

The Determinants of Equilibrium Unemployment

By ERAN YASHIV*

The paper takes the search and matching model of the aggregate labor market to the data. It tests the model's empirical validity and employs structural estimation to generate a characterization of the optimal behavior of firms and workers. The model is applied to Israeli data that are uniquely suited for this kind of empirical investigation. The structural estimates are used to quantify the frictions embodied in the model, including the costs of search, the congestion and trading externality effects, and the matching process. A calibration-simulation analysis then studies the effect of several key variables on equilibrium unemployment. (JEL E24, E32, J63, J64)

This paper sets out to take the search and matching model of the aggregate labor market to the data.¹ It tests the model's empirical validity and uses structural estimation to generate a characterization of the optimal behavior of firms and workers. The estimates are used to quantify the frictions embodied in the model, including the costs of search, the congestion and trading externality effects, and the matching process. The main obstacles which this kind of empirical analysis typically faces are severe limitations of the data. Usually macroeconomic data are unavailable and even at disaggregated levels there are substantial shortcomings, such as insufficient and inconsistent

job vacancy data or low frequency data with temporal aggregation problems. Here I make use of a data set which is of unique quality and thus offers a rare opportunity to undertake such a study: this is Israeli 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. These data are available due to the institutional setup of the market: posting of vacancies in the ES was mandatory in the sample period and there existed strong incentives for the unemployed to register at the same agency. I describe this data set in some detail below.

An innovation of the paper is the methodological approach it takes. This consists of structural estimation of all the major elements of a prototypical aggregate search and matching model, an empirical investigation hitherto unexplored.² The advantages of this approach are that it yields estimates of the "deep" parameters of the model's two essential ingredients: (i) Costly search by optimizing agents. I show that optimal behavior in this context is a solution to an intertemporal investment problem under uncertainty. The use of

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¹ Comprehensive discussions of this model and references to the literature may be found in Dale T. Mortensen and Christopher A. Pissarides (1999) and Pissarides (2000).

² The innovative aspects are both the fact that the empirical work covers all the key elements of an aggregate search and matching model simultaneously and the structural estimation approach which permits the study of optimality conditions.

structural estimation, nesting alternative specifications of functional forms, timing, and discounting, enables me to quantify this behavior and generate time series for search costs. This approach creates a link between empirical models of dynamic labor demand—such as the model proposed by Thomas J. Sargent (1978)—and the search and matching framework. (ii) Unemployment is a stochastic process determined by the matching of vacancies and unemployed workers. I estimate the parameters of the matching function and explore its features. One key finding is that it exhibits increasing returns to scale.

The findings lend empirical support to the model. Noting that this model has recently been fruitfully applied to study other key macroeconomic issues, the importance of its validation and quantification goes beyond questions of the labor market. For example, the quantitative estimates derived from structural estimation should prove useful when coming to study the linkages between the labor market and macroeconomic fluctuations. One set of implications is briefly explored in a calibration-simulation analysis which studies the effect of several key variables on equilibrium unemployment. Using a partial-equilibrium setup, I show, among other things, the effects of firms' profitability and workers' unemployment benefits on the rate of unemployment and derive some policy implications.

The paper proceeds as follows: Section I reformulates the prototypical search and matching model in stochastic terms and discrete time in order to take it to the data. Section II presents the institutional setup and the data set, discussing its unique qualities, and briefly describes the econometric methodology. The empirical work—structural estimation of the key elements of the model—is presented in Section III. Section IV explores the implications of the results with respect to equilibrium unemployment. Section V concludes. The sources and definitions of the data are presented in the Appendix.

I. The Model

In order to take the aggregate search and matching model to the data it needs to be cast in stochastic, discrete-time terms. In this section I construct such a model, building upon the seminal contributions of Mortensen (1982) and Pissarides

(1985, 2000 Chs. 1 and 3). As this formalization follows the prototypical model, I do not go into great detail and the reader is referred to the cited references for more elaborate discussion.

The Market Environment.—There are two types of agents: unemployed workers searching for jobs and firms searching for workers through vacancy creation. These agents maximize intertemporal objective functions to be elaborated below. 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 the 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. Workers are assumed to be separated from jobs at a stochastic, exogenous rate (the implications of this assumption are discussed below). The stochastic optimization framework to be presented accommodates random shocks to matching and to the variables affecting agents' optimal behavior: labor productivity, real wages, unemployment benefits, the rate of separation, and the real rate of interest. Table 1 introduces the notation convention to be used in the model.

Matching.—The parties to be matched are job vacancies V , opened by firms, and "efficiency units" of searching workers CU . The latter are defined by the product of search intensity C and unemployed workers U . The matching function (M) operates like a production function, taking CU and V as inputs and producing a flow of hires H at a certain level of matching technology, μ . Formally:

$$(1) \quad H_t = M(\mu_t, C_t U_t, V_t).$$

This function has positive first derivatives and should satisfy:

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

Firms' Search.—Firms maximize the expected present value of profits. Denote the production function by F with employment (n) and all other factors of production (de-

TABLE 1—NOTATION

Firms		
Variable	Firm level	Aggregate level
Job vacancies	v	V
Output		Y
Variables in production function	\mathbf{a}	\mathbf{A}
Employment stock	n	N
Hires		H
Variables in hiring cost function	\mathbf{b}	\mathbf{B}
Vacancy matching probability	q	Q
Workers		
Variable	Worker level	Aggregate level
Unemployment		U
Daily appearances at Employment Service		D
Search intensity	c	C
Search costs	σ	
Variables in search cost function	\mathbf{e}	\mathbf{E}
Matching probability	p	P
Wages	w	
Present value of wages	W	
Unemployment benefits	z	
Present value of unemployment	X	
Other variables		
Variable		Symbol
Interest rate		r
Rate of labor-force growth		g_l
Rate of productivity growth		g_f
Separation rate		s
Labor force		L
Matching technology		μ
Functions		
Function		Symbol
Matching		M
Production		F
Hiring costs		Γ
Worker search costs		Λ
Parameters		
Parameter		Symbol
Unemployment elasticity of matching		β
Labor share in production		$1 - \alpha$
Share of vacancies in hiring cost function		λ
Parameters of the hiring cost function		$\gamma_1, \gamma_2, \gamma_3, \gamma_4$
Parameters of the search cost function		$\sigma_1, \sigma_2, \sigma_3, \sigma_4$

noted by the vector \mathbf{a}) as its arguments, the real wage by w , the one-period discount rate by r , the probability of filling the vacancy by

q , the separation rate by s , and the hiring costs function by Γ . Firms solve the following dynamic optimization problem, where all

other variables have been “maximized out,” deciding on their choice variable, the number of job vacancies (v):

$$(2) \quad \max_{\{v_t\}} E_t \sum_{i=0}^{\infty} \frac{1}{\prod_{j=0}^i [1 + r_{t+j-1}]} [F(n_{t+i}, \mathbf{a}_{t+i}) - w_{t+i}n_{t+i} - \Gamma(v_{t+i}, n_{t+i}, q_{t+i+1}, \mathbf{b}_{t+i})]$$

subject to:

$$(3) \quad n_{t+1} = n_t[1 - s_{t+1}] + q_{t+1}v_t.$$

The decision v_t is based on the information available to the firm through time $t - 1$. Hiring costs include both the cost of advertising, screening and selecting new workers, and the cost of training. This formulation relates to gross hiring costs, with the firm incurring costs for both replacement hires and new hires. These costs depend on the number of vacancies (v) and the stock of employment (n), on the probability of filling the vacancy q (as training costs fall on hired workers, i.e., on qv), and potentially on other variables (denoted by the vector \mathbf{b}). The formulation of this function and its arguments are discussed in detail in the empirical Section III below.

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

$$(4) \quad \frac{\partial \Gamma}{\partial v}(v_t, n_t, q_{t+1}, \mathbf{b}_t) = \frac{1}{1 + r_t} q_{t+1} \times E_t \left[\frac{\partial F}{\partial n}(n_{t+1}, \mathbf{a}_{t+1}) - w_{t+1} - \frac{\partial \Gamma}{\partial n}(v_{t+1}, n_{t+1}, q_{t+2}, \mathbf{b}_{t+1}) + \left\{ \frac{[1 - s_{t+2}]}{q_{t+2}} \times \frac{\partial \Gamma}{\partial v}(v_{t+1}, n_{t+1}, q_{t+2}, \mathbf{b}_{t+1}) \right\} \right].$$

The condition results from the variational

approach of increasing v_t and decreasing v_{t+1} in order to hold n_{t+2} constant. The intuition is that the marginal cost of a vacancy (the left-hand side) equals its discounted expected marginal benefit (the right-hand side). The latter is the product of the probability of filling the vacancy and the expected marginal gain at period $(t + 1)$. This gain is made up of the four terms in the square brackets: the marginal product of the worker (the first term), the wage paid to this worker (the second term, which reduces the gain), the reduction in hiring costs next period (the third term, which is negative) and the savings of vacancy costs (fourth term) due to the filling of the vacancy this period.

Two implications of this optimality equation deserve emphasis: one is that in making its optimal decision, the firm takes into account the probability of filling a vacancy (q) and the probability of workers' separation (s). While the former probability depends on the matching process and on the number of vacancies in the economy (as shown below) the firm does not take into account its own influence on q . The other implication is that iterating the expression on the right-hand side and using a transversality condition yields the expected present value of future marginal profits. One can therefore think of workers as having an “asset value” and of equation (4) as an “asset-pricing” equation. In the empirical work these asset values are quantified.

