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by

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This paper studies the determinants of hiring. We use the search-matching model with imperfect competition in the product market from Carlsson, Eriksson and Gottfries (2011) to derive an equation for total hiring in a local labor market, and estimate it on Swedish panel data. When product markets are imperfectly competitive, product demand shocks have a direct effect on employment. Our results show that product demand is important for hiring. Moreover, we show that conventional measures of vacancies do not fully capture the effect of product demand on hiring. Finally, we show that the number of unemployed workers has a positive effect on hiring as predicted by search-matching models.

Keywords: Hiring, Search-matching, Imperfect Competition, Unemployment

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1. Introduction

In a labor market characterized by frictions, the number of unemployed workers is important for hiring. For a given wage, firms will open more vacancies if there are more unemployed workers around since it is then relatively easy – and thus inexpensive – to find workers. According to search-matching models, supply will create its own demand.

A potentially important factor affecting hiring, which is often neglected in the existing literature, is the demand conditions facing the firms. Most existing search models assume that the product market is characterized by perfect competition, 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. This means that product demand shocks will have direct effects on employment.

How important are demand factors, such as shocks to the firms' product demand and real wage costs? What role is played by supply factors, such as the availability 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 how easy it is for firms to recruit workers.

We use the search-matching model with imperfect competition in the product market from Carlsson, Eriksson and Gottfries (2011) to derive an equation for total hiring in a local labor market, and estimate it on Swedish panel data for the time period 1992-2008. The use of regional data allows us to separate the effects of different factors. We include fixed effects and time dummies, and rely on variation in 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 which are sold as exports and in the domestic market, and in the shares of production sold in the domestic market which are used for consumption and investment. We estimate the model using the full panel of all Swedish local labor markets. We also study some individual local labor markets. 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.

We find that product demand is important for hiring. This suggests that imperfect competition in the product market is important for understanding employment dynamics. Moreover, our results indicate that the effects of product demand shocks are not fully captured by including conventional measures of vacancies in the hiring equation. Also, we find that the number of unemployed workers has a positive effect on hiring. Supply, at least partially, creates its own demand as predicated by search-matching models. Thus, both demand and supply factors seem to matter for hiring.

A closely related paper is Carlsson, Eriksson and Gottfries (2011). They analyze the determinants of net employment change at the firm level using yearly data for the Swedish manufacturing sector, and find that demand and real wages are important, while the availability of unemployed workers is not important. Our paper takes the analysis further by analyzing the importance of these factors for total hiring. Also, we analyze a much longer time period (1992-2008), including all phases of the business cycle, and do the analysis on monthly and quarterly data.

Our paper is related to the literature analyzing the determinants of labor demand (see 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 affects employment dynamics. There are also some papers investigating the importance of search frictions; e.g. Yashiv (2000), Christiano, Trabandt and Walentin (2011), and Michaillat (2011). Another related literature is studies estimating matching functions (c.f. the survey in Petrongolo and Pissarides, 2001). Three representative studies using regional data are Bennett and Pino (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 typically do not include other explanatory variables than unemployment and vacancies. In contrast, we consider the importance of product demand explicitly, and show that it has an effect on hiring beyond the effect captured by vacancies.

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 presented, and identification and estimation issues are discussed. The results of the estimation are presented 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 from Carlsson, Eriksson and Gottfries (2011). From the 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 (e.g. 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 is 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 $P_{i,t}^{C}$. We assume that firms take wages as given. This assumption is made to keep the model simple, but can be justified by arguing that wages are set in collective agreements with trade unions on the national level.[1]

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 $c_V V_{i,t}$.
- 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. 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 $\frac{c_H}{2}\left(\frac{H_{i,t}}{N_{i,t-1}}\right)^2 N_{i,t-1}$.

[1] In Sweden, most wages are set in branch-level union contracts and there is evidence of high nominal wage rigidity. This implies that wages in a particular period to a large extent are predetermined.

- 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 $\mathrm{Y}_{i,t} = \left(P_{i,t} / P_{i,t}^{C}\right)^{-\eta} D_{i,t}^{\sigma}$, where $P_{i,t}$ is the firm's price, $D_{i,t}$ is a firm-specific demand-shifter, $\sigma > 0$ and $\eta > 1$.

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

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

$$s.t. \quad N_{i,\tau} = H_{i,\tau} + (1-\lambda) N_{i,\tau-1}, \quad H_{i,\tau} = \mathrm{Q}_{n,\tau} \mathrm{V}_{i,\tau} \quad \text{and} \quad N_{i,\tau} = \left(\frac{P_{i,\tau}}{P_{i,\tau}^{C}} \right)^{-\eta} D_{i,\tau}^{\sigma}. \tag{1}$$

Inserting the constraints and maximizing with respect to $N_{i,t}$, we get the Euler equation:

$$\mathrm{E_t} \left\{ \frac{\eta-1}{\eta} \left(\frac{D_{i,t}^{\sigma}}{N_{i,t}} \right)^{1/\eta} - \frac{W_{i,t}}{P_{i,t}^{C}} - c_H \left(N_{i,t} - (1-\lambda) N_{i,t-1} \right) N_{i,t-1}^{-1} - \frac{c_V}{Q_{n,t}} \right.$$

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

The firm hires more workers if the demand for the firm's product $(D_{i,t})$ is high, the real wage $(W_{i,t} / P_{i,t}^{C})$ is low, the probability of finding a worker $(Q_{n,t})$ is high, 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* (see Appendix A for the derivation):

$$\hat{h}_{i,t} = \frac{N}{H}(\Delta\hat{n}_{i,t} + \lambda\hat{n}_{i,t-1}) =$$

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

$$\left. -\beta\frac{c_V}{Q}(1-\lambda-\kappa_1)\sum_{\tau=t+1}^{\infty}\left(\frac{1}{\kappa_2}\right)^{\tau-t-1}\left[\alpha_u\hat{u}_{n,\tau} - (1-\alpha_v)\hat{v}_{n,\tau}\right]\right\} - (1-\lambda-\kappa_1)\hat{n}_{i,t-1},\Big], \qquad (3)$$

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 $H_{i,t}$, $N_{i,t}$, $D_{i,t}$, $W_{i,t}/P_{i,t}^C$, $U_{n,t}$ 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.[2] In local labor market *n*, hiring is:

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

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

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.

Hiring in period *t* depends on both the current and the expected future values of all variables. However, if we assume that the variables follow AR1 processes, we can rewrite the equation in terms of current values.

