Wage bargaining, the value of unemployment, and the labor share of income

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Abstract

The paper estimates a wage bargaining equation set within a model of the aggregate labor market with search and matching frictions. The equation posits that the wage is a function of current productivity, future productivity and the value of unemployment. The model is estimated using aggregate Israeli labor market data.

The estimated equation fits the data reasonably well. Workers' bargaining power – allowed to be endogenous – is estimated to be around 0.4 and does not vary much with market conditions. The workers' reservation wage plays a key role in the determination of wages both in terms of the mean and even more so in terms of volatility. Reservation wages themselves are determined mostly by the value of home production and any non-pecuniary value of unemployment and, to a lesser extent, by net unemployment benefits.

The empirical analysis makes several contributions: validation and quantification of a key element — wage formation – in the search and matching model; structural characterization of the Beveridge curve (the relation between unemployment and vacancies) and of the wage curve (the relation between wages and unemployment), showing how elements of the wage bargaining process affect them; and, quantification of the degree of market inefficiency in the presence of search externalities.

Wage bargaining, the value of unemployment, and the labor share of income[1]

1 Introduction

The paper estimates a wage formation equation set within a model of the aggregate labor market with frictions. The equation is derived from the Nash solution of the firm-worker bargaining problem in a stochastic, discrete time version of the prototypical search and matching model. The equation posits that the wage is a function of current productivity, future productivity and the value of unemployment. The latter is a function of net unemployment benefits, plus any non-pecuniary value of unemployment or home production, less search costs. The paper takes the model to aggregate Israeli labor market data. This data set has unique features that have already proved to be of significant value when coming to implement the model empirically [see Yashiv (2000a)]. Estimation generates two sets of results: one is the set of parameters defining the relative role of the determinants of wages – productivity (current and future) and the value of unemployment. The other is a set of time series of the components of wages, the bargaining strength of workers and firms, and reservation wages.

These sets of results allow the examination of a number of issues:

(i) An empirical test of the wage formation element of the search and matching model. This element plays a key role in the model: the division of the job-worker match surplus determines wages for workers and match asset values for firms. These in turn affect unemployed workers search intensity and firms' rates of vacancy creation. Consequently matching flows and the stocks of unemployment and job vacancies are determined in equilibrium. The results serve to indicate how empirically valid is the model and to quantify the wage formation process, an investigation

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hitherto unexplored. As this model has proved to be a useful tool for understanding business cycle fluctuations as well as labor market dynamics [see, for example, the discussion in Hall (1999)], the implications of this validation and quantification go beyond the search and matching model.

(ii) A steady state simulation analysis, based on the estimated structural parameters, allows the study of the influence of key variables and parameters in the wage bargaining process on equilibrium unemployment, vacancies and wages. In particular this analysis generates well-defined Beveridge curve and 'wage curve'. The latter is of importance in the context of macroeconomists' long-standing interest in the relationship between wages and labor market conditions, such as the level of unemployment or some other measure of market tightness. Recent contributions, in particular Blanchflower and Oswald's (1994) study of the wage curve, have posed challenges to some of the major models of the aggregate labor market. The afore-cited analysis shows what mechanism generates the wage curve and how elements of the wage formation process make it shift.

(iii) The issue of market efficiency is closely related to the bargaining outcome in this context. Thus the empirical estimates allow for the evaluation of market efficiency in a real-world aggregate labor market.

(iv) There have been attempts to reconcile the empirical evidence on short-term trade-offs between nominal changes in wages and unemployment, i.e. Phillips curve models, and the empirical implications of theories of the 'natural rate' of unemployment. One such attempt − made by Blanchard and Katz (1999) − shows that such reconciliation requires knowing the relationships between actual wages, reservation wages, and productivity and the effects of market conditions on these relationships. These are characterized and quantified in the paper.

The major findings are as follows: the estimated wage equation fits the data reasonably well. Workers' bargaining power – allowed to be endogenous – is estimated to be around 0.4 and does not vary much with market conditions. The workers' reservation wage plays a key role in the determination of wages both in terms of the mean and even more so in terms of volatility. Reservation wages themselves are determined mostly by the value of home or informal production and any non-pecuniary value and, to a lesser extent, by net unemployment benefits. A simulation analysis of the model's steady state demonstrates how the Beveridge and wage curves move when there is a change in key variables and parameters determining the wage bargain. Thus, an increase in workers' reservation wage or in their bargaining power shifts the Beveridge curve towards less job creation and moves the wage curve towards a higher labor share of income coupled with higher unemployment. The results also suggest that workers' share in the surplus division is "too high" from the standpoint of market efficiency, but not substantially so.

The paper proceeds as follows: Section 2 presents the model. Section 3 presents the data and methodology. Section 4 delineates estimation results. The implications of the results with respect to the determinants of wages and of reservation wages are discussed in Section 5. The steady state analysis of the Beveridge and wage curves is presented in Section 6. A discussion of the implications pertaining to Phillips curves and to market efficiency is given in Section 7. Section 8 concludes.

2 The Model

The main focus of this paper is on wage formation through bargaining over the division of the job-worker match surplus. Before describing the bargaining process it is necessary to formulate the search and matching context in which it takes place.

2.1 The Search and Matching Framework

The search and matching model of the labor market posits that there are two types of agents engaged in costly search: unemployed workers searching for jobs and firms searching for workers through vacancy creation. Agents maximize intertemporal objective functions − profits in the case of firms and income in the case of workers. Matching is not instantaneous: workers and firms are faced with different frictions, such as different locations leading to regional mismatch, lags and asymmetries in the transmission of information and time-consuming processing of job applications. These frictions are embedded in the concept of a matching function at the aggregate level which produces hires out of vacancies and unemployment, leaving certain jobs unfilled and certain workers unemployed. Following matching the firm and the worker bargain over the division of the rents created by the match. The Nash solution is used to determine the outcome, with the wage being the part of the worker in this bargain. In this paper we look at the version of the model whereby all workers and all firms are homogenous and matches dissolve at a stochastic, exogenous rate. In what follows we briefly present the model; for a more extensive treatment see Mortensen and Pissarides (1999a) and Pissarides (2000). The current presentation follows the stochastic, discrete-time formulation in Yashiv (2000a). The stochastic optimization framework to be presented accommodates random shocks to matching and to the variables affecting agents' optimal behavior: labor productivity, unemployment benefits, the rate of separation, and the real rate of interest. The notation uses lower-case letters for micro-level variables and upper-case letters for aggregate ones.

2.1.1 Matching

The matching function acts like a production function, taking as inputs the stocks of unemployed workers and vacant jobs, producing a flow of hires.[2] Formally:

$$H_t = M(\theta_t, C_t U_t, V_t) \tag{1}$$

where H is the number of hires, θ is the level of the matching technology, V is the number of job-vacancies, and CU is the number of "efficiency units" of searching workers. The latter are defined by the product of search intensity C and the number of unemployed workers U. This function has positive first derivatives and should satisfy:

$$0 \leq H_t \leq \min(U_t, V_t)$$

Matching at the aggregate level implies that for homogenous firms there is a common

[2] Petrongolo and Pissarides (2001) offer a survey of the literature on this topic.

probability Q of filling a vacancy defined as follows:

$$q_t = Q_t = \frac{M(\theta_t, C_t U_t, V_t)}{V_t} \tag{2}$$

where q, Q are the firm-level and aggregate vacancy matching probabilities, respectively.

Similarly with homogenous workers the matching probability for the unemployed worker is defined as follows:

$$p_t = P_t = \frac{M(\theta_t, C_t U_t, V_t)}{U_t} \tag{3}$$

2.1.2 Firms

The objective function of the firm is to maximize the sum of expected discounted profits where its decision variable is vacancy creation. The firm's problem may be examined with the tools of stochastic dynamic programming in the same way as has they have been used for capital investment problems, so the model is the analogue of "Tobin's q" model of investment in physical capital. The timing is as follows: the firm makes its decisions on vacancy creation in period t using the information set Ω_t. Hired workers enter production in the following period $(t+1)$. Separation of workers from jobs occurs at rate $s_{t.}$ The stochastic dynamic programming problem is formulated as follows:

$$\max_{\{v\}} E_t \sum_{i=0}^{\infty} \frac{1}{\prod_{j=0}^{i}(1+r_{t+j-1})} [F(n_{t+i}, \mathsf{A}_{t+i}) - w_{t+i}(1+\tau_t^s)n_{t+i} - \Gamma(v_{t+i}, \mathsf{B}_{t+i})] \tag{4}$$

subject to:

$$n_{t+1} = n_t(1-s_t) + q_t v_t \tag{5}$$

where E_t denotes expectations formed in period t based on the information set Ω_t; F is the production function with employment (n) and other factors of production (contained in the vector A) as its arguments; real wage payments are denoted by $w(1+\tau_t^s)n$, where w are wages and τ_t^s are employer taxes and contributions to social security (or any other overhead costs). We represent by Γ the costs of hiring which are of two types: (i) the cost of advertising, screening and selecting new workers and (ii) the cost of training. This function has as its arguments the number of vacancies (v) and possibly other variables (denoted by the vector B; this vector could include the matching rate q and the employment stock n). The firm uses the relevant interest rate r to discount future streams.

The F.O.C. (the so-called stochastic Euler equation) is:

$$\frac{\partial \Gamma_t}{\partial v_t} = q_t E_t \frac{1}{1+r_t}\left[\frac{\partial F_{t+1}}{\partial n_{t+1}} - (1+\tau_t^s)w_{t+1} - \frac{\partial \Gamma_{t+1}}{\partial n_{t+1}} + (1-s_{t+1})\frac{\frac{\partial \Gamma_{t+1}}{\partial v_{t+1}}}{q_{t+1}}\right] \tag{6}$$

The intuition here is that the marginal cost of hiring (the LHS) equals expected discounted marginal profits (the RHS). The latter depends on the rate at which vacancies get filled (q) and two terms expressing (i) the expected marginal profit at period $t+1$, which is made up of the marginal product and the reduction in hiring costs due to the additional hire less the wage paid; and (ii) the expected savings of hiring costs if the worker does not separate in the following period.

2.1.3 Workers

Workers maximize expected discounted earnings. When hired workers receive the real after-tax wage $w_t(1-\tau_t)$ where τ_t denotes wage taxes; with probability s_t they are separated from their jobs and return to unemployment. During unemployment workers receive the net value of unemployment at time t, to be denoted b_t. We formulate it as consisting of the following terms:

(i) unemployment benefits z_t, net of taxes τ_t.

plus

(ii) any non-pecuniary value, such as that derived from leisure activities[3], home production or the value of production in non-formal sectors. Evidently this value is unobservable. In coming

[3] Note that this value may be negative if, say, the value of leisure is dominated by the social and psychological costs of unemployment.

to implement the model empirically we formulate it as proportional to unemployment benefits (z). We use z because in the data we examine – on which we elaborate below – it is a function of workers' wages before the unemployment spell and therefore reflects their productivity [4]. The scale parameter used here is μ.

less,

(iii) costs of search, which are a convex function Λ of search intensity c_t and possibly some other variable/s to be denoted by the vector e (discussed in the empirical section).

Formally we use the following definition:

$$b_t = z_t(1 - \tau_t + \mu) - \Lambda(c_t, \mathsf{e}_t) \tag{7}$$

In what follows we shall refer to b_t as the reservation wage (though there are other formulations of the latter concept). Workers choose search intensity (c), which affects their probability of hire (p). The individual chooses his/her own search intensity taking as given the economy-wide average search intensity (C) as well as all other relevant magnitudes (w, z, s, r, U, θ, V). Let J^N be the present value of being employed and J^U be the value of being unemployed. The worker's value of being unemployed is the solution to:

$$J_t^U = \max_{c_t} E_t\{b_t + \frac{1}{1+r_t}[p_t J_{t+1}^N + [1 - p_t]\, J_{t+1}^U]\} \tag{8}$$

subject to

$$J_{t+1}^N = w_{t+1}(1 - \tau_t) + \frac{1}{1 + r_{t+1}}[(1 - s_{t+1})J_{t+2}^N + s_{t+1}J_{t+2}^U] \tag{9}$$

where:

$$p_{t+1} = \frac{c_t}{C_t}\frac{M(\theta_t, C_t U_t, V_t)}{U_t}$$

[4] Unemployment benefits are provided according to a formula which is essentially a function of the weighted average of wages earned in the quarter preceding the unemployment spell.

