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September 2020

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Labor shortages and wage growth

Erik Frohm*

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Abstract

This paper presents a novel measure of labor market conditions based on micro data from a large business survey in Sweden. The indicator, relative labor shortages (RLS), is the ratio of respondents' quantitative assessment of labor shortages and current employment. Contrary to other survey-based measures of labor market conditions and the vacancy-unemployment ratio, RLS remained relatively subdued during the 2013-2018 recovery from the Great Recession. As the indicator is highly correlated with annual wage growth at the establishment-level, its slow recovery can help explain why wage growth in Sweden has been sluggish since the Great Recession.

Keywords: Wage inflation, labor shortages, survey data.

JEL codes: E31, E60, J31, J23, C80.

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1. Introduction

Labor market conditions in several advanced economies have improved substantially in the recovery from the Great Recession. At the same time, wage growth has remained subdued and been systematically over-predicted by central banks and international organizations (Nickel et al., 2019). Jerome Powell, chairman of the Federal Reserve Board in the United States referred to the absence of higher wage growth as a "puzzle"¹ and similar sentiments have been expressed by Andrew Haldane, Chief Economist of the Bank of England and former European Central Bank (ECB) Executive Board member Benoît Cœuré.² The puzzle of high resource utilization and subdued nominal wage growth has also been prominent in Sweden, a small, open and inflation-targeting economy (Sveriges Riksbank, 2017).

Several explanations have been suggested for the apparent disconnect between labor market conditions and wages and the "flattening" of the wage Phillips curve.³ These include the globalization of production (Borio et al., 2018), automation (Leduc and Liu, 2020), lower matching efficiency in the labor market (Jonsson and Theobald, 2019) or weaker bargaining power of labor (Krueger, 2018). Other strands of the literature argue that traditional measures of labor market conditions underestimate the true slack in the labor market (see for example Hong et al. 2018, Barnichon and Mesters 2018 and Abraham et al. 2020) or that the relationship between wage growth and slack is non-linear (Daly and Hobijn 2014 and Lindé and Trabandt 2019.).

I contribute to these latter studies by constructing a new survey-based measure of labor shortages, derived from respondents' quantitative assessment in a large, representative, business survey in Sweden, the Public Employment Ser-

¹"But there is still a bit of a puzzle in that we're hearing about labor shortages now all over the country in many, many different occupations in different geographies. And one would have expected, I would have expected, that wages would move up a little bit more.", see Powell (2018).

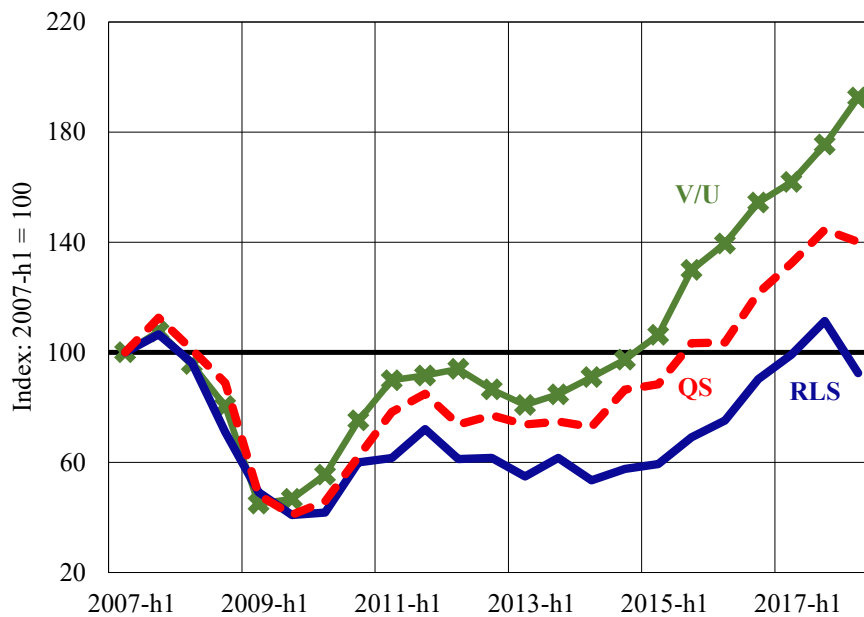
²"We have seen an unusual pattern emerge here over recent years. Jobs growth has been strong, with over 2 million new jobs created since the end of 2012. But pay growth has remained weak by historic standards, averaging around 2% annually.", see Haldane (2018) and "Despite a rapid fall in the unemployment rate, wages have remained stubbornly low. Annual growth in compensation per employee hovered around 1.2% since mid-2014 and only increased to 1.5% at the end of last year – substantially below its historical average of 2.1%", see Cœuré (2017).

³For example, Galí and Gambetti (2019) document changes to the wage Phillips curve in the United States, with reduced form as well as conditional estimates. They find a declining slope with conditional estimates, albeit somewhat less than reduced form estimates would suggest.

vice's interview survey. The new indicator, relative labor shortages (RLS), has the advantage over other indicators that it is direct measure as perceived by respondents themselves and not dependent on statistical filtering techniques or judgement that cause real-time estimates of "gaps" to be fraught with uncertainty (Orphanides and van Norden 2002 or Berge 2020). It is thus a survey-based complement to other types of conventional and non-conventional measures of labor market conditions.

According to RLS, there was markedly more slack in the Swedish labor market during the recovery from the Great Recession than conventional qualitative survey-based measures (QS) or the standard vacancy-unemployment (V/U) ratio suggested, see Figure 1.

Figure 1: A new indicator of labor shortages



Note: QS (the dashed line) is simply the share of respondents that responded "Yes" to whether or not they experienced labor shortages in connection to recruitment over the past six months. V/U (the crossed line) is the vacancy-unemployment ratio measured as total number of vacancies as percent of the labor force, over unemployed persons as percent of the labor force in the age group 15-74 years retrieved from the Swedish National Institute of Economic Research. RLS (the solid line) is the average ratio of number of positions where respondents experienced labor shortages to total employment at the establishment. All series are indexed to 2007h1 for comparison. For more details, see Section 3.

The reason why RLS indicate more labor market slack than other survey-based measures is that it provides a picture of the intensive margin (i.e the average number of positions with labor shortages normalized with total em-

ployment at the establishment-level) and not only the extensive margin of labor shortages (i.e the proportion of respondents experiencing labor shortages). RLS is thus not subject to the "New Modesty" affecting indicators based on purely qualitative survey data as highlighted by [Gayer and Marc \(2018\)](#) and [National Institute of Economic Research \(2018\)](#) in other contexts.⁴

I also provide evidence that RLS is correlated with wage growth at the establishment-level. The positive relationship is robust to a range of controls, such as fixed-effects for sector-time (controlling for sector-level productivity shocks or negotiated wages) and region-time (controlling for regional labor market conditions and inflation). The relationship is also positive *within* establishments. With establishment, sector-time and region-time fixed-effects for a sub-sample of establishments that have participated in more than 3/4 of all survey waves, there is evidence of wages responding non-linearly to RLS. For establishments below the 8th decile of RLS, there is no statistically significant relationship, whereas wage growth is estimated to be about 0.8 percentage points higher for establishments with RLS in the 10th decile. These findings therefore suggests that labor markets would have to tighten more substantially to increase wage growth, in line with the theoretical analysis of [Daly and Hobijn \(2014\)](#) and [Lindé and Trabandt \(2019\)](#) and aggregate empirical analyses by [Byrne and Zekaite \(2018\)](#) and [Nickel et al. \(2019\)](#) for the euro area.

The analysis in this paper is highly policy relevant. Several members of the Executive Board of the Swedish central bank highlighted record-level labor shortages as a motivation for the decision to begin tightening monetary policy at the December 2018 Monetary Policy Meeting ([Sveriges Riksbank, 2018a](#)). As the analysis in this paper shows, qualitative surveys of labor shortages likely underestimated the true labor market slack in the recovery from the Great Recession and thus provided a too strong signal for wage growth.⁵

The rest of this paper is organized as follows: Section 2 describes the Swedish

⁴"New Modesty" refers to a psychological or cognitive effect: that respondents' answers to qualitative survey questions are relative to a 'normal' benchmark. After a severe recession for example, respondents may have lowered their underlying reference standard to a lower level of economic activity or labor shortages. RLS on the other hand uses quantitative information on labor shortages to mitigate such biases.

⁵This conclusion also applies to other qualitative indicators of economic slack, some of which are used in [Frohm \(2020\)](#).

Public Employment Service's interview survey and the data used. Section 3 presents the measure of relative labor shortages and Section 4 the empirical analysis. Section 5 concludes.

2. Data

The data in this paper comes from the Swedish Public Employment Service's interview survey (AFU), which has existed in different constellations since the 1960s and been an important tool for the Swedish Public Employment Service's regional and national labor market forecasts.⁶ Before 2007, however, the micro data were not kept in a systematic manner and cannot be retrieved. The data used in this paper covers more than 200,000 responses and around 10,000 establishments participate in each survey wave, which is once every half year. The sample is drawn from Statistics Sweden's Business Register and is stratified by establishment sizes (employment at establishments), sectors (SNI 2007/NACE Rev.2.) and Swedish regions ("län"). The sample frame includes establishments with more than five employees and all establishments with more than 100 employees are included. The survey is representative for Sweden as a whole and at the regional level.

Table A.1 in the Appendix shows the representatives of the survey in terms of employment across industry, size-classes and regions. To increase the weight of small sample units that also represent many small units in the population that were not included in the sample, sample weights are included from 2013h1 and onward.⁷ When greater weight is given to small sample units (column 3), the respective sector employment shares in the survey are closer to the population. For example, industry accounts for a slightly smaller share in the sample with 18.8% (31.2% unweighted), compared to 20.4% in the population. The weight-
ing also improves the representatives among size-classes: for small establish-

⁶See for example the Swedish Public Employment Service report, Arbetsmarknadsutsikter hösten 2019-2020. ("Prospects of the Swedish labor market 2019-2020, fall").

⁷The sample weights are simply $w = \frac{N - O}{n}$, where N is the number of establishments in the population, O is oversampling and n the sampled units. When the Swedish Public Employment Service report their figures, they utilize sample weights from 2013h1 onward and equally weighted data from before then.

ments (0-19 employees), the weight increases from 6.2% to 34.1%, closer to 33.7% in the population. With weights, large establishments account for 30.2% instead of 71.2% unweighted and compared to 44.9% in the population.

