Social Welfare and Wage Inequality in Search Equilibrium with Persoanl Contacts

Anna Zaharieva *

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1 Introduction

The importance of social networks and personal contacts has been largely recognized in the empirical literature. Staiger (1990), Granovetter (1995), Addison and Portugal (1998), Pistaferri (1999) and Margolis and Simonnet (2003) show that between one and two-thirds of the employees in different countries have obtained their current job with a help of a friend or a relative (see table 1). In addition, one further refinement of this result presented in Capellari and Tatsiramos (2010) highlights the relevance of the employment status of a personal contact: "... employed social contacts are expected to be better informed about job opportunities available in the market and to pass this information to non-employed network members." (p. 2). However, despite the general agreement about the importance of personal contacts, empirical evidence on the effect of networks on wages is rather mixed. In particular, Pelizzari (2010) shows that in the European Union "... premiums and penalties to finding jobs through personal contacts are equally frequent and are of about the same size." (p. 1).

Study	Incidence	Wage effects	Sample	Country
D.N. Margolis V. Simonnet (2003)	36%	$W^I < W^M < W^P$	11275	France
D. Staiger (1990)	40%	$W < W^P$	965	US
L. Pistaferri (1999)	47%	$W > W^P$	1894	Italy
M. Granovetter (1995)	56%	$W^M < W^I < W^P$	275	US
J.T. Addison P. Portugal (1998)	47%	$W^I < W^P < W^M$	2281	Portugal

Table 1: Empirical evidence on job search through personal contacts

*Institute of Mathematical Economics, University of Bielefeld, 33501 Bielefeld, Germany, E-mail: azaharieva@wiwi.uni-bielefeld.de

The starting point of this paper is to incorporate these empirical findings into an equilibrium model with search frictions and the informal job market, where vacancy information is only transmitted through employed personal contacts. Wages in the public job market are set competitively, exploiting the fact that a more generous wage offer attracts a larger number of applications. The concept of competitive search employed in this paper is originally introduced in Moen (1997). In contrast, wages in the informal job market are set through bargaining reflecting the possibility of wage premiums or wage penalties observed in Pelizzari (2010).

The network structure of personal relations is kept simple, specifically it is assumed that every worker in the labour market has exactly one social link, which can be interpreted as a close relative, a friend or an acquaintance. In the baseline model of the paper a pair of connected individuals are fully sharing their labour income and therefore are treated as a single family. The model is further extended to relax the assumption of income sharing, which allows to analyze the inherent difference of a personal contact being a friend or a close relative. This research study is then the first to combine the literature on family search with income sharing, represented by Guler, Guvenen and Violante (2009) and Ek and Holmlund (2010) with the literature on social networks.

The aim of this paper is to analyze the implications of job search through personal contacts on equilibrium welfare and wage inequality using a search model with a free-entry of firms both into the public and the informal job market. Upon the decision to enter the labour market firms face a trade off between a high cost vacancy in the public job market with a large number of searching unemployed workers versus a low cost vacancy only available to workers with an employed personal contact. The closest study to analyse social welfare in an equilibrium search model with a free-entry of firms is Cahuc and Fontaine (2009). The choice of search methods by firms is also endogenous in their model, however there is only one search method prevailing in the equilibrium, whereas in this study both search methods are simultaneously used by workers with employed social contacts. This model property allows to study the spillovers between the public and the informal job market.

Specifically, the model predictions can be summarized in the following way. First of all, the model implies wage differentials among equally productive risk-neutral workers. This is due to the ex-post differentiation of reservation wages among unemployed workers depending on the employment status of their contact. In the baseline model wage competition between firms opening a vacancy in the public job market results in a segmentation of the public job market into the low wage segment targeted at unemployed workers with low social capital and a high wage segment for workers with a high reservation wage stemming from the additional possibility to obtain job offers from an employed personal contact. Wages in jobs obtained through personal contacts are then lower or higher than the market wages depending on the bargaining power of workers.

Furthermore, this paper shows that competitive equilibrium with family search and bargaining in the informal job market is constraint efficient for the Hosios[1] value of the bargaining power. The new contribution of this paper is then to prove that wage dispersion between workers with high and low social capital in the public job market is maximized for the efficient value of the bargaining power. If the bargaining power parameter is low, meaning that wages paid in jobs obtained through personal contacts are low, then a higher value of this parameter has a positive effect on wage dispersion in the public job market. The funtional relationship between the bargaining power and wage dispersion is reversed if the bargaining power parameter is large.

The model is then extended in two directions (see table 2). First the income-sharing assumption within a pair of connected workers is relaxed. This allows to treat workers as friends or acquaintances helping each other to find a job. In this case workers bargaining over wages in the informal job market do not internalize the positive externality imposed on their social contacts inducing firms to pay higher wages. As a consequence too few job vacancies are filled in the informal job market. The implications of network externality for the public job market are twofold. At low values of the bargaining power the network externality has a neutralizing effect on the externality from search frictions. Workers with low social capital gain from a higher probability to find a job in the low wage segment of the public job market but their wages are lower. On the contrary, workers with high social capital face a lower job-finding rate but are compensated by higher wages. The overall effect on output is positive but these effects are reversed when the bargaining power parameter is above the efficient level.

	Network type	Public job market
Extension 1	No income-sharing	Wage commitment
Baseline model	Income-sharing	Wage commitment
Extension 2	Income-sharing	No commitment

Table 2: The structures of the labour market

The second extension of the baseline model is to consider Nash bargaining in the public job market as an alternative to competitive search. Ex-post wage setting in the public job market implies that the separating equilibrium is not any longer incentive compatible. In the resulting pooling equilibrium firms in the public job market open general vacancies and employ both types of workers – with employed or unemployed

[1]The Hosios condition states that search equilibrium is efficient if and only if the bargaining power of workers is equal to the elasticity of the job-filling rate with respect to the market tightness.

social contacts. Moreover there does not exist a bargaining power parameter that could decentralize the efficient allocation of labour. Job creation in the public job market is excessive: firm's profits are inefficiently high in jobs employing workers with low social capital, while they are too low in jobs employing workers with high social capital. This finding challenges the conventional view that workers with low social capital are disadvantaged in labour markets with social networks. Further this paper shows that welfare in the pooling equilibrium can be improved by an optimal system of unemployment benefits and taxes. This means that unemployment benefits can induce a welfare improvement even if workers are risk neutral.

These results are closely related to the study by Blazquez and Jansen (2008) investigating the efficiency of the equilibrium allocation in a matching model with heterogeneous workers and firms. There are two types of vacancies in their model – simple and complex and there are two types of workers – skilled and unskilled. Moreover, only skilled workers can send applications to complex vacancies. This setup is similar to the one analyzed in the present study with two types of vacancies – formal and informal and two types of workers depending on the employment status of their contact. Similarly, only unemployed workers with an employed social contact have access to vacancies in the informal job market. Despite the similarity in the model framework, the overall conclusions are divergent. Whereas in their model the high wages of low ability workers discourage the creation of unskilled jobs, the job creation in the public job market is excessive in the current study. This comparison illustrates the importance of the source of worker heterogeneity, the crucial assumption in the model by Blazquez and Jansen (2008) is a large productivity difference between the skilled and the unskilled workers, in contrast all workers are equally productive in the current study, so that the worker heterogeneity is purely endogenous.

The topic of this paper is also related to the literature on personal contacts and social networks. The early studies to emphasize the importance of social contacts are Montgomery (1991, 1992) and Mortensen and Vishwanath (2004). The focus of Montgomery (1991) is on the effect of asymmetric information on wage inequality in the presence of the "inbreeding bias", impliying clustering of workers with respect to their ability type. As a result the equilibrium is characterised by the positive correlation between ability and wages. Mortensen and Vishwanath (2004) consider the population of workers differing with respect to the probability of receiving job offers through personal contacts, they show that wages paid in jobs obtained through personal contacts are more likely to be higher than wage offers obtained through a direct application. This conclusion is questioned in the recent empirical literature, moreover "both the models of Montgomery (1991) and Mortensen and Vishwanath (1994) ignore what may be the most important role for network: to increase the job offer arrival rate."(p. 7, Margolis and Simonnet (2002)).

2 Labour market modeling framework

The labour market is characterized by the following properties. There is a unit mass of infinitely lived risk neutral workers and an endogenous number of firms, both workers and firms are ex-ante identical and discount the future at rate r. Every worker has exactly one social link, which can be interpreted as a close relative, a friend or an acquaintance. In the baseline model of the paper a pair of connected individuals is treated as a family with a full income-sharing within the household. The model extension presented in section 3.3 considers consequencies for the labour market once the income-sharing assumption is relaxed and pairs of connected workers are treated as friends or acquaintances helping each other to find a job.

Every worker can be either unemployed, receiving the value of leisure z and searching for a job or employed and producing output $y > z$. Therefore all pairs of workers can be split into three mutually exhaustive groups: employed, mixed or unemployed. The total number of worker-pairs in each group is denoted p_e, p_m and p_u respectively:

$$p_e + p_m + p_u = 0.5$$

Every firm entering the labour market has an option to open a vacancy in the public job market with a high flow cost $c + \rho$ or in the informal job market with a low cost c. Vacancy information in the informal job market is transmitted through employed personal contacts, therefore only unemployed workers in mixed pairs have access to vacancies in the informal job market. In contrast every unemployed worker in the economy has access to vacancy information posted in the public job market. This creates a trade off for the firm: a costly public vacancy with a high number of searching workers $2p_u + p_m$ versus a low cost informal vacancy with a low number of searchers p_m. On-the-job search is prohibited, so that employed workers always forward job information to their unemployed contacts. This model structure implies that unemployed workers searching in the public job market are endogenously differentiated into two groups – with high or low social capital – depending on the employment status of a connected worker.

In the baseline model the concept of competitive search, originally introduced in Moen (1997), is used to model search frictions in the public job market. Here firms post vacancies with exact information about the wage, while workers observe vacancy information and direct their search to particular jobs. It is assumed that firms commit to the posted employment contract. This wage-setting mechanism provides foundations for the wage competition between employers: firms offering higher wages are more likely to fill their open vacancies as opposed to the firms with low wage offers.