The value of being unemployed J_t^U is the sum of the value of unemployment this period b_t and the expected value next period. This value is computed as the sum of two products: the product of the probability of being matched p_t and the value of being employed J_{t+1}^N and the product of the complementary probability $1 - p_t$ and the value of staying unemployed J_{t+1}^U. The value of being employed J_{t+1}^N is the sum of the current wage $w_{t+1}(1 - \tau_t)$ and the expected value next period. The latter is the sum of two terms: the product of the probability to stay on the job $1 - s_{t+1}$ and the value of staying employed J_{t+2}^N and the product of the probability of separation into unemployment s_{t+1} and the value of being unemployed J_{t+2}^U.

The F.O.C. is:

$$-\frac{\partial b_t}{\partial c_t} = \frac{1}{1+r_t}\frac{M(\theta_t, C_t U_t, V_t)}{C_t U_t} E_t[J_{t+1}^N - J_{t+1}^U] \tag{10}$$

The worker equates the marginal cost of search (the LHS) with the expected marginal benefit (the RHS). The latter is the product of the increase in probability of being hired (in terms of "efficiency units" of search) and the expected discounted net gain of moving from unemployment to employment.

Using the definition of J_{t+1}^N, J_{t+1}^U and the F.O.C. at time $t+1$ this can be re-written as:

$$-\frac{\partial b_t}{\partial c_t} = \frac{1}{1+r_t}\frac{M(\theta_t, C_t U_t, V_t)}{C_t U_t} E_t \left[\begin{array}{c} w_{t+1}(1-\tau_t) - b_{t+1} \\ + [1 - p_{t+1} - s_{t+1}] \left(\frac{-\frac{\partial b_{t+1}}{\partial c_{t+1}} C_{t+1} U_{t+1}}{M(\theta_{t+1}, C_{t+1} U_{t+1}, V_{t+1})} \right) \end{array} \right] \tag{11}$$

The expected discounted net gain of moving from unemployment to employment (given in the square brackets) is comprised of two discounted components: the net gain in period $(t+1)$, wages less reservation wages, and the future net gain, expressed as the value of marginal search costs next period.

2.1.4 Equilibrium Outcome

The partial equilibrium outcome is obtained by solving equations (1), (5), (6), (11) and the wage equation given below (equation 15), using the assumption of homogenous agents, for the stocks U (or N) and V, the flow of hiring H, search intensity C and the wage w. Consequently the matching rates Q and P are determined. This solution obtains given marginal productivity $\frac{\partial F_t}{\partial n_t}$, unemployment benefits z_t, taxes τ_t, employer contributions τ_t^s, the interest rate r_t, the separation rate s_t, the matching technology θ_t and the initial values of U, N and V. For a fully worked out example of such a partial equilibrium set-up see Pissarides (1985). The model may also be embedded in a general equilibrium framework using additional assumptions and imposing some constraints. Merz (1995) and Andolfatto (1996), for example, do so in the RBC framework where the exogenous driving shocks are technology shocks and hence the interest rate r_t and marginal productivity $\frac{\partial F_t}{\partial n_t}$ are endogenized.

2.2 The Wage Solution

The wage solution, using generalized Nash bargaining, is given by:

$$w_t = \arg\max (J_t^N - J_t^U)^{\beta_t} (J_t^F - J_t^V)^{1-\beta_t} \tag{12}$$

where $J_t^F - J_t^V$ is the firm's net value of the match, $J^N - J^U$ is the worker's net value of the match and β_t is the time-varying parameter capturing workers' bargaining power. The latter merits some discussion.

Binmore, Rubinstein and Wolinsky (1986) and Osborne and Rubinstein (1990) discuss the interpretation of this parameter in the context of mapping the Nash solution to a strategic bargaining model. This parameter may reflect differences in the bargaining environment which are not captured by the disagreement points, i.e. the outcome for the parties if bargaining does not result in an agreement. Thus, for example, it may capture the probability that workers make a wage demand in a given round of bargaining, or differences in impatience, with the value of β_t determined by the disparity in the subjective discount factors of the firms and the workers. A specific idea in this context was proposed by Shaked and Sutton (1984). They considered sequential bargaining between firms and workers, where the two sides alternate in making offers. In their analysis one party is free to switch between rival partners subject to a certain friction. We shall follow Shi and Wen (1999), who have applied the Shaked-Sutton model to the current context, and consider the case whereby the firm or the worker has the opportunity to switch to a new partner after T rounds of negotiations. Nature chooses which party makes the offer in each round; the worker's probability of making an offer shall be denoted by $\widetilde{\beta}$. The number of bargaining rounds till the switch (T) is modeled as a function of the relevant market conditions. There are two polar cases of interest: in the first it is the firm that gets to switch. Shi and Wen (1999) show that in these circumstances the worker bargaining parameter is given by:

$$\beta_t = \frac{T_t \widetilde{\beta}^2}{1 - \widetilde{\beta} + T_t \widetilde{\beta}} \tag{13}$$

where $T_t = \frac{1}{q_t}$ since each vacancy is matched at rate q_t. In the second case it is the worker that gets to switch and thus:

$$\beta_t = \frac{\widetilde{\beta} + T_t \widetilde{\beta}(1 - \widetilde{\beta})}{\widetilde{\beta} + T_t(1 - \widetilde{\beta})} \tag{14}$$

where $T_t = \frac{1}{p_t}$. In reality it is likely that both worker and firm may get to switch so the true parameter is bound to be between the two polar cases. Thus the bargaining power parameter becomes a time-varying, endogenous variable. This formulation is consistent with the interpretation of β_t as a type of summary statistic of the labor market position of workers [see the discussion in Flinn (2001)].

The solution of (12) yields:[5]

$$w_t = \frac{\beta_t}{(1+\tau_t^s)} \left[\frac{\partial F_t}{\partial n_t} - \frac{\partial \Gamma_t}{\partial n_t} + E_t \frac{p_t}{1+r_t} J_{t+1}^F \right] + \frac{(1-\beta_t)}{(1-\tau_t)} b_t \tag{15}$$

[5] The complete derivation is to be found in Appendix A.

Note that when there are no search costs ($\frac{\partial \Gamma_t}{\partial n_t} = J^F_{t+1} = 0$) and no taxes ($\tau^s_t = \tau_t = 0$) the wage is just a weighted average of current productivity and the reservation wage. Specifically when $\beta_t = 1$ we get the competitive solution i.e. $w_t = \frac{\partial F_t}{\partial n_t}$. Another way of interpreting equation (15) is the following. Suppose that there are no search costs i.e. $\gamma_1 = 0$ and no taxes i.e. $\tau_t = \tau^s_t = 0$ then:

$$\beta_t = \frac{w_t - b_t}{\alpha \frac{F_t}{N_t} - b_t}$$

Bargaining power β_t reflects the ratio between the actual wage-reservation wage premium $w_t - b_t$ and the productivity-reservation wage premium $\alpha \frac{F_t}{N_t} - b_t$.

In what follows we shall discuss the wage in terms of its share in average output $\frac{w}{\frac{F}{N}}$ or, in other words, in terms of the labor share of income $\frac{wN}{F}$. This is also equivalent to real unit labor costs.

The match surplus is given by:

$$S_t = J^F_t + J^N_t - J^U_t \tag{16}$$

The worker's share of the rent is therefore defined as follows:

$$\frac{J^N_t - J^U_t}{S_t} = \frac{(1 - \tau_t)}{(1 - \tau_t \beta_t) + \tau^s_t (1 - \beta_t)} \beta_t \tag{17}$$

Note that with taxes the worker's share differs from β_t.

3 Data and Methodology

3.1 The Data

We use aggregate Israeli labor market data to estimate the model. This data-set was chosen because it is of unique quality: this is Employment Service (ES) data on unemployment, vacancies, matches and workers' search intensity. Combined with data on real activity, wages, unemployment benefits, separation rates and interest rates, it covers a large segment of the market and contains measures of both sides of the search process (unemployed workers and firms' vacant jobs) which are consistent with the theoretical model and well defined. Moreover, structural estimates in Yashiv (2000a) indicate that the model - data fit is reasonably good. We briefly describe the institutional set-up of this market and then present the data series.

3.1.1 The Israeli Labor Market

This market is essentially composed of two main segments: the market for jobs that do not require a university degree and the market for jobs that require academic qualifications. Matching of workers and jobs in the former segment is done by the main institutional intermediary in the Israeli labor market, the Employment Service, which is affiliated to the Ministry of Labor. From 1959 until March 1991 private intermediaries were illegal and hiring of workers for these jobs was required by law to pass through the ES. On the other side of the market, unemployed workers must register with the ES in order to qualify for unemployment benefits. Firms post vacancies in quite specific terms: they are required to fill out a detailed form when registering vacancies including their exact number and the type of job required, and have to renew them at the beginning of each month. This procedure renders vacancies a concrete meaning and places them on equal footing with the unemployment figures. The latter are the result of workers' appearances at the ES bureau where they too filled out a detailed form. Therefore ES data give comprehensive coverage and offer the opportunity to study unemployment, vacancies and matches that are well defined. In this paper we deal exclusively with the ES segment of the market. There are several indications with respect to its relative size: the share of university graduates among employed workers was 35 percent at the end of the sample period and lower than that − at around 20-25 percent − in the course of the period. The ratio of ES unemployment to unemployment according to the Labor Force Survey (LFS) was about 60 percent on average in the years 1962 (when ES measurement began) till 1989 (the end of the sample period). Therefore a lower bound on the share of the ES segment is 60 percent of the market and it would not be unreasonable to estimate its actual share in the sample period as 70-80 percent.

3.1.2 Data Series

Unemployment, vacancies and matches data are taken from the administrative records of the ES. Wage and unemployment benefits data are taken from the National Insurance Agency (NIA). Other data used are business sector NIPA and LFS data from the Central Bureau of Statistics (CBS) and interest rate data from the Bank of Israel (BOI). Appendix B provides full definitions and a list of sources.

ES data generate the U, V and H series described above. We take business sector employment (N) from the LFS. The rate of separation (s), and the matching probabilities (Q and P) are derived from these series. ES data also provide a proxy for the unobservable search intensity (C) of unemployed workers. This is the average number of unemployed worker appearances at ES exchanges. The ES records the number of days workers visit the exchange each month; the average number D, measured in days, is obtained through division of the number of these daily appearances by the number of workers. While the legal appearance requirement was constant throughout the sample period, the series of actual appearances displays sufficient variation to be useful in estimation.[6] We compute search intensity as a function of this series by dividing it into the average number of working days in a month i.e $C = D/20$. Thus $0 \leq C \leq 1$.

Wage (w), unemployment benefits (z) and average output ($\frac{F}{N}$) are standard business sector data (see Appendix B for exact definitions). High frequency time series on taxes $-$ workers' wage and unemployment benefits taxes (τ) and employers' taxes and contributions (τ^s) $-$ are unavailable. In estimation we test for robustness by using alternative formulations elaborated below.

[6] We have checked whether the fluctuations in this series were generated by changes in the distribution of workers across various characteristics, but did not find this to be the case. We looked at the following characteristics of unemployed workers which are reported by the ES and considered important: whether they claim unemployment benefits or not, whether they are skilled or not, and whether they were referred to a job within the month (as most are) or not.

The real rate of interest r is an ex-post rate based on the most reliable nominal interest rate series. The latter is taken from the Bank of Israel. To generate the real rate, the nominal rate is deflated by the business sector GDP deflator rate of inflation in the case of firms and the CPI rate of inflation in the case of workers.

The data set includes 115 monthly observations in the years 1980-1989. The end points of the sample are restricted for two reasons: consistent vacancy, unemployment and hiring data from the ES are available only in the period 1975-1989; data on search intensity are available in consistent form only in sub-periods of the latter sample period. The longer period, 1980:05-1989:12, is used here. Table 1 presents sample summary statistics.

Table 1

The labor share of income including employer contributions ($\frac{wN(1+\tau_t^s)}{F}$) averaged 62.5% during the sample period.[7] This figure is comparable to the OECD average; for example Bentolila and Saint Paul (2001) report an average of 68.8% in 1980 and 65.5% in 1990 for 14 OECD economies.

3.2 Methodology

In this sub-section we present the parameterization of the functional forms, alternative specifications of the bargaining parameter, alternative formulations of the estimating equations, and the econometric methodology.