As sample weights are not available prior to 2013h1, I use simple averages to calculate the aggregate time-series. This means that the time-series are not necessarily representative for the population as a whole, although the total number of employees covered by the sample accounts for more than a fourth of the the total Swedish business employment.⁸

2.1 Design and survey questions

Respondents in the survey are typically the CEO, CFO or senior managers at the establishments and the interviewers are local employment officers at the Swedish Public Employment Service. The survey is conducted face-to-face or by phone, which allows the interviewers to ask more detailed questions than in mail-out questionnaires or web surveys. This is precisely what makes this survey unique: besides gathering qualitative Likert-scale type responses for assessments and expectations (that is, "Increase", "Unchanged", "Decreased"), it also gathers quantitative assessments (of for example labor shortages, employment and wage growth) and expectations (of employment).

Participation in the survey is voluntary. Nonetheless, the response rate is markedly high, on average above 80 percent. According to the Swedish Public Employment Service, the high response rate is a result of long-standing relationships between interviewers and interviewees.

The questions from the survey used in this paper reads as follows:⁹

- *The number of employees at the establishment (excluding contract staff).
Provide the number of persons and your expectations for the future:
A year ago: Currently: In a year: In two years:*
- *Have you experienced labor shortages in connection with recruitment over*

⁸In more detail, for 2014h1, the total number of employees covered by the survey sample was 732,329 as compared to 3,251,000 in the population for 2014. This is roughly equal across survey waves.

⁹The full questionnaire is available at <https://arbetsformedlingen.se/om-oss/statistik-och-analyser>.

the past six months?

Yes, No or Have not needed to recruit

If yes:

– *Provide the number of positions where you experienced labor shortages:*

- *Quantify how much the average salary (per employee) has increased at the establishment over the last year:*

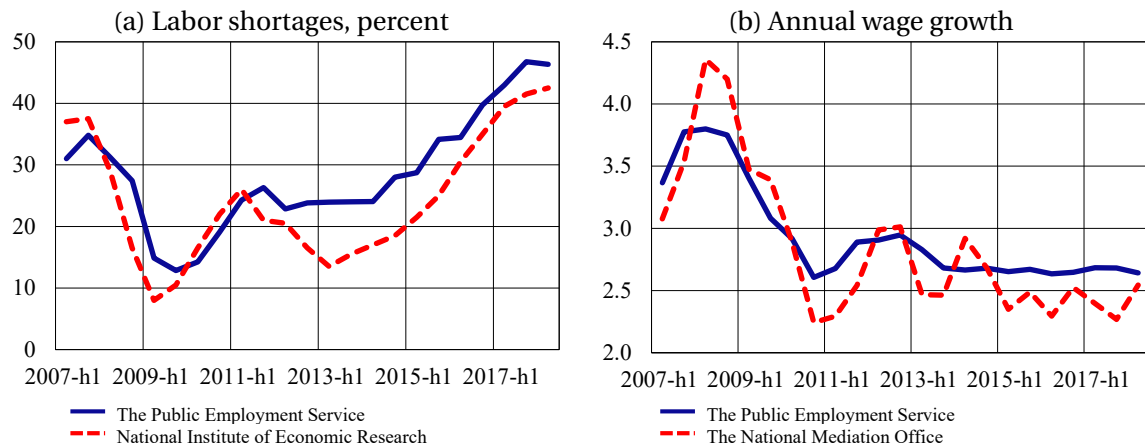
Less than 1%, 1%-2%, 2%-3%, 3%-4%, 4%-5%, 5%-6%, 6%-7% and above 7%

2.2 Comparison with other sources

One important aspect when dealing with non-standard sources is to ensure that the data corresponds to other conventional sources, when applicable. In the following, I compare some variables available from the AFU with other official statistics. For example, the proportion of respondents in the AFU who report labor shortages is compared with the same figure from the National Institute of Economic Research (NIER) Economic Tendency Survey, and wage growth is compared with short-term statistics from the National Mediation Office (NMO), see Figure 2.

To compare data on labor shortages with the NIER-survey, I calculate the proportion of respondents that respond "Yes" to whether they have experienced labor shortages. There are however a couple of differences between the two surveys. First, the AFU survey is conducted bi-annually whereas the NIER survey is conducted quarterly. Second, the NIER survey simply asks their respondents to answer the statement: "*Labor shortages at present?*" with the response alternative "Yes" or "No" whereas the AFU asks respondents to answer the question: "*Have you experienced labor shortages in connection with recruitment over the past six months?*" with the response alternatives "Yes", "No" or "Have not needed to recruit". To enable comparisons, I calculate the average of the NIER labor shortages for the first and second quarter when comparing to the AFU:s first half of the year observation, and the third and fourth quarter for the second half

Figure 2: Comparison with other sources



Note: (a) shows the share of respondents that are experiencing labor shortages in the Public Employment Service (solid line) and the National Institute of Economic Research (dashed line). (b) shows the annual growth in nominal wages from the Public Employment Service (solid line) and the National Mediation Office (dashed line). The midpoint for each response category has been used in the AFU. This means that wage growth is 0.5 percent if respondents answer less than 1 percent, 1.5 if they answer between 1.0 and 2.0 percent, 2.5 if they answer between 2.0 and 3.0 percent and so forth. Nominal annual wage growth from the NMO is the nominal hourly wages in businesses.

of the year.

Nominal annual wage growth computed from the AFU is also compared with data from the NMO, which is the main source used to track nominal wage developments in Sweden. I use the mid-point of answers to the wage question in the AFU survey. That is, 0.5% represents responses that are in the bin "less than 1%", 1.5% if the bin is "1%-2%" and 2.5% if the bin is "2%-3%" and so on. Nominal annual wage growth from the National Mediation Office is the wage sum divided by the number of hours worked.

Overall, qualitative labor shortages and aggregate wage growth are very similar to those obtained from other sources in Sweden, see Figure 2. The comparability is also matched for broad sectors of the economy: industry, construction, retail trade and services, see Figure A.1 and A.2 in the Appendix.

3. A measure of relative labor shortages, RLS

In modern search models of the labor market (see for example Shimer 2005), tightness is defined as the vacancy-unemployment ratio. A higher ratio of vacancies to unemployment entail a larger number of jobs that employers would like to fill relative to the number of unemployed people available to fill them

and implies a tighter labor market. In the AFU survey, respondents take a stand on how many positions they experienced shortages when they recruited over the past six months, S . One could conceivably think of this as points on the vacancy-unemployment curve, where few shortages indicate many applicants for each position (high unemployment and few vacancies) and more shortages corresponds to a small pool of applicants (low unemployment and several vacancies).

The number of shortages vary with the size of the establishment however. Large establishments tend to have greater absolute number of shortages than smaller establishments and if the establishment is growing, it is natural that the number of shortages increase as well. Fortunately, the survey also collect information about establishments' current number of employees, E . To obtain a establishment-level measure of relative labor shortages, the number of labor shortages S_{it} are divided by the total number of employees at the establishment E_{it} in (1):

$$RLS_{it} = \frac{S_{it}}{E_{it}} \quad (1)$$

Here, i is a establishment and t a survey round. This establishment-level measure of relative labor shortages (RLS) is continuous and relative: a higher value means that the number of positions where establishments experience labor shortages are increasing relative to the size of the establishment and is what one would expect when the labor market tightens. Similarly, a lower value means that establishments are experiencing less shortages and indicate a looser labor market.¹⁰ Establishments with no labor shortages or have not needed to recruit have a value of zero.

The aggregate measure of relative labor shortage (RLS) is simply the average of the establishment-level indicator over time:

$$RLS_t = \frac{1}{Y_t} \sum_{i=1}^{Y_t} \frac{S_{it}}{E_{it}} \quad (2)$$

¹⁰To deal with very extreme values reported by establishments in the survey, I winsorize the number of shortages and employment at the 99.5th percentile. The measures is however robust in choosing both higher and lower percentile values for winzorizing. See Figure A.6 in the Appendix.

where Y is the total number of responses to the question: "Have you experienced labor shortages in connection to recruitment over the past six months?". As compared to purely qualitative indicators of labor shortages that measure the proportion of establishments with a labor shortage (the extensive margin), this new measure provides additional information: it also takes into consideration the effective labor shortages per establishment (the intensive margin).¹¹ This can be shown with (3), which decomposes (2) into two parts: the extensive margin, which is simply the proportion of respondents that experience labor shortages, y/Y , where y is the number of respondents responding "Yes" to if they experience labor shortages and Y is all responses.¹² The second part of the expression is the average labor shortages per establishment, who experience labor shortages, i.e the intensive margin. Most business surveys record only the first part of (3) and implicitly assume that the second part is fixed, or not varying much, over time.

$$RLS_t = \underbrace{\frac{y_t}{Y_t}}_{\text{extensive margin}} \times \underbrace{\frac{1}{y_t} \sum_{i=1}^{y_t} \frac{S_{it}}{E_{it}}}_{\text{intensive margin}} \quad (3)$$

This assumption has clear downsides. If, for example, a large fraction of establishments experience shortages of specialized competencies, they may report a shortage of labor or perceive labor as an important factor limiting production in a survey (increasing y), even though the number of positions and wages for those staff are only a small part of the total employment and wage bill at the establishment. If this behavior is pervasive across many respondents, rising qualitative labor shortages, or the extensive margin, may not indicate that the labor market has tightened in overall terms, but simply that many establishments are experiencing shortages of a narrow set of skills and competencies.¹³ This means that the quantitative signal from such an indicator might

¹¹As example of extensive margin indicators are the DG-ECFIN survey questions to the industrial, construction and services sectors that ask respondents what main factors are currently limiting their production. Respondents can choose from a number of options, including insufficient demand, shortage of labor force, shortage of material and/or equipment, financial constraints, none or other. In the Swedish Economic Tendency Survey, respondents in all sectors except for construction are prompted to answer whether they experience labor shortages or not.

