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VACANCIES, HIRINGS, AND THE DURATION FUNCTION

by

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Abstract: While the matching function relates hirings (H) to vacancies (V) and unemployment, the duration function relates the average duration of vacancies as measured by V/H to unemployment. Shifts of the duration function are equivalent to shifts of the matching function but easier to interpret. Therefore, this paper focuses on the microfoundations of the duration function. We find, first, that outward shifts of the duration function, or, equivalently, longer recruitment times at given unemployment, have no direct effects on hirings. Second, the effect of longer recruitment times on hirings through higher recruitment costs depends on the relative importance of vacancy costs in total recruitment costs, where vacancy costs include the opportunity cost of unfilled jobs. Third, this paper reports information on unfilled jobs (unmet demand) as distinct from job vacancies (recruitment processes) according to a new business survey in Sweden.

Keywords: Job vacancies, hirings, friction, matching function, Beveridge curve

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1. Introduction

The matching function is a relation between hirings, job vacancies and unemployment which summarizes the effect of friction in job matching. The relation has been interpreted and estimated as a (Cobb-Douglas) production function, with stocks of vacancies and unemployment as inputs and the number of hirings per period as output, first by Pissarides (1986), Blanchard and Diamond (1989), and Layard, Nickel and Jackman (1991), and then by many others, as the comprehensive survey by Petrongolo and Pissarides (2001) shows.

A shift of the matching function with less hirings at given inputs of vacancies and unemployment suggests a change of the matching technology which reduces the number of hirings per period. But exactly what are the effects of a shift of the matching function on hirings and employment and how can they be estimated?

To investigate this problem we shall here use a function which contains the same information as the matching function but which turns out to be easier to interpret and analyse, namely the *duration function*. This is a function which uses the same variables as the matching function, namely hirings (H), vacancies (V), and unemployment, but in a different order. More precisely, the duration function relates the average duration of vacancies as measured by V/H to the unemployment rate (and other variables characterizing the state of the labour market).

A shift of the matching function is equivalent to a shift of the duration function. An outward shift of the duration function is equivalent to longer recruitment times at a given unemployment rate. Thus, we shall focus on the effects of longer recruitment times on hirings.

Section 2 reports some stylized facts about recruitment times, but also about some other aspects of friction, especially unmet labour demand.

In Section 3 we analyse the effect of longer recruitment times on a representative firm's hirings in equilibrium. We do this by extending the model in Pissarides (2000) to include price formation and all recruitment costs. We find that longer recruitment times reduce hirings only if they also raise recruitment costs. This means that effects on hirings of longer recruitment crucially depends on the *structure* of recruitment costs, more precisely the relative importance of vacancy costs in total recruitment costs.

In Section 4 we review the Beveridge curve and the matching function and see how indirect evidence on vacancy durations from these functions can be replaced by direct evidence from the duration function. We also find that a shift of the matching function or, equivalently, a shift of the duration function, has no *direct* effect on hirings. Longer recruitment times affect hirings only *indirectly*, for instance, through higher recruitment costs or more unfilled jobs. Section 5 concludes the paper.

2. Facts about friction

Purchases of goods or services in a market economy are generated by decisions to purchase, followed by search processes which, in general, are costly and time-consuming. This also applies to the labour market. Thus, hirings are generated by firms' recruitment decisions. Some of these decisions are followed (almost) instantaneously by hirings. Other recruitment decisions are followed by recruitment processes which end by hirings after waiting times which often are random and sometimes long. They sometimes also involve 'unsatisfied labour demand'. And some recruitment processes may end without hirings. In this section we review some stylized facts about all of these aspects of friction in the hiring process.

2.1. Hirings without job vacancies

Some hirings are made more or less directly, for example, by recalling workers previously laid off, or by offering jobs to spontaneous job applicants. In such cases a firm's recruitment activities are merely some phone calls or letters, or (answers to) direct questions. Then recruitment times are negligible and hirings are not preceded by job vacancies as measured in vacancy surveys. Information on such *instantaneous hirings* is scarce. But what information there is does suggest that not every hiring begins with time-consuming recruitment.

