Social Interactions and Labor Market Search∗

Semih Tumen †
University of Chicago
January 24, 2011

Abstract

This paper bridges the job search literature and the literature on social interactions in labor markets. I investigate the connections between informal hiring channels, employment, wages, and labor market institutions within the context of preference interactions. Heterogeneous unemployed workers choose whether to use their contacts to find jobs or rely only on formal search methods. This decision is embedded first into a simple McCall search model and, then, into the celebrated Mortensen-Pissarides search and matching model. The mean choice of the job search method in the relevant reference group also affects workers' decisions. I derive equilibrium distributions of unemployment and wages. I show that such a framework resolves several important issues reported in the informal networks literature. Finally, I extend the model into an environment with aggregate productivity shocks. I argue that the job search model with social interactions has a potential to generate large fluctuations in unemployment. More precisely, aggregate shocks may lead to phase transitions (i.e., transitions from a unique equilibrium to multiple stable equilibria and vice versa), which result in abrupt responses in aggregate unemployment that may look like cycles.

JEL codes: C31, D62, D85, E32, J63, J64.

Keywords: Search, informal networks, social interactions, employment dynamics, wage distribution.

∗I am grateful to Steve Durlauf, James Heckman, and Rafael Lopes de Melo for their valuable comments and continuous support. I also thank Daron Acemoglu, Ferdinanto Monte, Fabrizio Zilibotti and seminar/conference participants at Bielefeld University, Koc University, Sabanci University, the University of Chicago, and Royal Economic Society 2011 Annual Meeting for useful suggestions on an earlier draft of this manuscript. All errors are mine.

†semilhtumen@uchicago.edu. Department of Economics, University of Chicago, 60637, Chicago IL.
## Contents

**Overview** 3

1 Introduction 5  
  1.1 Motivation and objectives ........................................ 5  
  1.2 Why is this important? .............................................. 7  
  1.3 The plan of the paper ............................................... 11

2 The Baseline Model 11  
  2.1 Social forces in utility ............................................. 11  
  2.2 Description of heterogeneity ....................................... 13  
  2.3 Workers .......................................................... 16  
  2.4 Equilibrium ...................................................... 18  
  2.5 Comparative statics ............................................... 23

3 Social Forces as a State Variable 27  
  3.1 Turnover .......................................................... 27  
  3.2 Steady state ...................................................... 29

4 Search and Matching with Social Interactions 32  
  4.1 Description of heterogeneity ....................................... 32  
  4.2 The matching technology .......................................... 32  
  4.3 Workers .......................................................... 34  
  4.4 Firms ............................................................. 35  
  4.5 Wage determination ................................................. 35  
  4.6 Analysis of equilibrium wages .................................... 36  
  4.7 Optimal choice of the search method .............................. 40  
  4.8 The equilibrium threshold ........................................ 41

5 Aggregate Shocks 43

6 Concluding Remarks 45

A Appendix 47  
  A.1 Reservation wages and unemployment ............................ 47  
  A.2 Strong and weak ties ............................................. 51
Overview

Over the past thirty years, the complex connectedness of the modern society has become one of the major “priority topics” in scientific research. This connectedness is found in many different contexts including the rapid and intense spread of information, financial crises, epidemics, and ideas/innovations. To study the patterns of economic and behavioral interconnections among individuals, an entire literature called “social and economic networks” has emerged and grown with surprising speed. There are two major paths along which a social network can operate: (1) direct or indirect contacts in the form of information transfers and (2) spillover externalities in the form of the effect of aggregate behavioral outcomes on individual behavior.

The current paper focuses on a specific strand of the literature on social networks: job search networks. The literature on job search networks examines the patterns of information transfers (or referrals) in labor markets. As I mention above, this corresponds to the first type of channels that social networks operate. Second type of social interactions have never been studied in this literature. The traditional assumption is the following: a job search network is an information transmission channel through which workers learn about job opportunities. This way of thinking has proved useful to understand several aspects of the effects of social networks on labor market outcomes. However, there are still many important unanswered questions. Why different groups of people use informal channels in different intensities? Why jobs found through friends and acquaintances pay in some settings better and in some others worse than those found through formal search methods? What is the impact of labor market institutions on informal networks? How do aggregate shocks affect the use of informal job search networks in the society?

Considering the second type of social interactions within the context of job search networks is a potentially fruitful approach to answer these questions and many others. How people’s informal job search behavior is affected by incentives and by their expectations about the informal networking behavior of others in the reference group is the subject of the second type
of interactions. In this paper, I pursue the goal of integrating this second channel into the basic principles developed to study the first one. One natural environment for the marriage of these two channels is the standard labor market search framework. Using the standard tools that the search/matching models offer, I investigate how the individual search behavior is affected by the aggregate search spillovers in a model with formal and informal search methods available to workers. Such a setup offers intuitive explanations to group-level discrepancies in the use and outcomes of informal channels, and provides a useful framework to study the impact of labor market institutions and aggregate fluctuations on informal networks.

This work is also linked to the literature investigating how the equilibrium unemployment rates that the Mortensen-Pissarides (MP) search/matching model produces evolves along the business cycles. There is a consensus that the standard MP model cannot generate the observed fluctuations in unemployment in response to aggregate shocks. I contribute to this literature in two steps. First, I show that introducing social interactions of the second type into the MP model opens up the possibility of having multiple equilibria. Second, I demonstrate that aggregate shocks may create phase transitions (i.e., transitions from a unique equilibrium to multiple stable equilibria and vice versa), which result in abrupt responses in aggregate unemployment that may look like cycles.
1 Introduction

1.1 Motivation and objectives

What rationalizes the choice between using versus not using informal job search channels (i.e., friends, relatives, and social/professional acquaintances) is not well understood in the economics discipline. Neither is it often well-grounded why some groups rely more on these social contacts than others, nor why the patterns of employment and wages vary across these groups. The stylized fact that more than a half of all new jobs are filled through social contacts in Europe and in the United States [see, for example, Rees (1966), Corcoran et al. (1980), Holzer (1988), Marsden and Campbell (1990), Granovetter (1995), Bewley (1999), Addison and Portugal (2002), and Ioannides and Loury (2004)] throws the endeavour to investigate the connections between informal job search channels, employment, wages, and labor market institutions into sharp relief. Heterogeneity in worker characteristics has been a critical element in analyses of informal job search networks. Our main objective is to understand the association between individual-level disparities in using informal job search methods, social incentives affecting unemployed workers’ preferences over alternative job search methods, and some of the major labor market outcomes related to employment and wages.

A breakthrough study in the job networks literature is Calvo-Armengol and Jackson (2004), which offers an explanation for persistent race-based differences in employment.\(^1\) They take the role of a social network as a manner of obtaining information about job opportunities. Individuals randomly receive information about job openings, and can either act on those opportunities themselves or pass information to contacts. The dissemination of information about job opportunities within each network is made through the employed workers. This mechanism gives rise to a positive correlation in employment status among individuals who are connected to each other. Our view of social networks in job search is fundamentally different from Calvo-Armengol and Jackson (2004) and the related literature. In their paper, the labor market is a black box. Wage dispersion exists \textit{ex ante} and the job arrival rate is exogenous.

\(^1\)The companion paper, Calvo-Armengol and Jackson (2007), presents extended and more general results.
Yet the following insight in Calvo-Armengol and Jackson (2004) motivates our study: if there are costs associated with remaining in a network, those who have lower costs will be more willing to stay connected. This insight opens up new research directions featuring individual-level heterogeneity in unemployed workers’ willingness to bear these costs or not. We use this idea to study the implications of this cost-heterogeneity for the equilibrium distributions of unemployment rates and wages across workers.

To pursue this goal, we develop a theoretical framework—job search with social interactions—which is basically a combination of two distinct approaches: the discrete-choice model of social interactions pioneered by Brock and Durlauf (2001a) and job search models à la McCall (1970), Pissarides (1984), and Mortensen and Pissarides (1994) (MP hereafter). Heterogeneous unemployed workers choose between informal and/or formal search methods and the probability of finding a job is higher when the worker chooses informal methods. Workers who face higher costs in using informal methods are more likely to rely on formal methods. This cost consists of two pieces: a private component reflecting individual-level heterogeneity and a social component reflecting the tendency of individuals to conform to the behavior of others in the relevant reference group. The interactions between (1) the spread of individual-level heterogeneity, (2) the strength of social incentives, (3) the characteristics of the search and matching processes governing trade in the labor market, and (4) the composition of labor market institutions are the key factors in our analysis of the distributions of unemployment rates and wages in the economy. Equilibrium distributions of unemployment and wages are determined within our model of job search with social interactions.

Our analysis of social interactions in job search behavior is within the context of spillovers and associated economic models. Spillovers are classic examples of nonpecuniary externalities that affect individual behavior (Arrow and Hahn (1971), Becker and Murphy (2000)). There is a vast literature studying positive spillovers in the sense that social interactions induce a tendency for conformity in behavior across the members of a reference group. Our paper is closely related to Brock and Durlauf (2001a) in that workers care only about the mean of the
distribution of worker behavior in the relevant reference group. A related, but distinct, issue
is that there is a symmetry assumption in the way that workers interact, which comes down
to a *rational expectations* statement. We take a large population of workers and describe their
behavior conditional on the behavior of other workers in the reference group. That’s where
complementarities come in. Then we ask questions about the joint probability statements that
are associated with the conditional probability statements. Using generalized logistic models
of binary choice inherited by the general formulation of phase transitions, we show that workers
tend to conform to the group-level outcomes. Our model is a natural transition from micro-
foundations as a description of how workers make decisions to invoke social contacts or not
into a formulation of average behavior in the population as a reaction function.

1.2 Why is this important?

The main result of our paper is that there exists an endogenous threshold cost level above
which the unemployed workers rely only on formal search methods and below which they
invoke also their social contacts. Such a structure yields endogenous equilibrium distributions
of unemployment rates and wages across worker types. The four factors we outline above
determine the key properties of these distributions and the associated aggregate outcomes.
Below we summarize why this is progress:

1. The wage-differentials literature [see, for example, *Bowlus (1997)*] documents that around
   30% of the wage variation is due to the differences in job arrival rates. Several theoretical
   accounts link the differences in job arrival rates to the existence of social networks. For
   example, *Mortensen and Vishwanath (1994)* has used the idea that search frictions allow
   for the existence of different wage offer distributions for each method of search. In a more
   recent work, *Fontaine (2008)* formulate a search and matching model with network het-
   rogeneity in terms of job arrival rates. Wage dispersion is, therefore, generated through
   heterogeneous networks. In our framework, using informal and/or formal methods is a
   matter of choice. Given the structure of cost heterogeneity and the strength of confor-
   mity effects, workers’ choices of the search method generate a wage distribution in the
MP version of our model. There are two distinct job arrival rates: one for the agents who use informal methods and the other one for those who use formal channels only. The endogenous cost threshold determines the fraction of workers who are subject to one job arrival rate versus the other. Thus, the resulting equilibrium distributions of unemployment rates and wages are associated with differences in job arrival rates. We show, in particular, that the effect of differences in job arrival rates on the wage dispersion is magnified by the degree of cost heterogeneity and the strength of conformity effects.

2. Although it has widely been recognized in the social interactions literature that endogenous peer effects (or conformity behavior) are significant in a wide range of problems, the informal networks literature totally ignores those phenomena. Existing empirical findings (i.e., spatial correlations and correlations among individuals with similar sociodemographic characteristics) are mostly interpreted as consequences of information exchange between workers, which seems to be a relevant story. However, it is hard to rule out endogenous neighborhood effects in the decision to invoke informal contacts. For example, Topa (2001) finds significantly positive spatial correlations in employment between nearby locations. This geographical lumping is consistent with the existence of neighborhood effects in workers’ preferences over job search methods. If there are two methods and one method is more productive than the other in generating job offers, those groups who rely on the more productive method heavily are expected to have greater rate of employment. The evidence is totally consistent with this story too. Our paper is the first to investigate the effect of endogenous conformity effects on the distributions of unemployment and wages across workers. The search literature recognizes “congestion externalities” (searching harder makes other unemployed workers worse off by reducing their job finding rates) and “thick-market externalities” (searching harder makes the employers better off by increasing the rate at which vacancies are filled). Our paper is the first to discuss spillover type of externalities (if everyone else searches harder, then I search harder) in standard search and matching models.

---

2See Brock and Durlauf (2001b) and Ioannides and Loury (2004) for excellent literature surveys.
3. Our formulation of the conformity behavior is similar to Brock and Durlauf (2001a). We incorporate their basic preference interactions structure first into the simple McCall (1970) search model and then into the standard Mortensen and Pissarides (1994) model of search and matching. One key property of the Brock and Durlauf (2001a) model is that it creates a potential for multiple equilibria. Moreover, it presents conditions for moving from the solution with a unique equilibrium to the one with multiple (stable) equilibria. This is important for two distinct reasons:

(a) The literature reports that differences in using informal contacts by demographic characteristics show conflicting patterns. For example, Ports (1993) finds that the use of informal contacts in job search increases with age and/or experience. Corcoran et al. (1980) and Marsden and Campbell (1990), on the other hand, estimate that it declines with age and/or experience. Multiple equilibria embody both low usage and high usage as equilibrium outcomes.