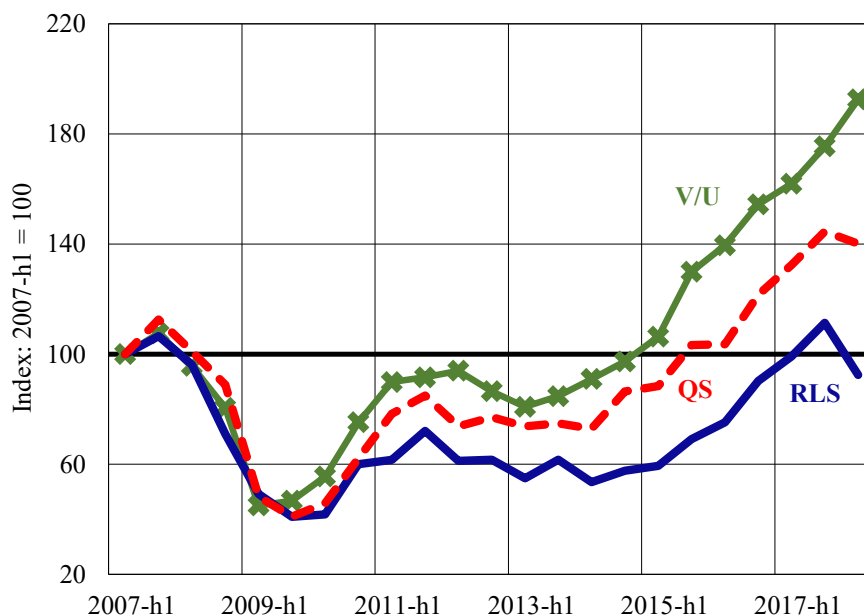
¹²That is, the sum of responses of "Yes", "No" and "Have not needed to recruit".

¹³In the Riksbank Business Survey, a small-scale interview survey conducted by the Swedish

change over time if the intensive margin moves in the opposite direction of the extensive margin. This problem with qualitative survey data has also been highlighted for other indicators by [Gayer and Marc \(2018\)](#) and [National Institute of Economic Research \(2018\)](#).

Indeed, the intensive margin of labor shortages vary over time.¹⁴ Figure 3 shows this by comparing RLS with the conventional survey-based indicator for labor shortages (QS), indexed to 100 in 2007h1.¹⁵

Figure 3: Relative labor shortages (RLS) and other indicators



Note: QS (the dashed line) is simply the share of respondents that responded "Yes" to whether or not they experienced labor shortages in connection to recruitment over the past six months. V/U (crossed line) is the vacancy-unemployment ratio measured as total number of vacancies as percent of the labor force, over unemployed persons as percent of the labor force in the age group 15-74 years retrieved from the Swedish National Institute of Economic Research. RLS (the solid line) is the average ratio of number of positions where respondents experienced labor shortages to total employment at the establishment. All series are indexed to 2007h1 for comparison.

From 2011h1 and onward, RLS was markedly lower than QS and the vacancy-unemployment ratio (V/U). Moreover and contrary to these other indicators,

Central Bank, respondents have highlighted that labor shortages have mainly been acute for specialized competencies rather than for broad groups of staff, see [Sveriges Riksbank \(2018b\)](#).

¹⁴Figure A.4 in the Appendix shows the evolution of the extensive and intensive margin over time for all establishments and the four broad sectors of the economy. Across all broad sectors, the intensive margin measure is markedly lower in the 2013-2018 period than in 2007 before the Great Recession.

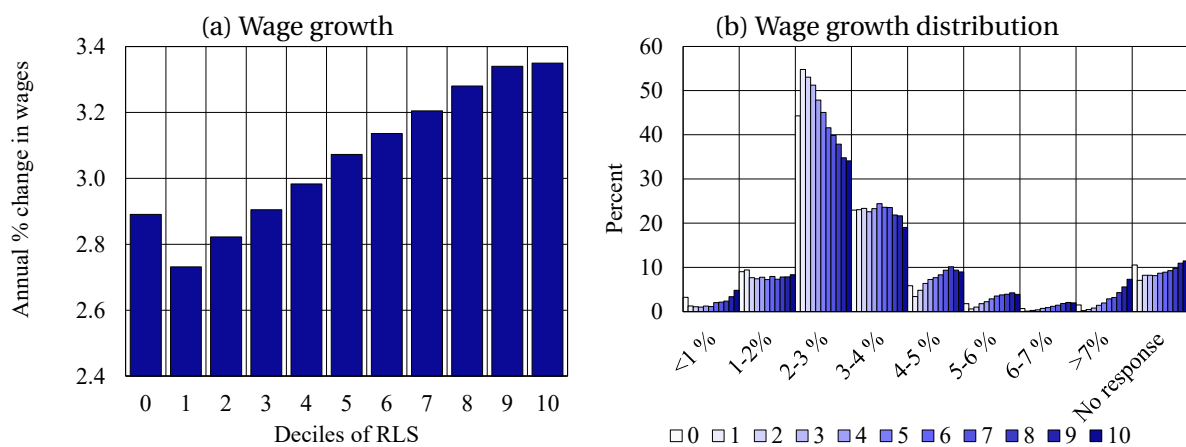
¹⁵The series are also calculated the broad sectors of the economy (industry, construction, retail trade and services) in Figure A.3 and for Swedish regions (NUTS1) in Figure A.7 in the Appendix. The measure is also constructed with sample weights from 2013h1-onward in Figure A.5.

RLS was only above its 2007h1 level in 2017h2 and fell back below it in 2018h1. Differently, the QS indicator was above the 2007h1 level already in 2015h2 and thus signalled stronger wage pressures than RLS.

Since the AFU survey collects both information on respondents assessment of their average annual nominal wage growth and RLS, it is possible to compute the average wage growth across levels of RLS. This is done in Figure 4 with deciles of RLS. Here, decile = 0 is all firms with no labor shortages. The rest of the deciles are computed for firms with positive values of RLS.¹⁶

Average wage growth is actually slightly higher for establishments with no labor shortages than establishments with labor shortages below the 3rd decile. From the 4th decile and onward, average wage growth is higher. For establishments at decile 10 for example, wage growth is 0.4 percentage points higher than if RLS = 0.

Figure 4: Wage growth across deciles of labor shortages



Note: The figure in (a) shows the average annual nominal wage growth for each decile of RLS. The group "0" is all establishments without any labor shortages. RLS at decile 1 for all establishments is 0.006, at 2 0.016, at 3 0.030, at 4 0.045, at 5 0.066, at 6 0.0914, at 7 0.120, at 8 0.159, at 9 0.230 and at 10 0.657.

Panel (b) in Figure 4 shows how also the distribution of wage growth varies across deciles of RLS. There are stark differences: for establishments in the first decile of RLS, 55 percent respond that wages increase by 2-3 percent which can be contrasted with around a third of establishments in the 10th decile.¹⁷ However, the left tail of the distribution also becomes fatter, meaning that the frac-

¹⁶Again, the same Figures are available for establishments in industry, construction, retail trade and services in Figure A.8 in the Appendix.

¹⁷This pattern is also visible across the broad sectors in the economy, see Figure A.9.

tion of establishments with very low wage growth (less than 1%) increases. This can probably be rationalized by the fact that high enough labor shortages might reduce growth prospects for some establishments who are then unable to pay higher wages. Figure 4 are however only cross-sectional correlations that do not account for omitted variables. The next section proceeds to investigate whether the relationship between RLS and wage growth is robust to further controls.

4. Econometric evidence

A panel fixed-effects regression is used to further control for observable and unobservable factors. The estimated regression is (4):

$$w_{it} = \gamma_i + \lambda_t + \sum_{d=1}^{10} \beta_d \tau_d + \beta_X X_{it} + \varepsilon_{it} \quad (4)$$

where, w is nominal annual wage growth, τ is a decile-dummy for relative labor shortages, X is a vector of additional controls, γ is a set of sector, region or establishment fixed-effects, λ is a time fixed-effect and ε is the error term. i is an establishment and t a survey wave. Note that the omitted group in τ is establishments with a value of RLS of 0 (establishments with no labor shortages). The rest of the deciles (1-10) are computed for establishments with a positive value of RLS, similar to Figure 4. This means that the coefficient β_d is the effect on wage growth compared to having no labor shortages.¹⁸

First, the coefficient and significance of β_d is examined with sets of fixed-effects for region, sector and time. Second, I add establishment-level controls for expected demand conditions and forward-looking behaviour and third, I investigate the relationship between wage growth and RLS by controlling for heterogeneity with establishment fixed-effects. To be able to use the within-establishment variation, I use a sub-sample of establishments that have responded to more than 3/4 of all survey waves.

Column (1) in Table 1 shows the baseline estimates with year fixed-effects (controlling for, for example, the aggregate business cycle, monetary policy or

¹⁸An alternative specification uses the continuous values of RLS directly in the estimation, see Table A.6. The positive economic and statistical significance remain in these specifications.

the inflation rate). The baseline estimates in column (1) confirms the picture in Figure 4. Moving from RLS = 0 to the 10th decile is associated with an increase in wage growth of 0.43 percentage points.

Table 1: Wage growth and RLS

	(1)	(2)	(3)	(4)
Constant	2.884***	2.898***	2.899***	2.899***
$d = 1$	-0.117***	-0.077***	-0.052***	-0.053***
$d = 2$	-0.003	-0.009	0.005	0.001
$d = 3$	0.085***	0.044***	0.045***	0.042***
$d = 4$	0.156***	0.100***	0.097***	0.095***
$d = 5$	0.234***	0.161***	0.152***	0.151***
$d = 6$	0.257***	0.189***	0.176***	0.176***
$d = 7$	0.325***	0.246***	0.235***	0.233***
$d = 8$	0.377***	0.309***	0.303***	0.301***
$d = 9$	0.418***	0.340***	0.326***	0.327***
$d = 10$	0.429***	0.355***	0.361***	0.360***
Observations	216,340	214,121	213,560	213,560
R ²	0.118	0.201	0.250	0.253
FE			S-R	S-R
Time-FE	T	T-S	T-S	T-S, T-R

Note: *, **, and *** denote $p < 0.10$, $p < 0.05$, and $p < 0.01$, respectively. S = sector, R = region and T = time. Standard errors are clustered at the sector-time level. The omitted group is all establishments without any labor shortages. RLS at $d = 1$ is 0.006, at 2 0.016, at 3 0.030, at 4 0.045, at 5 0.066, at 6 0.914, at 7 0.120, at 8 0.159, at 9 0.230 and at 10 0.657.

