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Firms' employment dynamics and the state of the labor market

Karolina Stadin

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Firms’ employment dynamics and the state of the labor market[a]

by

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Abstract

According to search and matching theory, a greater availability of unemployed workers should make it easier for a firm to fill a vacancy but more vacancies at other firms should make recruitment more difficult. But what can we say about the expected magnitudes of these effects on firms’ employment dynamics? In this paper, I simulate a theoretical model featuring search frictions in the labor market, imperfect competition in the product market and quadratic adjustment costs. The simulations show quite small employment effects of typical shocks to the number of vacancies in the local labor market and very small effects of typical shocks to the number of unemployed. The employment effects are smaller in recessions than in booms. Estimation of an employment equation using panel data for Swedish firms suggests that neither the number of unemployed nor the number of vacancies in the local labor market are important for firms’ employment dynamics. Thus, the empirical results are in line with the predictions from the theoretical simulations.

Keywords: Employment dynamics, search and matching frictions
JEL-codes: E24, J23, J63, J64

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1 Introduction

According to search and matching theory, the state of the labor market affects the probability of filling a vacancy, which in turn affects the creation of new vacancies and hiring. It is easier to fill vacancies when there are more unemployed workers available to hire, and it is more difficult when many other firms are also opening vacancies.

In order to say something about the magnitudes of the effects of changes in labor market conditions on firms' employment decisions, I simulate a theoretical model of firms' employment dynamics. The model used is a search and matching model with imperfect competition in the product market and convex adjustment costs from Carlsson, Eriksson, and Gottfries (2013). A firm's employment decision is affected by vacancies and unemployment in the local labor market through their effects on the probability of filling a vacancy, but employment also depends on product demand and real wage costs. Theoretical impulse responses resulting from shocks to the explanatory variables are simulated. This allows me to see how the employment of a firm changes over time when there is a typical change in the number of vacancies or unemployed in the local labor market where the firm is located.

The key results from the simulations show that shocks to the number of vacancies in the local labor market –and hence to the probability of filling a vacancy– have quite small effects on the employment at the firm and the effects of shocks to the number of unemployed are even smaller. The smaller simulated employment effect of a shock to the number of unemployed is due to the fact that in the data these shocks are typically much smaller than shocks to the number of vacancies. Employment responses to one percent shocks of both types are almost zero.

The baseline simulation results are quite robust with respect to reasonable changes in parameter values. The employment effects become large when the convex adjustment costs are set to zero and at the same time the degree of competition in the product market is set very high, so that the model approaches a standard search and matching model. Alternatively, the employment responses may become large when the linear vacancy cost per unit of time is set very high. These are not reasonable assumptions, however, according to the empirical findings in this and other studies.

The simulations suggest that the employment effects of shocks to the number of unemployed and the number of vacancies are smaller in recessions than in booms. This result is in line with the idea in Michaillat (2012) that matching frictions are less important in recessions.

In order to test the predictions from the simulated model I estimate an equation for employment using firm-level data. The empirical specification is based on Carlsson, Eriksson, and Gottfries (2013) who analyzed the determinants of net employment changes at the firm level. They used yearly data for Swedish manufacturing firms in the 1990s, which is a period dominated by a deep recession. They found that product demand and real wages were important for employment, while the availability of unemployed workers was not. Vacancies in the local labor market had a negative effect on employment in some specifications, indicating a congestion effect.

In this paper, I use a richer dataset than Carlsson, Eriksson, and Gottfries (2013). I use data for both the 1990s and 2000s and I use data for all firms in Sweden with at least ten employees. The estimation results show no economically significant effects of the number of unemployed or the number of vacancies on employment. These results indicate that search and matching frictions in the labor market are not important for firms' yearly employment dynamics. Instead, product demand has a robust positive effect and the real wage cost has a weak negative effect on firms' employment. Furthermore, the estimation results are in line with high convex adjustment costs. Thus, the empirical results in this paper point in the same direction as those in Carlsson, Eriksson, and Gottfries (2013) and they are in line with the results of the simulations.

Also, the results are largely consistent with those of Eriksson and Stadin (2015) who estimated an equation for hiring using monthly data for all local labor markets in Sweden in the 1990s and 2000s. When using the outflow of vacancies as the dependent variable, they found a positive effect of product demand, a negative effect of real wage costs, and no significant effect of the number of unemployed. When using hiring of unemployed workers as the dependent variable they found a positive effect of the number of unemployed which will be discussed in the conclusions.

The rest of the paper is organized as follows. In section 2, the theoretical model is presented and simulated. In section 3, firm level data are used to empirically estimate an employment equation in line with the theoretical model. Section 4 concludes the paper.

2 Theoretical simulation of firms' employment dynamics

2.1 The theoretical model

The theoretical model used is from Carlsson, Eriksson, and Gottfries (2013). It is a model of firm-level employment that includes search frictions, linear vacancy costs, convex hiring costs, and monopolistic competition in the product market. The model is based on the standard search and matching model (cf. Pissarides (2000)) with the main differences being that the product market is characterized by imperfect competition and that firms hire more than one worker.

There are a number of local labor markets and all matching is assumed to take place within these local labor markets. In each local labor market, indexed *n*, there is a large number of firms, indexed *i*. The firms sell their products in different product markets and they face different competitors' prices, denoted $P^{C}_{i,t}$. The nominal wages ($W_{i,t}$) are assumed to be exogenous to the firm. A conventional search and matching model with the wage in each period endogenously determined by Nash bargaining between individual firms and workers, induces too much volatility in wages compared to what can be observed in the data (see, e.g., Shimer (2005)). The exaggerated procyclical movement in wages dampens the cyclical movement in firms' incentives to hire. According to Yashiv (2007), there is agreement that wage behavior is not well explained by this model. Some wage stickiness has been found to better match US data in, for instance, Gertler and Trigari (2009) and Christiano, Eichenbaum, and Evans (2005). Wages in Sweden are to a large extent set in advance in nation-wide branch-level union contracts. The effect of wages is not a main focus of this study and therefore I stick with the exogenous wages as in Carlsson, Eriksson, and Gottfries (2013). This assumption is made to keep the model simple.

Production takes place with the CRS technology $Y_{i,t} = N_{i,t}$, where $N_{i,t}$ is the number of workers employed at the firm. Capital is not included in the production function in order to keep the model relatively simple. All firms sell their products in monopolistically competitive markets. The demand for a firm's output is $Y_{i,t} = \left(\frac{P_{i,t}}{P^{C}_{i,t}}\right)^{-\eta} D^{\sigma}_{i,t}$, where $P_{i,t}$ is the firm's price, $D_{i,t}$ is a firm specific demand-shifter, $\sigma > 0$ and $\eta > 1$. There is no price rigidity – the firms adjust their prices to sell what they have produced.

Matching of unemployed workers and vacancies takes place in each local labor market every period. The probability of filling a vacancy is given by $Q_{n,t} = \phi U_{n,t}^{\alpha_U} V_{n,t}^{\alpha_V - 1}$. For practical reasons it always takes some time to fill a vacancy and the matching process can be more and less efficient and this is reflected in the constant f. Because of the search frictions, the probability of filling a vacancy is affected by the number of unemployed and the number of vacancies in the local labor market. If there are no search frictions, α_U=(α_V-1)=0 and the probability of filling a vacancy is constant.

A fraction λ of the previously employed workers quit their jobs for exogenous reasons each period. This fraction is assumed to be sufficiently large for firms to be able to adjust the number of employees sufficiently downwards by hiring fewer workers, i.e., layoffs are not necessary. At the start of each period, firms choose the number of vacancies to open. Firm *i* opens $V_{i,t}$ vacancies and incurs real linear vacancy costs given by $c_V V_{i,t}$. Hiring is $H_{i,t} = Q_{n,t} V_{i,t}$ and the firm incurs real quadratic hiring costs given by $\frac{c_H}{2}\left(\frac{H_{i,t}}{N_{i,t-1}}\right)^2 N_{i,t-1}$. Convex hiring costs imply a smooth adjustment of the firms' labor force over time. The quadratic hiring costs include costs for training, reorganization, etc., while the vacancy cost includes costs for advertisement and recruiters for each period the vacancy is open.

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

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

s.t. $N_{i,\tau} = H_{i,\tau} + (1-\lambda) N_{i,\tau-1}$, $H_{i,\tau} = Q_{n,\tau} V_{i,\tau}$, and $N_{i,\tau} = \left(\frac{P_{i,\tau}}{P_{i,\tau}^C}\right)^{-\eta} D_{i,\tau}^{\sigma}$.

$N_{i,t}$ imizing with respect to the number of employees, $N_{i,t}$, yields:

$$E_t \left\{ \begin{array}{c} \frac{\eta-1}{\eta}\left(\frac{D_{i,t}^{\sigma}}{N_{i,t}}\right)^{\frac{1}{\eta}} - \frac{W_{i,t}}{P_{i,t}^C} - c_H\left(N_{i,t} - (1-\lambda)N_{i,t-1}\right){N_{i,t-1}}^{-1} - \frac{c_V}{Q_{n,t}} \\ + \beta c_H\left(N_{i,t+1} - (1-\lambda)N_{i,t}\right)(1-\lambda){N_{i,t}}^{-1} \\ + \beta \frac{c_H}{2}\left(N_{i,t+1} - (1-\lambda)N_{i,t}\right)^2 {N_{i,t}}^{-2} + \beta(1-\lambda)\frac{c_V}{Q_{n,t+1}} = 0 \end{array} \right\} \qquad (2)$$

From the first order condition (2), one can see that the firm will hire more workers if the probability of finding a worker in the current period ($Q_{n,t} = \phi U_{n,t}^{\alpha_U} V_{n,t}^{\alpha_V - 1}$) is higher, if the expected probability of finding a worker in the next period ($Q_{n,t+1}$) is lower, if the demand for the firm's products ($D_{i,t}$) is higher or if the real wage costs $\left(\frac{W_{i,t}}{P_{i,t}^{C}}\right)$ are lower. This equation will be used in the theoretical simulations of impulse-response functions. Since an individual firm is assumed to be small in relation to the market the probability of filling a vacancy in the local labor market is taken as given.

