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Wage Adjustment and Wage Rigidity: Industrial Empirical Analysis of Swedish Economy

Jiechao Sheng (41894)

Abstract. The main goal of this article is to estimate how the aggregate wage level is determined by the labour productivity and labour market tightness, as well as how the wage is adjusted, at industry level. I collect monthly data from ten industries in Sweden over 2019-2021, and I use an ordinary-least-square method to set up the regression. The results show that wage gap between industries can be explained by industry-level productivity and market tightness differences, however, strong wage rigidity is observed within industries. The aggregate wage level in an industry does not fluctuate as labour productivity does, nor as labour market tightness does. Next, I analyse the labour market of hospitality industry in Sweden, which has suffered most since the outbreak of Covid-19. Despite the enormous reduction in labour productivity, the wage level in hospitality industry did not fall as a response. However, the newly generated vacancies have been sharply reduced in the subsequent months after two pandemic waves. Meanwhile, there were more newly unemployed workers who have worked in hospitality industry, but the negative impact was not strong as the impact on reduced vacancies. Therefore, a reasonable explanation for the wage rigidity during recession is that employers would rather reduce their recruiting activities in the future than have a wage cut, due to fairness consideration. The negative impact on recruitment could probably exist for a long time, likely more than six months.

Keywords: Wage rigidity, Labour productivity, Labour market tightness, Vacancies, Productivity shock

JEL: J21, J23, J24, J31, J63, L83

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1 Introduction

For a long time economists have argued about how the aggregate wage level is determined, and how the wage rate is adjusted over the time. A common theory about how the wage is formed is the Marginal Productivity Theory, which concludes that labour is rewarded according to his contribution in production. Under this theoretical framework, a worker should be paid the marginal gains of the total revenue after he is put into production, keeping all other factors constant. However, it is unrealistic to calculate how much the marginal revenue is, and this theory is only based on static conditions.

Modern economic theories attach importance to all kinds of factors of production and the condition of labour market, regarding to how the wage is determined. The demand for labour, as well as the labour supply, has played a vital role in wage formation. Whether the labour market is tight or not can influence wage bargaining between employers and employees.

On the other hand, labour productivity is also incorporated as one of the key factors of wage determination. Although the Marginal Productivity Theory does not precisely predict the marginal revenue from the production, it emphasizes the importance of the "internal value" of a worker. Intuitively, the more products a worker can produce, the higher wage he should be given under a competitive market mechanism. This could also be applied to an industry, that aggregate wage rate should be raised as well when the labour productivity in this industry is growing.

This literature mainly contributes to labour economics on industry-level wage determination and adjustment. Although the dynamic relationship between wage and labour productivity has already been discussed by economists in the last few decades, most of them focus on nation-level instead of industry-level analysis. Theories about wage determination also lack empirical data to support economists' hypothesis, thereby making it hard for economists to link their theories with reality; while linking the wage theories and data in reality, economists encounter puzzles which they cannot explain well, including "wage rigidity" and "unemployment volatility". My research does not only illustrate how the wage is determined and adjusted using empirical analysis, but also interpret the reasons behind these two puzzles. In addition, different from former research, I include lag variables to show the long-term side effects of reluctant wage-cut on future recruitment and unemployment, taking the example of hospitality industry in Sweden.

To verify whether wage rate is determined and positively adjusted by labour productivity and labour market tightness, I empirically analyze the relationship between wage rate and another two factors, using the industry-level data from Sweden over 2019-2021. I refer to the work from Carlsson

et al. (2014) on wage adjustment and productivity shocks, but put more weight on the mechanism of labour market tightness. My results suggest that the wage gap among industries can be explained well by the between-industry labour productivity and labour market tightness differences, however, wage rate is rigid to the fluctuation of labour productivity and market tightness over time.

Then I focus on the hospitality industry, which was hit severely by the recession during pandemic period. The data suggests that this industry has suffered negative productivity shock while the wage stood firm during the recession. The explanation is that employers would be reluctant to cut employees' wage during economic downturns, but put less resources into hiring workers in the future (Hall and Milgrom, 2008). To verify whether this statement holds, I conduct a vector autoregression test and set up impulse response function. Later I find that employers indeed sacrificed recruitment in future and pushed unemployment at a higher level, while keeping aggregate wage rate stable.

The rest of the paper is organised as follows: I review the theories of wage determination and briefly present how the Swedish economy is affected by the pandemic shock in Section 2. Section 3 mainly covers how I obtain the raw data and convert it to the time series I need; In Section 4 I introduce how the regression is set up, as well as the results on how the wage is determined and adjusted; In Section 5 I analyse the labour market in hospitality industry under productivity shock, to explain why there is wage rigidity. Finally, Section 6 I conclude and point out some limitations in this article.

2 Background and literature review

2.1 Early research on wage determination and wage growth

Earliest theories of wages were put forward in the 18^{th} century, later developed by Malthus, Ricardo and other classical economists. The Subsistence Theory of wages links the wage growth with population growth, and predicts that working class will stay poor for a long time, which is often thought as too pessimistic. Later the Marginal Productivity Theory was formed, which thinks the wage should be equal to the marginal revenue generated by production, but it is regarded as unrealistic and unpractical to determine the wage level.

Empirical evidence on how the wage is determined and fluctuates is attached awareness by economists in recent decades. One of the early researchers exploring the relationship between the wage rate change and unemployment is Phillips (1958), who finds that wage rate change can be explained by unemployment level and unemployment change rate, by using data from Britain. Statistical

evidence, as illustrated by Phillips, shows that there exists an inverse non-linearity relationship between rate of change of money wage rates and the unemployment rate.

Another widely accepted model, search-and-matching model is developed by Mortensen (1982) and Pissarides (2000)[1]. They emphasize the bargaining power of workers, and think that the wage level is largely decided by the activities of searching and matching. Moreover, different from other early theories of wages, employers and employees are often separated and seen as two different groups; they share the surplus generated by production, and their bargaining power determines how the surplus is shared.

I establish my regression model largely based on the framework and the core of search-and-matching model, especially the wage Nash bargaining rules. Developed by Pissarides (1985), it shows how the equilibrium wage is determined:

$$w(y) = (1 - \beta)b + \beta(y + \theta k)$$

In this equation w is the aggregate wage level, y is the productivity of a job, and θ is the labour market tightness. Other parameters b, β and k respectively represent unemployment benefits, bargaining strength of workers, and fixed cost of machines, all of which are normally regarded as constant. Theoretically in a dynamic environment, the aggregate wage rate in an industry should move in the same direction as the labour productivity and labour market tightness do.

2.2 Empirical evidence of wage formation

Massive research have been exploring how the wage is adjusted by using empirical data, and trying to verify whether the search-and-matching model is sufficient enough to explain the wage adjustment.

Most of these papers find that the association between wages and labour supply and demand is not as close as predicted by Phillips and Pissarides, especially in the 21^{st} century. For instance, the wage growth in the United States in post-recession period after 2008 is not strongly associated with unemployment gap, compared to the 1990s crisis (Daly et al., 2013), though there is still an insignificant inverse correlation. Another research conducts a similar study on Euro area (Byrne and Zekaite, 2020). This study shows that a non-linear curve can better explain the relationship between unemployment rate and employee compensation growth. Furthermore, when labour mar-

[1]The book *Equilibrium unemployment theory* is first written by Pissarides in 1990, cited by many other papers. What I read is the second edition which was published in 2000.

ket is elevated, the sensitivity of wage to unemployment is also smaller.

Similar to the above findings, the association between wage growth and productivity growth is not obvious either. Carlsson et al. (2014) tests whether productivity shock is positively related with wage rate. Although the results from IV method suggests a positive and significant correlation coefficient, the magnitude of this coefficient is far away from unity, out of their expectation, which means wage is too rigid to adjust as the same speed as the productivity. Another economist Feldstein (2008) compares the relation between wage growth and productivity growth in different time periods, and find that productivity grows faster than wages, especially in the 21^{st} century.

The above empirical results raised awareness of many economists. Compared to the sticky wage, the fluctuation inside the labour market is overly acute and abnormal, which Pissarides (2009) terms as "unemployment volatility puzzle". Shimer (2005) uses data from the United States and finds that the trend pattern for unemployment is countercyclical while for vacancy it is procyclical. Vacancy-unemployment ratio, the one used to measure labour market tightness, is procyclical and volatile.

2.3 Spread of COVID-19 in Sweden and its impact on economy

This section is briefly written to cover when and how the coronavirus hit the Swedish economy.

COVID-19 has been confirmed to reach Sweden in the end of January 2020, however, it is not until March that the virus was spread among a number of communities. After the outbreak of the coronavirus in March 2020, a series of restrictions were imposed, including restricting the public gatherings, distance education, and postponement of sports events, etc. In October 2020, a second wave hit Sweden again and caused dangerous amounts of deaths in the next three months; in January 2021, the vaccination started, and the situation recovered.

The Swedish economy was severely hit in the second quarter of 2020, but much better than other European countries. In the second quarter of 2021, the GDP of Sweden recovered to the level before the outbreak of coronavirus (Ministry of Finance, 2021). Regarding to the labour market, more people lost their jobs due to the spread of COVID-19, especially in the 14^{th} calendar week in 2020 when the new unemployment reached the highest (Juranek et al., 2021). As expected, at the same time, the average and total working hours has reduced too, as more employees worked at home or left their jobs.