Column (2) further controls for negotiated wages and sector-level productivity with sector-time fixed effects, column (3) adds fixed-effects for sector-region to control for time-invariant differences across sectors in certain regions and column (4) adds region-time fixed effects, to control for local regional economic conditions. In this specification, wage growth is 0.36 percentage points higher if an establishment has RLS at the 10th decile. Note that this effect is the effect

on wage-drift, as negotiated wages are controlled for with the sector-time fixed effects.¹⁹

Table A.2 in the Appendix adds additional establishment-level controls, namely respondents expectations of employment growth at the establishment the next two years (a proxy for wage expectations). It is calculated by using the (log) difference of answers to the question on the number of employees currently and expectations of number of employees in the next 24 months. Column (2) swaps this variable with another proxy for forward-looking wage-setting, namely answers to the question *"Do you judge demand for your goods and or services to increase, decrease or remain unchanged over the next 6-12 months?"*. Column (3) weighs the results by sample weights, which restricts the sample to the 2013h1-2018h1 period, and column (4) by the number of employees at the establishments. The results are also replicated for the broad sectors of the economy with sector-region fixed-effects, as well as sector-time and region-time fixed effects in Table A.3, as well as for regions (NUTS1) in Table A.4.

Results remain significant and of the same magnitude as before. Next, I utilize only the within establishment-variation to estimate the effect of RLS on wage growth. Since the AFU is an unbalanced panel with a large number of respondents only participating once, I estimate the regressions for a sub-sample of establishments that have responded to the survey 18 or more times (3/4 of all survey waves).²⁰ The results are in Table A.5 and are plotted in Figure 5 with 90 % confidence bands.

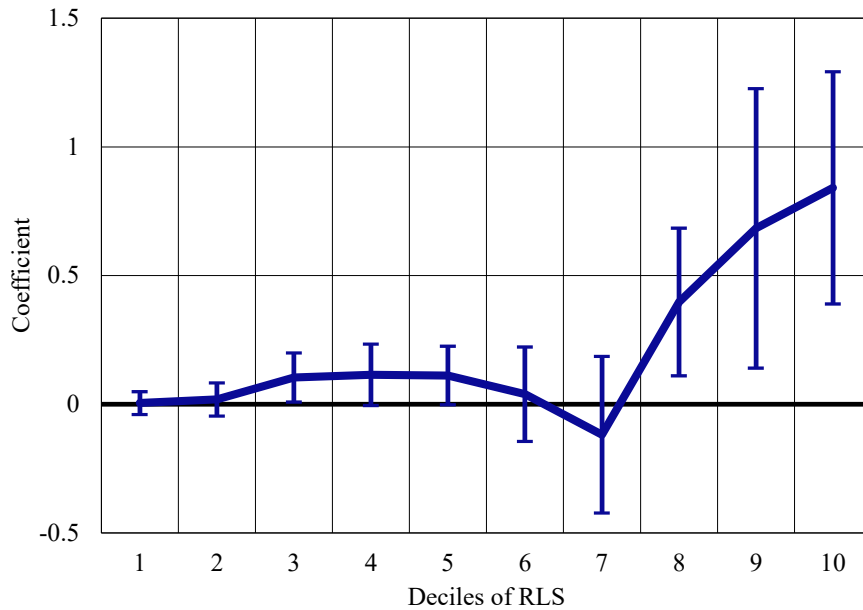
For establishments below the 8th decile of RLS, there is no statistically different effect on establishments' wage growth whereas there is a positive and both economically and statistically significant effect for establishments with RLS at or above the 8th decile. Moving from no labor shortages to the 10th decile is associated with 0.8 percentage points higher wage growth. Note that this is the effect when heterogeneity, sector shocks (sector productivity and negotiated wages) and regional shocks are controlled for.²¹ This empirical evidence supports the

¹⁹About 9/10 employees in Sweden are affected by sector-level collective bargaining agreements.

²⁰About 1/3 of respondents respond to the survey only once.

²¹Column (4) and (5) adds establishment-level controls for expectations and results are robust. Column (6) further weighs the regression with sample weights and the results are, if any-

Figure 5: Estimated impact on wage growth of RLS



Note: The regression controls for establishment, sector-time and region-time fixed-effects. Standard errors are clustered at the sector-time level. The whiskers are 90 percent confidence intervals and the solid lines are point estimates. The omitted group is all establishments without any labor shortages, RLS=0. RLS at $d = 1$ is 0.006, at 2 0.016, at 3 0.030, at 4 0.045, at 5 0.066, at 6 0.0914, at 7 0.120, at 8 0.159, at 9 0.230 and at 10 0.657.

notion that labor markets would have to tighten more significantly for wages to increase at a faster rate and is in line with the theoretical analysis by [Daly and Hobijn \(2014\)](#) and [Lindé and Trabandt \(2019\)](#), who argues that the absence of upward pressure of price and wage inflation during the recovery from the Great Recession could be due to a non-linear response of wages and prices to economic slack.

5. Concluding remarks

In this paper, I have presented a novel measure of labor market conditions in Sweden, relative labor shortages (RLS). The indicator provides a direct picture of labor market conditions and can thus be used to gauge the implications for aggregate wage growth. The indicator suggest that there has been markedly more slack in the labor market during the post-crisis period (2013-2018h1) than other thing, even stronger. See [Figure A.10](#) in the Appendix.

qualitative survey indicators. This is evidence that the Swedish labor market was not as tight as conventional survey measures suggested and can help explain why wage growth has been rather muted since the 2008-2009 crisis.

Looking ahead, the results suggests that labor markets would likely have to tighten more substantially to give a push to wage growth. The findings also suggest that conventional survey based measures of labor market conditions, that are based on the percentage of respondents answering "Yes" or "No" to whether they experience labor shortages or if labor is perceived as a limit to production, might overstate labor market conditions. Some caution about how to interpret these type of qualitative indicators (as in [Nyman 2010](#) or [ECB 2015](#)) is thus warranted.

Importantly, the measure in this paper is positively associated with establishments' wage growth in the data and there is evidence for a non-linear relationship in Sweden. The difference in wage growth of having high, instead of low, RLS is estimated to be about 0.8 percentage points when controlling for heterogeneity as well as sector and regional shocks. Nonetheless, the paper does not provide causal evidence that RLS *lead* to higher wage growth. Future research could examine the existence of a causal relationship with the use of either instruments or regional or sector-level shocks. Future studies could also examine in more detail how labor shortages of different occupations and/or sectors have varied over time to shed light on which competencies or roles are in shortage during different stages of the business cycle.

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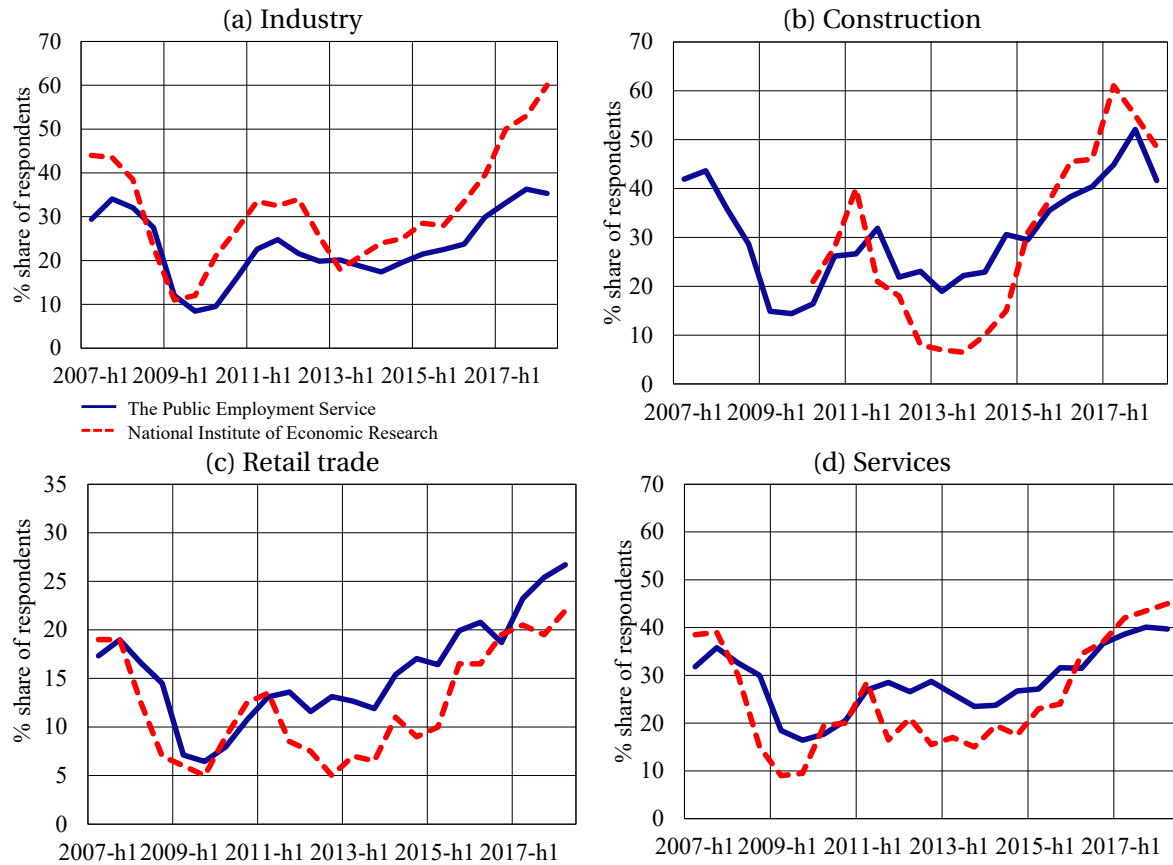
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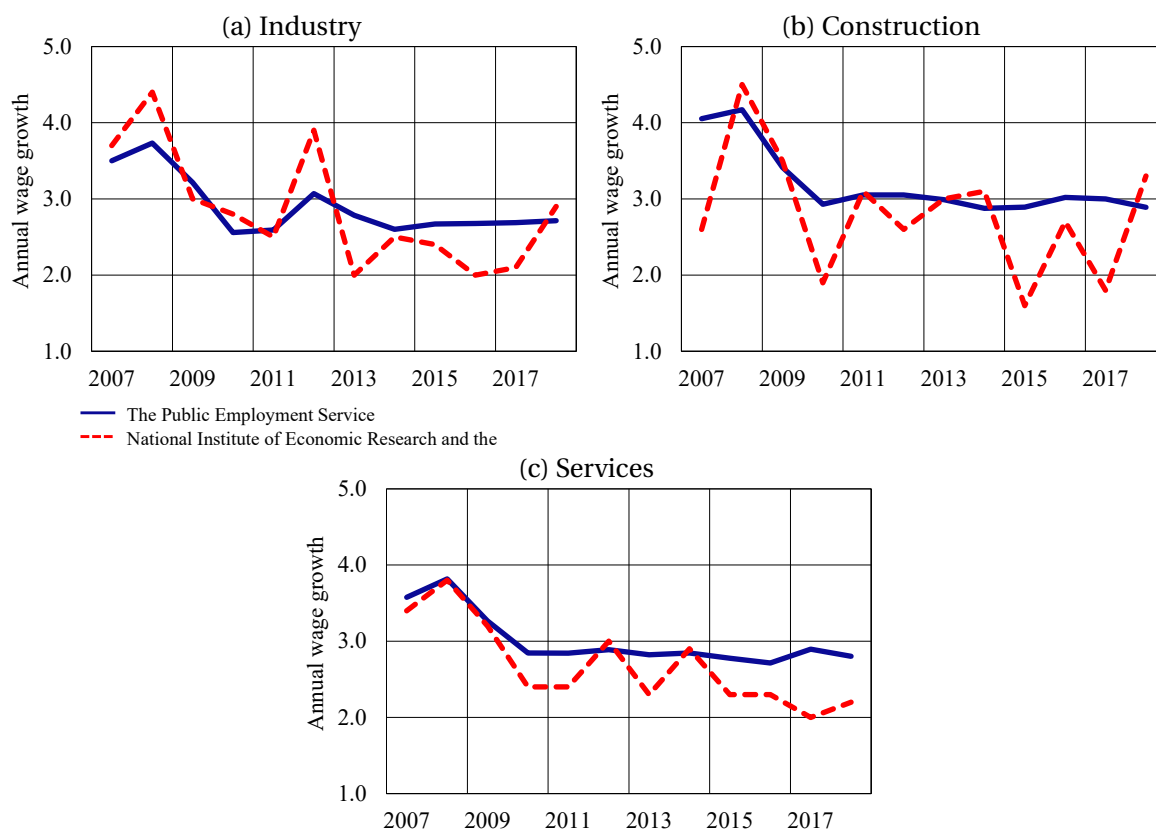
A. Appendix: Figures and tables