Endogenous heterogeneity of unemployed workers combined with competitive search implies that the public labour market in the baseline model is segmented into the submarket with low wages w_0 and short waiting queues, targeting at workers with low social capital, and a submarket with high wages w_1 and longer waiting queues, targetting at workers with high social capital. Let v_0 and v_1 denote the total number of vacancies in a low and high wage submarket respectively. Both unemployed workers and firms correctly anticipate the number of job matches m_i and the market tightness θ_i, in each of the submarkets $i = 0, 1$:

$$m_0 = m(2p_u, v_0) \qquad \theta_0 = \frac{v_0}{2p_u} \quad \text{and} \quad m_1 = m(p_m, v_1) \qquad \theta_1 = \frac{v_1}{p_m}$$

In contrast to the public job market, wages obtained through personal contacts (w_2) are not competitive, but set ex-post via the concept of Nash bargaining. Therefore search through personal contacts is random with a total number of job matches m_2 and the market tightness θ_2 given by:

$$m_2 = m(p_m, v_2) \qquad \theta_2 = \frac{v_2}{p_m}$$

The matching function m_i, $i = 0, 1$ is assumed to be increasing in both arguments – unemployment and vacancies, concave, and exhibiting constant returns to scale. Then the job finding rate $\lambda(\theta_i)$ and the vacancy filling rate $q(\theta_i)$ are given by:

$$q(\theta_i) = \frac{m_i}{v_i} = q_0\theta_i^{-\eta} \qquad \lambda(\theta_i) = \theta_i q(\theta_i) = q_0\theta_i^{1-\eta}, \qquad i = 0, 1, 2$$

where $0 < \eta < 1$ is the elasticity of the job filling rate $q(\theta_i)$. Any job can be destroyed for exogenous reasons with a Poisson destruction rate δ. Upon a separation the worker becomes unemployed and the firm may open a new job.

Section 5 presents a modification of the baseline model with random search and ex-post wage setting in the public job market. This allows to study the effect of a wage setting mechanism in a labour market with joint job search. In the absence of wage competition the public job market is not segmented: firms open general vacancies v and hire any of the two types of workers – with low and high social capital. The matching function m and the market tightness θ in this pooling equilibrium are then given by:

$$m = m(2p_u + p_m, v) \qquad \theta = \frac{v}{2p_u + p_m}$$

3 Competitive search with personal contacts

3.1 Workers: endogenous social capital

Let U and U_e denote asset values of unemployed workers with an unemployed and an employed partner respectively. Similarly, let W_u^i and W_e^i – asset values of workers employed at wage w_i with an unemployed and an employed partner. Note that the subindex $\{u, e\}$ shows the employment status of a connected worker. Then, using the continuous time Bellman equations, asset values U, U_e, W_u^i and W_e^i can be written as:

$$\begin{aligned} rU &= z + \lambda(\theta_0)(W_u^0 - U) + \lambda(\theta_0)(U_e - U) && (1)\\ rU_e &= z + \lambda(\theta_1)(W_e^1 - U_e) + \lambda(\theta_2)(W_e^2 - U_e) - \delta(U_e - U) && (2)\\ rW_u^i &= w_i - \delta(W_u^i - U) + (\lambda(\theta_1) + \lambda(\theta_2)(W_e^i - W_u^i), \qquad i = 0,1,2 && (3)\\ rW_e^i &= w_i - \delta(W_e^i - U_e) - \delta(W_e^i - W_u^i), \qquad i = 0,1,2 && (4) \end{aligned}$$

The market dynamics for the segmented labour market and the special case $w_1 = w_2$ is illustrated in figure 1.

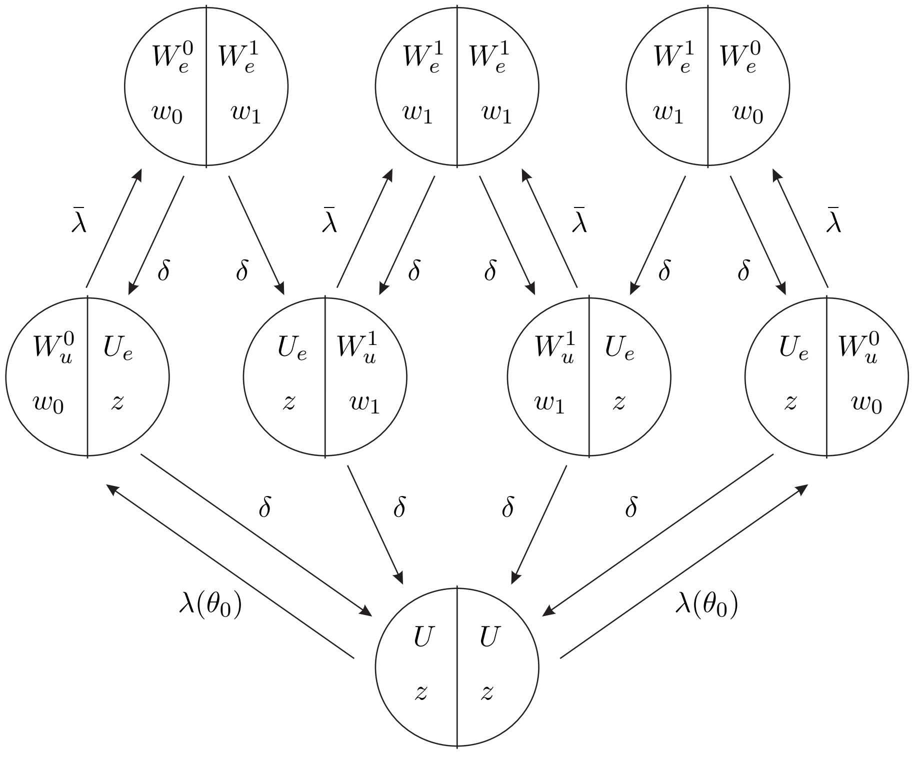

Figure 1: Competitive search with personal contacts, $\bar{\lambda} = \lambda(\theta_1) + \lambda(\theta_2)$, $w_2 = w_1$

Consider an unemployed pair of workers, both partners are searching in the low wage segment of the public labour market with a job-finding rate $\lambda(\theta_0)$ and a wage w_0. When either of the workers finds a job, the asset value of this worker is increased to the level W_u^0 with a corresponding job rent $R_u^0 \equiv W_u^0 - U$, while the surplus value of the connected worker is increased to U_e. The gain of the unemployed worker $\Delta U = U_e - U$ is twofold, on the one hand, the worker starts searching in a high wage segment of the public labour market with a high wage w_1 and the job-finding rate $\lambda(\theta_1)$, on the other, the worker obtains access to the informal job market through the employed personal contact. Value gain of the unemployed worker ΔU is then given by:

$$\Delta U = U_e - U \quad = \quad \frac{\lambda(\theta_1)R_e^1 + \lambda(\theta_2)R_e^2 - \lambda(\theta_0)R_u^0}{r + \delta + \lambda(\theta_0)} \tag{5}$$

where $R_e^1 = W_e^1 - U_e$, $R_e^2 = W_e^2 - U_e$ are, respectively, worker rents in the case of accepting a job at wage w_1 in the public job market or a wage w_2 in the informal job market. However, not only unemployed workers gain from a better employment status of their partner. The gain of the employed worker in the event when the unemployed partner finds a job is denoted by $\Delta\Phi = W_e^i - W_u^i$, it results from the fact, that the partner will have a higher surplus value U_e rather than a low value U if the job is destroyed. Therefore the surplus gain $\Delta\Phi$ is given by:

$$\Delta\Phi = W_e^i - W_u^i \quad = \quad W_e^i - W_u^i = \frac{\delta \Delta U}{r + 2\delta + \lambda(\theta_1) + \lambda(\theta_2)} < \Delta U \tag{6}$$

Note that value gains of a connected worker ΔU and $\Delta\Phi$ are endogenous in the model.

3.2 Household search with income sharing

3.2.1 Workers: indifferenece curves

This section describes a labour market where a pair of connected workers are fully sharing their income and therefore are treated as members of the same family and household. Let P_u denote asset value of the unemployed household, so that $P_u = 2U$, similarly $P_m^j = U_e + W_u^j$ – asset value of the mixed household where one of the two family members is employed at wage w_j, $j = 0, 1, 2$. Finally let $P_e^{ij} = W_e^i + W_e^j$ denote surplus of the employed household earning wages w_i and w_j, $i, j = 0, 1, 2$. Then Bellman equations for P_u, P_m^j and P_e^{ij} are written as:

$$rP_u = 2z + 2\lambda(\theta_0)(P_m^0 - P_u) \tag{7}$$

$$rP_m^j = z + w_j + \lambda(\theta_1)(P_e^{1j} - P_m^j) + \lambda(\theta_2)(P_e^{2j} - P_m^j) - \delta(P_m^j - P_u) \tag{8}$$

$$rP_e^{ij} = w_i + w_j - \delta(P_e^{ij} - P_m^i) - \delta(P_e^{ij} - P_m^j) \tag{9}$$

Then the net job rent of the unemployed household when one of the workers finds a job $P_m^0 - P_u$ can be expressed as follows:

$$(r + \delta)(P_m^0 - P_u) \quad = \quad z + w_0 - rP_u + \lambda(\theta_1)(P_e^{10} - P_m^0) + \lambda(\theta_2)(P_e^{20} - P_m^0) \tag{10}$$

For a given situation in other submarkets characterised by a vector of variables $\{w_1, \theta_1, w_2, \theta_2\}$ and therefore for fixed surplus values $P_e^{10} - P_m^0$ and $P_e^{20} - P_m^0$ equation (7) describes an indifference curve of the unemployed household searching in a low wage segment of the public labour market. The household is indifferent between obtaining a higher wage w_0 yielding a higher job rent $P_m^0 - P_u$ combined with a low job-finding rate $\lambda(\theta_0)$ versus a low wage w_0 combined with a high job-finding rate $\lambda(\theta_0)$. The slope of the indifference curve of the unemployed household ($P_u = cst$) in the variable space $\{\theta_0, w_0\}$ is then obtained from:

$$\lambda'(\theta_0)\frac{\partial\theta_0}{\partial w_0}(P_m^0 - P_u) + \lambda(\theta_0)\frac{1}{r+\delta} \quad = \quad 0 \tag{11}$$

