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What are the determinants of hiring?
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What are the determinants of hiring? The role of demand and supply factors[a]

by

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Abstract

In this paper, we study the relative importance of demand and supply factors for hiring. We use a search-matching model with imperfect competition in the product market to derive an equation for total hiring in a local labor market and estimate it on Swedish panel data. If product markets are imperfectly competitive, product demand shocks should have a direct effect on employment. Our main finding is that product demand is important for hiring. This highlights the importance of taking imperfect competition in the product market into account in studies of employment dynamics and hiring. We also find that the number of unemployed workers has a positive effect on hiring, confirming the importance of search frictions. Hence, both demand and supply factors seem to matter for hiring.

Keywords: Hiring, search-matching, imperfect competition, unemployment
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1 Introduction

Today, most studies of labor market issues are based on search-matching models, which emphasize the importance of search frictions in the labor market. These models imply that the number of unemployed workers should be an important determinant of hiring: for a given wage, firms should open more vacancies if there are more unemployed workers available, since it is then relatively easy, and thus inexpensive, to find workers. Therefore, supply should create its own demand. However, another potentially important determinant of hiring, which is often neglected in these models, is the demand conditions facing the firms. Most search models assume that the product market is perfectly competitive, so that firms can sell whatever they produce at the prevailing market price. However, if we allow for monopolistic competition, the dynamics of hiring changes in a fundamental way, since labor demand will depend on the position of the product demand curve. Product demand shocks will have a direct effect on employment.

How important are demand factors, such as shocks to the firms' product demand and real wage costs for hiring? What role is played by supply factors, such as the number of unemployed workers? In this paper, we study the determinants of hiring. We investigate the importance of the demand conditions facing the firms, the firms' wage costs relative to their competitors' prices, and the number of unemployed workers available.

We derive an equation for total hiring in a local labor market using the search-matching model with imperfect competition in the product market in Carlsson, Eriksson, and Gottfries (2013), and estimate this equation on Swedish panel data for the time period 1992-2008. The use of regional data allows us to separate the effects of the different demand and supply factors. We rely on variation in product demand, real wage costs, and unemployment across local labor markets and over time. In different local labor markets, different industries are important for employment, and industries differ in the shares of their production that are sold as exports and in the domestic market as well as in the shares of production sold in the domestic market that are used for consumption and investment. A major issue in the estimation is simultaneity and the effects of unobserved shocks. As will be described below, we construct the variables to take these simultaneity issues into account.

Our main finding is that product demand is important for hiring. This suggests that imperfect competition in the product market is important for understanding employment dynamics. We also find that the number of unemployed workers has a positive effect on hiring. Hence, supply seems to create its own demand, at least partially. Quantitatively, product demand seems to be more important for understanding the variation in hiring than the number of unemployed workers. Moreover, we find that real wage costs have a negative impact on hiring, but this effect seems less important quantitatively. Overall, these results suggest that both demand and supply factors matter for hiring.

In a closely related paper, Carlsson, Eriksson, and Gottfries (2013) analyze the determinants of net employment change at the firm level using yearly data (1990-2000) for the Swedish manufacturing sector. They find that product demand and real wages are important for firms' employment dynamics, while the number of unemployed workers is not. Our paper takes the analysis further by analyzing the importance of these factors for hiring in all sectors of the economy. Moreover, we analyze a longer time period (1992-2008), including all phases of the business cycle, and we do the analysis on monthly data.

Our paper is related to the literature analyzing the determinants of labor demand (cf. the survey in Nickell, 1986), but we also consider the effects of supply factors. Burgess (1993) uses aggregate times series data to estimate a labor demand model, but allows the speed of employment adjustment to depend on labor market tightness. He finds that both product demand and labor market tightness affect employment dynamics. Moreover, some recent papers have investigated the importance of product market demand for understanding labor demand (e.g. Bils *et al.*, 2013), while others have investigated the importance of search frictions (e.g. Yashiv, 2000, Christiano, Trabandt and Walentin, 2011, and Michaillat, 2012).

Another related literature is studies estimating matching functions (cf. the survey in Petrongolo and Pissarides, 2001). Three representative studies using regional data are Bennett and Pinto (1994), Coles and Smith (1996), and Anderson and Burgess (2000). Three studies using Swedish data are Forslund and Johansson (2007), Fransson (2009), and Aranki and Löf (2008). However, these papers focus on demonstrating the existence of a stable matching function and, in most cases, do not include other explanatory variables than unemployment and vacancies. In contrast, we consider the importance of product demand explicitly.

The rest of the paper is organized as follows. Section 2 presents a theoretical model of hiring in a local labor market and derives an equation for hiring. In Section 3, the data are described and identification and estimation issues are discussed. The results of the estimation are presented and discussed in Section 4. Section 5 concludes the paper.

2 Theory and empirical specification

In this section, we formulate a theoretical model of hiring in a local labor market. The model is a search-matching model with imperfect competition in the product market and it is based on the model in Carlsson, Eriksson, and Gottfries (2013). The model is deliberately kept simple; its purpose is to highlight the mechanisms we aim to study. From this model, we derive an equation for total hiring in a local labor market, which we then estimate.

2.1 The theoretical model

The model is based on the standard textbook search-matching model (cf. Pissarides, 2000) with two major changes. First, we assume that firms hire more than one worker. Second, we assume that the product market is characterized by imperfect competition.

The national labor market is divided into a number of distinct local labor markets. All matching is assumed to take place within the local labor markets, i.e., workers and firms are situated in a local labor market and cannot move to another local labor market. In each local labor market, indexed *n*, there are a large number of firms, indexed *i*. Firms belong to different industries, indexed *j*. Thus, the firms sell their products in different product markets and face different competitors' prices, denoted $P_{i,t}^{C}$. To keep the model simple, we assume that firms take wages $(W_{i,t})$ as given.[1]

[1]This assumption can be justified by arguing that wages are set in collective agreements with trade unions on the national level. In Sweden, most wages are set in branch-level union contracts and there is evidence of high nominal wage rigidity (cf. Forslund et al. 2008). This implies that wages in a particular period to a large extent are predetermined.

The following events take place every period:

- At the start of the period, firms choose the number of vacancies to open. Firm *i* opens $V_{i,t}$ vacancies and incurs real vacancy costs given by $c_V V_{i,t}$.[2]
- Matching of workers unemployed at the beginning of the period $(U_{n,t})$ and vacancies $(V_{n,t})$ takes place in each local labor market.[3] The matching process between vacancies and unemployment is described by a matching function: $M_{n,t} = \Phi U_{n,t}^{\alpha_u} V_{n,t}^{\alpha_v}$, where $M_{n,t}$ is the total number of matches in period *t*. Hence, the probability of filling a vacancy is $Q_{n,t} = M_{n,t} / V_{n,t} = \Phi U_{n,t}^{\alpha_u} V_{n,t}^{\alpha_v - 1}$.
- Hiring is $H_{i,t} = Q_{n,t} V_{i,t}$ and the firm incurs real hiring costs $\frac{c_H}{2}\left(\frac{H_{i,t}}{N_{i,t-1}}\right)^2 N_{i,t-1}$, where $N_{i,t-1}$ is employment in firm *i* in period *t-1*.[4]
- A fraction λ of the previously employed workers leave for exogenous reasons. This fraction is sufficiently large so that firms will always open some vacancies.
- Production takes place with the CRS technology $Y_{i,t} = N_{i,t}$.
- The firms sell their products in monopolistically competitive markets. Demand for a firm's output is determined by the Dixit-Stiglitz demand function $Y_{i,t} = \left(P_{i,t} / P_{i,t}^C\right)^{-\eta} D_{i,t}^{\sigma}$, where $P_{i,t}$ is the firm's price, $D_{i,t}$ is a firm-specific demand-shifter, $\sigma > 0$, and $\eta > 1$.

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[2]The vacancy cost captures search costs, i.e. costs of advertising, engaging a recruitment agency etc. These activities do not directly interfere with production and the cost of recruiting for two positions should be roughly twice as large as the cost of recruiting for one position. Therefore, we follow the search-matching literature and assume that this cost is linear.

[3]As in the standard textbook search-matching model, we do not allow for on-the-job search. In principle, we could include on-the-job search in the model, but not in the empirical analysis since there are no time-series data on on-the-job search available. This means that we implicitly treat on-the-job search as a constant. In Section 4, we discuss what happens if on-the-job search is procyclical.

[4]The hiring cost represents costs of training workers and reorganizing the workplace when the workforce is expanded. This cost is quadratic because the disruptions caused by newly hired workers can be expected to increase more than proportionally with the number of workers that are hired. Quadratic hiring costs imply a sluggish adjustment of employment, which is consistent with what is observed empirically.

Firm i chooses the number of vacancies to open by solving the profit maximization problem:

$$\max \quad E_t \sum_{\tau=t}^{\infty} \beta^{\tau-t}\left[\frac{(P_{i,\tau}-W_{i,\tau})}{P^C_{i,\tau}}N_{i,\tau} - \frac{c_H}{2}\left(\frac{H_{i,\tau}}{N_{i,\tau-1}}\right)^2 N_{i,\tau-1} - c_V V_{i,\tau}\right] \tag{1}$$

$$s.t. \quad N_{i,\tau} = H_{i,\tau} + (1-\lambda)N_{i,\tau-1}, \quad H_{i,\tau} = Q_{n,\tau} V_{i,\tau}, \quad \text{and} \quad N_{i,\tau} = \left(\frac{P_{i,\tau}}{P^C_{i,\tau}}\right)^{-\eta} D^s_{i,\tau}.$$

where $0 < \beta < 1$. Inserting the constraints and maximizing with respect to $N_{i,t}$, we get the Euler equation:

$$E_t\left\{\begin{array}{c} \frac{\eta-1}{\eta}\left(\frac{D^s_{i,t}}{N_{i,t}}\right)^{1/\eta} - \frac{W_{i,t}}{P^C_{i,t}} - c_H\left(N_{i,t}-(1-\lambda)N_{i,t-1}\right) - \frac{c_V}{Q_{n,t}} \\ +\beta c_H\left(N_{i,t+1}-(1-\lambda)N_{i,t}\right)(1-\lambda)N_{i,t}^{-1} + \beta\frac{c_H}{2}\left(N_{i,t+1}-(1-\lambda)N_{i,t}\right)^2 N_{i,t}^{-2} \\ +\beta(1-\lambda)\frac{c_V}{Q_{n,t+1}} \end{array}\right\} = 0 \tag{2}$$