(b) Following Shimer (2005), a strand of the search and matching literature has found that the basic Mortensen-Pissarides model generates too little cyclicality compared to the data. For example, Hall (2005) argues that the Nash bargaining assumption leads to too little volatility in unemployment. This potential problem regarding the wage bargain is pointed out also in Hall and Milgrom (2008) and Gertler and Trigari (2009), and wage stickiness is offered as a solution. This possibility has recently been ruled out by Pissarides (2009), who presents empirical evidence on wage flexibility for the new matches. Mortensen and Nagypal (2007) and Hagedorn and Manovskii (2008) argue that household production and the value of leisure are related to the cyclical properties of the Mortensen-Pissarides model. In our model, the existence of multiple equilibria in the aggregate behavioral outcome—i.e., multiple solutions for the mean choice of the job search method—can potentially lead large fluctuations in unemployment, if the aggregate shocks lead the economy switch between low and high equilibrium levels. In other words, endogenous social interactions—other than sticky wages or household production—may also offer a potential solution to this problem.
Again, the degree of cost heterogeneity and the strength of social influences will be the main determinants.

4. Our model provides an ideal framework to compare the wage offers generated through informal methods versus those generated through formal methods. This is an important problem in the informal networks literature. Theoretical predictions by Saloner (1985), Montgomery (1991), and Simon and Warner (1992) suggest that, compared to formal methods, informal methods lead to matches that pay higher wages. Several empirical papers, including Corcoran et al. (1980), Datcher (1983), and Marmaros and Sacerdote (2002), confirm this predictions. However, some authors have documented opposite results; that is, informal channels lead to offers associated with lower wages compared to those generated through formal channels [see, for example, Loury (2006), Antoninis (2006), and Bentolila et al. (2010)]. The MP version of our model embodies these two views. Using the equilibrium wage distribution that our model yields, we show that informal methods can generate higher (lower) wage offers than formal methods, if the general tendency in the relevant worker population is to use informal (formal) methods. This lowers (raises) the social cost of job search and provides advantages in the wage bargain to the workers who are more (less) likely to invoke their informal contacts. In other words, the direction and the strength of the aggregate behavioral outcome is the key to understanding this problem.

5. We extend Brock and Durlauf (2001a) by introducing explicit dynamics into the determination of the aggregate behavioral outcome. We study dynamic social interactions first in the McCall search model (Section 3) and, then, in the MP search and matching model. We establish clear connections between these dynamics and the distributions of unemployment and wages.

6. Pellizzari (2010) argues that labor market institutions matter in the relationship between the use of social networks and several labor market outcomes including wages and unemployment. Our model provides a natural environment for the analysis of such relationships.
1.3 The plan of the paper

In Section 2, we formulate a simplified version of the McCall search model, our baseline model, in which unemployed workers interact in the reference group. We model the use of informal hiring channels as a choice variable. We discuss the equilibrium properties and the workings of the model. We perform various comparative statics exercises. In the baseline model, social interactions are static. Section 3 extends the results developed in Section 2 and studies a model in which social interactions are formulated as a state variable. This extension results in a tractable distribution of unemployment rates across worker types. Section 4 carries the basic idea of the baseline model into a Mortensen-Pissarides search and matching model. Wages are determined within the model. Apart from the distribution of unemployment rates, an equilibrium wage distribution is also derived. We discuss the possibility of adding aggregate shocks to our model in Section 5. Section 6 concludes. The Appendix derives the implications of our model for reservation wages and relates our framework to the strength-of-weak-ties hypothesis.

2 The Baseline Model

In this section, we work out a baseline job search model with social interactions. The model presented here is built on several strong assumptions, which are imposed for the purpose of generating sharp results. After displaying the basics of our approach and understanding the mechanics of the model, we relax many of these assumptions and extend the model towards various directions in subsequent sections.

2.1 Social forces in utility

There is a continuum of workers indexed in the unit interval, \( i \in [0,1] \). The unit interval defines a large network in which workers interact in a specific way. Each worker seeks to maximize \( E \sum_{t=0}^{\infty} \beta^t U_t \), where \( U_t \) is the current period utility and \( 0 < \beta < 1 \) is a subjective
discount factor. We define the current period utility as

\[
U = \begin{cases} 
v(w), & \text{if the worker is employed,} \\
v(c) - \rho(a_i, m_i, \epsilon_i(a_i)), & \text{otherwise,}
\end{cases}
\]  

(2.1)

where \(v(0) = 0\), \(v'(\cdot) > 0\), \(w > 0\) is the wage that the employed worker is paid, and \(c > 0\) is the unemployment income. The most obvious component of \(c\) is unemployment insurance benefit. It may also be related to any other type of return that the workers enjoy while unemployed, i.e., irregular jobs in a secondary sector and imputed real return from any unpaid leisure activities. We assume throughout that \(c\) is constant and independent of market returns.

The function \(\rho(\cdot)\) describes the disutility associated with the unemployed worker’s decision to rely only on formal job search methods versus to invoke also his personal links. It has three arguments: \(a_i, m_i, \text{ and } \epsilon_i(\cdot)\). First, we define the unemployed worker’s decision to invoke personal contacts or not by \(a_i \in \{-1, 1\}\). For concreteness, we focus on the binary discrete choice case, a version of the binary choice model with externalities developed by Schelling (1973) and Brock and Durlauf (2001a), where we let the unemployed worker either to use formal search methods \((a = -1)\) or invoke also his informal contacts \((a = 1)\).

Second, \(m_i\) describes worker \(i\)’s subjective beliefs about the mean search method in the relevant reference group. More precisely,

\[
m_i = \int \left( \sum_{a \in \{-1, 1\}} a_j \mu_{i,j}(a_j) \right) dj,
\]

where \(\mu_{i,j}(\cdot)\) is a conditional probability measure describing worker \(i\)’s beliefs on the choices, \(a_j \in \{-1, 1\}\), of other unemployed workers which we index by \(j\).\(^3\) Note that we relax the subjective beliefs assumption in Section 3, where we let \(m_i\) to evolve over time and to reflect the actual average search method used by the pool of unemployed workers.

\(^3\)We abstract from the complexities associated with strategic decision making. See Milgrom and Roberts (1990) for a detailed treatment of strategic complementarities.
Finally, the individual-level heterogeneity, $\epsilon_i(\cdot)$, describes how different the group members are from each other in terms of the “private” cost of invoking contacts or not. The source of inspiration behind this formulation is the following insight from Calvo-Armengol and Jackson (2004): if there are costs associated with remaining in an informal network, those who have lower costs will be more willing to stay connected. In Section 2.2, we define the structure of heterogeneity in more detail.

We consider forms of search disutility, $\rho(a_i, m_i, \epsilon_i(a_i))$, which exhibit the key properties of the payoff functions widely used in the social interactions literature [see Brock and Durlauf (2001a)]. The function $\rho(\cdot)$ embodies two different cost components: a social component, which affects all workers homogeneously, and a heterogeneous private component. We define

$$\rho(a_i, m_i, \epsilon_i(a_i)) = Ja_i m_i + \epsilon_i(a_i),$$

where $J < 0$ describes how sensitive the worker is to the behavior of other agents.\(^4\) We restrict ourselves to the proportional spillovers case, $Ja_i m_i$, in which there is a multiplicatively separable interaction between the individual choice and the expected average choice. This exhibits the totalistic form of strategic complementarities discussed in Cooper and John (1988) and Brock and Durlauf (2001a). Moreover, it is the expectational analogue of the increasing differences idea studied by Milgrom and Roberts (1990).

### 2.2 Description of heterogeneity

The random component $\epsilon_i(a_i)$ defines the individual-level heterogeneity and it is actually a function of the unemployed worker’s choice of the search method. We assume $\epsilon_i(a_i) \perp \perp \epsilon_j(a_j)$, for all $i \neq j$, where $\perp \perp$ means statistical independence. $\epsilon_i(a_i)$ is indexed by $i$, because when we talk about unobserved heterogeneity, we associate the individuals with two distinct uncertainties: one is relevant if the worker decides to invoke social contacts in job search,\(^4\) A more general representation would be $\rho(a_i, m_i, \epsilon_i(a_i)) = ha_i + Ja_i m_i + \epsilon_i(a_i)$, where $h > 0$ characterizes private disutility that bias the worker from one choice towards another. But, we ignore that component to simplify our analysis. Note that dropping $ha_i$ does not alter our analysis.

13
and the other is relevant if he chooses to rely only on formal methods. For example, the uncertainty associated with invoking social contacts is only relevant when the worker chooses $a_i = 1$.

The workers are identical apart from their $\epsilon_i(\cdot)$s. In this basic version of our model, the workers know their own $\epsilon_i(\cdot)$s and nobody else’s. There is no learning. To simplify calculations, we impose the following assumptions:

**Assumption 1.** The conditional probability measure $\mu_{i,j}(a_j)$ which reflects worker $i$’s subjective beliefs on the choices of other workers do not evolve over time for all $i$.

**Assumption 2.** Workers believe that the pool of unemployed reflects the pool of all workers.

Assumption 1 means that $m_i$, the mean behavior, does not evolve over time.\(^5\) Therefore, $m_i$ is not a state variable in the search model that we study in this section. Assumptions 1 and 2 jointly imply that if we impose rationality, every agent must form the same beliefs about the expected value, $m$, of everyone else. So, the information sets are perfectly symmetric from the perspective of any agent. Following Brock and Durlauf (2001a), we impose a self-consistency assumption on workers’ beliefs. In other words, the beliefs are replicated in the worker population, i.e., $m = m_i$. This set of assumptions are rather strong and will be relaxed in Section 3, where we introduce a dynamic $m$. The version we develop in Section 3 keeps track of the choices of the mass of individuals who are unemployed. Our purpose in this section is to simplify the algebra and to understand the main mechanism that we focus on.

We represent unobserved heterogeneity with a canonical logit style distribution function such that we assume $\epsilon_i(1) \perp \perp \epsilon_i(-1)$ and are extreme-value distributed. The following theorem is well-known and is a key result for our analysis in this section.

**Theorem 2.1.** If $\epsilon_i(1)$ and $\epsilon_i(-1)$ are independent and extreme-value distributed random variables, then their difference has a logistic distribution; that is

$$
P\left[\epsilon_i(1) - \epsilon_i(-1) \leq x\right] = \frac{1}{1 + e^{-\kappa x}} = \frac{e^{\kappa x/2}}{e^{\kappa x/2} + e^{-\kappa x/2}}$$

\(^5\)The assumption of inexistent credit markets is implicit in this basic setup.
where $\kappa \geq 0$ describes how much spread there is in individual-level unobserved heterogeneity.

**Proof:** See Cameron and Trivedi (2005) section 14.8, page 486. ■

A small value for $\kappa$ says that the dispersion of unobserved heterogeneity is large. For our purposes, we need an extended version of this result. Following intermediate results need to be stated before we establish the extended version.

**Theorem 2.2.** Let $X$ be a random variable with pdf $f_X(x)$ and cdf $F_X(x)$ corresponding to a scale-family distribution. Let $Y = \theta X$ with $\theta > 0$. Then $F_Y(y) = F_X(y/\theta)$ and $f_Y(y) = (1/\theta)f_X(y/\theta)$.

**Proof:** See Klugman, Panjer, and Willmot (2008) page 62. ■

**Lemma 1.** If $\epsilon_i(1)$ and $\epsilon_i(-1)$ are independent and extreme-value distributed random variables, then $C_1\epsilon_i(1)$ and $C_2\epsilon_i(-1)$—where $C_1$ and $C_2$ are positive constants—are also independent and extreme-value distributed random variables.

**Proof:** The proof directly follows from Theorem 2.2. ■

Theorem 2.2 and Lemma 1 jointly state that multiplying by a constant changes only the “scale” (not the functional form) of an extreme-value distributed random variable. Using Theorem 2.2 and Lemma 1, we extend Theorem 2.1 as follows:

**Theorem 2.3.** If $\epsilon_i(1)$ and $\epsilon_i(-1)$ are independent and extreme-value distributed random variables, then their difference has a logistic distribution; that is

$$
\mathbb{P}\left[ C_1\epsilon_i(1) - C_2\epsilon_i(-1) \leq x \right] = \frac{1}{1 + e^{-\tilde{\kappa}x}} = \frac{e^{\tilde{\kappa}x/2}}{e^{\tilde{\kappa}x/2} + e^{-\tilde{\kappa}x/2}}
$$

(2.4)

where $\tilde{\kappa} \geq 0$ describes individual-level unobserved heterogeneity.