2.2 Parametrization

Carlsson, Eriksson, and Gottfries (2013) used the model to derive an empirical specification but they did not simulate their theoretical model. Simulations generate predictions concerning the magnitudes of the expected effects. Simulations and also allows me to see which parameter values of the model that are most crucial for the results. In this section, numerical values are assigned to the parameters of the model, aiming at being reasonable for the Swedish context. The period length is one month, which is the highest frequency for which I have the data to estimate the shocks and it seems like a reasonable time horizon according to the search and matching literature. The parameter values used are listed in Table 1.

I set $\alpha_U = \alpha_V = 0.5$, i.e., equal weights and constant returns to scale in the standard matching function. These parameter values are used in other studies such as Gertler and Trigari (2009). According to Petrongolo and Pissarides (2001), most studies estimating matching functions have found that a log-linear specification with coefficients around 0.5 for both vacancies and unemployment (CRS) fits the data well. Since the model is simulated around a steady state where the levels of the exogenous variables are one, the constant ϕ is set equal to the mean of Q in data I have for Sweden.[1] This gives $\phi = Q^{ss} = 1.6$, which means that vacancies are filled at the rate of 1.6 vacancies per month in steady state.

[1] Mean(Q)=$f * V^{\alpha} U^{\alpha-1} \rightarrow 1.6 = f * 1 * 1$. For a graph of a time series of Q for Sweden 1970-2011, see Figure 2. To calculate Q, monthly data for vacancies and unemployed from The Swedish Public Employment Service is used. Log deviations (≈percent changes) from the mean values of the exogenous variables in steady state are studied, not the steady state levels of these variables, and the model is simulated around a steady state where the levels of the exogenous variables are all normalized to 1.

Table 1. Parameter values

α_U	0.5	elasticity of Q with respect to U, standard CRS
α_V-1	-0.5	elasticity of Q with respect to V, standard CRS
f	1.6	constant in the Q function, from the data
λ	0.01	monthly exogenous separation rate
c_V	0.32	parameter in linear vacancy costs
c_H	7	parameter in quadratic hiring costs
η	7	elasticity of production with respect to the price
s	1.8	elasticity of production with respect to demand
β	0.997	monthly discount rate

The parameter λ is the rate at which employed workers quit their jobs for exogenous reasons. According to Statistics Sweden, around 3 percent or slightly more of the workers in the private sector left their jobs each quarter in 1990-2011, indicating a monthly separation rate of about 1 percent. I set λ= 0.01 to match this number.[2] The value 0.01 is smaller than the separation rate of 0.038 for the US in Michaillat (2012) and the monthly value that can be derived from the quarterly value for the US in Shimer (2005): 0.1/3≈0.033. A lower separation rate for Sweden than for the US is not surprising, since the US has a higher separation rate than many other countries. Yashiv (2000) set λ to 0.017 per month for Israel. Setting λ= 0.02 has almost no effect on my results.

The cost of recruiting a worker consists of two parts. The linear vacancy costs make the cost of recruitment higher the longer the duration of the vacancy. The other part is the quadratic hiring costs, which are independent of the probability of filling a vacancy. If the vacancy cost parameter, c_v, is set to zero, employment is not at all affected by shocks to vacancies and unemployment in the local labor market. If the hiring cost parameter c_H is set to zero, the employment effects of all shocks become stronger, and employment returns faster to steady state. With no convex adjustment costs (c_H=0) and a very high price elasticity (high η), the model approaches a standard search and matching model.

[2] Diagram in ”Kortperiodisk sysselsättningsstatistik 4:e kvartalet 2011”, AM 63 SM 1201, Statistics Sweden. Unfortunately, the data is only for the permanently employed and there is no corresponding diagram for all workers. Since the temporary workers are not included, λ=0.01 may be an understatement. Another issue is that, of course, separations being exogenous is a simplification. Especially in a recession, layoffs arise because firms close down or have to shrink their workforce drastically. Thus, the value for λ that I use might be an overstatement, since it includes some layoffs that are not exogenous but depend on the state of the labor market. It is not clear if the measure is overall overstating or understating the value of λ.

The value of the linear vacancy costs parameter, c_V, is taken from Michaillat (2012). In his calibration, the recruiting cost in the benchmark model was 0.32 $=0.32\bar{W}$, where $\bar{W}$ was the steady state wage. This value is a midpoint between two estimates based on data from two different US data sources.[3] I have seen no estimates of the vacancy cost parameter for Sweden. The steady state wage in my calibration is one and hence I calibrate c_V as 0.32. This might overstate the linear vacancy costs since some costs that should be included in the quadratic hiring costs might be included in this measure.

The value of the parameter in the quadratic hiring costs, $c_H=7$, is derived from the estimation of the Euler equation using Swedish firm-level data in Carlsson, Eriksson, and Gottfries (2013). There is support for convex hiring costs also in Yashiv (2012) and in Blatter, Muehlemann and Schenker (2012). There is, however, considerable uncertainty concerning the value of this parameter. Hence, I also examine cases with no quadratic hiring costs and markedly lower and higher hiring costs.[4]

Carlsson and Smedsaas (2007) have estimated the markup for Swedish manufacturing firms to 17 percent. Since the price markup over marginal cost is $\frac{\eta}{\eta-1}$, this translates into $\eta=7$. Thus I set $\eta=7$, which is not far from what is found in other studies. A steady-state markup of 10 percent ($\eta=11$) is a common value in the literature according to Krause, Lopez-Salido, and Lubik (2008). In the sensitivity analysis I examine what happens when I increase competition in the product market markedly.

The other parameter in the monopolistic demand function, s, is set to 1.8 as it was estimated for Swedish manufacturing firms in Carlsson, Eriksson, and Gottfries (2013).

The discount rate is the same as in Gertler and Trigari (2009), $\beta=0.99^{1/3}\approx0.997$, i.e., a monthly interest rate of 0.3 percent, which is close to the 0.4 percent in Yashiv (2000) and the values in most other studies.

Vacancies in the local labor market, unemployment, product demand, and real wage costs are exogenous in the theoretical model. Estimates of how these variables move over time are needed in order to simulate the model. Second order autoregressive processes are estimated, controlling for local linear time trends and seasonal effects. The

[3] The two data sources are Job Openings and Labor Turnover Survey and PricewaterhouseCooper. In the job market paper version from 2010, Michaillat also stated that his estimate was an average compared to other estimates found in the literature mentioning 0.213 in Shimer (2005), 0.357 in Pissarides (2009) and 0.433 in Hall and Milgrom (2008).

[4] For more information about the derivation of $c_H=7$ from CEG (2013), see Appendix A. A higher value, $c_H=13$, can also be derived from results in CEG (2013) with other assumptions. A lower value of $c_H=1.6$ can be derived from estimation on US data in Yashiv (2012). These two values are also derived in Appendix A, and they will be used in the sensitivity analysis.

aim is to identify unexpected variations that the firms haven't already taken into account in earlier employment decisions and neither the trend nor the seasonal variation should come as a surprise to the firms. AR(2) is chosen to keep it simple but still catch more of the dynamics than with AR(1).[5] The estimated AR(2) processes for the explanatory variables are presented in Table 2. The standard deviations of the residuals are the estimates that will be used as exogenous shocks to the variables. The coefficients for the lags provide information about how the variables will move over time until they return to steady state after the initial shock. The shocks should be of reasonable magnitude and persistence and are interpreted as standard unpredictable changes in economic conditions according to the data.

Data for unemployment and vacancies for all local labor markets in Sweden 1992-2011 are from the Swedish Public Employment Service. The variables representing product demand and real wage costs are constructed on the industry level using data from Statistics Sweden and the OECD. Product demand is an index including both domestic and foreign demand, weighted together by industry-level export shares. The real wage cost is the nominal wage deflated by a competitors' price consisting of domestic and international product prices. A more detailed description of these variables can be found in Eriksson and Stadin (2015). Data for these variables are not available on the firm level, but the industry level should work as an approximation.

Franco and Philippon (2007) used data for US firms and found that permanent changes in firm specific (relative) product demand and technology explain most of the firms' dynamics, but since these shocks are almost uncorrelated across firms, they are not important for aggregate dynamics. Transitory shocks, on the other hand, were found to be significantly correlated across firms, and accounted for most of the volatility in aggregate production and aggregate labor input. In this study, the focus is on the effects of typical, macro-related, transitory shocks (around a trend) on firm-level employment. The behavior of firms reflects back on the shock variables but how this happens is not modelled in this paper. The shocks are assumed to be exogenous to the firm that are simulated and their development over time is just taken from the data. This allows me to focus on firm behavior.

[5] Using AR(3) or AR(1) instead of an AR(2) in the simulations changes the employment dynamics very little.