The firm hires more workers if the demand for the firm's product $(D_{i,t})$ is high, the real wage $(W_{i,t}/P^C_{i,t})$ is low, the probability of finding a worker $(Q_{n,t})$ is high, and/or the expected probability of finding a worker in the future $(Q_{n,t+1})$ is low. Taking a log-linear approximation of the Euler equation, solving the resulting difference equation, and using the definition of $Q_{n,t}$, we get an equation for hiring in firm i (the derivation is shown in Appendix A):

$$\begin{aligned} \hat{h}_{i,t} &= \frac{N}{H}(\Delta\hat{n}_{i,t} + \lambda\hat{n}_{i,t-1}) = \\ &\frac{N}{H}\Bigg[\frac{\kappa_1}{c_H}E_t\Bigg\{\sum_{\tau=t}^{\infty}\left(\frac{1}{\kappa_2}\right)^{\tau-t}\left(\sigma\frac{\eta-1}{\eta^2}\frac{P}{P^C}\hat{d}_{i,\tau} - \frac{W}{P^C}\hat{w}_{i,\tau}\right) + \frac{c_V}{Q}\left[\alpha_u\hat{u}_{n,t} - (1-\alpha_v)\hat{v}_{n,t}\right] \\ &- \beta\frac{c_V}{Q}(1-\lambda-\kappa_1)\sum_{\tau=t+1}^{\infty}\left(\frac{1}{\kappa_2}\right)^{\tau-t-1}\left[\alpha_u\hat{u}_{n,\tau} - (1-\alpha_v)\hat{v}_{n,\tau}\right]\Bigg\} - (1-\lambda-\kappa_1)\hat{n}_{i,t-1}\Bigg], \end{aligned} \tag{3}$$

where $0 < \kappa_1 \leq 1$ and $\kappa_2 \geq 1/\beta$. Capital letters without time subscripts denote steady-state values and $\hat{h}_{i,t}$, $\hat{n}_{i,t}$, $\hat{d}_{i,t}$, $\hat{w}_{i,t}$, $\hat{u}_{n,t}$ and $\hat{v}_{n,t}$ denote log deviations of $H_{i,t}$, $N_{i,t}$, $D_{i,t}$, $W_{i,t}/P^C_{i,t}$, $U_{n,t}$, and $V_{n,t}$ from their steady-state values.

To get an expression for total hiring in a local labor market, we sum hiring in the firms within the area.[5] In local labor market *n*, hiring is:

$$\hat{h}_{n,t} = \frac{N}{H}\Bigg[\frac{\kappa_1}{c_H}\mathrm{E}_t\Bigg\{\sum_{\tau=t}^{\infty}\left(\frac{1}{\kappa_2}\right)^{\tau-t}\left(\sigma\frac{\eta-1}{\eta^2}\frac{P}{P^C}\hat{d}_{n,t} - \frac{W}{P^C}\hat{w}_{n,t}\right) + \frac{c_V}{Q}\left[\alpha_u\hat{u}_{n,t} - (1-\alpha_v)\hat{v}_{n,t}\right]$$

$$- \beta\frac{c_V}{Q}(1-\lambda-\kappa_1)\sum_{\tau=t+1}^{\infty}\left(\frac{1}{\kappa_2}\right)^{\tau-t-1}\left[\alpha_u\hat{u}_{n,t} - (1-\alpha_v)\hat{v}_{n,t}\right]\Bigg\} - (1-\lambda-\kappa_1)\hat{n}_{n,t-1}\Bigg], \tag{4}$$

where $\hat{h}_{n,t}$, $\hat{n}_{n,t}$, $\hat{d}_{n,t}$, $\hat{w}_{n,t}$ are the log deviations of the variables from their steady-state values.

Equation (4) contains vacancies. However, since there is a relationship between vacancies and hiring, it is straightforward to eliminate vacancies. Using the definition of $Q_{n,t}$ and the fact that $H_{n,t} = Q_{n,t}V_{n,t}$, we get:

$$\hat{v}_{n,t} = \frac{\hat{h}_{n,t} - \alpha_u\hat{u}_{n,t}}{\alpha_v}. \tag{5}$$

In our model, hiring in period *t* depends on both the current and the expected future values of all variables. To simplify, we assume that we can use current values as proxies for future values.[6] We make this assumption both to keep the model simple and because it allows us to derive a feasible empirical specification. Total hiring in local labor market *n* is:

$$\hat{h}_{n,t} = \xi_0 + \xi_1\hat{d}_{n,t} - \xi_2\hat{w}_{n,t} + \xi_3\hat{u}_{n,t} - \xi_4\hat{n}_{n,t-1} + \varepsilon_{n,t}, \tag{6}$$

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[5]For simplicity, we assume there are a fixed number of firms in each industry in each local labor market. It is possible to extend the model to include a condition for firm entry/exit by assuming that there is a fixed cost to enter the market.

[6]Formally, this is equivalent to assuming that the stochastic processes of the right hand side variables are first-order processes; e.g. AR(1).

where x_0, x_1, x_2, x_3 and x_4 are positive constants. Hiring depends on demand, competiveness (wages in relation to the competitors' prices), unemployment at the beginning of the period, and employment in the previous period. An increase in demand in the goods market induces firms to hire more workers, higher real wage costs decrease the firms' competitiveness and result in less hiring, and high unemployment makes it easier to find workers and results in more hiring. High employment in the previous period means that firms need to hire fewer workers in the current period for given levels of demand and wages.

2.2 The empirical specification

We use equation (6) to derive an empirical specification:

$$\ln H_{n,t} = a_n + b_1 \ln D_{n,t} + b_2 (\ln W_{n,t} - \ln P^C_{n,t}) + b_3 \ln U_{n,t} + b_4 \ln N_{n,t-1} + e_{n,t}\,, \tag{7}$$

where we expect $b_1 > 0$, $b_2 < 0$, $b_3 > 0$, and $b_4 < 0$.

We interpret equation (7) as a structural equation for total hiring in a local labor market during a period. The coefficient b_1 reflects the importance of product demand (imperfect competition in the product market), b_2 the importance of real wage costs, and b_3 the importance of the number of unemployed workers available at the beginning of the period. If the steady-state values of the variables are constant, equation (7) follows directly from equation (6). In the real world, the steady-state values may change over time, but since we include time trends in the estimation this is not a major issue (see Section 4).

3 Data and estimation

To estimate the model, we use Swedish regional labor market data for the time period 1992-2008. In this section, we describe the data, explain how we construct the variables, describe the identification strategy, motivate our choice of estimation method, and discuss how we handle a number of issues that arise in the estimation.

3.1 Data

Hiring and all the explanatory variables are measured at the regional level. We use data for local labor markets. A local labor market is a geographical level constructed by

Statistics Sweden for statistical purposes, and is intended to define areas that are independent from the surrounding areas concerning labor demand and supply. A local labor market consists of one or more municipalities. We use the 1993 definition with 109 local labor markets (see Appendix B for a list). In the analysis, we assume that all matching takes place within the local labor market where the workers live and the firm is located, i.e., we treat the local labor markets as isolated. This is in line with the definition of a local labor market as an independent labor market, but is of course a simplification since we know that some workers move to new jobs. However, there is empirical evidence that supports this assumption: Johansson and Persson (2000) report that 80-90 percent of all hired workers come from the local labor market where the firm is located. We follow the search-matching literature and use monthly data. In Appendix C, the variables are illustrated for some local labor markets.

3.1.1 Hiring and unemployment[7]

Data for hiring and unemployment come from the Swedish Public Employment Service (hereafter called “the Employment Service”), who do their measurements at the municipality level on a monthly basis. From this data, we calculate the corresponding measures for each local labor market. Hiring $(H_{n,t})$ is defined as the number of unemployed workers who are deregistered by the Employment Service because they have found a job during the month. The advantage of using this measure is that we know that these workers have found a job, although there is the disadvantage that it does not include workers who have found a job but not told the Employment Service. This measure of hires is often used in studies estimating matching functions.[8] Unemployment $(U_{n,t})$ is a wide measure of the number of unemployed workers registered at the Employment Service at the beginning of the month.

3.1.2 Product demand

The product demand variable $(D_{n,t})$ is constructed to capture the demand conditions facing the firms in each local labor market. We construct this variable in two steps.

First, we construct a measure of demand for each industry using data from Statistics Sweden and the OECD. Our measure of industry demand consists of a domestic part

[7]Our data on hiring and job seekers exclude on-the-job search. The main reason for this is that there is no time-series data on on-the-job search. This issue is discussed in Section 4.
[8]Cf. Forslund and Johansson (2007), Fransson (2009), and Aranki and Löf (2008).

and an international part. For the domestic part, we use data for 57 industries (SNI92), which taken together make up the whole economy. For the international part, we use data for 35 industries including all manufacturing sectors, mining, agriculture, forestry, and some service sectors dominated by business services. For the remaining industries, we set the export shares to zero since detailed export data are not available. However, the export shares of most of these industries—mainly the public sector and some service sectors—are very small. All the industries included in the analysis are listed in Appendix B. Demand for industry *j* is defined as

$$\ln D_{j,t} = (1-\delta_j)[\varphi_j^C \ln C_t + \varphi_j^G \ln G_t + \varphi_j^I \ln I_t + (1-\varphi_j^C-\varphi_j^G-\varphi_j^I)\ln EX_t] + \delta_j \ln D_{j,t}^I,$$

where δ_j is the direct export share in 2005, φ_j^C is the industry-specific share of output going to final private consumption in total domestic use, φ_j^G is the corresponding share going to public consumption, φ_j^I is the corresponding share going to investment, and $1-\varphi_j^C-\varphi_j^G-\varphi_j^I$ is the corresponding share used domestically as intermediate input to products which are eventually exported.[9] We use fixed shares computed from the 2005 input-output tables provided by Statistics Sweden, but these shares are rather constant over the time period we consider.[10] C_t, G_t, I_t and EX_t are all aggregate variables; C_t is real private consumption, G_t is real public consumption, I_t is real private sector gross fixed investment, and EX_t is real exports. The measures of these variables are only available at a quarterly frequency (from Statistics Sweden, National Accounts). Since all other variables are available at a monthly frequency, we interpolate these measures to get monthly data. The international demand component is calculated as $\ln D_{j,t}^I = \sum_m \omega_{j,m} \ln Y_{m,t}^F$, where $\omega_{j,m}$ is the average share of industry *j*'s direct export that goes to country *m* (we use the share for 2005), and $Y_{m,t}^F$ is the monthly industrial

[9]Intermediate goods used for products that are eventually sold in the domestic market are included in the consumption and investment shares.