**Proof:** The proof follows from Theorem 2.1 and Lemma 1. ■
2.3 Workers

If the worker $i$ is unemployed, he decides whether to invoke his informal contacts or rely only on formal methods and, with probability $\pi(a_i)$, he receives a job starts paying $w > 0$ at the beginning of the next period. All jobs are alike and pay wage $w > 0$ as long as the worker is employed.\textsuperscript{6} There is also an exogenous probability $\gamma > 0$ of being fired for the employed worker every period. We assume $\pi(-1) = \alpha \pi(1)$, $\alpha \in (0,1)$; that is, the probability that any unemployed worker receives a wage offer, $w$, is higher when the worker calls his informal contacts. This is consistent with Blau and Robins (1990) in that job search for those who use informal channels is more productive than those who do not use.

Let $V_e$ be the expected discounted sum of utility of an employed worker.\textsuperscript{7} When the worker is employed, his period utility becomes $v(w)$. Therefore,

$$V_e = v(w) + \beta\left[\gamma V_u + (1 - \gamma)V_e\right] \quad (2.5)$$

which means that

$$V_e = \frac{v(w)}{1 - \beta(1 - \gamma)} + \frac{\beta \gamma V_u}{1 - \beta(1 - \gamma)}. \quad (2.6)$$

Let $V_u$ be the expected present value of utility for an unemployed worker who makes an optimal decision of whether to call his contact or not. The Bellman equation for the unemployed worker is

$$V_u = \max_{a_i}\left\{v(c) - (Ja_i m + \epsilon_i(a_i)) + \beta\left[\pi(a_i)V_e + (1 - \pi(a_i))V_u\right]\right\}. \quad (2.7)$$

Since there is no state variable in this infinite horizon problem, there is a time-invariant optimal search intensity $a_i \in \{-1,1\}$ and an associated value of being unemployed that we

\textsuperscript{6}This is a degenerate version of the basic McCall (1970) search model. See Hopenhayn and Nicolini (1997) and Chapter 21 in Ljungqvist and Sargent (2004) for some examples of this setup. We relax this assumption in Appendix A.1 by bringing in a wage distribution $F(\cdot)$ from which the unemployed agent draws a wage offer. The version we present in Appendix also incorporates the more general idea that $a_i$ is continuous and lives in the unit interval. We show that a reservation wage strategy is optimal in such a model. See Appendix A.1 for details.

\textsuperscript{7}All the value functions are indexed by individuals, which we drop for notational simplicity.
denote $V_{u,a}$. The solution is either $a_i = 1$ or $a_i = -1$, with values $V_{u,1}$ and $V_{u,-1}$, respectively. We derive these values by substituting (2.6) into the Bellman equation (2.7), which yields

$$V_{u,1} = \frac{v(c) - Jm - \epsilon_i(1) + \frac{\beta \pi(1)v(w)}{1 - \beta(1 - \gamma)}}{1 - \beta(1 - \pi(1)) - \frac{\beta^2 \pi(1)\gamma}{1 - \beta(1 - \gamma)}}$$

(2.8)

and

$$V_{u,-1} = \frac{v(c) + Jm - \epsilon_i(-1) + \frac{\beta \alpha \pi(1)v(w)}{1 - \beta(1 - \gamma)}}{1 - \beta(1 - \alpha \pi(1)) - \frac{\beta^2 \alpha \pi(1)\gamma}{1 - \beta(1 - \gamma)}}$$

(2.9)

Next we provide a probabilistic description of the behavior of the unemployed. The unemployed worker chooses to start an informal contact if $V_{u,1}$ exceeds $V_{u,-1}$. By definition,

$$\mathbb{P}[a_i = 1|m] = \mathbb{P}[V_{u,1} \geq V_{u,-1}|m],$$

(2.10)

which can be rewritten, by simple substitution, as

$$= \mathbb{P}\left[\frac{v(c) - Jm - \epsilon_i(1) + \frac{\beta \pi(1)v(w)}{1 - \beta(1 - \gamma)}}{1 - \beta(1 - \pi(1)) - \frac{\beta^2 \pi(1)\gamma}{1 - \beta(1 - \gamma)}} \geq \frac{v(c) + Jm - \epsilon_i(-1) + \frac{\beta \alpha \pi(1)v(w)}{1 - \beta(1 - \gamma)}}{1 - \beta(1 - \alpha \pi(1)) - \frac{\beta^2 \alpha \pi(1)\gamma}{1 - \beta(1 - \gamma)}} | m\right]$$

$$= \mathbb{P}\left[C_1 \epsilon_i(1) - C_2 \epsilon_i(-1) \leq \Psi_1 v(c) + \Psi_2 Jm + \Psi_3 v(w) | m\right]$$

(2.11)

where $\Psi_1 = C_1 - C_2$, $\Psi_2 = -(C_1 + C_2)$, $\Psi_3 = (C_1 - \alpha C_2)K$,

$$K = \frac{\beta \pi(1)}{1 - \beta(1 - \gamma)}$$

(2.12)

and

$$C_1 = 1 - \beta(1 - \alpha \pi(1)) - \frac{\beta^2 \alpha \pi(1) \gamma}{1 - \beta(1 - \gamma)}, \quad C_2 = 1 - \beta(1 - \pi(1)) - \frac{\beta^2 \pi(1) \gamma}{1 - \beta(1 - \gamma)}.$$  

(2.13)

Using equation (2.3), the probability that the unemployed worker chooses the effort level
\( a_i = 1 \) can be formulated by setting

\[
x = \frac{\kappa}{2} [\Psi_1 v(c) + \Psi_2 Jm + \Psi_3 v(w)]
\]

in expression (2.11). Thus,

\[
\mathbb{P}[a_i = 1 | m] = \frac{e^{\frac{\kappa}{2} (\Psi_1 v(c) + \Psi_2 Jm + \Psi_3 v(w))}}{e^{\frac{\kappa}{2} (\Psi_1 v(c) + \Psi_2 Jm + \Psi_3 v(w))} + e^{-\frac{\kappa}{2} (\Psi_1 v(c) + \Psi_2 Jm + \Psi_3 v(w))}}. \tag{2.15}
\]

There is a similar expression for \( \mathbb{P}[a_i = -1 | m] \). Our analysis crucially relies on the calculation of the conditional mean, \( \mathbb{E}[a_i | m] \). Obviously,

\[
\mathbb{E}[a_i | m] = \mathbb{P}[a_i = 1 | m] \times 1 + \mathbb{P}[a_i = -1 | m] \times (-1). \tag{2.16}
\]

After plugging in the formulas for the conditional probabilities we derive above and setting \( x = \frac{\kappa}{2} [\Psi_1 v(c) + \Psi_2 Jm + \Psi_3 v(w)] \), we obtain

\[
\mathbb{E}[a_i | m] = \frac{e^x}{e^x + e^{-x}} - \frac{e^{-x}}{e^x + e^{-x}}. \tag{2.17}
\]

This can be simplified to yield

\[
\mathbb{E}[a_i | m] = \frac{e^x - e^{-x}}{e^x + e^{-x}} = \tanh(x), \tag{2.18}
\]

where \( \tanh(x) \) denote the hyperbolic tangent. Next we explain how we use the hyperbolic tangent to describe the general properties of the informal hiring channels that our model produces.

### 2.4 Equilibrium

In describing the equilibrium outcomes, our main assumption is that workers choose whether to invoke their informal contacts or to rely only on formal methods non-cooperatively. From (2.18), \( \mathbb{E}[a_i | m] \) is of the hyperbolic tangent form. By self-consistency, we get \( \mathbb{E}[a_i | m] = m \).

That is, the actual mean behavior conditional on the self-consistent beliefs about the mean
behavior must be equal to the self-consistent beliefs about the mean behavior. Therefore,

\[ m = \tanh \left( \frac{\kappa}{2} \left[ \Psi_1 v(c) + \Psi_2 Jm + \Psi_3 v(w) \right] \right), \]  

(2.19)

The intuition is simple: the hyperbolic tangent is a reaction function. It tells us that \( m \) will be the equilibrium expected mean behavior in the group, given the belief structure. It is easy to show that \( \Psi_1, \Psi_2 < 0 \) and \( \Psi_3 > 0 \). Given the signs of these parameters, we can discuss the determinants of the magnitude of \( m \). The number of equilibria depends on: (i) the degree of individual heterogeneity, \( \kappa \), (ii) the strength of social interactions, \( J \), and (iii) the amount of pecuniary incentives, \( c \) and \( w \). In other words, the interplay of social incentives, pecuniary incentives, and unobserved heterogeneity will tell us something about the structure of the choices.

We determine the magnitude of \( m \)—the mean behavior—by employing a simple fixed point algorithm since both sides of the expression (2.19) are well-defined functions of \( m \). The left-hand side of the Equation (2.19) is a 45-degree line passing through the origin. It is monotonically increasing in \( m \). The right-hand side is a hyperbolic tangent. The shape of a hyperbolic tangent may vary, but we know that it is increasing in \( m \). Since both sides are increasing in \( m \), depending on the shape and slope of the hyperbolic tangent, there exists at least one solution for \( m \). We next impose more structure on these statements.

To characterize the equilibrium relationship in a sensible way, we assume that there is no unemployment insurance in our economy \( (c = 0) \). This is a relatively uninteresting case, but it motivates how we look at our results. Thus, the equilibrium outcome is characterized as follows:

\[ m = \tanh \left( \frac{\kappa}{2} \left[ \Psi_2 Jm + \Psi_3 v(w) \right] \right), \]  

(2.20)

Suppose \( J = 0 \) and \( w = \delta \), where \( \delta > 0 \) is arbitrarily small. We need a strictly positive wage to induce the unemployed worker to search for a job. But, for illustrative purposes, we assume
$w$ to be a very small number—almost zero—to understand the behavior of the hyperbolic tangent. The graph of the hyperbolic tangent, the right-hand side, is a horizontal line at the origin because $\tanh(\frac{\kappa}{2} [\Psi_3v(\delta)]) \approx 0$, for all $m$. The left-hand side of Equation (2.20) is a 45-degree line going through the origin. In this case, we have a unique fixed point, which is at the origin. But, we knew this *ex ante*. This case implies that everybody is randomly choosing between 1 and -1 with probabilities 0.5. So, the mean behavior is of course 0.

Now assume the other extreme: $J = -\infty$ and $w = \delta$ for an arbitrarily small $\delta > 0$. If $m = 0$, it doesn’t matter what the magnitude of $J$ is (so we still have the origin as a solution). If $m > 0$, the hyperbolic tangent gives us 1 since $\tanh(-\infty) = 1$. If $m < 0$, on the other hand, the hyperbolic tangent gives us -1 since $\tanh(\infty) = -1$ (see Figure (1)). Now we have three equilibria that give us self-consistent expected average choice levels. $m = 0$ is not shocking to have, though under reasonable stability analysis it will disappear. When we set $J = -\infty$, other than the unstable $m = 0$ case, the population completely tips.

These two extreme assumptions about $J$ give us useful insights about the structure of the answer to the question we pose. We know that when $J = 0$, there will be a unique equilibrium and when $J = -\infty$, two new equilibria will emerge. What happens in between is the crucial question. Notice that, when $J = -\infty$, the hyperbolic tangent is a very sharp $S$ curve. The one with $J = 0$ is a degenerate $S$ curve. We will see that in the intermediate cases that those hyperbolic tangents are generically $S$-shaped. Figure (2) demostrates what happens in between. As long as $w = \delta$, the hyperbolic tangent has to go through the origin (approximately). Therefore, we can focus on $S$-shaped curves going through the origin. In the upper panel, there is only one equilibrium obviously, whereas on the lower one, we have three equilibria. So, everything is controlled by the slope of the hyperbolic tangent at the origin. These results give us a theorem, which is a version of the basic theorem developed in Brock and Durlauf (2001a).

**Theorem 2.4.** Suppose $w = \delta$, where $\delta > 0$ is arbitrarily small. If $\frac{\kappa}{2} \Psi_2 J < 1$, then $m$ is unique. If $\frac{\kappa}{2} \Psi_2 J > 1$, then there exists three $m$. 
This tells us that there is an interplay between the degree of heterogeneity, the strength of social interactions, the characteristics of the labor market (which we describe by $\Psi_2 < 0$) and the number of equilibria. For the rest of this subsection, we hold the labor market characteristics constant. We perform comparative statics exercise on labor market characteristics in the next subsection. A small $\kappa$ means that the distribution of individual heterogeneity has fat tails and, therefore, the degree of heterogeneity is high. With a small $\kappa$, a high percentage of agents is experiencing very large draws of the difference between $\epsilon_i(\cdot)$s. So we have a lot people in the population who are on the extremes in terms of their individual preferences to invoke their informal contacts in job search. If this is the case, there are not enough people left to bunch and become reinforcing self-consistently. Therefore, social influences are not so effective. In this case, we tend to have a unique equilibrium. In other words, the uniqueness of the equilibrium is determined by the interaction of fat tails and the strength of the social interactions. So, even if $|J|$ is reasonably high, these social influences could be negated by a high degree of heterogeneity. This can kill off the potential for multiple equilibria. Econometrically, $\kappa$ and $J$ cannot be separately identified, but from the viewpoint of theory, we can separately think about them and their distinction motivates our theoretical results. But, in the data, we do not have a natural way of distinguishing between $\kappa$ and $J$.\textsuperscript{8} We can normalize $\kappa$, but this time what we have is the “econometric” $J$.