My sample data ranges from 2019 to 2021, covering pre-pandemic, post-pandemic, and recovery periods. In section 5, I will mainly discuss how the hospitality industry was hit, as well as the performance of labour market.

3 Data and descriptive statistics

This section mainly contributes to the literature by listing how the data is collected and how the variables are measured.

Three variables, including wage, labour market tightness and labour productivity, are calculated based on industry-level panel data in Sweden. Wage and labour productivity are deflated by price index, so they are real terms[2]. All these parameters are monthly time series from January 2019 to December 2021.

Totally there are 10 industries in my sample, including:
1) Administrative and support service;
2) Arts, entertainment and recreation;
3) Construction;
4) Education;
5) Hotels and restaurants;
6) Human health and social work;
7) Information and communication;
8) Mining, quarrying and manufacturing;
9) Trade, and repair for motor vehicles and motorcycles;
10) Transport and storage.
Note that there is no data about the real wage of manual workers in information and communication industry, therefore the time series remains blank.

In the following sections I may describe in detail where the data comes from and how I convert the raw data to monthly time series.

3.1 Real wage

The aggregate wage level can be reflected from the average hourly earnings or monthly salary in the industry. Here I use hourly earnings as the parameter, for a better comparison with labour

[2]In the following sections, all the wages are real wages, unless specifically noted as "nominal wages". This is applied to real labour productivity too.

productivity, which is also measured as hourly output. Hourly earnings are respectively collected for manual workers and non-manual workers, and the currency unit is Swedish Krona (SEK).

Manual workers are usually those who do physical works, whose wages are hourly paid. In contrast, non-manual workers are paid at a monthly base. There is no data on the weight of these two types of workers in labour market, so I often list the wages of both types in a parallel way.

All the data about the wages comes from Statistics Sweden. For manual workers, the information about the hourly earnings can be retrieved directly from the database; however, for non-manual workers, there is only time series data for their monthly salary. Therefore, I firstly convert their monthly earnings to weekly earnings, that is, monthly salary divided by 4.34524, which is roughly the total number of weeks each month; then I divide the weekly salary by 40 so that I get the average hourly earnings for non-manual workers.

Note that the above data is nominal wage, not yet adjusted for inflation. Therefore, I apply the following formula to deflate the nominal wage:

$$RealWage_{i,t} = NominalWage_{i,t} * CPI_{2020}/CPI_t$$

The average CPI of Sweden in 2020 is 335.92 (1980=100). The above formula helps to adjust the average hourly wage to the real term based on the year 2020.

Table 1
Mean and standard deviation of real hourly earnings (SEK), for manual and non-manual workers across industries in Sweden 2019-2021

industry	mean(wage_manual)	sd(wage_manual)	mean(wage_nonmanual)	sd(wage_nonmanual)
administrative&support service	**163.14384**	**1.826277**	**194.23133**	**1.804029**
arts&entertainment&recreation	**153.40827**	**3.716103**	**200.80363**	**2.797875**
construction	**193.70224**	**2.409905**	**251.57659**	**2.61805**
education	**153.53981**	**1.548905**	**197.08369**	**3.927447**
hotels&restaurants	**147.25057**	**2.135898**	**211.36232**	**2.336492**
human health&social work	**162.62336**	**2.926955**	**216.84198**	**3.294653**
information&communication			**264.78483**	**4.446664**
mines&quarries&manufacturing	**187.81701**	**2.565672**	**263.195**	**2.201921**
trade&repair	**173.27886**	**3.114034**	**231.17179**	**3.60039**
transport&storage	**171.35613**	**2.121779**	**203.1861**	**2.396975**

Table 1 presents the mean values and standard deviation of real wages for manual and non-manual workers in ten industries over 2019-2021. The aggregate wage level for IT-related, construction, mining and manufacturing industries is the highest among these industries. Meanwhile, the deviation of wages for IT-related, trade and repair companies is relatively larger than others; the

deviation for education industry is among the largest for only non-manual workers' wages, but rather small for manual workers' earnings.

3.2 Labour market tightness

As mentioned by Pissarides (1985) and a series of research papers thereafter, labour market tightness is measured by using vacancies-unemployment (v-u) ratio, which delivers information about the excess or shortage of labour force. The higher the ratio is, the tighter is the labour market, and there would be more unoccupied jobs available per unit of unemployed worker.

It is difficult to measure the unemployment for a specific industry, because in reality people can move between different industries and they may not stay in one industry for the whole lifetime. An alternative way to measure the temporary unemployment for a industry is to use the worker outflow. Both Carlsson et al.(2018) and Muchlemann and Strupler Leiser (2018) use this method to calculate the sector-level labour market tightness, that the number of unemployed people who lastly worked in a sector is the unemployment of the corresponding sector. As a matter of fact, this method has also been applied by other institutions and government agencies. However, the most obvious drawback is that we have no idea whether the unemployed person is ready to work in the same industry as the job he leaves before, but so far this is the best alternative.

Since the denominator of v-u ratio, the unemployment, is worker outflow, the nominator should also be flow instead of stock. Therefore, I collect the data about the newly generated vacancies each month. The number of new vacancies reported and the population who leave their jobs from January 2019 to December 2021 are provided by Swedish Public Employment Agency (Arbetsförmedlingen). Vacancies and unemployment monthly time series are both collected at industry level. Then the monthly labour market tightness can be calculated using new vacancies divided by new unemployment.

From the table 2 we can easily infer that among the 10 industries, the human health and social work industry has the tightest labour market, of which the v-u ratio is over 0.6; for other industries, their v-u ratio is roughly between 0.1 and 0.4.

3.3 Real labour productivity

Labour productivity is the output that an average worker can produce for each hour. To some extent, labour productivity can be regarded as a long-term factor of real wage. Labour productivity

Table 2
Average newly reported vacancies, new unemployment and labour market tightness across industries in Sweden over 2019-2021

industry	mean(vacancies)	mean(unemployment)	mean(tightness)
administrative&support service	8990.3333	56084.306	.16266073
arts&entertainment&recreation	512.5	4568.1389	.13189666
construction	3531.0556	15631.556	.2359152
education	8125.1944	33200.417	.25314143
hotels&restaurants	5421.7222	44584.917	.1319689
human health&social work	23477.111	36993.472	.64258688
information&communication	6656.8889	16884.111	.41122516
mines&quarries&manufacturing	4212.2778	21754.444	.19882538
trade&repair	17979.056	55770.278	.33370487
transport&storage	4285.1667	18118.25	.25202602

growth driven by technological progress can possibly push the real wage up in the medium or long run (Meager and Speckesser, 2011).

To minimize the impact of inflation, the labour productivity is deflated into the real term, and the base year is 2010. Here I use labour-input method to measure the labour productivity, as Carlsson et al. (2014) do. Relevant data is retrieved from Statistics Sweden; however, there is no information about the monthly real labour productivity but the quarterly real gross domestic product (GDP) by industries. So I interpolate the quarterly real GDP into the monthly one, by selecting industrial production index (IPI) and service production index (SPI) as preliminary time series. IPI is applied on predicting the monthly real GDP for "mining, quarrying and manufacturing industry" over the three years, while SPI is applied for other 9 industries. The key issue of interpolation is that the preliminary series need to be highly correlated with the low-frequency time series we predict (Guerrero, 2003).

Then I convert the monthly real GDP into monthly real labour productivity. I divide the monthly real GDP by 4.34524 to get the weekly GDP, then divide the weekly real GDP by the total number of hours worked in the corresponding industry. In the end, I get the real labour productivity by industry.

From the table 3 we can see that mining, manufacturing and IT related industries share the highest labour productivity, while education, human health and social work have the lowest labour productivity. It is not abnormal that several industries here have extremely low labour productivity, because industries differ from each other on labour intensity and capital intensity, as well as how much other input they bear during production. Further details will be discussed in section 5.

Table 3
Mean values and standard deviation of real labour productivity in Sweden over 2019-2021, by industry

industry	mean(labour_product)	sd(labour_product)
administrative&support service	**793.27486**	**121.5691**
arts&entertainment&recreation	**197.49727**	**29.80105**
construction	**509.79221**	**86.01233**
education	**68.290654**	**40.99519**
hotels&restaurants	**320.6057**	**52.04866**
human health&social work	**109.8304**	**9.294602**
information&communication	**886.89334**	**216.6745**
mines&quarries&manufacturing	**881.18554**	**133.7018**
trade&repair	**563.28457**	**58.7628**
transport&storage	**477.20025**	**62.94595**

4 Regression Empirical Analysis

In this section, I will apply ordinary least squares method to explore the relationship among the wage and labour productivity, as well as how they move interactively with each other, and also the one between the wage and labour market tightness, using the industry-level panel data in Sweden.

4.1 Empirical Strategy

Here I take the reference of the regression model put forward by Carlsson et al. (2014). Like what they do, I take log value of real wage as dependent variable and log value of real labour productivity as the explanatory variable, which can be used to measure the elasticity of wage rate.

One difference between their method and mine is that they estimate how the wage responds to productivity shock at firm level, while I focus on industry level. They decompose the productivity into sectoral mean and orthogonal idiosyncratic residual to capture sector-level and idiosyncratic movements. However, it is not necessary for me to decompose the movements of labour productivity here, as I estimate the aggregate wage at industry level. The idiosyncratic shock to firms is unable to be captured.