Figure A.1: Comparison of qualitative labor shortages with the NIER-survey



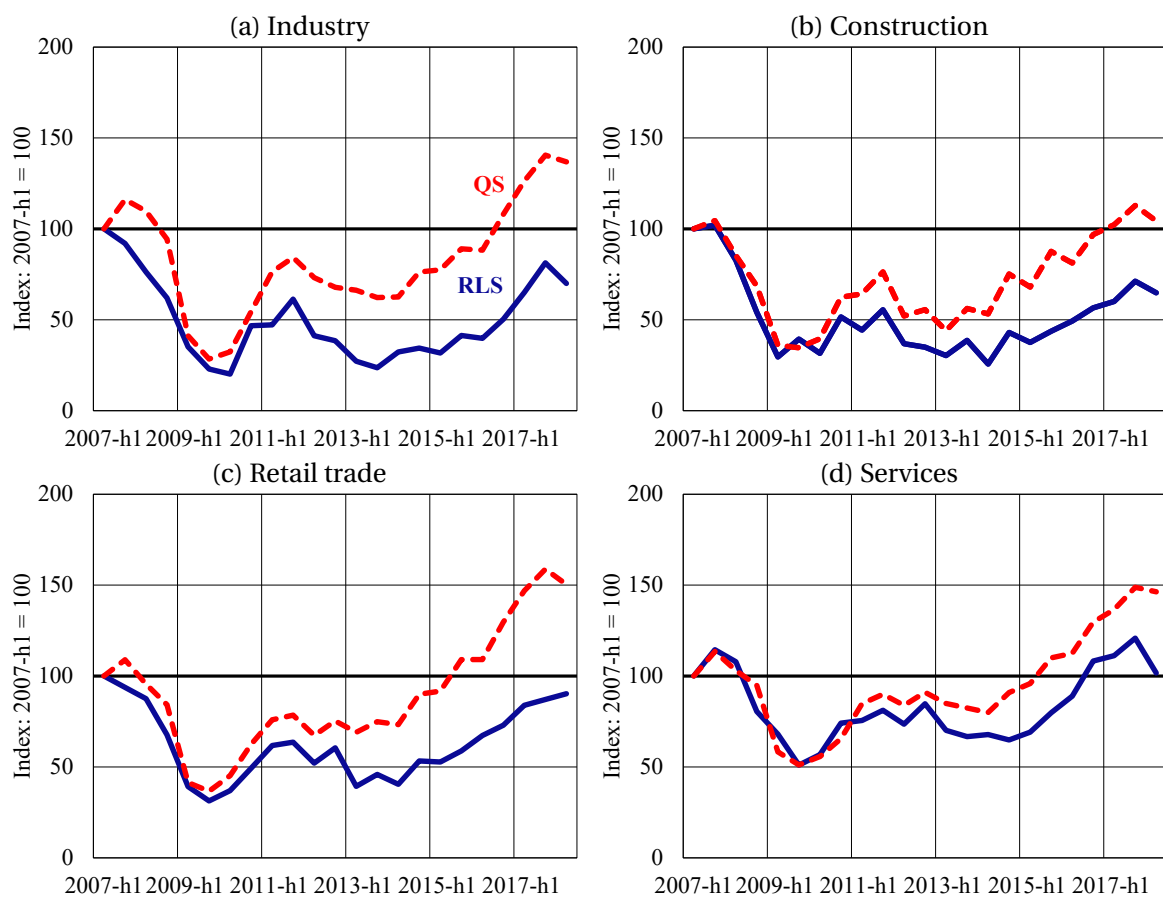
Note: The solid lines in the Figure are calculated as the share of respondents responding "Yes" to whether they experience labor shortages or not in the AFU. The dashed lines are data from the NIER. It is a weighted average across all establishments in the sample (from 2013 for the AFU and the whole sample for data from the NIER). For construction, the comparison is made with answers to the question: *What are the greatest impediments for more construction* and the response alternative "labor shortages".

Figure A.2: Comparison of annual wage growth with the NIER/NMO



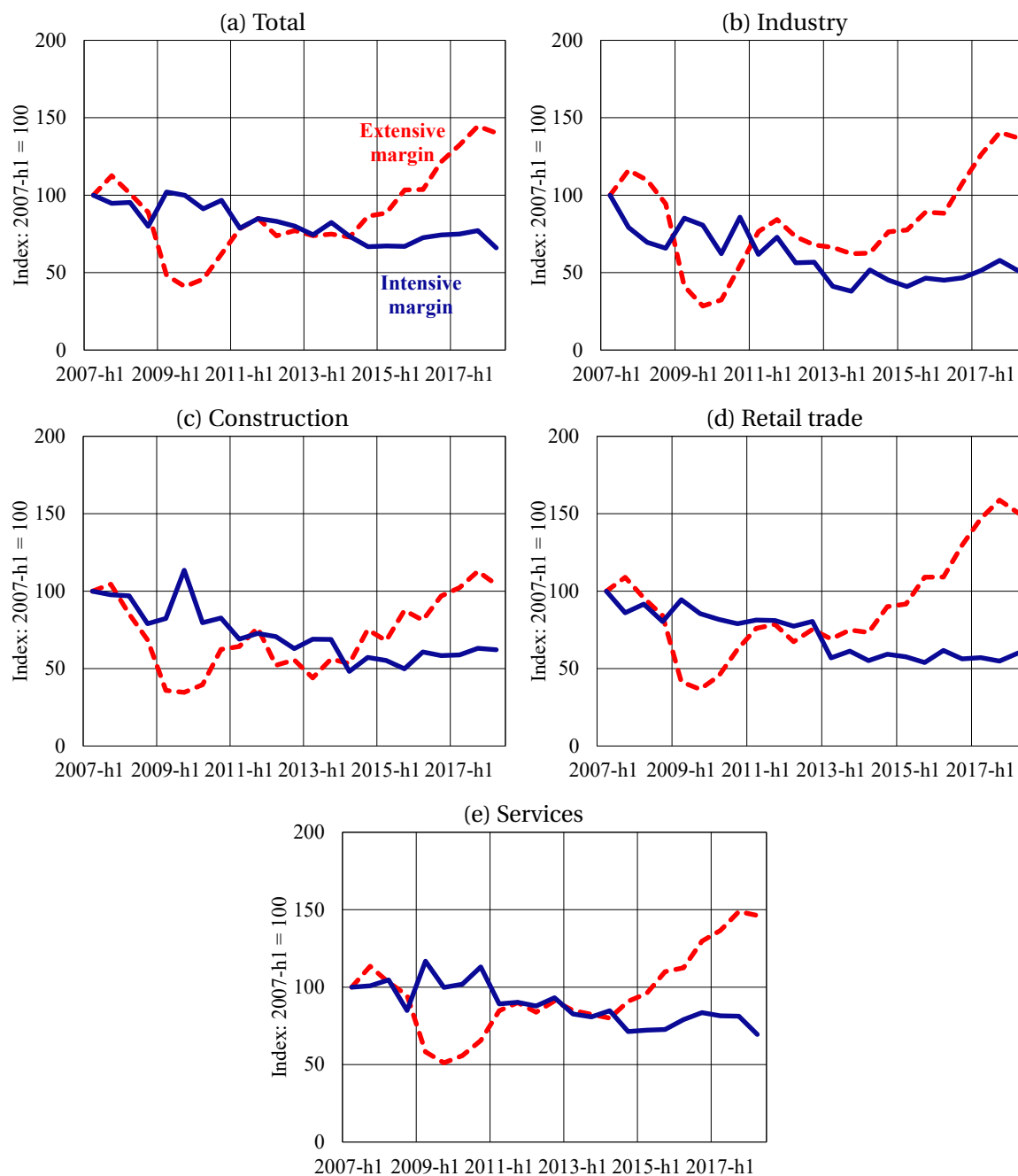
Note: The Figure shows the annual nominal wage growth from the AFU (solid lines) and estimates for three sectors by the National Institute of Economic Research and the National Mediation Office (NMO) (dashed lines). The midpoint for each response category has been used for wage growth from the AFU. This means that wage growth is 0.5 percent if respondents answers less than 1 percent, 1.5 if they answer between 1.0 and 2.0 percent, 2.5 if the answer between 2.0 and 3.0 percent and so forth. Nominal wage growth from the National Institute of Economic Research and the NMO is wage growth per hour worked. Services sector includes retail trade. Data is annual.