Notice that there is a small margin in this model that with a small change in the compound parameter $\frac{\kappa}{2} \Psi_2 J$, we move from having a unique equilibrium to having multiple equilibria. In the literature, this is called a phase transition. The idea of phase transition is that there is a discontinuity in the description of the environment. So, this is a phase transition with respect to the polarization in the population. Within the context of our discussion, this is a polarization related to the willingness to invoke informal hiring channels from the viewpoint of the unemployed workers. The data reveal that there may be two different forms of behavior related to checking with friends and relatives to find jobs. One group of individuals may prefer

\textsuperscript{8}See Brock and Durlauf (2007) for a detailed discussion of identification in the social interactions models of this sort. For further reading on identifying social interactions, see Manski (1993), Moffitt (2001), Brock and Durlauf (2003), Blume and Durlauf (2005), Lee (2007), and Bramoule, Djebbari, and Fortin (2009).
not to invoke contacts, whereas the other group may prefer to do so. Our model is able to accommodate these differences within the same economic environment.

Now we introduce a wage offer, $w$, which is significantly different from zero. Since $w > 0$ and $\Psi_3 > 0$, it shifts the hyperbolic tangent up (see Figure (3)). The intuition is simple: fix $m$ and raise the pecuniary incentive on average to choose $a_i = 1$ (i.e., a largely positive $w$). This affects the actual behavior in the group since it raises the expected value. The upper panel demonstrates that we increase the pecuniary incentive $w$ and preserve three equilibria. Once again the interior equilibrium is unstable. Between the upper panel in Figure (3) and the case in which $w = \delta$ with multiple equilibria is that there is something about welfare that is different. If we increase $w$ further, we will eventually get a hyperbolic tangent which looks like the lower panel in Figure (3). The equilibrium is unique again, but it is stable this time. The intuition is the following: we fix the degree of heterogeneity, $\kappa$, the parameters characterizing the effect of labor market characteristics, $\Psi_2$, $\Psi_3$, and the strength of social interactions, $J$, in the population. We only increase pecuniary incentives. When we raise the incentives high enough, they swamp the social interactions. Remember that if $J = -\infty$, it swamps all private and pecuniary incentives considerations. In the present case, if we raise the private incentives high enough, that has to swamp the other terms. As a result, we have a full characterization of the phase transition in this model. The following theorem complements our analysis.

**Theorem 2.5.** If $w$ is significantly greater than zero, then

(i) we have a unique equilibrium, if $\frac{\kappa}{2} \Psi_2 J < 1$;

(ii) $\exists$ a threshold $T(\Psi_3, w)$ such that if $\frac{\kappa}{2} \Psi_2 J > T(\Psi_3, w)$, there will be three equilibria.

In words, if $\frac{\kappa}{2} \Psi_2 J < 1$, there will not be enough social activity to create multiple equilibria. In order to have multiple equilibria, $\frac{\kappa}{2} \Psi_2 J$ has to be greater than 1. That’s necessary but not sufficient. Rather, for each pair $(\Psi_3, w)$, there will be a threshold $T(\Psi_3, w)$ such that if $\frac{\kappa}{2} \Psi_2 J$ exceeds that threshold, there will be multiple equilibria. This is the full characterization of the qualitative structure of our model.
2.5 Comparative statics

In the previous subsection, we held the labor market parameters $c$, $\Psi_1$, $\Psi_2$, and $\Psi_3$ fixed to focus on the basic description of the equilibrium outcome. The result was straightforward. Changes in the social component alter the slope of the hyperbolic tangent, whereas changes related to pecuniary and private incentives shift the hyperbolic tangent itself. In this subsection, we examine the effect of labor market parameters on the equilibrium. These parameters are: the unemployment compensation ($c$), the probability of finding a job via informal channels ($\pi(1)$), the parameter for the relative effectiveness of job search via informal channels ($\alpha$), and the probability of getting fired ($\gamma$). To focus on the labor market parameters, we hold $\kappa$, $J$, and $w$ fixed throughout this section. We assume risk-neutral utility, i.e., $v(x) = x$, for simplicity.

We start with the unemployment compensation, $c$. One novel feature of our model is that it enables us to examine the interaction between informal hiring channels and labor market institutions. What is the effects of introducing various labor market institutions on unemployed workers’ willingness to use informal hiring channels? The easiest one is the unemployment compensation. It is a pecuniary incentive. Therefore, the analysis we perform for $w$ in the previous subsection holds for $c$ as well. However, the signs are different since $\Psi_1 < 0$ and $\Psi_3 > 0$. That is, an increase in the wage offer would induce unemployed workers to use informal hiring channels more intensively, since it would provide a greater expected present value of earnings. An increase in $c$, on the other hand, induces unemployed workers to use informal channels less intensively since $\Psi_1 < 0$. To be concrete, an increase in unemployment compensation will shift the hyperbolic tangent down. This means that, with a higher unemployment compensation, it is more likely to end up with a unique equilibrium placed on the third quadrant of the Euclidean space on which the hyperbolic tangent is defined. This is a new result in the informal hiring channels literature. More generally, any labor market institution affecting employment incentives also affects the use of informal hiring channels.

The second parameter we examine is $\pi(1)$: the probability of finding a job when the unem-
ployed worker prefers to use the informal hiring channels. It appears in \( \Psi_1, \Psi_2, \) and \( \Psi_3, \) which means that a change in \( \pi(1) \) both alters the slope of the hyperbolic tangent and shifts it. Thus, it is a rather difficult task to perform comparative statics exercise using \( \pi(1) \). We start with examining its effect on the slope of the hyperbolic tangent. After trivial algebra, we find

\[
\frac{\partial \Psi_2}{\partial \pi(1)} = -\frac{\beta(1 - \beta)(1 + \alpha)}{1 - \beta(1 - \gamma)} < 0. \tag{2.21}
\]

That is, after shutting down \( c \) and \( w \) by setting them equal to zero, we find that increasing \( \pi(1) \)—given \( \kappa \) and \( J \)—increases the likelihood of having multiple equilibria by Theorem (2.4). This means that a higher probability of finding a job via informal channels reinforces social influences. However, when \( c \) and \( w \) are nonzero, the analysis becomes more complicated since a change in \( \pi(1) \) shifts the hyperbolic tangent. Again, simple differential calculus yields

\[
\frac{\partial \Psi_1}{\partial \pi(1)} = \frac{\beta(1 - \beta)(\alpha - 1)}{1 - \beta(1 - \gamma)} < 0 \tag{2.22}
\]

and

\[
\frac{\partial \Psi_3}{\partial \pi(1)} = \frac{\beta(1 - \beta)(1 - \alpha)}{1 - \beta(1 - \gamma)} > 0. \tag{2.23}
\]

Notice that

\[
\frac{\partial \Psi_1}{\partial \pi(1)} = -\frac{\partial \Psi_3}{\partial \pi(1)}. \tag{2.24}
\]

Let \( \frac{\partial \Psi_3}{\partial \pi(1)} = d > 0 \). Then, the effect of an increase in \( \pi(1) \) on the level of the hyperbolic tangent is simply \( d(w - c) \). If \( w > c \) (which is normally the case), then an increase in \( \pi(1) \) shifts the hyperbolic tangent up. This increases the probability of ending up with a unique equilibrium placed on the first quadrant of the Euclidean space. It is perhaps useful to summarize our results regarding the effect of an increase in \( \pi(1) \): (1) it increases the slope of the hyperbolic tangent (i.e., makes it a sharper \( S \)-curve) and (2) it shifts the hyperbolic tangent up if \( w > c \).

In terms of the language of the Theorem (2.5), it increases \( \frac{\kappa}{2} \Psi_2 J \). But it also increases the threshold \( T(\Psi_3, w) \) which makes the overall effect ambiguous.
Our third parameter is $\alpha$: the relative effectiveness of searching a job via informal channels. When $\alpha$ goes up, the difference between the productivity of searching via formal versus informal channels goes down. Again, $\alpha$ appears in all of $\Psi_1$, $\Psi_2$, and $\Psi_3$. Similar algebra yields

$$\frac{\partial \Psi_1}{\partial \alpha} = \frac{\beta(1 - \beta)\pi(1)}{1 - \beta(1 - \gamma)} > 0, \quad (2.25)$$

$$\frac{\partial \Psi_2}{\partial \alpha} = \frac{\beta(1 - \beta)\pi(1)}{1 - \beta(1 - \gamma)} > 0, \quad (2.26)$$

and

$$\frac{\partial \Psi_3}{\partial \alpha} = -\frac{\beta(1 - \beta)\pi(1)}{1 - \beta(1 - \gamma)} < 0. \quad (2.27)$$

Obviously, an increase in $\alpha$ works in the opposite direction of an increase in $\pi(1)$. The magnitudes are different but same interpretations hold for this case. So, we do not elaborate further on this.

The most difficult comparative statics analysis is on $\gamma$: the probability of getting fired. It appears in all three $\Psi$s in both numerator and denominator. Taking derivatives, we get

$$\frac{\partial \Psi_1}{\partial \gamma} = \frac{(1 - \beta)\beta^2\pi(1)(1 - \alpha)}{[1 - \beta(1 - \gamma)]^2} > 0, \quad (2.28)$$

$$\frac{\partial \Psi_2}{\partial \gamma} = \frac{(1 - \beta)\beta^2\pi(1)(1 + \alpha)}{[1 - \beta(1 - \gamma)]^2} > 0, \quad (2.29)$$

and

$$\frac{\partial \Psi_3}{\partial \gamma} = -\frac{(1 - \beta)\beta^2\pi(1)(1 - \alpha)}{[1 - \beta(1 - \gamma)]^2} < 0. \quad (2.30)$$

Again, similar interpretations hold: an increase in $\gamma$ makes the hyperbolic tangent flatter
which means that it weakens the social influences. Moreover, it shifts the hyperbolic tangent down if \( w > c \). The number of equilibria depends on the magnitudes of the parameters.

Although the results look ambiguous, there is a systematic way by which we can bring sharper interpretations. We can group our parameters under three categories: unemployment insurance \((c)\), employment protection \((\gamma)\), and productivity of job search via informal channels \((\pi(1), \alpha)\). For example, an increase in the unemployment insurance decreases unemployed workers' willingness to accept a given wage offer, \( w \). This has two implications about the informal hiring channels: (1) it makes the unemployed workers put less effort on job search via the informal channels, therefore, pushes the system toward a unique equilibrium in which all unemployed workers tend to put low effort, and (2) it reinforces the social effects—therefore, increases the likelihood of multiple equilibria—since the difference \( w - c \) closes down and the role of social forces become more important in the decision process. The tradeoff between these two forces determines the outcome. Similar interpretations hold for the other parameters.

The analysis we present in this section extends the Brock and Durlauf (2001a) model into a simple job search environment, where the unemployed workers chooses between using their informal contacts in job search or relying only on formal methods. There are several directions that one can pursue to improve upon the basic results presented in this section. The most significant one is to relax Assumption 1 and introduce some tractable dynamics into the determination of social interactions. Such an extension would take the distribution of unemployment across worker types more seriously. In the present setup, the mass of unemployed workers and, therefore, the unemployment dynamics rely crucially on workers' subjective beliefs about the behaviors of other workers. This obscure structure should be extended to display a comprehensible unemployment dynamics. We perform this task in Section 3 by letting the mean behavioral outcome to be determined by the actions of the workers in the pool of unemployed.
3 Social Forces as a State Variable

In this section, we relax the assumption that the mean choice of unemployed agents, $m$, is fixed and, therefore, is not a state variable. We let $m$ determined by the actions of the unemployed workers rather than fixed subjective beliefs. The mass of unemployed agents evolves over time making $m$ an endogenous state variable. We start by laying out the setup.

3.1 Turnover

Each worker is characterized by a time-invariant random variable $z = \epsilon(1) - \epsilon(-1)$ representing the individual-level heterogeneity, where $z$ has a logistic distribution—over the support $Z$—similar to the setup in Section 2. Let $u_t(z)$ denote the fraction of unemployed workers of type $z$ at the end of period $t - 1$. A fraction $\gamma[1 - u_t(z)]$ of employed workers of type $z$ is then exogenously laid off in period $t$. Another fraction $[1 - \pi(a_{z,t})]u_t(z)$ of unemployed workers of type $z$ does not receive a job offer, where $a_z \in \{-1, 1\}$ denote the optimal choice of the method of contact.