Workers' Search.—Workers maximize expected discounted earnings. During unemployment they receive unemployment benefits (z). Workers choose search intensity (c), which affects their probability of hire (p), and incur search costs (σ). I model these costs as increasing in search intensity and as potentially depending on other variables (denoted by the vector \mathbf{e}). If hired, workers receive a given real wage w ; with probability s they are separated from their jobs and return to unemployment. The individual chooses his/her own search intensity taking as given the economywide average search intensity (C) as well as all other relevant magnitudes ($w, z, s, r, U, \mathbf{e}, \mu, V$). Let W be the present value of being employed and X be the value of being unemployed. The

worker's value of being unemployed is the solution to:

$$(5) \quad X_t = \max_{c_t} E_t \left\{ z_t - \sigma_t + \frac{1}{1+r_t} [p_{t+1}W_{t+1} + [1 - p_{t+1}]X_{t+1}] \right\}$$

subject to

$$(6) \quad W_{t+1} = w_{t+1} + \left\{ \frac{1}{1+r_{t+1}} \times [[1 - s_{t+2}]W_{t+2} + s_{t+2}X_{t+2}] \right\}$$

where:

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

$$\sigma_t = \Lambda(c_t, \mathbf{e}_t), \quad \frac{\partial \Lambda}{\partial c} > 0.$$

The value of being unemployed X_t is the sum of unemployment benefits z_t net of search costs σ_t this period 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+1} and the value of being employed W_{t+1} and the product of the complementary probability $1 - p_{t+1}$ and the value of staying unemployed X_{t+1} . The value of being employed W_{t+1} is the sum of the current wage w_{t+1} and the expected value next period. The latter is the sum of two terms: the product of the probability to stay on the job $1 - s_{t+2}$ and the value of staying employed W_{t+2} and the product of the probability of separation into unemployment s_{t+2} and the value of being unemployed X_{t+2} .

The F.O.C. is:

$$(7) \quad \frac{\partial \Lambda}{\partial c}(c_t, \mathbf{e}_t) = \frac{1}{1+r_t} \frac{M(\mu_t, C_t U_t, V_t)}{C_t U_t} \times E_t [W_{t+1} - X_{t+1}].$$

The worker equates the marginal cost of search (the left-hand side) with the expected marginal benefit (the right-hand side). 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 W_{t+1} , X_{t+1} and the F.O.C. at time $t + 1$ this can be rewritten as:

$$(8) \quad \frac{\partial \Lambda}{\partial c}(c_t, \mathbf{e}_t) = \frac{1}{1+r_t} \frac{M(\mu_t, C_t U_t, V_t)}{C_t U_t} \times E_t \left[w_{t+1} - [z_{t+1} - \sigma_{t+1}] + [1 - p_{t+2} - s_{t+2}] \frac{\left(\frac{\partial \Lambda}{\partial c}(c_{t+1}, \mathbf{e}_{t+1}) C_{t+1} U_{t+1} \right)}{M(\mu_{t+1}, C_{t+1} U_{t+1}, V_{t+1})} \right].$$

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 net unemployment benefits, and the future net gain, expressed as the value of marginal search costs next period. This equation may also be given an "asset-pricing" interpretation: it represents the present value of wages relative to net unemployment benefits and is thus the relative value of the match from the worker's point of view.

The Market.—All firms and workers are assumed to be homogenous so in the aggregate the following obtains (using, wherever relevant, capital letters to denote aggregate values that were previously lowercase at the firm or worker level).

For firms there is a common probability Q of filling a vacancy, i.e.:

$$(9) \quad q_{t+1} = Q_{t+1} = \frac{M(\mu_t, C_t U_t, V_t)}{V_t}.$$

The firms' Euler equation in the aggregate economy is thus:

$$(10) \quad \frac{\partial \Gamma}{\partial V} (V_t, N_t, Q_{t+1}, \mathbf{B}_t) = \frac{1}{1+r_t} Q_{t+1} \times E_t \left[\frac{\partial F}{\partial N} (N_{t+1}, \mathbf{A}_{t+1}) - w_{t+1} - \frac{\partial \Gamma}{\partial N} (V_{t+1}, N_{t+1}, Q_{t+2}, \mathbf{B}_{t+1}) + \left\{ \frac{[1-s_{t+2}]}{Q_{t+2}} \times \frac{\partial \Gamma}{\partial V} (V_{t+1}, N_{t+1}, Q_{t+2}, \mathbf{B}_{t+1}) \right\} \right].$$

Workers choose the same search intensity and thus their probability of finding a job is identical:

$$(11) \quad c_t = C_t \Rightarrow p_{t+1} = P_{t+1} = \frac{M(\mu_t, C_t U_t, V_t)}{U_t}.$$

Optimal search intensity is determined by:

$$(12) \quad \frac{\partial \Lambda}{\partial C} (C_t, \mathbf{E}_t) = \frac{1}{1+r_t} \frac{P_{t+1}}{C_t} \times E_t \left\{ \left[w_{t+1} - [z_{t+1} - \sigma_{t+1}] + [1 - P_{t+2} - s_{t+2}] \left[\frac{\frac{\partial \Lambda}{\partial C} (C_{t+1}, \mathbf{E}_{t+1})}{\frac{P_{t+2}}{C_{t+1}}} \right] \right] \right\}.$$

Summing up, the model describes investment in workers by firms within an aggregate, homogenous setup, and worker separation, though stochastic, is exogenous. This model-

ing choice corresponds to the prototypical models in the search and matching literature [such as the models of Peter A. Diamond (1982a, b), Mortensen (1982), and Pissarides (1985)]. The exogeneity of s corresponds to a situation whereby workers and firms never find it optimal to sever their relationship voluntarily. This is the case when, for example, shocks to productivity and to unemployment benefits are such that they do not change the value of employment relative to unemployment to such an extent so as to make the latter preferable to the former. The model, nonetheless, produces interesting dynamics: unemployed workers and firms optimally decide on changes in their search activity in response to changes in the expected value of the match and in the costs of forming it, and the matching process embodies externalities generated by this search activity. The question of the model being a useful approximation of the labor market in the real world is an empirical one and the results below seem to suggest a positive answer. Note that in the empirical work s is taken at its actual value. Moreover, it is shown that setting s to be a fixed parameter induces very small changes in the results.

Equilibrium Concepts.—Equations (1), (10), and (12) may be combined to produce a partial-equilibrium framework or embedded in a larger framework to produce a general-equilibrium model.

For the former, note that unemployment dynamics are given by (using L to denote the labor force):

$$(13) \quad U_{t+1} - U_t = -M(\mu_t, C_t U_t, V_t) + s_{t+1}[L_t - U_t] + [L_{t+1} - L_t].$$

Unemployment rises with separation from employment and net increases in the labor force and declines with matching. Usually an additional equation, catering for the determination of wages, is added; following Diamond (1982b) this is specified as a Nash bargaining

solution.³ Combining these equations with the aforesaid three equations yields a dynamic system in the endogenous variables V , C , U , H , and w , and the paths of the exogenous variables $\partial F/\partial N$, \mathbf{A} , \mathbf{B} , \mathbf{E} , r , s , z , μ , and L . For a fully worked-out example of such a partial-equilibrium setup see Pissarides (1985).

Equations (1), (10), and (12) may also be embedded in a general-equilibrium framework, where households maximize the present value of utility streams, choosing consumption and search intensity, and firms maximize profits, choosing the capital stock and vacancies. The F.O.C. from these optimization problems are combined with the matching function, with the aforesaid Nash bargaining solution and with market-clearing conditions to produce a competitive general equilibrium. The latter is equivalent, under certain conditions, to the solution of a social-planner problem, and includes an endogenous solution for w and r . For the complete derivation of this structure see Monika Merz (1995) and David Andolfatto (1996).⁴

II. The Institutional Setup, the Data, and the Estimation Methodology

In this section I present the institutional setup of the Israeli labor market and discuss the unique qualities that make its data so appropriate to use within the framework outlined in the previous section. I subsequently report the major stylized facts and briefly discuss the estimation methodology.

The Institutional Setup.—The Israeli labor 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.⁵ 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.⁶ 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 I 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.

The Data Set and Its Stylized Facts.—The data set includes 180 monthly observations in the years 1975–1989.⁷ Beyond the

³ The basic idea is that the matching of a worker and a vacancy against the backdrop of search costs creates some pure economic rent: it is the sum of the expected search costs for the firm and for the worker. Wages need to share this rent in addition to compensating for costs of forming the match.

⁴ In comparison to these references, the empirical work presented below allows for more general functional forms of search costs and of the matching function and for a time-varying (rather than fixed) separation rate.

⁵ Any worker may register with the ES. Benefits are received from the National Insurance Agency conditional on confirmation of registration with the ES. These procedures were unchanged throughout (and after) the sample period.

⁶ Thus there is no “double counting” or other forms of bias in vacancy numbers as typically found in measures such as help-wanted ads.

⁷ The sample begins in 1975, as there was a change in definitions for the vacancy series in 1974. It ends in 1989 because the series are no longer comprehensive once private intermediaries were allowed.

aforementioned data from the ES, I use other labor-market data from the National Insurance Agency (NIA) and macro data from the Central Bureau of Statistics (CBS) and the Bank of Israel (BOI). The Appendix provides full definitions and a list of sources. Figures 1–6 present the data. Wherever relevant I look at rates out of the labor force and use the quarterly frequency in order to present the data in conventional terms, comparable to other studies.

Figure 1 shows the rate of unemployment using both LFS and ES data. The two measures have a 0.93 correlation and are shown to have substantially increased in the course of the sample period. The ES reports the number of vacancies posted in a given month in the same way that it reports the unemployment figures. Figure 2 shows this series in the same terms as Figure 1, as well as the actual rate of matching. The latter rate is defined as filled vacancies and is equivalent to the series of unemployed workers referred to these job vacancies. Thus, by construction, the restriction that hires be less than the minimum of the unemployment rate and the vacancy rate is satisfied. Both series declined over the sample period, with hiring rates closely following vacancy rates beginning in 1980. The average rate of hiring (unemployment to employment flow) shown here—at 3.5 percent of the labor force in quarterly terms—is quite similar to the one reported by Olivier Jean Blanchard and Diamond (1989) for the U.S. economy and by Michael Burda and Charles Wyplosz (1994) for the French and German economies. Note that ES coverage includes workers that previously have been classified as “out of the labor force.” Unlike the U.S. case, discussed by Blanchard and Diamond (1990), the flows into employment from out of the labor force in Israel are small—roughly 5 percent annually, while in U.S. Current Population Survey (CPS) data this is 2.8 percent in monthly terms.