Also, there is a close relationship between vacancies and hiring. Using the definition of $Q_{n,t}$ and the fact that $H_{n,t} = Q_{n,t}V_{n,t}$, we get:

[2] 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.

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

Using this expression to eliminate vacancies in equation (4), we get an equation for total hiring in local labor market *n*:

$$\hat{h}_{n,t} = C_0 + C_1\hat{d}_{n,t} - C_2\hat{w}_{n,t} + C_3\hat{u}_{n,t} - C_4\hat{n}_{n,t-1} + \varepsilon_{n,t}, \quad (6)$$

where C_0, C_1, C_2, C_3 and C_4 are positive constants. Hiring depends on demand, competiveness (wages in relation to the competitors' prices), unemployment, 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 Empirical specification

In principle, we can derive an empirical specification from equation (6). However, since there is a very close relationship between employment and unemployment in a local labor market, it is difficult to separate the effects of employment in the previous period and unemployment at the start of the current period. Therefore, it is problematic to include both variables in the estimation. Moreover, to understand what determines hiring, it is preferable to do the empirical analysis on high frequency data, but in Sweden monthly or quarterly data on employment in local labor markets are not available. Therefore, we need to eliminate lagged employment in the hiring equation. We can do this in two ways.

The first way is to use the relationship between the employment level at the end of the previous period and the unemployment level at the start of the current period given by the equation $N_{n,t-1} = L_{n,t} - U_{n,t}$, where $L_{n,t}$ is the size of the labor force in local labor market *n*. The size of the labor force changes rather slowly so one approach is to treat it as constant. Then, we can use this relationship to eliminate lagged employment in equation (6). This gives us the following empirical specification:

$$\ln H_{n,t} = \beta_0 + \beta_1 \ln D_{n,t} + \beta_2(\ln W_{n,t} - \ln P_{n,t}^C) + \beta_3 \ln U_{n,t} + \varepsilon_{n,t}, \quad (7)$$

where we expect $\beta_1 > 0,\ \beta_2 < 0$ and $\beta_3 > 0$. In this equation, it should be noted that the coefficient on unemployment (β_3) reflects both the direct effect of unemployment (that it is easier to find workers) and the indirect effect of lagged employment (that there is less need to hire workers). High unemployment means that it is easy to recruit workers, but also that too few workers were employed in the previous period, so there is a greater need to hire workers for given levels of demand and wages.

The second way to eliminate lagged employment is to use the definition of hiring (i.e. $H_{n,t} = N_{n,t} - (1-\lambda)N_{n,t-1}$) to eliminate $\hat{n}_{n,t-1}$ from equation (6). Then, it can be shown that (see Appendix A for the derivation):

$$\hat{h}_{n,t} = D_0 + D_1\hat{d}_{n,t} - D_2\hat{w}_{n,t} + D_3\hat{u}_{n,t} - (1-\lambda)\left(D_1\hat{d}_{n,t-1} - D_2\hat{w}_{n,t-1} + D_3\hat{u}_{n,t-1}\right) + D_4\hat{h}_{n,t-1} + D_5\varepsilon_{n,t} - (1-\lambda)D_5\varepsilon_{n,t-1}, \tag{8}$$

where $D_0,\ D_1,\ D_2,\ D_3, D_4$ and D_5 are positive constants. Hiring depends on the current and lagged values of demand, competiveness (wages in relation to the competitors' prices) and unemployment. The expected sign of these effects are the same as before. Since $(1-\lambda)$ is close to unity, what matters for hiring is essentially the changes in demand, wages and unemployment. Also, hiring in the previous period enters the equation. 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, high hiring in period *t-1* is an indication that there is still a need to hire workers in period *t*. From equation (8), we get the following empirical specification:

$$\ln H_{n,t} = \gamma_0 + \gamma_1 \ln D_{n,t} + \gamma_2(\ln W_{n,t} - \ln P^C_{n,t}) + \gamma_3 \ln U_{n,t} + \gamma_4 \ln D_{n,t-1} + \gamma_5(\ln W_{n,t-1} - \ln P^C_{n,t-1}) + \gamma_6 \ln U_{n,t-1} + \gamma_7 \ln H_{n,t-1} + \varepsilon_{n,t}, \tag{9}$$

where we expect $\gamma_1 > 0$, $\gamma_2 < 0$, $\gamma_3 > 0$, $\gamma_4 < 0$, $\gamma_5 > 0$, $\gamma_6 < 0$ and $\gamma_7 > 0$. Theoretically, the only difference between this specification and the previous one is that it does not require a constant labor force. However, we can also think of it as a specification which allows for dynamics not fully captured by the theoretical model.

We interpret equations (7) and (9) as structural equations for total hiring in a local labor market. The coefficients β_1 and γ_1 / γ_4 reflect the importance of product demand (imperfect competition in the product market), β_2 and γ_2 / γ_5 the importance of real wage costs, and β_3 and γ_3 / γ_6 the importance of the availability of unemployed workers.

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 which 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, which are defined by Statistics Sweden. A local labor market consists of one or more municipalities, and is constructed based on commuting patterns. 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 worker lives and the firm is located, i.e. we treat the local labor markets as isolated. This assumption is supported by evidence reported by Johansson and Persson (2000). They report that 80-90 percent of all hired workers are from the local labor market where the firm is located. We use both quarterly and monthly data, but mostly focus on monthly data. In Appendix C, the variables are illustrated for some local labor markets.

Hiring and unemployment

Data for hiring and unemployment are from the Swedish Public Employment Service. All data are measured at the municipality level and at a monthly frequency. 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, but it does not include workers who have found a job but not told the Employment Service. 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.

Demand

The 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 and an international part. For the domestic part, we use data for 57 industries (SNI92), which together make up the whole economy. For the international part, we use data for 34 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 those 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 $\ln D_{j,t} = (1-\delta_j)[\phi_j^C \ln C_t + \phi_j^G \ln G_t + \phi_j^I \ln I_t + (1-\phi_j^C - \phi_j^G - \phi_j^I)\ln Y_t\ ] + \delta_j \ln D_{j,t}^I$, 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 as intermediate input to products which are eventually exported.[3] We use fixed shares computed from the 2005 input-output tables provided by Statistics Sweden. C_t, G_t, I_t and Y_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 Y_t is a volume index of industrial production. The measures of C_t, G_t and I_t are only available at a quarterly frequency. Since all other variables are available at a monthly frequency, we do linear interpolations of these measures to get monthly data. However, as we will describe below, we estimate the model both on monthly and quarterly data. The

[3] Intermediate goods which are used for products sold in the domestic market are included in the consumption and investment shares.

international demand component is calculated as $\ln D^I_{j,t} = \sum_m \omega_{j,m} \ln Y^F_{m,t}$, where $\omega_{j,m}$ is the average share of industry *j*'s export that goes to country *m* (calculated as the average of the shares for 1995, 2000 and 2005) and $Y^F_{m,t}$ is industrial production in country *m*. The countries included are Sweden's main trading partners.[4]

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 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 industry structure in 1995.