The law of motion for the type-specific unemployment rate is, therefore,

$$u_{t+1}(z) = \gamma[1 - u_t(z)] + [1 - \pi(a_{z,t})]u_t(z)$$

(3.1)

or, equivalently,

$$u_{t+1}(z) = \gamma + [1 - \gamma - \pi(a_{z,t})]u_t(z).$$

(3.2)

Thus, the steady-state unemployment rate for type $z$ workers is

$$u(z) = \frac{\gamma}{\gamma + \pi(a_z)}.$$  

(3.3)

Notice that, under the discrete-choice setup, the type-specific steady state unemployment rate
$u(z)$ can take only two values:

$$u(z) = \begin{cases} \frac{\gamma}{\gamma + \pi(1)}, & \text{if } a_z = 1, \\ \frac{\gamma}{\gamma + \alpha(1)}, & \text{if } a_z = -1. \end{cases} \quad (3.4)$$

In other words, two distinct rates of unemployment emerge at the steady state; one for those workers who choose $a_z = 1$ and one for $a_z = -1$. Since $0 < \alpha < 1$, the rate of unemployment for those who choose $a_z = -1$ (i.e., who rely only on formal methods) is higher than those who choose $a_z = 1$. The aggregate unemployment rate at the steady state is

$$u = \int_Z \frac{\gamma}{\gamma + \pi(a_z)} g(z) dz, \quad (3.5)$$

where $g(z)$ is the pdf of the logistic distribution characterizing the distribution of worker types. This result says that the steady state aggregate unemployment rate $u$ is a weighted average of two unemployment rates. The key point is to determine which workers choose $a_z = 1$ and which workers choose $a_z = -1$ at the steady state. In the rest of this section, we seek to derive a simple rule, using which we can analytically determine the factors underlying this split.

Let $k_t(z)$ denote the type-level behavioral outcome in terms of using informal contacts; that is,

$$k_t(z) = a_{z,t} u_t(z). \quad (3.6)$$

The interpretation is the following. Take a specific type $z$. All members of this type make the same choice at time $t - 1$; they either choose $a_z = 1$ or $a_z = -1$. We weight this choice with $u_t(z)$, the rate of unemployment among type-$z$ workers realized at time $t - 1$ for the purpose of determining the type-specific mean search method. Notice that $|k_t(z)| = u_t(z)$, for all $z \in Z$. The mean choice intensity for all unemployed workers, $m_t$, can thus be calculated by integrating over the support of $z$ as follows

$$m_t = \int_Z k_t(z) g(z) dz. \quad (3.7)$$
This formulation attributes a much richer set of interpretations to our formulation in Section 2, which closely follows Brock and Durlauf (2001a) in nature. In Section 2, \( m \) is time invariant. In fact, we calculate \( m \) based on a fixed subjective density reflecting the workers’ beliefs on the behaviors of other workers. In that formulation, the rate of unemployment does not affect unemployed workers’ decision about whether to use informal contacts or not. In this dynamic setting, however, the rate of unemployment is a crucial object in determining \( m_t \).

The unemployed workers decide whether to use informal links or not. \( u_t(z) \) evolves for each \( z \) and, therefore, the mass of workers who make this decision evolves. As a result, \( m_t \) evolves.

For the rest of this section, we focus on steady state outcomes since the dynamics of \( m_t \) is complicated. Notice that, at the steady state,

\[
k(z) = \begin{cases} 
\frac{\gamma}{\gamma + \alpha(1)}, & \text{if } a_z = 1, \\
-\frac{\gamma}{\gamma + \alpha(1)}, & \text{if } a_z = -1.
\end{cases} \tag{3.8}
\]

Therefore, the population-level mean behavior at the steady state is

\[
m = \int_Z k(z) g(z) dz. \tag{3.9}
\]

### 3.2 Steady state

Using the setup in Section 2, the expected discounted sum of utility of an employed worker at the steady state is

\[
V_e(m) = v(w) + \beta \left[ \gamma V_u(m) + (1 - \gamma) V_e(m) \right], \tag{3.10}
\]

which can be rewritten as

\[
V_e(m) = \frac{v(w)}{1 - \beta(1 - \gamma)} + \frac{\beta \gamma V_u(m)}{1 - \beta(1 - \gamma)}. \tag{3.11}
\]
The steady state Bellman equation for the unemployed worker is

$$V_u(m) = \max_{a_i} \left\{ v(c) - (Ja_i m + \epsilon_i(a_i)) + \beta [\pi(a_i)V_e(m) + (1 - \pi(a_i))V_u(m)] \right\}. \tag{3.12}$$

Thus, just as in Section 2, the choice problem yields the probability rule

$$\mathbb{P}[a_z = 1 | m] = \mathbb{P}[V_{u,1}(m) \geq V_{u,-1}(m) | m] \tag{3.13}$$

$$= \mathbb{P} \left[ z \leq \Psi_1 v(c) + \Psi_2 Jm + \Psi_3 v(w) \bigg| m \right]. \tag{3.14}$$

Since $z$ is a cost element, unemployed workers who have small $z$ will be more likely to choose $a_z = 1$. From (3.14), it easy to see that there exists a steady-state threshold $\bar{z}$, below which workers choose $a_z = 1$ and above which $a_z = -1$. Formally,

$$a_z = \begin{cases} 
1, & \text{if } z \leq \bar{z}, \\
-1, & \text{if } z > \bar{z}. 
\end{cases} \tag{3.15}$$

The location of $\bar{z}$ over the logistic distribution determines whether $m$ is large or small. If there exist two stable equilibrium, as we describe in Section 2, then there must exist two solution for $\bar{z}$.

Let $G(\cdot)$ denote the cdf corresponding to the standard logistic pdf $g(\cdot)$. We restate the steady state aggregate unemployment rate as follows:

$$u = \frac{\gamma}{\gamma + \pi(1)} G(\bar{z}) + \frac{\gamma}{\gamma + \alpha \pi(1)} [1 - G(\bar{z})]. \tag{3.16}$$

The steady-state mean behavior is, then,

$$m = \frac{\gamma}{\gamma + \pi(1)} G(\bar{z}) - \frac{\gamma}{\gamma + \alpha \pi(1)} [1 - G(\bar{z})]. \tag{3.17}$$

Next, we propose a simple algorithm that we can solve for $m$, $\bar{z}$, and $u$.

**Step 1.** Determine values for the model parameters $\kappa$, $J$, $\beta$, $\alpha$, $\gamma$, and $\pi(1)$. Assume a
functional form for the period utility, $v(\cdot)$.

**Step 2.** Solve for $m$ using the formula we derive in Section 2 for the hyperbolic tangent:

$$m = \tanh\left(\frac{\kappa}{2} [\Psi_1 v(c) + \Psi_2 Jm + \Psi_3 v(w)]\right).$$

This will give either a unique solution or two stable solutions for $m$.

**Step 3.** Solve for $\bar{z}$ using (3.17), the parameter values that we assume in Step 1, and the solution for $m$ in Step 2.

**Step 4.** Solve for $u$ using (3.16) and the solution for $\bar{z}$ in Step 3.

This section introduces the idea that, contrary to what we assume in Section 2, the mean behavioral outcome (i.e., social interactions) can be considered as an endogenous state variable. Although we derive a tractable distribution of unemployment over different worker types, wages are still exogenous which is unsatisfactory. One option is to introduce a wage offer distribution and to focus on the reservation wage strategy (see Appendix A.1 for such an extension).\(^9\) One problem is that, since our model does not have on-the-job search the Diamond (1971) paradox applies: if the firms could choose the wages to offer the workers, they would collude on a single wage and there would be no offer distribution. Another path to follow is to extend our analysis into the Mortensen-Pissarides search and matching framework. In such a version, wages will be determined via Nash bargaining. Since workers are heterogeneous, there will be a wage distribution in the equilibrium rather than a single wage. Next section extends our analysis into the Mortensen-Pissarides world. We link our results to the discussions in the informal networks literature.

---

\(^9\)In the Appendix, we show that an increase in the mean tendency among workers to use informal contacts increases the reservation wage. This is in line with Granovetter (1995).
4 Search and Matching with Social Interactions

4.1 Description of heterogeneity

Similar to the previous sections, we define \( z = \epsilon(1) - \epsilon(-1) \). Unlike what we have done before, we set \( \epsilon(-1) = 0 \), which implies that \( z = \epsilon(1) \). The interpretation is the following: \( z \) is the worker-specific cost of searching via informal channels. The heterogeneous private cost is zero when the worker uses only formal channels. This assumption is not critical for our analysis and just serves to simplify the algebra. For concreteness, we assume that the distribution of \( z \), which we denote with the cdf \( G(z) \), is logistic. But this assumption can be relaxed to allow for a general cdf \( G(z) \).

4.2 The matching technology

Let \( a_z \in \{-1, 1\} \) be the job search method for the type-\( z \) unemployed worker with \( a_z = -1 \) corresponds to formal job search and \( a_z = 1 \) when the worker uses also her informal contacts in job search. We write the job matching technology for each type-\( z \) unemployed worker as

\[
\mathcal{M} = \mathcal{M}(u(z), v) \tag{4.1}
\]

where \( u(z) \) is the rate of type-specific unemployment, \( v \) is the vacancy rate, and \( \mathcal{M}(\cdot) \) is of constant returns to scale with positive first-order and negative second-order partial derivatives. The functional form of the matching technology \( \mathcal{M}(\cdot) \) is homogeneous across types. See Galenianos (2010) for a similar formulation of the matching technology.

The type-specific Poisson process transfers workers from unemployment to employment at rate \( \mathcal{M}(u(z), v)/u(z) \). Hence, the transition probability of type-\( z \) unemployed worker in unit time is given by

\[
q(a_z) = h(a_z) \frac{\mathcal{M}(u(z), v)}{u(z)}, \tag{4.2}
\]
where \( h(-1) = \alpha h(1) \) with \( 0 < \alpha < 1 \) implying that job search via informal contacts is more productive. Following the conventional notation, we let \( \theta_z = v/u(z) \) to describe tightness of the labor market for type-\( z \) workers. So,

\[
q(a_z) = h(a_z)M(1, \theta_z).
\]  

(4.3)

Since \( \theta_z \) is a parameter, we switch to the notation \( q(a_z, \theta_z) \).

The process that transfers a job from a vacant state to a filled one (with a type-\( z \) worker) is also Poisson with rate \( M(u(z), v)/v \). Hence, each vacancy’s transition probability in unit time is

\[
q_{f,z} = \frac{M(u(z), v)}{v} = M(1/\theta_z, 1).
\]  

(4.4)

Notice that \( q(a_z, \theta_z) \) and \( q_{f,z} \) (switching to notation \( q_f(\theta_z) \)) are related by

\[
q(a_z, \theta_z) = h(a_z)\theta_z q_f(\theta_z),
\]  

(4.5)

for all \( z \in \mathcal{Z} \).

Let \( \gamma \) be the rate at which job destruction shocks arrive. Standard calculations yield that the equilibrium condition for unemployment—i.e., the Beveridge curve—for type-\( z \) workers, for all \( z \in \mathcal{Z} \), is given by

\[
u(z) = \frac{\gamma}{\gamma + h(a_z)\theta_z q_f(\theta_z)}.
\]  

(4.6)

and, therefore, the equilibrium rate of aggregate unemployment is

\[
u = \int_{\mathcal{Z}} \frac{\gamma}{\gamma + h(a_z)\theta_z q_f(\theta_z)} dG(z),
\]  

(4.7)

where \( G(\cdot) \) is the cdf of worker types. As before, the average choice of the job search method
for type-\(z\) unemployed workers is

\[
m = \int_{z} k(z) dG(z) \tag{4.8}
\]

where \(k(z) = a_z u(z)\).