Figure A.3: Relative labor shortages, RLS



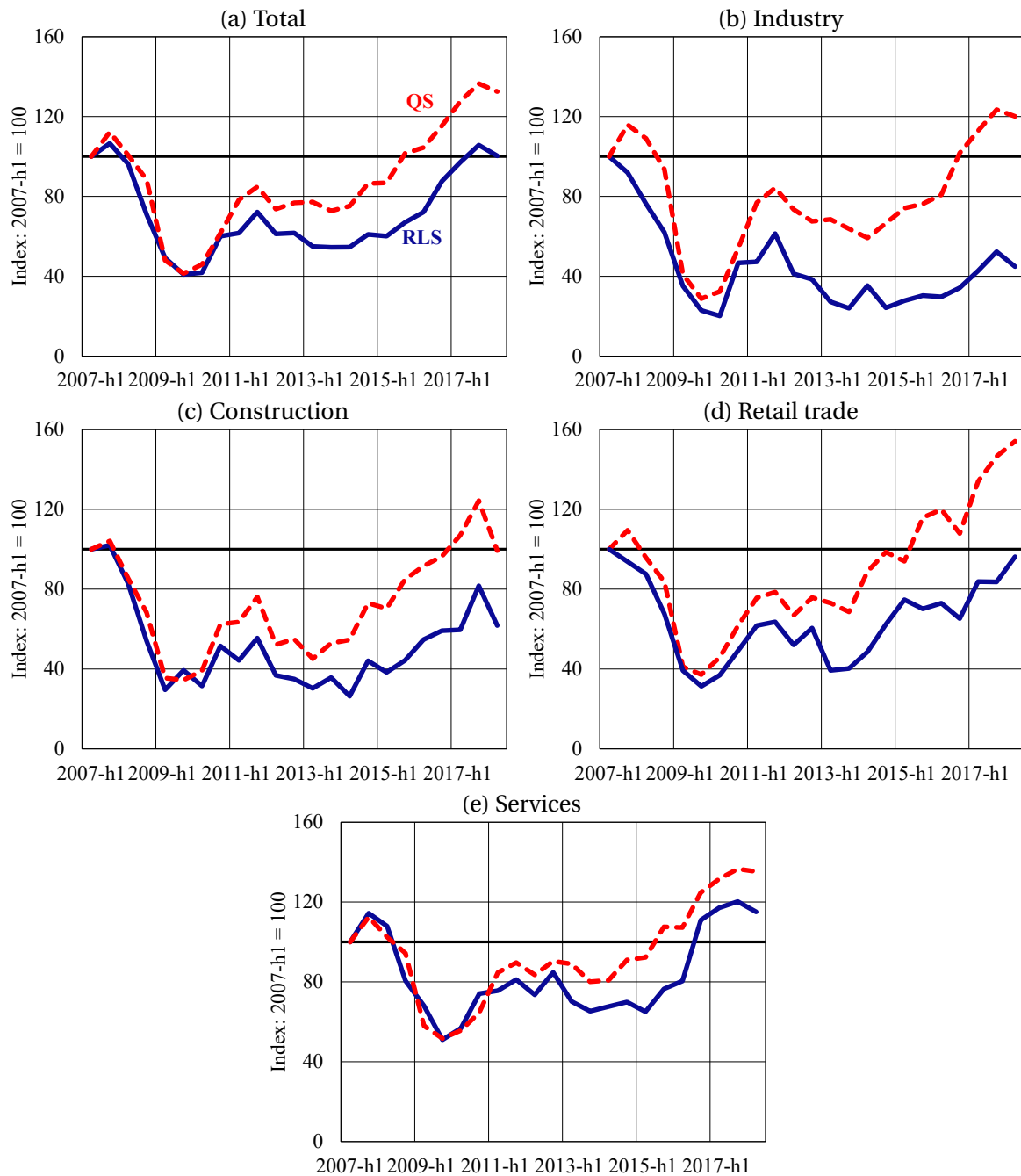
Note: NACE Rev. 2. codes corresponding to industry is 10-33, construction is 41-43, retail trade 45-47 and services all NACE Rev. 2. codes above 47.

Figure A.4: Relative labor shortages, RLS: extensive and intensive margin



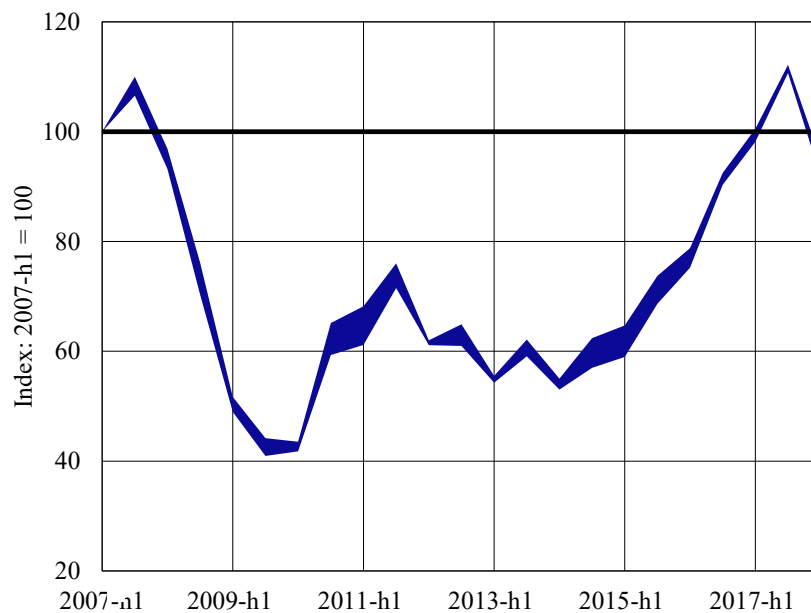
Note: NACE Rev. 2. codes corresponding to industry is 10-33, construction is 41-43, retail trade 45-47 and services all NACE Rev. 2. codes above 47.

Figure A.5: Labor shortages, sample weights from 2013h1-onward



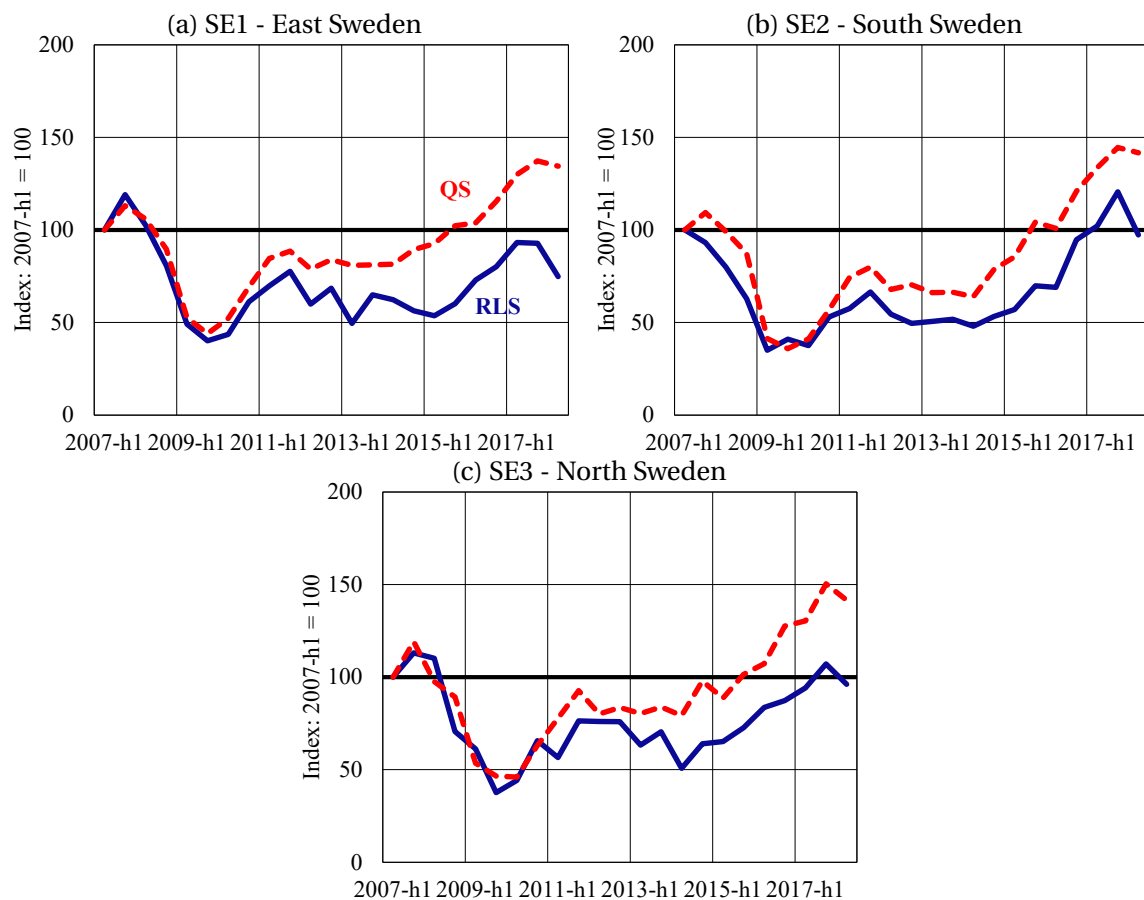
Note: NACE Rev. 2. codes corresponding to industry is 10-33, construction is 41-43, retail trade 45-47 and services all NACE Rev. 2. codes above 47. The series uses sample weights from 2013h1 onward and utilizes the non-weighted averages to back-link the series.