Consider, for instance, the Employment Opportunity Pilot Project (EOPP) surveys in the United States in 1980 and 1982.¹ In these surveys employers were asked questions about the hiring process for the most recent newly hired person. In the first survey the first question asked concerned the length of time between the time recruitment started and the time the individual started to work. Twenty-eight per cent

responded that they did not recruit for the position, suggesting that a third of the hires were instantaneous.

2.2. *Job vacancies and recruitment times*

Hirings which are *not* instantaneous arise when there is no existing pool of job applicants which a firm can turn to. In this case the firm has to attract new job applicants by advertising its demand for personnel in newspapers or other media, by placing job orders with a public or private employment agency, or by contacting potential candidates directly. Then vacancies understood as ‘recruitment processes’ arise, as discussed in, e.g., Burdett and Cunningham (1998).

More precisely, a job vacancy begins when a firm starts to recruit a worker and it ends when a worker offered the job accepts it (or when recruiting is discontinued for other reasons). This is also the usual definition in vacancy surveys, including all the surveys discussed in NBER (1966), Muysken (1994), and Verhage et al. (1997).

The average duration of recruitment times, as measured by V/H , is usually under a month. This is confirmed by data in Table 1 from a new vacancy survey in Sweden.

2.3. *Job vacancies and unfilled jobs*

As emphasized by Holt and David (1966 p. 82), firms create vacancies (recruitment processes) in anticipation of future needs. But a firm does not always succeed in hiring a new worker in time to replace a separation or begin an expansion according to plan, and then an ‘unfilled job’ exists from the day the employer wants the worker to start to the day the worker starts. Measurement of ‘unfilled jobs’ in this sense gives information on ‘unsatisfied labour demand’ as defined in the classical literature on vacancies, including Dow and Dicks-Mireaux (1958) and Hansen (1970).

Thus, unfortunately, ‘vacancies’ is an ambiguous term. It sometimes means ‘recruitment processes’ and sometimes ‘unmet labour demand’, both in the economics literature and in everyday language. This is particularly unfortunate since firms *create* ‘vacancies’ in one sense (recruitment processes) in order to *avoid* ‘vacancies’ in another sense (unmet demand). When necessary to emphasize this distinction, vacancies as recruitment processes (that is, job vacancies as defined in Section 2.2)

¹ Results from the first wave are reported in Barron, Bishop and Dunkelberg (1985) and results from

Table 1 *Job openings, unfilled jobs, and average recruitment times in Sweden. Quarterly averages of monthly figures in the private sector.*

Period	Employment (thousands)	Hirings (thousands per month)	Job openings (thousands)	Job openings (per cent)	Average duration (months)	Unfilled jobs (per cent)
2000 Q3	2550	88.4	69.2	2.7	0.81	1.1
Q4	2493	72.2	63.1	2.6	1.05	1.1
2001 Q1	2504	70.3	57.9	2.3	0.93	1.0
Q2	2538	91.8	49.4	2.0	0.58	0.8
Q3	2647	83.2	44.7	1.7	0.55	0.7
Q4	2574	65.1	38.8	1.5	0.65	0.6
2002 Q1	2522	61.4	38.4	1.6	0.64	0.6
Q2	2573	97.7	39.1	1.6	0.40	0.6
Q3	2575	84.1	35.2	1.4	0.43	0.6

Notes: See Farm (2003) for operational definitions of job openings and unfilled jobs. Columns 5 and 7 report job openings and unfilled jobs as per cent of employment. Column 6 reports estimates of V/H (not estimates in column 4 divided by estimates in column 3). Standard deviations are approximately 0.05 in columns 5 and 7 and approximately 0.03 in column 6. Since 2000 Q3, when unemployment was 4.7 %, unemployment has fluctuated around 4.0 % (between 3.8 % and 4.2 %).

Source: Statistics Sweden (business surveys). See SCB (2002a) and SCB (2002b) for examples of reports from the quarterly surveys.

may perhaps be called *job openings*, while vacancies as unmet demand may be called *unfilled jobs*.

Surveys on unmet labour demand are so far in short supply but now include, for instance, the new vacancy surveys in the US and Sweden.² According to these surveys the rate of unfilled jobs in the private sector in 2001 was (on average) 2.9 per cent in the US and 0.8 per cent in Sweden. According to the Swedish survey, which measures both job openings (recruitment processes) and unfilled jobs (unmet demand), the rate of job openings was 1.9 per cent in 2001, which shows that the distinction between job openings and unfilled jobs cannot be ignored.