Therefore, the regression model for my estimation is given by:

$$w_{i,t} = \lambda_i + \rho_t + \alpha_0 + \alpha_1 y_{i,t} + \alpha_2 \theta_{i,t} + \epsilon_{i,t}$$

where w denotes the log wage; y denotes the log labour productivity; θ is the labour market tightness, represented by vacancy-unemployment ratio; i denotes the industry and t denotes the month. λ is the industry-level fixed effects; and ρ is the time-fixed effects.
In addition, α_1 and α_2 are coefficients of log labour productivity and labour market tightness, respectively.

4.2 Assumptions

The basic assumption of this regression model is that the wage rate responds to shocks through two channels - productivity and the labour market competitiveness. As mentioned in section 2.1, wage Nash equation illustrates a steady state where the aggregate wage w is solely determined by these two factors, while any other shocks or variation are absorbed by productivity y and market tightness θ:

$$w(y) = (1 - \beta)b + \beta(y + \theta k)$$

Pissarides (2000) makes a further interpretation on decomposing this aggregate wage equation. The term θk is the average hiring cost for each unemployed worker[3]. A higher labour market tightness indicates that job arrives earlier to a worker than worker manages to find a job, which gives the worker a higher bargaining power during hiring process.

On the other side, productivity y reflects the true value that a worker can make to the vacant. Pissarides (2009) explains how the productivity shock is transmitted to wages: wage rate can be directly affected by the own-job productivity due to sharing assumptions; or the coefficient of productivity on wage rate can be indirectly biased by the change of reservation values of firms and workers.

In summary, I assume that all the shocks or growth are influencing the wage rate through labour productivity and market tightness channels. Although some research papers consider life-cycle wage growth and contribute it to the human capital accumulation, it may not apply to industry-level aggregate wage; human capital accumulation can still be absorbed by labour productivity growth,

[3]In this book, Pissarides terms the aggregate wage equation, or wage Nash equation, as $w(y) = (1-\beta)b+\beta y(1+c\theta)$. There is no differences between this one and the one written by him in 1985, as $k = cy$, where c is a parameter expressed as how much percentage of productivity y is the hiring cost.

which thereafter affects wage level.

Another assumption is that there could be exogenous differences or shocks which affect wage rate outside these two channels. For instance, parallel assumption that the aggregate wage level are equal across industries may not hold due to exogenous factors. This inter-industry wage premium may be explained by union worker bargaining (Dickens and Katz, 1987), or industry-specific policy regulation. Therefore industry-level fixed effects may be included to examine the existence of industry-level wage premium which cannot be explained by these two channels.

Time fixed effects are applied in case there is a exogenous shock at specific time periods, which affect the wage rate at all industries. However, I doubt whether it is reasonable enough to include time-specific fixed effect, as time-variant fixed effects (e.g. policy regulation on hiring or firing employees) may be absorbed by labour market supply. In addition, some papers do not include time fixed effects, either (Muehlemann and Strupler Leiser, 2018).

Therefore, to get a comprehensive understanding about the results and compare the coefficients, I conduct each regression test for three times - without fixed effects, with only industry-fixed effects, and with both industry-fixed effects and time fixed effects.

I conduct regression tests respectively for manual and non-manual workers. Besides, in case the policies and other exogenous factors during pandemic interfere with the observations, I set up one more model which exclude the observations after March 2020, the period when the coronavirus was spread commonly among communities in Sweden.

4.3 Results

The results of the regression test are listed in table 4 and table 5, respectively for manual workers and non-manual workers. Note that when including fixed effects, the data is clustered at industry-level. I have not displayed the results for non-clustering regression, because their differences on standard error are trivial.

First take a look at table 4, the results for manual workers. The coefficients of log labour productivity and labour market tightness are positive and significant (column 1) at 1% level, where the former one is 0.0676 and the latter one is 0.1298. However, the magnitude of the coefficients of these two explanatory variables becomes smaller when including industry and time fixed effects (column 3), and we cannot reject the hypothesis they are different from 0 at 10% significance level, except

Table 4: The coefficients of labour productivity and market tightness on wages of manual workers

	(1)full sample b/se	(2)full sample b/se	(3)full sample b/se	(4)only before pandemic b/se
log_labour_product~y	0.0676***	−0.0127*	0.0034	0.0013
	(0.0047)	(0.0066)	(0.0047)	(0.0029)
market_tightness	0.1298***	−0.0209	−0.0048	0.0043
	(0.0215)	(0.0199)	(0.0104)	(0.0125)
_cons	4.6918***	5.1949***	5.1003***	5.1088***
	(0.0295)	(0.0392)	(0.0255)	(0.0153)
industry fe	no	yes	yes	yes
time fe	no	no	yes	yes
N	324.0000	324.0000	324.0000	126.0000
r2	0.3972	0.0414	0.6761	0.6367
bic	−794.7739	−1791.4253	−2108.2767	−836.0811

* p<0.10, ** p<0.05, *** p<0.010

Note: full sample - from January 2019 to December 2021; only before pandemic - from January 2019 to February 2020.

Table 5: The coefficients of labour productivity and market tightness on wages of non-manual workers

	(1)full sample b/se	(2)full sample b/se	(3)full sample b/se	(4)only before pandemic b/se
log_labour_product~y	0.0776***	−0.0027	0.0019	−0.0060**
	(0.0056)	(0.0033)	(0.0035)	(0.0025)
market_tightness	0.1758***	−0.0237**	0.0018	−0.0008
	(0.0257)	(0.0082)	(0.0100)	(0.0066)
_cons	4.8982***	5.4245***	5.3795***	5.4268***
	(0.0354)	(0.0202)	(0.0218)	(0.0151)
industry fe	no	yes	yes	yes
time fe	no	no	yes	yes
N	360.0000	360.0000	360.0000	140.0000
r2	0.3678	0.0456	0.7201	0.7136
bic	−683.5360	−2082.1901	−2482.6497	−1065.6559

* p<0.10, ** p<0.05, *** p<0.010

Note: full sample - from January 2019 to December 2021; only before pandemic - from January 2019 to February 2020.

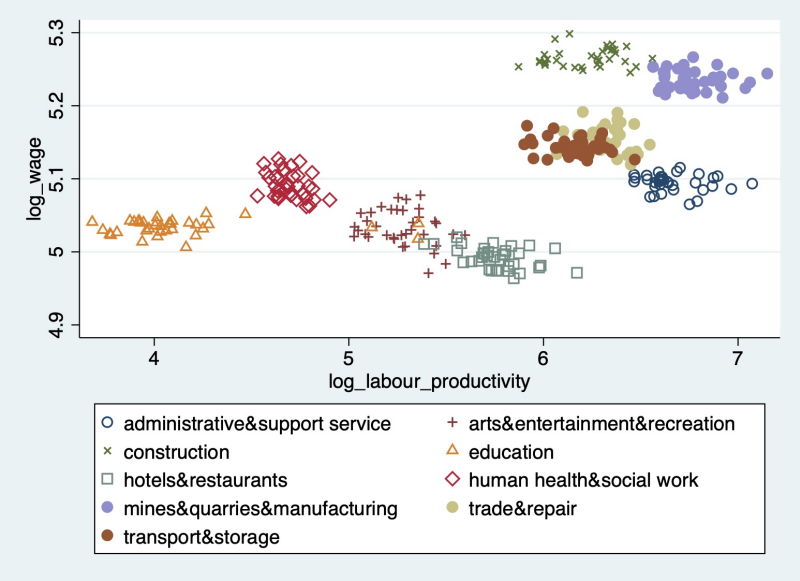
the coefficient of log productivity in column 2, where the coefficient is -0.0127 and significant at 10% level. The coefficient of of productivity is even smaller when keeping observations only before the break-out of the coronavirus (column 4).

Then take a look at table 5 for non-manual workers, which delivers similar results as the manual one. The wage for non-manual workers is even more sensitive to productivity and market tightness than the one for manual workers, and coefficients are positive and significant at 1% level (column 1), where the coefficient of productivity is 0.0776 and the one for market tightness is 0.1758. However, the significance level is substantially reduced and close to 0 when including fixed effects (column 2 and 3). The coefficient of column(4) even suggests a negative relationship between labour productivity and wage of non-manual workers, and this coefficient is significant at 5% level.

It appears that the magnitude of these coefficients are weakened after including fixed effects, which

does not match wage Nash equilibrium theory on the relevance of wage to other two variables. The impact of labour productivity and market tightness are much more limited than what I expect at the beginning. The most striking result is that wage does not respond sensitively to the productivity growth, where the correlation coefficient should be around 0.5 if the generated surplus from production is equally shared between employers and employees.