[10]We have input-output tables for 1995, 2000, and 2005, but the first two do not include information on where products that are used as intermediates eventually end up. However, the shares for direct use are very similar in the three tables.

production in country *m* (data from OECD, MEI). The countries included are Sweden's main trading partners.[11]

Second, we calculate an index of demand for each local labor market by weighing together the demand measures for the different industries using weights reflecting the shares of workers employed in each industry in each local labor market (using data from Statistics Sweden, the RAMS database). The demand variable for local labor market *n* is defined as $\ln D_{n,t} = \sum_j \kappa_{j,n} \ln D_{j,t}$, where $\kappa_{j,n}$ is the weight of industry *j* in local labor market *n*. We use fixed weights given by the mean of the industry structure in 1992-2008.[12]

3.1.3 Real wage cost

The real wage cost $(W_{n,t} / P_{n,t})$ is a measure of the competitiveness of the firms in a local labor market relative to their domestic and international competitors. It is defined as the nominal wage cost per hour divided by the relevant competitor price. We only construct this variable for the manufacturing industries, for two reasons. First, the only detailed wage data we have is for these industries. Second, competitiveness—as we define it—is not really a relevant concept for the other sectors. The public sector does not maximize profits and has no relevant competitor price. Many service sectors do not compete internationally. For these sectors, if we divide the wage with the competitor price, we essentially divide the wage with itself since prices in the service sector to a large extent reflect wage costs.

An industry's competitor price is calculated as a weighted average of domestic and foreign prices and is given by $\ln P^C_{j,t} = (1 - \delta_j) \ln P^D_{j,t} + \delta_j \ln P^{IC}_{j,t}$, where $P^D_{j,t}$ are domestic prices, $P^{IC}_{j,t}$ are international prices, and δ_j is the fixed export share of the industry. For domestic prices, we use industry-specific producer price indices from Statistics Sweden. For international prices, we use aggregate country-specific producer price indices from the OECD. We define the international prices as $P^{IC}_{j,t} = \sum \omega_{j,m} (\ln E_{m,t} + \ln P^F_{m,t})$, where

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[11]Sweden's main trading partners in 2010, according to Statistics Sweden, were Germany, Norway, the United Kingdom, Denmark, Finland, the US, France, the Netherlands, Belgium, Italy, and Spain. Due to lack of data, China and Poland are not included. However, these two countries have only recently become important trading partners.

[12]We get very similar results if we instead use weights for a particular year, e.g. 1992.

$w_{j,m}$ is the average share of industry *j*'s export that goes to country *m*, $E_{m,t}$ is the exchange rate between SEK and the currency in country m, and $P^F_{m,t}$ is the producer price index for country *m*.

We calculate the nominal wage and the competitor price relevant for each local labor market using the same weighting procedure as for the demand variable, i.e., using the employment shares of the industries in each local labor market. Thus, $\ln W_{n,t} = \sum_j k_{j,n} \ln W_{j,t}$ and $\ln P^C_{n,t} = \sum_j k_{j,n} \ln P^C_{j,t}$. Subtracting the logarithm of the price from the logarithm of the nominal wage, we get our measure of competitiveness, the real wage cost.

3.1.4 Employment

In Sweden, there is no official data series for local employment at a monthly frequency. However, since firms are required to report to the tax authorities which months of the year each of their employees has been employed by them, we can use this information to construct a monthly employment series for each of the local labor markets. In these calculations, we have to make some assumptions. First, in cases where workers have more than one employer the same month, we assign them to the employer from which they earn their highest income. However, this is not a big issue since most of the workers who work for several employers do this within a local labor market. Second, the default value in the employers' report to the tax authorities is twelve months of employment, and hence for workers who have only been employed for a part of the year there is a risk that some employers have not reported the actual months of employment. However, the total number of employees in Sweden in our calculation is roughly in line with official yearly employment data.

3.2 Estimation

To estimate the model, we need to consider a number of issues concerning identification and simultaneity, stationarity, and estimation method.

3.2.1 Identification and simultaneity

We estimate equation (7) on a panel of local labor markets with fixed effects for each local labor market. To identify the effects of demand and supply factors on hiring, we rely on variation across local labor markets and over time in product demand, real wage costs, and unemployment. The demand and wage cost variables differ between different local labor markets due to differences in the industry composition. The demand variable varies across industries because different industries have different shares of production going to private consumption, public consumption, and investment in domestic use, as well as different export shares. The real wage cost variable varies across industries because different industries face different wage costs and competitor prices. Unemployment varies across local labor markets.

An important issue in the estimation is simultaneity. Unobserved shocks—aggregate, industry-specific, and local—may cause biased estimates. Aggregate shocks affect the whole economy; to take such shocks into account, we include linear and quadratic time trends, and as a robustness check we also include monthly time dummies. Second, an unobserved industry-specific shock may affect not only the industry's demand and hiring, but also unemployment in local labor markets where the industry employs a large share of the workforce. To avoid simultaneity due to industry-specific shocks, we do not use industry production to construct our measure of demand. Instead, and as described above, we construct a measure of demand for each industry by weighing together international demand with the components of domestic aggregate demand using fixed weights. Then, we construct a measure of demand for each local labor market by weighing together the demand variables for the industries using data on the industry structure of the local labor markets using fixed weights. Therefore, unobserved industry-specific shocks will not affect our measure of demand.[13] For the real wage cost, industry-specific shocks may cause problems since this variable is based on industry-specific wages and prices. In particular, such shocks may have an effect if there is continuous wage bargaining at the industry level. However, in Sweden, wages are traditionally set in collective agreements that are valid for at least a year. This means that monthly wages to a large extent can be considered to be predetermined. Still, it is difficult to fully rule out the possibility that industry-specific shocks may affect this variable.[14] Third, unobserved local labor market shocks, such as changes in local taxes

[13]It should be noted that we get very similar results if we instead use industry production as a measure of product demand. This suggests that unobserved industry-specific shocks are not a major issue in the estimation.

[14]One way of mitigating this problem would be to construct the variable based only on the competitors' prices. Another way would be to use aggregate data on wages. However, a disadvantage of these

and other policies, may also cause biased estimates. The demand and real wage cost variables should not be affected by local shocks since they are not constructed using regional time series data. The demand variable is based only on aggregate and international data using fixed weights. The real wage cost variable is based only on industry-specific nominal wages and producer prices. In reality, it is possible that local shocks may affect the wages in the area. However, by construction, our real wage cost variable does not take such local effects on wages into account. Unemployment is measured at the beginning of the period, so it is predetermined relative to the shock in period *t*. However, if local shocks are serially correlated, this may still cause a simultaneity problem for this variable.[15]

3.2.2 Stationarity

An important issue in the estimation is stationarity. The plots of the product demand and real wage cost variables in Appendix C indicate that these variables may be non-stationary. If this is the case, we must take measures to handle the non-stationarity to avoid spurious regressions.

To test for stationarity, we use two tests. The first is a Fisher-type unit root test with the null hypothesis of all panels (i.e., local labor markets) containing a unit root (cf. Choi, 2001). This test conducts Dickey-Fuller unit-root tests for each panel separately, and then combines the p-values from these tests to produce an overall test statistic. The second is the Hadri LM test with the null hypothesis that all panels are stationary against the alternative hypothesis that at least one of the panels contains a unit root (cf. Hadri, 2000). Both tests indicate that some of the variables may be non-stationary.[16]

To handle this issue, we have detrended the variables for each local labor market and then performed the tests again. We find that the tests strongly suggest that the detrended

alternatives is that they remove some of the variation in the data. Yet another alternative would be to use suitably chosen lags of real wage costs as instruments for current real wage costs.

[15]A potential solution to this problem would be to instrument unemployment, for example by using lags of unemployment.

[16]For hiring, unemployment, product demand, real wage costs, and employment the Hadri LM test rejects that all panels are stationary. For product demand, real wage costs, and employment the Fisher-type unit root test also rejects that all panels have a unit root. For unemployment and hiring, this test suggests that all panels have a unit root.

variables are stationary.[17] Thus, we can use them as regressors if we include trends. For this reason, we include local linear and quadratic trends in the estimation.

3.2.3 Estimation

In the main specification, we include fixed effects for local labor markets, local time trends (linear and quadratic), and local seasonal effects. The trends are local to take into account differences in productivity growth across different industries.[18] The seasonal effects are local to take into account the fact that seasonal patterns may differ across different industries and local labor markets. To estimate the hiring equation in (7), we use a within estimator with fixed effects. The full specification is:

$$\ln H_{n,t} = a_n + b_1 \ln D_{n,t} + b_2 (\ln W_{n,t} - \ln P_{n,t}^C) + b_3 \ln U_{n,t} + b_4 N_{n,t-1} + t_n + t_n^2 + s_n + e_{n,t}. \qquad (8)$$

where t_n $(t_n{}^2)$ are linear (quadratic) local time trends and s_n are local seasonal effects.

A potential concern is autocorrelation and heteroskedasticity. A Wald test for groupwise heteroskedasticity rejects the null hypothesis of homoskedasticity, and a Wooldridge test for autocorrelation rejects the null hypothesis of no first-order autocorrelation (cf. Greene, 2003, and Wooldridge, 2002). Therefore, we cluster the standard errors at the local labor markets. This means that the standard errors of the coefficients are robust to arbitrary within-group autocorrelation and heteroskedasticity.

An important issue is if we have enough variation to estimate the effects of the variables in equation (8). To investigate this, we have run a panel regression for each right hand side variable with local labor market fixed effects, time trends, and seasonal effects as explanatory variables. The standard deviation of the residuals is 0.018 for demand, 0.039 for real wage costs, and 0.179 for unemployment. Since all variables are in logs, these numbers give the approximate percentage variation in each variable. Hence, there is economically significant variation in all the right hand side variables after elimination of fixed effects, trends, and seasons. Table A1 in Appendix D shows the correlations between this remaining variation in each of the variables. Although

[17]The p-values for all panels having a unit root are 0.0000 for all detrended variables, while the p-values for all panels being stationary are in the range of 0.65-1. We have also plotted the detrended variables and performed separate tests for some individual local labor markets, confirming that the detrended variables are stationary.