3.2.1 Functional Forms

In order to implement the model empirically, it is required to parameterize the production function F, the firm's hiring cost function Γ and the worker's search costs function Λ.

[7] Without employer contributions ($\frac{wN}{F}$) the share averaged 55% in the sample period. The difference, due to τ^s, is comparable to that reported by Krueger (1999) for the U.S.

For the production function (F) we take a "traditional" route and specify a Cobb-Douglas function; this enables us to use the average product, which is proportional to the marginal product, in estimation:

$$F_t = A_t n_t^{\alpha} k_t^{1-\alpha} \tag{18}$$

For the hiring cost function (Γ), first consider the arguments of the function. We refer here to gross hiring costs as distinct from net costs. By gross costs we refer to both the costs of screening (interviewing, testing, etc.) and the costs of training. The former relate to all vacancies; the latter only to actual hires. In order to take into account the size of the firm in terms of employment and output, we model these costs as a function of hiring rates out of employment and as proportional to output, i.e. $\Gamma = \widetilde{\Gamma}(\frac{v}{n}, \frac{qv}{n})F$, where $\widetilde{\Gamma}$ is some increasing function. This implies that costs are internal to the production process. Estimation results in Yashiv (2000a,b) show that for the functional form of hiring costs (the shape of $\widetilde{\Gamma}$) a general, unconstrained power works best. Thus we use:

$$\Gamma_t = \frac{\gamma_1}{\gamma_2}(\psi\frac{v_t}{n_t} + (1-\psi)\frac{q_t v_t}{n_t})^{\gamma_2} F_t \tag{19}$$

The parameter γ_2 captures the elasticity of the hiring function w.r.t. its determinants, γ_1 is a scale parameter and ψ is the fraction of costs that fall on screening. Note that in the special case $\psi = \gamma_2 = 1$ the linear specification obtains.

Below we make use of the following derivatives of this function:

$$\frac{\partial\Gamma_t}{\partial v_t} = \gamma_1(\psi\frac{v_t}{n_t} + (1-\psi)\frac{q_t v_t}{n_t})^{\gamma_2 - 1}(\psi + (1-\psi)q_t)\frac{F_t}{n_t} \tag{20}$$

$$\frac{\partial\Gamma_t}{\partial n_t} = -\gamma_1(\psi\frac{v_t}{n_t} + (1-\psi)\frac{q_t v_t}{n_t})^{\gamma_2}\frac{F_t}{n_t} + \left(\frac{\gamma_1}{\gamma_2}(\psi\frac{v_t}{n_t} + (1-\psi)\frac{q_t v_t}{n_t})^{\gamma_2}\right)\alpha\frac{F_t}{n_t} \tag{21}$$

Note that these derivatives are predicated on the set-up whereby the firm takes q as given.

For workers we model search costs as an increasing function of search intensity and as proportional to unemployment benefits.[8] For the functional form we use again a general, unconstrained power function i.e.:

$$\Lambda_t = \frac{\sigma_1}{\sigma_2} C^{\sigma_2} z_t \tag{22}$$

3.2.2 Wage Bargaining

The discussion in section 2.2 implied two possibilities for modelling the bargaining power parameter β_t : (i) a fixed parameter $\beta_t = \widetilde{\beta}$; (ii) a time-varying parameter dependent on market conditions. For the latter five alternative formulations are used: two are given by equation (13) i.e. $\beta_t = \frac{T_t \widetilde{\beta}^2}{1-\widetilde{\beta}+T_t\widetilde{\beta}}$ where $T_t = \frac{1}{q_t}$ and equation (14) i.e. $\beta_t = \frac{\widetilde{\beta}+T_t\widetilde{\beta}(1-\widetilde{\beta})}{\widetilde{\beta}+T_t(1-\widetilde{\beta})}$ where $T_t = \frac{1}{p_t}$. The other three are functions of market tightness $\frac{v}{u}$ and use three prevalent functional forms – linear, power and logistic:[9]

$$\beta_t = \widetilde{\beta}\left(\frac{v_t}{u_t}\right) \tag{23}$$

$$\beta_t = \widetilde{\beta}(\frac{v_t}{u_t})^{\beta_2} \tag{24}$$

$$\beta_t = \frac{\exp \widetilde{\beta}\left(\frac{v_t}{u_t}\right)}{1+\exp \widetilde{\beta}\left(\frac{v_t}{u_t}\right)} \tag{25}$$

The idea of these formulations is to try a functional form less specific than the Shi-Wen formulation.

3.2.3 Estimating Equations

The equation which is at the heart of the analysis is equation (15) i.e.:

[8] Modelling costs as proportional to z is not essential and is required for scaling purposes. We can alternatively model search costs as proportional to w or to $\frac{F}{n}$.

[9] Note that under a constant returns to scale matching function q and p used in the first two formulations are also functions of $\frac{v}{u}$.

$$w_t = \frac{\beta_t}{(1+\tau_t^s)}\left[\frac{\partial F_t}{\partial n_t} - \frac{\partial \Gamma_t}{\partial n_t} + E_t \frac{p_t}{1+r_t} J_{t+1}^F\right] + \frac{(1-\beta_t)}{(1-\tau_t)} b_t$$

At the aggregate level this equation may be re-written as follows, dividing throughout by $\frac{F_t}{N_t}$ to induce stationarity and inserting equations (18), (21), as well as (33) (given in Appendix A):

$$\begin{aligned} \frac{w_t}{\frac{F_t}{N_t}} &= \frac{\beta_t}{(1+\tau_t^s)} \left(\begin{array}{c} \alpha \left[1 - \frac{\gamma_1}{\gamma_2}\left(\psi \frac{V_t}{N_t} + (1-\psi)\frac{Q_t V_t}{N_t}\right)^{\gamma_2}\right] \\ +\gamma_1 \left(\psi \frac{V_t}{N_t} + (1-\psi)\frac{Q_t V_t}{N_t}\right)^{\gamma_2} \\ +\frac{V_t}{U_t}\gamma_1(\psi \frac{V_t}{N_t} + (1-\psi)\frac{Q_t V_t}{N_t})^{\gamma_2 - 1}(\psi + (1-\psi)Q_t) \end{array} \right) \\ &\quad + \frac{(1-\beta_t)}{(1-\tau_t)} \frac{b_t}{\frac{F_t}{N_t}} \end{aligned} \tag{26}$$

Note that some of the parameters in this equation emerge from other equations. The parameters $\alpha, \gamma_1, \gamma_2, \psi$ come from the firms' F.O.C (6) which may be written as follows:

$$\begin{aligned} & \frac{\gamma_1(\psi \frac{V_t}{N_t} + (1-\psi)\frac{Q_t V_t}{N_t})^{\gamma_2 - 1}(\psi + (1-\psi)Q_t)\frac{F_t}{N_t}}{\frac{F_{t+1}}{N_{t+1}}} \\ = \;& Q_t \frac{1}{1+r_t} \left[\begin{array}{c} \alpha \left[1 - \frac{\gamma_1}{\gamma_2}\left(\psi \frac{V_{t+1}}{N_{t+1}} + (1-\psi)\frac{Q_{t+1}V_{t+1}}{N_{t+1}}\right)^{\gamma_2}\right] \\ -\frac{(1+\tau_t^s)w_{t+1}N_{t+1}}{F_{t+1}} + \gamma_1\left(\psi \frac{V_{t+1}}{N_{t+1}} + (1-\psi)\frac{Q_{t+1}V_{t+1}}{N_{t+1}}\right)^{\gamma_2} \\ +(1-s_{t+1})\gamma_1(\psi \frac{V_{t+1}}{N_{t+1}} + (1-\psi)\frac{Q_{t+1}V_{t+1}}{N_{t+1}})^{\gamma_2 - 1}(\psi \frac{1}{Q_{t+1}} + (1-\psi)) \end{array} \right] \end{aligned} \tag{27}$$

This equation has been extensively explored in Yashiv (2000 a,b) using the same data set and econometric methodology. Thus we shall use the point estimates of $\alpha, \gamma_1, \gamma_2, \psi$ obtained there. These were in general robust except for the estimates of γ_1 for which we use alternative values, based on the findings in the cited papers.

The parameters σ_1, σ_2 and μ emerge from the workers' F.O.C (11) which may be written as follows, using (7):

$$\left(\frac{\sigma_1 C_t^{\sigma_2 - 1} \frac{z_t}{\frac{F_t}{N_t}}}{\frac{P_t}{C_t}} \right) \frac{\frac{F_t}{N_t}}{\frac{F_{t+1}}{N_{t+1}}} = \frac{1}{1+r_t} \left[\begin{array}{c} \frac{w_{t+1}}{\frac{F_{t+1}}{N_{t+1}}}(1-\tau_t) - \left[\frac{z_{t+1}}{\frac{F_{t+1}}{N_{t+1}}} \left[(1-\tau_t) + \mu - \frac{\sigma_1}{\sigma_2} C_{t+1}{}^{\sigma_2} \right] \right] \\ +(1 - P_{t+1} - s_{t+1}) \left[\left(\frac{\sigma_1 C_{t+1}{}^{\sigma_2 - 1} \frac{z_{t+1}}{\frac{F_{t+1}}{N_{t+1}}}}{\frac{P_{t+1}}{C_{t+1}}} \right) \right] \end{array} \right] \quad (28)$$

We shall simultaneously estimate (26) and (28) under alternative specifications spelled out below.

3.2.4 Estimation Methodology

We estimate the above equations using Hansen's (1982) GMM methodology. For equation (28) we use rational expectations to replace expected values by actual ones and estimate the orthogonality conditions whereby the workers' expectational error is uncorrelated with any variable in their information set at the search decision time. In equation (26) the error reflects random deviations of the actual wage from the Nash bargain.

4 Estimation Results

Table 2 presents the results of estimation. As implied by the preceding discussion we explore several formulations:

(i) The various specifications of the bargaining power β_t discussed in sub-section 3.2.2. These are shown in Panel (a) of the table. The motivation for testing alternative formulations is to allow different functional forms for the dependence of the bargaining power on market conditions.

(ii) Alternative series for the tax rates (τ_t and τ_t^s) and the separation rate (s). The basic idea is to examine alternatives to data series that are not available at the monthly frequency. These are shown in Panel (b) of the table.

(ii) As mentioned in section 3.2.3 there is need to examine alternative values for the point estimate of γ_1, the scale parameter of the firms' hiring costs function [based on the structural estimation results in Yashiv (2000b)]. That parameter was usually estimated to be around 300,000 and this is the value used in most specifications here. However to test for robustness we also examine the value of 600,000 which was the upper bound on the range of point estimates in the cited paper. This is shown in Panel (c) of the table.

(v) We also examine the constraint of no worker search costs ($\sigma_1 = 0$) and the constraint of no search costs on both sides ($\gamma_1 = \sigma_1 = 0$). These are shown in Panel (c) of the table. The idea here is to offer a comparison to models in which there are no costs to search.

The table's notes elaborate on these alternatives and on the values of the restricted parameters $(\alpha, \gamma_1, \gamma_2, \psi)$. The results specify the point estimates and standard errors of the four estimated parameters (μ, $\widetilde{\beta}$, σ_1, σ_2) and two test statistics: the value and p-value of Hansen's J-statistic [see Hansen (1982)] and the correlation between actual and fitted $\frac{w}{F/N}$. The latter computes the correlation between the LHS and the RHS of equation (26).[10]

Table 2

Panel (a) reports the sample mean and standard deviation of β_t as implied by the point estimates of $\widetilde{\beta}$. The main lesson is that the alternative specifications do not change much the average value of β_t or its volatility. The sample mean is generally somewhat less than 0.40 and the standard deviation is small, ranging between 0 and 0.07. The implication is that a fixed β is a fairly reasonable approximation.[11] Note that column 3 gives similar statistics for the implied β_t but has a negative point estimate of $\widetilde{\beta}$, implying an unreasonable negative dependence on market tightness. The values of β in Panel (b) and in column 9 of Panel (c) are the same as the one implied by Panel (a). Differences do arise when constraining workers' search costs to zero by imposing $\sigma_1 = 0$ in columns 10 and 11. In particular, the latter column indicates that if search costs of both firms and workers are ignored (hence only the wage equation (26) is estimated) the estimated bargaining

[10] The GMM estimation procedure for the general power specification for β_t did not converge.