ES data also provide a proxy for the unobservable search intensity (C) of these unemployed workers. This is the average number of appearances at ES exchanges. The ES records the number of days workseekers visit the exchange each month; the average number, measured in days, is obtained through division of the number of these daily appearances by the number of workseekers. While the series has no

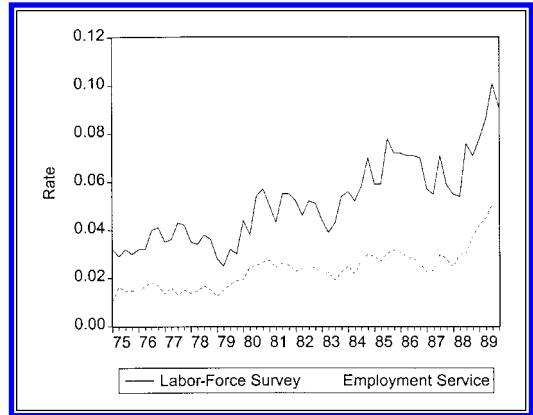


FIGURE 1. UNEMPLOYMENT RATE $\left(\frac{U}{L}\right)$

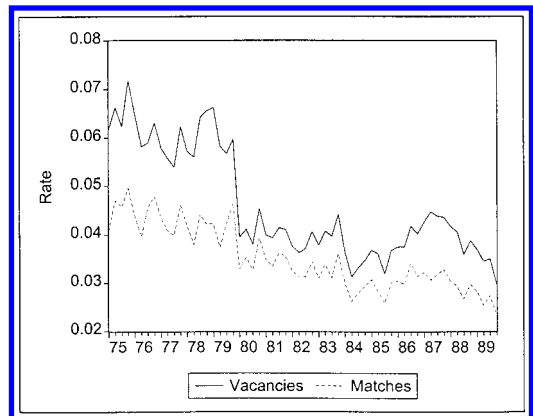


FIGURE 2. VACANCY $\left(\frac{V}{L}\right)$ AND MATCHING $\left(\frac{H}{L}\right)$ RATES

trend, it displays an upward jump in 1980, probably due to the noteworthy fact that a change was made in the unemployment benefit law in April 1980. The latter was a de facto indexation: the past average wage of the unemployed, which forms the basis for unemployment benefits, was to be updated four times per annum according to the rise in the average (economy-wide) nominal wage. Consequently the replacement ratio, which was on a downward trend since 1978, jumped by about 80 percent in the course of the year. This generated a big increase in claims for unemployment benefits: from 21,000 in 1979 the total number of claims went up to 127,000 in 1980. I return below to discuss this issue and the construction of the search

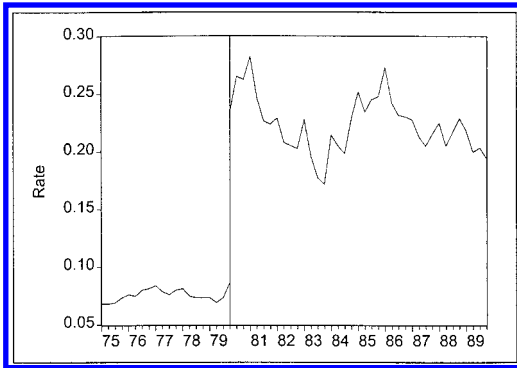


FIGURE 3. SEARCH INTENSITY (C)

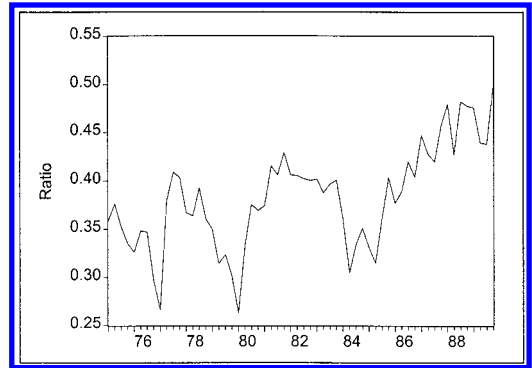
Notes: Vertical line indicates the 1980 break due to the indexation of unemployment benefits (see discussion in Section II).

intensity series, in the context of estimating the workers' F.O.C. Figure 3 shows average appearances divided by 25, the average number of working days in a month (so that it takes values between 0 and 1), in the two subperiods.

Figure 4 documents the replacement ratio (z/w) and Figure 5 the labor share in income (wN/Y) which is the inverse of the firms' profitability rate. Both are in the range of values reported for the major Western economies.

Finally, Figure 6 shows the rate of separation from employment (in the same terms as above, i.e., as the rate out of the labor force sN/L). While this series is not directly observed, i.e., there is no direct measure of gross separations, I deduce its value by subtracting net employment growth from the flow of gross hiring. This is done by solving the firms' budget constraint (3) period by period. It should be noted that the resulting series has no trend and is stationary around its average value (3 percent a quarter), while the hiring rate displays a decline in the sample period. This behavior is markedly different from the employment to unemployment flow series in U.S. CPS data (see, for example, Steven J. Davis et al., 1996 Figure 6.4) in which the two flows display much greater comovement (0.8 contemporaneous correlation as compared to 0.2 here).

Estimation Methodology.—I use Lars P. Hansen's (1982) Generalized Method of Moments (GMM) methodology to estimate the

FIGURE 4. REPLACEMENT RATIO $\left(\frac{z}{w}\right)$

firms' Euler equation (10), the workers' F.O.C. (12), and the matching function (1).⁸ Following estimation I compute the J -statistic of the over-identifying restrictions [see Hansen (1982)].

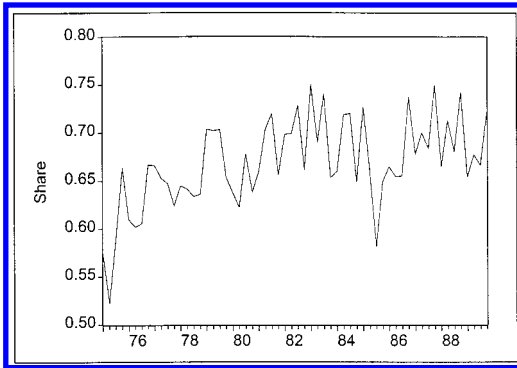
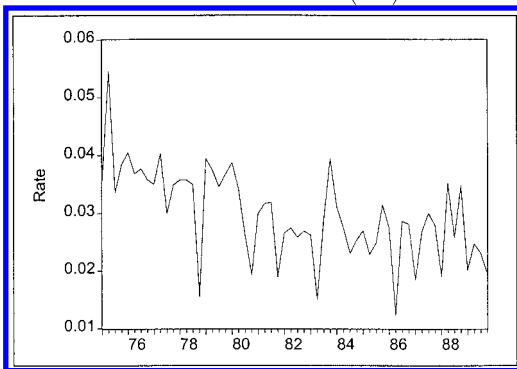
III. Structural Estimation

In this section I discuss specification issues, present the results of estimation, and explore their implications with respect to the quantification of search costs and externalities. Search by firms is presented in subsection A, search by workers in subsection B, and the matching function in subsection C.

A. Estimation of the Firms' Euler Equation

The firms' Euler equation (10) includes the parameters of the hiring cost function and the production function. These parameters are estimated by using the property of rational expectations whereby the firm's expectational error is uncorrelated with any variable in the

⁸ I use the Hansen-Heaton-Ogaki GMM Package in Gauss version 3.01. A key advantage of the GMM approach, relative to the alternative of ML estimation, is that it is based only on the specification of moment conditions derived from the F.O.C. and does not presuppose knowledge of the full density, i.e., of the form of the likelihood function. In particular, Hansen and Kenneth J. Singleton (1982) show that in a consumption-based asset-pricing model, ML implicitly uses orthogonality conditions which are valid only if returns are lognormally distributed. The current setup has an analogous condition on the distribution of the rate of growth of the asset value of the match, which is not required under GMM estimation.

FIGURE 5. LABOR SHARE $\left(\frac{wN}{Y}\right)$ FIGURE 6. SEPARATION RATE $\left(\frac{sN}{L}\right)$

firms' information set. Formally there is a set of orthogonality conditions involving the expectational error ε_t^f and a vector of instruments \mathbf{Z} :

$$(14) \quad E_t[\mathbf{Z}_t \otimes \varepsilon_t^f(\mathbf{x}_{t+1}, \Theta_0)] = 0$$

where \mathbf{x} is a vector of variables, Θ_0 is a vector of parameters to be estimated, \otimes is the Kronecker product operator, and \mathbf{Z}_t is a vector of elements in the firms' information set Ω_t .

What is the variation in the data that allows the estimation of the parameters? The estimation procedure looks for a nonlinear function (the hiring cost function) that would relate vacancy and hiring rates at period t to expected, discounted marginal profits at future dates. For example, in the case of a power function specification it is the covariation of

vacancy and hiring rates with expected marginal profits that would pin down the value of the power parameter. The level of expected marginal profits conditional on these rates pins down the scale parameter. Note that expected marginal profits are made up of three elements: marginal profits at $t + 1$, the interest rate and separation rate (both stochastic) that are used for discounting, and the same nonlinear function of vacancy and hiring rates at $t + 1$. In other words it is the nonlinear relationship between current vacancy and hiring rates, discounted marginal profits, and next period (discounted) vacancy and hiring rates that is estimated here using instrumental variables. The estimates are predicated on the functional form allowed for the nonlinear function, on the variables used to discount future values (r and s), and on the set of instruments used. I examine the robustness of the estimates to variations in these by using different functional forms, different variables for r and s , and different instrument sets.

In order to derive the expectational error and cater for robustness as indicated, the following issues need to be addressed:

- (i) The functional form of the production function (F) has to be specified. I take the "traditional" route and specify a Cobb-Douglas function, using the conventional notation whereby α is the share of capital and $1 - \alpha$ is the share of labor. Thus the marginal product (denoting output by Y), is proportional to the average product:

$$(15) \quad \frac{\partial F}{\partial N}(N_t, \mathbf{A}_t) = (1 - \alpha) \frac{Y_t}{N_t}.$$

- (ii) The variables to be included in the hiring cost function (Γ) have to be considered. Basically I focus here on gross adjustment costs of employment as distinct from net costs (Daniel S. Hamermesh, 1993 Ch. 6) elaborates on this point]. By hiring costs I refer to both the costs of screening (interviewing, testing, etc.) and the costs of training. I therefore use a weighted average of V (total vacancies) and H (filled vacancies, actual hires). Costs are internal to the production process so they are modeled as proportional to

output, i.e., $\Gamma = \Phi \left\{ \lambda \frac{V}{N} + (1 - \lambda) \frac{H}{N} \right\} Y$,

where Φ is some increasing function. In order to take into account the size of the firm in terms of employment, the arguments of Φ are $\frac{V}{N}$ and $\frac{H}{N}$, i.e., costs as a fraction

of output $\left(\frac{\Gamma}{Y} \right)$ depend on the rates of vacancies and hires, not on their absolute numbers. Thus production net of costs ($Y - \Gamma$) is linearly homogenous in V , H , N , and A .