[18]Typically, an industry with rapid productivity growth, such as the IT industry, will experience falling prices, which make the real wage cost rise faster in this industry than in others.

some of the variables are correlated, they are not highly correlated. Hence, multicollinearity is not likely to be an issue in the estimation.

4 Results

To study the determinants of hiring, we estimate the specification in equation (8). Then, we consider robustness issues and whether conventional measures of vacancies are a good proxy for product demand.

4.1 Main results

Table 1 presents the results of the regressions for the panel of all local labor markets. The results show that the coefficients have the expected signs. First, product demand has a clear positive effect on hiring, implying that imperfect competition in the product market is important for hiring. When product demand increases by one percent, hiring increases by 2.7 percent. Second, the number of available unemployed workers has a positive effect on hiring, implying that search frictions are important for hiring and that supply, at least partially, creates its own demand. When the number of unemployed workers available in the beginning of the period increases by one percent, hiring increases by 0.2 percent. Third, real wage costs have the expected negative effect on hiring. When the real wage cost increases by one percent, hiring decreases by 0.6 percent. Finally, lagged employment has no significant effect on hiring. The results for product demand, unemployment, and real wage costs are all in line with the theoretical predictions, and are strongly statistically significant. These results suggest that both demand and supply factors matter for hiring.

The size of the coefficients shows that a one percent shock to product demand has an around 13 times larger effect on hiring than a one percent shock to unemployment. However, in economic terms the size of the effects also depends on the size of a typical shock to product demand or unemployment. To illustrate this, we can compare the effect of a one standard deviation shock to each of these two variables. The standard deviation of the product demand and unemployment variables is 0.13 and 0.36, respectively (variation in log variables after removing fixed effects for the local labor markets). Hence, the effect of a one standard deviation shock to product demand and unemployment is 0.35 and 0.08, respectively. This suggests that product demand is more important than unemployment for understanding the variation in hiring. For real wage costs, the corresponding effect is 0.04 (standard deviation 0.07), i.e., it seems to be the least important factor for understanding the variation in hiring 1992-2008.

Table 1. Explaining hiring in local labor markets in Sweden 1992-2008

Product demand	2.684***
	(0.222)
Real wage cost	-0.628***
	(0.106)
Unemployment	0.229***
	(0.027)
Lag of employment	0.064
	(0.238)
Observations	22,127
Number of llm	109
R^2 (within)	0.638

Notes: Robust standard errors are in parentheses, clustered at the local labor markets (llm). ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively. All variables are logarithms. Fixed effects for local labor markets, local linear and quadratic time trends, and local seasonal dummies are included in the regression. The dependent variable is monthly hiring of unemployed workers registered at the Public Employment Service within each local labor market.

How do these results compare to the results in previous studies? Comparing our results to Carlsson, Eriksson, and Gottfries (2013), both studies find strong effects on hiring of product demand and real wage costs. Hence these results seem to hold both for yearly net employment change in the manufacturing sector in the 1990s and for monthly hiring in all sectors of the economy in the 1990s and early 2000s. A major difference is that we find a statistically significant positive effect of unemployment. One way to analyze this difference further would be to estimate our model on the same time period as they do and only consider the manufacturing sector. Our data do not allow us to distinguish between hiring in different sectors. However, if we do the estimation for a similar time period (i.e. 1992-2000), unemployment is no longer statistically significant.[19] This can be interpreted as an indication that changes in the availability of unemployed workers matters less in periods of high unemployment (which was the case in Sweden in the 1990s). This is related to the finding in Michaillat (2012) that search frictions are less important in recessions.

[19]These results are available on request.

4.2 Robustness

To investigate whether our results are robust, we have performed a number of robustness checks. Some of the results are presented in Table 2.

Table 2. Explaining hiring in local labor markets in Sweden 1992-2008, robustness

	Baseline	(1) With time dummies	(2) Common trends and season	(3) Outflow of vacancies as dep. var.	(4) Estimated in differences
Product demand	2.684***	2.814	2.013***	6.199***	3.518***
	(0.222)	(2.019)	(0.301)	(0.345)	(0.402)
Real wage cost	-0.628***	0.365	-0.312**	-2.463***	-1.015***
	(0.106)	(0.228)	(0.130)	(0.157)	(0.213)
Unemployment	0.229***	0.141***	0.242***	-0.042	0.953***
	(0.027)	(0.043)	(0.031)	(0.033)	(0.048)
Lag of employment	0.064	-0.280	-0.099	-0.392	-0.039
	(0.238)	(0.230)	(0.152)	(0.260)	(0.346)
Observations	22,127	22,127	22,127	22,120	22,018
Number of llm	109	109	109	109	109
R^2 (within)	0.638	0.711	0.448	0.492	0.666

Notes: Robust standard errors are in parentheses, clustered at the local labor markets (llm). ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively. All variables are logarithms. Fixed effects for local labor markets, local linear and quadratic (except in column 4) time trends, and local seasonal dummies are included in all regressions, except for column 2 where the trends and seasonal effects are common and not local. In all columns except column 3, the dependent variable is monthly hiring of unemployed workers registered at the Public Employment Service within each local labor market. In column 3, the dependent variable is the outflow of vacancies registered at the Public Employment Service within each local labor market.

A first concern is that shocks to the whole economy may affect the results. In the main specification, we include a number of time controls (local linear and quadratic time trends and seasonal effects), but it may be that these variables do not fully pick up all aggregate shocks. Therefore, an important robustness check is to include monthly time dummies. However, a problem with including such time dummies is that most of the variation in product demand and real wage costs is common to all local labor markets and, therefore, is picked up by these monthly time dummies.[20] Hence, it may be difficult to identify the effects on hiring of product demand and real wage costs in regressions with monthly time dummies. Column 1 in Table 2 shows that the point estimate for

[20]For unemployment, real wage costs, and product demand, 85, 82, and 99.6 percent of the variation is explained by the time dummies and fixed effects for llm. The standard deviation of the remaining variation is 0.14 for unemployment, 0.03 for real wage costs, and 0.009 for product demand (all variables are in logs).

product market demand is very similar to the corresponding estimate in the baseline regression, but is no longer statistically significant. With monthly time dummies, the standard error is substantially increased in size, suggesting a much less precise estimate. In contrast, the positive effect of unemployment remains statistically significant, although reduced in size. Real wage costs are no longer statistically significant, and the sign of the estimate is reversed. This may indicate that our wage measure is an imperfect proxy for the relevant real wage costs. Lagged employment remains statistically insignificant. It is also worth noting that we get very similar results as in the baseline regression if we use common rather than local time trends and seasonal effects, see column 2 in Table 2.

A second concern is that our measure of hiring may be inaccurate. In particular, the fact that we do not include on-the-job search may cause problems. Our dependent variable measures hiring of unemployed workers, which is only a share of total hiring. This could result in a too small coefficient for product demand since vacancies opened due to increased demand may be filled with on-the-job searchers. That on-the-job search is not included as an explanatory variable essentially means that we treat it as a constant. However, in reality on-the job-search is probably procyclical since the incentives to search is stronger in booms when there are many job opportunities. Petrongolo and Pissarides (2001) show that regressions of standard matching functions with hiring from unemployment as the dependent variable that omit on-the-job search as an explanatory variable will get a too big coefficient for unemployment if on-the-job search is procyclical. A similar argument applies to our baseline regression: When unemployment is high, on-the-job search is probably less common, which means less competition for unemployed workers searching for jobs. Less on-the-job search is thus expected to increase hiring from unemployment (which is our dependent variable), but this does not mean that total hiring will increase.

We cannot directly test this issue since there are no time series data for on-the-job search. However, we have considered some alternative measures of hiring. Most importantly, we use the outflow of vacancies rather than the outflow of unemployed workers. The outflow of vacancies measures the number of vacancies deregistered at the Employment Service. It is defined as the stock of vacancies at the beginning of the month plus the inflow of new vacancies during the month minus the stock of vacancies registered at the beginning of next month.[21] In column 3 in Table 2, we report the results when we use this variable as the dependent variable. The results show that the positive effect of product demand remains statistically significant. Compared to the baseline regression, the point estimate is substantially bigger. This seems reasonable since this measure includes hiring of on-the-job searchers, and hence is expected to vary more with the business cycle. The negative effect of real wage costs also remains statistically significant. In contrast, unemployment no longer has a statistically significant effect on hiring. One reason for the absence of a positive effect of the number of unemployed workers may be that we do not include on-the-job search as an explanatory variable. A smaller coefficient for the number of unemployed than in the baseline regression is expected since the unemployed workers are always only a share of all job searchers filling vacancies. But furthermore, if on-the-job search is not constant but procyclical, the omission of this variable in the estimation will result in a too small coefficient for unemployment when the dependent variable in the outflow of vacancies: When unemployment is high, on-the-job search is probably less important and this will have a negative impact on the outflow of vacancies which counteracts the positive effect of more unemployed workers available. Thus, the bias due to procyclical on-the-job search goes in the opposite direction compared to the baseline regression where the dependent variable is the outflow of unemployed and the coefficient for the number of unemployed is probably too big. The estimation results using the outflow of vacancies as a measure of hiring strengthen the conclusion that the product demand effect is more important than the effect of the number of unemployed.

Another alternative measure of hiring is net employment change. However, if we use this variable, the number of observations is greatly diminished since for each period only local labor markets with a positive employment change can be included in the estimation. Using this variable as the dependent variable, we find that the effects of product demand, real wage costs, and unemployment remain similar to the baseline specification.[22]

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[21] A disadvantage of this measure is that, in some cases, a vacancy may be withdrawn even if no worker has been hired. However, according to surveys conducted by Employment Service, around 80 percent of the employers who have posted a vacancy report that they have hired a worker.

[22] These results are available on request.

A third concern has to do with the nature of the shocks. In the specifications that we have estimated so far, we include a deterministic trend to take into account shocks to productivity. However, an alternative is to think of the productivity trend as stochastic and estimate the model in differences. Column 4 in Table 2 shows that the results of estimating the model in first differences are similar to the results in the baseline regression: The coefficients for product demand, unemployment, and real wage costs all have the expected sign and are all statistically significant.