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. We do this for two reasons. First, we only have detailed wage data for the manufacturing 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 the wage 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 aggregated 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 $\omega_{j,m}$ is the

[4] Sweden's main trading partners in 2010 were Germany, Norway, the United Kingdom, Denmark, Finland, the US, France, the Netherlands, Belgium, Italy, and Spain. China and Poland are excluded due to lack of data. However, these two countries

average share of industry *j*'s export which 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, $\ln W_{n,t} = \sum_j \kappa_{j,n} \ln W_{j,t}$ and $\ln P^C_{n,t} = \sum_j \kappa_{j,n} \ln P^C_{j,t}$. Subtracting the logarithm of the price from the logarithm of the nominal wage, we get our measure of competitiveness.

3.2 Identification and estimation

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

Identification and simultaneity

The baseline estimation is made on a panel of local labor markets with fixed effects and time dummies. 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 product 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.

A crucial prerequisite for this estimation to work is that we have enough variation in unemployment, real wage costs and demand across local labor markets. We have analyzed this issue and find that there is variation across local labor markets, but that much of the total variation in these variables is common to all local labor markets.[5] Thus, there is limited

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have become important trading partners quite recently.

[5] For unemployment, real wage costs and demand, 85, 81 and 99.8 percent of the variation is explained by the time dummies and fixed effects. The remaining standard deviations after including these controls are 0.095 for unemployment, 0.015 for real wage costs and 0.002 for demand.

variation across local labor markets in several of the explanatory variables, especially in the demand variable.

An important issue in the estimation is simultaneity. Unobserved shocks – aggregate, industry-specific and local – may cause biased estimates. First, we need to consider unobserved aggregate shocks affecting the whole economy, such as general business cycle effects. To take into account such shocks, we include 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. Thus, unobserved industry-specific shocks will not affect our measure of demand. 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 valid for at least a year. This means that monthly and quarterly wages to a large extent can be viewed as predetermined. Still, it is difficult to fully rule out the possibility that industry-specific shocks may affect this variable.[6] Third, unobserved local labor market shocks, such as changes in local taxes 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 abstracts from such local effects on wages. Unemployment is measured at the beginning of the period so it is predetermined relative to the shock in period t. Still, there may be problems if local shocks are serially correlated.

[6] Two ways of mitigating this problem would be to use data on aggregate wages or to construct the variable based only on the competitors' prices. However, a disadvantage of these alternatives is that they remove some of the variation in the data. Another alternative would be to use suitably chosen lags of real wage costs as instruments for current real wage costs.

Stationarity

An important issue in the estimation is stationarity. The plots of the 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 different 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. This test conducts Dickey-Fuller unit-root tests for each panel individually, 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. Both tests indicate that some of the variables may be non-stationary.[7]

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 variables are stationary.[8] Thus, we can use them as regressors if we include trends. Therefore, we include local linear and quadratic trends in all regressions.

Estimation

In all specifications, we include time dummies, fixed effects for local labor markets, local seasonal effects, and local time trends (linear and quadratic). The trends are local to take into account differences in productivity growth across different industries.[9] The seasonal effects are local to take into account 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:

$$\ln H_{n,t} = \alpha_n + \beta_1 \ln D_{n,t} + \beta_2 (\ln W_{n,t} - \ln P^C_{n,t}) + \beta_3 \ln U_{n,t} + Time\ dummies + \\ Local\ seasonal\ effects + Local\ linear\ and\ quadratic\ time\ trends + \varepsilon_{n,t}, \quad (10)$$

To estimate the hiring equation in (9), we use the specification:

[7] For hiring, unemployment, demand and real wage costs the Hadri LM test rejects that all panels are stationary. However, for all of these variables, except unemployment, the Fisher-type unit root test also rejects that all panels have a unit root. For unemployment, this test suggests that all panels have a unit root.

[8] The p-values for all panels having a unit root are 0.0000 for all detrended variables and the p-values for all panels being stationary are in the range 0.95-1 (in the quarterly dataset). We have also plotted the detrended variables and performed separate tests for some individual local labor markets (including the five largest in both the quarterly and the monthly dataset). These tests confirm that the detrended variables are stationary.

[9] 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 other industries.

$$\ln H_{n,t} = \alpha_n + \gamma_1 \ln D_{n,t} + \gamma_2 (\ln W_{n,t} - \ln P^C_{n,t}) + \gamma_3 \ln U_{n,t} + \gamma_4 \ln D_{n,t-1} +$$

$$\gamma_5 (\ln W_{n,t-1} - \ln P^C_{n,t-1}) + \gamma_6 \ln U_{n,t-1} + \gamma_7 \ln H_{n,t-1} + Time\ dummies + \tag{11}$$

$$Local\ seasonal\ effects + Local\ linear\ and\ quadratic\ time\ trends + \varepsilon_{n,t}.$$

To estimate this specification, we must take into account that $H_{n,t-1}$ is, by definition, correlated with the error term (see equation (8)). 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.[10]

A potential concern is autocorrelation and heteroskedasticity. For specification (10), 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.[11] Therefore, we cluster the standard errors at the local labor markets. This means that the standard errors are robust to arbitrary within-group autocorrelation as well as arbitrary heteroskedasticity. An advantage of this approach is that it takes into account that small local labor markets are characterized by more variation in the variables.

4. Results

To study the determinants of hiring, we now estimate the specifications derived above. First, we estimate the model including all local labor markets in a panel. Second, we estimate the model for the largest local labor markets separately.

4.1 The determinants of hiring in all local labor markets

The specifications implied by the theoretical model

Table 1 presents the results of the regressions for the full panel with all local labor markets.

[10] Precise definitions of the instrument sets are given in the notes to the tables containing estimation results.
[11] This test can not be used to test for autocorrelation in the specification in equation (11) since it includes lags.