[11] Panels (b) and (c) of Table 2 use the fixed β specification but in Tables 3-5 below we use the variable β_t specifications of columns 2 and 4, as well.

power rises to 0.57 i.e. increases by about 20 percentage points. This indicates that wage equations that ignore search costs may be significantly biased.

The estimate of μ, which captures home production, non-pecuniary benefits and losses, or production in the non-formal sector, is fairly stable at around 1.5 with small standard errors across most specifications.

Less stable are the estimates of the worker search costs function, with the point estimates of σ_1 being insignificant. However using the point estimates to compute the value of $\Lambda = \frac{\sigma_1}{\sigma_2} C_t^{\sigma_2} \frac{z_t}{F_t/N_t}$ in the sample period yields relatively stable results: the average value ranges between 0.7% and 3.3% across specifications and the standard deviations range between 0.3% and 0.7%. The point estimates of σ_2 are for the most part above 2, i.e. indicate a function that has higher convexity than the quadratic.

The overall fit of the wage equation is given by the correlation of the fitted series and the actual series ($\frac{w}{F/N}$): across all specifications it is around 0.70. The reason for the stability of the fit is that β and μ are essentially stable around 0.4 and 1.5 and that the range of estimates for $\frac{\sigma_1}{\sigma_2} C_t^{\sigma_2} \frac{z_t}{F_t/N_t}$ (as reported above) is small. The J-statistics in most specifications, however, reject the null hypothesis. The reason for this rejection may be understood when we set $\sigma_1 = 0$ and estimate only the wage equation. In these cases the J-statistics are lower with better p values. This indicates that it is the imprecise estimates of σ_1, and to some extent σ_2, that generate the J-statistic results. As pointed out, these point estimates produce small worker search costs estimates with little variation.

In what follows we explore the implications of the estimates. As the variation in the point estimates across the columns of Table 2 is not large, we shall restrict attention to a number of representative specifications (columns 1,2,4 and 9 of Table 2).

5 Implications I: Decomposing Wages

We analyze the results reported in Table 2. We begin by decomposing the wage equation (subsection 5.1) and one of its elements – reservation wages (5.2). In the next two sections we discuss additional implications of the estimates.

5.1 Decomposing the labor share of income

The labor share of income $\frac{wN}{F}$ is essentially made up of three terms:

(i) Current productivity, captured by the production function parameter α[12]. The latter is multiplied by the appropriate worker share i.e. $\frac{\beta_t}{(1+\tau_t^s)}$ which is the worker's bargaining strength β_t corrected for employer taxes and contributions τ_t^s. Note that the competitive case $\frac{wN}{F} = \alpha$ obtains as a special case i.e. when there are no search costs ($\gamma_1 = \sigma_1 = 0$), no employer contributions ($\tau_t^s = 0$) and the workers' bargaining power is full ($\beta_t = 1$).

(ii) Future productivity and net reduction in hiring costs, captured by the term FV_t multiplied by the same worker share $\frac{\beta_t}{(1+\tau_t^s)}$. The term FV_t includes: (a) net reduction in hiring costs [see equation (21)] $\gamma_1(1 - \frac{\alpha}{\gamma_2})\left(\psi \frac{v_t}{n_t} + (1-\psi)\frac{q_t v_t}{n_t}\right)^{\gamma_2}$ and (b) the expected discounted future value of the match J_{t+1}^F multiplied by the worker's matching probability P_t.

(iii) The reservation wage $\frac{b}{\frac{F}{N}}$ multiplied by $\frac{(1-\beta_t)}{(1-\tau_t)}$. This factor is the complement of the worker's bargaining strength $1-\beta_t$ corrected for wage taxes τ_t. If workers had no bargaining power ($\beta = 0$) then the wage would be set to the reservation wage, i.e. $w_t(1-\tau_t) = b_t$.

Table 3 reports the decomposition of the labor share into these components according to the estimates of Table 2. The table also reports the value of the bargaining parameter β_t and the workers' share in the match surplus $\frac{J_t^N - J_t^U}{S_t}$. Each entry reports the sample mean and standard deviation of the relevant variable using the point estimates of the parameters in Table 2.

[12] The discussion here is set in terms of values relative to $\frac{F}{N}$ i.e. $\frac{\frac{\partial F}{\partial N}}{\frac{F}{N}}$. Note that without hiring costs $\frac{\partial F}{\partial N} = \alpha \frac{F}{N}$. Hence $\frac{\frac{\partial F}{\partial N}}{\frac{F}{N}} = \alpha$. With hiring costs $\frac{\frac{\partial F}{\partial N}}{\frac{F}{N}} = \alpha\left[1 - \frac{\gamma_1}{\gamma_2}\left(\psi \frac{V}{N} + (1-\psi)\frac{QV}{N}\right)^{\gamma_2}\right]$ and the second term in brackets is included in the next term to be discussed.

Table 3

Table 4 reports the results of a variance decomposition of the fitted labor share into the afore-mentioned components along with the value of the variance of the actual labor share. Note that each component may be lower than 0% or higher than 100%.

Table 4

Three basic points emerge from Tables 3 and 4:

(i) As noted above, the value of β_t for most specifications is around 0.35–0.40. The workers' share in the match surplus $\frac{J_t^N - J_t^U}{S_t}$, taking taxes into account, is lower and varies between 0.23–0.31. Note that even with a fixed β_t this share exhibits variation as taxes are variable. However, as the standard error of the estimates of β_t are small, there is not much difference between the results with fixed or variable β.

How reasonable are the estimates of β and of the worker share in the surplus? There are few micro studies of this topic, with researchers often assuming a value of 0.5. One exception is a recent study by Flinn (2001), using U.S. CPS data on young workers and structural estimation. His major estimates are in the range of 0.42 to 0.50 for certain specifications with relatively low standard errors.[13] The results here are consistent with these findings.

(ii) In terms of the mean, as can be seen in Panel b of Table 3, across most specifications about 40% of the labor share is due to current productivity, with most of the rest due to the reservation wage. The role of future productivity (and the current reduction in hiring costs) is very small.

(iii) In terms of variance, as can be seen in Table 4, the reservation wage plays by far the major part while current and future productivity have very small parts. Note the sources of

[13] Other specifications of the model imply much lower estimates – in the range of 0.07 to 0.29 –but typically with large standard errors.

variability here: for the current productivity term they are due to variations in β_t (when allowed) and in taxes τ_t^s; for future productivity variability is generated by the variation in the relation between vacancies and unemployment as well as in β_t and in τ_t^s; for the reservation wage term variability stems from variation in unemployment benefits, wage tax rates, and search intensity as well as variations in β_t. The co-variation of the reservation wage and current productivity is also of significance.[14]

5.2 The reservation wage

The preceding discussion indicates that the reservation wage b is important for the determination of the labor share, both in terms of mean and even more so in terms of variance. As discussed in section 2.1.3 this value is made up of three terms: (i) net unemployment benefits, (ii) the value of home production, production in the informal sector or any non-pecuniary value, less (iii) search costs. Table 5 reports the decomposition of $\frac{b}{\frac{F}{N}}$ into these components according to the estimates of Table 2. As in Tables 3 and 4, each entry reports the sample mean and standard deviation of the relevant variable using the point estimates of the parameters in Table 2.

Table 5

The estimated reservation wage is 40% of output per worker ($\frac{F}{N}$).[15] Net benefit payments constitute a little over 40% of this value; about 65% are due to the home-production/informal

[14] Although qualitatively similar, specification 2 differs from the other three. The reason is that it features a bargaining parameter β which is more variable than in the other specifications. Hence the current productivity term is more volatile. Because β_t appears in mp and $(1-\beta_t)$ in b, the covariance between mp and b is negative here. It is positive in the other specifications because $\frac{1}{1+\tau^s}$ co-varies positively with b.

[15] The following shares may be noted based on the average estimate:

(i) reservation wages as a share of output per worker $\frac{b}{\frac{F}{N}} = 0.40$

(ii) reservation wages as a share of employer wage costs $\frac{b}{w(1+\tau^s)} = 0.65$

(iii) reservation wages as a share of net wages $\frac{b}{w(1-\tau)} = 0.88$

(iv) the share of reservation wages in the wage solution $\frac{1-\beta}{1-\tau}\frac{b}{\frac{F}{N}} = 0.30$

sector/non-pecuniary value. Then search costs deduct about 5%. In terms of volatility, the reported standard deviations indicate that a little over 60% in reservation wage variation is due to the term capturing home-production/informal sector/non-pecuniary value, almost 25% due to fluctuations in net benefits, about 3% due to search costs (with the remainder due to co-variation between these terms).

To judge the plausibility of these reservation wage estimates there are a number of studies to consider:

(i) Two recent micro studies structurally estimated a search model with bargaining using U.S. data: Eckstein and Wolpin (1995), using NLSY data, report (see their Table 5, p.282) reservation wages defined as rJ^U at the steady state. In the current model this is given by:

$$rJ^U = \frac{(1+r)(r+s)}{r+s+p}[b + \frac{pw(1-\tau_t)}{r+s}]$$

If we divide the predicted mean rJ^U by the mean of actual wages (i.e. by $\frac{rJ^U}{w}$) their estimates range between 49% and 65%. The afore-cited study by Flinn (2001), using CPS data, reports values in a similar range – 49% to 60% (based on his Tables 1 and 2a). Inserting the sample mean values of r, s, p, w and the implied estimate of b from Table 2 we get 84%. Thus the estimated b here generates a higher value of rJ^U than the afore-cited studies. The differences in economies and labor market policies notwithstanding, this is a reasonable difference, given that the cited studies use data on young workers, whose reservation wages are likely to be lower than the average worker.

(ii) A range of estimates of the value of aggregate home production in the U.S. is presented in Eisner (1988). The estimates are mostly between 30% and 50% of output net of home production. Here the estimate of b is 40% of average output per worker.

We can briefly sum up the results of this section: the wage equation is reasonably well fitted, with a fixed workers' bargaining parameter of around 0.4 constituting a good approximation. The reservation wage b plays a key role in the determination of wages both in terms of the mean (around 60%) and even more so in terms of the variance. The role of the future productivity of the match is small. Reservation wages themselves are determined mostly by the value of home or informal production and any non-pecuniary value and, to a lesser extent, by net unemployment benefits.

6 Implications II: Beveridge Curves and Wage Curves

The results can provide some lessons with respect to the behavior of some well-known relations – the relation between unemployment and vacancies, known as the 'Beveridge curve', and the relation between wages and unemployment, known as the 'wage curve.' We derive these curves as follows: we formulate the non-stochastic steady state of the model. The two curves are obtained by deriving the model's solution under different values of the exogenous variables. We then examine how the curves move when key parameters change. In particular we look at the effects of changing the bargaining power (β), unemployment benefits (z), the value of unemployment (via μ) and search costs (via σ_1).

6.1 The Steady State

We write the wage equation (26) and the firms' and workers' Euler equations (27 and 28) in their steady state form as follows:

$$\frac{w}{\frac{F}{N}} = \frac{\beta}{(1+\tau^s)}\begin{pmatrix} \alpha\left[1-\frac{\gamma_1}{\gamma_2}\left(\psi\frac{V}{N}+(1-\psi)\frac{QV}{N}\right)^{\gamma_2}\right] \\ +\gamma_1\left(\psi\frac{V}{N}+(1-\psi)\frac{QV}{N}\right)^{\gamma_2} \\ +\frac{V}{U}\gamma_1(\psi\frac{V}{N}+(1-\psi)\frac{QV}{N})^{\gamma_2-1}(\psi+(1-\psi)Q) \end{pmatrix} + \frac{(1-\beta)}{(1-\tau)}\frac{b}{\frac{F}{N}} \tag{29}$$

$$\gamma_1\left(\psi\frac{V}{N}+(1-\psi)\frac{QV}{N}\right)^{\gamma_2-1}(\psi+(1-\psi)Q) = Q\frac{1+g^f}{r+s-g^f(1-s)} \left[\alpha-\frac{(1+\tau^s)w}{F/N}+\gamma_1\left(\psi\frac{V}{N}+(1-\psi)\frac{QV}{N}\right)^{\gamma_2}(1-\frac{\alpha}{\gamma_2})\right] \tag{30}$$

where g^f is the gross rate of growth of labor productivity $\frac{F}{N}$.

$$\frac{\sigma_1 C^{\sigma_2 - 1} z}{\frac{P}{C} w} = \frac{1}{r + P + s} \left[\begin{array}{c} (1 - \tau) \\ - \left[\frac{z}{w} (1 - \tau + \mu - \frac{\sigma_1}{\sigma_2} C^{\sigma_2} \right] \end{array} \right] \tag{31}$$

We add a steady state flow equation whereby the flow into unemployment equals the flow out of it:

$$\theta (CU)^{\xi} V^{1-\xi} = sN \tag{32}$$

where θ is the matching technology parameter and ξ is the elasticity parameter.