Figure A.6: RLS across various winzorizing percentiles



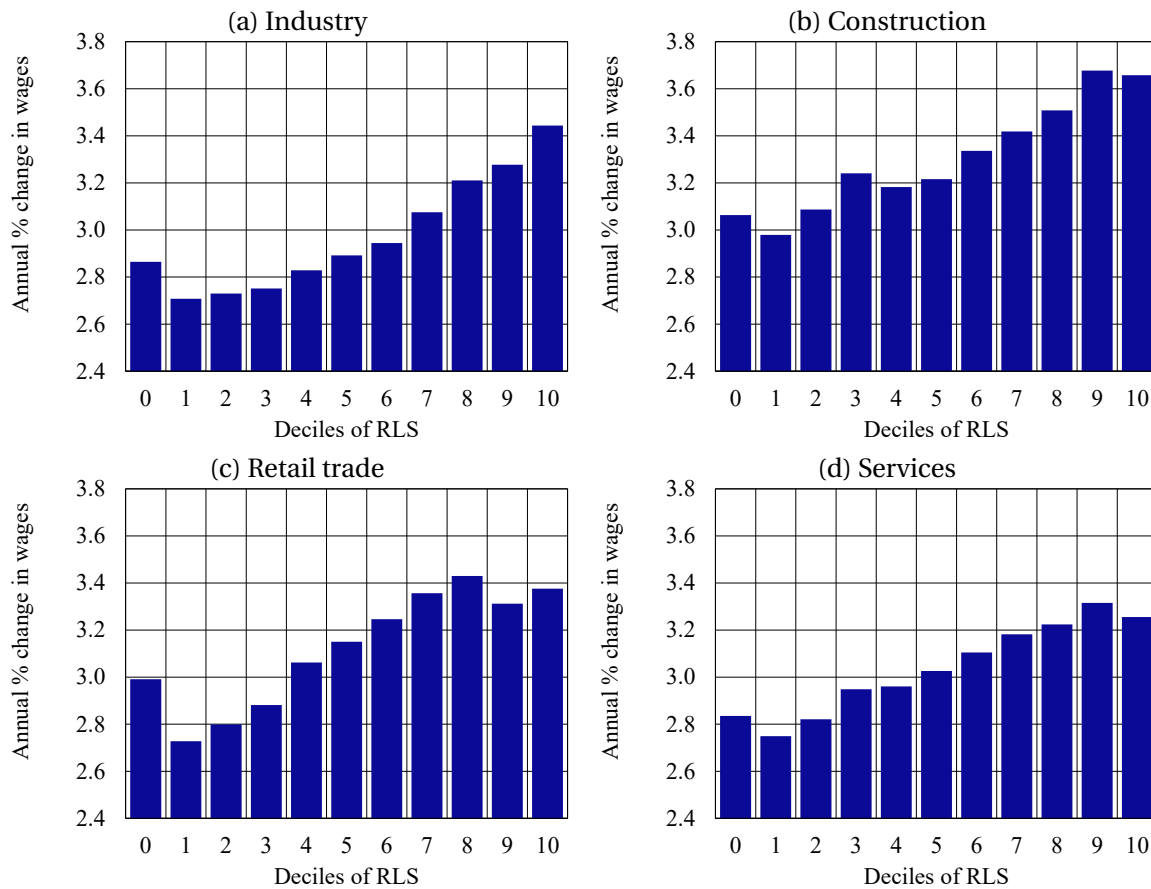
Note: The figure shows the RLS measure computed for various choices of winzorizing percentile, indexed to 2007-h1 = 100. The bands cover the 99.9th to 85th percentile.

Figure A.7: Labor shortages for regions (NUTS1)



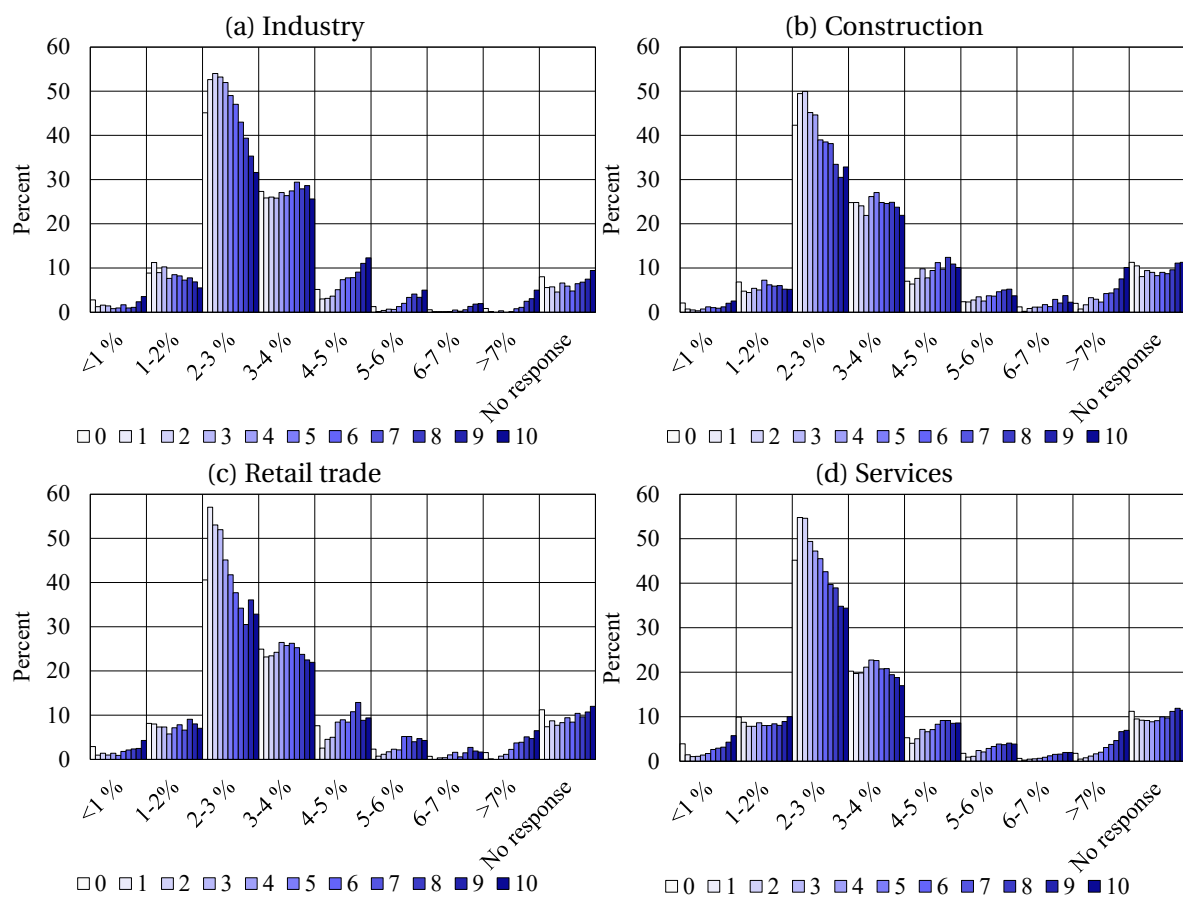
Note: NUTS1 SE1 correspond to East Sweden, which includes the "län" Stockholm, Uppsala, Södermanland, Östergötland, Örebro and Västmanland. SE2 - South Sweden includes Jönköping, Kronoberg, Kalmar, Gotland, Blekinge, Sk, Halland and Västergötland. SE3 - North Sweden includes Värmland, Dalarna, Gävleborg, Västerbotten, Jämtland, Västerbotten and Norrbotten.

Figure A.8: Wage growth across deciles of labor shortages



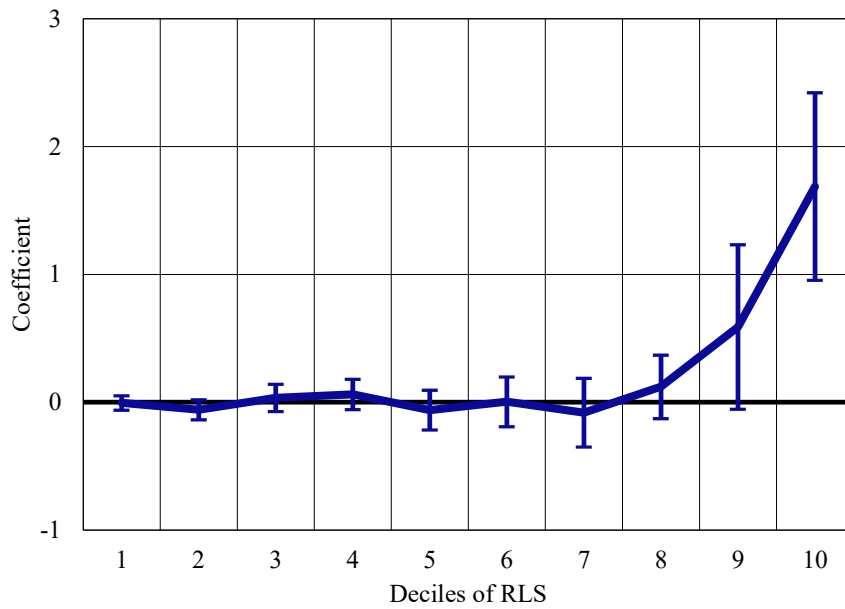
Note: The figure shows the average annual nominal wage growth for each decile of RLS across sector groupings, which corresponds to NACE Rev. 2. Industry (10-33), construction (41-43), retail trade (45-47) and services (all sectors above 47). The group "0" is all establishments without any labor shortages. RLS at decile 1 for industry are 0.003, 0.007, 0.011, 0.018, 0.025, 0.038, 0.059, 0.093, 0.143 and 0.368. For construction, its 0.013, 0.032, 0.050, 0.070, 0.093, 0.117, 0.150, 0.200, 0.283, 0.684. For retail trade, 0.007, 0.017, 0.0299, 0.045, 0.066, 0.092, 0.127, 0.166, 0.221, 0.489. For services, 0.009, 0.023, 0.037, 0.054, 0.074, 0.010, 0.131, 0.179, 0.251 0.699.

Figure A.9: Wage growth distribution across deciles of labor shortages



Note: The figure shows the distribution of wage growth across deciles of RLS. The group "0" is all establishments without any labor shortages. See Figure A.8 for the RLS values for the various deciles.