2.4. *Job vacancies without hirings*

Job vacancies can be cancelled by firms before hiring. This can happen simply because the situation has changed, so that the firms no longer want to recruit new

the second wave in Barron and Bishop (1985).

² See <http://stats.bls.gov> for monthly data since the end of 2000 from the Job Openings and Labor Turnover Survey (JOLTS) in the US and Table 1 for quarterly data from the Swedish survey since the end of 2000. Note that unfilled jobs are called 'job openings' in JOLTS, which measures unmet demand but not recruitment processes.

personnel, or because firms having difficulties in forecasting their labour demand realize that they have exaggerated their needs.³ Or some job vacancies may be cancelled because firms realize that no recruitment is possible at the moment and have to solve their staffing problems by other means, for instance reorganization followed by posting vacancies which are easier to fill.

Information on cancelled job vacancies is rare, but some sample surveys by the Public Employment Service in Sweden in the beginning of the 1990's suggest that the proportion of vacancies which end in hiring is very high, and at least equal to 90 per cent.⁴ Results by van Ours and Ridder (1992 p. 145) suggest the same thing. Thus, it seems to be approximately true that all vacancies (sooner or later) end in hiring, which is a standard assumption in the search literature, including Mortensen and Pissarides (1999).

3. Hirings, vacancies, and employment in equilibrium

In equilibrium with recruitment costs a firm's flow of profits is

$$(1) \quad \pi = R(N) - wN - \alpha H - \gamma V,$$

where R denotes the firm's (net) revenue function, N its employment, H its number of hirings per period, and V its number of job vacancies. The wage level is denoted by w and recruitment costs are captured by the parameters α , as in Nickell (1986), and γ , as in Pissarides (1990). For simplicity we ignore firing costs.

Note that recruitment costs in general are composed of both 'fixed' costs (α per hiring) and 'variable' costs (γ per vacancy and period). Fixed recruitment costs are independent of the length of the recruitment process. Suppose, for example, that a firm finds it necessary to announce a position in a newspaper. If this is done only once, or a predetermined number of times, it is a fixed cost or, in other words, a *hiring cost*. Then it is part of α . If, on the other hand, the firm advertises once a week until the vacancy is filled, then the cost is variable (dependent on the length of the recruitment process) and thus part of the *vacancy cost* γ . The same is true if the firm is using a private employment agency and is paying the agency for its services per week. But if the agency is paid per job match, then the cost is a hiring cost and thus

³ As emphasized, for instance, by Thomson (1966 p. 177).

⁴ See Falk (1996).

part of α . We incorporate both hiring costs α and vacancy costs γ in the model because it turns out that not only the size but also the structure of recruitment costs matter.

Next we assume that the flow of a firm's hirings is proportional to its recruitment efforts as measured by its stock of vacancies,

$$(2) \quad H = qV .$$

Thus, in contrast to Nickel (1986), where *all* hirings are instantaneous, we assume here that a firm has to generate vacancies to obtain new employees, so that *no* hirings are instantaneous, as in Pissarides (2000).

The constant of proportionality q in (2) can be interpreted as the probability per week that one of the V vacancies leads to a hiring, so that the waiting time has an exponential distribution with expected value equal to $1/q$ weeks. Of course, in a stochastic environment such a direct link between the stock of vacancies and the flow of hirings as in (2) can only apply to a large firm exploiting the law of large numbers, as emphasized by Pissarides (2000 p. 68), or to a large group of (small) firms. In general q depends on the state of the labour market, but we postpone discussion of this dependence to Section 4.

3.1. Profit maximization with recruitment costs

We assume (for simplicity) that a firm's separations are given by $S = sN$, where the separation rate s is constant. Then we have $H = sN$ in a steady state and substituting this expression and $V = H/q = sN/q$ into (1) we obtain

$$(3) \quad \pi = R(N) - wN - (\alpha + \gamma/q)sN .$$

Now we use the simple economic principles in Nickel (1986 p. 481) and argue as follows. According to (3) a unit increase in employment generates additional costs of $w + (\alpha + \gamma/q)s$ per period in equilibrium. But in order to obtain a new employee the firm also has to generate a vacancy for $1/q$ weeks (on the average). A unit increase in employment consequently also involves a once for all cost of $\alpha + \gamma/q$, or, equivalently, a flow cost of $r(\alpha + \gamma/q)$ per period, where r is the interest rate. It follows that

$$(4) \quad R'(N) = w + (r + s)(\alpha + \gamma/q)$$

in equilibrium for a profit-maximizing firm. Note that (4) reduces to the job creation condition in Pissarides (2000) for a competitive firm with constant returns and $\alpha = 0$.