This system of four equations is to be solved numerically for the four endogenous variables U, V, C and w. Their solution determines N, Q, and P. The system is solved given the exogenous variables $\frac{F}{N}, g^f, L, r, z, \tau, \tau^s$ and s. We also use a fixed and exogenous β.

6.2 Baseline Values

In order to solve the model we use the following baseline values. We express labor force variables (U, N, V) in terms of rates out of the labor force (i.e. divide by L) and output variables (w, z) in terms of output per worker (i.e divide by $\frac{F}{N}$). We set the variables at their sample average value using the longest sample available. The resulting values are thus given by:

Exogenous Variables

variable	steady state value
g^f	0.004
r	0.01
z	0.18
τ	0.14
τ^s	0.12
s	0.024

As to the parameters we use the point estimates from Table 2 column 1:

Parameter Values

parameter	value
β	0.38
μ	1.5
σ_1	4.5
σ_2	2.3
γ_1	$300,000$
γ_2	4.74
ψ	0.3
α	0.68
ξ	0.3
θ	0.54

Two parameters did not appear in the empirical section above: ξ, the matching function elasticity parameter, was structurally estimated in Yashiv (2000a) to be about 0.3. The matching function scale parameter θ is calibrated so that the model will produce a steady state solution for $\frac{U}{L}$ that will match its data average of 7.2%.

The solution of this baseline is the following:

variable	solution
$\frac{U}{L}$	7.2%
$\frac{V}{L}$	4.5%
C	0.46
$\frac{w}{\frac{F}{N}}$	0.60

6.3 Steady State Curves

The above system has produced a solution consisting of one steady state value for each variable $\frac{U}{L}, \frac{V}{L}, C$ and $\frac{w}{\frac{F}{N}}$. If we now vary two exogenous variables – productivity growth g^f or the real rate of interest r – within a reasonable range we get a steady state curve in $\frac{U}{L} - \frac{V}{L}$ and in $\frac{U}{L} - \frac{w}{\frac{F}{N}}$ space as shown in the four panels of Figure 1. The origin in each plot is the steady state point described above.

Figure 1

Note that we graphically depict three endogenous variables $\frac{U}{L}, \frac{V}{L}$ and $\frac{w}{\frac{F}{N}}$. The fourth, search intensity C, evidently changes too as exogenous variables and parameters change. The mechanism underlying the curves is the following: when the interest rate rises or productivity growth declines the firm's present value of the match declines. Hence vacancy creation declines. This leads to lower matching and higher unemployment. As the value of the match declines so do wages. Hence vacancies and wages go down as unemployment rises. Note that this mechanism provides a foundation for the downward sloping wage curve. This feature of the wage curve is inconsistent with some models of the labor market, including the traditional textbook model [see the discussion in Blanchflower and Oswald (1994)].

We now generate families of Beveridge and wage curves. Each curve is generated by varying the real rate of interest and is plotted in different color in the figures. Each family of curves is generated by varying one of the following parameters within reasonable ranges: the bargaining power (β), unemployment benefits (z), the value of unemployment (via μ) and search costs (via σ_1). The results for the Beveridge curves are given in the four panels of Figure 2 and for the wage curves in the four panels of Figure 3. Note that each curve's length is determined by the variation in the rate of interest, as shown in Figure 1.

Figures 2 and 3

The effect of the bargaining parameter is substantial: as workers gain bargaining power, wages increase and firms' profits are eroded; this leads to lower vacancy rates and higher unemployment. The Beveridge curve shifts downwards and to the right in $\frac{U}{L} - \frac{V}{L}$ space while the wage curve shifts upwards and to the right in $\frac{U}{L} - \frac{w}{\frac{F}{N}}$ space. At the extreme, when the bargaining power rises about 30 percentage points from 0.4 to 0.7, the rate of unemployment rises from 7% to 16% i.e. by 9 percentage points.

The effect of changing the parameter μ is to change the value of unemployment through the reservation wage b. As this value rises wages increase, eroding the profitability of firms. Vacancy creation falls and unemployment rises. As in the preceding case, the Beveridge curve shifts downwards and to the right in $U-V$ space while the wage curve shifts upwards and to the right in $U-w$ space. The only difference is that in this case the downward movement of the Beveridge curve is "smoother" and looks almost as though the "family" lies on one curve, while in the preceding case it is accompanied by a gradual movement of the curve towards the origin. As may be expected the effect of changing z is very much the same as changing μ.

Taken together, the changes shown in panels (a)-(c) relate to workers' share of the match surplus. The underlying mechanism is that an increase in this share, whether through β, μ or z, erodes firms' profits leading to lower job vacancies creation and to higher unemployment. This, in effect, is a quantification of the idea – often raised in the context of the discussion of U.S.-Europe unemployment differences – that greater worker wage bargaining power is detrimental to employment.

Figures 2d and 3d show the effects of changing workers' search costs. As σ_1 rises, these costs rise and search intensity (C) declines. This decline leads to lower matching and higher unemployment. Consequently the wage curve shifts to the right (almost in parallel, as there is little effect on the wage bargain) and the Beveridge curve shifts out. The figures imply that a doubling of search costs from the baseline value (i.e. from $\sigma_1 = 4.5$ to 9) raises unemployment by 1.4 percentage points.

7 Implications III: Phillips Curves and Market Efficiency

In this section we briefly comment on two more macroeconomic implications of the empirical results.

7.1 Phillips Curve Models and Natural Rate Models

The results shed some light on a recent discussion on the relation between the empirical evidence on the short-term trade-off between nominal changes in wages and unemployment – the Phillips curve – and the empirical implications of theories of the 'natural rate' of unemployment. Blanchard and Katz (1999) have made the point that the relative dependence of real wages on reservation wages and on productivity is essential for reconciling the two types of model. Their argument is the following, using their notation, not to be confused with the model's notation given above:

The traditional 'expectations-augmented' Phillips curve is given by:

$$w_t - w_{t-1} = a + (p_t^e - p_{t-1}) - \beta u_t + \varepsilon_t$$

where u denotes deviations from the natural rate of unemployment. Expressing the curve in terms of the real wage we get:

$$w_t - p_t^e = a + (w_{t-1} - p_{t-1}) - \beta u_t + \varepsilon_t$$

Blanchard and Katz formulate the wage curve as follows, allowing real wages to depend on reservation wages b and on productivity y as well as on deviations from the natural rate of unemployment:

$$w_t - p_t^e = \mu b_t + (1 - \mu) y_t - \beta u_t + \varepsilon_t$$

Reservation wages themselves are a weighted average of lagged real wages and current productivity:

$$b_t = c + \lambda(w_{t-1} - p_{t-1}) + (1 - \lambda) y_t$$

Hence the wage curve can be re-written as follows:

$$w_t - p_t^e = \mu c + \mu\lambda(w_{t-1} - p_{t-1}) + (1 - \mu\lambda)y_t - \beta u_t + \varepsilon_t$$

To reconcile the Phillips curve and the wage curve the following condition needs to hold true:

$$\mu\lambda = 1$$

Thus there is importance to two parameter values: μ, the dependence of real wages on reservation wages, and λ the dependence of reservation wages on lagged wages. The findings here show that wages are closely related, but not fully related, to reservation wages. In the terminology of Blanchard and Katz this means that μ is high but is less than 1. The findings show that taking into account hiring costs and search costs is essential for determining the value of μ. The findings here relate to a formulation of b that is different than the Blanchard-Katz definition, and indicate that home production or production in the informal sector is important. It is unclear whether this result supports a high or a low level of λ as it is predicated on the question whether this kind of production is more closely related to lagged wages or to current productivity.

7.2 Market Efficiency

Hosios (1990) has shown that under certain conditions the market is efficient if the contribution of unemployed workers to matching equals the workers' share in the match surplus. This efficiency condition balances between the negative congestion and positive trading externalities induced by search. The estimates in Table 2 above indicate that the share of workers in the surplus averages around 0.3. Yashiv (2000a) provides estimates of the matching function in the same period with the same data set. The estimates indicate that the matching function exhibits increasing returns to scale, a finding which is inconsistent with the conditions needed − constant returns to scale in matching among them − for the Hosios result. However the departure from constant returns to scale is not big. According to the matching function estimates the contribution of workers to matching is around 0.20-0.25 under one specification and 0.01-0.05 under another. Hence, comparing the two sets of estimates [Table 2 here and Yashiv (2000a)], workers got in wages more than they contributed to matching, implying market inefficiency. However the difference does not appear to be substantial.

8 Conclusions

The findings of this paper lend empirical support to the modelling of wage formation as a bargaining process in the search and matching model. The results show that reservation wages play a key role, especially in the volatility of the wage bargain. The reservation wage is driven mostly by net unemployment benefits and by a term capturing home production or production in the non-formal sector and any non-pecuniary value of unemployment. The simulation analysis showed that well-defined Beveridge curve and 'wage curve' are generated by the model's steady state. The curves were structurally characterized and it was shown how key variables and parameters in the wage bargaining process affect them. In particular, increases in the reservation wage were shown to lead to higher wages, lower job creation and higher unemployment. Quantifying these changes in a calibrated framework indicated that substantial increases in equilibrium unemployment may occur for reasonable variation in bargaining parameters. The extent of inefficiency in this market was also empirically evaluated, revealing some, but not substantial, departure from efficiency.

The paper provides a framework that may be useful in evaluating policy schemes. Thus the effects of UI and taxation policies on wages, job vacancy creation and unemployment may be studied. Another area for future research is the examination of cross-country differences such as U.S.-Europe differences, where unemployment benefits and labor taxation have been often cited as explanatory variables. Such a study is evidently predicated on the availability of relevant data; the type of data needed is implied by the current analysis.

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9 Appendix A

Derivation of the Wage Equation and Rent Sharing

The following derivation is based on Nash (1950) and its application to the search and matching context by Diamond (1982b).

9.1 Asset Values

In order to derive the solution the relevant asset value expressions need to be derived.

A match that is formed and is to begin production at time t is worth to the firm:

$$J_t^F = \frac{\partial F_t}{\partial n_t} - w_t(1+\tau_t^s) - \frac{\partial \Gamma_t}{\partial n_t} + E_t \frac{1}{1+r_t}\left[(1-s_t)J_{t+1}^F + s_t J_{t+1}^V\right] \tag{33}$$

The value of a vacancy is:

$$J_t^V = -\frac{\partial \Gamma_t}{\partial v_t} + E_t \frac{1}{1+r_t}\left[q_t J_{t+1}^F + (1-q_t)J_{t+1}^V\right] \tag{34}$$

Due to free entry the following obtains:

$$J_t^V = 0 \tag{35}$$

For the unemployed worker the present value of unemployment consists of the sum of (i) the net value of unemployment at time t (b_t) and (ii) the expected future value which takes into account the probability of matching into employment the next period, and the continuation value of employment J^N :

$$J_t^U = b_t + E_t \frac{1}{1+r_t}\left[p_t J_{t+1}^N + (1-p_t)J_{t+1}^U\right] \tag{36}$$

Similarly the present value of employment consists of the sum of (i) the net wage at time t; and (ii) the expected future value which takes into account the probability of separating from employment into unemployment in the next period, s_{t+1}, and the continuation value of unemployment J^U :

$$J_t^N = w_t(1-\tau_t) + E_t \frac{1}{1+r_t}\left[(1-s_t)J_{t+1}^N + s_t J_{t+1}^U\right] \tag{37}$$

The net value of the match for the worker is thus:

$$J_t^N - J_t^U = w_t(1-\tau_t) - b_t + E_t \frac{(1-s_t-p_t)}{1+r_t}(J_{t+1}^N - J_{t+1}^U) \tag{38}$$