A fourth concern has to do with the variable for lagged employment. Essentially there are two potential problems with this variable. First, as explained above, it may contain measurement errors. Second, the relationship between employment and unemployment in a local labor market may make it difficult to separate the effects of employment in the previous period and unemployment at the start of the current period. Hence, it may be problematic to include both variables in the estimation. To investigate if this may affect the results, we can eliminate lagged employment in equation (6) by using the definition of hiring (i.e. $H_{n,t} = N_{n,t} - (1-\lambda)N_{n,t-1}$).[23] Then, it can be shown that (see Appendix A for the derivation):

$$\begin{aligned}\hat{h}_{n,t} = {} & \zeta_0 + \zeta_1\hat{d}_{n,t} - \zeta_2\hat{w}_{n,t} + \zeta_3\hat{u}_{n,t} - (1-\lambda)\left(\zeta_1\hat{d}_{n,t-1} - \zeta_2\hat{w}_{n,t-1} + \zeta_3\hat{u}_{n,t-1}\right) + \\ & \zeta_4\hat{h}_{n,t-1} + \zeta_5\varepsilon_{n,t} - (1-\lambda)\zeta_5\varepsilon_{n,t-1},\end{aligned} \tag{9}$$

where ζ_0, ζ_1, ζ_2, ζ_3, ζ_4 and ζ_5 are positive constants. Hiring depends on the current and lagged values of demand, competitiveness (wages in relation to the competitors' prices), and unemployment. In most labor markets, the monthly rate of separations is rather low, so $(1-\lambda)$ is close to unity. Hence, what matters for hiring are essentially the changes in demand, wages, and unemployment. Also, hiring in the previous period enters the equation. In our model, we expect this effect to be positive; if hiring was high in period *t-1* (for given values of the other variables), this means that the firm entered period *t-1* with too few workers and thus needed to hire, but since hiring costs are quadratic, the firm did not hire all the workers it needed within the period. Therefore,

[23] An alternative way to eliminate lagged employment is to simply omit it from the specification, i.e. essentially assume that the size of the labor force is fixed. Using this method, we get very similar results as in the baseline regression.

high hiring in period *t-1* is an indication that there is still a need to hire workers in period *t*. From equation (9), we get the following empirical specification:

$$\begin{aligned} \ln H_{n,t} &= \gamma_n + \gamma_1 \ln D_{n,t} + \gamma_2 (\ln W_{n,t} - \ln P_{n,t}^C) + \gamma_3 \ln U_{n,t} \\ &+ \gamma_4 \ln D_{n,t-1} + \gamma_5 (\ln W_{n,t-1} - \ln P_{n,t-1}^C) + \gamma_6 \ln U_{n,t-1} + \gamma_7 \ln H_{n,t-1} + \\ &+ \tau_n + \tau_n^2 + s_n + \varepsilon_{n,t}, \end{aligned} \tag{10}$$

where we expect $\gamma_1 > 0$, $\gamma_2 < 0$, $\gamma_3 > 0$, $\gamma_4 < 0$, $\gamma_5 > 0$, $\gamma_6 < 0$, and $\gamma_7 > 0$. An additional advantage of this specification is that it allows for more dynamics than the baseline specification. To estimate this specification, we must take into account that $H_{n,t-1}$ is, by definition, correlated with the error term. Therefore, we must use suitable instruments for $H_{n,t-1}$. In the estimation, we use lags of hiring and the other explanatory variables (which are assumed to be exogenous) as instruments. In Table A2 in Appendix D, we report the results of this estimation. Again, the results are similar to the baseline regression: Product demand, unemployment, and real wage costs all have effects in the expected direction.

A final issue is that the results may differ across local labor markets. Table A3 in Appendix D shows the results for each of the five largest local labor markets in Sweden estimated separately. An obvious disadvantage with these regressions is that the sample size is substantially reduced. Most of the results for the individual local labor markets are qualitatively similar to the baseline results: The coefficients tend to have the right sign, but the size of the coefficients vary.

Overall, the robustness analysis suggests that our main results are rather robust. However, it should be noted that the statistical significance of the effect of product demand and real wage costs are not robust to removing all common variation by, in addition to the local linear and quadratic time trends and local seasonal effects, including monthly time dummies in the regression. Moreover, the effect of the number of unemployed workers in the baseline regression is probably too big due to procyclical on-the-job search.

4.3 Vacancies as a proxy for product demand

The results in Table 1 show that the product demand variable helps to explain hiring, suggesting that imperfect competition in the product market is important for hiring.

However, it may be argued that an alternative way of capturing the effects of product demand would be to include a measure of vacancies in the model since vacancies is a measure of labor demand and hence should reflect product demand. This is similar in spirit to estimating a standard matching function.[24] To investigate this, we use data for vacancies reported to the Employment Service.[25] Since many vacancies are rather short-lived, we construct our vacancy measure as the stock of vacancies at the beginning of the period plus half of the inflow of new vacancies during the period.[26]

In Table 3, we show the results of estimating specifications with vacancies included. In column 1, we include both product demand and vacancies in the same regression. The results show that both variables are statistically and economically significant, but the size of the product demand estimate is reduced. This is hardly surprising since we expect product demand and vacancies to be related. However, the fact that our measure of product demand remains statistically significant when we include vacancies suggests that conventional measures of vacancies, which are typically used to estimate matching functions, may not capture all aspects of product demand. Rather surprisingly, the correlation between our product demand and vacancy variables is only 0.27 (taking into account fixed effects, time trends, and seasons; see Table A1). The other estimates are very similar to the baseline regression. Column 2 shows that this is also true if we exclude our measure of product demand. Overall, these results suggest that vacancies are a rather imperfect proxy of product demand.

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[24]We have estimated a standard matching function including all local time controls, and find rather reasonable coefficients for unemployment (0.18) and vacancies (0.13).

[25]A well-known problem is that many vacancies are not reported to the Employment Service. Around 40 percent of all hires are connected to a vacancy reported to the Employment Service according to their own estimates (see e.g. Arbetsmarknadsrapport 2007:1). However, this is the only available time series for vacancies that covers the entire time period under consideration.

[26]This is a common way to handle this issue (cf. Petrongolo and Pissarides, 2001). This variable is illustrated in Figure A 6 in Appendix.

Table 3. Explaining hiring in local labor markets in Sweden 1992-2008, including vacancies

	Baseline	(1)	(2)
Product demand	2.684***	1.832***	-
	(0.222)	(0.239)	
Vacancies	-	0.111***	0.129***
		(0.008)	(0.008)
Real wage cost	-0.628***	-0.379***	-0.193**
	(0.106)	(0.101)	(0.097)
Unemployment	0.229***	0.241***	0.187***
	(0.027)	(0.027)	(0.025)
Lag of employment	0.064	0.111	0.332
	(0.238)	(0.244)	(0.236)
Observations	22,127	22,127	22,127
Number of llm	109	109	109
R^2 (within)	0.638	0.648	0.645

Notes: Robust standard errors are in parentheses, clustered at the local labor markets (llm). ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively. All variables are logarithms. Fixed effects for local labor markets, local linear and quadratic time trends, and local seasonal dummies are included in all regressions. The dependent variable is hiring of unemployed workers registered at the Public Employment Service within each local labor market.

5 Concluding remarks

Most studies of labor market dynamics rely on some variant of search-matching theory. In these models, labor market frictions are emphasized, while the product market is typically assumed to be perfectly competitive. However, most actual firms sell their products in markets that seem to be characterized by imperfect competition. This suggests that product demand should also be important for hiring.

In this paper, we study the relative importance of demand and supply factors by estimating equations for hiring in local labor markets. In the regressions, we include measures of the product demand conditions facing the firms, the firms' wage costs relative to their competitors' prices, and the number of unemployed workers available. Our main finding is that product demand has a positive effect on hiring in most of the specifications, suggesting that imperfect competition in the product market is important for hiring. We also find that the number of unemployed workers at the beginning of the period has a positive effect on hiring, suggesting that labor supply, at least partially, seems to create its own demand. Quantitatively, product demand seems to be more important than the number of unemployed workers. Real wage costs have a negative impact on hiring, but this effect seems less important quantitatively. Finally, we find that that a conventional measure of vacancies is a rather imperfect proxy of product demand.

Our empirical results suggest that both demand and supply factors are important for hiring. Comparing our study to the existing literature, our results extend the results in Carlsson, Eriksson, and Gottfries (2013). They find that product demand is important for firm-level net employment change in the 1990s. We find that this result holds for hiring in all sectors of the economy at the local labor market level in the 1990s and the early 2000s. In contrast to their results, we also find that the availability of unemployed workers matters. This difference is probably explained mainly by the fact that we consider a period of both high (the 1990s) and low (the early 2000s) unemployment. When we only include the 1990s in the estimation, the unemployment effect is no longer significantly different from zero. This result can be interpreted as an indication that changes in the availability of unemployed workers are more important when unemployment is low than when unemployment is high, which is related to the finding in Michaillat (2012) that search frictions are less important in a recession.

In terms of policy, our results have implications for, e.g., the effectiveness of countercyclical fiscal- and monetary policy, which essentially depends on changes in product demand effecting employment and production.

Taken together, our results suggest that future studies of employment dynamics and hiring should explicitly take into account both imperfect competition in the product market and labor market frictions. If this is not done, there is a risk that the analyses do not capture important aspects of the dynamics of real-world labor markets.