Figure A.10: Estimated impact on wage growth of RLS, with sample weights



Note: The regression controls for establishment, sector-time and region-time fixed-effects. Standard errors are clustered at the sector-time level. The whiskers are 90 percent confidence intervals and the solid lines are point estimates. The omitted group is all establishments without any labor shortages. RLS at $d = 1$ is 0.006, at 2 0.016, at 3 0.030, at 4 0.045, at 5 0.066, at 6 0.0914, at 7 0.120, at 8 0.159, at 9 0.230 and at 10 0.657. The regressions are weighted with sample weights.

Table A.1: Employment in the AFU sample and total population, in 2014

	Emp, smpl	Emp, pop	Emp, smpl*
Industry	31.2%	20.4%	18.8%
Construction	6.8%	11.0%	9.8%
Retail trade	11.3%	18.7%	17.7%
Services	50.6%	49.9%	53.7%
0-19 employees	6.2%	33.7%	34.1%
20-49 employees	9.3%	12.7%	21.7%
50-99 employees	13.3%	8.7%	14.0%
100+ employees	71.2%	44.9%	30.2%
Stockholm	23.0%	26.1%	27.6%
Västergötland	16.8%	16.9%	17.1%
Skåne	10.3%	12.4%	14.3%
Östergötland	3.5%	4.3%	3.9%
Jönköping	3.8%	3.7%	3.8%
Uppsala	2.8%	3.4%	2.6%
Halland	3.0%	3.0%	2.7%
Örebro	3.5%	2.8%	2.6%
Dalarna	3.1%	2.6%	2.7%
Västerbotten	2.8%	2.6%	2.2%
Gävleborg	3.0%	2.6%	2.5%
Norrbottn	2.9%	2.5%	2.2%
Västmanland	3.6%	2.5%	2.5%
Värmland	2.9%	2.4%	2.2%
Södermanland	2.7%	2.4%	2.1%
Västernorrland	2.9%	2.4%	2.2%
Kalmar	2.7%	2.2%	2.2%
Kronoberg	3.0%	2.0%	2.0%
Blekinge	1.9%	1.5%	1.3%
Jämtland	1.1%	1.2%	0.9%
Gotland	0.6%	0.6%	0.4%

Note: The percentages are calculated for the establishments in the AFU (sample) and the population (pop) and are aggregated across broad industry classifications according to NACE Rev. 2. The figures for the population are obtained from Statistics Sweden. * denotes employment figures with sample weights.

Table A.2: Additional controls

	(1)	(2)	(3)	(4)
Constant	2.884***	2.861***	2.723***	2.755***
$d = 1$	-0.050***	-0.057***	-0.050	-0.008
$d = 2$	0.000	-0.005	-0.019	0.046***
$d = 3$	0.032**	0.031**	0.030	0.076***
$d = 4$	0.088***	0.088***	0.088**	0.098***
$d = 5$	0.144***	0.143***	0.181***	0.161***
$d = 6$	0.162***	0.164***	0.084*	0.228***
$d = 7$	0.223***	0.221***	0.173***	0.249***
$d = 8$	0.276***	0.292***	0.284***	0.328***
$d = 9$	0.307***	0.324***	0.335***	0.377***
$d = 10$	0.311***	0.350***	0.366***	0.541***
Observations	200,820	210,543	100,934	213,560
R ²	0.259	0.255	0.326	0.406

Note: *, **, and *** denote $p < 0.10$, $p < 0.05$, and $p < 0.01$, respectively. All regressions include fixed effects for sector-region, section-time and region-time. Standard errors are clustered at the sector-time level. Column (1) includes respondents expectations of employment growth at the establishment next 24 months as a measure of expectations and Column (2) a qualitative measure if the level of demand is expected to increase in the next 12 months. (3) includes sample weights and (4) weights for employment. The omitted group is all establishments without any labor shortages, RLS=0. RLS at $d = 1$ is 0.006, at 2 0.016, at 3 0.030, at 4 0.045, at 5 0.066, at 6 0.914, at 7 0.120, at 8 0.159, at 9 0.230 and at 10 0.657.

Table A.3: Sector-level estimates

	Industry	Construction	Retail trade	Services
Constant	2.874***	3.081***	2.988***	2.848***
$d = 1$	-0.029	0.013	-0.094***	-0.051***
$d = 2$	-0.043*	0.088**	-0.045	0.006
$d = 3$	-0.043*	0.210***	0.050	0.091***
$d = 4$	0.019	0.210***	0.147***	0.109***
$d = 5$	0.009	0.122***	0.182***	0.128***
$d = 6$	0.054*	0.175***	0.173***	0.208***
$d = 7$	0.138***	0.274***	0.299***	0.275***
$d = 8$	0.230***	0.305***	0.374***	0.310***
$d = 9$	0.220***	0.427***	0.288***	0.385***
$d = 10$	0.329***	0.412***	0.315***	0.352***
Observations	42,196	24,259	40,809	96,067
R ²	0.359	0.211	0.264	0.225

Note: *, **, and *** denote $p < 0.10$, $p < 0.05$, and $p < 0.01$, respectively. Standard errors are clustered at the sector-time level. All regressions include sector-region, sector-time and region-time fixed effects. The omitted group is all establishments without any labor shortages, RLS=0. Deciles are calculated within each broad industry. For industry, the figures are 1 = 0.003, 2 = 0.007, 3 = 0.011, 4 = 0.018, 5 = 0.025, 6 = 0.038, 7 = 0.059, 8 = 0.093, 9 = 0.143 and 10 = 0.368. For construction, its 0.013, 0.032, 0.050, 0.070, 0.093, 0.117, 0.150, 0.200, 0.283, 0.684. For retail trade, 0.007, 0.017, 0.029, 0.045, 0.066, 0.092, 0.127, 0.166, 0.221, 0.489. For services, 0.009, 0.023, 0.037, 0.054, 0.074, 0.101, 0.131, 0.179, 0.251 0.699.

Table A.4: Region-level estimates (NUTS1)

	SE1 - East SE	SE2 - South SE	SE3 - North SE
Constant	2.898***	2.915***	2.895***
$d = 1$	-0.044*	-0.087***	-0.022
$d = 2$	-0.042*	-0.005	0.015
$d = 3$	0.039	0.023	0.097***
$d = 4$	0.067**	0.085***	0.132***
$d = 5$	0.223***	0.105***	0.135***
$d = 6$	0.210***	0.153***	0.191***
$d = 7$	0.292***	0.184***	0.238***
$d = 8$	0.381***	0.287***	0.186***
$d = 9$	0.372***	0.314***	0.268***
$d = 10$	0.406***	0.428***	0.306***
Observations	55,306	96,920	50,455
R^2	0.268	0.290	0.314

Note: *, **, and *** denote $p < 0.10$, $p < 0.05$, and $p < 0.01$, respectively. Standard errors are clustered at the sector-time level. All regressions include sector-region, sector-time and region-time fixed effects. The columns shows the establishment size in terms of employment. The omitted group is all establishments without any labor shortages, RLS=0. Deciles are calculated within each broad region classification. For SE1, the figures are 1 = 0.006, 2 = 0.015, 3 = 0.027, 4 = 0.043, 5 = 0.062, 6 = 0.089, 7 = 0.119, 8 = 0.157, 9 = 0.229 and 10 = 0.594. For SE2, its 0.006, 0.015, 0.027, 0.042, 0.060, 0.082, 0.111, 0.151, 0.214, 0.615. For SE3, 0.009, 0.023, 0.041, 0.062, 0.083, 0.114, 0.143, 0.184, 0.273, 0.848.

Table A.5: Reduced sample and establishment fixed-effects

	(1)	(2)	(3)	(4)	(5)	(6)
$d = 1$	-0.024	0.008	0.004	0.001	0.007	-0.006
$d = 2$	0.020	0.029	0.019	-0.012	0.017	-0.059
$d = 3$	0.041	0.092	0.104*	0.054	0.094	0.034
$d = 4$	0.119	0.102	0.114	0.045	0.105	0.061
$d = 5$	0.084	0.095	0.112	0.137*	0.105	-0.062
$d = 6$	-0.071	0.001	0.039	-0.036	0.021	0.003
$d = 7$	-0.198	-0.180	-0.119	-0.119	-0.151	-0.082
$d = 8$	0.339*	0.340*	0.397**	0.396**	0.393**	0.121
$d = 9$	0.597*	0.633*	0.683**	0.794**	0.675**	0.589
$d = 10$	1.016**	0.803**	0.841***	0.545**	0.819***	1.688***
Observations	6,008	6,008	6,008	5,499	5,921	2,928
FE		S-R	F	F	F	F
Time-FE	T-S	T-S, T-R	T-S, T-R	T-S, T-R	T-S, T-R	T-S, T-R
R ²	0.562	0.644	0.653	0.669	0.656	0.675

Note: *, **, and *** denote $p < 0.10$, $p < 0.05$, and $p < 0.01$, respectively. F = establishment, S = sector, R = region and T = time. Standard errors are clustered at the sector-time level. (4) Controls for employment growth the next 24 months and (5) a qualitative measure of demand expectations in the next 6-12 months. Column (6) is results with sample weights. The omitted group is all establishments without any labor shortages, RLS=0. RLS at $d = 1$ is 0.006, at 2 0.016, at 3 0.030, at 4 0.045, at 5 0.066, at 6 0.0914, at 7 0.120, at 8 0.159, at 9 0.230 and at 10 0.657.

Table A.6: Estimates with continuous RLS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
β_{RLS}	0.193*** (0.033)	0.192*** (0.034)	0.155*** (0.032)	0.309*** (0.034)	0.191** (0.084)	1.881*** (0.529)	2.003*** (0.800)
FE		S-R	S-R	S-R	S-R	F	F
Time-FE	T-S	T-S, T-R	T-S, T-R	T-S, T-R	T-S, T-R	T-S, T-R	T-S, T-R
Observations	214,121	213,560	200,820	210,543	100,934	6,008	2,928
R ²	0.195	0.255	0.250	0.322	0.403	0.651	0.670

Note: *, **, and *** denote $p < 0.10$, $p < 0.05$, and $p < 0.01$, respectively. F= establishment, S = sector, R = region and T = time. Standard errors are clustered at the sector-time level. (3) Controls for employment growth the next 24 months and (4) controls for a qualitative measure of demand expectations in the next 6-12 months. Column (5) is results with sample weights. Column (6) is estimates for establishments that have participated 18/23 survey waves and (7) utilizes sample weights.

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