### 4.3 Workers

Before we state workers’ problem, we impose the following assumption on preferences for the sake of algebraic simplicity:

**Assumption 3.** *Workers are risk neutral in the sense that the period utility is a linear function of earnings, i.e., \(v(w) = w\).*

The unemployed worker receives the unemployment insurance \(c > 0\). The present discounted value from unemployment, for a worker of type \(z\), is

\[
rV_u^z(m) = c - (Ja_z m + \epsilon(a_z)) + [h(a_z) \theta_z q_f(\theta_z)] (V_e^z(m) - V_u^z(m)) \tag{4.9}
\]

and the present discounted value from employment, for a worker of type \(z\), is

\[
rV_e^z(m) = w(z) + \gamma (V_u^z(m) - V_e^z(m)). \tag{4.10}
\]

Clearly,

\[
V_e^z(m) = \frac{w(z) + \gamma V_u^z(m)}{r + \gamma}. \tag{4.11}
\]

As a result,

\[
V_u^z(m) = \frac{(r + \gamma) [c - (Ja_z m + \epsilon(a_z))] + h(a_z) \theta_z q_f(\theta_z)w(z)}{r \left[ r + \gamma + h(a_z) \theta_z q_f(\theta_z) \right]} \tag{4.12}
\]
and

\[ V^z_e(m) = \gamma \frac{[c - (Ja_z m + \epsilon(a_z))] + [r + h(a_z)\theta_z q_f(\theta_z)] w(z)}{r [r + \gamma + h(a_z)\theta_z q_f(\theta_z)]}. \] (4.13)

### 4.4 Firms

Let \( W_o \) be the present-discounted value of expected profit from an occupied job and \( W_v \) the present-discounted value of expected profit from a vacant job. Let the value of the job’s output when it is filled be \( p \), where \( p > 0 \) is fixed.

The asset value of an occupied job, \( W_o \), satisfies the Bellman equation, for a given wage \( w(z) \),

\[ r W_o^z = p - w(z) - \gamma W_o^z \quad \Rightarrow \quad W_o^z = \frac{p - w(z)}{r + \gamma}. \] (4.14)

The firm’s expected profit from one more job vacancy is

\[ r W_v^z = -p\tau + q_f(\theta_z)(W_o^z - W_v^z), \] (4.15)

where \( p\tau > 0 \) is the fixed hiring cost per time unit. Imposing the well-known equilibrium condition \( W_v^z = 0 \), for all \( z \), we get

\[ W_o^z = \frac{p\tau}{q_f(\theta_z)}. \] (4.16)

Combining the equations (4.14) and (4.16) gives

\[ p - w(z) - \frac{(r + \gamma)p\tau}{q_f(\theta_z)} = 0. \] (4.17)

### 4.5 Wage determination

We derive the wage rate via a Nash bargaining solution; that is, \( w(z) \) maximizes the weighted product of the type-\( z \) worker’s and the firm’s net return from the match. The wage rate
satisfies

\[ w(z) = \arg \max (V_e^z - V_u^z) \chi (W_o^z - W_v^z)^{1-\chi} \]  

(4.18)

where \( 0 \leq \chi < 1 \) is a constant and may be interpreted as a relative measure of labor’s bargaining strength. Note that \( \chi \) has to be strictly smaller than 1 for the firms to have an incentive to open a job. The first-order condition can be expressed as

\[ V_e^z - V_u^z = \chi (W_o^z + V_e^z - W_v^z - V_u^z), \]  

(4.19)

which, by substituting \( V_e^z \) and \( W_o^z \) in, can be converted into the following wage equation:

\[ w(z) = rV_u^z + \chi (p - rV_u^z). \]  

(4.20)

Using the formula for \( V_u^z \), we derive the final wage equation

\[ w(z) = (1 - \chi) [c - (Ja_zm + \epsilon(a_z))] + \chi p [1 + \tau h(a_z)\theta_z]. \]  

(4.21)

Notice that now we obtain an equilibrium wage distribution determined—apart from model parameters—by three major elements: (1) the distribution of \( z \), (2) the unemployed workers’ choice of whether to invoke her social contacts or not, and (3) the mean behavioral outcome, \( m \). Obviously,

\[ w(z) = \begin{cases} 
(1 - \chi) [c - (Jm + z)] + \chi p [1 + \tau h(1)\theta_z], & \text{if } a_z = 1, \\
(1 - \chi) [c + Jm] + \chi p [1 + \tau h(1)\theta_z], & \text{if } a_z = -1.
\end{cases} \]  

(4.22)

Next we present a detailed analysis of the wage structure in this economy.

### 4.6 Analysis of equilibrium wages

In this subsection, we bring together the equations (4.17) and (4.22) which come from the firms’ problem and workers’ problem, respectively.\(^\text{10}\) We carry out our analysis on a case by case basis.

\(^{10}\)In the literature, these two equations are also called the job creation equation and the wage equation, respectively.
case basis to increase the interpretability of the results.

**Case 1:** \((\chi = 0 \text{ and } a_z = -1)\). Suppose that the firm enjoys the entire surplus from the job and that the worker chooses to search via the formal methods only. Under such a scenario, bringing together the equations (4.17) and (4.22) yields the expression

\[
q_f(\theta_z) = \frac{p\tau(r + \gamma)}{p - (c + Jm)}.
\] (4.23)

Obviously, the tightness parameter \(\theta_z\) does not depend on the type of the workers when \(\chi = 0\) and \(a_z = -1\). In other words, the unemployment rate is the same across worker types who search jobs only through formal channels. This can easily be generalized into the case with \(0 \leq \chi < 1\).

**Case 2:** \((0 \leq \chi < 1 \text{ and } a_z = -1)\). Now we consider intermediate values for \(\chi\). It is easy to see that \(\theta_z\), and therefore \(u(z)\), does not depend on \(z\). The equation now becomes

\[
(1 - \chi)[c + Jm] + \chi p(1 + \tau\alpha h(1)\theta_z) = p \left(1 - \frac{\tau(r + \gamma)}{q_f(\theta_z)}\right).
\] (4.24)

It is clear that \(\theta_z\) is independent of \(z\). The following proposition formally states this result without proof.

**Proposition 1.** \(\theta_z = \tilde{\theta}\) for all worker types who choose \(a_z = -1\). This implies that \(u(z) = \tilde{u}\), when \(a_z = -1\).

Next we consider what happens for those workers who also invoke their informal contacts in their job search. It is instructive to start with the case for \(\chi = 0\).

**Case 3:** \((\chi = 0 \text{ and } a_z = 1)\). When the workers invoke also their informal contacts, the tightness parameter \(\theta_z\) becomes a function of \(z\) as below:

\[
q_f(\theta_z) = \frac{p\tau(r + \gamma)}{p - c + (Jm + z)}.
\] (4.25)

The relationship between \(\theta_z\) and \(z\) is clear in this case. As \(z\) (the worker-specific cost of
invoking informal contacts) goes up, $\theta_z$ increases since, by definition, $q'_f(\theta_z) \leq 0$. This result is intuitive. Rejecting an offer and staying unemployed for at least one more period is less costly, the lower $z$ is. Given the vacancy rate $v$, this leads to greater unemployment rates for those enjoying stronger links (low $z$). To see this more clearly, remember that $\theta_z = v/u(z)$. Given $v$, a decrease in $z$ (i.e., a decrease in the cost of informal job search) will lead to a decline in $\theta_z$, which means that $u(z)$ will go up. Another interpretation is that reservation wages are higher for those enjoying lower values of $z$. This result is easy to generalize for the case $0 \leq \chi < 1$.

**Case 4:** ($0 \leq \chi < 1$ and $a_z = 1$). The result that $\theta_z$ increases with type $z$ holds for this general case as well. Before we formally state this result, we write out the formula

$$(1 - \chi)[c - (Jm + z)] + \chi p(1 + \tau h(1)\theta_z) = p\left(1 - \frac{\tau(r + \gamma)}{q_f(\theta_z)}\right).$$

(4.26)

The following proposition gives a formal statement.

**Proposition 2.** For those workers who invoke their informal contacts, the labor market becomes tighter as the worker-specific cost of searching via informal channels goes up.

**Proof:** It is sufficient to differentiate the expression above with respect to $z$, which yields

$$p\tau \left[\chi h(1) - \frac{(r + \gamma)\partial q_f}{q_f(\theta_z)^2}\right] d\theta_z = (1 - \chi)dz.$$ 

(4.27)

By definition, $\frac{\partial q_f}{\partial \theta_z} \leq 0$. It follows that $d\theta_z/dz \geq 0$. ■

To put it differently, unemployment rates are lower, the higher the cost of invoking social contacts. This is again related to reservation wages as we explain above. The tightness parameter and, thus, the unemployment rate are constant for those who invoke formal contacts only. For workers who invoke also their informal contacts however, there are distributions of labor market tightness and the unemployment rate across types. These distributions can easily be calculated using $G(z)$, and equations (4.17) and (4.22).
The main goal in this section is to demonstrate that our model is able to capture the stylized fact #1. The question that we try to answer is the following. What is the relationship between the decision to invoke social contacts and the level of the wage received? The results that the literature report are dispersed in a wide spectrum. At one extreme, several papers including Rosenbaum et al. (1999), Marmaros (2001), and Marmaros and Sacerdote (2002) find large positive correlations between invoking informal networks and obtaining high-paying jobs. On the other extreme, Elliot (1999) and Loury (2006) show that the wages received by at least some types of workers who find job through informal contacts are correlated with lower wages. At the middle, Bridges and Villemez (1986), Holzer (1987), and Marsden and Hurlbert (1988) document no general earnings effects.

The framework we present unifies and embeds all the results reported along this spectrum. More precisely, we show that invoking informal contacts is associated with higher wages—than wages paid by jobs found through formal ways—for some workers and lower wages for others. The direction and the strength of social forces are the main determinants of the cutoff point.

Before we state our major findings, we state the following propositions.

**Proposition 3.** The wages that the jobs found via formal channels pay are fixed, whereas the wages paid by jobs found through informal channels depend on the type. Formally,

\[
w(z) = \begin{cases} 
\omega(z), & \text{if } a_z = 1, \\
\bar{w}, & \text{if } a_z = -1.
\end{cases}
\]  

(4.28)

**Proof:** The proof follows from the result that the labor market tightness parameter is fixed at \( \tilde{\theta} \) for those workers who rely on formal job search channels and from Equation (4.17). \( \blacksquare \)

**Proposition 4.** \( \omega(z) \) < \( \bar{w} \) for those \( z \) who have \( \theta_z > \tilde{\theta} \), and vice versa.

**Proof:** The proof follows from Equation (4.17) and, by definition, from \( q'_{\theta}() \leq 0 \). \( \blacksquare \)

In words, the wage levels are particularly low for the worker types whose tightness parameters are high. The key issue here is to determine whether \( \theta_z > \tilde{\theta} \) or not. This is where social forces come in. The following proposition clears up this issue.
To understand fully how the wage determination works, one needs to figure out systematically which workers choose \( a_z = -1 \) and which ones choose \( a_z = 1 \). Next we solve this question.

### 4.7 Optimal choice of the search method

As in Section 2, the unemployed worker of type \( z \) chooses \( a_z = 1 \) over \( a_z = -1 \) if \( V_{u,1}^z(m) > V_{u,-1}^z(m) \). Therefore, \( \mathbb{P}[a_z = 1|m] = \mathbb{P}[V_{u,1}^z(m) > V_{u,-1}^z(m)|m] \). Using the formulas we derive above,

\[
V_{u,1}^z(m) = \frac{(r + \gamma)[c - (Jm + z)] + h(1)\theta_z q_f(\theta_z)(1 - \chi)}{r + \gamma + h(1)\theta_z q_f(\theta_z)} w(z). \tag{4.29}
\]

The unemployed worker takes the firms’ actions as given when making her own choice of the search method. From (4.17), we know that

\[
w(z) = (1 - \chi)[c - (Jm + z)] + \chi p [1 + \tau h(1)\theta_z] \tag{4.30}
\]

when \( a_z = 1 \). Therefore,

\[
V_{u,1}^z(m) = \frac{[r + \gamma + h(1)\theta_z q_f(\theta_z)(1 - \chi)] (c - (Jm + z)) + \chi ph(1)\theta_z q_f(\theta_z) [1 + \tau h(1)\theta_z]}{r + \gamma + h(1)\theta_z q_f(\theta_z)}. \tag{4.31}
\]

Similarly, when \( a_z = -1 \), the wage equation becomes

\[
w(z) = (1 - \chi)[c + Jm] + \chi p [1 + \tau \alpha h(1)\theta_z], \tag{4.32}
\]

which implies that

\[
V_{u,-1}^z(m) = \frac{[r + \gamma + \alpha h(1)\theta_z q_f(\theta_z)(1 - \chi)] (c + Jm) + \chi p \alpha h(1)\theta_z q_f(\theta_z) [1 + \tau \alpha h(1)\theta_z]}{r + \gamma + \alpha h(1)\theta_z q_f(\theta_z)}. \tag{4.33}
\]
Following the choice rule,

$$\mathbb{P}[a_z = 1|m] = \mathbb{P}[V_{u,1}^z(m) \geq V_{u,-1}^z(m)|m] \quad (4.34)$$

it is easy to show that

$$\mathbb{P}[a_z = 1|m] = \mathbb{P}[z \leq \Psi_1 c + \Psi_2 Jm + \Psi_3 \chi p], \quad (4.35)$$

where we set

$$\Psi_1 = \int_Z \left( \frac{r + \gamma + h(1)\theta q_f(\theta_z)(1 - \chi)}{r + \gamma + h(1)\theta q_f(\theta_z)} - \frac{r + \gamma + \alpha h(1)\theta q_f(\theta_z)(1 - \chi)}{r + \gamma + \alpha h(1)\theta q_f(\theta_z)} \right) dG(z), \quad (4.36)$$

$$\Psi_2 = -\int_Z \left( \frac{r + \gamma + h(1)\theta q_f(\theta_z)(1 - \chi)}{r + \gamma + h(1)\theta q_f(\theta_z)} + \frac{r + \gamma + \alpha h(1)\theta q_f(\theta_z)(1 - \chi)}{r + \gamma + \alpha h(1)\theta q_f(\theta_z)} \right) dG(z), \quad (4.37)$$

and

$$\Psi_3 = \int_Z \left( h(1)\theta q_f(\theta) \left[ \frac{1 + kh(1)\theta}{r + \gamma + h(1)\theta q_f(\theta)} - \frac{\alpha(1 + k\alpha h(1)\theta)}{r + \gamma + \alpha h(1)\theta q_f(\theta)} \right] \right) dG(z). \quad (4.38)$$

It is straightforward to prove that $\Psi_1 \leq 0$, $\Psi_2 \leq 0$, and $\Psi_3 > 0$ just as in Sections 2 and 3.