9.2 The Nash problem

The Nash bargaining problem is given by:

$$w_t = \arg\max (J_t^N - J_t^U)^{\beta_t}(J_t^F - J_t^V)^{1-\beta_t} \tag{39}$$

To derive the solution take logs of the relevant expression i.e.:

$$\beta_t \ln(J_t^N - J_t^U) + (1-\beta_t)\ln(J_t^F - J_t^V) \tag{40}$$

Differentiating with respect to w and setting equal to zero:

$$\beta_t \frac{\frac{\partial (J_t^N - J_t^U)}{\partial w_t}}{J_t^N - J_t^U} + (1-\beta_t)\frac{\frac{\partial (J_t^F - J_t^V)}{\partial w_t}}{J_t^F - J_t^V} = 0 \tag{41}$$

The relevant derivatives are:

$$\frac{\partial (J_t^F - J_t^V)}{\partial w_t} = -(1+\tau_t^s)$$

$$\frac{\partial (J_t^N - J_t^U)}{\partial w_t} = (1-\tau_t)$$

Thus (41) becomes:

$$\beta_t \frac{(1-\tau_t)}{J_t^N - J_t^U} = (1-\beta_t)\frac{(1+\tau_t^s)}{J_t^F - J_t^V} \tag{42}$$

9.3 The wage equation and surplus division

Inserting the asset value expressions into the Nash solution (42) one gets:

$$\begin{aligned} & \beta_t(1-\tau_t)\left[\frac{\partial F_t}{\partial n_t} - w_t(1+\tau_t^s) - \frac{\partial \Gamma_t}{\partial n_t} + E_t\frac{1}{1+r_t}\left[(1-s_t)J_{t+1}^F + s_t J_{t+1}^V\right]\right] \\ = \; & (1-\beta_t)(1+\tau_t^S)\left[w_t(1-\tau_t) - b_t + E_t\frac{(1-s_t-p_t)}{1+r_t}(J_{t+1}^N - J_{t+1}^U)\right] \end{aligned} \tag{43}$$

Rearranging:

$$\begin{aligned} w_t\left[(1-\beta_t)(1-\tau_t)(1+\tau_t^S) + \beta_t(1-\tau_t)(1+\tau_t^s)\right] \;=\; & \beta_t(1-\tau_t)\left[\frac{\partial F_t}{\partial n_t} - \frac{\partial \Gamma_t}{\partial n_t}\right] \\ & +(1-\beta_t)(1+\tau_t^S)b_t \\ & +\beta_t(1-\tau_t)E_t\frac{1}{1+r_t}\left[(1-s_t)J_{t+1}^F\right] \\ & -(1-\beta_t)(1+\tau_t^S)E_t\frac{(1-s_t-p_t)}{1+r_t}(J_{t+1}^N - J_{t+1}^U) \end{aligned} \tag{44}$$

Noting that (42) holds true at $t+1$ i.e.:

$$\beta_t(1-\tau_t)J_{t+1}^F = (1-\beta_t)(1+\tau_t^S)\left[J_{t+1}^N - J_{t+1}^U\right]$$

We get:

$$\begin{aligned} w_t\left[(1-\beta_t)(1-\tau_t)(1+\tau_t^S) + \beta_t(1-\tau_t)(1+\tau_t^s)\right] \;=\; & \beta_t(1-\tau_t)\left[\frac{\partial F_t}{\partial n_t} - \frac{\partial \Gamma_t}{\partial n_t}\right] \\ & +(1-\beta_t)(1+\tau_t^S)b_t \\ & +(1-\beta_t)(1+\tau_t^S)E_t\frac{p_t}{1+r_t}(J_{t+1}^N - J_{t+1}^U) \end{aligned} \tag{45}$$

Hence:

$$w_t\left[(1-\beta_t)(1-\tau_t)(1+\tau_t^S)+\beta_t(1-\tau_t)(1+\tau_t^s)\right] = \beta_t(1-\tau_t)\left[\frac{\partial F_t}{\partial n_t}-\frac{\partial \Gamma_t}{\partial n_t}+E_t\frac{p_t}{1+r_t}J_{t+1}^F\right] +(1-\beta_t)(1+\tau_t^S)b_t \tag{46}$$

Solving for w :

$$w_t=\frac{\beta_t}{(1+\tau_t^s)}\left[\frac{\partial F_t}{\partial n_t}-\frac{\partial \Gamma_t}{\partial n_t}+E_t\frac{p_t}{1+r_t}J_{t+1}^F\right]+\frac{(1-\beta_t)}{(1-\tau_t)}b_t \tag{47}$$

This is equation (15) in the text.

Note that the match surplus is given by:

$$S_t=J_t^F+J_t^N-J_t^U \tag{48}$$

Using (42):

$$\begin{aligned}\beta_t J_t^F &= \frac{(1-\beta_t)(1+\tau_t^s)}{1-\tau_t}\left[J_t^N-J_t^U\right]\\ &= \frac{(1-\beta_t)(1+\tau_t^s)}{1-\tau_t}\left[S_t-J_t^F\right]\end{aligned}$$

Thus the surplus is given by:

$$S_t=\frac{1-\beta_t\tau_t+\tau_t^s(1-\beta_t)}{(1-\beta_t)(1+\tau_t^s)}J_t^F \tag{49}$$

Rent sharing is therefore defined as follows:

$$\begin{aligned}\frac{J_t^F}{S_t} &= \frac{(1+\tau_t^s)}{1-\beta_t\tau_t+\tau_t^s(1-\beta_t)}(1-\beta_t)\\ \frac{J_t^N-J_t^U}{S_t} &= \frac{(1-\tau_t)}{1-\beta_t\tau_t+\tau_t^s(1-\beta_t)}\beta_t\end{aligned} \tag{50}$$

10 Appendix B

Data - Sources and Definitions

The data set is comprised of 115 monthly observations in the period 1980:05-1989:12.

The following abbreviations are used for the agencies that are the sources of the data:

ES = Employment Service; CBS = Central Bureau of Statistics; LFS = Labor Force Survey of the CBS; BOI = Bank of Israel; NIA = National Insurance Agency.

ES data is taken from its quarterly statistical publications (Employment Service, 1975-1990). All other data (including data originating with the NIA or BOI) appear in the monthly bulletin of the CBS (Central Bureau of Statistics, 1975-1990).

1. Vacancies (V), unemployment (U) and matches (H):

Source: ES. Number of vacancies posted by firms, number of workseekers who registered at the ES, and number of vacancies matched respectively. The vacancies and unemployment series are the sum of end of month stocks (unfilled vacancies and unreferred workseekers) and within the month inflows (total vacancies less unfilled vacancies of the previous month and total workseekers less unreferred workseekers of the previous month).

2. Business sector employment (N):

Source: LFS of the CBS. Number of employess in the business sector.

3. Separation rate (s):

Source: computed on the basis of CBS and ES series. There is no direct gross flow measure of worker separations. We use the firms' budget constraint (5) to solve for s at each period. For N we use the above measure. As ES data does not capture all hires made we also explore an alternative definition of s where we double the number of ES matches. Thus the true s should be between the first and the second measure.

4. Number of workseekers appearances at the ES exchanges (D) and search intensity (C):

Source: ES. Average number of daily appearances per month by workseekers at ES exchanges, i.e. total number of days of appearance by workseekers divided by their number. We compute search intensity as a function of this series by dividing it into the average number of working days in a month i.e $C = D/20$.

5. Average product (F/N):

Source: CBS, NIA. Net domestic product of the business sector divided by business sector employment (the above N). The net product is obtained by subtracting depreciation and net production taxes from GDP (note that F represents firms' income in the model). As these data are not available but on annual basis, we assume that it is fixed within the year. The product and employment series are quarterly and are transformed into the monthly frequency by assuming linear geometric growth within the quarter.

6. Wages (w)

Source: NIA The average wage for employee post in the business sector.

7. Employer taxes and contributions (τ^s):

Source: NIA. Employer taxes and social security contributions levied from wages. The series is available at the annual frequency. In estimation we assume it is fixed throughout the year.

8. Worker wage taxes (τ) :

Source; BOI. Taxes and net social security contributions (i.e net of benefits received) by workers levied from wages. Here to the data are annual and we assume constancy within the year.

9. Unemployment benefits (z):

Source: NIA. The monthly average of nominal unemployment benefits per person. This is obtained by dividing total benefit payments by the total number of days paid for the entire relevant population (benefits are paid on a working day basis) and then multiplying by 20, which is the average number of working days a month. The series represent what a person would get on average if unemployed.

10. The real rate of interest (r):

Source: BOI, CBS. (1+ the basic nominal interest rate charged by banks) divided by (1 + the rate of business sector GDP deflator inflation) for firms and (1+the rate of CPI inflation) for workers minus 1. The numerator is the most reliable nominal interest rate series in the sample period and is the benchmark rate on bank credit to firms and households.

Table 1

Sample Summary Statistics

monthly, 1980:05-1989:12

symbol	variable	mean	s.d.
$\frac{wN}{F}$	labor share of income	0.55	0.06
$\frac{w(1+\tau^s)N}{F}$	labor share of income including employer's taxes	0.63	0.06
$\frac{z}{w}$	replacement ratio	0.32	0.04
C_t	search intensity	0.28	0.03
P_t	worker match probability	0.38	0.09
Q_t	vacancy match probability	0.80	0.05
$\frac{V}{N}$	vacancy rate	0.019	0.002
$\frac{U}{N}$	unemployment rate	0.043	0.011
$\frac{V}{U}$	market tightness	0.47	0.11
τ^s	firms' average tax rate	0.14	0.03
τ	workers' average tax rate	0.17	0.02
$s(1)$	separation rate (specification 1)	0.014	0.005
$s(2)$	separation rate (specification 2)	0.030	0.006

Note: Appendix B elaborates on data sources and definitions.

Table 2

GMM Estimates

a. β variations

	1	**2**	**3**	4	5
	$\beta_t = \widetilde{\beta}$	$\beta_t = \widetilde{\beta}\left(\frac{V_t}{U_t}\right)$	$\beta_t = \frac{\exp \widetilde{\beta}(\frac{V_t}{U_t})}{1+\exp \widetilde{\beta}(\frac{V_t}{U_t})}$	$\beta_t = \frac{\frac{1}{Q_t}\widetilde{\beta}^2}{1-\widetilde{\beta}+\frac{1}{Q_t}\widetilde{\beta}}$	$\beta_t = \frac{\widetilde{\beta}+\frac{1}{P_t}\widetilde{\beta}(1-\widetilde{\beta})}{\widetilde{\beta}+\frac{1}{P_t}(1-\widetilde{\beta})}$
μ	1.54	1.52	1.54	1.55	1.53
	(0.04)	(0.02)	(0.03)	(0.05)	(0.03)
$\widetilde{\beta}$	0.38	0.62	-1.29	0.60	0.27
	(0.03)	(0.07)	(0.28)	(0.02)	(0.02)
implied β_t	0.38	0.29	0.35	0.40	0.36
	(0.00)	(0.07)	(0.03)	(0.01)	(0.02)
σ_1	4.49	38.8	6.29	3.50	5.62
	(4.90)	(74.0)	(7.83)	(3.40)	(6.77)
σ_2	2.32	4.37	2.68	2.05	2.56
	(0.94)	(1.66)	(1.08)	(0.83)	(1.04)
J-stat	42.7	46.8	42.5	42.2	43.8
p-value	0.005	0.002	0.005	0.006	0.004
$\rho(actual, fitted)$	0.68	0.65	0.70	0.68	0.67

b. Variations in variables (τ, τ^s, s)

	6	**7**	**8**
	$\tau = 0.25$	$\tau^s = 0.20$	$s = s(2)$
μ	1.39	1.56	1.52
	(0.05)	(0.02)	(0.03)
$\widetilde{\beta}$	0.40	0.36	0.37
	(0.03)	(0.03)	(0.03)
σ_1	3.12	6145	6.93
	(3.11)	(23,457)	(8.31)
σ_2	2.03	9.04	2.72
	(0.85)	(3.42)	(1.03)
J-stat	42.6	39.9	42.6
p-value	0.005	0.010	0.005
$\rho(actual, fitted)$	0.68	0.67	0.68

c. Variations in constrained values

	9	**10**	**11**
γ_1	**600,000**	**300,000**	**0**
μ	1.59	1.35	1.43
	(0.09)	(0.05)	(0.04)
$\widetilde{\beta}$	0.35	0.50	0.57
	(0.03)	(0.04)	(0.04)
σ_1	2.02	**0**	**0**
	(1.64)		
σ_2	1.53	-	-
	(0.69)		
J-stat	43.3	19.9	17.2
p-value	0.004	0.05	0.10
$\rho(actual, fitted)$	0.65	0.67	0.72

Notes:

1. Standard errors appear in parentheses.

2. The following parameter values were constrained throughout: $\alpha = 0.68, \gamma_2 = 4.74, \psi = 0.3$. The value of γ_1 was set to be $300,000$ except for columns (9) and (11) in Panel (c). These values are based on the estimates reported in Yashiv (2000a,b).