Table 1. Hiring in local labor markets, 1992-2008

Dependent: Hiring	Monthly frequency		Quarterly frequency	
	(1)	(2)	(3)	(4)
Unemployment	0.156***	0.775***	0.121***	0.208***
	(0.042)	(0.063)	(0.040)	(0.030)
Real wage costs	0.344	0.961***	0.232	0.193
	(0.212)	(0.258)	(0.234)	(0.157)
Demand	4.526*	7.788**	3.667	10.294***
	(2.287)	(3.590)	(2.494)	(2.745)
Lag of unemployment		-0.635***		-0.077**
		(0.061)		(0.035)
Lag of real wage costs		-0.848***		-0.022
		(0.255)		(0.177)
Lag of demand		-7.710**		-10.854***
		(3.732)		(2.532)
Lag of hiring		0.740***		0.506***
		(0.032)		(0.054)
Observations	22,127	21,909	7,303	7,085
R^2	0.711	0.660	0.763	0.776
Local labor markets	109	109	109	109

Notes: All variables are logarithms. Fixed effects, time dummies, local labor market specific linear and quadratic time trends and local labor market specific seasonal effects are included in all regressions. In the IV-regressions in columns 2 and 4, the instruments for the first lag of hiring are the second and third lags of hiring and the second lags of unemployment and demand. Robust standard errors are in parentheses. The standard errors are clustered at the local labor markets. ***, ** and * denote significance at the 1, 5 and 10 percent levels, respectively.

The first two columns show the results of the two specifications implied by the theoretical model (i.e. equations (10) and (11)) estimated on monthly data. Most of the variables have the expected signs: The availability of workers (i.e. unemployment) has a positive effect on hiring, implying that supply, at least partially, creates its own demand as predicted by search-matching models. Also, demand has a positive effect on hiring, implying that imperfect competition in the product market is important for hiring. Surprisingly, we find a positive effect from the real wage costs, though statistically significant in only one case. This may be because our wage measure is an imperfect proxy for the relevant real wage costs or because industry-specific shocks create endogeneity problems. The implied long-run elasticities for the dynamic model in column 2 are 0.538 for unemployment and 0.300 for demand. Columns 3 and 4 report the results of the estimation on quarterly data. Most of the results are similar to the results for monthly data. Also, we have estimated the main specifications for different subperiods – e.g. periods with unusually high (1992-1999) or low unemployment (2000-2008) – but find no statistically significant differences.

A concern with the regressions in Table 1 is that the time dummies may explain so much of the variation that little variation remains, making it difficult to get precise estimates of the effects of unemployment, real wage cost and demand on hiring. Table 2 shows the results of estimating the same specifications excluding the time dummies. Here, the results are much stronger; demand and unemployment have clear positive effects and real wage costs a clear negative effect. The fact that we get much stronger results without time dummies is probably explained by the fact that much of the variation in the demand and real wage cost variables are common to all local labor markets (c.f. Section 3.2).

Table 2. Hiring in local labor markets, 1992-2008, no time dummies

Dependent: Hiring	Monthly frequency		Quarterly frequency	
	(1)	(2)	(3)	(4)
Unemployment	0.199***	0.826***	0.169***	0.316***
	(0.027)	(0.047)	(0.025)	(0.026)
Real wage costs	-0.843***	-1.215***	-0.872***	-0.636***
	(0.173)	(0.257)	(0.172)	(0.165)
Demand	2.205***	4.995***	2.099***	4.036***
	(0.197)	(0.571)	(0.191)	(0.308)
Lag of unemployment		-0.751***		-0.243***
		(0.045)		(0.026)
Lag of real wage costs		0.967***		-0.193
		(0.235)		(0.129)
Lag of demand		-4.453***		-3.901***
		(0.537)		(0.291)
Lag of hiring		0.753***		0.349***
		(0.024)		(0.050)
Observations	22,127	21,909	7,303	7,085
R^2	0.637	0.609	0.670	0.728
Local labor markets	109	109	109	109

Notes: All variables are logarithms. Fixed effects, local labor market specific linear and quadratic time trends and local labor market specific seasonal effects are included in all regressions. In the IV-regressions in columns 2 and 4, the instruments for the first lag of hiring are the second and third lags of hiring and the second lags of unemployment and demand. Robust standard errors are in parentheses. The standard errors are clustered at the local labor markets. ***, ** and * denote significance at the 1, 5 and 10 percent levels, respectively.

Robustness

To investigate if our results are robust, we have performed a number of robustness checks. Some of the results are presented in Appendix D.

A first issue is if our choice of including local labor market specific seasonal effects and time trends affect the results. To investigate this, we have estimated the model using common seasonal effects and time trends. As can be seen in Tables A1 and A2, our results are sensitive to the way the trends are specified. However, we believe that there are strong reasons for including local labor market specific trends since productivity growth is likely to differ significantly between different local labor markets with different industry structures.

A second issue has to do with the nature of the shocks. In the specifications, which we have estimated so far, we include a deterministic trend to take into account shocks to productivity. An alternative is to think of the productivity trend as stochastic and estimate the model in first-differences. Table A3 present the results for the model estimated in first-differences. In these specifications, the positive effect of demand disappears, while the effect of unemployment is similar to the models estimated in levels. This difference in results may be explained by the fact that a model estimated in differences is more sensitive to short-term distortions and measurement errors in real wage costs and demand.

Vacancies as a proxy for product demand

The results in Table 1 indicate that imperfect competition in the product market is important for hiring, and thus that a variable measuring product demand helps to explain hiring. However, it may be argued that an alternative way of capturing the effects of product demand could be to include a measure of vacancies in the model. To test this, we use data for vacancies reported to the Public Employment Service.[12] 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.[13]

In Table 3, we show the results of estimating specifications where we include vacancies. In column 1 (and 4) we estimate a standard matching function, and in columns 2 and 3 (and 5 and 6) we estimate our baseline specifications with vacancies included. The results are similar to the results in Table 1. The fact that our measure of product demand

[12] A well-known problem with vacancy data is that many vacancies are not reported to the Public Employment Service. However, this is the only available time series for vacancies which covers the whole time period under consideration.

[13] This is the standard way to handle this issue (c.f. Petrongolo and Pissarides, 2001). This variable is illustrated in Figure A5 in Appendix C.

remains statistically significant when we include vacancies suggests that the conventional measures of vacancies, which are typically used in estimating of matching functions, do not fully capture the effects of product demand. In fact, it turns out that the correlation between product demand and vacancies is rather low. As a result, the coefficient for the demand variable remains statistically significant in most of the regressions when vacancies are included.[14] Apparently, our product demand variable and vacancies capture different aspects of labor demand.