This indifference curve is decreasing and convex in the space θ_0, w_0. The total job rent $P_m^0 - P_u$ can be decomposed into the personal gain of the worker R_u^0 and the partner's gain ΔU: $P_m^0 - P_u = R_u^0 + \Delta U$, it can then be expressed as:

$$P_m^0 - P_u = \frac{w_0 - z + \lambda(\theta_1)(P_e^{10} - P_{ue}^0) + \lambda(\theta_2)(P_e^{20} - P_{ue}^0)}{r + \delta + 2\lambda(\theta_0)} \tag{12}$$

Further the net job rent of the mixed household $P_e^{i0} - P_m^0$, when one of the members is employed at wage w_0 and the unemployed member finds a job at wage w_i, can be expressed as:

$$(r+2\delta)(P_e^{i0} - P_m^0) \quad = \quad w_i + w_0 - rP_m^0 + \delta\frac{w_i - w_0}{r+\delta}, \quad i = 1,2 \tag{13}$$

Note that surplus values $P^{10} - P_m^0$ and $P^{20} - P_m^0$ are independent of variables w_0, θ_0 for a given value of P_u, which also means that these surplus values do not depend on the partner's wage:

$$P_e^{10} - P_m^0 \quad = \quad \frac{w_1 - z - \lambda(\theta_2)(P_e^{20} - P_m^0) + \delta(P_m^1 - P_u)}{r + 2\delta + \lambda(\theta_1)} \tag{14}$$

$$P_e^{20} - P_m^0 \quad = \quad \frac{w_2 - z - \lambda(\theta_1)(P_e^{10} - P_m^0) + \delta(P_m^2 - P_u)}{r + 2\delta + \lambda(\theta_2)} \tag{15}$$

Therefore all of the unemployed workers in mixed households search in the same high wage segment of the public labour market. This simplification of the model is attributed to the assumption of risk neutrality. The total gain of the household $P_e^{i0} - P_m^0$ can be similarly decomposed into the gain of the worker and the gain of the partner: $P_e^{i0} - P_m^0 = R_e^i + \Delta\Phi$.

For a given vector of variables $\{w_0, \theta_0, w_2, \theta_2\}$ the indifference curve of the mixed household where one worker is employed at wage w_0 is given by: $P_m^0 = cst$. Unemployed family members in a mixed household face a similar trade off between a high wage w_1 and therefore a high rent value $P_e^{10} - P_m^0$ combined with a low job arrival rate $\lambda(\theta_1)$ versus a low wage w_1 combined with a high job arrival rate $\lambda(\theta_1)$. The slope of the indifference curve $P_m^0 = cst$ in the space $\{\theta_1, w_1\}$ is then given by:

$$\lambda'(\theta_1)\frac{\partial \theta_1}{\partial w_1}(P_e^{10} - P_m^0) + \lambda(\theta_1)\frac{1}{r+\delta} \quad = \quad 0$$

This indifference curve is similarly decreasing and concave in the variable space $\{\theta_1, w_1\}$, however it will be shown later that $P_e^{10} - P_m^0$ is smaller than $P_m^0 - P_u$ despite the fact that $w_1 > w_0$. Indeed given the equal productivity of workers, it should be the case that the rent gain of a household with a better outside option is lower than the gain of a household with a worse outside opportunity. This means that the indifference curve $P_u = cst$ is flatter than $P_m^j = cst$ in the space $\{\theta, w\}$. Both of the indifference curves $P_u = cst$ and $P_m^j = cst$ are illustrated on figure 2.

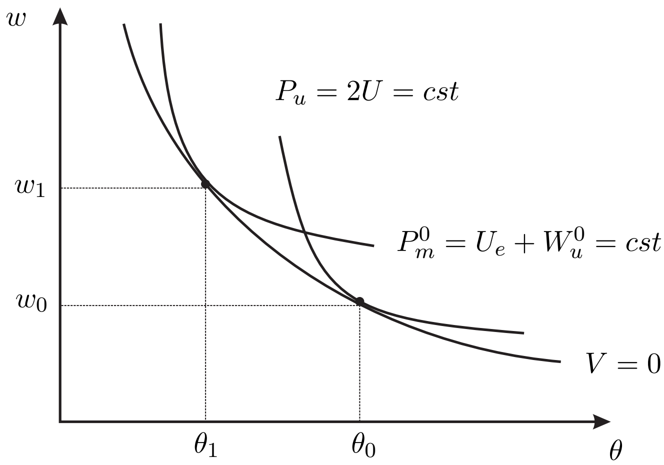

Figure 2: Labour market equilibrium with family job search

3.2.2 Firms: wage determination

Firms are free to open a vacancy in the public labour market with a flow cost $c + \rho$ or in the informal market with a lower cost c. In addition, firms can freely choose between the two segments within the public labour market. Let V_0 and V_1 denote asset values of an open vacancy in a low/high wage segment of the public labour market, respectively, and V_2 – vacancy value in the informal job market. Bellman equations for V_0, V_1 and V_2 are then given by:

$$rV^i \quad = \quad -(c+\rho) + q(\theta_i)(J^i - V^i), \quad i = 0, 1 \tag{16}$$

$$rV^2 \quad = \quad -c + q(\theta_2)(J^2 - V^2) \tag{17}$$

where J_0, J_1 and J_2 are the corresponding asset values of a filled job:

$$rJ^i \quad = \quad y - w_i - \delta J^i \quad i = 0, 1, 2 \tag{18}$$

Upon the decision to open a vacancy in the public job market firms face a similar trade off as households. Paying a higher wage w_i, $i = 0, 1$ should be compensated by a higher probability to fill the job $q(\theta_i)$. It can be shown that the firms indifference curves $V_i = cst$ are downward-sloping and convex (see figure 2) in the space $\{\theta_i, w_i\}$. For given values $\{w_1, \theta_1, w_2, \theta_2\}$ denoted as information set I_0 firms in the low wage segment maximize their surplus V_0, with respect to a combination $\{\theta_0, w_0\}$ and subject to the worker indifference curve $P_u = cst$:

$$V^0(P_u, I_0) = \max_{w_0, \theta_0} V^0(w_0, \theta_0) \qquad \text{s.t.} \qquad P_u(w_0, \theta_0, I_0) = cst \tag{19}$$

Solution of this maximization problem with a free-entry of firms meaning that in the equilibrium $V_0 = 0$ gives rise to the following rent-sharing condition:

$$J^0 = \frac{(1-\eta)}{\eta}(P_m^0 - P_u), \quad \text{where} \quad P_m^0 - P_u = R_u^0 + \Delta U \tag{20}$$

This equation is an extension of the result by Moen (1997) for the case of family job search. The wage w_0 is then given by:

$$w_0 = \eta y + (1-\eta)[rU - (\lambda(\theta_1) + \lambda(\theta_2))\Delta\Phi - (r+\delta)\Delta U] \tag{21}$$

$$= \eta y + (1-\eta)[rU - (r+2\delta)(\Delta U - \Delta\Phi)] \tag{22}$$

There are two new terms in the reservation wage of the worker. The first of them, $(\lambda(\theta_1) + \lambda(\theta_2))\Delta\Phi$ is a future gain of the worker once the partner finds a job, while the second $(r+\delta)\Delta U$ is an immidiate gain of the partner due to the possibility to search in the informal job market. Both gains act to reduce the reservation wage of the worker. Intuitively individuals are ready to work for lower wages if their partners and household members gain from additional job opportunities.

Similarly for given values $\{w_0, \theta_0, w_2, \theta_2\}$ denoted as information set I_1 firms in the high wage segment maximize their surplus V_1 with respect to a combination $\{w_1, \theta_1\}$ and subject to the worker indifference curve $P_m^0 = cst$:

$$V^1(P_m^0, I_1) = \max_{w_1, \theta_1} V^1(w_1, \theta_1), \qquad \text{s.t.} \qquad P_m^0(w_1, \theta_1, I_1) = cst \tag{23}$$

This maximization problem combined with a free-entry requirement $V_1 = 0$ gives rise to the following rent-sharing condition:

$$J^1 = \frac{(1-\eta)}{\eta}(P_e^{10} - P_m^0), \quad \text{where} \quad P_e^{10} - P_m^0 = R_e^1 + \Delta\Phi \tag{24}$$

and the following wage equation:

$$w_1 = \eta y + (1-\eta)[rU_e + \delta\Delta\Phi - (r+\delta)\Delta\Phi] \tag{25}$$

$$= \eta y + (1-\eta)[rU + r(\Delta U - \Delta\Phi)] \tag{26}$$

The first new term in the reservation wage $\delta\Delta\Phi$ is a future surplus loss of the worker once the partner looses the job, while the second term $(r+\delta)\Phi$ is an immidiate gain of the partner. Here again the immidiate surplus gain of the partner $\Delta\Phi$ is reducing the reservation wage of the worker. Comparison of equations (21) and (25) allows to evaluate the wage difference $w_1 - w_0$ showing the extent of wage dispersion in the public job market resulting from the introduction of personal contacts:

$$w_1 - w_0 = (1-\eta)2(r+\delta)(\Delta U - \Delta\Phi) \tag{27}$$

$$= (1-\eta)2(r+\delta)\Big[\frac{r+\delta+\lambda(\theta_1)+\lambda(\theta_2)}{r+2\delta+\lambda(\theta_1)+\lambda(\theta_2)}\Big]\Delta U \tag{28}$$

The more valuable is the access to the informal job market ΔU, the higher is the difference in the reservation wages of unemployed workers in the unemployed and the mixed household $2(r+\delta)(\Delta U - \Delta\Phi)$. In tern the difference in the reservation wages is raising the wage dispersion in the public job market $w_1 - w_0$.

In the informal job market wages are determined ex-post, after the meeting between the firm and the unemployed worker. I use the concept of Nash bargaining in order to determine wage w_2, the rent-sharing condition with $V_2 = 0$ and β denoting the bargaining power of the worker is then:

$$J^2 = \frac{(1-\beta)}{\beta}(P_e^{20} - P_m^0), \quad \text{where} \quad P_e^{20} - P_m^0 = R_e^2 + \Delta\Phi \tag{29}$$

with the following equation for wage w_2:

$$w_2 = \beta y + (1-\beta)[rU + r(\Delta U - \Delta\Phi)] \tag{30}$$

Clearly $w_2 = w_1$ if and only if $\beta = \eta$ and $w_2 > (<) w_1$ if and only if $\beta > (<) \eta_q$. This completes the analysis of wages.

