H)]\}$$

s.t.

$$\begin{aligned} c + \frac{a'_H}{1 + r(S)} + p(S)\, s' &= w(S, s_H)\, nh(S, s_H) + (1-n)b + a_H \\ &+ [p(S) + d(S)]\, s - T(S) \\ n' &= (1-\chi)n + \Psi(S)(1-n) \\ S' &= G(S),\ c \geq 0,\ \text{No-Ponzi condition} \end{aligned}$$

Let λ_H and π_H be the Lagrange multipliers on budget constraint and law of motion for employment respectively. Then, we have the following first order conditions:

$$\begin{array}{ll} [c] & u'(c) - \lambda_H = 0 \\ [s'] & \beta E[V'_s] - \lambda_H p = 0 \\ [a'_H] & \beta E[V'_{a'_H}] - \lambda_H \frac{1}{1+r} = 0 \end{array}$$

Also, from the envelope conditions we have

$$\begin{aligned} V_{a_H} &= \lambda_H \\ V_s &= \lambda_H (p + d) \end{aligned}$$

By combining the first order conditions and envelope conditions, we get the following the no-arbitrage condition between shares and bonds.

$$\begin{aligned} 1 &= E\left[m'(1+r)\right] \\ 1 &= E\left[m'\left(\frac{p'+d'}{p}\right)\right] \end{aligned}$$

where $m' = \beta u_c(c')/u_c(c)$ is the stochastic discount factor.

Now, the representative firm solves following problem.

$$J(S, s_F) = \max_{d,k',a'_F,v,n'} \{d + E[m'J(S', s'_F)]\}$$

s.t.

$$\begin{aligned} k' + a_F + \varphi(d, d_-) &= F(z, k, nh(S, s_F)) + (1-\delta)k \\ &\quad - w(S, s_F)\, nh(S, s_F) - c_v v + \frac{a'_F}{R(S)} \\ \xi\left(k' - \frac{a'_F}{1+r(S)}\right) &\geq F(z, k, nh(S, s_F)) \\ n' &= (1-\chi)n + \Phi(S)\, v \\ S' &= G(S),\ k', v \geq 0 \end{aligned}$$

Let λ, γ, and π be the Lagrange multipliers on the budget constraint, enforcement constraint, and law of motion for employment respectively. Then, we have the following first order conditions.

$$\begin{array}{cc} [d] & 1 + E[m'J'_{d_-}] - \lambda\varphi_d = 0 \\ [k'] & E[m'J'_k] - \lambda + \gamma\xi = 0 \\ [a'_F] & E[m'J'_{a_F}] + \lambda\frac{1}{1+r(1-\tau)} - \gamma\xi\frac{1}{1+r} = 0 \\ [v] & -\lambda c_v + \pi\Phi = 0 \\ [n'] & E[m'J'_n] = \pi \end{array}$$

Also, from the envelope conditions we have

$$\begin{aligned} J_k &= (\lambda - \gamma) F_k + (1-\delta)\lambda \\ J_{a_F} &= -\lambda \\ J_n &\equiv (\lambda - \gamma) z F_{nh} h - \lambda w h + (1-\chi) E[m'J'_n] \\ J_{d_-} &= -\lambda\varphi_{d_-} \end{aligned}$$

By combining the first order conditions and envelope conditions, we simply get the following first order conditions for the firm.

$$\begin{aligned}
1 - E[m'\lambda'\varphi'_{d_}] &= \lambda\varphi_d \\
\lambda c_v &= \Phi E\left[m' J'_n\right] \\
\lambda - \gamma\xi &= E\left[m'\left[\left(\lambda' - \gamma'\right)F'_k + (1-\delta)\,\lambda'\right]\right] \\
\lambda\,(1+r) - \gamma\xi R &= R\,(1+r)\,E\left[m'\lambda'\right]
\end{aligned}$$

where $R = 1 + r(1-\tau)$ is the *effective* gross interest rate.

A.2 Derivation of Nash Bargaining Solutions

Given the worker's bargaining weight $\mu \in (0,1)$, the wage and hours are solutions to the Nash bargaining problem:

$$(w,h) = \arg\max_{w,h} \left(\frac{V_n}{u_c}\right)^{\mu} (J_n)^{1-\mu}$$

The first order conditions for this problem are

$$[w] \quad \mu J_n = (1-\mu)\lambda(\tfrac{V_n}{u_c})$$

$$[h] \quad \begin{aligned}
\mu J_n\left(-\tfrac{v_{(1-h)}(1-h)}{u_c} + w\right) &= -(1-\mu)\tfrac{V_n}{u_c}((\lambda-\gamma)F_{nh} - \lambda w) \\
(1-\mu)\left(\tfrac{V_n}{u_c}\right)\left(-\tfrac{v_{(1-h)}(1-h)}{u_c} + w\right) &= -(1-\mu)\left(\tfrac{V_n}{u_c}\right)((\lambda-\gamma)F_{nh} - \lambda w) \\
\left(-\tfrac{v_{(1-h)}(1-h)}{u_c} + w\right) &= -(1-\tfrac{\gamma}{\lambda})F_{nh} + w \\
\tfrac{v_{(1-h)}(1-h)}{u_c} &= \left(1-\tfrac{\gamma}{\lambda}\right)F_{nh}
\end{aligned}$$