Table 3. Hiring in local labor markets, 1992-2008, including vacancies

Dependent: Hiring	Monthly frequency			Quarterly frequency		
	(1)	(2)	(3)	(4)	(5)	(6)
Unemployment	0.160***	0.162***	0.770***	0.127***	0.128***	0.223***
	(0.042)	(0.042)	(0.062)	(0.041)	(0.041)	(0.029)
Vacancies	0.027***	0.027***	0.003	0.065***	0.066***	0.061***
	(0.005)	(0.005)	(0.005)	(0.009)	(0.009)	(0.009)
Real wage costs		0.352	0.955***		0.250	0.138
		(0.213)	(0.256)		(0.239)	(0.152)
Demand		4.432*	7.253**		3.616	4.656*
		(2.245)	(3.420)		(2.436)	(2.709)
Lag of unemployment			-0.630***			-0.093***
			(0.060)			(0.034)
Lag of vacancies			0.004			-0.019*
			(0.005)			(0.010)
Lag of real wage costs			-0.835***			0.054
			(0.253)			(0.180)
Lag of demand			-7.095**			-5.343**
			(3.601)			(2.515)
Lag of hiring			0.735***			0.535***
			(0.031)			(0.053)
Observations	22,123	22,123	21,897	7,303	7,303	7,085
R^2	0.711	0.712	0.662	0.766	0.767	0.777
Local labor markets	109	109	109	109	109	109

Notes: All variables are logarithms. Fixed effects, time dummies, local labor market specific linear and quadratic time trends and local labor market specific seasonal effects are included in all regressions. In the IV-regressions in columns 3 and 6, the instruments for the first lag of hiring are the second and third lags of hiring and the second lags of unemployment, vacancies and demand. Robust standard errors are in parentheses. The standard errors are clustered at the local labor markets. ***, ** and * denote significance at the 1, 5 and 10 percent levels, respectively.

[14] If we estimate the model without time dummies, the coefficient for demand decreases when vacancies are included.

4.2 The determinants of hiring in some large local labor markets

Table 4 shows the results on monthly data for each of the five largest local labor markets separately. Obviously, these regressions do not include time dummies since there is only one observation per period for each local labor market. Most of the results are qualitatively similar to the results in Table 2. For the first specification, the effect of unemployment is positive and statistically significant in four of the five labor markets, the effect of the real wage cost variable is negative and (weakly) statistically significant in four labor markets, and the effect of the demand measure is positive and statistically significant in three labor markets. However, the size of the coefficients varies. The results for the quarterly data are similar.

Table 4. Hiring in the five largest local labor markets, monthly frequency 1992-2008

Dependent: Hiring	Stockholm		Gothenburg		Malmö		Helsingborg		Uppsala	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Unemployment	0.305***	0.538***	0.326***	0.503**	0.265**	0.694***	0.143	0.828***	0.298***	0.710***
	(0.068)	(0.140)	(0.119)	(0.205)	(0.105)	(0.156)	(0.159)	(0.186)	(0.073)	(0.222)
Wage cost	-0.952*	-2.270**	-0.255	-1.807*	-0.785*	-1.502	-1.305**	-3.172**	-1.106**	-2.657***
	(0.519)	(1.008)	(0.755)	(1.035)	(0.430)	(1.291)	(0.577)	(1.458)	(0.512)	(0.700)
Demand	5.495***	3.746***	1.587	2.958**	2.670***	1.864	1.987	6.139***	3.853***	5.097***
	(1.016)	(1.376)	(1.134)	(1.195)	(0.996)	(1.562)	(1.294)	(1.835)	(1.098)	(1.846)
Lag of U		-0.469***		-0.455**		-0.612***		-0.838***		-0.558**
		(0.143)		(0.208)		(0.156)		(0.176)		(0.243)
Lag of W		2.039*		1.674		1.168		2.667*		2.127***
		(1.059)		(1.032)		(1.320)		(1.531)		(0.757)
Lag of D		-2.871**		-2.816**		-1.299		-5.794***		-2.939*
		(1.312)		(1.110)		(1.545)		(1.724)		(1.749)
Lag of H		0.868***		0.868***		0.817***		0.764***		0.510**
		(0.088)		(0.061)		(0.081)		(0.081)		(0.210)
Observations	203	201	203	201	203	201	203	201	203	201
R-squared		0.879		0.830		0.867		0.763		0.846

Notes: The five largest labor markets according to the mean of hiring. All variables are logarithms. Seasonal effects and a linear and a quadratic time trend are included in all regressions. In the IV-regressions in columns 2, 4, 6, 8 and 10, the instruments for the first lag of hiring are the second and third lags of hiring and the second lags of unemployment and demand. Robust standard errors are in parentheses. ***, ** and * denote significance at the 1, 5 and 10 percent levels, respectively.

5. Concluding remarks

In this paper, we estimate equations for hiring to investigate the relative importance of demand and supply factors. The factors we include are the demand conditions facing the firms, the firms' wage costs relative to their competitors' prices, and how easy it is for firms to recruit workers. We find that our measure of product demand has a positive effect on hiring in most of the specifications, suggesting that imperfect competition in the product market is important. The demand variable remains significant when we include conventional measures of vacancies in the regressions. This indicates that vacancies do not fully capture the effects of product demand. Also, we find that the number of unemployed workers has a positive effect on hiring as predicted by search-matching models.

Our results show that both demand and supply factors matter for hiring. This suggests that search-matching models should include imperfect competition in the product market when they are used to analyze employment dynamics. Moreover, our results suggest that future empirical studies of employment dynamics and hiring should include measures of product demand and not only focus on the effects of labor market frictions.