Figure 1: Scatter plot between wage and labour productivity of manual workers in Sweden over 2019-2021, log value, by industry

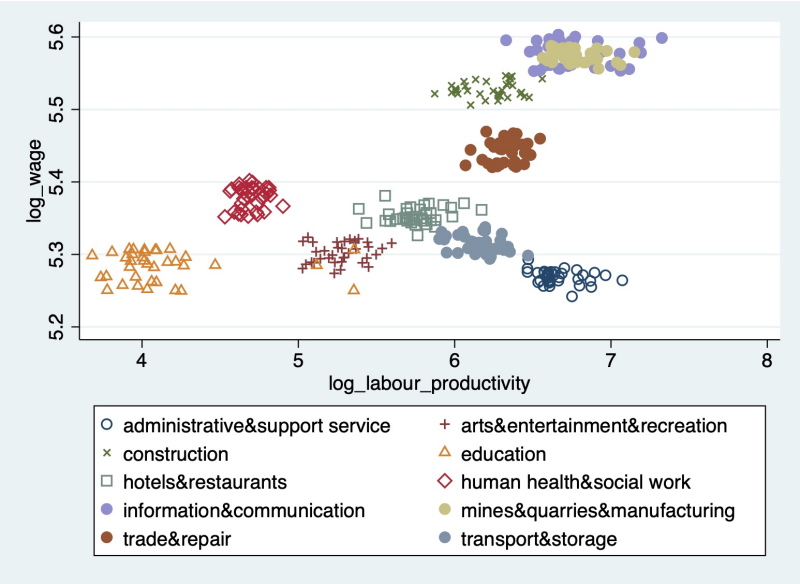


To better display how the wage is correlated with labour productivity, and how the wage differences can be decomposed into with-industry and between-industry gaps, here I draw two scatter plots. From the figure 1 and figure 2, we can clearly see that the aggregate wage level is higher in the industry with higher labour productivity, no matter whether it is manual or non-manual workers. However, if we look at the within-industry wage differences, we will find that the aggregate wage in a industry is reluctant to fluctuation of labour productivity and market tightness over time. The conclusion is that the aggregate wage rate at industry-level is not sensitive enough to the move of productivity and market tightness, using data of Sweden over 2019-2021.

4.4 Comparison studies on labour productivity and wage

It is not out of surprise that wage rate responds insensitively to labour productivity change, if comparing the results above with other papers. Carlsson et al. (2014) conduct a similar study, focusing

Figure 2: Scatter plot between wage and labour productivity of non-manual workers in Sweden over 2019-2021, log value, by industry



on the impact of labour productivity on wage. As mentioned in section 4.1, they decompose productivity into sector-level and idiosyncratic firm-level. They also include labour market tightness as a control variable, as well as time fixed effects and time-varying heterogeneity. By using OLS regression test, they suggest that although both sector-level and idiosyncratic firm-level productivity shock are positively related with wage growth, the sector-level one is insignificant and smaller than the latter one; only when including physical total factor productivity as the instrumental variable, the coefficients become much larger and significant at 5% level. However, the coefficients are still much lower than what they expect.

If we compare the coefficient of the productivity shock within a sector from their paper, that is, 0.043, with my result in this literature, 0.0034 and 0.0019, we can find that there exists similarity - much smaller than expected, and insignificant at 10% level. Considering that Carlsson et al.(2014) use log monthly payments as dependent variable while mine is hourly earnings, the coefficient I get in this literature should be around 1.14 larger if measured at monthly base. In summary, as stated by Carlsson et al., the elasticity for productivity shock is far away from unity, considering the magnitude of coefficients.

The fact that the wage adjustment is reluctant to the productivity change has also been discussed in other papers. The reluctance is especially obvious during economic downturns. Kaur (2019)

empirically examines how the wages are affected by transitory productivity shocks in villages of India. The productivity shock is a dummy variable, indicating whether it is "positive" or "negative", based on rainfall level in the corresponding year. His results show that while positive shocks have persistent effects on wages in the following year, lagged negative shocks have no persistent effects. Nominal wages rise in response to positive productivity shocks; but during negative shocks, the wage does not fall, or sometimes even keep rising. Kaur attributes this phenomenon to fairness preferences. Another research shows similar results by summarising the path wage growth in the United States during and after 2008 financial crisis (Daly et al., 2013). They find that few employees experienced wage cuts during the recession, and similar phenomenon can be tracked in previous economics downturns.

What about the wage growth in economic booming? Shimer (2005) investigates the wage growth and cyclical pattern of vacancy-unemployment ratio during 1951-2003, and finds that most of the productivity shock during economic booming was absorbed by wage growth. However, an interesting finding from Feldstein (2008) shows that since the 2000s, productivity has been growing more rapidly than wages, which means most of the productivity growth is not absorbed by wage growth. In another word, in the 21^{st} century, the real wage level is more stable and the employment is more volatile nowadays than the past. A possible explanation given by Feldstein is the rise of capacity utilization, which climbed up to 82% in the United States before 2008 recession, accounting for the enormous gap between productivity growth and wage growth; on the other hand, capital deepening is raising the capital intensity, and the productivity growth is mostly absorbed by capital gains.

Furthermore, Feldstein (2008) also emphasizes that compensation instead of purely wages should be incorporated as the benefits shared by employees. As my target is Swedish economy after 2000s, the capacity utilization, capital deepening, fairness preferences, and compensation growth may collectively explain the insignificant magnitude of the coefficient of labour productivity on wage rate.

4.5 Discussions about labour market tightness, hiring costs and wages

The results shown in section 4.3 does not reject the null hypothesis that there is no relationship between labour market tightness and wages, either. The wage fluctuation within a industry may not be explained well by the change of labour market tightness.

As a matter of fact, in many research papers, labour market tightness is included in regression as a inconsequential control variable. Only in papers which concentrate on competitiveness of unemployed workers, labour market tightness becomes a important explanatory parameter. For example,

Carlsson et al. (2014) have not provided much detail on how the labour market tightness, as a control variable, affects or distorts the empirical test results.

However, labour market tightness should indeed be seen as an important parameter to measure labour supply and demand, despite its limited functions. As I mention in section 4.2, Pissarides (2000) concludes that labour market tightness affects aggregate wage rate through the hiring costs[4]. How the labour market tightness influences hiring costs is discussed by Muehlemann and Strupler Leiser (2018), who find that the pre-match component of hiring costs "search cost" is positively correlated with labour market tightness; however, no significant association has been discovered between the post-match component "adaption cost" and labour market tightness. Moreover, there is no robust evidence that v/u ratio is positively related to weekly wages of skill workers, no matter whether state and occupation controls are included.

Paper written by Carlsson et al. (2018) even gets an "abnormal" result - they find that ethnic discrimination rises in labour market tightness, against previous research results about ethnic employment gaps during business cycles. The bargaining power of workers, especially those minorities, should have increased when the labour market has a stronger demand for new labour force; the fact is that during economic booming, companies are more likely to recruit natives than ethnic minorities than before. Despite the differences on dependent variables, the similarity between Carlsson et al.'s paper and mine is that the target is Swedish labour market.

One explanation on why labour market tightness is not working well as an explanatory variable of wage rate as predicted by search and matching model is that the assumptions about bargaining process are unrealistic (Hall and Milgrom, 2008). The threat posed by a qualified worker to walk away when negotiating with the employer is not credible. Furthermore, according to Hall and Milgrom, the causality between labour market tightness and wages can be reversed - when facing economic downturn and low productivity, employers are reluctant to cut staff's wages, instead they take most of the burden of the recession compared to employees; to alleviate the burden, employers would rather put fewer resources into recruiting in the future, leading to a higher unemployment rate and a slacker labour market. This statement is partially supported by the statistical evidence from the United States provided by Hall (2005), who finds that the unemployment is raised substantially and quickly in the early months following a negative productivity shock, and it takes several years to gradually decline. Meanwhile, job-finding rate follows an opposite pattern to the unemployment following the negative impulse - workers feel extremely difficult to find jobs when there comes a negative productivity shock, and it takes years for it to adjust to normal level.

[4]Recall that θk is the averaging hiring cost for each unemployed worker. Since $\theta = v/u$, vk is the total hiring cost in the economy.

In summary, in most literature, labour market tightness is even a "worse" variable to explain the fluctuation of hiring costs and aggregate wage level, compared to the performance of the labour productivity. In the following section, I will display how the wage stay rigid during productivity shock, taking the example of hospitality industry. In addition, I will also explain how the vacancies and unemployment absorbed the negative productivity shock during recession.

5 Negative productivity shock and labour market

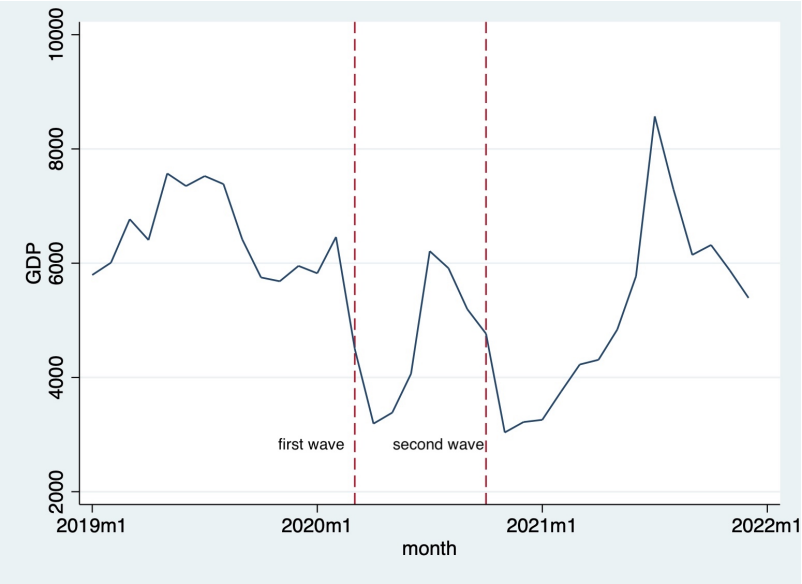
In this section, I will analyze how the wage, newly generated vacancies and worker outflow are influenced by the negative productivity shock caused by coronavirus, by taking the example of hospitality industry in Sweden over the last three years. I will also explain how the wage rigidity distort the fluctuation of wage.