3.2.3 The decentralized equilibrium

The free entry of firms into every of the three submarkets implies that in the equilibrium $V_i = 0,\ i = 0,1,2$. Inserting these conditions into the asset value equations for V_i produces the following:

$$\frac{c+\rho}{q(\theta_i)} = J^i, \quad i = 0,1 \qquad\qquad \frac{c}{q(\theta_2)} = J^2 \tag{31}$$

The left hand-side of these equations is the expected cost of opening a vacancy, since $q(\theta_i)$, $i = 0, 1, 2$, describes expected duration of the open vacancy. Expected cost of a vacancy in the equilibrium should be equal to the present value of flow profits from a filled job J_i. The rent-splitting equations (20), (24) and (29) imply that firms in the low wage segment of the public job market obtain fraction $(1 - \eta)$ of the total job surplus $S^0 \equiv J^0 + P_m^0 - P_u$. Firms in the high wage segment obtain a similar fraction of the total job surplus $S^1 \equiv J^1 + P_e^{10} - P_m^0$, while firms operating in the informal job market obtain a fraction $(1 - \beta)$ of the total surplus $S^2 = J^2 + P_e^{20} - P_m^0$, this means:

$$\frac{c+\rho}{q(\theta_i)} = (1-\eta)S^i, \quad i = 0, 1 \qquad \frac{c}{q(\theta_2)} = (1-\beta)S^2 \tag{32}$$

A larger surplus value S^i attracts more entrants into the submarket, which is reflected in a higher value of the market tightness θ_i, $i = 0, 1, 2$. Equations (10) and (13) allow to rewrite surplus values S^0, S^1 and S^2 as follows:

$$\begin{aligned} (r+\delta)S^0 &= y + z - rP_u + \lambda(\theta_1)(P_e^{10} - P_m^0) + \lambda(\theta_2)(P_e^{20} - P_m^0) \\ (r+2\delta)S^1 &= y + w_0 - rP_m^0 + \delta J^0 \qquad \text{and} \qquad S^2 = S^1 \end{aligned}$$

Note that the total surplus S^2 does not directly depend on the exact surplus split between the firm and the worker and therefore does not directly depend on β, which means that $S^1 = S^2$. This equality allows to express the market tightness θ_2 in the equilibrium as a linear function of θ_1:

$$q(\theta_2) = \frac{c(1-\eta)}{(c+\rho)(1-\beta)} q(\theta_1) \qquad \Rightarrow \qquad \theta_2 = \theta_2(\theta_1), \qquad \frac{\partial\theta_2(\theta_1)}{\partial\theta_1} > 0$$

Intuitively a larger surplus $S^1 = S^2$ has a positive effect on both variables θ_1 and θ_2. Moreover it can be shown that the benchmark case $\beta = \eta$ implies that $\theta_2 > \theta_1$. If $w_1 = w_2$ then more firms exploit the cost advantage of the informal job market. Further it can be shown that there exists a threshold value β^* such that:

$$\begin{cases} \text{if} \quad \beta > \beta^* \quad \text{then} \quad \theta_2 < \theta_1 \\ \text{if} \quad \beta < \beta^* \quad \text{then} \quad \theta_2 > \theta_1 \end{cases} \qquad \text{where} \qquad \beta^* = \eta + \frac{\rho(1-\eta)}{c+\rho}$$

Using the functional relationship $\theta_2 = \theta_2(\theta_1)$ allows to simplify the characterisation of the equilibrium to a vector of variables $\{\theta_0, \theta_1\}$. Using expressions $P_m^0 - P_u = \eta S^0$, $P_e^{10} - P_m^0 = \eta S^1$ and $P_e^{10} - P_m^0 = \beta S^1$ allows the following reformulation of surplus variables S^0 and S^1:

$$S^0 = \frac{y - z + [\eta\lambda(\theta_1) + \beta\lambda(\theta_2)]S^1}{r + \delta + 2\lambda(\theta_0)\eta} \tag{33}$$

$$S^1 = \frac{y - z + \delta S^0}{r + 2\delta + \eta\lambda(\theta_1) + \beta\lambda(\theta_2)} \tag{34}$$

The system of equations (33)-(34) describes spillovers between the submarkets. Consider a worker with an unemployed partner, a larger surplus gain S^1 created in the event when the unemployed partner finds a job (at rate $\lambda(\theta_1)$ or $\lambda(\theta_2)$) has a positive effect on the current surplus value of this worker and therefore on the total surplus value S^0. Now consider a worker with an employed partner, a larger surplus loss S^0 in the event when the employed partner looses the job (at rate δ) has a negative effect on the reservation value of the household P_m^0 and therefore a positive effect on the current surplus value S^1. Lemma 1 describes the effects of variables θ_0 and θ_1 on surplus values $S^0(\theta_0, \theta_1)$ and $S^1(\theta_0, \theta_1)$.

Lemma 1: *Denote $\alpha(\theta_1) = \lambda(\theta_1) + \frac{\beta}{\eta}\lambda(\theta_2(\theta_1))$ – weighted job-finding rate for workers with high social capital, so that $\alpha'(\theta_1) > 0$ then total surplus values $S^0(\theta_0, \theta_1)$ and $S^1(\theta_0, \theta_1)$ can be expressed as follows:*

$$S^0 = \frac{(y-z)(r+2\delta+2\eta\alpha(\theta_1))}{(r+2\eta\lambda(\theta_0))(r+2\delta+\eta\alpha(\theta_1))+\delta(r+2\delta)}$$

$$S^1 = \frac{(y-z)(r+2\delta+2\eta\lambda(\theta_0))}{(r+2\eta\lambda(\theta_0))(r+2\delta+\eta\alpha(\theta_1))+\delta(r+2\delta)}$$

Moreover, $S^0(\theta_0, \theta_1)$ is a decreasing function of θ_0 but an increasing function of θ_1 while $S^1(\theta_0, \theta_1)$ is decreasing in both arguments, formally:

$$\frac{\partial S^0(\theta_0,\theta_1)}{\partial\lambda(\theta_0)} < 0 \quad \frac{\partial S^0(\theta_0,\theta_1)}{\partial\alpha(\theta_1)} > 0 \quad \frac{\partial S^1(\theta_0,\theta_1)}{\partial\lambda(\theta_0)} < 0 \quad \frac{\partial S^1(\theta_0,\theta_1)}{\partial\alpha(\theta_1)} < 0$$

Proof: Differentiate surplus variable S^0 with respect to $\alpha(\theta_1)$:

$$\frac{\partial S^0(\theta_0,\theta_1)}{\partial\alpha(\theta_1)} = \frac{(y-z)\eta(r+2\delta)(r+2\delta+2\eta\lambda(\theta_0))}{[(r+2\eta\lambda(\theta_0))(r+2\delta+\eta\alpha(\theta_1))+\delta(r+2\delta)]^2} > 0$$

Differentiate surplus variable S^1 with respect to $\lambda(\theta_0)$:

$$\frac{\partial S^1(\theta_0,\theta_1)}{\partial\lambda(\theta_0)} = -\frac{(y-z)2\eta\delta(r+2\delta+2\eta\alpha(\theta_1))}{[(r+2\eta\lambda(\theta_0))(r+2\delta+\eta\alpha(\theta_1))+\delta(r+2\delta)]^2} < 0$$

Intuitively a larger job finding rate $\lambda(\theta_0)$ has a positive effect on the reservation surplus of the unemployed household P^u which has a direct negative effect on surplus $S^0 = J^0 + P_m^0 - P_u$. There is then a spillover into the high wage segment since a lower value of S^0 is reducing the surplus value S^1. In addition, a larger weighted job finding rate $\alpha(\theta_1)$ has a direct positive effect on S^0 but also a negative effect on $S^1 = J^1 + P_e^{10} - P_m^0$ due to a higher reservation surplus P_m^0. Lemma 1 shows that the direct positive effect of $\alpha(\theta_1)$ on S^0 is dominating, in addition a direct negative effect of $\alpha(\theta_1)$ on S^1 is dominating despite a higher value of S^0.

The main conclusion following from lemma 1 is that the free-entry condition in the low wage public market segment describes an increasing functional relationship between variables θ_0 and θ_1. A higher probability to find a job for the partner θ_1 has a positive effect on the total job surplus S^0, the fraction $1-\eta$ of this surplus accrues to firms and therefore has a positive effect on the job creation θ_0:

$$\frac{c+\rho}{q(\theta_0)} = (1-\eta)S^0(\theta_0,\theta_1) \Rightarrow \quad \theta_0 = \theta_0(\theta_1), \quad \frac{\partial\theta_0(\theta_1)}{\partial\theta_1} > 0$$

In contrast the free-entry condition in the high wage public market segment describes a negative relationship between variables θ_0 and θ_1 – the higher the job finding rate $\lambda(\theta_0)$ which means the easier is it to find an initial job, the lower is the surplus of this job S^0. This has a negative effect on the surplus S^1 and a lower job creation θ_1:

$$\frac{c+\rho}{q(\theta_1)} = (1-\eta)S^1(\theta_0,\theta_1) \Rightarrow \quad \theta_1 = \theta_1(\theta_0), \quad \frac{\partial\theta_1(\theta_0)}{\partial\theta_0} < 0$$

The unique intersection between the increasing curve $\theta_0(\theta_1)$ and the decreasing curve $\theta_1(\theta_0)$ allows to obtain the equilibrium values of θ_0 and θ_1, this is illustrated in figure 3. The equilibrium is defined in the following way:

Definition 1 *A competitive search equilibrium with network effects and full income sharing within the household is a vector of variables* $\{P_u, P_m^j, P_e^{ij}, V^i, J^i, w_i, \theta_i\}$, $i,j = 0,1,2$ *satisfying the asset value equations (7), (8), (9), (18), (16) and (17) the three rent-sharing equations (20), (24), (29) and the free-entry conditions* $V_i = 0$.