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Appendix A: Derivations of some equations

Net employment change and hiring at the firm level:

Inserting the constraints, we get the following maximization problem:

$$\max\ \mathrm{E}_t \sum_{\tau=t}^{\infty}\beta^{\tau-t}\left\{\left[\left(\frac{N_{i,\tau}}{D_{i,\tau}^{\sigma}}\right)^{-1/\eta}-\frac{W_{i,\tau}}{P_{i,\tau}^{C}}\right]N_{i,\tau}-\frac{c_H}{2}\frac{\left(N_{i,\tau}-(1-\lambda)N_{i,\tau-1}\right)^2}{N_{i,\tau-1}}-c_V\frac{N_{i,\tau}-(1-\lambda)N_{i,\tau-1}}{Q_{n,\tau}}\right\}\ .$$

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

$$\mathrm{E}_t\left\{\frac{\eta-1}{\eta}\left(\frac{D_{i,t}^{\sigma}}{N_{i,t}}\right)^{1/\eta}-\frac{W_{i,t}}{P_{i,t}^{C}}-c_H\left(N_{i,t}-(1-\lambda)N_{i,t-1}\right)N_{i,t-1}^{-1}-\frac{c_V}{Q_{n,t}}\right.$$

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

Log-linearizing, we get:

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

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

This can be rewritten as:

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

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

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

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

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

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

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

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

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:

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

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

The equation for lagged employment:

The definition of hiring and the hiring equation:

$H_{n,t} = N_{n,t} - (1-\lambda)N_{n,t-1}$ (or log-linearized $\hat{h}_{n,t} = \frac{N}{H}\hat{n}_{n,t} - (1-\lambda)\frac{N}{H}\hat{n}_{n,t-1}$), (A4)

$$\hat{n}_{n,t} = \hat{x}_{n,t} + \kappa_1\hat{n}_{n,t-1} + \varepsilon_{n,t}, \quad \text{(A5)}$$

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

Combining (A4) and (A5):

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

Using the definition of $\hat{n}_{t-1}$ in equation (A5):

$$\hat{h}_{n,t} = \frac{N}{H}\left(\hat{x}_{n,t} - (1-\lambda-\kappa_1)(\hat{x}_{n,t-1} + \varepsilon_{n,t-1}) - \kappa_1(1-\lambda-\kappa_1)\hat{n}_{n,t-2} + \varepsilon_{n,t}\right). \quad \text{(A7)}$$

Using the lagged version of (A6) to eliminate $\hat{n}_{n,t-2}$ in (A7):

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

Simplifying:

$$\hat{h}_{n,t} = \frac{N}{H}\left(\hat{x}_{n,t} - (1-\lambda)\hat{x}_{n,t-1}\right) - \kappa_1\hat{h}_{n,t-1} + \frac{N}{H}\left(\varepsilon_{n,t} - (1-\lambda)\varepsilon_{n,t-1}\right). \quad \text{(A8)}$$

Appendix B: Local labor markets and industries

Local labor markets (1993 definition; Statistics Sweden)

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

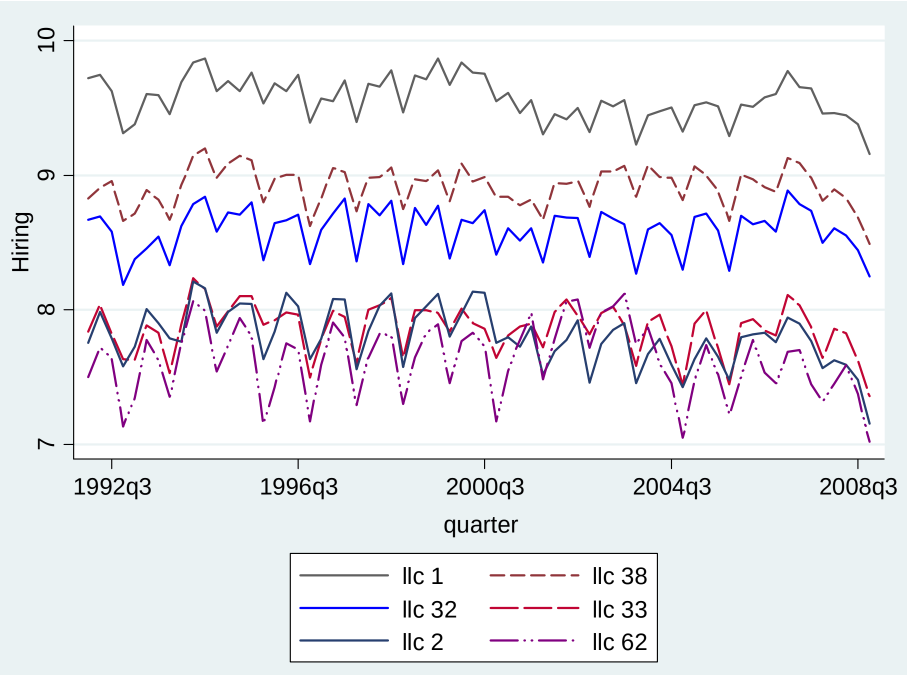
Industries (SNI92; Statistics Sweden)

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
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 fibres
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 defence 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 organisation services n.e.c.
92	Recreational, cultural and sporting services
93	Other services
95	Private households with employed persons

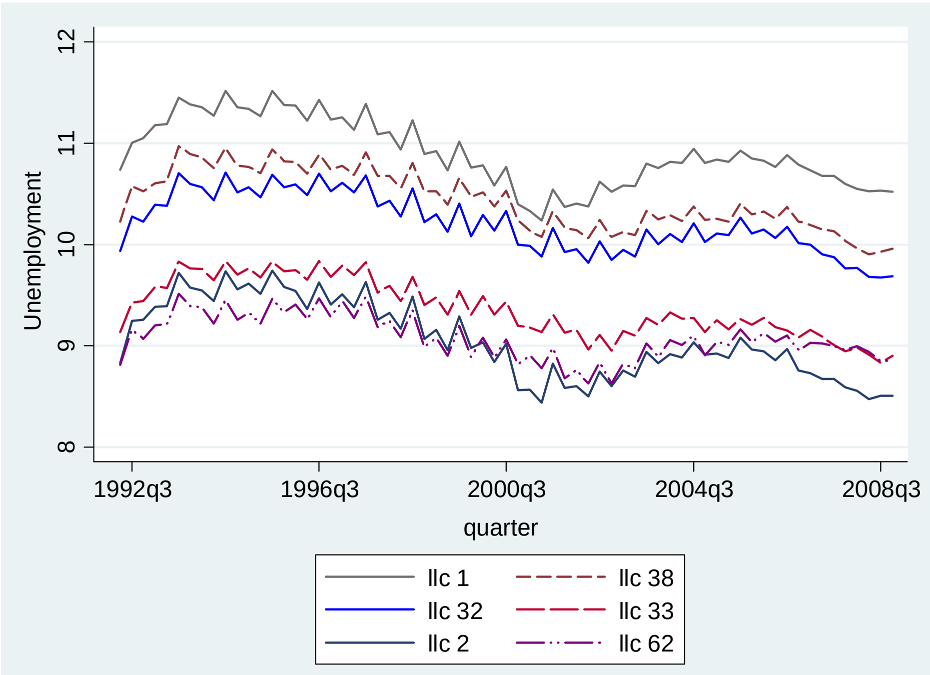
Appendix C: Illustrations of the variables for some local labor markets