Again, given the parameters, the mean behavioral outcome, $m$, can be computed by calculating the conditional mean $\mathbb{E}[a_z|m]$, which yields

$$m = \tanh \left( \frac{K}{2} [\Psi_1 c + \Psi_2 Jm + \Psi_3 \chi p] \right). \quad (4.39)$$

### 4.8 The equilibrium threshold

From (4.35), there exists an endogenous threshold $\bar{z}$ below which the unemployed worker chooses $a_z = 1$ (because of the cost advantage of informal search) and above which the unemployed worker sets $a_z = -1$. As a result, the following equations for the unemployment rate, the wage level, the tightness parameter, and the mean behavioral outcome hold at the
equilibrium:

\[ u(z) = \frac{\gamma}{\gamma + h(a_z)\theta q_f(\theta_z)}, \quad (4.40) \]

\[ w(z) = (1 - \chi)[c - (Ja_z m + z)] + \chi p[1 + \tau h(a_z)\theta], \quad (4.41) \]

\[ p - w(z) - \frac{(r + \gamma)p\tau}{q_f(\theta_z)} = 0, \quad (4.42) \]

\[ k(z) = a_z u(z), \quad (4.43) \]

and

\[ m = \tanh\left(\frac{K}{2}\left[\Psi_1 c + \Psi_2 Jm + \Psi_3 \chi p\right]\right). \quad (4.44) \]

This is a system with five equations in the five unknowns \( \bar{z}, m, u, \theta, w \). The first equation is equivalent to (4.7), which corresponds to the Beveridge curve. The second equation is the aggregate version of the type-specific wage equation (4.22), which corresponds to the wage curve. The third equation comes from the firms’ equilibrium condition (4.17) and it corresponds to the marginal condition for the aggregate demand for labor. The fourth equation describes the steady-state condition for the mean behavioral outcome. The fifth equation describes the social interactions in the spirit of Brock and Durlauf (2001a).

In this section, we study a Mortensen-Pissarides search and matching model of social interactions. We derive equilibrium distributions of unemployment and wages across worker types. The solution is consistent with several stylized facts documented in the informal networks literature. It shows that wage offers generated through informal job search channels can be higher or lower than those generated through formal channels depending on the strength of social interactions. Moreover, with multiple equilibria, it is possible to have more than one
stable solution to the model. This motivates the discussion in the next section. If there are multiple equilibria and if the economy switch between low and high equilibrium outcomes as a response to aggregate shocks, then unemployment rate—which is closely related to the mean behavioral outcome—can vary significantly with aggregate shocks. Next we relate this discussion to the so-called “Shimer puzzle” [see Shimer (2005)].

5 Aggregate Shocks

In this section, we build on the model we present in the previous section. Time is discrete and indexed by $t$. The aggregate state of the economy is characterized by $p_t \in \{p_1, \ldots, p_N\}$, where the changes of the state are determined by a Poisson process with state-contingent arrival rates, $\tau_i$, and state-contingent transition probabilities, $\lambda_{ji} = \mathbb{P}[j|i]$. As in the previous section, $p$ corresponds to the value of the job’s output. Aggregate shocks accrue at the beginning of each period.

**Workers.** The structure of heterogeneity is the same as the one we describe in the previous section (i.e., $z = \epsilon(1) - \epsilon(-1)$, where $\epsilon(-1) = 0$, $\epsilon(1) = z$, and $z$ has a logistic cdf $G(\cdot)$). Now we normalize the mass of all workers to 1. Workers are paired with identical firms to form productive units. The matching procedure is described in the previous section. The period output of a job, if the worker is of type $z$ and aggregate productivity is $p_i$, is denoted $P_i(z) = p_i - \epsilon(a_{z,i})$. We assume that firms cannot direct their search to specific worker types.

**Turnover.** Matches form and break at the beginning of each period, after the aggregate state has been reset for the whole period. The definitions we made for the type-specific and aggregate unemployment rates hold also in this case with one difference. If the economy remains in state $i$ forever, the steady state unemployment rate for type-$z$ workers is

$$u_i(z) = \frac{\gamma}{\gamma + h(a_{z,i})\theta_i q_f(\theta_i)}.$$  \hspace{1cm} (5.1)
The associated value equations can then be written as

\[ rW_o^{z,i} = (p_i - \epsilon(a_{z,i})) - w_i(z) - \gamma W_o^{z,i} + \tau_i \sum_j \lambda_{ji}(W_o^{z,j} - W_o^{z,i}), \]  
\[ (5.2) \]

\[ rW_v^{z,i} = -p_i k + q_f(\theta_i)(W_o^{z,i} - W_v^{z,i}) + \tau_i \sum_j \lambda_{ji}(W_v^{z,j} - W_v^{z,i}), \]  
\[ (5.3) \]

\[ rV_e^{z,i}(m_i) = w_i(z) + \gamma (V_u^{z,i}(m_i) - V_e^{z,i}(m_i)) + \tau_i \sum_j \lambda_{ji}(V_e^{z,j}(m_j) - V_e^{z,i}(m_i)), \]  
\[ (5.4) \]

\[ rV_u^{z,i}(m_i) = c - (Ja_{z,i}m_i + \epsilon(a_{z,i})) + [h(a_{z,i})\theta_iq_f(\theta_i)](V_e^{z,i}(m_i) - V_u^{z,i}(m_i)) \]  
\[ + \tau_i \sum_j \lambda_{ji}(V_u^{z,j}(m_j) - V_u^{z,i}(m_i)). \]  
\[ (5.5) \]

The economy with aggregate risk can be analyzed in almost closed form similar to the one we present in Section 4. Now the aggregate behavioral outcome, \( m_i \), can be formulated as

\[ m_i = \frac{\gamma}{\gamma + h(1)\theta_iq_f(\theta_i)}G(\bar{z}_i) - \frac{\gamma}{\gamma + \alpha h(1)\theta_iq_f(\theta_i)} [1 - G(\bar{z}_i)]. \]  
\[ (5.6) \]

We show, in previous sections, that the economy may exhibit multiple equilibria in the sense that \( m_i \) may either have a unique solution or two stable solutions. This means that the mean tendency in the economy may either to heavily rely on informal sources or on formal sources. Mechanically, aggregate shocks can lead to such sharp unemployment movements in our model. Therefore, other than wage stickiness, household production, and value of leisure, the existence of social interactions in search effort can also generate significant volatility in unemployment.
6 Concluding Remarks

Standard models of the labor market focus on individual characteristics, such as human capital levels, but usually disregard group level variables, such as the pattern of social connections between individuals in the market. Yet, several empirical accounts show that employment is widely influenced by networks and interpersonal ties. Moreover, workers belonging to the same group tend to behave similarly. Many social scientists have hypothesized that this is due to interactions in which the propensity of an agent to behave in some way varies positively with the prevalence of this behavior in the group. There is, thus, more to labor markets than a mere anonymous confrontation between demand and supply. The informal networks literature identifies this missing piece as the relationship between informal contacts and employment.

Most of the initial research on the economics of informal contacts have assessed the role of job contacts on outcomes by comparing outcomes with to outcomes without job contacts. The modern literature, on the other hand, studies the specific ways in which the effects of informal networks depend on differences among job seekers, on the characteristics of the job search methods they use, and on various aspects of group level variables. Empirical research makes clear that these components interact with each other to produce the variation we observe in the use and effects of informal hiring channels. This has been confirmed by modern theoretical research.

Our paper proposes a novel way to understand various aspects of the relationship between informal networks and labor market outcomes. We embed the “preference interactions” structure (see Manski (2000) for a precise definition of this concept) first into a standard sequential job search model and then into the Mortensen-Pissarides search and matching model to assess how informal search methods affect unemployment dynamics and associated economic outcomes. More generally, our paper proposes a new approach for examining the effect of social interactions based on variation in preference on whether to establish contact with friends and relatives to find a job or not. This is important because, if more than fifty percent of all jobs
are filled by means of informal hiring channels, then mechanisms describing the evolution of unemployment should take these into account. Our paper serves to fill this gap.

The literature on informal hiring channels in job search focuses almost exclusively on the behavioral differences among groups with different sociodemographic characteristics. There is only little work on modeling the economic foundations of the use and extent of these channels. This paper proposes such a model which is consistent and coherent with the major stylized facts documented in the literature. In addition, we show that our model is capable of dealing with many other unanswered and not-yet-studied questions including the effect of labor market institutions on the development of informal hiring channels. This is a potentially interesting research topic because we observe that informal contacts are used with differing intensities in regions with different labor market institutions.
A Appendix

A.1 Reservation wages and unemployment

The basic model we study in Section 2 makes—for the purpose of concreteness—two important assumptions: binary discrete choice on whether to use informal channels or not and degenerate wage draws. These assumptions are very useful in establishing rigorous links between the basic search theory and the literature on social interactions and employment. However, these are oversimplifying assumptions especially if one wants to study the implications of social interactions for reservations wages and the flows between employment and unemployment. In this section, we relax these assumptions and consider a modification of our model in which (i) we assume that the unemployed worker $i$ can choose the degree of using the informal channels within the interval $a_i \in [0, 1]$ and (ii) we relax the degenerate wage draws assumption and introduce a distribution function $F(\cdot)$ from which the worker draws an offer $w$ each period. This is the basic textbook model of job search.

We use the following trick to characterize the optimal search strategy. Let $Z$ denote the mathematical expectation of the value function for an optimally behaving unemployed worker before getting an offer. For notational simplicity, we assume risk-neutrality, i.e., $v(c) = c$. Parallel to our formulation in Section 2, the value function for an employed worker is

$$V_e(w,a) = w + \beta \left[ \gamma Z + (1 - \gamma)V_e(w,a) \right] \quad (A.1)$$

which can be rewritten as

$$V_e(w,a) = \frac{w}{1 - \beta(1 - \gamma)} + \frac{\beta \gamma Z}{1 - \beta(1 - \gamma)} \quad (A.2)$$

The Bellman equation of an unemployed worker, who has an offer $w$ in hand and who prefers
to use informal hiring channels with intensity \(a > 0\), is

\[
V_u(w, a) = \max \left\{ w - \rho(a, m, \epsilon_i(a)) + \beta \left[ \gamma Z + (1 - \gamma) V_e(w, a) \right], \ c - \rho(a, m, \epsilon_i(a)) + \beta Z \right\}. \quad (A.3)
\]

We plug \(V_e(w, a)\) into Equation (A.3). Obviously, the optimal strategy is to accept the offer if it is greater than or equal to the reservation wage, \(\bar{w}\), and to reject the offer if it is smaller than \(\bar{w}\). The reservation wage makes the worker indifferent between accepting or rejecting the offer. Therefore,

\[
\bar{w} = \left[ 1 - \beta(1 - \gamma) \right] (c + \beta Z) - \beta \gamma Z. \quad (A.4)
\]

In this formulation, the expected value of being unemployed before the offer has been received, \(Z\), must be determined endogenously. The optimal strategy of the unemployed worker formulated in terms of the value functions is given by

\[
V_u(w, a) = \begin{cases} 
\left( \frac{1}{1 - \beta(1 - \gamma)} \right) w - \rho(a, m, \epsilon_i(a)) + \beta \gamma \left( \frac{1}{1 - \beta(1 - \gamma)} \right) Z, & w \geq \bar{w}, \\
\frac{1}{1 - \beta(1 - \gamma)} (c - \rho(a, m, \epsilon_i(a)) + \beta Z), & w < \bar{w}.
\end{cases} \quad (A.5)
\]