Table 2. Estimated autoregressive processes for exogenous variables

Dependent: Current value of variable	(1) $\overline{\ln V}_{n,t}$	(2) $\overline{\ln U}_{n,t}$	(3) $\ln D_{j,t}$	(4) $\ln W^{r}_{j,t}$
First lag of variable	0.929***	1.471***	1.249***	0.992***
Second lag of variable	-0.303***	-0.548***	-0.307***	-0.050**
Time trends	yes	yes	yes	yes
Seasonal effects	yes	yes	yes	yes
Std.Dev. of residual	0.335	0.053	0.006	0.027
R-squared (within)	0.803	0.985	0.999	0.966

Notes: ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively. Unemployment and vacancy data are for all local labor markets (n) in Sweden in 1992-2011, the product demand for all industries (j) in Sweden in 1992-2008, and the real wage costs for all industries in manufacturing and mining 1992-2008, all in logs and at monthly frequency. The standard errors are robust, clustered at local labor market or industry. Fixed effects for local labor markets or industry, local or industry specific linear and quadratic time trends and seasonal effects are included in all regressions. Excluding the trends has little effect on the estimated processes.

2.3 Simulation of impulse response functions

The simulations show the employment dynamics for an individual firm which is calibrated to be an average Swedish firm. To do the simulations, the theoretical model is approximated around a steady state and he effects of temporary but persistent shocks to the exogenous variables are simulated.[6] Shocks to the explanatory variables are induced one at a time, and then the effects of each of these changes on the firm's employment can be observed. The shocks are log deviations from steady state, which are referred to as approximate percentage changes. I start with the baseline case, using the parameters listed in Table 1, and then I do some sensitivity analysis.

The simulated responses to positive and negative shocks are symmetric. However, the focus is on situations where the firm increases employment since the model assumes all employment adjustments to take place through changes in hiring. In most simulated cases, a corresponding downward adjustment of employment can be handled by simply reducing hiring.[7]

[6] The Matlab application Dynare is used, which by default makes a second order approximation of the model around steady state. The second order approximation is also what is used in the results presented in this paper. Using a first order approximation (linearization) or a third order yields almost identical employment dynamics.

[7] In more extreme cases, the exogenous quits are not enough and hence layoffs would be necessary in order to achieve big enough decreases in employment. Then the simulated employment responses are not really reliable. There are no vacancy costs associated with layoffs of workers, and the quadratic adjustment costs are probably different when hiring and when firing.

2.3.1 Baseline simulation

Impulse response functions for the baseline case are presented in Figure 1. A typical shock to vacancies consisting of a decrease of 34 percent[8] in the number of vacancies in the local labor market where the firm is located leads to a 17 percent increase in the probability of filling a vacancy and a maximum increase of 0.75 percent in the number of workers employed at the firm.

A typical shock to unemployment consisting of a 5 percent increase in the number of unemployed in the local labor market leads to a 4 percent increase in the probability of filling a vacancy and a maximum increase of 0.25 percent in the number of workers employed at the firm. It takes about two years for employment to return to steady state after a shock to the probability of filling a vacancy.

A 0.6 percent shock to product demand leads to a maximum response of 0.5 percent increase in employment, and a 2.7 percent negative shock to the real wage costs leads to a maximum response of 7.7 percent higher employment. It takes more than three years for employment to return to steady state after a shock to product demand or real wage costs.

I have also simulated impulse responses when one-percent shocks are induced, still using the baseline parameter values. This is to ease the interpretation of the effects, making them like elasticities. The maximum response in employment to a one-percent shock is 0.02 percent when the shock is to vacancies, 0.05 percent when the shock is to unemployment, 0.9 when the shock is to product demand, and 2.9 percent when the shock is to real wage costs. The unemployment shock is more persistent than the vacancy shock and rises after the initial one percent.

2.3.2 Sensitivity analysis

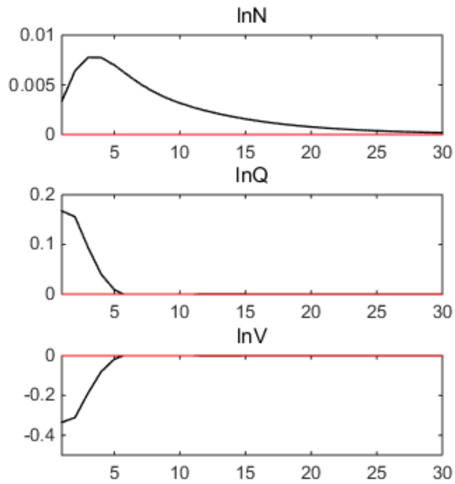
Table 3 shows the maximum employment responses in simulations changing some of the parameter values. Changing the parameter values for the quadratic hiring costs, the linear vacancy costs, and the degree of competition in the product market, I come to the conclusion that the convex adjustment costs seem to be important for the sizes of the employment responses, particularly in combination with the degree of competition in the product market. With no convex hiring costs and very high competition in the product market, the model approaches a standard search and matching model. Without

[8] The relatively big shock of a 0.34 log deviation is actually not very well approximated by 34 percent. When lnV goes from 0 to 0.34, V goes from 1 to 1.4, i.e., a 40 percent increase.

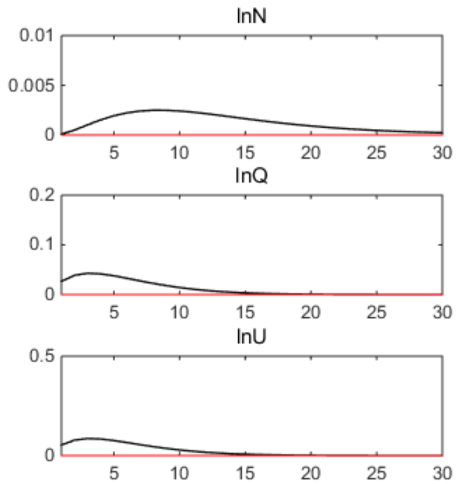
convex costs associated with adjusting the number of employees and at the same time high competition from other firms, the firm's responses to temporary shocks are fast and strong. For baseline convex hiring costs and baseline degree of competition in the product market, the vacancy cost per unit of time would have to be very high for substantial changes in employment to occur due to typical changes in the probability of filling a vacancy. The duration of a vacancy is always quite short, and compared to the potential gain in production and the wage costs for another employee, a few weeks' vacancy costs seem to be relatively unimportant in the decision to hire someone or not.

Figure 1. Simulation of a firm's employment responses to exogenous shocks

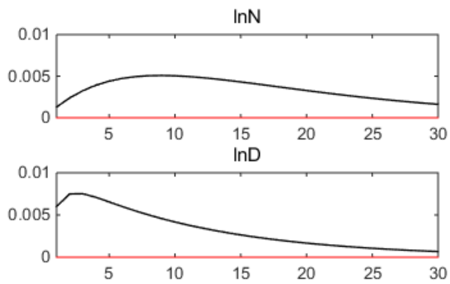
1a. Shock to the number of vacancies



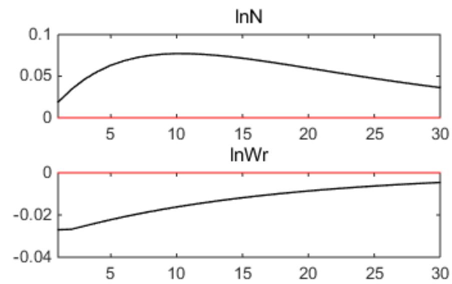
1b. Shock to the number of unemployed



1c. Shock to product demand



1d. Shock to the real wage costs



Note: The employment (N) is at the firm level, and the number of unemployed (U) and the number of vacancies (V) are at the local labor market level and are assumed to be taken as given by the individual firm, just as the demand for the firm's type of product (D) and the real wage cost facing the firm for each worker (Wr) are assumed to be taken as given. These theoretical impulse response functions are simulated with Dynare, Matlab. On the y-axis is log deviation from steady state and on the x-axis is the number of months. The graphs show the return to steady state after an exogenous shock. The sizes of the shocks and the development of the exogenous variables over time are given by the data, see Table 2. Parameter values are listed in Table 1.

Table 3. Simulated maximum firm level employment responses to shocks to the number of unemployed and to the number of vacancies in the local labor market

		(1) V-shock (-34%)	(2) U-shock (+5%)	(3) V-shock (-1%)	(4) U-shock (+1%)
1)	baseline	0.78%	0.25%	0.02%	0.05%
2)	c_H=13	0.48%	0.18%	0.01%	0.03%
3)	c_H=1.6	2.2%	0.45%	0.06%	0.09%
4)	c_H=0	8.7%	0.81%	0.26%	0.16%
5)	c_V=0.5	1.2%	0.39%	0.04%	0.08%
6)	c_H=0 & c_V=0.5	13.6%	1.23%	0.41%	0.25%
7)	η=50	1.1%	0.53%	0.03%	0.10%
8)	c_H=0 & η=50	63%	6.0%	1.85%	1.10%
9)	α_U=0.2 & (α_V-1)=-0.3	0.48%	0.10%	0.01%	0.02%
10)	Q^{ss} =1.3	0.96%	0.32%	0.03%	0.06%
11)	Q^{ss} =2.6	0.48%	0.16%	0.01%	0.03%

Notes: Employment responses simulated using Dynare, Matlab. Baseline parameter values are listed in Table 1. Q^{ss} can be changed by, e.g., changing U^{ss} and V^{ss} or f .