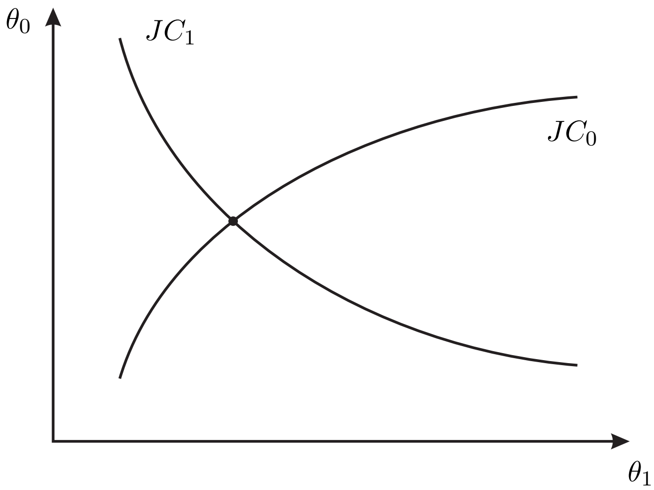

Figure 3: Equilibrium values of θ_0 and θ_1

Proposition 1 shows that there exists a unique competitive equilibrium with joint search and bargaining in the informal job market.

Proposition 1: *There exists a unique competitive search equilibrium with network effects and full income sharing where:*

(a.) *the market tightness θ_0 is an increasing function of θ_1, specifically:*

$$\frac{c+\rho}{q(\theta_0)} = \frac{(1-\eta)(y-z)(r+2\delta+2\eta\alpha(\theta_1))}{(r+2\eta\lambda(\theta_0))(r+2\delta+\eta\alpha(\theta_1))+\delta(r+2\delta)}$$

(b.) *the market tightness θ_1 is a decreasing function of θ_0, specifically:*

$$\frac{c+\rho}{q(\theta_1)} = \frac{(1-\eta)(y-z)(r+2\delta+2\eta\lambda(\theta_0))}{(r+2\eta\lambda(\theta_0))(r+2\delta+\eta\alpha(\theta_1))+\delta(r+2\delta)}$$

(c.) *wage dispersion in the public job market Δw is given by:*

$$\Delta w = \frac{2(1-\eta)\eta(r+\delta)(y-z)(\alpha(\theta_1)-\lambda(\theta_0))}{(r+2\eta\lambda(\theta_0))(r+2\delta+\eta\alpha(\theta_1))+\delta(r+2\delta)}$$

Wage dispersion Δw is increasing in θ_1 and decreasing in θ_0.

Proof: Parts (a) and (b) follow directly from lemma 1. For part (c) differentiate $\Delta\tilde{w} = \Delta w/(2(1-\eta)\eta(r+\delta)(y-z))$ with respect to θ_1:

$$\frac{\partial\Delta\tilde{w}}{\partial\theta_1} = \frac{(r+2\eta\lambda(\theta_0))(r+2\delta+\eta\lambda(\theta_0))+\delta(r+2\delta)}{[(r+2\eta\lambda(\theta_0))(r+2\delta+\eta\alpha(\theta_1))+\delta(r+2\delta)]^2} > 0$$

Corollary 1: *Competitive equilibrium in the family search model with bargaining in the informal job market entails positive wage dispersion $w_0 < w_1$ and $w_1 < (>) w_2$ for $\eta < (>) \beta$ among equally productive risk-neutral workers if $0 < \beta < 1$. For β=0, it is true that $w_0 = w_1 > w_2$, while $w_0 = w_1 < w_2$ for $\beta = 1$.*

In contrast to the study by Ek and Holmlund (2010) corollary 1 shows that risk aversion is not necessary to generate endogenous wage dispersion in a model with family search if household members can help each other to find a job.

3.2.4 The equilibrium unemployment

Let p_u, p_m and p_e denote the number of unemployed, mixed and employed households respectively. The equilibrium values of these variables can be obtained from the following system of differential equations:

$$\begin{cases} \dot{p_u} = & \delta p_m - 2\lambda(\theta_0)p_u \\ \dot{p_e} = & (\lambda(\theta_1)+\lambda(\theta_2))p_m - 2\delta p_e \\ 0.5 = & p_u + p_m + p_e \end{cases} \quad (35)$$

In the stationary equilibrium the inflow of households into a particular state should be equal to the outflow of households from this state, namely $\dot{p_u} = 0$, $\dot{p_m} = 0$, $\dot{p_e} = 0$. In the equilibrium the number of households of each type is then:

$$
\begin{aligned}
p_u &= \frac{0.5\delta^2}{[\delta^2 + \lambda(\theta_0)(2\delta + \lambda(\theta_1) + \lambda(\theta_2))]} \\
p_m &= \frac{\delta\lambda(\theta_0)}{[\delta^2 + \lambda(\theta_0)(2\delta + \lambda(\theta_1) + \lambda(\theta_2)]}
\end{aligned}
$$

and $p_e = 0.5 - p_u - p_m$. The number of unemployed households is falling in any of the job finding rates $\lambda(\theta_i)$, $i = 0, 1, 2$, in contrast the number of employed households is increasing. The effects on the number of mixed households are inversely directed: p_m is falling in $\lambda(\theta_1)$ and $\lambda(\theta_2)$ but it is increasing in $\lambda(\theta_0)$.

Further consider the special case $\beta = \eta$, so that the wage distribution in the equilibrium is binary $w_1 = w_2$. Lemma 2 shows the distribution of workers into the income categories $\{z, w_0, w_1\}$:

Lemma 2: *Let $\beta = \eta$, then the equilibrium unemployment rate u and the fraction of workers employed at wage w_1 denoted f are given by:*

$$
u = \frac{\delta(\delta + \lambda(\theta_0))}{[\delta^2 + \lambda(\theta_0)(2\delta + \lambda(\theta_1) + \lambda(\theta_2))]} \qquad f = \frac{\lambda(\theta_1) + \lambda(\theta_2)}{\delta + \lambda(\theta_1) + \lambda(\theta_2)}
$$

The fraction $1 - f$ of workers are employed at wage w_0.

Proof: The equilibrium unemployment is given by $u = 2p_u + p_m$, while the total number of workers e_0, e_1 employed at wages w_0, w_1 are given by:

$$
e_0 = \frac{2\delta(p_m + p_e)}{2\delta + \lambda(\theta_1) + \lambda(\theta_2)} \qquad e_1 = \frac{(\lambda(\theta_1) + \lambda(\theta_2))(p_m + p_e)}{2\delta + \lambda(\theta_1) + \lambda(\theta_2)} + p_e
$$

The fraction f is then $e_1/(e_0 + e_1)$.

Note that the equilibrium unemployment is falling in all of the job finding rates $\lambda(\theta_i)$, $i = 0, 1, 2$, but the wage distribution $\{1 - f, f\}$ is independent of the job finding rate $\lambda(\theta_0)$. In addition, for a general value of $0 < \beta < 1$, it can be shown that the conditional probability of being unemployed for a worker with an employed contact $P\{u|e\}$ is lower than the conditional probability of being unemployed with an unemployed contact $P\{u|u\}$:

$$
P\{u|e\} = \frac{0.5p_{eu}}{p_e + 0.5p_{eu}} = \frac{\delta}{\delta + \lambda(\theta_1) + \lambda(\theta_2)} < P\{u|u\} = \frac{\delta}{\delta + \lambda(\theta_0)}
$$

so the labour market exhibits a positive correlation in the employment status of workers within one family.

3.2.5 Comparative statics

Empirical studies presented in section 1 show that wages in jobs obtained through personal contacts can be higher or lower than wages obtained through a direct job application. This section addresses the effect of the bargaining power β, and therefore the effect of wage w_2, on market tightness variables, wages and wage dispersion in the public job market. Clearly a larger bargaining power parameter β has a positive direct effect on wage w_2 and a negative effect on θ_2 since a larger wage in the informal job market reduces the number of open vacancies. The spillovers of this effect into the public job market are summarised in proposition 2:

Proposition 2: *The economic effects of a larger bargaining power* $0 < \beta < 1$ *in the informal submarket on variables* $\{\theta_0, \theta_1, \theta_2, w_0, w_1, w_2\}$ *are summarized in table 3.*
Proof: Appendix I.

$\uparrow \beta$	θ_0	θ_1	θ_2	w_0	w_1	w_2
$\beta < \eta$	$+$	$-$	$-$	$-$	$+$	$+$
$\beta > \eta$	$-$	$+$	$-$	$+$	$-$	$+$

Table 3: Economic effects of a higher bargaining power

The effect of a higher bargaining power β is additionally illustrated on figure 4. For the corner case $\beta = 0$ jobs obtained through personal contacts pay exactly the reservation wage of the worker and for this reason do not add any additional value, so that $w_0 = w_1$. The situation is similar for $\beta = 0$ meaning that $\theta_2 = 0$. For $0 < \beta < \eta$, the term $\beta\lambda(\theta_2)$ is falling in β due to a lower value of θ_2 that has a negative effect on $\alpha(\theta_1) = \lambda(\theta_1) + \frac{\beta}{\eta}\lambda(\theta_2)$ – the weighted job finding rate. This is raising the total job surplus S^0 and the market tightness θ_0 (see lemma 1). In contrast a lower value of S^1 implies a lower job creation θ_1. There is then a reverse prediction for wages w_0 and w_1. The situation is exactly the opposite for $1 > \beta > \eta$ when the effect of a higher bargaining power is dominating so the term $\beta\lambda(\theta_2)$ is increasing. The above analysis shows that wage dispersion in the public job market Δw achieves maximum at $\beta = \eta$ when the economic effect of the informal job market is maximized.