Figure A1. Hiring



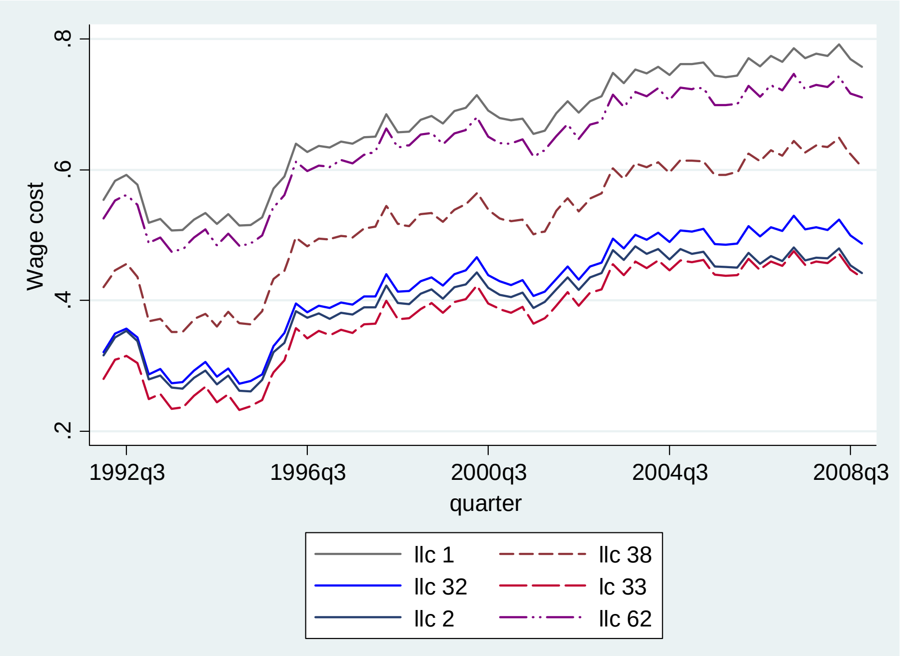
Note: Stockholm (llc 1), Gothenburg (llc 38), Malmö (llc 32), Helsingborg (llc 33), Uppsala (llc 2) and Örebro (llc 62)

Figure A2. Unemployment



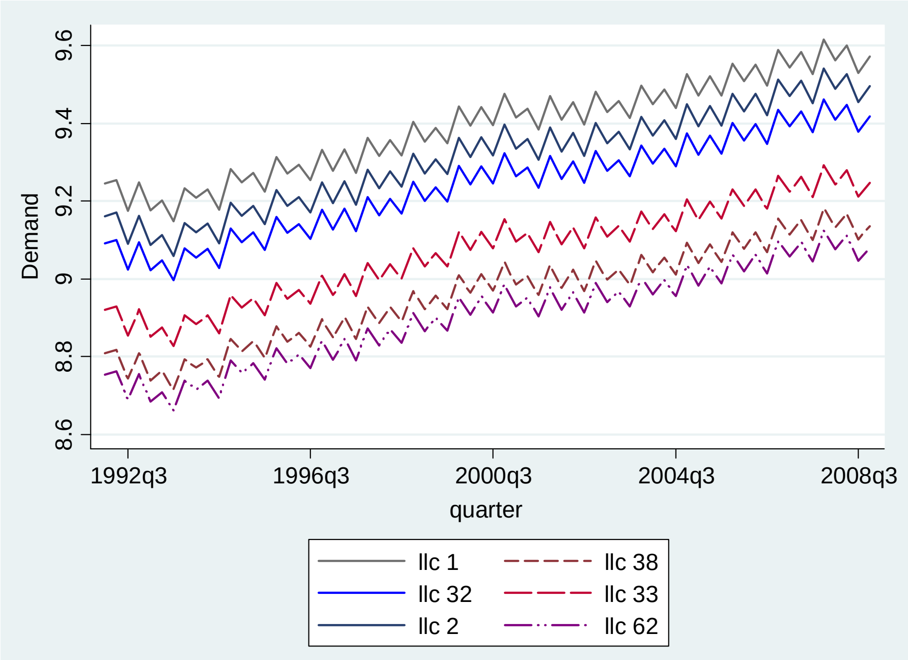
Note: Stockholm (llc 1), Gothenburg (llc 38), Malmö (llc 32), Helsingborg (llc 33), Uppsala (llc 2) and Örebro (llc 62)

Figure A3. Real wage costs



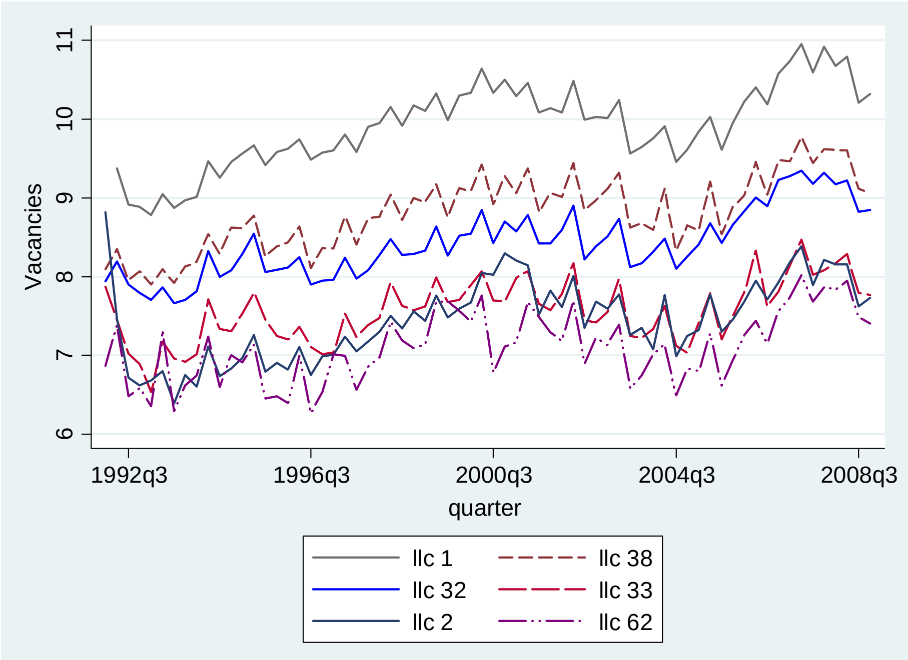
Note: Stockholm (llc 1), Gothenburg (llc 38), Malmö (llc 32), Helsingborg (llc 33), Uppsala (llc 2) and Örebro (llc 62)