2.3.4 Simulations using estimated matching elasticities

Since I have data for the number of vacancies and unemployed for each local labor market in Sweden each month 1992m1-2011m12, I use this data to estimate the coefficients in the matching function. The results are presented in Appendix B. The number of unemployed in the local labor market has a rather small positive effect on the probability of filling a vacancy. The estimated effect is not robust, and in some specifications there is no effect at all. The number of vacancies, on the other hand, has a significant, negative, and robust effect on the probability of filling a vacancy. The weak estimated effect of the number of unemployed on the probability of filling a vacancy suggests that the employed job seekers and those out of the labor force make up a big share of all job seekers. Perhaps it also implies that it is often hard for unemployed workers to compete with employed workers searching on the job.[9] There could also be such a serious structural mismatch between the skills supplied and the skills demanded

[9] A more complex specification could include all job searchers: $Q_{n,t} = \phi J_{n,t}^{\alpha_J} V_{n,t}^{\alpha_V - 1}$, $J = \mu_U U + \mu_E E + \mu_O O$, where μ_U depend on the search intensity, abilities, choosiness etc. of the unemployed job searchers, and μ_E and μ_O are the corresponding parameters for job searchers that are employed and out of the labor force, respectively. If unemployed job searchers are less productive than others (or assumed to be less productive by the recruiting firms) they can somewhat compensate by spending more time searching and by accepting less attractive job offers, but the possibilities for less productive job searchers to compete for jobs by accepting lower wages are much limited in Sweden.

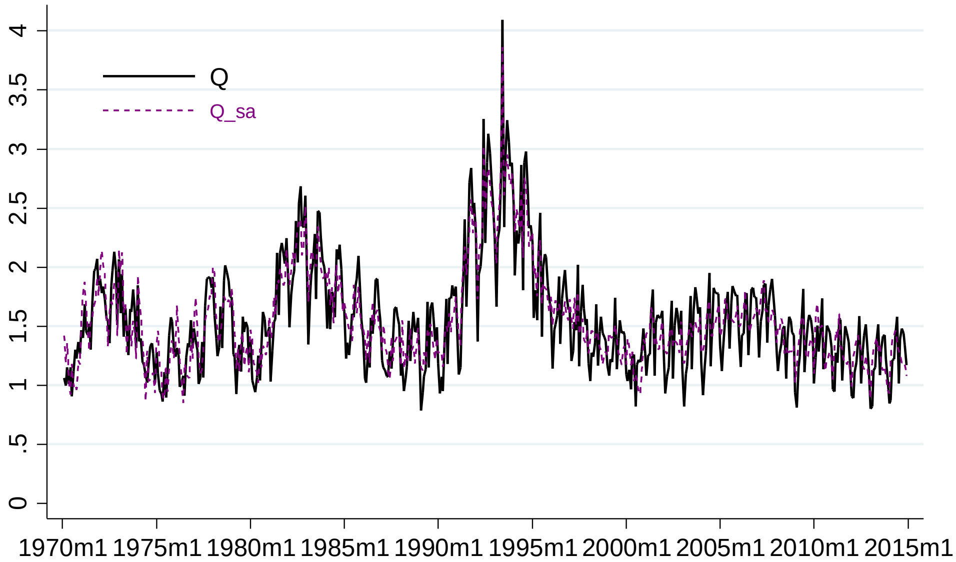
that those who are unemployed to a large extent cannot do the type of jobs for which there are vacancies. The mismatch can change because of, e.g., changed production technology or immigration of workers lacking basic education. The problem of mismatch has worsened in Sweden (according to, e.g., the Swedish Public Employment Service), which could be a reason for a smaller coefficient for unemployed than what was typically found in studies using data from earlier decades. Furthermore, if on-the-job search (for which there is no data) is an omitted variable which is procyclical, this will decrease the coefficient for unemployment; see Eriksson and Stadin (2015) for a discussion.

Setting α_U=0.2 and (α_V-1)=-0.3, in line with the estimated results, the employment responses to shocks to the number of unemployed and the number of vacancies decrease (see row 9 in Table 3). The employment response to the typical vacancy shock is 0.5 percent (0.8 in baseline) and the response to the typical unemployment shock is 0.1 percent (0.3 in baseline). The reason for using the parameter values $\alpha_U=\alpha_V$=0.5 as baseline and not my own, smaller estimates, is to make it clear that the employment responses are very small using values which are standard in the search and matching literature.

2.3.5 Different stages of the labor market

Michaillat (2012) has presented a theoretical model where the probability of filling a vacancy varies over the business cycle depending on labor market conditions. He found that matching frictions are less important during recessions when the probability of filling a vacancy is high. I will not test his exact theoretical model, because it is different than the model adopted in this paper. However, I will also bring up the subject of the importance of search frictions during different stages of the business cycle. David, Faberman, and Haltiwanger (2013) found that the job-filling rate in the US during the 2000s has moved countercyclically. Looking at aggregate monthly data for Sweden in 1970-2014 in Figure 2, I also find that the mean probability of filling a vacancy has been higher during recessions, particularly during the deep crisis in the early 1990s. According to simulations, a shock of the same size to the probability of filling a vacancy has a smaller impact on employment when the mean probability of filling a vacancy is high, see rows 10-11 in Table 3. When the probability of filling a vacancy is already at a high level, the duration of vacancies is short and the costs associated with vacancies are small. A typical shock to these costs of small importance is also of small importance.[10] Hence, search and matching frictions seem to be less important in a recession.[11]

Figure 2. Monthly aggregate vacancy filling rate in Sweden 1970-2014



Note: Q is defined as the outflow of vacancies during the month in relation to the mean stock of vacancies each month. The variable is calculated using data series from AMS/AF (Swedish Public Employment Service). For more information about the data, see Appendix C. For the probability of filling a vacancy plotted together with the number of unemployed and the number of vacancies in some local labor markets in 1992-2011, see Figure A1 in Appendix B.

The model used in this study assumes a log-linear form of the matching function in the labor market, which is standard in the search and matching literature. If there is in fact a non-linearity, such that the coefficients in the Q-function are different at different levels of unemployment and vacancies, this would further diverge the results between different stages of the business cycle. In Appendix D, there are some empirical estimation results indicating a non-linearity, particularly the unemployment effect seems to be bigger when unemployment is at a low level and then decrease when unemployment increases. In Carlsson, Eriksson, and Gottfries (2013) and Eriksson and Stadin (2015), unemployment had no significant impact on employment change and hiring of

[10] To better understand this result, look at the term $-\frac{c_V}{Q_{n,t}}$ in the Euler equation (2). When $Q_{n,t}$ is big, $\frac{c_V}{Q_{n,t}}$ is small. The potential gain in production and the real wage costs are relatively more important in the optimal decision to hire or not. This is the case regardless of the reason for a big $Q_{n,t}$. If a stage of a business cycle is long enough for firms to adjust such that it can be thought of as a steady state, one can think of U^{ss} and V^{ss} as being different at different stages of the business cycle and simulate the model for just one stage. The levels of U^{ss} and V^{ss} affect Q^{ss}, such that Q^{ss} is bigger in a recession, but they do not affect the percent Q-responses to percent shocks in V and U since the relation is log-linear. However, the firm's percent employment response to a certain percent change in Q is affected by the level of Q^{ss}.

[11] A more thorough analysis of this issue could include shocking the vacancy costs in a general equilibrium model (where aggregate vacancies and unemployed are endogenous variables).

unemployed workers, respectively, during the years of the deep crisis of 1990s when unemployment was at a high level. This would mean shutting down the unemployment effect altogether in the simulations (setting $\alpha_U = 0$).

3 Empirical estimation of determinants of employment on the firm level

The model used in this paper has been applied to data by Carlsson, Eriksson, and Gottfries (2013) and Eriksson and Stadin (2015). The reason for doing this yet another time is that I have access to richer data. In the first case they used yearly data for only a few hundred firms in manufacturing in the 1990s, which a period of a deep recession in Sweden. In the second case they used monthly data for all local labor markets in Sweden 1992-2008, but no firm level data. In this section I will estimate an employment equation which is derived from the theoretical model using yearly data for firms in all sectors in Sweden 1996-2008. Unfortunately, firm level data are not available at monthly frequency.

3.1 Data and empirical specification

3.1.1 Data

Register data from Statistics Sweden for firms in Sweden are used together with other data from Statistics Sweden, the OECD, and the Swedish Public Employment Service. Only firms that have at least ten employees all their years of existence are included in the estimations. This is because export data do not exist for firms with less than ten employees, but this limitation is also motivated by the fact that there is a lot of noise and large percentage changes for very small firms. Furthermore, many small firms consist of one person with no intention to employ others, and concerning those it would be more interesting to study the number of firms rather than employment growth in existing firms.

In order to diminish attrition bias, all firms with at least 10 employees all their years of existence are included instead of for each year including the firms with at least 10 employees that year. Otherwise firms with around 10 employees would be likely to drop out when they experience a negative shock, leaving observations only for those firms in the lower end of the firm size distribution that experience positive shocks, leading to series with missing observations for years with bad shocks for these firms. Using the current definition, such firms are not included any year. As a robustness check, only big firms with a mean of at least 50 employees are used. This is a limit far above the 10-limit, such that there could be big negative shocks and the firms would still be included in the sample.

The panel is unbalanced since new firms enter the sample and others exit during the sample period. The surviving firms do not constitute a random sample from the population of all firms. Furthermore, the 10-employees rule described above makes the sample less representative. One should keep in mind that the firms in my sample are typically bigger, older, and more profitable than the population of all firms.