As Sweden implemented a relatively looser policy compared to other countries, the impact of the spread of COVID-19 varied across industries. Industries that require social interaction, gatherings, outdoor activities or long-distance transportation were estimated to be heavily affected, compared to IT-related or manufacturing industries. Therefore, I pick "hotels and restaurants" as the target, which was the mostly affected industry due to a series of restrictions on social interaction and travelling.

5.1 Recession of hospitality industry

From the figure 3 we can observe that hospitality industry has experienced severe recession since the first and the second wave of coronavirus outbreak. The GDP dropped from around 6000 million SEK to less than 4000 million SEK; despite its temporary climb-up in summer 2020, it fell again in winter. Only after the vaccination was offered in January 2021, the GDP began to recover to its level before pandemic period.

Figure 3: Monthly real gross domestic product (million SEK) of the hospitality industry in Sweden over 2019-2021, base year: 2010



However, this raises a question: what is the driving factor of the recession in hospitality industry? Is it the reduction of labour productivity, or the decreasing total working hours?

Figure 4: Real labour productivity (SEK) of the hospitality industry in Sweden over 2019-2021, log values, base year: 2010

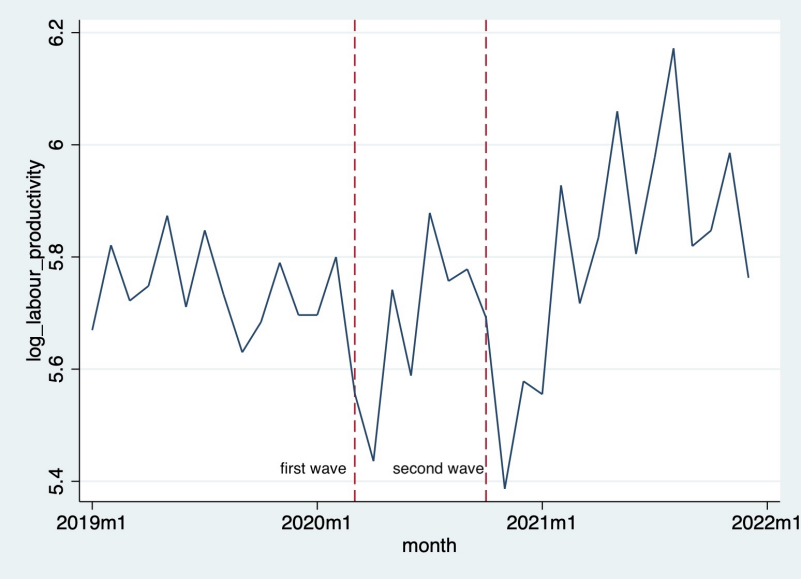


Figure 5: Weekly working hours (million) for the whole hospitality industry in Sweden over 2019-2021

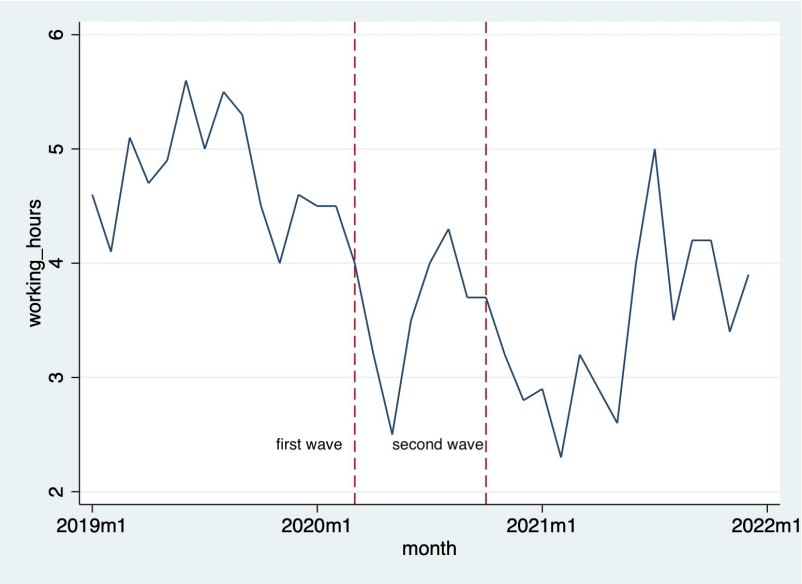


Figure 4 and figure 5 illustrate that both labour productivity and working hours substantially dropped after the first and the second wave of coronavirus. We can infer that the recession of the hospitality industry was the result of the both factors.

The reduction of the total working hours is partially due to the higher unemployment. From figure 6 we can see that during the first wave, the number of workers who left hospitality industry and became unemployed climbed from around 40000 to over 55000 in a short time, meanwhile the number of vacancies dropped by more than a half; a similar pattern can be observed during the second wave, but the scale was much smaller.

As mentioned before, labour market tightness is measured using v/u ratio. Then here is the trend of labour market tightness in figure 7. The labour market tightness of hospitality industry fluctuated around 0.16 before the spread of coronavirus, then it suddenly dropped to only around 0.05. Since the beginning of vaccination, it has gradually recovered to its original level.

5.2 Wage rigidity during recession

Although from previous section we learn that hospitality faced a severe recession due to the substantial reduction of labour productivity and high unemployment, the aggregate wage level in this

Figure 6: Newly unemployed and new vacancies in hospitality industry in Sweden over 2019-2021

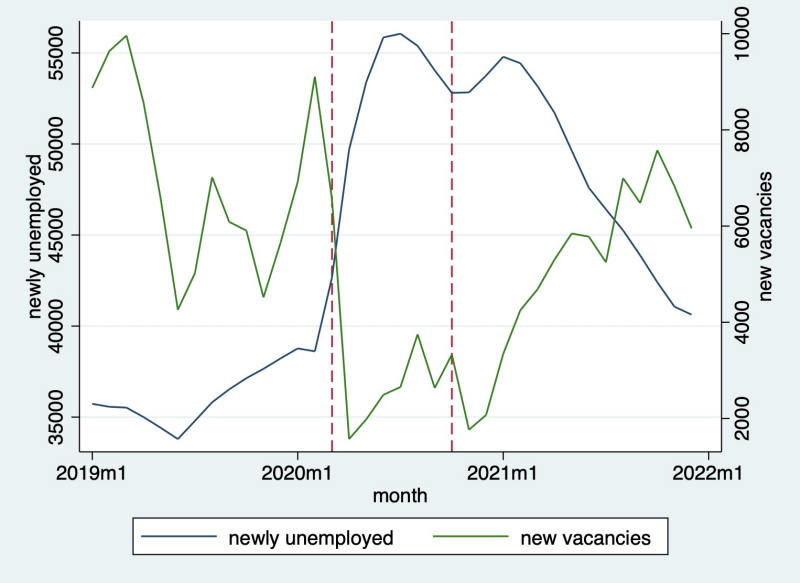
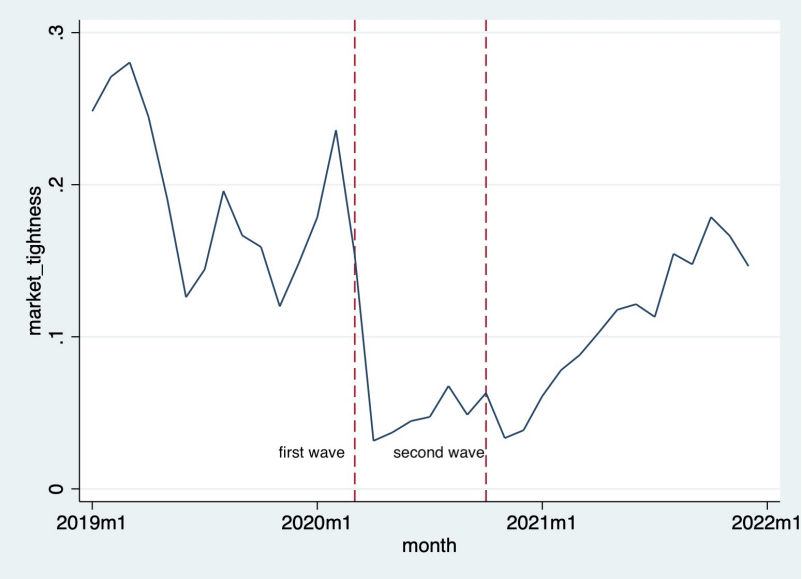


Figure 7: Labour market tightness of hospitality industry in Sweden over 2019-2021



industry did not change too much.