- (iii) The functional form of hiring costs (Φ) is another key issue. The most prevalent one, in both the labor and capital investment empirical literatures, is the quadratic formulation, applied in numerous cases [see, for example, Sargent (1978) for the labor literature and the survey in Robert S. Chirinko (1993) for the investment literature]. This specification, which implies linear marginal costs, often failed empirical tests. The approach I follow here is to examine several alternatives: power functions, which include the quadratic formulation as a special case, and polynomials of various degrees, as these may serve as approximations of smooth functions of unknown form.⁹ These are given by:

$$(16) \quad \Gamma(V_t, N_t, Q_{t+1}, Y_t)$$

$$= \begin{cases} \frac{\gamma_2}{2} \left(\frac{\lambda V_t + (1 - \lambda) H_t}{N_t} \right)^2 Y_t \\ \frac{\gamma_3}{3} \left(\frac{\lambda V_t + (1 - \lambda) H_t}{N_t} \right)^3 Y_t \\ \frac{\gamma_1}{\gamma_2} \left(\frac{\lambda V_t + (1 - \lambda) H_t}{N_t} \right)^{\gamma_2} Y_t \\ \sum_{i=1}^d \frac{\gamma_i}{i} \left(\frac{\lambda V_t + (1 - \lambda) H_t}{N_t} \right)^i Y_t \end{cases}$$

⁹ Polynomials have been tried in the investment literature by Toni M. Whited (1995), who finds that higher degree polynomials give superior results relative to the quadratic function.

where $H_t = Q_{t+1} V_t$, there are three polynomials with $d = 2, 3, 4$, and $\gamma_1, \gamma_2, \gamma_3$, and γ_4 are positive parameters.

- (iv) There is a question as to the timing of hiring costs relative to production. Given that the observation unit is the month, I try two formulations: in one costs occur in the month before production takes place; in the other I cater for the possibility that the hiring process is completed within the month and adjustment costs are incurred in the month of production.
- (v) An issue that has received a lot of attention in the investment literature is that of discounting. While many models used a fixed rate of discount, it has been argued that variability in discount rates should be catered for as it may substantially affect the results. In the current context, discounting includes both the interest rate and the separation rate. I therefore look at two alternatives: for r I use either the actual, *ex post* real rate of interest on bank credit, which was the major form of firm financing in the sample period, or a fixed real rate of 5 percent per annum. For s I use either the actual rate, or a fixed rate of 1.7 percent a month, which is its sample average.
- (vi) As some of the variables are nonstationary the equation is divided throughout by the average product (Y/N). Thus all variables included in the estimating equations are stationary.
- (vii) For the choice of instruments, it should be noted that while any variable in the information set at period t is a valid instrument, two additional considerations play a role: First, Monte Carlo simulations suggest that it is preferable to be parsimonious in the selection of instruments. Second, the instruments need to satisfy a relevance condition, i.e., to be correlated with the variables appearing in the equation [see Masao Ogaki (1993, 1998 Ch. 8) and references therein]. As a consequence, the basic instrument set used includes a constant and four lags of the hiring rate H/N and profitability $(Y/N)/w$. I test for robustness of the ensuing results by (a) experimenting with different

lag structures and (b) using other key variables as additional instruments (the unemployment rate U/N , the rate of separation s , and productivity growth g_j), keeping the total number roughly constant by reducing the number of lags.

The expectational error ε_t^f is obtained by inserting the functional forms of the production function and of the hiring costs function given by equations (15) and (16) into (10), replacing the expected values by actual ones and dividing the equation throughout by Q_{t+1} and by Y_{t+1}/N_{t+1} (an unpublished Appendix, available from the author, provides for the full derivation). In the case of power functions this yields:

$$\begin{aligned}
 (17) \quad \varepsilon_t^f = & \left\{ \gamma_1 \left(\frac{\lambda V_t + (1 - \lambda)H_t}{N_t} \right)^{\gamma_2 - 1} \right. \\
 & \times \left. \left[\frac{\lambda V_t}{H_t} + (1 - \lambda) \right] \frac{\frac{Y_t}{N_t}}{\frac{Y_{t+1}}{N_{t+1}}} \right\} - \frac{1}{1 + r_t} \\
 & \times \left\{ (1 - \alpha) \left[1 - \frac{\gamma_1}{\gamma_2} \right. \right. \\
 & \times \left. \left. \left(\frac{\lambda V_{t+1} + (1 - \lambda)H_{t+1}}{N_{t+1}} \right)^{\gamma_2} \right] \right. \\
 & + \left. \gamma_1 \left(\frac{\lambda V_{t+1} + (1 - \lambda)H_{t+1}}{N_{t+1}} \right)^{\gamma_2} \right. \\
 & - \left. \frac{w_{t+1}N_{t+1}}{Y_{t+1}} + [1 - s_{t+2}] \gamma_1 \right. \\
 & \times \left. \left(\frac{\lambda V_{t+1} + (1 - \lambda)H_{t+1}}{N_{t+1}} \right)^{\gamma_2 - 1} \right. \\
 & \times \left. \left[\frac{\lambda V_{t+1}}{H_{t+1}} + (1 - \lambda) \right] \right\}.
 \end{aligned}$$

For the quadratic and cubic functions, replace

γ_2 by 2 and 3 respectively. In the case of polynomial functions the error is:

$$\begin{aligned}
 (18) \quad \varepsilon_t^f = & \left\{ \sum_{i=1}^d \gamma_i \left(\frac{\lambda V_t + (1 - \lambda)H_t}{N_t} \right)^{i-1} \right. \\
 & \times \left. \left(\frac{\lambda V_t}{H_t} + (1 - \lambda) \right) \frac{\frac{Y_t}{N_t}}{\frac{Y_{t+1}}{N_{t+1}}} \right\} - \frac{1}{1 + r_t} \\
 & \times \left\{ (1 - \alpha) \left[1 - \sum_{i=1}^d \frac{\gamma_i}{i} \right. \right. \\
 & \times \left. \left. \left(\frac{\lambda V_{t+1} + (1 - \lambda)H_{t+1}}{N_{t+1}} \right)^i \right] \right. \\
 & + \left. \sum_{i=1}^d \gamma_i \left(\frac{\lambda V_{t+1} + (1 - \lambda)H_{t+1}}{N_{t+1}} \right)^i \right. \\
 & - \left. \frac{w_{t+1}N_{t+1}}{Y_{t+1}} + (1 - s_{t+2}) \right. \\
 & \times \left. \sum_{i=1}^d \gamma_i \left(\frac{\lambda V_{t+1} + (1 - \lambda)H_{t+1}}{N_{t+1}} \right)^{i-1} \right. \\
 & \times \left. \left(\frac{\lambda V_{t+1}}{H_{t+1}} + (1 - \lambda) \right) \right\} \\
 & \qquad \qquad \qquad d = 2, 3, 4.
 \end{aligned}$$

Note that the first term on the right-hand side in these equations expresses marginal hiring costs while the other terms express future marginal benefits from the match. Testing the alternative functional forms of hiring costs specified in (16), the general power function emerges as the preferred specification. The selection criteria are the J -statistic, the preciseness of the estimated parameters in terms of standard errors, and the plausibility of the implied search costs in terms of magnitude. Table 2 presents results for this functional form

TABLE 2—THE FIRMS' F.O.C.

Specification	(1) Free λ	(2) $\lambda = 0$	(3) Fixed r	(4) Fixed s	(5) Timing
γ_1	229,626 (147,609)	296,348 (127,876)	479,516 (215,373)	300,988 (140,528)	571,760 (207,652)
γ_2	4.73 (0.001)	4.73 (0.01)	4.82 (0.92)	4.73 (0.008)	4.74 (0.03)
a	-0.8 (1.7)				
λ	0.3	0	0	0	0
$1 - \alpha$	0.68 (0.01)	0.68 (0.01)	0.68 (0.01)	0.68 (0.01)	0.68 (0.01)
J -statistic	4.5	6.7	4.4	6.5	7.1
p -value	0.48	0.35	0.63	0.37	0.31

Notes: Sample size is 180 observations (1975:01–1989:12). Standard errors are in parentheses. Hansen's (1982) J -statistic is distributed χ^2 with $n_1 - n_2$ degrees of freedom, where n_1 is the number of moment conditions (equal to the number of instruments, nine in this table) and n_2 is the number of estimated parameters.

(the unpublished Appendix reports the results for the other functional forms). The table looks first [column (1)] at the case of a free λ (the weight of vacancies in the cost function). In order to estimate a logistic function $e^a/(1 + e^a) \equiv \lambda$ is used. The table reports the estimate and standard deviation of a and the implied point estimate of λ . As the latter's estimates are imprecise, all other columns examine the constrained case of $\lambda = 0$. This constrained case is of interest because the point estimates for λ are usually low (often close to zero) across specifications and because one might expect that it is actual hires that generate most of the costs. Column (2) has the same specification as column (1) except for the constrained λ . In column (3) r is fixed at 0.4 percent per month. In column (4) s is fixed at 1.7 percent per month. In column (5) the timing of hiring costs and production is set to occur within the same month.

The power specification performs relatively well whatever the specification used and is also robust to further modifications of the instrument set. The labor share $1 - \alpha$ is always precisely estimated to be 0.68. The power γ_2 varies only slightly around 4.7 and the standard errors of the estimates are small, indicating that the covariation of hiring rates with expected marginal profits is relatively stable in the data. The estimates imply a highly convex function: the elasticity of marginal costs with respect to the rate of hiring rate is equal to $\gamma_2 - 1 = 3.7$. The scale parameter γ_1 is estimated less precisely, i.e., the standard errors indicate that there is a fair amount of variation in the value of expected marginal profits conditional on hiring rates.