It is not obvious when a firm is different enough to be seen as a new firm, and hence be given a new firm identification number in the dataset. In this study, the firm identities are the FAD-units from Statistics Sweden. Since this study focuses on employment changes caused by changes in product- and labor market conditions, it is relevant to try to diminish the noise caused by firms buying and selling establishments. The FAD-units are based on the organizational numbers, but the FAD-unit number changes if there are large mergers or splits affecting more than 50 percent of the workforce even though the organizational number is still the same.[12]

The number of employed is defined as full-year equivalents of the number of employees at each firm. The nominal mean wage at the firm is instrumented with a wage measure which is defined as the nominal total wage sum for all other firms in the same industry each year divided by the number of employees at these firms. The firm itself is excluded to make the instrument variable more exogenous to the firm. The real wage cost is defined as the nominal wage cost divided by the market price relevant for the firm.

The variables representing product demand and market price are constructed using data from Statistics Sweden and the OECD. Similar variables have been used by Carlsson, Eriksson, and Gottfries (2013) and in Eriksson and Stadin (2015). Product demand is an index including both domestic and foreign demand at the industry level weighted together using the firm-specific mean export share. In order to avoid simultaneity due to unobserved industry-specific shocks, industry production is not used

[12] More information about the definitions can be found in the document “Företagens och arbetsställenas dynamik (FAD)” from Statistics Sweden. This way of dealing with large organizational changes is somewhat similar to the approach taken by Franco and Philippon (2007). They used a panel of large US companies that did not experience a large merger defined as increases in the assets of the company by more than 50 percent.

when constructing the measure of industry-specific domestic demand. Product demand is constructed to be as exogenous as possible to the firm by using only data for aggregate components of domestic demand, data for foreign demand, and weights that do not vary over time. Similarly, the price measure consists of domestic and international product prices at the industry level weighted together by the fixed, firm-specific export shares. For more information about these two variables, see Appendix F.

The data for vacancies cover the stock of vacancies registered at the Swedish Public Employment Service in each local labor market. The yearly measure that I use is the mean of the monthly stocks during the year. Many vacancies were never announced at the Public Employment Service, even though it was mandatory to do so,[13] but this is the best measure of vacancies available for the period studied. Unemployment is measured by the number of openly unemployed workers registered at the Public Employment Service in each local labor market and again the yearly measure is the mean of the monthly stocks. There is a strong incentive for unemployed workers to register since this is required to qualify for unemployment benefits. These measures of vacancies and unemployed can be compared to survey measures from Statistics Sweden using aggregate data in the 2000s, see Appendix E.

Local labor markets consists of one or more municipalities and they are entities constructed by Statistics Sweden to be geographical areas that are as independent as possible in terms of labor demand and supply. Firms with several establishments are assigned the local labor market of the main establishment reported in the data. As a robustness check, the regression is run only for the firms with one establishment. More than 90 percent of the firms are located in the same local labor market throughout their period of existence. A firm switching labor market number is assigned the local labor market to which it belonged the longest period of time.

More than 90 percent of the firms are in the same industry throughout the time period that they exist in the data. A firm changing industry is assigned the industry to which it belonged for the longest period of time. Typically, a firm doesn't change its production totally but just tips over in the composition of goods leading to a change in industry classification.

[13] It was mandatory for all employers to announce their vacancies at the PES until 2007 and still is for the state.

3.1.2 Empirical specification

The empirical specification is

$$\ln N_{i,t} = \beta_{0,i} + \beta_{1,i}\ln N_{i,t-1} + \beta_{2,i}\ln D_{i,t} + \beta_{3,i}\ln W^{r}_{i,t} + \beta_{4,i}\ln U_{i(n),t} + \beta_{5,i}\ln V_{i(n),t} \qquad (3)$$
$$+d_t + \epsilon_{i,t}.$$

The specification is based on the solution to the model in section 2 (see equation 2 and the derivation in Carlsson et al 2013). Employment at the firm is expected to depend positively on product demand, negatively on real wage costs, positively on the number of unemployed workers available and negatively on the number of vacancies posted by other firms in the same local labor market. Since there are convex adjustment costs in the model, firms don't adjust employment immediately so high employment last period indicates that employment will be high also in the current period.

Fixed effects for firms are included in all regressions ($\beta_{0,i}$). Time dummies for each year 1996-2008 (d_t) are included to control for unobserved aggregate shocks and common time trends. The standard errors are clustered at the firms to make them robust to autocorrelation and heteroskedasticity.[14] The variables $\ln U_{i(n),t}$ and $\ln V_{i(n),t}$ are instrumented with the stocks at the end of the previous year to make them predetermined and hence reduce simultaneity problems. If, for example, an unemployed worker is hired by a firm in the sample there is one less unemployed worker and simultaneously one more employed, implying a negative correlation which disturbs the positive supply effect which I try to estimate. To use lags as instruments for stocks of vacancies and unemployed is common in the literature estimating matching functions, but can be problematic due to serial correlation. One way to make the vacancy measure more exogenous would be to subtract the firm's own vacancies from the vacancies in the local labor market, but unfortunately there is no data for the number of vacancies at the firm level.

Inclusion of the lag of the dependent variable will possibly lead to a bias since part of the coefficient for the lagged dependent variable may be picked up by the firm fixed effects. This type of bias diminishes when the number of periods increases. Since the time dimension is not very long in my data (13 years), there is a possible dynamic panel

[14] Wald tests indicate heteroskedasticity and Wooldridge tests indicate autocorrelation in the residuals.

bias.[15] Arellano and Bond (1991) suggested handling this problem by first differencing the fixed effects away and then instrumenting the lagged dependent variable with older lags in a GMM-type estimation. I first do fixed effects 2SLS estimations and then difference GMM estimations as a robustness check. However, for the GMM method to be more reliable than the 2SLS, it is essential to find a good instrument set which is both relevant and valid, and this is difficult.

It is problematic to formally test for stationarity in such a large, unbalanced panel with missing values and a relatively short time dimension, but some kind of time trends may be included in the estimated equations to avoid spurious correlations. The time dummies include common time trends. As a robustness check, industry-specific trends and local time trends are also included in the regression.

3.2 Estimation results

Estimation results are shown in Table 4 and Table 5, with column 1 in both tables showing the baseline specification. The coefficients for number of unemployed and the number of vacancies in the local labor market are small, have the opposite sign to that predicted by the theory, and they are statistically significant in the main specification but not in several of the robustness checks. The expected effects are absent also in the case when only one-establishment firms are included in the estimation (see column 2, Table 5). Coefficient estimates quite close to zero are in line with the prediction from the theoretical simulation: variations in the number of vacancies and the number of unemployed in the local labor market do not seem to be important for explaining the variation in firms' employment.

The unexpected signs for the coefficients for vacancies and unemployed in the local labor market might be an indication that the instruments used, i.e. the stocks in the end of last period, are not exogenous enough. Another issue is that matching processes are probably better studied using higher frequency data since the number of unemployed and the number of vacancies vary substantially during the year such that yearly measures become rough.[16] Moreover, the expected effects from shocks of one percent in

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[15] A rough rule of thumb is that the problem should be considered up to T=30, and seriously considered when T<10, such as the six years in Arellano and Bond (1991).

[16] Forslund and Johansson (2007) have studied matching functions using high frequency data and they found that time aggregation is problematic and warned against strong beliefs in yearly estimates. In Eriksson and Stadin (2015), the theoretical model in this study has been tested on monthly data at the local labor market level.

the simulations are very small and if this is correct it is probably hard to identify these effects empirically.

Table 4. Explaining firms' employment

Dependent variable: Employment at firm $(\ln N_{i,t})$	(1) baseline	(2) industry trends	(3) GMM A-B	(4) GMM A-B i-t
Lag of employment $(\ln N_{i,t-1})$	0.647***	0.641***	0.627***	0.579***
	(0.006)	(0.007)	(0.023)	(0.025)
Product demand $(\ln D_{i,t})$	0.121***	0.261***	0.168***	0.256***
	(0.021)	(0.035)	(0.031)	(0.047)
Real wage costs $(\ln W^{r}_{i,t})$	-0.030***	0.022*	-0.065***	-0.033
	(0.006)	(0.013)	(0.012)	(0.024)
Unemployment in llm $(\ln U_{i(n),t})$	-0.012**	-0.015**	-0.001	-0.007
	(0.006)	(0.006)	(0.014)	(0.014)
Vacancies in llm $(\ln V_{i(n),t})$	0.013**	0.014***	0.011	0.008
	(0.005)	(0.005)	(0.010)	(0.010)
Time dummies	yes	yes	yes	yes
Industry trends	no	yes	no	yes
2SLS	yes	yes	no	no
GMM Arellano-Bond	no	no	yes	yes

Note: Robust standard errors are in parentheses, clustered at the firms. ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively. Yearly data for firms in Sweden with at least 10 employees 1996-2008, about 140 000 observations. Fixed effects for firms and time dummies are included in the 2SLS estimations ('xtivreg2' in Stata). The mean log stocks of unemployed and vacancies are instrumented with the log stocks in the end of the previous period. The wage cost of the firm is instrumented with a measure where the nominal wage part is the mean wage for all the firms in the industry except the firm itself. In the Arellano-Bond estimation ('xtabond2' in Stata) the instruments used are three lags of the stocks of vacancies and unemployed in the end of last period, the second and third lag of employment, and three lags of product demand and industry real wage costs. The instruments seem to be relevant but not really valid, so the results should be interpreted with caution. It's hard to find a relevant and valid instrument set. An instrument set only including lags of product demand and real wage costs seem to be valid (according to Hansen test), but the relevance of this instrument set for the lag of the firm's employment, the number of unemployed and the number of vacancies in the local labor market seems to be low, and the resulting coefficients for these variables doesn't seem reasonable.