Figure 8: Average hourly earning (SEK, log values) for manual workers in hospitality industry in Sweden over 2019-2021, deflated by CPI in 2010

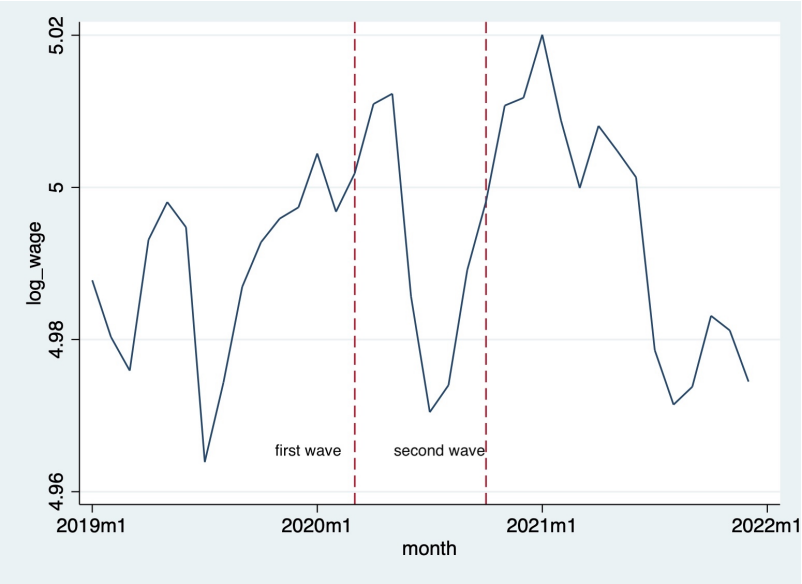
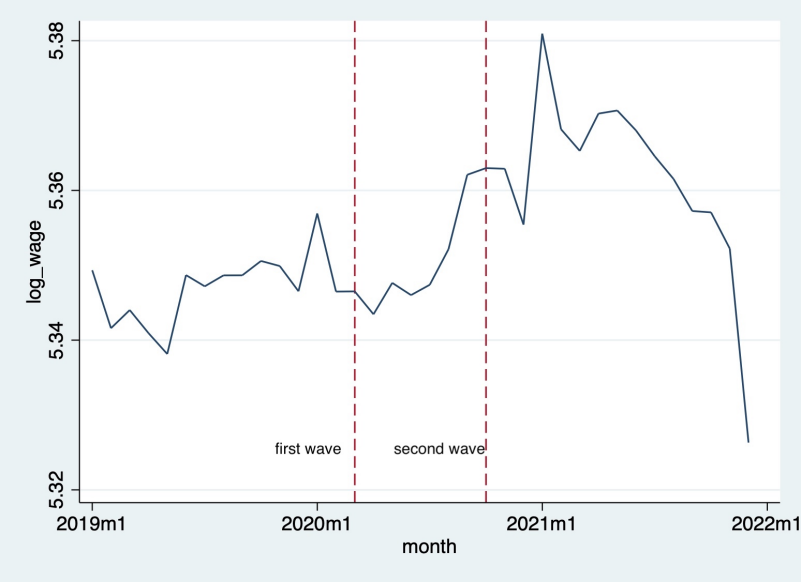


Figure 9: Average hourly earning (SEK, log values) for non-manual workers in hospitality industry in Sweden over 2019-2021, deflated by CPI in 2010

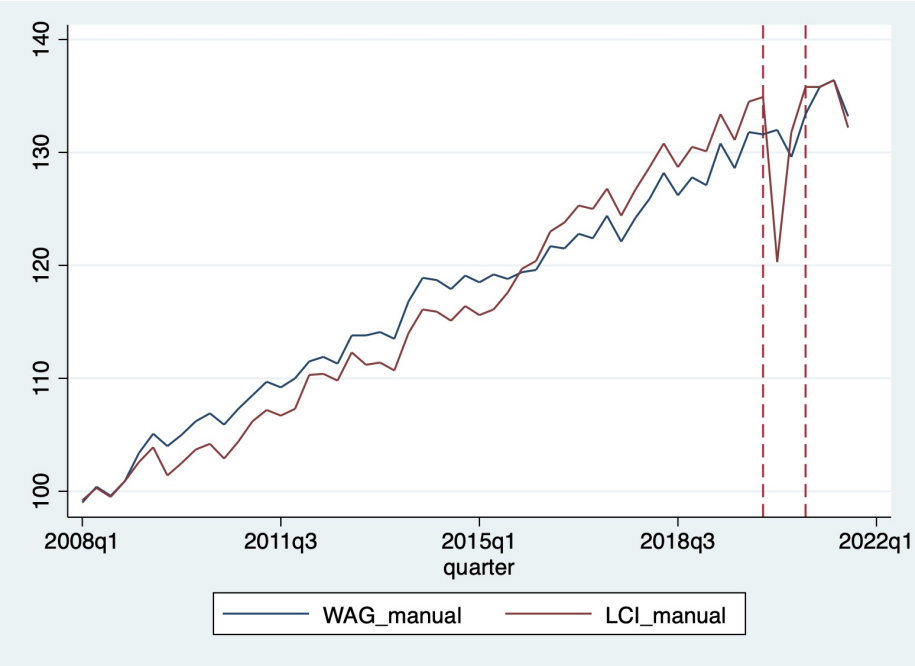


From figure 8 and figure 9 we can see that the trends of real wage for both types of workers are random walk, of which the former one displays an obvious seasonal pattern. It appears that the

aggregate wage is not affected too much by the recession caused by the coronavirus. This is against the hypothesis that wage is determined purely by labour productivity and labour market tightness, at least, not evident for short-term wage adjustment.

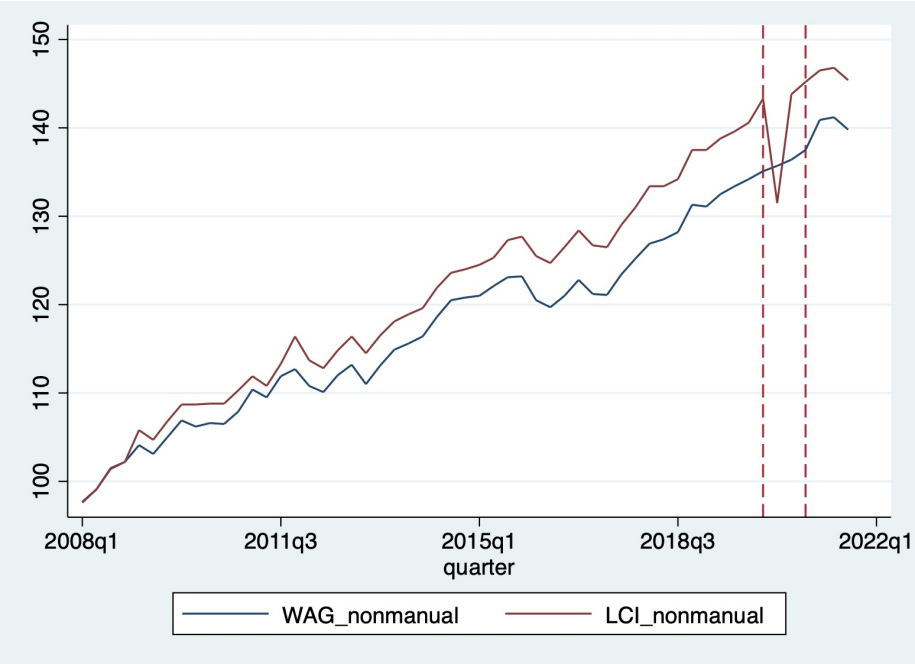
The above figures may not be sufficient enough to explain the wage adjustment in the long run, and we can hardly observed whether there is a substantial drop due to the existing seasonal pattern. Therefore I plot the trend of the labour cost index of hospitality industry in Sweden over 2008-2021.

Figure 10: Labour cost index (manual workers) for hospitality industry in Sweden over 2008-2021, quarterly time series, 2008=100



Note: The above data is retrieved from Statistics Sweden. LCI stands for total labour cost per hour, including salary, variable salary increments, benefits, sick pay and employer contributions and bonuses. WAG stands for wage and salary costs, where social contributions are not included.

Figure 11: Labour cost index (non-manual workers) for hospitality industry in Sweden over 2008-2021, quarterly time series, 2008=100



Note: The above data is retrieved from Statistics Sweden. LCI stands for total labour cost per hour, including salary, variable salary increments, benefits, sick pay and employer contributions and bonuses. WAG stands for wage and salary costs, where social contributions are not included.

We can easily observe from figure 10 and figure 11 that salaries and wage cost paid by employers did not experience a substantial drop during pandemic periods, while the total labour cost, which contains sick pay and other social contributions, experienced a relative larger reduction. The reason for such a significant reduction in total labour cost is probably the financial coverage of sick pay and contributions by Swedish states, from the second quarter in 2020 to the second quarter in 2021.

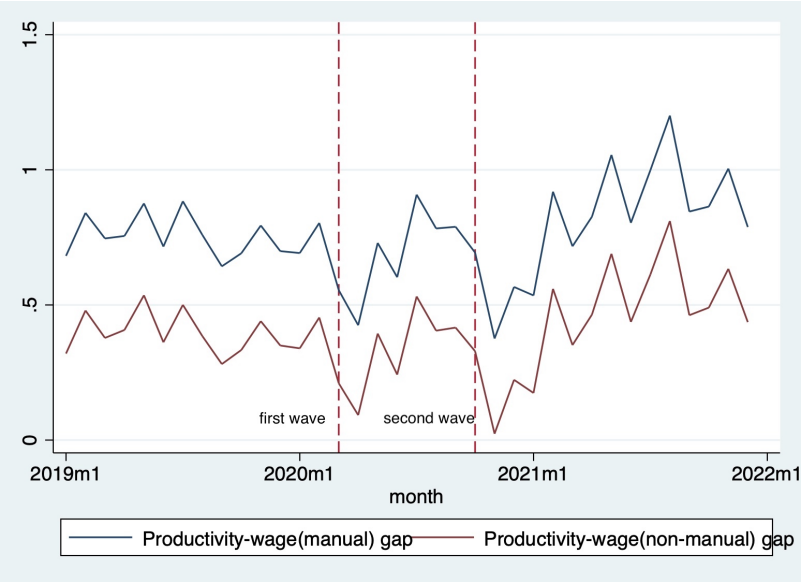
However, the financial support by the government cannot fully explain the wage rigidity during recession. What the government did is to save the loss of employers caused by reduced working hours, so it would not affect the regular hourly earnings of employees. The loss triggered by the reduction of labour productivity has not driven employers to have a notable wage cut, especially for those manual workers who had fixed and short-term contracts.