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Appendix

Appendix A: Derivations of some key equations

Net employment change and hiring at the firm level

Inserting the constraints, we get the following maximization problem:

$$\max \ \mathrm{E}_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} \left\{ \left[\left(\frac{N_{i,t}}{D^s_{i,t}} \right)^{-1/\eta} - \frac{W_{i,t}}{P^C_{i,t}} \right] N_{i,t} - \frac{c_H}{2} \frac{\left(N_{i,t} - (1-\delta)N_{i,t-1}\right)^2}{N_{i,t-1}} - c_V \frac{N_{i,t} - (1-\delta)N_{i,t-1}}{Q_{n,t}} \right\}$$

Taking the first-order condition with respect to $N_{i,t}$ we get:

$$\mathrm{E}_t \left\{ \frac{\eta-1}{\eta} \left(\frac{D^s_{i,t}}{N_{i,t}} \right)^{1/\eta} - \frac{W_{i,t}}{P^C_{i,t}} - c_H \left(N_{i,t} - (1-\delta)N_{i,t-1} \right) N^{-1}_{i,t-1} - \frac{c_V}{Q_{n,t}} \right.$$

$$\left. + \beta c_H \left(N_{i,t+1} - (1-\delta)N_{i,t} \right)(1-\delta)N^{-1}_{i,t} + \beta \frac{c_H}{2} \left(N_{i,t+1} - (1-\delta)N_{i,t} \right)^2 N^{-2}_{i,t} + \beta(1-\delta)\frac{c_V}{Q_{n,t+1}} \right\} = 0$$

Log-linearizing, we get:

$$\mathrm{E}_t \left\{ \sigma \frac{\eta-1}{\eta^2} \frac{P}{P^c} \hat{d}_{i,t} - \frac{\eta-1}{\eta^2} \frac{P}{P^c} \hat{n}_{i,t} - \frac{W}{P^C} \hat{w}_{i,t} - (1+\beta) c_H \hat{n}_{i,t} + c_H \hat{n}_{i,t-1} + \frac{c_V}{Q} \hat{q}_{n,t} \right.$$

$$\left. + \beta c_H \hat{n}_{i,t+1} - \beta(1-\delta) \frac{c_V}{Q} \hat{q}_{n,t+1} \right\} = 0$$

This can be rewritten as:

$$\beta \hat{n}_{i,t+1} - \phi \hat{n}_{i,t} + \hat{n}_{i,t-1} = -\frac{1}{c_H} \left[\sigma \frac{\eta-1}{\eta^2} \frac{P}{P^C} \hat{d}_{i,t} - \frac{W}{P^C} \hat{w}_{i,t} + \frac{c_V}{Q} \hat{q}_{n,t} - \frac{\beta c_V (1-\delta)}{Q} \hat{q}_{n,t+1} \right],$$

where $\phi = \frac{\eta-1}{\eta^2} \frac{P}{P^C} \frac{1}{c_H} + 1 + \beta$, or using lag operators:

$$\beta \left[1 - \frac{\phi}{\beta} L + \frac{1}{\beta} L^2 \right] \hat{n}_{i,t+1} = -\frac{1}{c_H} \left[\sigma \frac{\eta-1}{\eta^2} \frac{P}{P^C} \hat{d}_{i,t} - \frac{W}{P^C} \hat{w}_{i,t} + \frac{c_V}{Q} \left(\hat{q}_{n,t} - \beta(1-\delta)\hat{q}_{n,t+1} \right) \right]$$

Factorizing the left hand side and solving for $\hat{n}_{i,t+1}$ we get:

$$\hat{n}_{i,t+1} = \kappa_1 \hat{n}_{i,t} + \frac{\kappa_1}{c_H} \sum_{j=0}^{\infty} \left(\frac{1}{\kappa_2} \right)^j \left[\sigma \frac{\eta-1}{\eta^2} \frac{P}{P^C} \hat{d}_{i,t+1+j} - \frac{W}{P^C} \hat{w}_{i,t+1+j} + \frac{c_V}{Q} \left(\hat{q}_{n,t+1+j} - \beta(1-\delta)\hat{q}_{n,t+2+j} \right) \right],$$

where $\kappa = \frac{\phi}{2\beta} \pm \sqrt{\frac{\phi^2}{4\beta^2} - \frac{1}{\beta}}$. Substituting back into the Euler equation, the same equation holds for period *t*. The solution can be rewritten as:

$$\hat{n}_{i,t} = \kappa_1 \hat{n}_{i,t-1} + \frac{\kappa_1}{c_H} \sum_{j=0}^{\infty} \left\{ \left(\frac{1}{\kappa_2}\right)^{j} \left(\sigma \frac{\eta - 1}{\eta^2} \frac{P}{P^C} \hat{d}_{i,t+j} - \frac{W}{P^C} \hat{w}_{i,t+j} \right) \right\}$$

$$+ \frac{\kappa_1 c_V}{c_H Q} \hat{q}_{n,t} - \frac{\kappa_1 c_V}{c_H Q} \left(\beta(1-\lambda) - \frac{1}{\kappa_2} \right) \sum_{j=1}^{\infty} \left(\frac{1}{\kappa_2}\right)^{t+j-1} \hat{q}_{n,t+j}$$

Using $\hat{q}_{n,t} = \alpha_u \hat{u}_{n,t} - (1-\alpha_v)\hat{v}_{n,t}$ and $1/\kappa_2 = \beta\kappa_1$, and setting $t + j = \tau$ we get:

$$\hat{n}_{i,t} = \kappa_1 \hat{n}_{i,t-1} + \frac{\kappa_1}{c_H} \mathrm{E}_t \left\{ \sum_{\tau=t}^{\infty} \left(\frac{1}{\kappa_2}\right)^{\tau - t} \left(\sigma \frac{\eta - 1}{\eta^2} \frac{P}{P^C} \hat{d}_{i,\tau} - \frac{W}{P^C} \hat{w}_{i,\tau} \right) + \frac{c_V}{Q} \left[\alpha_u \hat{u}_{n,\tau} - (1-\alpha_v) \hat{v}_{n,\tau} \right] \right.$$

$$\left. - \beta \frac{c_V}{Q} (1 - \lambda - \kappa_1) \sum_{\tau=t+1}^{\infty} \left(\frac{1}{\kappa_2}\right)^{\tau - t - 1} \left[\alpha_u \hat{u}_{n,\tau} - (1-\alpha_v) \hat{v}_{n,\tau} \right] \right\} \tag{A1}$$

Hiring in each firm is given by $H_{i,t} = N_{i,t} - (1-\lambda) N_{i,t-1}$ (or log-linearized $\hat{h}_{i,t} = \frac{N}{H}[\hat{n}_{i,t} - (1-\lambda)\hat{n}_{i,t-1}]$) so equation (A1) can be written as:

$$\hat{h}_{i,t} = \frac{N}{H} \Big[\frac{\kappa_1}{c_H} \mathrm{E}_t \left\{ \sum_{\tau=t}^{\infty} \left(\frac{1}{\kappa_2}\right)^{\tau - t} \left(\sigma \frac{\eta - 1}{\eta^2} \frac{P}{P^C} \hat{d}_{i,\tau} - \frac{W}{P^C} \hat{w}_{n,\tau} \right) + \frac{c_V}{Q} \left[\alpha_u \hat{u}_{n,\tau} - (1-\alpha_v) \hat{v}_{n,\tau} \right] \right.$$

$$\left. - \beta \frac{c_V}{Q} (1 - \lambda - \kappa_1) \sum_{\tau=t+1}^{\infty} \left(\frac{1}{\kappa_2}\right)^{\tau - t - 1} \left[\alpha_u \hat{u}_{n,\tau} - (1-\alpha_v) \hat{v}_{n,\tau} \right] \right\} - (1 - \lambda - \kappa_1) \hat{n}_{i,t-1}, \Big] \tag{A2}$$

Substituting for lagged employment

The definition of hiring and the hiring equation:

$$H_{n,t} = N_{n,t} - (1-\lambda) N_{n,t-1} \text{ (or log-linearized } \hat{h}_{n,t} = \frac{N}{H} \hat{n}_{n,t} - (1-\lambda) \frac{N}{H} \hat{n}_{n,t-1}), \tag{A3}$$

$$\hat{n}_{n,t} = \hat{x}_{n,t} + \kappa_1 \hat{n}_{n,t-1} + \varepsilon_{n,t}, \tag{A4}$$

where $\hat{x}_{n,t}$ comprises all the other terms in the local labor market version of the employment equation in (A1).

Combining (A3) and (A4):

$$\hat{h}_{n,t} = \frac{N}{H} \left(\hat{x}_{n,t} - (1 - \lambda - \kappa_1) \hat{n}_{n,t-1} + \varepsilon_{n,t} \right) \tag{A5}$$

Using the definition of $\hat{n}_{t-1}$ in equation (A4):

$$\hat{h}_{n,t} = \frac{N}{H} \left(\hat{x}_{n,t} - (1 - \lambda - \kappa_1)(\hat{x}_{n,t-1} + \varepsilon_{n,t-1}) - \kappa_1 (1 - \lambda - \kappa_1) \hat{n}_{n,t-2} + \varepsilon_{n,t} \right) \tag{A6}$$

Using the lagged version of (A5) to eliminate $\hat{n}_{n,t-2}$ in (A6):

$$\hat{h}_{n,t} = \frac{N}{H}\left(\hat{x}_{n,t} - (1-\lambda-\kappa_1)(\hat{x}_{n,t-1} + \varepsilon_{n,t-1}) - \kappa_1 (x_{n,t-1} + \varepsilon_{n,t-1} - \frac{H}{N}\hat{h}_{n,t-1}) + \varepsilon_{n,t} \right)$$

Simplifying:

$$\hat{h}_{n,t} = \frac{N}{H}\left(\hat{x}_{n,t} - (1-\lambda)\hat{x}_{n,t-1} \right) - \kappa_1 \hat{h}_{n,t-1} + \frac{N}{H}\left(\varepsilon_{n,t} - (1-\lambda)\varepsilon_{n,t-1} \right) \qquad \text{(A7)}$$

Appendix B: Local labor markets and industries

Local labor markets (1993 definition; Statistics Sweden)

1	Stockholm	38	Göteborg (Gothenburg)	75	Hofors
2	Uppsala	39	Lysekil	76	Ljusdal
3	Nyköping	40	Uddevalla	77	Gävle
4	Katrineholm	41	Strömstad	78	Söderhamn
5	Eskilstuna	42	Bengtsfors	79	Bollnäs
6	Linköping	43	Trollhättan	80	Hudiksvall
7	Norrköping	44	Borås	81	Ånge
8	Gnosjö	45	Gullspång	82	Härnösand
9	Gislaved	46	Mariestad	83	Sundsvall
10	Jönköping	47	Lidköping	84	Kramfors
11	Nässjö	48	Skövde	85	Sollefteå
12	Värnamo	49	Tidaholm	86	Örnsköldsvik
13	Sävsjö	50	Torsby	87	Strömsund
14	Vetlanda	51	Munkfors	88	Åre
15	Eksjö	52	Årjäng	89	Härjedalen
16	Tranås	53	Sunne	90	Östersund
17	Älmhult	54	Karlstad	91	Storuman
18	Markaryd	55	Kristinehamn	92	Sorsele
19	Växjö	56	Filipstad	93	Dorotea
20	Ljungby	57	Hagfors	94	Vilhelmina
21	Hultsfred	58	Arvika	95	Åsele
22	Emmaboda	59	Säffle	96	Umeå
23	Kalmar	60	Laxå	97	Lycksele
24	Oskarshamn	61	Hällefors	98	Skellefteå
25	Västervik	62	Örebro	99	Arvidsjaur
26	Vimmerby	63	Karlskoga	100	Arjeplog
27	Gotland	64	Västerås	101	Jokkmokk
28	Olofström	65	Fagersta	102	Överkalix
29	Karlskrona	66	Köping	103	Kalix
30	Karlshamn	67	Vansbro	104	Övertorneå
31	Kristianstad	68	Malung	105	Pajala
32	Malmö	69	Älvdalen	106	Gällivare
33	Helsingborg	70	Mora	107	Luleå
34	Hylte	71	Falun	108	Haparanda
35	Halmstad	72	Hedemora	109	Kiruna
36	Falkenberg	73	Avesta		
37	Varberg	74	Ludvika		