3.3 Extension 1: Competitive search equilibrium with network effects

Lemma 3: to be written
Proposition 3: to be written

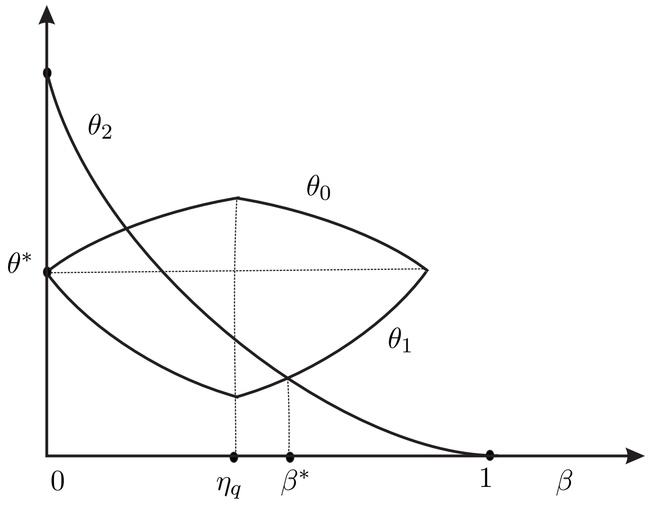

Figure 4: Economic effects of a higher bargaining power

4 Social optimum: segmented public labour market

Hosios (1990) and further Pissarides (2000) show, that the Nash wage equation is not likely to internalize search externalities resulting from the dependence of transition probabilities $\lambda(\theta_i)$ and $q(\theta_i)$ on the tightness of the market. Nevertheless Hosios (1990) proves that search externalities may be internalized, if $\beta = \eta$, where η is the elasticity of the job-filling rate $q(\theta_i)$. This section investigates efficiency properties of the competitive search equilibrium with bargaining in the informal job market, and shows that the classical Hosios condition is sufficient for the constrained efficiency. To obtain this result, consider the problem of a social planner, whose objective is to maximize the present discounted value of output minus the costs of job creation:

$$\max_{\theta_0,\theta_1,\theta_2} \int_0^\infty e^{-rt} \Big[p_u 2z + p_m(z+y) + p_e 2y \\ -(c+\rho)\theta_0 2p_u - (c+\rho)\theta_1 p_m - c\theta_2 p_m \Big] dt$$

Proposition 4: *Consider a social planner choosing the optimal number of vacancies $v_0 = 2p_u\theta_0$, $v_1 = p_m\theta_1$ – in the public job market and $v_2 = p_m\theta_2$ – in the market for internal job offers. Then the optimal job creation is:*

$$\frac{c+\rho}{q(\theta_0)} = (1-\eta)\mu_u \qquad \frac{c+\rho}{q(\theta_1)} = (1-\eta)\mu_e \qquad \frac{c}{q(\theta_2)} = (1-\eta)\mu_e$$

where variables μ_u and μ_e are obtained from the following system of equations:

$$\mu_u = \frac{y - z + (c+\rho)[2\theta_0 - \theta_1] - c\theta_2 + (\lambda(\theta_1) + \lambda(\theta_2))\mu_e}{r + \delta + 2\lambda(\theta_0)} \quad (36)$$

$$\mu_e = \frac{y - z + (c+\rho)\theta_1 + c\theta_2 + \delta\mu_u}{r + 2\delta + \lambda(\theta_1) + \lambda(\theta_2)} \quad (37)$$

Proof:

$$\begin{aligned} H &= p_u 2z + p_m(z+y) + p_e 2y - (c+\rho)\theta_0 2p_u - (c+\rho)\theta_1 p_m - c\theta_2 p_m \\ &+ \mu_u[2\lambda(\theta_0)p_u - \delta p_m] + \mu_e[(\lambda(\theta_1) + \lambda(\theta_2))p_m - 2\delta p_e] \\ &+ \mu[0.5 - [p_u + p_m + p_e]] \end{aligned}$$

$$\begin{aligned} \frac{\partial H}{\partial p_m} &= z + y - (c+\rho)\theta_1 - c\theta_2 - \mu_u\delta + \mu_e(\lambda(\theta_1) + \lambda(\theta_2)) - \mu = 0 \\ \frac{\partial H}{\partial p_u} &= 2z - 2(c+\rho)\theta_0 + \mu_u 2\lambda(\theta_0) - \mu = -r\mu_u \\ \frac{\partial H}{\partial p_e} &= 2y - \mu_e 2\delta - \mu = r\mu_e \\ \frac{\partial H}{\partial \theta_0} &= -(c+\rho)2p_u + \mu^u 2\lambda'(\theta_0)p_u = 0 \\ \frac{\partial H}{\partial \theta_1} &= -(c+\rho)p_m + \mu_e\lambda'(\theta_1)p_m = 0 \\ \frac{\partial H}{\partial \theta_1} &= -cp_m + \mu_e\lambda'(\theta_2)p_m = 0 \end{aligned}$$

Proposition: *The decentralized labour market equilibrium with family search, competitive wage setting in the public submarket and bargaining in the informal submarket is constrained efficient if $\beta = \eta$, where $\eta = -(\partial q(\theta)/\partial\theta)(\theta/q(\theta))$, – elasticity of the job filling rate $q(\theta)$ or if firms in the informal submarket mimic wages of identical workers in the public job market $w_2 = w_1$.*

5 Extension 2: pooling equilibrium with joint search

This section presents a modification of the baseline model, in particular the assumption of firms commiting to posted wages is relaxed throughout this section, wages are then determined ex-post after the match using the mechanism of Nash bargaining. Separation in the public job market is no longer incentive compatible under the ex-post determination of wages. If firms do not commit to the posted wages workers do not direct their search. Therefore in the equilibrium both types of workers are pooled in the public job market. Denote θ – the market tightness in the public job market. Bellman equations for the asset values P_u, P_m^j, P_e^{ij}, $i, j = 0, 1, 2$ are then modified in the following way:

$$
\begin{aligned}
rP_u &= 2z + 2\lambda(\theta)(P_m^0 - P_u) && (38)\\
rP_m^j &= z + w_j + \lambda(\theta)(P_e^{1j} - P_m^j) + \lambda(\theta_2)(P_e^{2j} - P_m^j) - \delta(P_m^j - P_u) && (39)\\
rP_e^{ij} &= w_i + w_j - \delta(P_e^{ij} - P_m^i) - \delta(P_e^{ij} - P_m^j) && (40)
\end{aligned}
$$

Consider the public job market, let γ denote the probability for the firm to match with an unemployed household, so that $1-\gamma$ – the probability to match with a mixed household. The probability variable γ can be obtained as:

$$
\gamma = \frac{2p_u}{2p_u + p_m} \qquad (41)
$$

The equilibrium numbers of the unemployed and the mixed households are modified in the following way:

$$
p_u = \frac{0.5\delta^2}{(\lambda(\theta)+\delta)^2 + \lambda(\theta)\lambda(\theta_1)} \qquad p_m = \frac{\delta\lambda(\theta)}{(\lambda(\theta)+\delta)^2 + \lambda(\theta)\lambda(\theta_1)}
$$

so that probability variables γ and $1-\gamma$ are then given by:

$$
\gamma = \frac{\delta}{\delta + \lambda(\theta)} \qquad (1-\gamma) = \frac{\lambda(\theta)}{\delta + \lambda(\theta)} \qquad (42)
$$

Further, let V denote asset value of an open vacancy in the public job market, it is then obtained from the following Bellman equation:

$$
\begin{aligned}
rV &= -(c+\rho) + q(\theta)[\gamma J^0 + (1-\gamma)J^1 - V] && (43)\\
rJ^i &= y - w_i - \delta J^i, \qquad i = 0,1,2 && (44)
\end{aligned}
$$

Conditions in the informal job market remain unchanged, so that:

$$
rV^2 = -c + q(\theta_2)(J^2 - V^2) \qquad (45)
$$

As follows from conditions (38), (39) and (40) job rents $P_m^0 - P_u$ for the unemployed household and $P_e^{i0} - P_m^0$ for the mixed household are given by:

$$
\begin{aligned}
(r+\delta)(P_m^0 - P_u) &= z + w_0 - rP_u + \lambda(\theta)(P_e^{10} - P_m^0) + \lambda(\theta_2)(P_e^{20} - P_{ue}^0)\\
(r+2\delta)(P_e^{i0} - P_m^0) &= w_i + w_0 - rP_{ue}^0 - \delta(W_u^0 - W_u^i), \qquad i = 1,2
\end{aligned}
$$

When bargaining over w_0 unemployed workers act to maximize the total job rent of their household $P_m^0 - P_u$ which is an increasing function of w_0, in contrast firms are maximizing the surplus value J^0, so that the rent sharing condition becomes:

$$J^0 = \frac{(1-\beta)}{\beta}(P^0_{ue} - P_u), \quad \text{where} \quad P^0_{ue} - P_u = R^0_u + \Delta U \tag{46}$$

with the corresponding equation for w_0:

$$w_0 = \beta y + (1-\beta)[rU - (r+2\delta)(\Delta U - \Delta\Phi)]$$

Unemployed workers with high social capital bargain over wages both in the public job market and in the informal job market, this means that $w_1 = w_2$ and is given by the following rent sharing condition:

$$J^i = \frac{(1-\beta)}{\beta}(P^{i0}_e - P_u), \quad \text{where} \quad P^{i0}_e - P_u = R^i_e + \Delta\Phi, \quad i = 1, 2$$

with the corresponding equation for w_i

$$w_i \;\; = \;\; \beta y + (1-\beta)[rU + r(\Delta U - \Delta\Phi)], \qquad i = 1, 2 \tag{47}$$

Denote $\tilde{S}^0 \equiv J^0 + P^0_m - P_u$ – total job surplus in a match between a firm and an unemployed household, similarly let $\tilde{S}^2 \equiv J^2 + P^{20}_e - P_u$ – total job surplus in a match between a firm and a mixed household, note that surplus values $\tilde{S}^1$ and $\tilde{S}^2$ are equal and also $J^1 = J^2$ and $P^{10}_e = P^{20}_e$. Surplus values $\tilde{S}^1$ and $\tilde{S}^2$ are given by the following system of equations:

$$\begin{aligned}
\tilde{S}^0 &= \frac{y - z + \beta(\lambda(\theta) + \lambda(\theta_2))\tilde{S}^2}{r + \delta + 2\beta\lambda(\theta)} \\
\tilde{S}^2 &= \frac{y - z + \delta\tilde{S}^0}{r + 2\delta + \beta(\lambda(\theta) + \lambda(\theta_2))}
\end{aligned}$$

There are several economic effects of a larger job-finding rate $\lambda(\theta)$ on surplus values $\tilde{S}^0$ and $\tilde{S}^2$. First, a higher value of $\lambda(\theta)$ has a positive effect on the reservation wage of the unemployed household and thereof a negative effect on the total job surplus S_0. If it is easier to find a job unemployed households become more picky, which means a higher asset value P_u. This is the effect in the denominator of $\tilde{S}^0$. On the contrary $\lambda(\theta)$ makes it easier for the remaining unemployed partner to find a job. This is the positive effect in the numerator of $\tilde{S}^0$. In addition there is a negative spillover effect of $\tilde{S}^2$ on $\tilde{S}^1$. Lemma 4 shows that the final effect of θ on surplus value $\tilde{S}^0$ is negative despite the higher probability for the partner to find a job:

Lemma 4: *Total surplus values $\tilde{S}^0(\theta, \theta_2)$ and $\tilde{S}^2(\theta, \theta_2)$ can be expressed as follows:*

$$S^0 = \frac{(y-z)(r + 2\delta + 2\beta(\lambda(\theta) + \lambda(\theta_2)))}{(r + 2\lambda(\theta)\beta)(r + 2\delta + \beta(\lambda(\theta) + \lambda(\theta_2))) + \delta(r + 2\delta)}$$

$$S^2 = \frac{(y-z)(r+2\delta+2\beta\lambda(\theta))}{(r+2\lambda(\theta)\beta)(r+2\delta+\beta(\lambda(\theta)+\lambda(\theta_2)))+\delta(r+2\delta)}$$

Moreover, both surplus values $\tilde{S}^0(\theta,\theta_2)$ *and* $\tilde{S}^2(\theta,\theta_2)$ *are decreasing in variable* $\lambda(\theta)$*,* $\tilde{S}^2(\theta,\theta_2)$ *is in addition decreasing in* $\lambda(\theta_2)$*, while there is a positive effect on* $\tilde{S}^0(\theta,\theta_2)$*. The surplus difference* $\tilde{S}^0-\tilde{S}^2>0$ *is increasing in* $\lambda(\theta_2)$*, but decreasing in* $\lambda(\theta)$*:*

$$\frac{\partial(\tilde{S}^0-\tilde{S}^2)}{\partial\lambda(\theta_2)}>0 \qquad \frac{\partial(\tilde{S}^0-\tilde{S}^2)}{\partial\lambda(\theta)}<0 \tag{48}$$

Proof: Appendix ??