Figure A4. Demand



Note: Stockholm (llc 1), Gothenburg (llc 38), Malmö (llc 32), Helsingborg (llc 33), Uppsala (llc 2) and Örebro (llc 62)

Figure A5. Vacancies



Note: Stockholm (llc 1), Gothenburg (llc 38), Malmö (llc 32), Helsingborg (llc 33), Uppsala (llc 2) and Örebro (llc 62)

Appendix D: Robustness

Table A1. Hiring in local labor markets, monthly data 1992-2008, robustness

Dependent: Hiring	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Unemployment	0.245***	0.732***	0.167***	0.838***	0.256***	0.603***	0.289***	0.531***
	(0.049)	(0.074)	(0.045)	(0.058)	(0.052)	(0.085)	(0.054)	(0.093)
Real wage costs	-0.012	0.665**	-0.032	0.962***	0.255	0.668**	0.512**	0.650*
	(0.256)	(0.337)	(0.266)	(0.272)	(0.224)	(0.335)	(0.228)	(0.334)
Demand	-0.299	0.405	-1.121	3.848	2.560	1.266	3.465*	1.518
	(1.443)	(1.510)	(1.600)	(3.638)	(1.628)	(1.456)	(1.876)	(1.486)
Lag of unemployment		-0.478***		-0.749***		-0.273***		-0.156*
		(0.071)		(0.058)		(0.080)		(0.089)
Lag of real wage costs		-0.693*		-1.011***		-0.516		-0.217
		(0.359)		(0.275)		(0.360)		(0.379)
Lag of demand		0.345		-4.100		2.757		3.804*
		(1.570)		(3.690)		(1.927)		(2.201)
Lag of hiring		0.541***		0.846***		0.425***		0.359***
		(0.039)		(0.019)		(0.044)		(0.050)
Time dummies	yes	yes	yes	yes	yes	yes	yes	yes
Local seasons	no	no	yes	yes	no	no	no	no
Local linear trends	no	no	no	no	yes	yes	yes	yes
Local quadr. trends	no	no	no	no	no	no	yes	yes
Observations	22,127	21,909	22,127	21,909	22,127	21,909	22,127	21,909
R^2	0.524	0.569	0.668	0.626	0.554	0.592	0.568	0.603
Local labor markets	109	109	109	109	109	109	109	109

Notes: All variables are logarithms. Fixed effects are included in all regressions. In the IV-regressions in columns 2, 4, 6 and 8 the instruments for the first lag of hiring are the second and third lags of hiring and the second lags of unemployment and demand. Robust standard errors are in parentheses. The standard errors are clustered at the local labor markets. ***, ** and * denote significance at the 1, 5 and 10 percent levels, respectively.

Table A2. Hiring in local labor markets, quarterly data 1992-2008, robustness

Dependent: Hiring	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Unemployment	0.220***	0.408***	0.157***	0.284***	0.222***	0.292***	0.243***	0.121
	(0.037)	(0.045)	(0.042)	(0.028)	(0.036)	(0.036)	(0.036)	(0.088)
Real wage costs	0.011	1.514***	-0.087	0.082	0.260	1.404***	0.559**	1.149***
	(0.283)	(0.373)	(0.289)	(0.148)	(0.225)	(0.241)	(0.252)	(0.328)
Demand	0.548	3.318**	-1.234	3.187	3.303**	3.370***	4.102**	3.400**
	(1.388)	(1.546)	(1.618)	(2.580)	(1.576)	(0.593)	(1.687)	(1.598)
Lag of unemployment		-0.164***		-0.179***		0.029		0.204**
		(0.056)		(0.030)		(0.035)		(0.096)
Lag of real wage costs		-1.637***		-0.156		-1.198***		-0.755**
		(0.365)		(0.168)		(0.243)		(0.317)
Lag of demand		-3.577***		-3.441		-2.151***		-0.670
		(1.327)		(2.586)		(0.606)		(1.097)
Lag of hiring		0.623***		0.790***		0.309***		-0.033
		(0.053)		(0.029)		(0.055)		(0.152)
Time dummies	yes	yes	yes	yes	yes	yes	yes	yes
Local seasons	no	no	yes	yes	no	no	no	no
Local linear trends	no	no	no	no	yes	yes	yes	yes
Local quadr. trends	no	no	no	no	no	no	yes	yes
Observations	7,303	7,085	7,303	7,085	7,303	7,085	7,303	7,085
R^2	0.589	0.590	0.685	0.725	0.645	0.658	0.669	0.675
Local labor markets	109	109	109	109	109	109	109	109

Notes: All variables are logarithms. Fixed effects are included in all regressions. In the IV-regressions in columns 2, 4, 6 and 8 the instruments for the first lag of hiring are the second and third lags of hiring and the second lags of unemployment and demand. Robust standard errors are in parentheses. The standard errors are clustered at the local labor markets. ***, ** and * denote significance at the 1, 5 and 10 percent levels, respectively.

Table A3. Hiring in local labor markets 1992-2008, first-differences

	Monthly frequency		Quarterly frequency	
	(1)	(2)	(3)	(4)
Unemployment	0.927***	1.304***	0.298***	0.373***
	(0.061)	(0.138)	(0.031)	(0.049)
Wage cost	1.072***	1.105***	0.137	-0.006
	(0.318)	(0.411)	(0.202)	(0.202)
Demand	2.296	-0.579	2.355	-2.560
	(3.988)	(4.837)	(2.411)	(2.901)
Lag of unemployment		-0.265**		-0.014
		(0.127)		(0.051)
Lag of real wage costs		-0.411		-0.106
		(0.398)		(0.261)
Lag of demand		-7.401		-3.850
		(5.177)		(3.702)
Lag of hiring		0.419***		0.282*
		(0.117)		(0.150)
Observations	22,018	21,800	7,194	6,976
R^2	0.705	0.549	0.777	0.707
Local labor markets	109	109	109	109

Notes: All variables are logarithms. Fixed effects, time dummies, local labor market specific linear time trends and local labor market specific seasonal effects are included in all regressions. In the IV-regressions in columns 2 and 4, the instruments for the first lag of the first difference in hiring are the third and fourth lags of hiring and the second and third lags of unemployment and demand. Robust standard errors are in parentheses. The standard errors are clustered at the local labor markets. ***, ** and * denote significance at the 1, 5 and 10 percent levels, respectively.

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