3. Alternative specifications:

a. Panel (a) presents variations in the specification of β_t as indicated in the second row; the alternatives are spelled out in section 3.2.3.

b. Panel (b) presents variations in the definition of the variables used for τ, τ^s and s; the alternative definitions are spelled out in Appendix B.

c. Panel (c) presents variations in the constrained value of γ_1 and sets $\sigma_1 = 0$ in columns 10 and 11. In these two columns only equation (26) is estimated.

4. Instruments used are a constant and 4 lags of $\frac{z}{F/N}$, C and $\frac{QV}{N}$.
5. Period estimated is 1980:05-1989:12 (n=115).

Table 3

Wage Decomposition and Workers Bargaining Share

a. Bargaining Power and Bargaining Share

specification	β_t	$\frac{J_t^N - J_t^U}{S_t}$
1	0.38 (0.00)	0.31 (0.01)
2	0.29 (0.07)	0.23 (0.06)
4	0.40 (0.01)	0.32 (0.02)
9	0.35 (0.00)	0.28 (0.01)

b. Components of Wages

specification	fitted $\frac{w_t}{\frac{F_t}{n_t}}$	$\frac{\beta_t}{(1+\tau_t^s)}\alpha$	$\frac{\beta_t}{(1+\tau_t^s)}FV_t$	$\frac{(1-\beta_t)}{(1-\tau_t)}\frac{b_t}{\frac{F_t}{n_t}}$
1	0.54 (0.06)	0.22 (0.01)	0.01 (0.01)	0.30 (0.06)
2	0.54 (0.07)	0.18 (0.04)	0.01 (0.01)	0.35 (0.09)
4	0.54 (0.06)	0.24 (0.01)	0.01 (0.01)	0.29 (0.05)
9	0.54 (0.06)	0.21 (0.00)	0.02 (0.01)	0.31 (0.06)

Notes:

1. The specification numbers correspond to the columns of Table 2.

2. Each entry reports the sample mean and in parentheses the standard deviation. Wherever relevant point estimates of the parameters from Table 2 are used.

3. Actual $\frac{w_t}{\frac{F_t}{n_t}}$ has a mean of 0.548 and standard deviation of 0.057.

4. The term FV_t captures:

(i) net reduction in hiring costs $\gamma_1(1-\frac{\alpha}{\gamma_2})\left(\psi\frac{v_t}{n_t}+(1-\psi)\frac{q_t v_t}{n_t}\right)^{\gamma_2}$

(ii) the expected discounted future value of the match J_{t+1}^F multiplied by the worker's matching probability P_t.

Formally it is defined as follows:

$$
\begin{aligned}
FV_t = \quad & \gamma_1(1-\tfrac{\alpha}{\gamma_2})\left(\psi\tfrac{v_t}{n_t}+(1-\psi)\tfrac{q_t v_t}{n_t}\right)^{\gamma_2} \\
& +\tfrac{v_t}{u_t}\gamma_1(\psi\tfrac{v_t}{n_t}+(1-\psi)\tfrac{q_t v_t}{n_t})^{\gamma_2-1}(\psi+(1-\psi)q_t)
\end{aligned}
$$

Table 4

Wage Equation Variance Decomposition

specification	var fitted $\frac{w_t}{\frac{F_t}{n_t}}(\times 10^{-3})$	mp	fv	b	cov(mp, fv)	cov(mp,b)	cov(fv,b)
1	3.57	1%	1%	90%	-1%	13%	-4%
2	4.75	36%	1%	159%	9%	-93%	-12%
4	3.43	3%	1%	77%	-1%	23%	-3%
9	3.72	1%	4%	92%	-1%	12%	-8%

Notes:

1.The specification numbers correspond to the columns of Table 2.

2. The variance of actual $\frac{w_t}{\frac{F_t}{n_t}} = 4.4609 \times 10^{-3}$

3. The variables are defined as follows:

$sum = \frac{\beta_t}{(1+\tau_t^s)}(\alpha + FV_t) + \frac{(1-\beta_t)}{(1-\tau_t)}\frac{z_t}{\frac{F_t}{N_t}}\left[1 - \tau_t + \mu - \frac{\sigma_1 C_t^{\sigma_2}}{\sigma_2}\right])$

mp=marginal product share=$\frac{\text{var}(\frac{\beta_t}{(1+\tau_t^s)}\alpha)}{\text{var } sum}$

fv=future value share=$\frac{\text{var}(\frac{\beta_t}{(1+\tau_t^s)}FV_t)}{\text{var } sum}$

b=reservation wage share=$\frac{\text{var}(\frac{(1-\beta_t)}{(1-\tau_t)}\frac{z_t}{\frac{F_t}{N_t}}\left[1-\tau_t+\mu-\frac{\sigma_1 C_t^{\sigma_2}}{\sigma_2}\right])}{\text{var } sum}$

cov(mp,fv)=cov(marginal product, future value)=$\frac{2Cov(\frac{\beta_t}{(1+\tau_t^s)}\alpha, \frac{\beta_t}{(1+\tau_t^s)}FV_t)}{\text{var } sum}$

cov(mp,b)=$\frac{2Cov(\frac{\beta_t}{(1+\tau_t^s)}\alpha, \frac{(1-\beta_t)}{(1-\tau_t)}\frac{z_t}{\frac{F_t}{N_t}}\left[1-\tau_t+\mu-\frac{\sigma_1 C_t^{\sigma_2}}{\sigma_2}\right])}{\text{var } sum}$

cov(fv,b)=$\frac{2Cov(\frac{\beta_t}{(1+\tau_t^s)}FV_t, \frac{(1-\beta_t)}{(1-\tau_t)}\frac{z_t}{\frac{F_t}{N_t}}\left[1-\tau_t+\mu-\frac{\sigma_1 C_t^{\sigma_2}}{\sigma_2}\right])}{\text{var } sum}$

Table 5

Reservation Wage Decomposition

specification	$\frac{b_t}{\frac{F_t}{n_t}}$	$\frac{z_t}{\frac{F_t}{n_t}}(1-\tau_t)$	$\mu\frac{z_t}{\frac{F_t}{n_t}}$	$\frac{\sigma_1}{\sigma_2}\frac{C_t^{\sigma_2}z_t}{\frac{F_t}{n_t}}$
1	0.40 (0.08)	0.17 (0.03)	0.27 (0.05)	0.02 (0.01)
2	0.41 (0.08)	0.17 (0.03)	0.27 (0.05)	0.01 (0.003)
4	0.40 (0.08)	0.17 (0.03)	0.28 (0.05)	0.02 (0.01)
9	0.40 (0.08)	0.17 (0.03)	0.28 (0.05)	0.03 (0.01)

Notes:

1. Specification numbers correspond to the columns of Table 2.

2. Each entry reports the sample mean and in parentheses the standard deviation. Wherever relevant point estimates of the parameters are used.