5.3 Recruiting activities absorb productivity loss?

The explanation given by Hall and Milgrom (2008), cited in section 4.5, may possibly explain why the aggregate wage level stayed strong during productivity downturn. Due to the consideration of fairness, employers are reluctant to cut workers' wages when they are facing a recession. A preferred solution to offset the negative impact of the recession is to reduce new vacancies in the future, or terminate contracts with workers.

Therefore, I first derive the labour productivity-wage gap, then plot it along the time periods from 2019-2021 (figure 12). I refer to the report written by López-Villavicencio and Silva (2011), using the log difference between labour productivity and wage rate as the gap. The larger the gap is, the less the workers share the surplus generated by production. According to the search-and-matching model, productivity-wage gap can be seen as the surplus shared by employers; however in reality, this gap may interpreted as the share left to all the stakeholders except employees. There is no specialized data for manual workers or non-manual workers' labour productivity, so I respectively plot two time series for the gap.

Figure 12: The gap between labour productivity and wage, for hospitality industry in Sweden, over 2019-2021



We clearly see that the productivity-wage gap for both types of workers was shortened for a short period of time after pandemic shock. This means that employers tended to bear the loss of pro-

ductivity reduction without adjusting wage rate too much. It is much likely that the burden of the loss was mostly transmitted to workers who left their jobs, or the workers expected to be hired in the future.

Here I conduct a vector auto-regression model test on productivity-wage gap, the number of newly generated vacancies, and the number of workers who leave their jobs. I originally applied two lags, but the coefficients of the second lag are not significant and might even interfere with the first lag, so here I keep only one lag. In addition, note that for a better comparison, all these three variables are log values.

From table 6 and table 7 we can see that apart from the auto correlations, there are two correlations significantly correlated with each other at 10% level. The productivity-wage gap in the last month could have an positive impact on the number of newly generated vacancies this month, and also a negative impact on the outflow of labour force. In contrast, the number of new vacancies and unemployment would not have a reverse impact on productivity-wage gap, which is intuitively reasonable.

From the VAR model, we know that employers indeed decide their future recruitment activity and dismissal based on current surplus shared between themselves and employees. Here the lag is one month, so it means current wage level could possibly affect newly generated vacancies and unemployment the next month; however, it might also affect these two variables in the same month, but there is no way to verify it as all of them are monthly time series.

Table 6:Vector Auto-regression model among productivity-wage gap, new vacancies and new unemployment, 1 lag, manual

	var1 b/se
Product-wage gap	
L.Product-wage gap	**0.2907**
	(0.1877)
L.new vacancies	**0.0773**
	(0.0893)
L.newly unemployed	**0.1822**
	(0.2206)
_cons	**-2.0577**
	(2.9138)
new vacancies	
L.Product-wage gap	**0.7597****
	(0.3709)
L.new vacancies	**0.4550*****
	(0.1764)
L.newly unemployed	**-0.6437**
	(0.4358)
_cons	**10.9151***
	(5.7565)
newly unemployed	
L.Product-wage gap	**-0.1096*****
	(0.0405)
L.new vacancies	**-0.0142**
	(0.0193)
L.newly unemployed	**0.9178*****
	(0.0476)
_cons	**1.0866***
	(0.6287)

* p<0.10, ** p<0.05, *** p<0.010

Table 7:Vector Auto-regression model among productivity-wage gap, new vacancies and new unemployment, 1 lag, non-manual

	var2 b/se
Product-wage gap	
L.Product-wage gap	**0.2220**
	(0.1888)
L.new vacancies	**0.0915**
	(0.0852)
L.newly unemployed	**0.1881**
	(0.2107)
_cons	**-2.4704**
	(2.8054)
new vacancies	
L.Product-wage gap	**0.7498***
	(0.3895)
L.new vacancies	**0.4722*****
	(0.1758)
L.newly unemployed	**-0.6062**
	(0.4349)
_cons	**10.6465***
	(5.7890)
newly unemployed	
L.Product-wage gap	**-0.1079****
	(0.0428)
L.new vacancies	**-0.0167**
	(0.0193)
L.newly unemployed	**0.9123*****
	(0.0477)
_cons	**1.1268***
	(0.6355)

* p<0.10, ** p<0.05, *** p<0.010

Figure 13: Response of new unemployment and new vacancies to impulse of productivity-wage gap, manual workers, hospitality industry

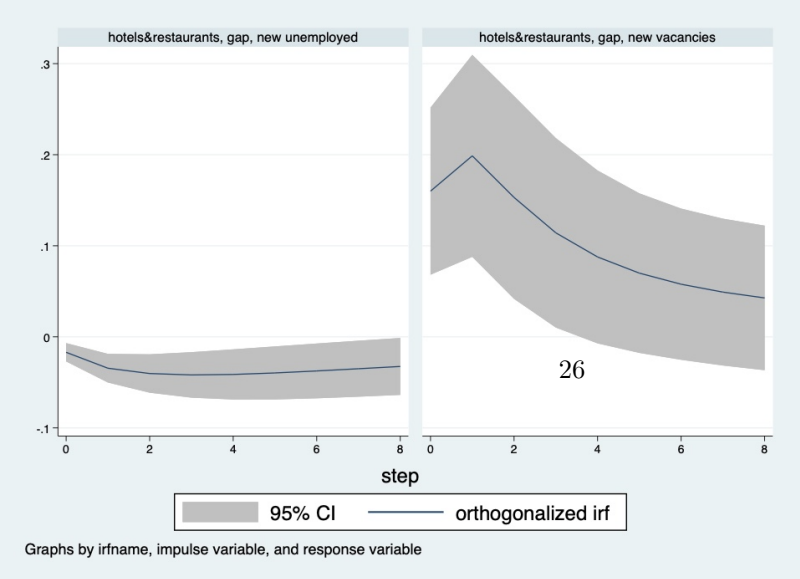


Figure 14: Response of new unemployment and new vacancies to impulse of productivity-wage gap, non-manual workers, hospitality industry

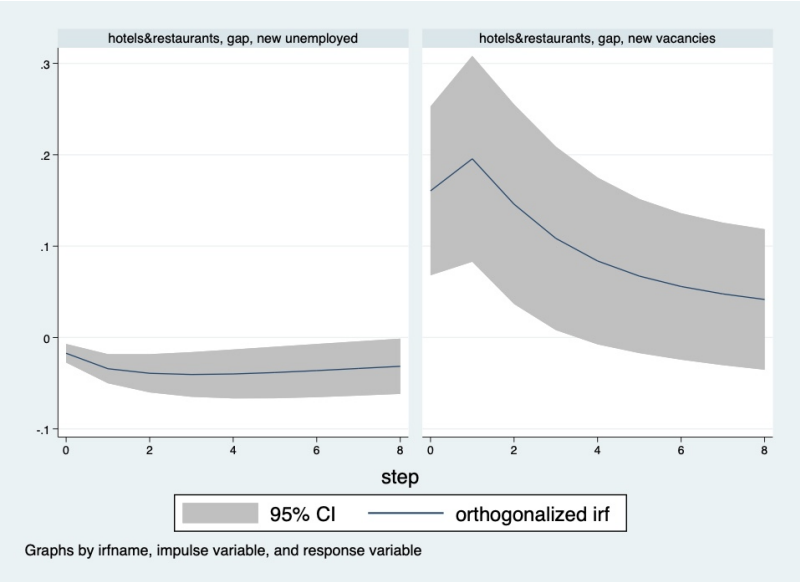


Figure 13 and figure 14 illustrate how the newly registered vacancies and worker outflow respond to the unit change of productivity-wage gap. Note that the impulse in these two figures is positive, but during recession the impulse should be negative because employers cut down their own shared surplus from production. The interpretation is that, during economic downturn and reduction of labour productivity, employers would be reluctant to cut wages of employees but consequently reduce their own share from production surplus; employers might fire only few more workers, but this effect would be persistent in the long term; employers would save most of their loss by reducing their future recruiting activities, thus decreasing the labour demand; the reduced labour demand would recover gradually to its pre-recession level in the future, but it normally takes a long time.