3.2. Employment and price formation

As emphasized by Layard, Nickel, and Jackman (1991 p. 341) for a non-competitive firm *without* recruitment costs, equation (4) is an equilibrium relationship: ‘It is not a labour demand function because prices are chosen jointly with employment’. This is also true for a representative competitive firm. For with $R(N) = pF(N)$, where F denotes the production function and p the market price, condition (4) reduces to

$$(5) \quad pF'(N) = w + (r + s)(\alpha + \gamma/q),$$

and assuming that the firm is one of n identical firms in a competitive industry, the market price and a firm’s employment are determined by equation (5) and the equation

$$(6) \quad nF(N) = D(p),$$

where $D(\cdot)$ is the industry’s product-demand function.

Pissarides (2000) assumes that the marginal product of labour is constant. But then it is particularly clear that equation (5) can be interpreted not only as a job creation condition, as in Pissarides (2000), but also as a *price equation*. For if $F'(N) = a$ equation (5) can be written as

$$(7) \quad p/w = 1/a + (r + s)(\alpha + \gamma/q)/aw.$$

As emphasized by Pissarides elsewhere, in Pissarides (1984 p. 133), an equation like (5) with $F'(N) = a$ is basically a modification of the classical condition on wages under constant returns to scale. The marginal product of labour (a) exceeds the real wage (w/p) because firms need to cover their recruitment costs. And in equilibrium in a competitive economy prices adjust to marginal costs, including recruitment costs.

A change in wages will change market prices, sales, and employment. Assuming that the effect of a change in wages has a well-defined effect on employment, there is a well-defined wage elasticity of labour demand. It follows from (5) and (6) that the effects of recruitment costs on employment depend on this wage elasticity of labour demand and the relative importance of recruitment costs in total labour costs.

Moreover, according to equation (5) the effect of a change in the average duration of vacancies ($1/q$) on employment depends on how important vacancy costs (γ) are relative to hiring costs (α). And if q depends on the state of the labour market, then variations in the state of the labour market have effects on employment through their effects on the average duration of vacancies.

3.3. *Vacancy costs*

The structure of recruitment costs for time-consuming recruitment depends on the search strategy used by firms. This question has been addressed by, for instance, van Ours and Ridder (1992). Using vacancy data from the Netherlands they conclude that employer search is mostly non-sequential. Almost all applicants arrive during the first two weeks after the announcement of a vacancy. The rest of the duration of a vacancy is a selection period.

These results suggest, firstly, that resources spent on job advertising are concentrated to the beginning of the recruitment process. Hence these costs do not depend on the duration of the vacancy and should be treated as a hiring cost (as defined in the beginning of this section).

Secondly, suppose that company personnel spend c hours per week on screening and interviewing until the best applicant is found. In this case we would have $\gamma = c$. But c cannot be interpreted as a given parameter, since after the pool of applicants has been formed, the employer knows the number of applicants and then also the number of hours needed for screening and interviewing. It is these costs which characterize the situation faced by the employer. The distribution of the costs between weeks is up to the employer. The employer may choose to concentrate all interviews to one week or, say, contact two applicants per week until all applicants who have passed the initial screening have been interviewed. The strategy chosen, and hence also the length of the selection period, should depend on how urgent it is to fill the vacancy. But the decision to begin recruiting in the first place only depends on the (expected) *total* number of hours needed for screening and interviewing.

The structure of recruitment costs also depends on the occurrence of unfilled jobs. Note that the opportunity cost of an unfilled job may be high. Vacancy costs may consequently be high if all vacancies are unfilled jobs. But this is exactly why firms try to avoid them. It follows that the number of unfilled jobs also depends on

firms' possibility and ability to anticipate separations and recruitment times and reduce the risk for unfilled jobs by starting to recruit replacements early.