There is a positive employment effect of product demand which is significant and robust. This result confirms that imperfect competition in the product market should be taken into account when studying employment dynamics. The real wage costs have a small and negative employment effect which is not robust.[17] The big coefficient for the lag of employment in all specifications indicates a sluggish response which could be explained by large convex adjustment costs.

[17] The simulated employment response to a wage shock is much larger. The responses to wage shocks are modelled in a very simplified way and could be made more realistic by, e.g., introducing customer markets where the consumers have formed habits which make them stay longer with a product even when there is an increase in the price due to an increase in the wage cost of the firm. However, the size of the simulated responses to shocks to the real wage costs are not in focus in this study.

Table 5. Explaining firms' employment, robustness

Dependent variable: Employment at firm	(1) baseline	(2) one-establish-ment firms	(3) mean N≥50	(4) groups with the same owner	(5) manufacturing
Lag of employment	0.647***	0.635***	0. 675***	0.602***	0. 693***
	(0.006)	(0.007)	(0.014)	(0.010)	(0.012)
Product demand	0.121***	0.118***	0.192***	0.106***	0. 221***
	(0.021)	(0.023)	(0.041)	(0.032)	(0.033)
Real wage costs	-0.030***	-0.027***	-0.042***	-0.036***	0. 007
	(0.006)	(0.007)	(0.011)	(0.009)	(0.006)
Unemployment in llm	-0.012**	-0.015**	-0.005	-0.014	-0.009
	(0.006)	(0.007)	(0.012)	(0.011)	(0.010)
Vacancies in llm	0.013**	0.005	0.025	0.007	0.011
	(0.005)	(0.006)	(0.010)	(0.007)	(0.008)
Time dummies	yes	yes	yes	yes	yes
2SLS	yes	yes	yes	yes	yes
Observations	140,554	103,889	40,356	116,432	46,316

Note: Robust standard errors are in parentheses, clustered at the firms. ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively. Yearly data for firms in Sweden with at least 10 employees 1996-2008. The mean log stocks of unemployed and vacancies are instrumented with the log stocks in the end of the previous period. The wage cost of the firm is instrumented with a measure where the nominal wage part is the mean wage for all the firms in the industry except the firm itself.

Inclusion of industry-specific linear time trends in addition to the time dummies causes the wage measure to lose its negative significance, while the coefficient for the product demand variable is increased (see column 2, Table 4). Inclusion of local time trends in addition to the time dummies has very little effect on the estimation results (not in table). Including local and industry specific linear trends but no time dummies in the regression (not in table) gives similar results as when including these trends in addition to the time dummies. When I only include firms in manufacturing in the sample there is, somewhat surprisingly, no significant wage effect (see column 5, Table 5). Only including big firms (column 3, Table 5) or using groups of firms with the same owner as units in the estimation (column 4, Table 5) has little effect on the results. Only including firms existing all 13 years, i.e., balancing the panel, (not in table) has very little effect on the results.

A product demand effect on employment is present in all robustness checks. There are other studies emphasizing the importance of product demand. Carlsson, Eriksson, and Gottfries (2013) found support for product demand to be important for explaining employment at Swedish firms in manufacturing 1992-2000, and in another closely related paper Eriksson and Stadin (2015) found that product demand was important for hiring in local labor markets in Sweden 1992-2008. Michaillat and Saez (2015) used US data and came to the conclusion that labor market fluctuations are mostly explained to labor demand shocks reflecting aggregate demand shocks (and not by shocks to labor supply or technology).

4 Conclusions

When it is easier to recruit workers, this should have a positive effect on hiring, according to search and matching theory. Carlsson, Eriksson, and Gottfries (2013) presented a model featuring search frictions in the labor market and imperfect competition in the product market. In this model, the employment at a firm is explained by product demand, real wage costs, and the probability of filling a vacancy. The probability of filling a vacancy is positively affected by the number of unemployed workers available and negatively affected by the number of vacancies posted by other firms. Numerical simulations of this theoretical model show a quite small employment effect of a typical shock to the number of vacancies and a very small employment effect of a typical shock to the number of unemployed. The employment effects of these shocks seem to be even smaller in recessions than in booms. The reason for the smaller response to the unemployment shock is the empirical fact that shocks to unemployment are typically not as big as those to the number of vacancies in the local labor market.

The conclusion from the simulations is that even if the number of unemployed and the number of vacancies affect the time it takes to fill a vacancy, this does not seem to matter much for firms' decision to hire or not. The linear vacancy costs would have to be very high for shocks to the probability of filling a vacancy to be important for employment dynamics, or there must be no convex adjustment costs and extremely high competition in the product market so that the model approaches a standard search and matching model. None of these special cases seem to be reasonable considering empirical findings in this and other studies.

A very small simulated firm-level employment effect of temporary (but persistent) shocks to the number of unemployed does not mean that the level of labor supply is unimportant for the aggregate level of employment in the long run. A permanent increase in supply is expected to create its own demand in the long run.

To see how well these theoretical predictions match the data, an employment equation in line with the theory is estimated using yearly data for all firms in Sweden with at least ten employees 1996-2008. In line with the predictions from the theoretical simulation, the estimation results suggest that neither the number of unemployed nor the number of vacancies in the local labor market is important for firms' employment dynamics. The responses to one percent shocks are almost zero both in the theoretical simulation and in the empirical estimation.

The estimations show a robust positive effect of product demand and weak negative effect of real wage costs on firms' employment. These empirical results are roughly in line with what was found in Carlsson, Eriksson, and Gottfries (2013) for manufacturing firms in the 1990s. Also, the results are largely consistent with those of Eriksson and Stadin (2015) who estimated an equation for hiring in a local labor market based on the same theory as is used in the current paper. While the current study uses yearly firm level data, Eriksson and Stadin (2015) used monthly data for all local labor markets in the 1990s and 2000s. When using the outflow of vacancies as the dependent variable, they found a positive effect of product demand, a negative effect of real wage costs and no significant effect of the number of unemployed workers in the local labor market. When using the hiring of unemployed workers as the dependent variable, they found a positive effect of unemployment. This positive effect was present during the 2000s but not during the years of deep recession in the 1990s. However, it is only in the simplest search and matching model that the filling of a vacancy is the same thing as the hiring of an unemployed worker. A large fraction of the vacancies are filled with workers who go directly between jobs or in and out of the labor force. Matching is not the same thing when looking at it from the perspective of the firm as when looking at it from the perspective of the unemployed worker.

Overall in these three closely related studies, the positive product demand effect on employment seems to be rather robust, the negative wage cost effect is usually present but smaller, and the effects of the number of unemployed and the number of vacancies in the local labor market seem to be small and often not present, particularly not during recessions.

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Appendix

Appendix A: Derivation of the quadratic hiring costs parameter

The value of the parameter in the quadratic hiring costs is derived from the estimation of the Euler equation in Carlsson, Eriksson, and Gottfries (2013). Setting η=7 and s=1.8, I can use their estimated coefficient for the product demand variable to derive a monthly value of 2.6. I use $\gamma_d = \frac{\sigma(\eta-1)}{c_H\eta^2}$ and calculate c_H per year as 1*(7-1)/(0.38*7^2) ≈0.58, and hence the monthly value as 0.58*12≈7.

Carlsson, Eriksson, and Gottfries themselves reported a yearly value of 1.1 for c_H, indicating a monthly value of 1.1*12≈13. However, this is consistent with η=2.6, which is improbably small, implying a markup of over 60 percent in the product market. This is why c_H =13 is not used in baseline but as a special case.

The relation between the yearly and monthly value can be derived as follows: Approximately setting $H^y = 12H^m$ (constant hiring during the year) and $N_t = N_{t-1}$ (constant N, i.e., few hires in relation to a large number of employed at the firm), the yearly costs are $\sum_{t=1}^{t=12} \frac{c_H^m}{2}\left(\frac{N_t-(1-\lambda)N_{t-1}}{N_{t-1}}\right)^2 \approx 12\frac{c_H^m}{2}\left(\frac{H^m}{N}\right)^2 = 12\frac{c_H^m}{2}\left(\frac{\frac{H^y}{12}}{N}\right)^2 = \frac{1}{12}\frac{c_H^m}{2}\left(\frac{H^y}{N}\right)^2$, and $\frac{1}{12}\frac{c_H^m}{2}\left(\frac{H^y}{N}\right)^2 = \frac{c_H^y}{2}\left(\frac{H^y}{N}\right)^2 \rightarrow c_H^m = 12c_H^y$. If c_H^m is 12 times bigger than c_H^y, there is about 12 times less adjustment per month than per year.

There is not much evidence concerning the size of quadratic hiring costs in the literature to compare to. In Yashiv (2012), there is a quarterly estimate of quadratic hiring costs of 0.39, which very roughly translates into a monthly value of 1.6 (fourth times bigger in order to have four times less adjustment).

Appendix B: Estimating matching elasticities

The Q-equation is estimated on monthly panel data from the Swedish Public Employment Service (AF) for the time period of 1992-2011. The data includes the stock of vacancies registered at the Public Employment Service in the beginning of each month and the inflow of new vacancies during the month. Unemployment is measured by the number of openly unemployed workers registered at the Public Employment Service in the beginning of the month. The data from the Public Employment Service are measured at the municipality level and at a monthly frequency. I aggregate the data to get a dataset with variables for local labor markets. A local labor market consists of one or more municipalities and is constructed by Statistics Sweden to be a geographical area that is as independent as possible concerning labor demand and labor supply. All the 90 local labor markets (in the 2000 version) are listed in Appendix G. (Instead using the 109 local labor markets according to the 1993 version has little effect on the results.) Figure A1-A3 show some illustrations of the data.