The equilibrium wage bill can be derived from the sharing rule and the definition of $\frac{V_n}{u_c}$ and J_n.

$$\mu J_n = (1-\mu)\lambda\left(\frac{V_n}{u_c}\right)$$

$$\mu\Bigg((\lambda-\gamma)F_{nh}h - \lambda wh + (1-\chi)E[m'J'_n]\Bigg) =$$
$$(1-\mu)\lambda\left(\frac{v(1-h)-v(1)}{u_c} + (wh-b) + (1-\chi-\Psi)E\left[\beta\frac{V'_n}{u_c}\right]\right)$$

$$
\begin{aligned}
wh &= \mu\left(\left(1-\frac{\gamma}{\lambda}\right)F_{nh}h\right)+(1-\mu)\left(\frac{v(1)-v(1-h)}{u_c}+b\right)\\
&\quad +\mu(1-\chi)E\left[m'\frac{J_n'}{\lambda}\right]-(1-\mu)(1-\chi-\Psi)E\left[\beta\frac{V_n'}{u_c}\right]\\
&= \mu\left(\left(1-\frac{\gamma}{\lambda}\right)F_{nh}h\right)+(1-\mu)\left(\frac{v(1)-v(1-h)}{u_c}+b\right)\\
&\quad +\mu(1-\chi)E\left[m'\frac{J_n'}{\lambda}\right]+\mu\Psi E\left[m'\frac{J_n'}{\lambda'}\right]-(1-\mu)(1-\chi)E\left[\beta\frac{V_n'}{u_c}\right]
\end{aligned}
$$

Using the sharing rule $\mu J_n = \lambda(1-\mu)(V_n/u_c)$ and $F_{nh}h = F_n$, along with the definition of V_n/u_c and J_n, gives the wage bill per worker:

$$
\begin{aligned}
wh &= \mu\left[\left(1-\frac{\gamma}{\lambda}\right)F_n+(1-\chi)E\left[m'\frac{J_n'}{\lambda}\right]+\frac{V}{1-N}\Phi E\left[m'\frac{J_n'}{\lambda'}\right]\right]\\
&\quad +(1-\mu)\left[\frac{\nu(1)-\nu(1-h)}{u_c}+b-(1-\chi)E\left[\beta\frac{V_n'}{u_c}\right]\right]
\end{aligned}
\tag{A.1}
$$

A.3 Data

Data for Employment, Average Weekly Hours Worked, and the Labor Force are taken from the Bureau of Labor Statistics. Total GDP and business GDP are taken from the National Income and Product Accounts (NIPA) published by the Bureau of Economics Analysis. Real wages are defined as labor compensation plus labor's share of proprietors income deflated by the GDP deflator and divided by total hours (employment multiplied by average weekly hours). Labor productivity is defined as total GDP divided by total hours. Vacancies are constructed using the Conference Board's Help-Wanted Index and the composite Help-Wanted Index by Barnichon (2010).

Equity Payouts and Debt Repurchases are taken from the Flow of Funds published by the Federal Reserve Board. Equity Payouts are defined as Net dividends of nonfinancial business minus Net increase in corporate equities of nonfinancial business minus Proprietors' net investment of nonfinancial business.

Debt Repurchases are the negative of Net increase in credit markets instruments of nonfinancial business. Both Equity payouts and Debt repurchases are divided by business GDP from NIPA. Total GDP is used to compute the correlations reported in Table 2.1.

The capital stock is constructed similar to JQ. Using the law of motion of capital

$$k_{t+1} = k_t + Investment - Depreciation$$

we define *Depreciation* as Consumption of fixed capital in nonfinancial corporate business plus Consumption of fixed capital in nonfinancial noncorporate business taken from the Flow of Funds. *Investment* is measured as Capital expenditures in non financial business, also from the Flow of Funds. Both variables are deflated by the price index for business GDP from NIPA. The initial capital stock is chosen so that the capital-output ratio in the business sector does not display any trend over the period 1952:Q1-2012:Q1.

The stock of debt is constructed (again, similar to JQ) using the law of motion

$$b^e_{t+1} = b^e_t + Net\,New\,Borrowing$$

where *Net New Borrowing* is defined as the Net increase in credit markets instruments of nonfinancial business taken from the Flow of Funds. $b^e_{t+1} = b_{t+1}/\left(1 + r_t\right)$ since this is the model equivalent of the end-of-period debt reported in the data. We take the initial value of the stock of debt to be the nonfinancial business sector's stock of debt in 1952:Q1 from the balance sheet data reported in the Flow of Funds. We deflate the constructed series by the price index for business GDP from NIPA.