Moreover, since it may be too costly to eliminate all unfilled jobs with certainty, the existence of unfilled jobs also depends on what firms consider to be the optimal recruitment strategy and the associated (expected) number of unfilled jobs. In a model where unfilled jobs are generated endogenously, recruitment costs will consequently comprise not only the opportunity cost of the risk for unfilled jobs but also the cost of reducing this risk.

It may be possible to design models where unfilled jobs are generated endogenously, but so far this has not been done, and this is also outside the scope of the present paper. But note that what matters for firms' decisions to start recruiting can only be *expected* recruitment costs for the optimal recruitment strategy, including the opportunity cost of the *expected* number of unfilled jobs. On the other hand, unfilled jobs can also arise as complete surprises (shocks). Then they cannot reduce employment and hirings through (expected) effects on recruitment costs. But they will nevertheless reduce employment, namely by creating gaps between firms' employment plans and actual employment.

3.4. Vacancies, employment, and hirings

A firm stabilizes employment at its equilibrium level N by generating vacancies and hirings at the rate of sN per period, so that the stock of vacancies is

$$(8) \quad V = sN/q$$

in equilibrium. Equation (8) for a firm, or a group of firms, shows how vacancies adjust to variations in employment. It also shows that a change in q will change the number of vacancies. Employment and hirings are affected only if variation in the average duration of vacancies ($1/q$) affects employment by affecting recruitment costs.

Note finally that in equilibrium a firm's number of hirings per period is proportional not only to its employment, $H = sN$, as discussed above, but also to its separation rate. Focusing on the effects of recruitment costs on hirings through employment, we have so far assumed that the separation rate is constant. But even if a firm's number of separations is increasing in its employment, it need not be strictly proportional. Moreover, the separation rate may depend on the state of the labour

market, as measured, for instance, by the unemployment rate or the degree of reallocation in the economy, and on structural factors, including, in particular, the share of temporary jobs, as emphasized, for instance, by Verhage et al. (1987 p. 17).

4. Beveridge curves, matching functions, and duration functions

In this section we review the Beveridge curve and the matching function and see how indirect evidence on vacancy durations from these functions can be replaced by direct evidence from the duration function.

4.1. The Beveridge curve

Since, in general, q (and perhaps also s) depends on unemployment (and perhaps also vacancies), equation (8) for a group of firms defines a relation between the vacancy rate (V/N) and the unemployment rate in a labour market. This is the long-run Beveridge curve, which in a UV diagram connects UV points for which employment is constant. Note that its derivation here does not presuppose that all separations are to unemployment or that only unemployed people are hired.

In the literature on vacancies an outward shift of the Beveridge curve, or, equivalently, increased unemployment at a given vacancy rate, has been interpreted as an increase in ‘maladjustment’ in the labour market, beginning with Dow and Dicks-Mireaux (1958), or as a decline in the ‘search effectiveness’ of the unemployed, as in Jackman, Layard, and Pissarides (1989) and Layard, Nickell, and Jackman (1991). But more vacancies at a given unemployment rate may also suggest a rise in job turnover or job reallocation, as emphasized by, for instance, Thomson (1966 p. 191), Abraham (1987 p. 230), Schager (1987 p. 33) and Blanchard and Diamond (1989).

More precisely, controlling for separations an outward shift of the Beveridge curve suggests a rise in the average duration of vacancies ($1/q$), according to (8). But with information on hirings as well as vacancies, indirect evidence on vacancy durations from Beveridge curves can be replaced by direct evidence. For, according to (2) we have $1/q = V/H$, so that V/H is a direct measure of the average duration of vacancies, independent of labour turnover.

4.2. The matching function

In the search and matching literature the relation between hirings, vacancies, and unemployment in a labour market has been interpreted as an aggregate production function, showing how vacancies and unemployment as inputs give rise to output in the form of hirings. This is also what equation (2) suggests.

In fact, equation (2) for a representative firm merely formalizes the idea that a firm in most cases (excluding instantaneous hirings) has to ‘do something’ (V) in order to recruit people. In other words, a hiring presupposes a job vacancy, that is, a recruitment process, and this recruitment process generates a hiring with some probability per week (q). It follows that at any given moment in time the number of hirings per period should be (roughly) proportional to the number of ongoing recruitment processes, as equation (2) tells us.