TABLE 3—THE ASSET VALUE OF THE MATCH FOR THE FIRMS (PERCENTAGE OF AVERAGE OUTPUT)

	(1)	(2)	(3)	(4)	(5)
Mean	15	12	14	12	22
Standard deviation	12	9	10	9	16

Notes: The period covered is 1975:01–1989:12. The table is based on the estimates of γ_1 , γ_2 , and λ reported in Table 2. The columns here match the columns of that table.

Using the estimates reported in Table 2, Table 3 reports the mean and standard deviation of the implied series of search costs in the sample period. I look at marginal costs which represent the costs of hiring the marginal worker in percentage terms out of average output $[(\partial\Gamma/\partial V)/Q_{t+1}]/(Y_t/N_t)$. As mentioned above, these represent the asset value of the match for the firm.

The table shows that the sample mean varies between 12 percent and 22 percent of average output and the standard deviation varies between 9 percent and 16 percent in monthly terms. Several other specifications (from among those reported in the unpublished Appendix) imply somewhat higher mean values. These differences reflect the different estimates of the scale parameter γ_1 . The above range is equivalent to 7–10 days of wage payments or, when using the higher estimates, to two weeks. A very similar range of estimates is reported in micro studies of gross hiring costs surveyed by Stephen J. Nickell (1986 pp. 475–76) and Hamermesh (1993 p. 208) for the hiring of labor which is not highly skilled.

B. Estimation of the Workers' F.O.C.

From the workers' F.O.C. (12), moment conditions similar to (14) may be derived, using the worker's expectational error ε_t^w . Here the estimation procedure looks for a nonlinear function (the search cost function) that would relate search intensity at period t to the expected, discounted marginal gain from moving to employment from unemployment. The parameters of the search cost function are pinned down by the covariation of search intensity and the marginal gain and by the level of the gain conditional on search intensity. The estimates are predicated on the functional form allowed for search costs, on the variables used to discount future values (r and s), and on the set of instruments used. Thus, as in the case of firms, I try to examine the robustness of the estimates to variations in these. Here some additional issues arise:

- (i) Workers' search intensity C , needs to be formulated. While this variable is basically unobservable, as mentioned above a reasonable proxy is the average number (per month) of daily appearances by workseekers at the ES exchanges, to be denoted D . While the legal appearance requirement was constant throughout the sample period, the series of actual appearances displays sufficient variation to be useful in estimation (see Figure 3 above). I model C as a function of the observed series, trying three functional forms: a log-linear formulation ($C = D^n$), which implies a constant elasticity of the unobserved C with respect to the observed D ; a linear formulation ($C = D/25$), which produces a number between 0 and 1, as there were on average 25 working days a month in Israel in the sample period; and a logistic function ($C = e^D/(1 + e^D)$). The last two functional forms have the appealing interpretation of converting the number of unemployed persons (U) to a number of effectively searching unemployed persons (CU) as C is given in percentage terms.
- (ii) An important empirical issue for this data set is the apparent break in workers' search behavior in 1980, as the aforementioned series of workseekers appearances at ES exchanges displays a big upward jump at the beginning of 1980. A plausible explanation for this time pattern has to do with the de facto indexation of unemployment benefits, discussed in Section II above. Prior to indexation, the percentage of workseek-

ers actually claiming unemployment benefits and thus subject to an appearance requirement was lower,¹⁰ hence a smaller average number of appearances. After indexation their share increased, generating the rise in appearances. Given this jump, I have checked whether the fluctuations in D in the subperiod before 1980 and in the one following it were generated by changes in the distribution of workers across various characteristics, but did not find this to be the case.¹¹ I therefore consider the possibility of a structural break in the equation in 1980. In the context of structural estimation this break should be interpreted to mean that behavioral parameters changed as the "identity" of searching workers changed, i.e., workers were reacting differently to changes in wages and unemployment benefits before and after indexation. I cater for the break by running the equation separately for the relevant subperiods. I compare the ensuing results to the results of the full sample.

- (iii) I model search costs as an increasing function of search intensity and as proportional to unemployment benefits.¹² I use the same alternative functional forms for Λ as in the firms' case:

$$(19) \quad \Lambda(C_t, z_t) = \begin{cases} \frac{\sigma_1}{2} C_t^2 z_t \\ \frac{\sigma_1}{3} C_t^3 z_t \\ \frac{\sigma_1}{\sigma_2} C_t^{\sigma_2} z_t \\ \sum_{i=1}^d \frac{\sigma_i}{i} C_t^i z_t \end{cases}$$

with $d = 2, 3, 4$, and $\sigma_1, \sigma_2, \sigma_3$, and σ_4 are positive parameters.

- (iv) The basic instrument set used is a constant and four lags of D and z/w . I also experiment with different lag structures and with

¹⁰ When the workseeker does not claim unemployment benefits there is no particular incentive to abide by the legal appearance requirement.

¹¹ I 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.

¹² Formulating costs as proportional to wages yielded the same results in terms of the magnitude of costs.

the addition of the workers' hazard rate P or the separation rate s to the instrument set, keeping the total number roughly constant by reducing the number of lags.

To derive the expectational error used in estimation of the moment conditions, the functional forms for search costs as given by equation (19) are inserted into (12), the expected values are replaced by actual ones and the equation is divided throughout by P_{t+1}/C_t and by w_{t+1} to yield the following (the unpublished Appendix, available from the author, shows the full derivation).

For the power functions:

(20)

$$\begin{aligned} \varepsilon_t^w = & \frac{\sigma_1 C_t^{\sigma_2 - 1} z_t}{\frac{P_{t+1}}{C_t} w_{t+1}} - \frac{1}{1 + r_t} \\ & \times \left[1 - \left(\frac{z_{t+1}}{w_{t+1}} - \frac{\sigma_1 C_{t+1}^{\sigma_2} z_{t+1}}{\sigma_2 w_{t+1}} \right) \right. \\ & \left. + (1 - P_{t+2} - s_{t+2}) \frac{\sigma_1 C_{t+1}^{\sigma_2 - 1} z_{t+1}}{\frac{P_{t+2}}{C_{t+1}} w_{t+1}} \right]. \end{aligned}$$

For the quadratic and cubic functions replace γ_2 by 2 and 3 respectively.

For the polynomial functions:

(21)

$$\begin{aligned} \varepsilon_t^w = & \sum_{i=1}^d \frac{\sigma_i C_t^{i-1} z_t}{\frac{P_{t+1}}{C_t} w_{t+1}} - \frac{1}{1 + r_t} \\ & \times \left[1 - \left(\frac{z_{t+1}}{w_{t+1}} - \sum_{i=1}^d \frac{\sigma_i C_{t+1}^i z_{t+1}}{i w_{t+1}} \right) \right. \\ & \left. + (1 - P_{t+2} - s_{t+2}) \sum_{i=1}^d \frac{\sigma_i C_{t+1}^{i-1} z_{t+1}}{\frac{P_{t+2}}{C_{t+1}} w_{t+1}} \right] \end{aligned}$$

$d = 2, 3, 4.$

Note that the first term on the right-hand side in these equations expresses marginal search costs while the other terms express future marginal gains from employment relative to unemployment. I find that the best results are obtained when the linear function ($C = D/25$) is used, although qualitatively similar results are obtained for the other two specifications. The split into two subsamples is indeed warranted as the residuals that are generated by estimation over the full sample display a marked break in 1980. Testing the alternative functional forms of search costs specified in (19), the quadratic function emerges as the preferred specification, though this conclusion is not as clear-cut as in the case of firms. The selection criteria are the same as before: the J -statistic, the preciseness of the estimated parameters in terms of standard errors, and the plausibility of the implied search costs in terms of magnitude. Table 4 presents results for this functional form (the unpublished Appendix reports the results for the other functional forms). In column (1) the instrument set contains a constant and four lags of z/w and D . The variations here include fixing r at 0.4 percent per month in column (2), fixing s at 1.7

TABLE 4—THE WORKERS' F.O.C.

First subperiod: 1975:01–1979:10 ($n = 58$)				
Specification	(1)	(2)	(3)	(4)
	Benchmark	Fixed r	Fixed s	Timing
σ_1	647 (25)	643 (24)	657 (25)	639 (20)
J -statistic	10.8	10.6	10.7	14.8
p -value	0.21	0.22	0.22	0.06
Second subperiod: 1980:05–1989:12 ($n = 116$)				
Specification	(1)	(2)	(3)	(4)
	Benchmark	Fixed r	Fixed s	Timing
σ_1	40 (4)	45 (5)	40 (4)	43 (4)
J -statistic	21.0	20.6	21.0	25.9
p -value	0.01	0.01	0.01	0.001

Notes: Standard errors are in parentheses. Hansen's (1982) J -statistic is distributed χ^2 with $n_1 - n_2$ degrees of freedom, where n_1 is the number of moment conditions (equal to the number of instruments, nine in this table) and n_2 is the number of estimated parameters.

TABLE 5—WORKER SEARCH COSTS
(PERCENTAGE OF THE MONTHLY WAGE)

First subperiod: 1975:01–1979:10 ($n = 58$)						
Specification	(1)	(2)	(3)	(4)	Cubic	Power
Mean	65	64	65	63	33	67
Standard deviation	12	10	10	10	7	11
Second subperiod: 1980:05–1989:12 ($n = 116$)						
Specification	(1)	(2)	(3)	(4)	Cubic	Power
Mean	41	46	41	44	21	30
Standard deviation	10	11	10	11	7	8

Notes: Columns (1)–(4) use the estimates of σ_1 reported in Table 4. The other columns report the implications of the estimates of the cubic and power functions. The latter estimates are reported in an unpublished Appendix available from the author.

percent per month in column (3), and setting the timing of search costs and employment to occur within the same month in column (4).

The quadratic specification has estimates of the scale parameter σ_1 that are relatively precise and that are stable across specifications. However the J -statistic indicates rejection in the second subperiod and this is true for the other functional forms too. These results imply that in the first subperiod a linear relation seems to fit well the relation between *marginal* costs and expected future benefits for the workers, and that there is some, but not full, support for it in the second subperiod too.

Table 5 uses these results to report total monthly search costs relative to the wage (σ_1/w_t), i.e., what the worker spends on search in real wage terms.