Firms open vacancies in the informal job market up to the point where $V^2=0$, this free-entry condition can then be rewritten as:

$$\frac{c}{q(\theta_2)}=(1-\beta)S^2(\theta,\theta_2)\Rightarrow \quad \theta_2=\theta_2(\theta), \quad \frac{\partial\theta_2(\theta)}{\partial\theta}<0 \tag{49}$$

and implies a negative relation between variables θ and θ_2. A larger value of θ has a positive effect on the reservation wage of unemployed workers in mixed households (P_m^j is higher), consequently the surplus value $S^2(\theta,\theta_2)$ is lower for every value of θ_2 (see lemma ??), a lower total surplus value discourages firms to create jobs in the informal submarket, so the market tightness θ_2 falls. The free-entry condition in the public job market can be written as:

$$\begin{aligned}\frac{c+\rho}{q(\theta)} &= (1-\beta)[\gamma S^0(\theta,\theta_2)+(1-\gamma)S^2(\theta,\theta_2)]\\ &= \frac{c}{q(\theta_2)}+(1-\beta)\gamma[S^0(\theta,\theta_2)-S^2(\theta,\theta_2)]\Rightarrow \quad \theta=\theta(\theta_2), \quad \frac{\partial\theta(\theta_2)}{\partial\theta_2}>0\end{aligned}$$

This condition implies a positive relation between variables θ_2 and θ. A larger value of θ_2 has a positive effect on $\tilde{S}^0(\theta,\theta_2)$ but a negative effect on $\tilde{S}^2(\theta,\theta_2)$. The first effect is explained by a higher probability for the unemployed member of a mixed household to find a job. The second effect is explained by a higher reservation wage of these workers (P_m^j is higher), consequently the surplus value $S^2(\theta,\theta_2)$ is lower. Nevertheless lemma ?? show that the first positive effect is dominating. As a result more firms open vacancies in the public job market and θ grows for every value of θ_2. The unique intersection between the increasing curve $\theta(\theta_2)$ and the decreasing curve $\theta_2(\theta)$ defines the equilibrium values of θ and θ_2, this is illustrated in figure **??**. The equilibrium is defined in the following way:

Definition 2 *Search equilibrium with bargaining, network effects and full income sharing within the household is a vector of variables* $\{P_u, P_m^j, P_e^{ij}, J^i, V, V^2, w_i, \theta, \theta_2\}$*,* $i,j=0,1,2$ *satisfying the asset value equations (38), (39), (40), (43), (44) and (45), the rent-sharing equations (46) and (47) as well as the free-entry conditions* $V=0$ *and*

$V^2 = 0$.

Proposition 5 shows that there exists a unique search equilibrium with bargaining, network effects and income-sharing.

Proposition 5: *There exists a unique search equilibrium with bargaining, network effects and full income sharing where:*

(a.) *the market tightness θ is an increasing function of θ_2, specifically:*

$$\frac{c+\rho}{q(\theta)} = \frac{c}{q(\theta_2)} + \frac{(1-\beta)\gamma(y-z)2\beta\lambda(\theta_2)}{(r+2\lambda(\theta)\beta)(r+2\delta+\beta(\lambda(\theta)+\lambda(\theta_2)))+\delta(r+2\delta)}$$

where $\gamma = \delta/(\delta+\lambda(\theta))$ – is the probability for the firm to match a worker with an unemployed contact.

(b.) *the market tightness θ_2 is a decreasing function of θ, specifically:*

$$\frac{c}{q(\theta_2)} = \frac{(1-\beta)(y-z)(r+2\delta+2\beta\lambda(\theta))}{(r+2\lambda(\theta)\beta)(r+2\delta+\beta(\lambda(\theta)+\lambda(\theta_2)))+\delta(r+2\delta)}$$

(c.) *wage dispersion variable $\Delta w = w_2 - w_0 = w_1 - w_0$ is given by:*

$$\Delta w = \frac{(1-\beta)(y-z)2\beta\lambda(\theta_2)(r+\delta)}{(r+2\lambda(\theta)\beta)(r+2\delta+\beta(\lambda(\theta)+\lambda(\theta_2)))+\delta(r+2\delta)}$$

Wage dispersion Δw is increasing in θ_2 and decreasing in θ.

Proof: Parts (a) and (b) follow directly from lemma 4. For part (c) differentiate $\Delta\tilde{w} = \Delta w/(2(1-\beta)\beta(r+\delta)(y-z))$ with respect to θ_2:

$$\frac{\partial\Delta\tilde{w}}{\partial\theta_1} = \frac{(r+2\beta\lambda(\theta))(r+2\delta+\beta\lambda(\theta))+\delta(r+2\delta)}{[(r+2\lambda(\theta)\beta)(r+2\delta+\beta(\lambda(\theta)+\lambda(\theta_2)))+\delta(r+2\delta)]^2} > 0$$

6 Comparative statics

This section addresses the effect of a larger cost difference parameter ρ on wage dispersion and job creation in both the public and the informal submarket. As follows from proposition 5, part (a), the cost difference parameter ρ has a direct negative effect on job creation in the public job market, impliying a lower value of θ for every value of θ_2. Consequently there is a downward shift in the job creation curve (JC) (see figure **??**). The job creation curve (JC2) does not shift. This means that a larger value of ρ has a business shrinking effect in the public job market and a positive shift of job creation towards the informal job market: a larger value of θ_2 for a lower value of θ. Proposition 6 shows that there exists a threshold value $\rho^* > 0$ such that $\rho > (<)\rho^*$ implies $\theta_2 > (<)\theta$:

Proposition 6: *The economic effects of a larger cost difference parameter $\rho > 0$ on variables $\{\theta, \theta_2, w, w_1, w_2, \Delta w\}$, where $\Delta w = w_2 - w_0 = w_1 - w_0$ are summarized in table 4. In addition, there exists a threshold value ρ^* such that:*

$$\begin{cases} \text{if} \quad \rho > \rho^* \quad \text{then} \quad \theta_2 > \theta \\ \text{if} \quad \rho < \rho^* \quad \text{then} \quad \theta_2 < \theta \end{cases} \qquad \text{where} \quad \rho^* = c\gamma^* \frac{2\beta\lambda(\theta^*)}{(r + 2\delta + 2\beta\lambda(\theta^*))}$$

$$\text{and} \quad \frac{c}{q(\theta^*)} = \frac{(1-\beta)(y-z)(r+2\delta+2\lambda(\theta^*)\beta)}{(r+2\delta)(r+2\beta\lambda(\theta^*)+\delta)+2\beta\lambda(\theta^*)(r+2\beta\lambda(\theta^*))}$$

	θ	θ_2	w	w_1	w_2	Δw
$\uparrow \rho$	$-$	$+$	$-$	$-$	$-$	$+$

Table 4: Economic effects of a higher cost difference parameter

Proof: Let $\theta = \theta_2 = \theta^*$ at $\rho = \rho^*$, the free-entry consitions are then writtens as:

$$c = (1-\beta)q(\theta^*)S^0(\theta^*) \tag{50}$$

$$c + \rho^* = (1-\beta)q(\theta^*)[\gamma^* S^0(\theta^*) + (1-\gamma^*)S^2(\theta^*)] \tag{51}$$

where $\gamma^* = \delta/(\delta + \lambda(\theta^*))$. The ratio between these two equations produces:

$$\frac{\rho^*}{c} = \gamma^* \left[\frac{S^0(\theta^*)}{S^2(\theta^*)} - 1 \right] \quad \Rightarrow \quad \rho^* = c\gamma^* \frac{2\beta\lambda(\theta^*)}{(r+2\delta+2\beta\lambda(\theta^*))} \tag{52}$$

It also follows from the free-entry conditions that, if $\rho = 0$, then $\theta_2 < \theta$. Figure **??** shows that θ_2 is increasing in ρ, while there is an opposite effect on θ, this means:

$$\frac{\partial \Delta w}{\partial \rho} = \frac{\partial \Delta w}{\partial \theta}\frac{\partial \theta}{\partial \rho} + \frac{\partial \Delta w}{\partial \theta_2}\frac{\partial \theta_2}{\partial \rho} > 0 \tag{53}$$

The free-entry condition in the informal job market implies that θ_2 is growing in response to ρ due to a lower value of w_2:

$$w_2 = y - \frac{c(r+\delta)}{q(\theta_2)} \quad \Rightarrow \quad \frac{\partial w_2}{\partial \rho} = \frac{c(r+\delta)q'(\theta_2)}{q^2(\theta_2)}\frac{\partial \theta_2}{\partial \rho} < 0 \tag{54}$$

A lower value of w_2 in response to a higher ρ combined with a higher dispersion of wages Δw, implies a lower value of $w_0 = w_2 - \Delta w$.