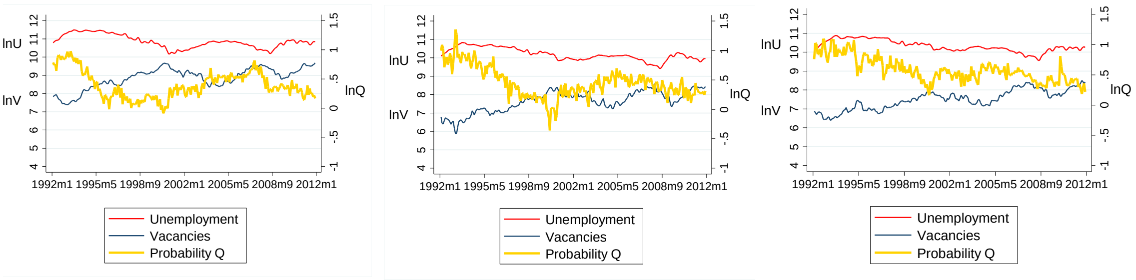
The main estimation method is 2SLS with fixed effects for the local labor markets and time dummies. A test for constant returns to scale indicates decreasing returns to scale for column 1, Table A1. Time dummies for each period are included to diminish the risk of biased estimates due to unobserved aggregate shocks. They handle, e.g., changes in regulation that change the variables at all local labor markets at a certain point in time. They also control for seasonal effects. Matching functions are typically estimated in log linear form, as in columns 1-2 in Table A1. In columns 3-4, a poisson GMM estimation technique is used to deal with the problem of biased estimated due to log transformation in combination with heteroskedastic residuals (cf. Silvana and Tenreyo (2006)). This estimation method doesn't rely on log linearization and the dependent variable is Q instead of lnQ. The reason for the IV-approach (col 1-4) is that unemployment and vacancies are reduced by matches, which biases the estimated coefficients. Due to this, the lags, which are predetermined, are used as instruments for the mean log stocks during the period.

The variables do not seem to be stationary, but trend-stationary around local trends, according to Fisher and Hadri tests. Thus, I want include local trends in the estimations. However, theory suggests a long run linear relation between the three variables lnQ, lnU, and lnV. I test for cointegration between these variables and find that a cointegrating relation is most likely present using Westerlund ECM panel tests (and using Johansen and Engle-Granger tests for the aggregate data). Hence, the time trends are probably not necessary in the estimation. Table A1 and Table A2 show estimations with and without the local trends included.

The local trends remove some of the variation that can be used to identify the effects. The standard deviation of the log variables (lnV and lnU) after removing the variation explained by fixed effects for local labor markets, time dummies and local time trends is still at least 0.12, which indicates that this is not a big concern.

Figure A1. Monthly data for unemployment, vacancies, and the probability of filling a vacancy for some large local labor markets in Sweden 1992-2011

a. Stockholm (llc 1) b. Göteborg (llc 32) c. Malmö (llc 25)



Note: All variables are in logs and seasonally adjusted for each local labor market using dummies for month of the year. Data from AF (Swedish Public Employment Service).

Table A1. Explaining the probability of filling a vacancy

Dependent variable: $\overline{\ln Q}_{n,t}$	**(1)**	**(2)**	**(3)**	**(4)**
Unemployment ($\overline{\ln U}_{n,t}$)	0.162***	-0.006	0.284***	0.050
	(0.044)	(0.043)	(0.067)	(0.060)
Vacancies ($\overline{\ln V}_{n,t}$)	-0.266***	-0.287***	-0.386***	-0.416***
	(0.020)	(0.020)	(0.030)	(0.031)
Fixed effects for llm	yes	yes	yes	yes
Time dummies	yes	yes	yes	yes
Local time trends	no	yes	no	yes
2SLS	yes	yes	no	no
GMM IV-poisson	no	no	yes	yes
Observations	21,270	21,270	21,270	21,270
R-squared (within)	0.499	0.548	-	-
Number of llm	90	90	90	90

Note: Robust standard errors are in parentheses, clustered at the local labor markets. ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively. Monthly data for all local labor markets in Sweden in 1992-2011 from AF (PES). All variables are in logs. Fixed effects for local labor markets are included in all regressions ("xivtreg2, fe" in Stata). 2SLS estimations where the mean log stocks of the number of unemployed and vacancies ($\overline{\ln U}_{n,t}$ and $\overline{\ln V}_{n,t}$) are instrumented with initial log stocks each month. The local time trends are both linear and quadratic.

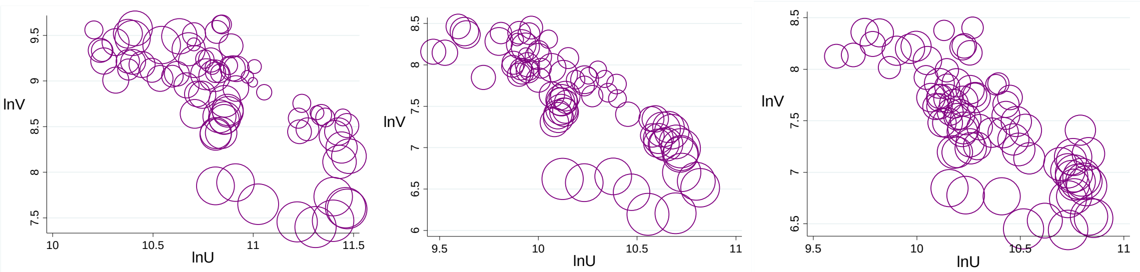
Table A2. Explaining the probability of filling a vacancy, robustness

	Local seasons, panel Dep.: $\overline{\ln Q}_{n,t}$		First-differences, panel Dep.: $\overline{\ln Q}_{n,t}$		Aggregate variables Dep.: $\overline{\ln Q}_{t}$	
	(1)	(2)	(3)	(4)	(5)	(6)
Unemployment $(\overline{\ln U}_{n,t})$	0.054**	-0.062	-0.049	-0.053	-0.062	-0.133
	(0.026)	(0.040)	(0.160)	(0.157)	(0.118)	(0.086)
Vacancies $(\overline{\ln V}_{n,t})$	-0.310***	-0.318***	-0.325***	-0.326***	-0.420***	-0.346***
	(0.017)	(0.019)	(0.024)	(0.024)	(0.083)	(0.075)
Fixed effects for llm	yes	yes	yes	yes	no	no
Time dummies	no	yes	yes	yes	no	no
Local time trends	yes	yes	no	yes	no	no
Local seasons	yes	yes	no	no	no	no
Common seasons	no	(yes)	(yes)	(yes)	yes	yes
Common time trends	no	(yes)	(yes)	(yes)	no	yes
2SLS	yes	yes	yes	yes	yes	yes
Observations	21,270	21,270	21,080	21,080	239	239
R-squared (within)	0.577	0.613	0.270	0.270	0.750	0.804
Number of llm	90	90	90	90	-	-

Note: Robust standard errors are in parentheses, clustered at the local labor markets. ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively. Monthly data from AF for all local labor markets in Sweden 1992-2011. All variables are in logs. IV estimations where the mean log stocks of unemployment and vacancies (in col 3-4 in differences) are instrumented with lags of the stocks. All the time trends are both linear and quadratic except for the local trends in col 3-4 which are only linear after the differentiation.

Figure A2. Bubble scatter plots for some large local labor markets in Sweden

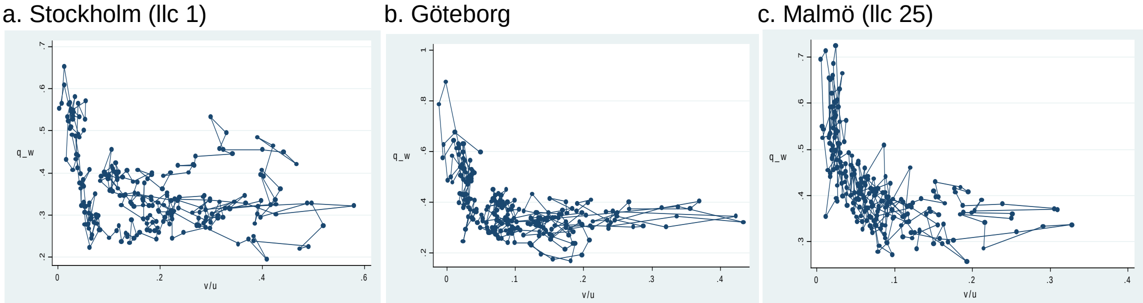
a. Stockholm (llc 1) b. Göteborg c. Malmö (llc 25)



Note: The larger probability of filling a vacancy the larger the bubble. All variables are in logs. Quarterly means of seasonally adjusted monthly values 1992-2011. Data from AF (PES).

Figure A3. Plots of the probability of filling a vacancy (Q, y-axis) vs tightness (V/U, x-axis)

a. Stockholm (llc 1) b. Göteborg c. Malmö (llc 25)



Note: Variables are seasonally adjusted and not in logs. Stocks of the number of unemployed and vacancies are measured in the very beginning of the month. q_w is the mean probability of filling a vacancy within a week during the month. Monthly data from AF (PES) for the three largest local labor markets in Sweden in 1992-2011. The mean aggregate tightness for Sweden in 1992-2011 is 0.1 and the mean of probability of filling vacancy within a week is 0.4.