Because the specification selection above was somewhat ambiguous, beyond looking at the power function specifications of Table 4, the table also examines the cubic and power specifications. The table indicates different estimates of the magnitude of costs: the quadratic specifications imply costs which are around 65 percent of the monthly wage on average in the first subperiod and around 40 percent in the second subperiod. The general power specification yields estimates that are not too different but the cubic function implies costs that are half as big. As data on workers' search are usually unavailable, I am not aware of any studies that could be compared to these results and help pick out one specification.

The estimates of Table 4 can be used to draw

another implication, not reported in Table 5. This is the computation of the conditional expectations of the gain generated by moving from unemployment to employment $E_t[W_{t+1} - X_{t+1}]$. This gain may be computed from equation (7). Note that the value of being unemployed (X) takes into account the probability of a match (p) and the continuation value of employment (W). Thus, this gain may be interpreted as the price of being unemployed for the duration of an unemployment spell. The estimates indicate that the sample average of this value is equivalent to 6 weeks of wages. With the average spell lasting 9.6 weeks, this "price" (6 weeks of wages) is lower than wages for the duration of the unemployment spell. This wedge reflects the existence of unemployment benefits.

C. Estimation of the Matching Function

In estimating the matching function I consider the following issues.¹³

- (i) The prevalent form used to estimate this function is the Cobb-Douglas specification. However an inspection of Figures 1 and 2 indicates that there may have been non-

¹³ For estimates of matching functions in the Israeli economy using disaggregated data on seven occupation groups and further discussion of the matching process, see Eli Berman (1997). His sample period, specifications, and econometric methodology differ somewhat from those used here.

linearities in the matching process: in the 1980's as U rose while V declined, the series of matches H drew closer to the vacancy series. This is probably because firms could easily find workers so any increase in vacancies would quickly result in a match while further increases in unemployment mattered less and less to matching. This is not allowed for in the Cobb-Douglas case which imposes constant elasticities. I cater for this possibility in two ways: by using a dummy variable for the 1980's for each parameter of the Cobb-Douglas specification and by estimating a flexible functional form—the trans-log function. This function allows for nonconstant elasticities and nests the cases of Cobb-Douglas and constant returns to scale (CRS). I compute the implied elasticity of matching with respect to unemployment and to vacancies for the whole sample and separately for the 1970's and the 1980's.

- (ii) The role of search intensity, C . I experiment with two specifications: no role for search intensity (i.e., $C = 1$) with the inputs in the matching function being unemployment and vacancies; and search intensity as modeled in the preceding discussion (i.e., $C = D/25$) and so the inputs are vacancies and “effective” unemployment (CU).
- (iii) The vacancies and unemployment series are compiled as end of month stocks (unfilled vacancies and unreferred workseekers) or as within the month inflows (total vacancies less unfilled vacancies of the previous month and total workseekers less unreferred workseekers of the previous month). I have experimented with stocks and inflows separately; it turns out that superior results are obtained with the sum of both, and thus the latter is used in estimation.
- (iv) I use first differences to cater for nonstationarity, and lagged values as instruments to cater for simultaneity, given that shocks to matching within the month affect unemployment and vacancies in the course of the same month.

The functional specifications, before differencing, are thus:

$$(22) \quad \ln H_t = \ln \bar{\mu} + (\beta_0 + \beta_1 \times D80) \ln C_t U_t + (\delta_0 + \delta_1 \times D80) \ln V_t + \varepsilon_t^M$$

$$(23) \quad \ln H_t = \ln \bar{\mu} + \beta_1 \ln C_t U_t + \delta_1 \ln V_t + \beta_2 (\ln C_t U_t)^2 + \delta_2 (\ln V_t)^2 + \tau (\ln C_t U_t \times \ln V_t) + \varepsilon_t^M$$

where $D80$ is a dummy variable that takes the value 1 in the 1980's and 0 otherwise. The matching technology (in logs) is the sum of a constant $\bar{\mu}$ and random shocks (ε^M).

Table 6 reports the results: panel (a) considers the Cobb-Douglas specification without and with the 1980 dummy; panel (b) considers the trans-log specification.

The results imply the following four conclusions:

- (i) Both functional specifications indicate that the matching elasticities indeed changed in the 1980's: the dummies for the elasticity parameters in the Cobb-Douglas specifications are significant and the sample averages for the elasticities in the trans-log specification vary across the subsamples. Referring to the $C = 1$ case, both functional forms indicate that the unemployment elasticity went down from around 0.5–0.6 in the period 1975–1979 to 0.2–0.25 in 1980–1989 as the vacancy elasticity went up from 0.6–0.7 to 0.9–1, which is consistent with the hypothesis discussed above. The results indicate that, even in the first subperiod and across the functional specifications, the elasticity of matching with respect to vacancies is higher than that with respect to unemployment, a result also reported by Patricia M. Anderson and Simon M. Burgess (1995) for the U.S. economy.

Given that the Cobb-Douglas specification is nested in the trans-log and that the latter's parameter estimates are mostly significant, the trans-log is to be preferred. However within subperiods the estimates of the elasticities across the two specifications are not very different (using subsample averages for the trans-log to compare to the constant Cobb-Douglas elasticities).

TABLE 6—THE MATCHING FUNCTION

(a) Cobb-Douglas Specification				
	(1)	(2)	(3)	(4)
	$C = 1$	$C = 1$	$C = \frac{D}{25}$	$C = \frac{D}{25}$
β_0	0.49 (0.08)	0.60 (0.08)	0.28 (0.07)	0.40 (0.08)
$\beta_1 \times D80$		-0.35 (0.12)		-0.39 (0.11)
δ_0	0.87 (0.06)	0.71 (0.08)	1.03 (0.13)	0.80 (0.11)
$\delta_1 \times D80$		0.32 (0.10)		0.55 (0.23)
R^2	0.97	0.98	0.96	0.94
DW	2.3	2.3	2.07	2.57
RTS	1.36	1.31/1.28	1.31	1.20/1.36
CRS p -value	0.00	0.00	0.00	0.07
(b) Trans-Log Specification				
	(1)	(2)		
	$C = 1$	$C = \frac{D}{25}$		
β_1	2.41 (1.45)	1.0 (0.94)		
β_2	-0.17 (0.08)	-0.09 (0.03)		
δ_1	5.70 (4.06)	7.36 (6.20)		
δ_2	-0.32 (0.17)	-0.35 (0.28)		
τ	0.14 (0.12)	0.07 (0.10)		
R^2	0.97	0.96		
DW	2.42	2.35		
CRS p -value	0.00	0.00		
	(1)	(2)		
	$C = 1$	$C = \frac{D}{25}$		
Average $\frac{\partial \ln M}{\partial \ln CU}$ entire sample	0.28	0.17		
Average $\frac{\partial \ln M}{\partial \ln V}$ entire sample	0.80	1.01		
Average $\frac{\partial \ln M}{\partial \ln CU}$ 1975–1979	0.48	0.40		
Average $\frac{\partial \ln M}{\partial \ln V}$ 1975–1979	0.61	0.79		
Average $\frac{\partial \ln M}{\partial \ln CU}$ 1980–1989	0.18	0.05		
Average $\frac{\partial \ln M}{\partial \ln V}$ 1980–1989	0.90	1.12		

Notes: The independent variables used are first differences of total workseekers and total vacancies. The instruments are four lags of these variables from $t - 2$ backward. Sample period is 1975:01–1989:12 ($n = 180$). Standard errors are in parentheses computed using Halbert White's (1980) heteroskedasticity-consistent covariance matrix. $D80$ is a dummy variable taking the value 1 in the 1980's and 0 otherwise. RTS computes the Returns To Scale; when two numbers appear they refer to each subperiod separately. The CRS p -value is the probability of the χ^2 statistic testing the null of CRS.

TABLE 7—MATCHING HAZARDS AND SEARCH EXTERNALITIES

	$P = \frac{M}{U}$	$Q = \frac{M}{V}$	$\frac{\partial \ln P}{\partial \ln U}$	$\frac{\partial \ln P}{\partial \ln V}$	$\frac{\partial \ln Q}{\partial \ln V}$	$\frac{\partial \ln Q}{\partial \ln U}$	$\frac{V}{U}$
Mean—full sample	0.57	0.77	-0.72	0.80	-0.20	0.28	0.76
Standard deviation—full sample	0.28	0.07	0.16	0.16	0.16	0.16	0.43
Mean—first subperiod	0.94	0.71	-0.52	0.61	-0.39	0.48	1.33
Mean—second subperiod	0.39	0.81	-0.82	0.90	-0.10	0.18	0.48

Notes: First subperiod refers to 1975:01–1979:12; second subperiod refers to 1980:01–1989:12. The elasticities series are the sample values using the point estimates of the parameters of the trans-log function in Table 6(b), column (1).

- (ii) There is a role for search intensity: inclusion of $C = D/25$ changes the estimates of the elasticities [comparing columns (3) and (4) to (1) and (2) in panel (a) and (2) to (1) in panel (b)]. The difference is that allowing for variation in C reduces the elasticity with respect to U and increases it for V .
- (iii) The test statistics indicate that the model, which allows for random shocks to the matching technology, is not rejected. Given that the residuals are stationary, there is no evidence for any trend in matching effectiveness.
- (iv) An important issue is the returns to scale of the function. The assumption in much of the search and matching literature is that it is constant returns to scale. The table reports the point estimates of the degree of returns to scale for the Cobb-Douglas specifications and the results of a χ^2 -test for CRS in all specifications. The results show that CRS is rejected. In the Cobb-Douglas case the evidence is for increasing returns to scale (IRS) in the order of 1.3.¹⁴ On this issue two remarks are in order: First, it should be noted that increasing returns to scale were also found in several studies using U.S. data—it is reported by Blanchard and Diamond (1989) for certain (but not all) specifications, and by Anderson and Burgess (1995), using disaggregated data as well as aggregate data at the state level. Second, there is a question as to what extent the finding of IRS may be accounted for by composition effects. If the unemployment and vacancy pools have better quality, with more high-exit rate types in

times when these pools become bigger, then this would appear to generate IRS even with a CRS matching function. LFS data seem to suggest that this was not the case, at least not for workers: when unemployment increased there was little change in the share of unemployed workers that could be considered of high quality (prime age, highly educated, or with strong labor-market attachment).