Industries (SNI92; Statistics Sweden)

1	Products of agriculture, hunting, and related services
2	Products of forestry, logging, and related services
5	Fish and other fishing products; services incidental of fishing
10	Coal and lignite; peat
11	Crude petroleum and natural gas; services incidental to oil and gas extraction excluding surveying
12	Uranium and thorium ores
13	Metal ores
14	Other mining and quarrying products
15	Food products and beverages
16	Tobacco products

Industries (SNI92; Statistics Sweden)

17	Textiles
18	Wearing apparel; furs
19	Leather and leather products
20	Wood and products of wood and cork (except furniture); articles of straw and plaiting materials
21	Pulp, paper, and paper products
22	Printed matter and recorded media
23	Coke, refined petroleum products, and nuclear fuels
24	Chemicals, chemical products, and man-made fibers
25	Rubber and plastic products
26	Other non-metallic mineral products
27	Basic metals
28	Fabricated metal products, except machinery and equipment
29	Machinery and equipment n.e.c.
30	Office machinery and computers
31	Electrical machinery and apparatus n.e.c.
32	Radio, television, and communication equipment and apparatus
33	Medical, precision and optical instruments, watches, and clocks
34	Motor vehicles, trailers, and semi-trailers
35	Other transport equipment
36	Furniture; other manufactured goods n.e.c.
37	Secondary raw materials
40	Electrical energy, gas, steam and hot water
41	Collected and purified water, distribution services of water
45	Construction work
50-52	Trade, maintenance, and repair services of motor vehicles and motorcycles; retail sale of automotive fuel (50). Wholesale trade and commission trade services (51). Retail trade services, repair services of personal and household goods (52)
55	Hotel and restaurant services
60	Land transport; transport via pipeline services
61	Water transport services
62	Air transport services
63	Supporting and auxiliary transport services; travel agency services
64	Post and telecommunication services
65	Financial intermediation services, except insurance and pension funding services
66	Insurance and pension funding services, except compulsory social security services
67	Services auxiliary to financial intermediation
70	Real estate services
71	Renting services of machinery and equipment without operator and of personal and household goods
72	Computer and related services
73	Research and development services
74	Other business services
75	Public administration and defense services; compulsory social security services
80	Education services
85	Health and social work services
90	Sewage and refuse disposal services, sanitation, and similar services
91	Membership organization services n.e.c.
92	Recreational, cultural and sporting services
93	Other services
95	Private households with employed persons