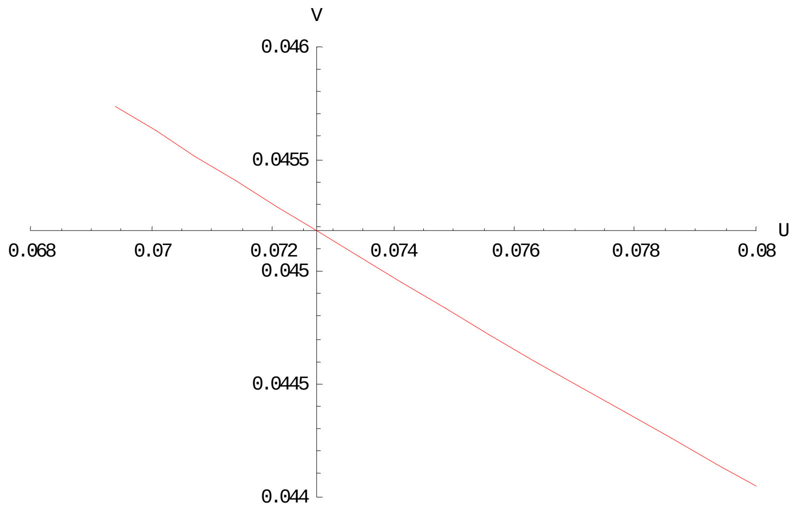

Figure 1a: Beveridge Curve – variations in $r \in [0.005, 0.02]$

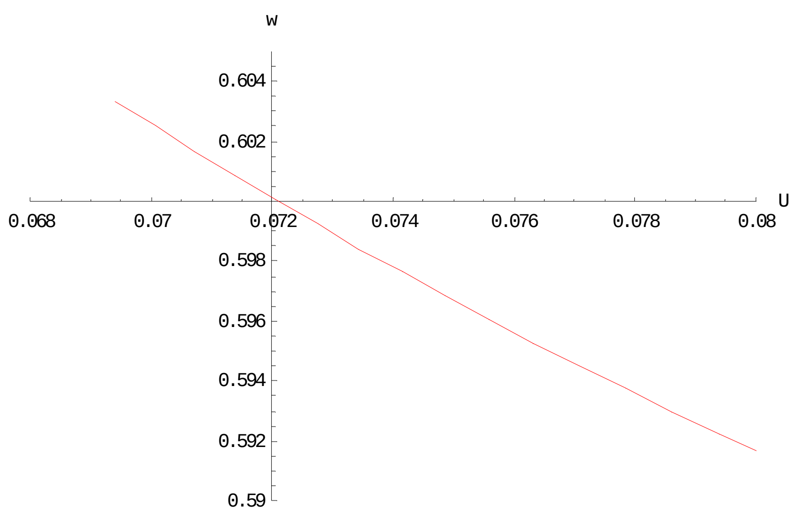

Figure 1b: Wage Curve– variations in $r \in [0.005, 0.02]$

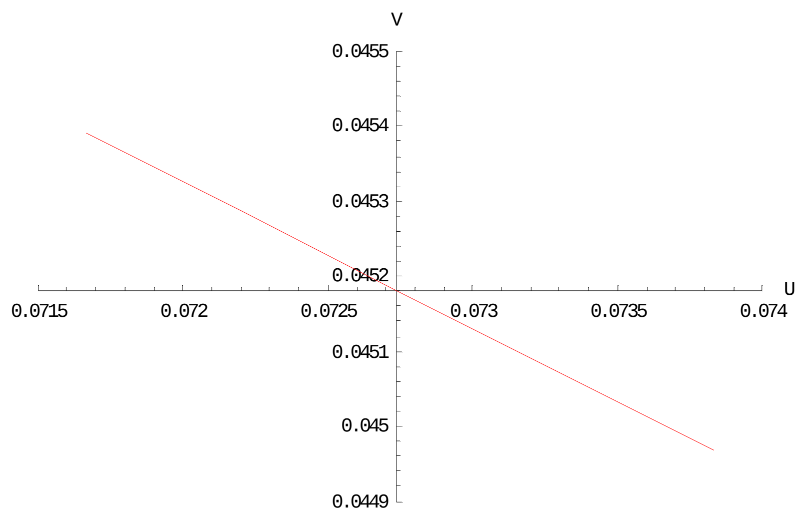

Figure 1c: Beveridge Curve– variations in $g^f \in [0.002, 0.006]$

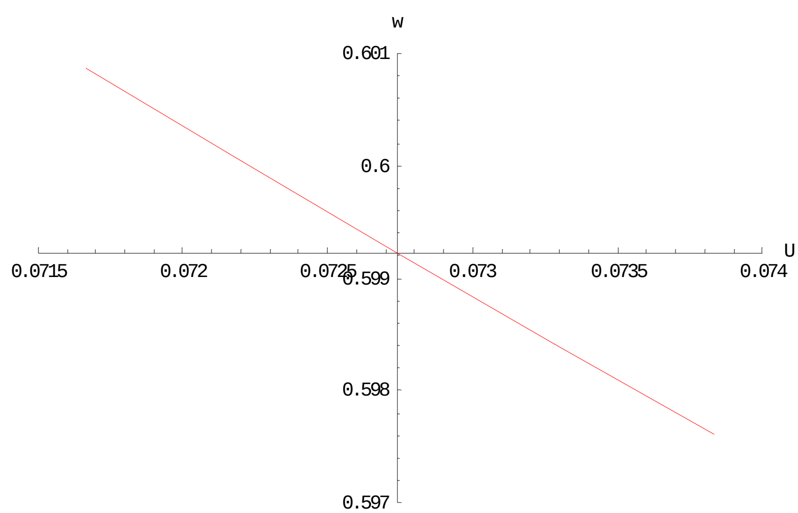

Figure 1d: Wage Curve– variations in $g^f \in [0.002, 0.006]$

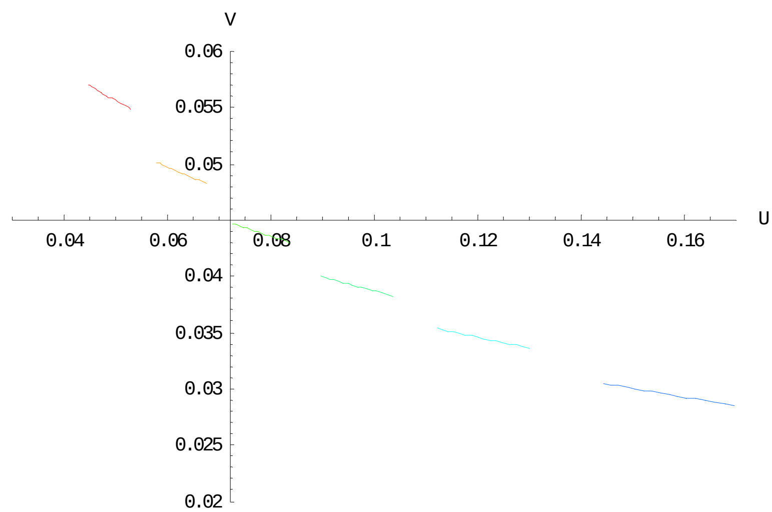

Figure 2a: Family of Beveridge Curves – variations in $\beta \in [0.2, 0.7]$

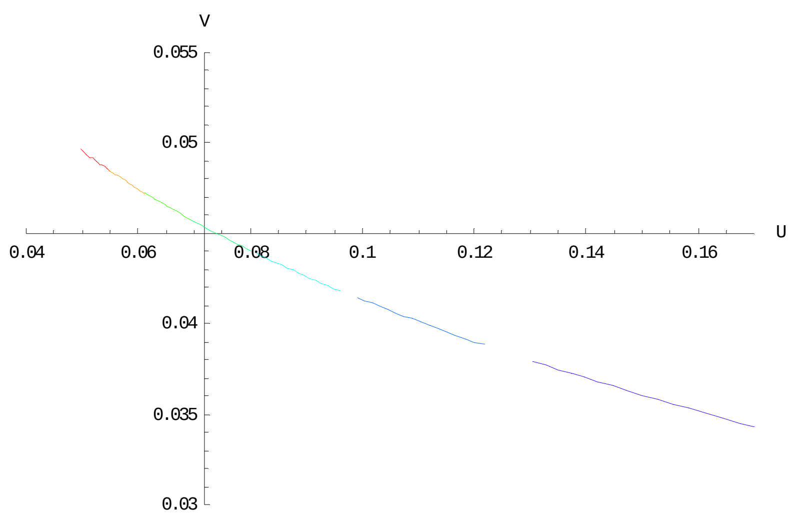

Figure 2b: Family of Beveridge Curves – variations in $\mu \in [1.2, 1.8]$

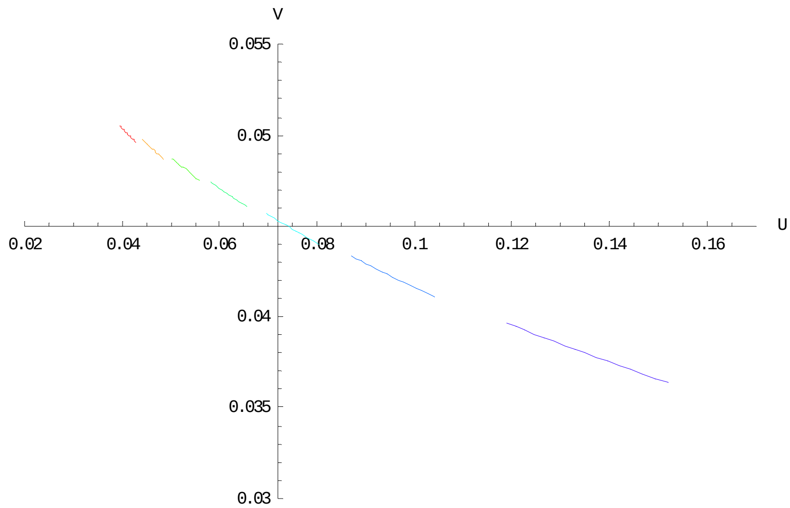

Figure 2c: Family of Beveridge Curves – variations in $\frac{z}{F/N} \in [0.14, 0.22]$

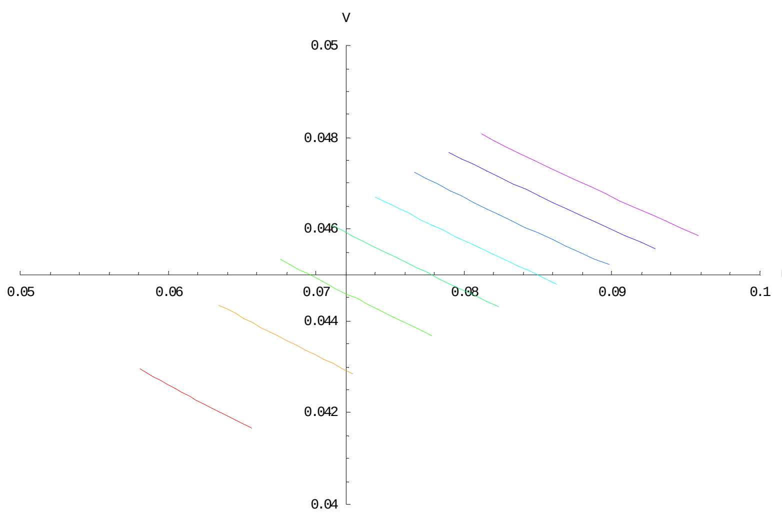

Figure 2d: Family of Beveridge Curves – variations in $\sigma_1 \in [2, 9]$

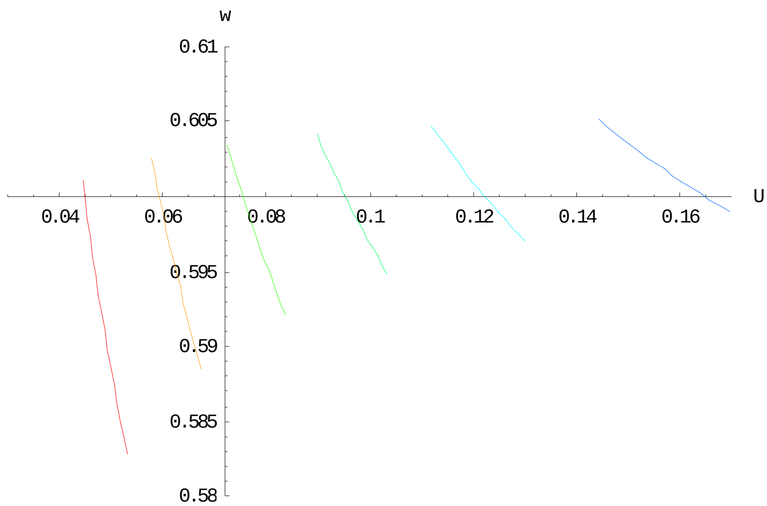

Figure 3a: Family of Wage Curves – variations in $\beta \in [0.2, 0.7]$

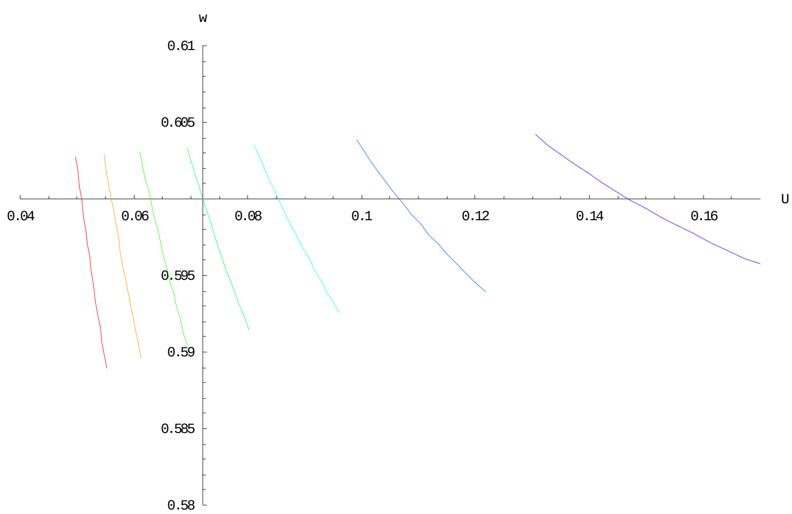

Figure 3b: Family of Wage Curves – variations in $\mu \in [1.2, 1.8]$

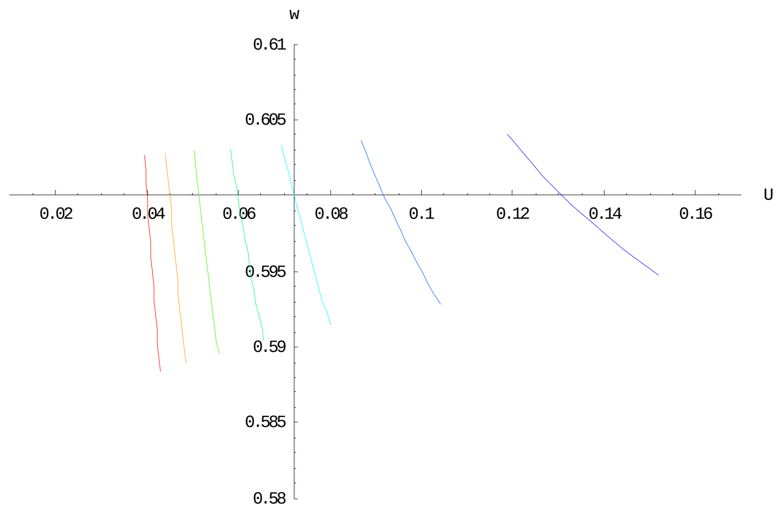

Figure 3c: Family of Wage Curves – variations in $\frac{z}{F/N} \in [0.14, 0.22]$

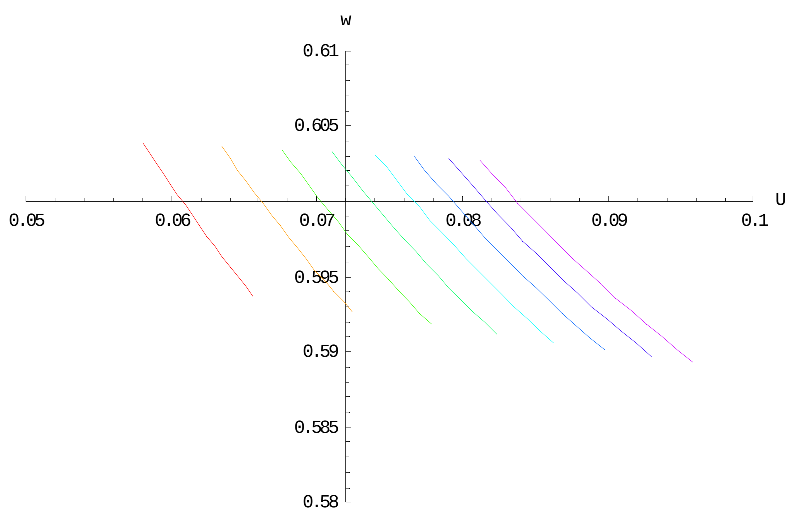

Figure 3d: Family of Wage Curves – variations in $\sigma_1 \in [2, 9]$