The matching function estimates have implications with respect to the quantification of the “macroeconomic hazards” (P and Q) and the search externalities associated with them. Consider the following relationships:

$$(24) \quad \frac{\partial \ln P}{\partial \ln U} = \frac{\partial \ln M}{\partial \ln U} - 1; \quad \frac{\partial \ln P}{\partial \ln V} = \frac{\partial \ln M}{\partial \ln V}$$

$$(25) \quad \frac{\partial \ln Q}{\partial \ln U} = \frac{\partial \ln M}{\partial \ln U}; \quad \frac{\partial \ln Q}{\partial \ln V} = \frac{\partial \ln M}{\partial \ln V} - 1.$$

When the elasticity of matching with respect to unemployment ($\partial \ln M / \partial \ln U$) is lower than 1 then ($\partial \ln P / \partial \ln U$) is negative—there is a congestion externality induced by the presence of other unemployed workers. Vacancies generate a positive trading externality on the unemployed ($\partial \ln P / \partial \ln V$ is always positive). A similar reasoning applies to the probability of filling a vacancy. While in the Cobb-Douglas case these elasticities are fixed, in the trans-log case they depend on U and V . Table 7 uses the estimates of the elasticities from Table 6 to report sample statistics of these variables. The table differentiates between the 1970’s and the 1980’s and studies the relationship to market tightness (V/U).

¹⁴ Note that the trans-log function does not impose homogeneity of any degree a priori.

Two conclusions may be drawn from this table. First, the workers hazard P exhibits considerable volatility and has declined from a high level (around 0.9) in the 1970's to a relatively low level (0.4) in the 1980's (in monthly values). Put differently, unemployment duration rose significantly. Q was much more stable at about 0.7–0.8 throughout the sample period. Second, as market tightness V/U went down considerably going from the 1970's to the 1980's (see the last column in the table), $\partial \ln M/\partial \ln U$ declined and $\partial \ln M/\partial \ln V$ increased (see Table 6). As a consequence, the effects of congestion and trading externalities increased for the workers (see the third and fourth columns in Table 7) and weakened for the firms (see the fifth and sixth columns). Thus there is a negative relation between the hazard rate (P or Q) and the strength of the search externalities.

IV. Implications for Equilibrium Unemployment

The focus of the empirical work presented in the preceding section was on the structure of the search and matching model, and on the resulting quantification of search costs, matching hazards, and trading and congestion externalities. This examination naturally leads to the question as to what lessons may be drawn from these findings

ment rate, given alternative values of the exogenous variables.¹⁵ A caveat should be noted: the results of this simulation—the solution of the model's endogenous variables—will depend on the particular functional forms chosen for Γ , Λ , and M , the point estimates of the parameters of these functions, and the calibrated values for the exogenous variables. In particular, the functional forms and point estimates dictate the shape of the curves depicting the results, and using other functional forms or parameter values is likely to affect the smoothness and curvature of these curves. However the idea here is not to offer a sensitivity analysis of the model but rather to get a sense of the implications of the estimates presented above.

The simulated model contains the three estimated equations and the equation for unemployment dynamics (13). It caters for steady-state growth in the labor force, to be denoted g_b , and in productivity, g_f . All labor-force variables (unemployment, vacancies, and matches) grow at the former rate and all variables expressed in terms of output—marginal (or average) product, wages, and unemployment benefits—grow at the latter rate.

In the steady state, using the preferred functional forms from the preceding section, the firms' F.O.C. is given by (26) below:

$$(26) \quad \gamma_1 \left(\lambda \frac{V}{N} + (1 - \lambda) \frac{H}{N} \right)^{\gamma_2 - 1} \left(\frac{\lambda V}{N} \left(\frac{H}{N} \right)^{-1} + (1 - \lambda) \right) \\ = \frac{(1 - \alpha) \left[1 - \frac{\gamma_1}{\gamma_2} \left(\frac{\lambda V + (1 - \lambda)H}{N} \right)^{\gamma_2} \right] - \frac{wN}{Y} + \gamma_1 \left(\lambda \frac{V}{N} + (1 - \lambda) \frac{H}{N} \right)^{\gamma_2}}{r + s(1 + g_f) - g_f} \cdot \frac{1}{1 + g_f}.$$

for unemployment determination. This question may be answered in a number of ways. I have opted for a calibration-simulation analysis: the estimated relationships constitute the core of a partial-equilibrium model proposed by Pissarides (2000 Ch. 1); I calibrate its nonstochastic steady state with the estimates from the preceding section and then use simulation to solve for the unemploy-

¹⁵ Were I to embed the estimated relations within a general-equilibrium model, the variables that are exogenous in the analysis below would be determined by more "primitive" elements. For example, the interest rate would be the rate of intertemporal substitution in consumption. I refrain from doing so because it would require an elaborate discussion that is beyond the scope of this paper. This would include the formulation of preferences, technology and market structure, functional forms for these, and calibration of a whole range of additional parameters and steady-state values.

The workers' F.O.C. is given by:

$$(27) \quad \frac{\sigma_1 Cz}{w} = \frac{\frac{P}{C} \left(1 - \frac{z}{w}\right)}{r + s(1 + g_f) - g_f \left(1 - \frac{P}{2}\right) + \frac{P}{2}} \cdot \frac{P}{1 + g_f}$$

The matching function is approximated as a CRS function and is expressed in terms of rates out of employment:

$$(28) \quad \frac{H}{N} = \bar{\mu} C^\beta \left(\frac{U}{N}\right)^\beta \left(\frac{V}{N}\right)^{1-\beta}$$

The unemployment dynamics equation in the steady state is:

$$(29) \quad \frac{H}{N} = s + g_l$$

I calibrate the model to have the following baseline: First, I take the average of each of the exogenous variables wN/Y , z/w , s , r , g_f , and g_l using the longest sample period available.¹⁶ I take the point estimates of the parameters α , γ_1 , γ_2 , λ , and σ_1 as reported in Table 2 [column (1)] and Table 4 [column (1)]. For the matching function, constrained here to be CRS, I take $\beta = 0.3$, which is an approximation of the results of Table 6. This leaves the scale parameter of the matching function $\bar{\mu}$ (which was not estimated as the equation was run in first differences) to be calibrated. I look for a value of this parameter that would generate a solution in which the unemployment rate U/L would equal its 1960–1997 average of 5.5 percent. I then solve the four equations (26–29) for the four endogenous variables U/N , C , V/N , and H/N . The rate of unemployment as conventionally defined—as

¹⁶These values are $\frac{wN}{Y} = 0.67$, $r = 1$ percent, $s = 1.7$ percent, $g_l = g_f = 0.22$ percent, $\frac{z}{w} = 0.4$.

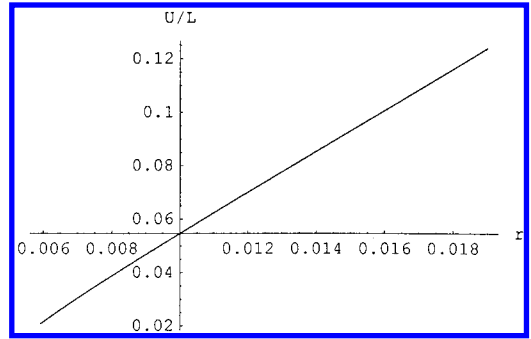


FIGURE 7. STEADY-STATE INTEREST RATE (r) EFFECTS

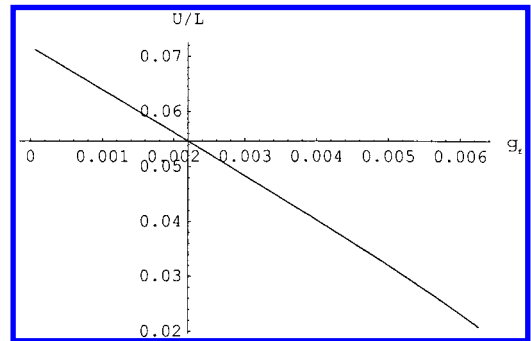


FIGURE 8. STEADY-STATE PRODUCTIVITY GROWTH (g_f) EFFECTS

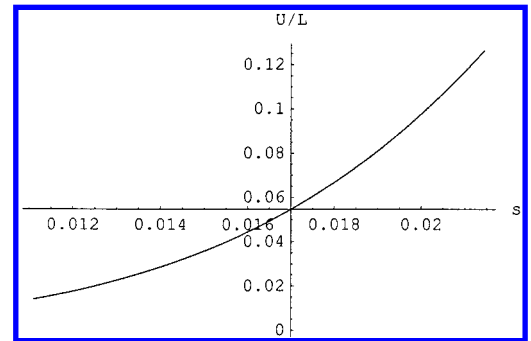


FIGURE 9. STEADY-STATE SEPARATION RATE (s) EFFECTS

the rate out of the labor force (U/L)—satisfies the relationship $U/L = (U/N)/(1 + (U/N))$.

Figures 7–12 report the results of a simulation which solves for the unemployment rate (U/L) given a range of values of the exogenous variables. The baseline is shown as the origin in each graph. The range was chosen so that in

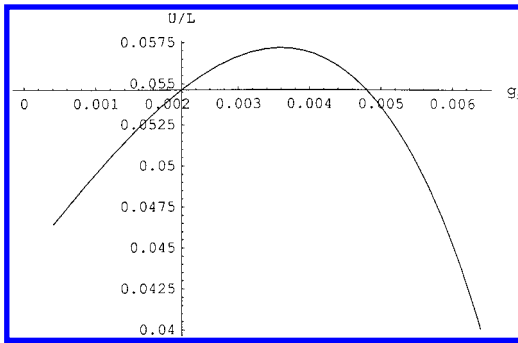


FIGURE 10. STEADY-STATE LABOR-FORCE GROWTH (g_l) EFFECTS

each figure the (endogenous) unemployment rate would vary between 2 percent and 12 percent, which is the full range of unemployment variation in Israel in the period 1960–1997.¹⁷

The figures quantify the following equilibrium mechanisms.