We define

\[
\mathbb{E}[V_u(w, a)] = \int_0^\infty V_u(w, a) dF(w) \quad (A.6)
\]

which, using the Leibniz rule for differentiation under the integral sign, can be decomposed as follows:

\[
\mathbb{E}[V_u(w, a)] = (c + \beta Z) F(\bar{w}) + \left( \frac{1}{1 - \beta(1 - \gamma)} \right) \int_{\bar{w}}^\infty w dF(w) - \rho(a, m, \epsilon_i(a)) + \beta \gamma \left( \frac{1}{1 - \beta(1 - \gamma)} \right) Z (1 - F(\bar{w})). \quad (A.7)
\]
We rearrange Equation (A.4) and get
\[
\frac{\beta \gamma Z}{1 - \beta (1 - \gamma)} = (c + \beta Z) - \frac{\bar{w}}{1 - \beta (1 - \gamma)} \tag{A.8}
\]
which we plug into Equation (A.7) and obtain
\[
\mathbb{E}[V_u(w, a)] = \frac{1}{1 - \beta (1 - \gamma)} \int_{\bar{w}}^{\infty} (w - \bar{w}) \, dF(w) + c + \beta Z - \rho(a, m, \epsilon_i(a)). \tag{A.9}
\]
When the unemployed worker chooses not to invoke his social contacts, i.e., \( a = 0 \), the probability of receiving an offer becomes zero which implies that
\[
\mathbb{E}[V_u(w, 0)] = c + \beta Z \tag{A.10}
\]
and, therefore, that
\[
\mathbb{E}[V_u(w, a)] = \frac{1}{1 - \beta (1 - \gamma)} \int_{\bar{w}}^{\infty} \ell(w) \, dF(w) + \mathbb{E}[V_u(w, 0)] - \rho(a, m, \epsilon_i(a)) \tag{A.11}
\]
where \( \ell(w) = w - \bar{w} \). If the unemployed worker invokes his social contacts with intensity \( a \), he gets an offer with probability \( \pi(a) \) and expected value \( \mathbb{E}[V_u(w, a)] \). With probability \( 1 - \pi(a) \) he gets no offers. This alternative has value \( \mathbb{E}[V_u(w, 0)] - \rho(a, m, \epsilon_i(a)) \). Then the value of the problem for an unemployed worker who behaves optimally is given by \( Z \), where \( Z \) satisfies
\[
Z = \max_{a} \left\{ \pi(a) \mathbb{E}[V_u(w, a)] + (1 - \pi(a)) \left[ \mathbb{E}[V_u(w, 0)] - \rho(a, m, \epsilon_i(a)) \right] \right\}. \tag{A.12}
\]
This is equivalent to the formula
\[
Z = \max_{a} \left\{ \frac{\pi(a)}{1 - \beta (1 - \gamma)} \int_{\bar{w}}^{\infty} \ell(w) \, dF(w) + c + \beta Z - \rho(a, m, \epsilon_i(a)) \right\}. \tag{A.13}
\]
The right-hand side defines a mapping from \( Z \) into real numbers. To guarantee that the problem is well behaved, we want to show that one such \( Z \) exists. \( Z \) affects \( \bar{w} \) and \( \ell(w) \), so that the mapping is highly nonlinear. In any case, it is clear that \( Z \), and therefore \( \bar{w} \), are independent of \( a \) but depends on \( m \). Let \( R \) be the mapping defined by the right-hand side of
Equation (A.13). Because $\pi(a)$ is increasing in $a$, we have that

$$RZ \leq \frac{1}{1 - \beta(1 - \gamma)} \int_\bar{w}^\infty \ell(w)dF(w) + c + \beta Z$$  \hspace{1cm} (A.14)

$$\leq \frac{1}{1 - \beta(1 - \gamma)} \int_0^\infty wdF(w) + c + \beta Z \equiv \bar{R}Z.$$  \hspace{1cm} (A.15)

Therefore, if $Z'$ is such that $Z' = \bar{R}Z'$ (such a $Z'$ is easy to compute directly), it follows that, for all $Z \geq Z'$, $Z \geq \bar{R}Z$. Thus $\forall Z \geq Z'$, $RZ \leq Z$. On the other hand,

$$RZ \geq \left\{ \frac{\pi(0)}{1 - \beta(1 - \gamma)} \int_\bar{w}^\infty \ell(w)dF(w) + c + \beta Z \right\} = c + \beta Z \equiv RZ.$$  \hspace{1cm} (A.16)

Then, we have that, for all $Z \geq 0$, $RZ \leq RZ \leq \bar{R}Z$ and $R \cdot 0 > 0$. Hence, we have established that $R \cdot 0 > 0$ and that there exists $Z' < \infty$ such that $RZ \leq Z$ for $Z \geq Z'$. Because of the fact that $R$ is a continuous function of $Z$ (this follows because $\bar{w}$ is continuous in $Z$, as is $\ell(w)$), we establish that there exists a $\bar{Z}$ such that $R\bar{Z} = \bar{Z}$.

We next prove that $\bar{Z}$ is unique. To do so, it suffices to show that the mapping $R$ is monotone in $Z$. A sufficient condition is that

$$0 \leq \frac{\partial}{\partial \bar{w}} \left[ \int_\bar{w}^\infty \ell(w)dF(w) \right] \frac{\partial \bar{w}}{\partial Z} + \beta < 1.$$  \hspace{1cm} (A.17)

Still, $(\partial/\partial \bar{w}) \left[ \int_\bar{w}^\infty \ell(w)dF(w) \right]$ is (using the Leibniz rule) equal to $-\left[1 - 1/\bar{w}\right]\left[1 - F(\bar{w})\right]$. From the equation determining $\bar{w}$, we get that $\left[1 - 1/\bar{w}\right](\partial \bar{w}/\partial Z) = \beta(1 - \beta)(1 - \gamma)$. Because

$$\left[ -\left[1 - F(\bar{w})\right] \beta(1 - \beta)(1 - \gamma) + \beta \right] \in (0, 1),$$

however, $R$ is increasing. Next, we use Equation (A.13) to characterize the optimal choice of $a$. It is clear that it satisfies

$$\pi'(\bar{a}) \frac{1}{1 - \beta(1 - \gamma)} \int_\bar{w}^\infty \ell(w)dF(w) = 1,$$  \hspace{1cm} (A.18)

if the solution is interior. We assume that the distribution of $w$ has sufficient mass in the
tail to make informal job search attractive—that is, we assume that the solution is interior. It is being claimed that it is possible to make assumptions about the deep parameters of the model, $F(w), \gamma, \beta, c, \pi(a), m$, that will guarantee that the optimal choice of $a$ is $a > 0$. We focus on this case only because the other case is trivial. From Equation (A.13), it is clear that the optimal $Z$ satisfies

$$Z = \frac{1}{1 - \beta} \left[ \frac{\pi(\bar{a})}{1 - \beta(1 - \gamma)} \int_{\bar{w}}^{\infty} \ell(w) dF(w) + c - \rho(\bar{a}, m, \epsilon_i(\bar{a})) \right].$$

(A.19)

Using this equation in Equation (A.4), we obtain another, more familiar characterization of the optimal reservation wage,

$$\bar{w} = c - \beta(1 - \gamma)\rho(\bar{a}, m, \epsilon_i(\bar{a})) + \frac{\beta(1 - \gamma)\pi(\bar{a})}{1 - \beta(1 - \gamma)} \int_{\bar{w}}^{\infty} (w - \bar{w}) dF(w).$$

(A.20)

Then, Equations (A.20) and (A.18) summarize the determination of the endogenous variables, $\bar{a}$ and $\bar{w}$. Obviously, greater social interactions (i.e., greater $Jm$) would reduce the cost of job search via informal channels and, therefore, would increase the reservation wage.

This result displays our contribution to the search literature. The search-theoretic models have the property that the effort level $a$ does not affect the choice of the reservation wage. Our result is consistent with this. We show, however, that the reservation wage depends also on the mean behavior $m$. That is, the average behavior in the population, in terms of the intensity of job search via informal channels, affects the optimal search strategy.

### A.2 Strong and weak ties

In this section, we extend the basic model presented in Section 2 to incorporate several implications of the strength-of-weak-ties hypothesis developed in Granovetter (1973, 1995). According to this hypothesis, workers find jobs through personal contacts (weak and strong ties) and formal channels. It says that workers frequently locate jobs through “weak ties” (i.e., acquaintances) rather than “strong ties” (i.e., close friends). This idea is motivated in different ways in the literature. For example, Granovetter (1973) argues that weak ties produce
more valuable information about job openings than strong ties do. Lin (1982), on the other hand, suggests that job offers generated through weak ties are drawn from a superior wage distribution. In a related paper, Montgomery (1992) argues that workers who find job through strong ties earn strictly lower wages.\footnote{Goel and Lang (2009) establish that this wage differential is increasing in absolute value in network strength.}

Our purpose in this section is to establish connections between this literature and the basic model we present in section 2. To pursue this goal, we first re-interpret the set of discrete choices $a_i = \{-1, 1\}$ that the unemployed worker has. In this version of our model, $a_i = -1$ means that the unemployed worker invokes only his strong ties to search via informal channels and $a_i = 1$ means that he invokes also his weak ties. The interpretation is simple; it requires less effort—therefore, it is less costly (where the cost is in units of utiles)—to keep in touch with strong ties.

Unlike the setup in Section 2, there are now two distinct wages available for the unemployed. When the unemployed worker chooses only to invoke his strong ties, the wage available to him is $w_s$. When he invokes also his weak ties, the wage available to him becomes $w_w$. Following the convention in the literature, we assume that $w_w > w_s$; that is, the unemployed worker is paid a strictly higher wage when he finds a job by choosing $a_i = 1$. Notice that, although the formulation is simple, it captures that idea that the weak ties are more likely to provide new information than are strong ties, which is similar to Granovetter (1973, 1995). This simplification enables us to capture the salient features of the strength-of-weak-ties hypothesis.

When the worker chooses to invoke only his strong ties, the probability that he receives an offer, $\pi(-1) \in [0, 1]$, is greater than the probability of receiving a job offer when he also invokes his weak ties, which we denote with $\pi(1) \in [0, 1]$. In other words, $\pi(-1) > \pi(1)$ implies that strong ties are more likely to generate a job offer. This is similar to Montgomery (1992).\footnote{Notice that this simple exercise captures the idea that greater probability of accepting a job offer reduces the reservation wage and provides incentives for the unemployed worker to accept lower wages.}

After these definitions, we can formulate the value functions for the employed workers as
follows. The value function for an employed worker who works in a job paying $w_s$ is

$$V_e^s = v(w_s) + \beta \left[ \gamma V_u + (1 - \gamma) V_e^s \right]$$  \hspace{1cm} (A.21)

which implies that

$$V_e^s = \frac{v(w_s)}{1 - \beta(1 - \gamma)} + \frac{\beta \gamma V_u}{1 - \beta(1 - \gamma)}.$$  \hspace{1cm} (A.22)

Similarly, the value function for the employed worker who is paid $w_w$ is

$$V_e^w = \frac{v(w_w)}{1 - \beta(1 - \gamma)} + \frac{\beta \gamma V_u}{1 - \beta(1 - \gamma)}.$$  \hspace{1cm} (A.23)

The Bellman equation for the unemployed worker is

$$V_u = \max_{a_i} \left\{ v(c) - (J a_i m + \epsilon_i(a_i)) + \beta \left[ \pi(a_i) V_e^{a_i} + (1 - \pi(a_i)) V_u \right] \right\}. \hspace{1cm} (A.24)$$

In this setup, the social network that $m$ describes incorporates the idea that unemployed workers’ decisions to invoke strong or weak ties are affected by group-level (or the aggregate) decision. This formulation says that the within- and across-group differences in the use of informal channels could be generated by differentiating individuals in their preferences for invoking their strong or weak ties. Introducing individual level heterogeneity and adding social interactions into preferences can potentially generate multiple equilibria. Following the procedure described in Section 2, it is trivial to solve for the mean effort $m$ and compute multiple equilibria within the context of the strength-of-weak-ties framework described in this section.

The key feature of this discussion should perhaps be reemphasized. This formulation assumes that the source of individual level heterogeneity is the difference between workers in terms of their preferences to use their strong and weak ties in job search. Heterogeneity along with the structure of preference interactions allows us to show that it is possible to obtain multiple equilibria in such a setup. We do not present a detailed discussion of the fundamentals of
this heterogeneity, but it is possible to attribute several intuitive explanations. One plausible 
explanation in line with the “social capital” literature (see, for example, Lin (2001)) is that 
workers who possess more highly valued resources (or contacts that improve outcomes for job 
seekers) have access to links to generate better job offers.
References


Figure 1: **Sketch of the equilibrium outcome when** $J = -\infty$ **and** $w = \delta$. 
Figure 2: Sketch of the equilibrium outcome for intermediate $J$ values, when $w = \delta$. 
Figure 3: Sketch of the equilibrium outcome when $w$ is large.