Appendix C: Data for the aggregate probability of filling a vacancy

Figure 2 shows the monthly mean vacancy filling rate in Sweden each month 1970-2014 calculated using data from the Swedish Public Employment Service. The data includes the stock of vacancies registered at the Public Employment Service in the beginning of each month and the inflow of new vacancies during the month. Qtot = $(V_t + F_t^m - V_{t+1}) \div \frac{V_t + V_{t+1}}{2}$, where F_t^m = inflow of vacancies during the month beginning at time *t*, V_t = stock of vacancies at the beginning of month *t*, and the outflow of vacancies is $(V_t + F_t^m - V_{t+1})$.

The mean of this vacancy filling rate is 1.6, which implies that a vacancy has usually been filled within slightly more than half a month. This duration seems to be in line with earlier findings. Edin and Holmlund (1991) found that the average duration of registered vacancies varied in the range of two to four weeks in Sweden in 1970-1988. In Blanchard and Diamond (1989), the average duration of vacancies in the US in 1968-1981 also varied between two and four weeks.

Many vacancies are never announced at the Public Employment Service, even though it is mandatory to do so (for private employers it has no longer been mandatory since 2008), but this is the best measure of vacancies available for a longer time period. The fact that not all vacancies are registered is a problem if these vacancies are not representative of all vacancies concerning how fast they are filled.

If many vacancies are closed without getting filled, this measure of the probability of filling vacancies is too big and not very good. According to a survey conducted by AF in 2011, about 80 percent of the employers posting vacancies reported having received enough applications to hire. Edin and Holmlund (1991) referred to evidence indicating that the major part of the outflow of vacancies was associated with hiring; Farm (1989), for instance, found that only 10 percent of the posted vacancies were withdrawn because of failure to find a suitable worker.

Appendix D: Non-linearity in the matching function

Table A3. Explaining the probability of filling a vacancy, including quadratic terms

Dep.: $\overline{\ln Q}_{n,t}$	(1)	(2)
$\overline{\ln U}_{n,t}$	0.698***	0.220
	(0.145)	(0.171)
$\overline{\ln V}_{n,t}$	-0.428***	-0.397***
	(0.059)	(0.064)
$\overline{\ln U}_{n,t}{}^2$	-0.047***	-0.017
	(0.011)	(0.012)
$\overline{\ln V}_{n,t}{}^2$	0.020**	0.015*
	(0.008)	(0.009)
Fixed effects for llm	yes	yes
Time dummies	yes	yes
Local time trends	no	yes
2SLS	yes	yes
Observations	21,082	21,082
R-squared (within)	0.517	0.549
Number of llm	90	90

Note: 2SLS. Robust standard errors are in parentheses, clustered at the local labor markets. ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively. Monthly data for all local labor markets in Sweden in 1992-2011. All variables are in logs. Data for local labor markets in Sweden 1992-2011 from AF. Fixed effects for local labor markets are included in all regressions. The local time trends are both linear and quadratic. IV-estimations where the mean log stocks of vacancies and unemployment are instrumented with the initial stocks, and the quadratic terms are instrumented with their first lags. There seems to be some evidence of quadratic relations. The probability of filling a vacancy seems to be more affected by the number of unemployed when this stock is at a lower level.

Appendix E: Comparing measures from PES and Statistics Sweden

Figure A4. Different measures of vacancies and unemployed for Sweden 2001-2013

a. Number of vacancies

b. Number of unemployed

Note: AF is The Public Swedish Employment Service (the data used in this study). SCB is Statistics Sweden. The main series for vacancies from SCB is defined as the number of recruiting processes going on according to respondents in a survey. The alternative series is the share of these vacant jobs which are currently unmanned according to the same survey (this is the variable called vacancies by SCB). The main series for unemployment from SCB is from the AKU-survey and includes, e.g., students saying they are applying for a job for the summer vacation. The alternative measure of unemployed from SCB is the old definition used in the same survey (not including these students etc.), which is not available after 2005. All series are seasonally adjusted.

Appendix F: The product demand and the market price variable

Product demand variable:

$$\ln D_{i,t} = (1-\delta_i)\ln D^{D}_{j,t} + \delta_i \ln D^{I}_{j,t}$$

$$\ln D_{i,t} = (1-\delta_i)\left(\phi^{C}_{j}\ln C_t + \phi^{G}_{j}\ln G_t + \phi^{I}_{j}\ln I_t + \left(1-\phi^{C}_{j}-\phi^{G}_{j}-\phi^{I}_{j}\right)\ln EX_t\right) + \delta_i\left(\sum\nolimits_m \omega_{j,m}\ln Y^{F}_{j,m,t}\right)$$

Domestic and international product demand for the industry of the firm are weighted together using the firm's mean export share. In order to avoid simultaneity due to unobserved industry specific shocks, industry production is not used when constructing the measure of industry specific domestic demand. Fixed components of aggregate demand can be used instead.

Market price variable:

$$\ln P^{0}_{i,t} = (1-\delta_i)\ln P^{D}_{j,t} + \delta_i \ln P^{I}_{j,t}$$

$$\ln P^{0}_{i,t} = (1-\delta_i)\ln P^{D}_{j,t} + \delta_i\left(\sum_m \omega_{j,m}\left(\ln E_{m,t} + \ln P^{F}_{j,m,t}\right)\right)$$

The subscript *i* denotes firm, *j* denotes industry, *t* denotes year and *m* denotes country.

Domestic and international product demand for the industry of the firm are weighted together using the firm's mean export share. In order to avoid simultaneity due to unobserved industry specific shocks, industry production is not used to construct the measure of industry specific domestic demand ($\ln D^{D}_{j,t}$). Fixed components of aggregate demand can be used instead

δ_i is the fixed firm-specific (direct) export share. Data used is from the register dataset from Statistics Sweden. This is the mean export share for each firm during the firm's years of existence 1996-2008.

ϕ^{C}_{j} is the industry-specific share of output going to final private consumption in total domestic use. ϕ^{G}_{j} is the industry-specific share of output going to final public consumption in total domestic use. ϕ^{I}_{j} is the industry-specific share of output going to final investment in total domestic use. $1-\phi^{C}_{j}-\phi^{G}_{j}-\phi^{I}_{j}$ is the industry-specific share of output going to indirect export, i.e., the share of output used as intermediate input to domestic products which are eventually exported. These shares are based on data from input-output tables from Statistics Sweden for 2005. I have input-output tables also for

1995 and 2000, but these tables do not include information on where products that are used as intermediates eventually end up. The shares for direct use are very similar in all the three tables, however, why the shares including indirect use probably are similar as well during the time period studied (1996-2008). The weights are kept fixed over time in order to make the variable as exogenous as possible.

C_t is real private consumption. G_t is real public consumption. I_t is real gross fixed investment. EX_t is real exports. These four variables are all volume indexes from Statistics Sweden's table for the gross national product from the user side.

$\omega_{j,m}$ is the share of industry *j*'s direct exports that goes to country *m*. Data from Statistics Sweden for 2005. Some missing values are replaced with zero for completeness. For some industries there is no data (mainly in public sector and private service sector) and for those the export share δ_i is set to zero. Included export countries are Germany, Norway, the United Kingdom, Denmark, Finland, the USA, France, the Netherlands, Belgium, Italy, and Spain.

$Y^F_{j,m,t}$ is an industry-specific production index for each export country. The variable used is value added volumes from the OECD STAN database.

$P^D_{j,t}$ is an industry-specific domestic price index for Sweden. $P^F_{j,m,t}$ is an industry-specific price index for each export country. The variable used is the value added deflator for each industry from the OECD STAN database.

$E_{m,t}$ is the exchange rate, SEK/foreign currency, using data from the OECD.

Similar definitions have been used and discussed in Eriksson and Stadin (2015) and Carlsson, Eriksson, and Gottfries (2013).

Appendix G: Industries and local labor markets

Local labor markets (2000 definition; Statistics Sweden)

1	Stockholm	31	Bengtsfors	61	Bollnäs
2	Nyköping-Oxelösund	32	Göteborg (Gothenburg)	62	Hudiksvall
3	Katrineholm	33	Strömstad	63	Ånge
4	Eskilstuna	34	Trollhättan	64	Härnösand
5	Linköping	35	Borås	65	Sundsvall
6	Norrköping	36	Lidköping-Götene	66	Kramfors
7	Gislaved	37	Skövde	67	Sollefteå
8	Jönköping	38	Torsby	68	Örnsköldsvik
9	Värnamo	39	Årjäng	69	Strömsund
10	Vetlanda	40	Karlstad	70	Härjedalen
11	Tranås	41	Filipstad	71	Östersund
12	Älmhult	42	Hagfors	72	Storuman
13	Markaryd	43	Arvika	73	Sorsele
14	Växjö	44	Säffle	74	Dorotea
15	Ljungby	45	Laxå	75	Vilhelmina
16	Hultsfred	46	Hällefors	76	Åsele
17	Emmaboda	47	Örebro	77	Umeå
18	Kalmar	48	Karlskoga	78	Lycksele
19	Oskarshamn	49	Västerås	79	Skellefteå
20	Västervik	50	Fagersta	80	Arvidsjaur
21	Vimmerby	51	Vansbro	81	Arjeplog
22	Gotland	52	Malung	82	Jokkmokk
23	Olofström	53	Mora	83	Överkalix
24	Karlskrona	54	Falun-Borlänge	84	Kalix
25	Malmö	55	Avesta	85	Övertorneå
26	Kristianstad	56	Ludvika	86	Pajala
27	Simrishamn-Tomelilla	57	Hofors	87	Gällivare
28	Halmstad	58	Ljusdal	88	Luleå
29	Falkenberg	59	Gävle	89	Haparanda
30	Varberg	60	Söderhamn	90	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

Industries (SNI92; Statistics Sweden)

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

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