Moreover, introducing the plausible assumption that the average duration of vacancies ($1/q$) depends on the tightness of the labour market as measured by the ratio of vacancies to unemployment, $q = q(V/U)$, it follows from (2) and a log-linear approximation, $q = c(U/V)^\alpha$, that

$$(9) \quad H = Vq(V/U) = cV^{1-\alpha}U^\alpha.$$

This suggests that a Cobb-Douglas specification with constant returns to scale should be successful in empirical work, as indeed it is.⁵

It might be tempting to conclude that a shift of the matching function with less hirings at given inputs of vacancies and unemployment indicates a change of the matching technology which *in itself* reduces the number of hirings per period, and which consequently also reduces the arrival rate of job offers which face the unemployed and thus increases unemployment by prolonging unemployment spells. But this is a hasty conclusion. To see this, note first that a shift of the matching function is equivalent to a shift of the duration function $T = 1/q(V/U)$, where $T = V/H$. Of course a rise in T suggests fewer hirings per period – other things being equal. But other things will not be equal, as we have seen in Section 3. Longer vacancy spells will increase the stock of vacancies in equilibrium, so that hirings, employment and unemployment are stable – unless recruitment costs increase.

4.3. *The duration function*

Since the number of vacancies is proportional to the number of hirings per period it is an often used indicator of changes in employment in the near future. But controlling for hirings the number of vacancies is also an indicator of how difficult it is to recruit personnel. More precisely, V/H is a measure of friction in terms of deviations from instantaneous hirings, since it equals the average duration of all vacancies, including ‘vacancies with negligible duration’, like recalls by phone calls of former employees. Since ‘vacancies with negligible duration’ are not usually measured in vacancy surveys, it is perhaps more accurate to say that V/H equals the average duration of vacancies weighted with the proportion of non-instantaneous hirings.

Of course friction as measured by V/H in general depends on the state of the labour market. This dependence can be characterized by a duration function, where the independent variables include not only the unemployment rate but also, for instance, the share of long-term unemployment and the share of youth in the population.

Shifts of the vacancy duration function are equivalent to shifts of the matching function but easier to interpret. Longer vacancy spells may reduce employment by raising recruitment costs, as outlined in Section 3. But longer recruitment times probably tend to reduce employment by increasing not only recruitment costs but also risks for unfilled jobs. For this reason V/H should be a useful general indicator of recruitment problems.

However, longer recruitment times do not *necessarily* reduce employment. Of course longer recruitment times may, *if they are unanticipated*, increase the risk of not succeeding in hiring new workers in time to replace separations or expand employment according to plan. But when a firm can anticipate its need for new hires, it can also reduce the risk for unmet demand by starting to recruit earlier. In other words, gaps between planned and actual employment as measured by the rate of unfilled jobs may be reduced by longer recruitment times as measured by V/H .

⁵ See, in particular, the survey by Petrongolo and Pissarides (2001).

5. Conclusions

According to the dynamic theory of labour demand the number of hirings per period chosen by a firm when hirings are *instantaneous* is in general determined by the firm's desired net change of employment and its need to replace workers who, for various reasons, are leaving the firm. And the firm's desired net change of employment depends on 1) current employment, 2) current sales, prices and costs (including recruitment costs), and 3) expectations of future sales, prices and costs, as elaborated, for instance, in Nickell (1986) or Hamermesh (1993). Thus, individual hirings, and hence also aggregate hirings, are functions of current and expected prices, sales and costs, including recruitment costs.

This hiring function for instantaneous hirings is modified by deviations from instantaneous hirings. The matching function is, of course, not intended to be a short cut to such a modified dynamic hiring function, not even in equilibrium. A reasonable first approximation to a dynamic hiring function for non-instantaneous hirings is obtained instead by substituting all recruitment costs for hiring costs in a dynamic hiring function.

The matching function, on the other hand, provides information on friction in job matching and the dependence of friction on the state of the labour market. To emphasize this role of the relation between vacancies (V), hirings (H), and unemployment (and other variables characterizing the state of the labour market), it should be specified as a relation with V/H as a dependent variable, since this is a summary measure of deviations from instantaneous hirings. Note, however, that longer recruitment times as measured by V/H do not indicate a negative effect of friction on employment unless corroborated by, for instance, an increasing rate of unfilled jobs.

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