Appendix C: Illustrations of the variables for some local labor markets

Figure A1: Hiring

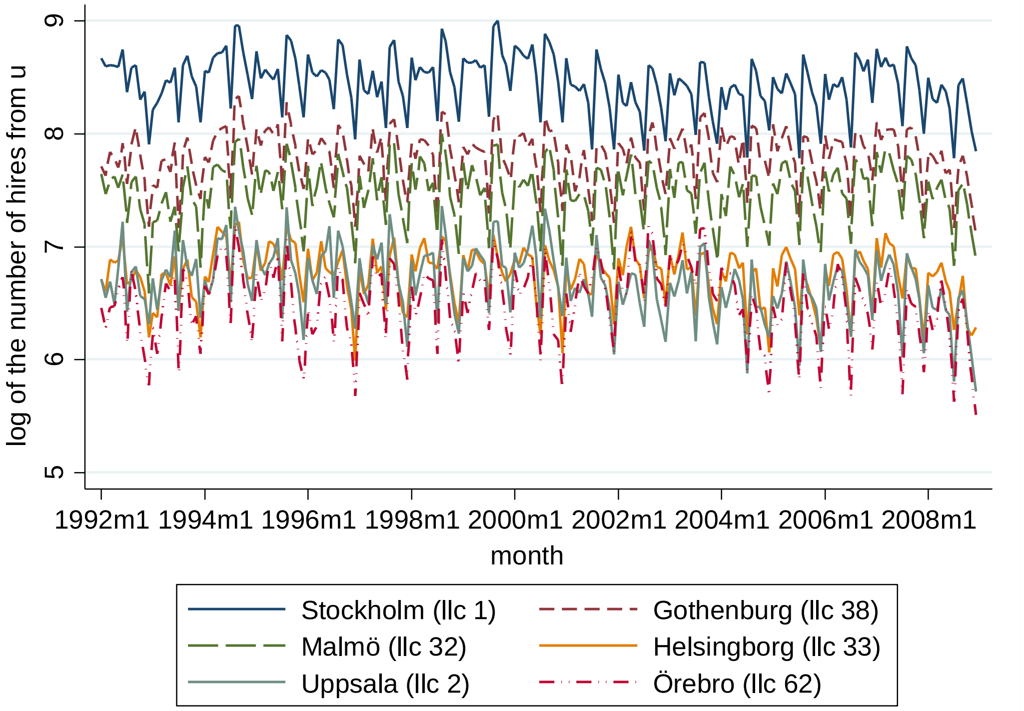


Figure A2: Product demand

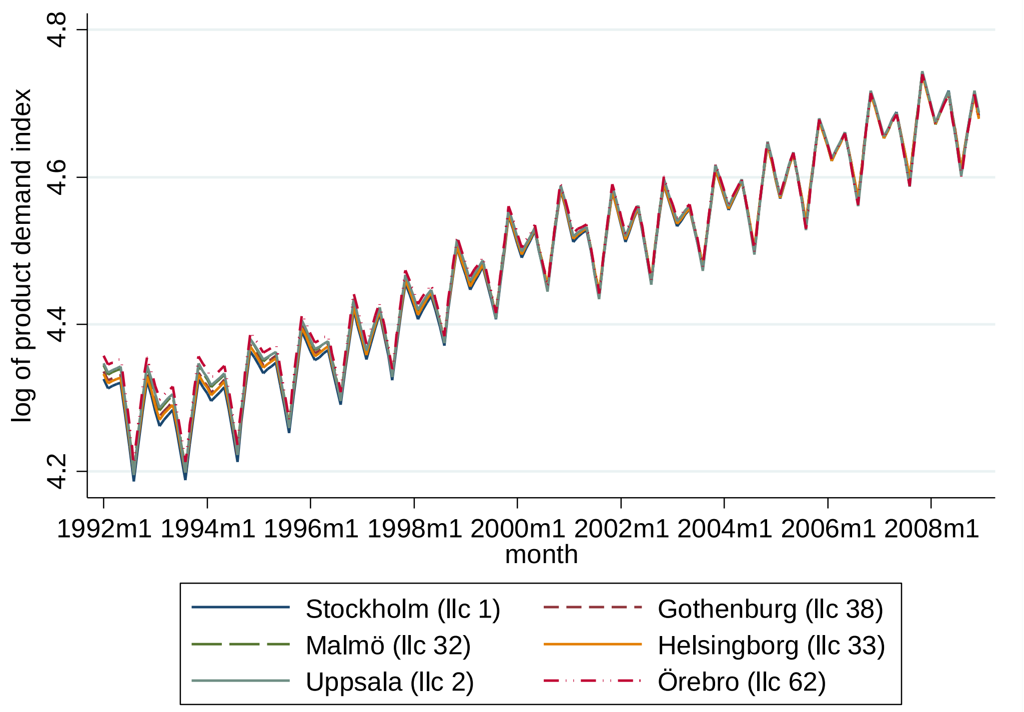


Figure A3: Real wage costs

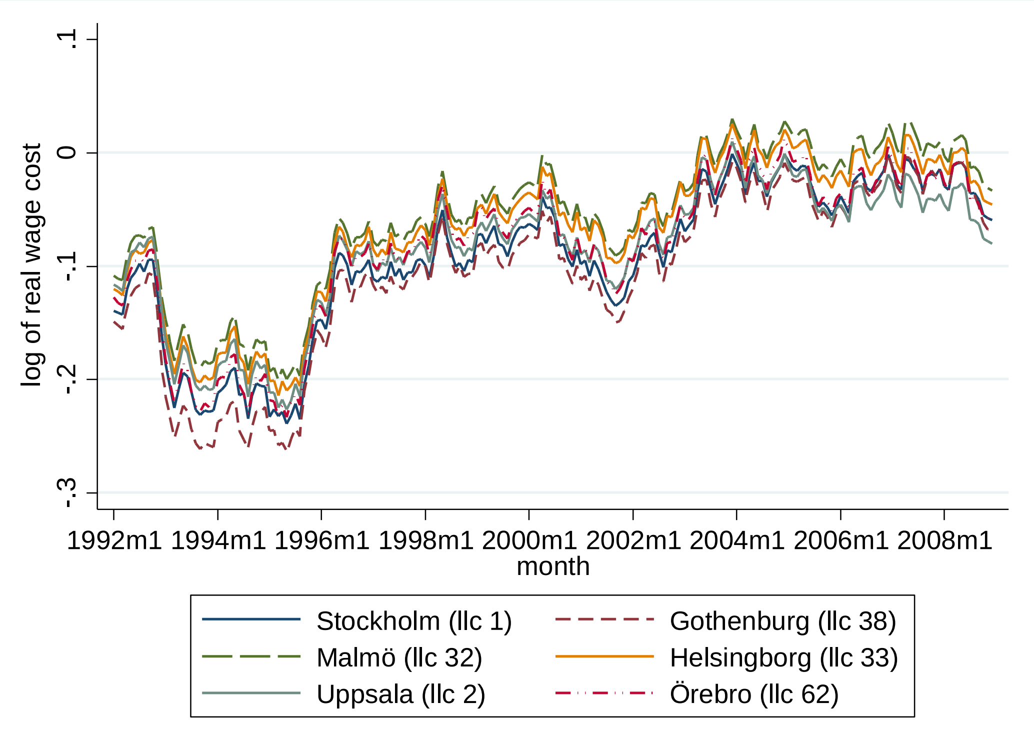


Figure A4: Unemployment

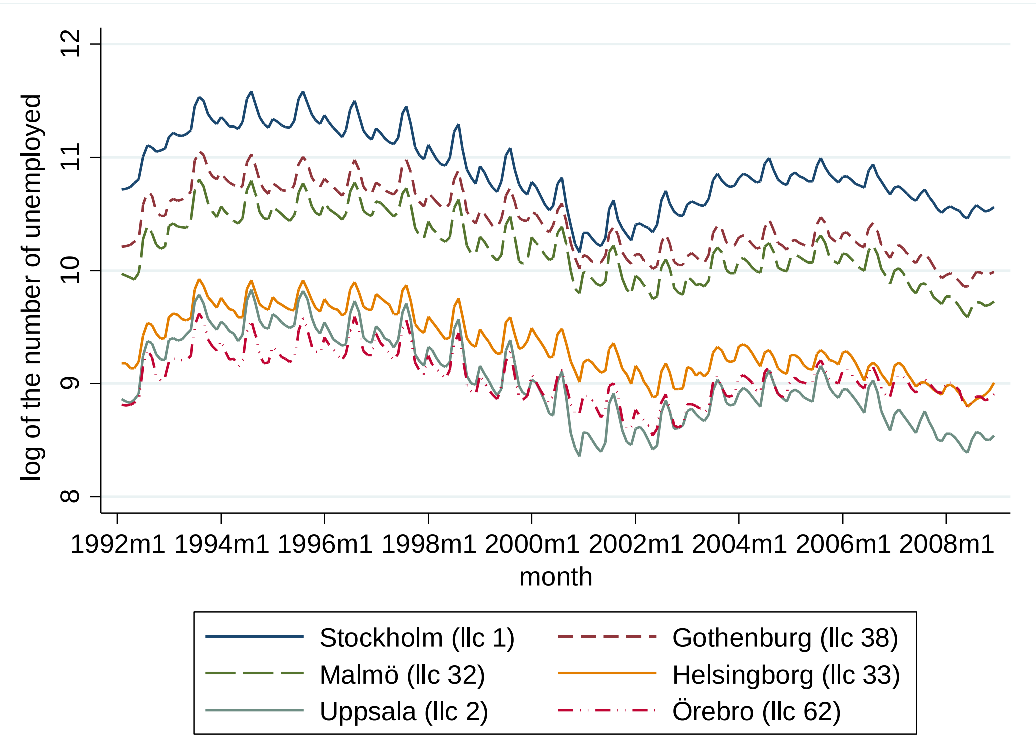


Figure A5: Employment

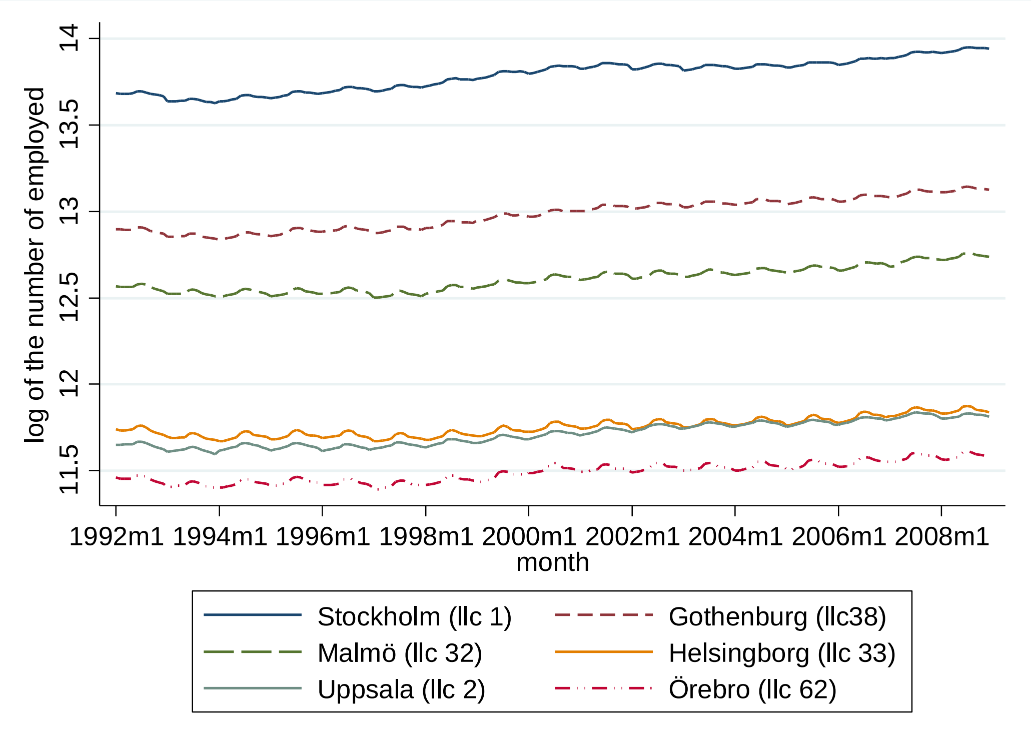
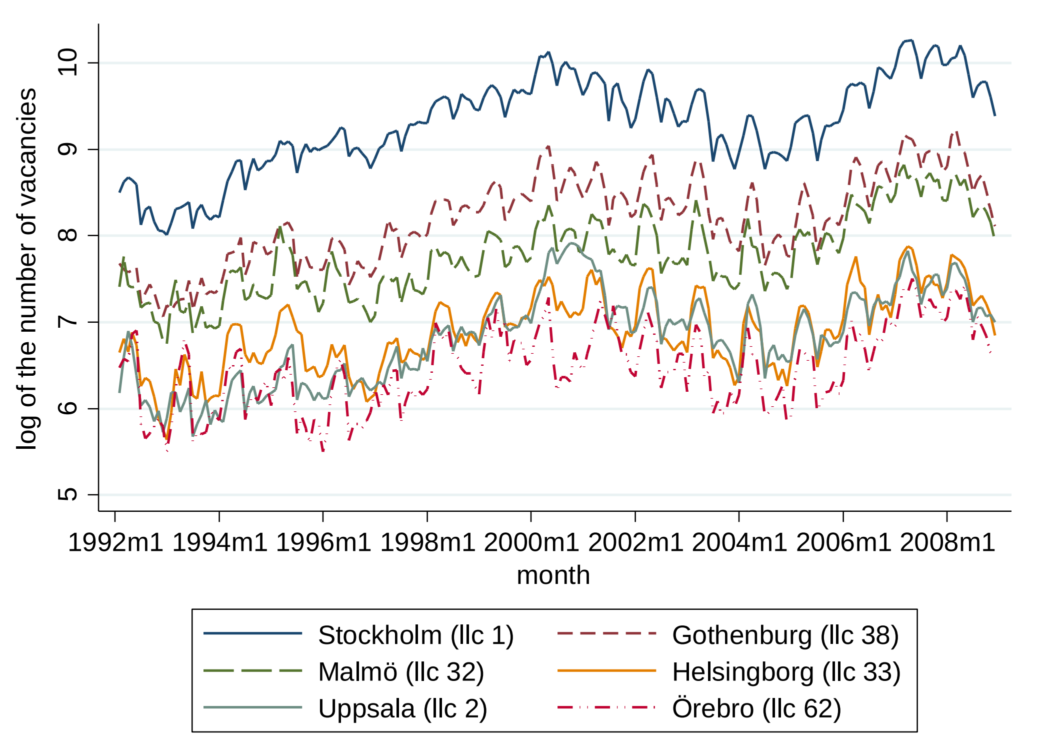


Figure A6: Vacancies



Appendix D: Descriptive statistics and further robustness analysis

Table A1. Correlation matrix

	$\ln H_t$	$\ln D_t$	$\ln U_t$	$\ln W_t$	$\ln N_{t-1}$	$\ln V_t$
$\ln H_t$	1					
$\ln D_t$	0.083	1				
$\ln U_t$	0.090	-0.429	1			
$\ln W_t$	-0.065	0.283	-0.169	1		
$\ln N_{t-1}$	-0.005	0.315	-0.316	0.191	1	
$\ln V_t$	0.190	0.268	-0.139	-0.111	0.052	1

Note: Correlations of variation remaining in the variables after removing variation explained by fixed effects for local labor markets as well as local time trends and seasons.

Table A2. Explaining hiring in local labor markets in Sweden 1992-2008, the lag of employment eliminated

Product demand	3.228***
	(0.404)
Real wage cost	-0.909***
	(0.195)
Unemployment	0.872***
	(0.048)
Lagged product demand	-2.251***
	(0.380)
Lagged real wage cost	0.667***
	(0.192)
Lagged unemployment	-0.765***
	(0.047)
Lagged hiring	0.800***
	(0.023)
Observations	21,909
Number of llm	109
R^2	0.593

Notes: Robust standard errors are in parentheses, clustered at the local labor markets (llm). ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively. All variables are logarithms. Fixed effects, llm-specific linear and quadratic time trends, and llm-specific seasonal dummies are included in the regression. Lagged hiring is instrumented with the second and third lag of hiring and with the second lags of unemployment and product demand. Kleibergen-Paap LM and Wald tests indicate that the instruments are relevant (cf. Kleibergen and Paap, 2006). However, a Hansen test indicates that the validity of the instruments is rather low.

Table A3. Explaining hiring in Sweden's largest local labor markets 1992-2008

	(1) Stockholm (llm 1)	(2) Gothenburg (llm 38)	(3) Malmö (llm 32)	(4) Helsingborg (llm 33)	(5) Uppsala (llm 2)
Product demand	4.918***	1.001	2.711***	1.245	4.775***
	(0.921)	(1.033)	(0.925)	(1.208)	(1.140)
Real wage cost	-0.548*	0.026	-0.430	-0.736	-0.686**
	(0.306)	(0.586)	(0.374)	(0.499)	(0.330)
Unemployment	0.516***	0.488***	0.187	0.233	0.382***
	(0.102)	(0.147)	(0.150)	(0.196)	(0.108)
Lag of employment	2.460**	1.749	-1.067	1.613	1.005
	(1.215)	(1.160)	(1.114)	(1.643)	(1.364)
Observations	203	203	203	203	203

Notes: Robust standard errors are in parentheses, clustered at the local labor markets (llm). ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively. These are the five largest labor markets according to mean of hiring. A linear and a quadratic time trend and seasonal dummies are included in all regressions.

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