- (i) The rate of interest r and the rate of productivity growth g_f affect unemployment through their effects on the future value of the match for both firms and workers. In the relevant range the relationship is practically linear and therefore symmetric. To give a sense of the magnitudes involved, a 1-percentage-point increase in the interest rate in annual terms, or a decrease in productivity growth of the same magnitude, would increase unemployment relative to the baseline by 0.66 percentage points.
- (ii) Changes in the separation rate s affect both the steady-state flow of matching and the discounting of the future value of the match. While the latter effect is symmetric as in the case of r and g_f , the former effect on the flows in the steady state is asymmetric: as separations from employment increase, bigger and bigger pools of unemployment are required to create the offsetting matching flow. This is due to the fact that the marginal matching flow is diminishing in the rate of unemployment ($\beta < 1$). Overall the effect of s is thus asymmetric.
- (iii) A higher rate of labor-force growth (g_l) has to be matched with higher outflow rates, which require a bigger unemployment pool. This relationship is not monotone—it is positive at “normal” rates of growth and negative at high rates.¹⁸ It is asymmetric for the reason just explained in the case of s , noting that the effects of s and g_l on worker flows are the same. The differences in impact are due to the fact that the separation rate has in addition a discounting effect.
- (iv) A decrease in profitability due to a rise in the wage share (wN/Y) leads to lower vacancy rates and hence to higher unemployment. The relationship is highly nonlinear and there are “decreasing returns” to profitability. This is due to the fact that the product $(U/N)^\beta(V/N)^{1-\beta}$ is constant when all other exogenous variables remain unchanged. Given declines in V/N —gen-

Here a 1-percentage-point increase (in annual terms) would increase unemployment by 1 percentage point.

Note that r , g_f , and s are steady-state values, i.e., they are used to discount profits that accrue every period over an infinite horizon and that they are given in monthly terms. The baseline values for s and g_f are not far from their U.S. counterparts; for example, the baseline of productivity growth in Figure 8 is 2.4 percent annually (0.6 percent quarterly), while in many U.S. business-cycle studies it is often taken to be 1.6 percent annually (0.4 percent quarterly) and the latter value lies well within the simulation range. In fact if the latter value holds true, the simulation indicates that the resulting unemployment rate is 6 percent, which is roughly the average rate of U.S. unemployment. On the other hand, the real rate of interest r , based on bank credit rates, has a high baseline value, reflecting the high interest rates prevailing in the sample period.

- (iii) A higher rate of labor-force growth (g_l) has to be matched with higher outflow rates, which require a bigger unemployment pool. This relationship is not monotone—it is positive at “normal” rates of growth and negative at high rates.¹⁸ It is asymmetric for the reason just explained in the case of s , noting that the effects of s and g_l on worker flows are the same. The differences in impact are due to the fact that the separation rate has in addition a discounting effect.
- (iv) A decrease in profitability due to a rise in the wage share (wN/Y) leads to lower vacancy rates and hence to higher unemployment. The relationship is highly nonlinear and there are “decreasing returns” to profitability. This is due to the fact that the product $(U/N)^\beta(V/N)^{1-\beta}$ is constant when all other exogenous variables remain unchanged. Given declines in V/N —gen-

¹⁷ In the figures for g_f and g_l the unemployment range is further restricted by the requirement that growth rates be positive.

¹⁸ The positive relationship is to be expected according to the mechanism described above. However at sufficiently high rates of growth, vacancy creation becomes particularly strong [as deduced from the solution of (26) and (29)], so much so that the unemployment rate goes down to maintain (28). The relatively low value of β plays a role here.

erated by lower profitability—induce bigger changes in unemployment the higher is U/N . The slope of the resulting curve, shown in Figure 11, is a function of parameter values (γ_2 and β). One policy implication is that the higher is the rate of unemployment, the more effective is a subsidy policy that increases profitability. A subsidy that increases profitability by 10 percent relative to the baseline would lower unemployment by 0.39 percentage points.

- (v) A rise in the replacement ratio (z/w) lowers search intensity and leads to an increase in unemployment. At relatively high levels of unemployment the negative impact of increases in the replacement ratio strengthens. This is so because here the product $C(U/N)$ is constant when the other exogenous variables are held constant. Given declines in C —generated by a higher replacement ratio—induce bigger changes in unemployment the higher is U/N . Thus here too, at relatively high levels of unemployment, any policy which would reduce the replacement ratio would be relatively more effective. Around the baseline, a 10-percent fall in the level of the replacement ratio would lower unemployment by almost half a percentage point.

It may be of interest to note that the big rise in Israeli unemployment, going from 3.3 percent in the 1970's to 6 percent in the 1980's and reaching 9.1 percent by the end of the decade, was accompanied by a substantial decline in profitability and by a significant rise in the rate of interest, with small changes in the other variables. These developments are consistent with mechanisms (i) and (iv). However, the current analysis, being focused on the nonstochastic steady state, cannot directly account for these changes. One way the rise in Israeli unemployment may be explained is to use the estimated parameters in a dynamic analysis specifying the stochastics of the system.

The foregoing calibration-simulation analysis has obvious limitations, including the fact that it refers to the steady state only and is partial equilibrium in nature. Nevertheless it produces reasonable results, which serve the

purpose of quantifying the unemployment implications of the structural estimates.

V. Conclusions

The paper has corroborated the search and matching model's approach whereby vacancy creation and hiring (in the case of firms) and search intensity (in the case of workers) may be accounted for by an intertemporal optimization approach with convex search costs. It has been able to quantify the relevant "asset values" of the match from the point of view of both firms and workers. The matching process was found to exhibit nonlinearities and the matching function is of the IRS type. The congestion and trading externality effects of search were quantified and were shown to covary negatively with the relevant hazard rates. Plugging in the model's estimated parameters into a partial-equilibrium model and simulating, it has demonstrated the usefulness of the search and matching model in accounting for changes in unemployment.

The paper has shown that the aggregate search and matching model is not only theoretically appealing but also has substantial empirical content. There is evidently ample room for further research, mostly in terms of a richer structure of agents' types and greater elaboration of the processes of search and matching. Within the current framework a task for further exploration would be to use the estimated model to study the dynamic, short-run behavior of key variables. For example, dynamic simulations of the model's equations may generate additional insight with respect to the fluctuations in unemployment, vacancies, and matches. In particular the sources of these fluctuations, their implications for business cycles and the role of policy could prove to be of major interest.

APPENDIX: DATA—SOURCES AND DEFINITIONS

The data set is comprised of 180 monthly observations in the years 1975–1989.

I use the following abbreviations 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.

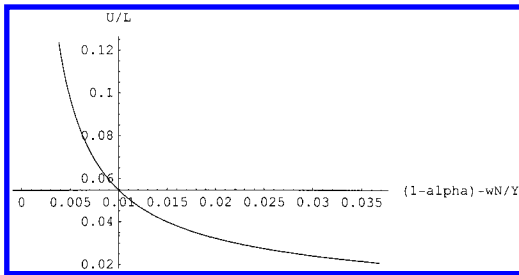


FIGURE 11. STEADY-STATE PROFITABILITY

$$\left((1 - \alpha) - \frac{wN}{Y} \right) \text{ EFFECTS}$$

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. Separation rate (s):

Source: computed on the basis of NIA and ES series. There is no direct gross flow measure of worker separations. I use the firms' budget constraint (3) to solve for s at each period. Doing so, the implicit assumption is that the relevant stock of employment (N) for the ES sector of the market grows at the same rate as the total stock of employment of the business sector. Note that Figure 6 above presents the separation rate in terms out of the labor force rather than out of employment.

3. Number of workseekers appearances at the ES exchanges (D):

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. I compute search intensity as a func-

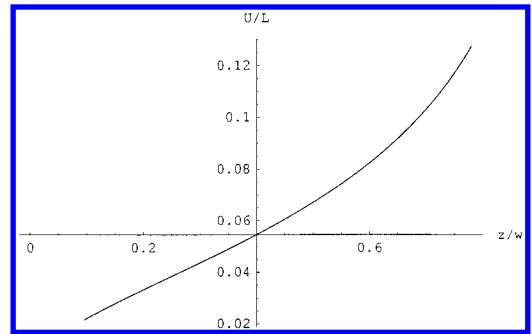


FIGURE 12. STEADY-STATE REPLACEMENT

$$\text{RATIO} \left(\frac{z}{w} \right) \text{ EFFECTS}$$

tion of this series by dividing it into the average number of working days in a month ($C = D/25$).

4. Average product (Y/N):

Source: CBS, NIA. Net domestic product of the business sector divided by business-sector employee posts. To compute this series the following procedure was employed: the basis for computation is the real GDP of the business sector; from this series depreciation and net production taxes should be deducted as Y represents firms' income in the model; as these data are not available but on annual basis, I take the average deduction (27 percent) and subtract it from the gross product series. One check on the validity of this procedure is possible for a limited number of quarters in the 1980's when the CBS did compute these deductions. Comparing the "true" series with the series computed in the above manner I find extremely high correlations (0.99). The product series is quarterly and is transformed into a monthly one by assuming linear geometric growth within the quarter. The net product series is divided by a measure of the labor input which is the total number of business-sector employee posts (jobs).

5. Real wages (w):

Source: NIA, CBS. I differentiate between the case of firms and the case of workers: In the case of firms w is the average nominal wage for employee post in the business sector divided by the GDP deflator. I multiply the original series by a factor of 1.26, which is the annual average for overhead costs (mostly social welfare contributions by the employer), as once more data

of higher than the annual frequency are unavailable. This multiplication is needed in order to make the data internally consistent with the Y series described above. In the case of workers I deflate the average nominal wage for employee post in the business sector by the CPI.

6. The replacement ratio (z/w):

Source: NIA, CBS. The numerator is 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 25, which is the average number of working days a month. The denominator is the average nominal wage for employee post in the business sector. Thus both series are in monthly terms and represent what a person would get (on average) if unemployed relative to what s/he will get if employed in an employee post in the business sector.

7. The real rate of interest (r):

Source: BOI, CBS. For firms: $(1 + \text{the basic nominal interest rate charged by banks})$ divided by $(1 + \text{the rate of GDP deflator inflation})$ minus 1. For workers: $(1 + \text{the basic nominal interest rate charged by banks})$ divided by $(1 + \text{the rate of CPI inflation})$ 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.

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