Figure 5 shows that a higher value of ρ has a direct negative effect on the job creation in the public job market θ. A lower number of vacancies in this submarket induces lower reservation wages of workers in unemployed and mixed households (lower values of P_u and P_m^j). Consequently the bargaining position of unemployed workers is weakned and wages w_0, w_1 and w_2 fall. In the public job market this indirect feedback has a softening effect on the job creation, whereas in the informal job market a lower wage w_2 attracts a higher number of firms and stimulates the job creation.

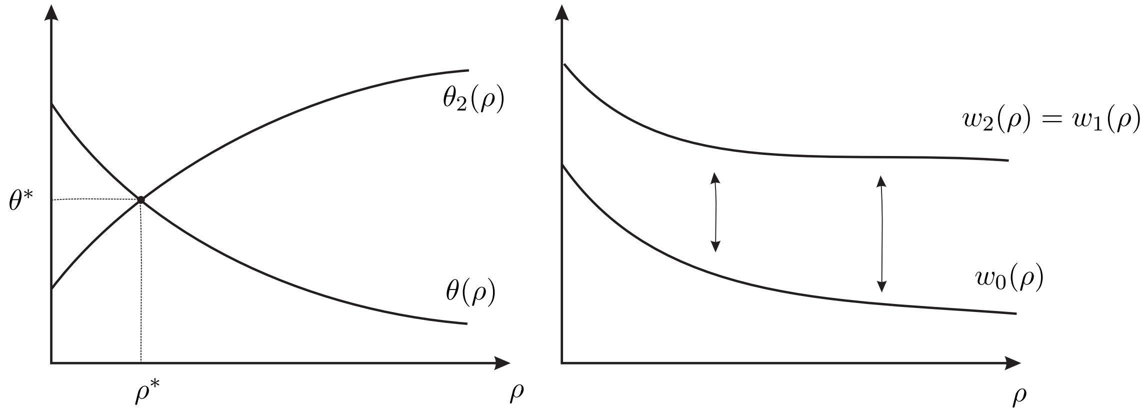

Figure 5: Economic effects of a higher cost difference parameter ρ

7 Social optimum

Objective function of the social planner:

$$\max_{\theta,\theta_2} \int_0^\infty e^{-rt}\Big[p_u 2z + p_m(z+y) + p_e 2y - (c+\rho)\theta(2p_u+p_m) - c\theta_2 p_m\Big]dt$$

Proposition 7: *Consider a social planner choosing the optimal number of vacancies* $v = \theta(2p_u + p_m)$ *– in the public job market and* $v_2 = p_m\theta_2$ *– in the market for internal job offers. Then the optimal job creation is:*

$$\frac{c+\rho}{q(\theta)} = (1-\eta)[\gamma\mu_u + (1-\gamma)\mu_e] \qquad \frac{c}{q(\theta_2)} = (1-\eta)\mu_e$$

where variables μ_u *and* μ_e *are obtained from the following system of equations:*

$$\mu_u = \frac{y - z + (c+\rho)\theta - c\theta_2 + (\lambda(\theta) + \lambda(\theta_2))\mu_e}{r + \delta + 2\lambda(\theta_0)} \qquad (55)$$

$$\mu_e = \frac{y - z + (c+\rho)\theta + c\theta_2 + \delta\mu_u}{r + 2\delta + \lambda(\theta) + \lambda(\theta_2)} \qquad (56)$$

$$\mu_u = \frac{y - z + \eta(\lambda(\theta) + \lambda(\theta_2))\mu_e - (2-\gamma)\lambda(\theta)(1-\eta)\Delta\mu}{r + \delta + 2\eta\lambda(\theta)} \tag{57}$$

$$\mu_e = \frac{y - z + \delta\mu_u + \gamma\lambda(\theta)(1-\eta)\Delta\mu}{r + 2\delta + \eta(\lambda(\theta) + \lambda(\theta_2))} \tag{58}$$

8 Conclusions

This paper investigates the implications of job search through personal contacts on social welfare and wage dispersion in an equilibrium model with matching frictions. Upon entry firms have an option to post a high cost vacancy in the public job market or a low cost vacancy in the informal job market. Vacancy information in the informal submarket is only transmitted through employed personal contacts. In the baseline model of the paper workers are grouped into a continuum of two-person households with a full income and information sharing between the members. Therefore this study combines the literature on joint job search with a focus on income sharing within a family and the literature on social networks with a focus on information sharing.

This paper shows that unemployed workers in mixed households gain from an additional option to screen jobs in the informal labour market, which is a result of information transmission from the employed to the unemployed household members. Ex-post differentiation of workers by social capital reflecting differences in the employment status of a connection gives rise to endogenous wage dispersion among equally productive risk-neutral workers. This is an extension of the result by Ek and Holmlund (2010) stating that risk-aversion is a neccessary condition for wage dispersion in an equilibrium model with family job search. Moreover, the model exhibits a positive correlation in the employment status of household members observed in a number of empirical studies.

Wages in the public job market are set via the mechanism of competitive search utilizing the link between the probability to fill a vacancy and the posted wage offer. Endogenous heterogeneity of workers with respect to their reservation wages induces a segmentation in the public job market. Firms in a low wage segment of the public job market target at workers with low social capital and unemployed personal contacts, in contrast firms in a high wage segment target at workers with high social capital. Wages in the informal job market are set through individual bargaining. This highlights the non-competitive nature of wages paid in jobs obtained through personal contacts and allows for the possibility of wage penalties or wage premiums between the public and the informal job market.

Further, this paper proves that search equilibrium with competition in the public job market and bargaining in the informal market is unique and constrained efficient at the Hosios value of the bargaining power parameter. The new contribution of the paper is then to show that the efficient resource allocation is associated with a maximum wage dispersion in the public job market. This is due to the fact that the total output created in the informal job market is maximized at the efficient allocation, implying the highest value of the employed social contact granting access to the informal market and leading to the maximum heterogeneity in the reservation wages of workers.

The model is further extended to relax the assumption of income sharing, a pair of connected workers can then be interpreted as friends or acquaintances helping each other to find a job. The decentralized equilibrium without income sharing is inefficient at the Hosios value of the bargaining power parameter, which is explained by the positive externality of workers bargaining over wages in the informal job market on their friends. In a situation when the total gain of a connected worker is not internalised, wages in jobs obtained through personal contacts are inefficiently high. This leads to the insufficient job creation in the informal job market. The spillovers of this inefficiency into the public job market depend on the exact value of the bargaining power parameter. If the bargaining power of workers is low, the network inefficieincy is neutralizing the classical inefficiency from search frictions. This leads to an unambiguous increase in the total output. The effects on workers with different levels of social capital are however adverse. Unemployed workers with low social capital gain from a higher probability to find jobs in a low wage segment of the public job market despite a corresponding reduction in wages. On the contrary, unemployed workers with high social capital are confronted with a lower probability to find a job, but are compensated by higher wages. Furthermore welfare and output are reduced and the effects on workers with different level of social capital are reversed if the bargaining power parameter and wages in the informal job market are high.

The final extension of the baseline model relaxes the assumption of wage commitment in the public job market. Without commitment all wages in the economy are determined via the concept of Nash bargaining and the public labour market is not segmented. This allows a convenient characterisation of the effect of a cost difference parameter between the public and the informal job market. Higher relative hiring costs in the public job market have a negative impact on job creation in this market, stimulating thereby the reallocation of jobs into the informal submarket. Wages fall, but there is only an indirect negative effect on wages in the informal job market, so that the equilibrium wage dispersion is increased.

From the perspective of social welfare, the Hosios value of the bargaining power parameter is not sufficient to guarantee efficiency in the decentralized equilibrium where both worker types are pooled in the public job market. Firms enter the public job market up to the point where the costs of job creation are equal to the expected profits. Ex-post profits are then too high in jobs employing workers with low social capital, while they are too low in jobs employing workers with high social capital. This paper proves that the first effect is dominating and the pooling equilibrium is characterized by an excessive job creation in the public job market. This finding challenges the conventional view that workers with low social capital are disadvantaged in labour markets with social networks. Finally, this paper presents a system of unemployment benefits and taxes that would decentralize the efficient allocation and shows that unemployment benefits can induce a welfare improvement even if workers are risk neutral.

9 Appendix

Appendix ?? Proof of lemma ??:
Differentiate surplus value $\tilde{S}^0(\theta, \theta_2)$ with respect to $\lambda(\theta)$:

$$\frac{\partial \tilde{S}^0}{\partial \lambda(\theta)} = -\beta(y-z)\frac{(r+2\delta+2\beta(\lambda(\theta)+\lambda(\theta_2)))^2+(r+2\delta)2\beta\lambda(\theta_2)}{[(r+2\lambda(\theta)\beta)(r+2\delta+\beta(\lambda(\theta)+\lambda(\theta_2)))+\delta(r+2\delta)]^2} < 0$$

Differentiate surplus value $\tilde{S}^0(\theta, \theta_2)$ with respect to $\lambda(\theta_2)$:

$$\frac{\partial \tilde{S}^0}{\partial \lambda(\theta_2)} = \beta(y-z)\frac{(r+2\delta)(r+2\delta+2\lambda(\theta)\beta)}{[(r+2\lambda(\theta)\beta)(r+2\delta+\beta(\lambda(\theta)+\lambda(\theta_2)))+\delta(r+2\delta)]^2} > 0$$

Differentiate surplus value $\tilde{S}^2(\theta, \theta_2)$ with respect to $\lambda(\theta)$:

$$\frac{\partial \tilde{S}^2}{\partial \lambda(\theta)} = -\beta(y-z)\frac{(r+2\delta+2\beta\lambda(\theta))^2+4\delta\beta\lambda(\theta_2)}{[(r+2\lambda(\theta)\beta)(r+2\delta+\beta(\lambda(\theta)+\lambda(\theta_2)))+\delta(r+2\delta)]^2} < 0$$

Differentiate surplus difference $\tilde{S}^0 - \tilde{S}^2$ with respect to $\lambda(\theta)$:

$$\frac{\partial(\tilde{S}^0-\tilde{S}^2)}{\partial \lambda(\theta)} = -\beta(y-z)\frac{2\beta\lambda(\theta_2)[2(r+2\delta+\beta(\lambda(\theta)+\lambda(\theta_2)))+r+2\beta\lambda(\theta)]}{[(r+2\lambda(\theta)\beta)(r+2\delta+\beta(\lambda(\theta)+\lambda(\theta_2)))+\delta(r+2\delta)]^2} < 0$$

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