5.4 Pandemic shock and labour market in other industries

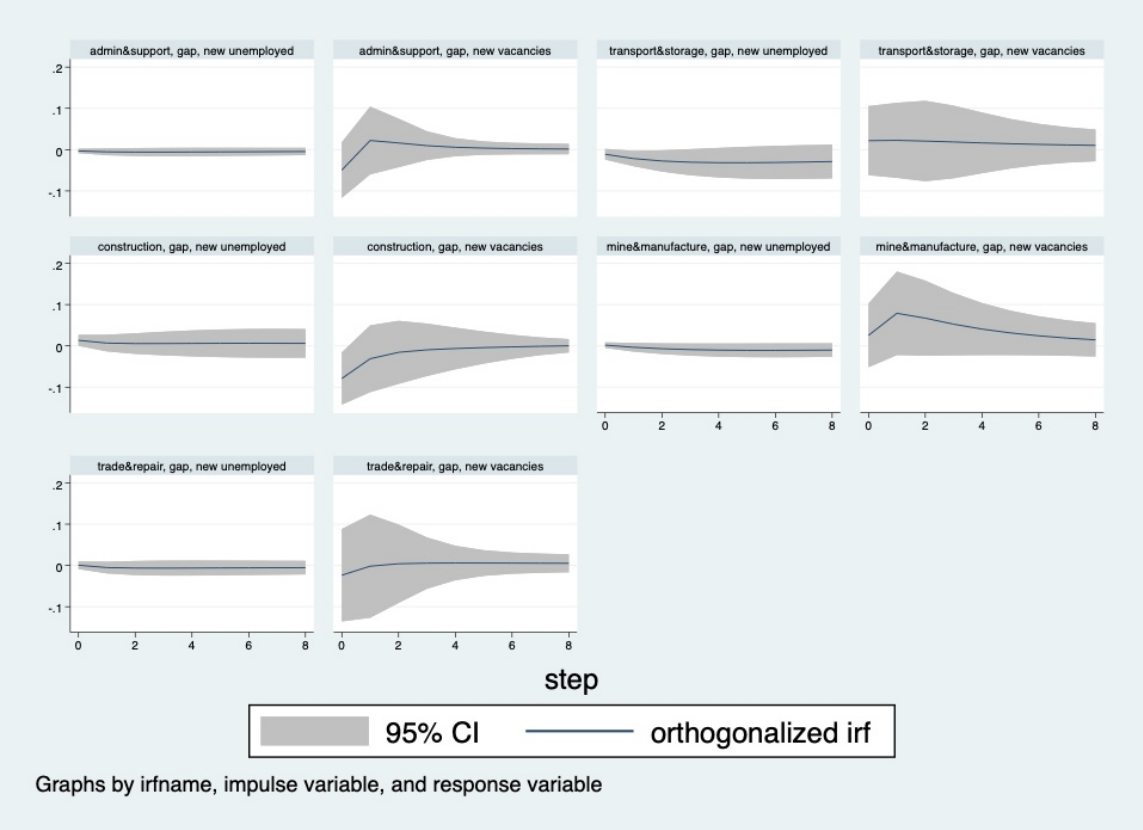
Hospitality has been one of the industries which suffered the most after pandemic shock. Other industries such as transport, healthcare, and education in Sweden also experienced a trivial recession. My purpose for this section is to derive a similar VAR model and analyze how the labour market responds to recession, as well as productivity-wage gap in other industries.

One problem here is that for some industries, labour productivity is lower than the wage. One possible explanation is that it is difficult to classify the productivity into different industry-level

categories, especially for creative industries such as arts, entertainment and education. For instance, it is often difficult to capture the purely output of arts and culture, as they are always accompanied by industrial economic activities such as publication of books; and it is controversial to classify those who are doing culture-related work into a specific creative industry, because they may also be involved in manufacturing.

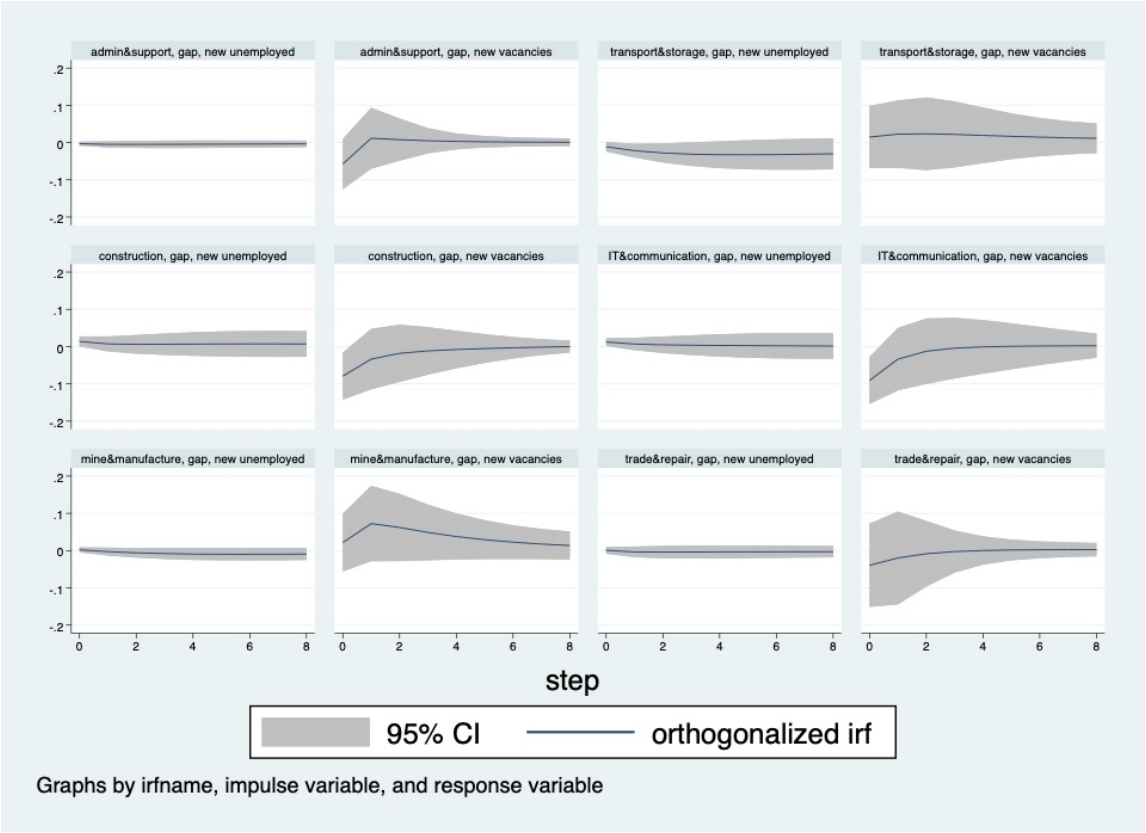
Productivity-wage gap is not sufficient here when wage rate is higher than labour productivity, so I exclude the industries with a negative productivity-wage gap: "arts, entertainment and recreation", "education", and "human health and social work".

Figure 15: Response of new unemployment and new vacancies to impulse of productivity-wage gap, manual, other industries



Note: IT & communication industry is not include here, because the data about the wage of manual workers is missing

Figure 16: Response of new unemployment and new vacancies to impulse of productivity-wage gap, non-manual, other industries



As shown in figure 15 and figure 16, it is hard to conclude whether these industries demonstrate similar patterns as the hospitality industry does, because the impulse response is not significantly different from 0 in a short time period. The reason behind this could be that these industries did not suffer severely from the recession caused by coronavirus; even the gross domestic product experienced a substantial drop, it was not driven by the reduction of labour productivity.

Therefore, for industries not influenced much by the productivity shock, the newly generated vacancies and unemployed work force were not likely to respond rapidly, so it is hard to capture such dynamic relationship during economic downturn. The hospitality industry demonstrates such significant relationship among productivity-wage gap, vacancies and unemployment because it was one of the few industries which suffered from labour productivity loss.

5.5 More discussions about productivity-wage gap and labour market under productivity shock

Many economists have discussed about the relationship between productivity-wage gap and unemployment rate. López-Villavicencio and Silva (2011) find that many European countries with a tighter employment protection, including Sweden, display a negative correlation coefficient between the gap and unemployment, but this relation is less clear-out for Sweden compared to other countries like France, Italy and Germany; for countries like the United States and Canada, this correlation coefficient is positive. According to the authors, in countries with a higher degree of employment protection legislation, workers have a higher bargaining power and push up their wages during economic booming, due to the high firing costs and the weight of permanent employees. Moreover, the percentage of temporary contracts in the labour market can affect the relation between productivity-wage gap and unemployment rate.

What I am more interested in the paper written by López-Villavicencio and Silva (2011) is that Swedish economy demonstrated a strong negative correlation between the productivity-wage gap and unemployment rate during its 1990s recession - the productivity-wage gap substantially narrowed, while the unemployment rate rose rapidly. This pattern is very similar to what I find about the labour market of hospitality industry during pandemic shock in Section 5. However, López-Villavicencio and Silva have not given any information about worker outflow and newly generated vacancies but static unemployment rate, so it is not clear whether the decision on surplus sharing by employers was the driving factor of the high unemployment rate in the 1990s.

More statistics about the hiring activities during recessions can be found when taking the United States as the example. During the 2008 economic crisis, men's (log) real wage in the United States only gradually dropped by 0.02 over the four years after the financial shock; but the unemployment rate rose from 4.6 to 9.6 during 2008-2010, and only recovered to 8.1 in 2012 (Elsby et al., 2016). More detailed data on hiring activities is given by Davis et al. (2012), that recruiting intensity per vacancy[5] fell sharply by over 21 percent during the 2008 Great Recession, and in December 2011 it still remained 11 percent below its pre-recession level.

Considering the limited negative impact of the coronavirus on Swedish economy, compared to 1990s Sweden financial crisis and 2008 Great Recession, it is reasonable that only hospitality industry demonstrated such wage rigidity and reduction in hiring activities after a productivity shock. In addition, the degree of employee protection in Sweden is thought to be higher than the United

[5] According to Davis et al.(2012), recruiting intensity refers to other instruments that employers use to influence pace of recruiting new staff, including advertising expenditures, screening methods, hiring standards and compensation packages.

States, so the labour market in Sweden should be more stable. Recalling what Hall and Milgrom (2008) state in their paper, I think the employers' decision on surplus sharing could possibly account for wage rigidity and reduction in hiring activities after productivity shock. A shortcoming from Hall's paper (2005) is that he does not talk about productivity-wage gap to show how employers decide to cut down their future recruitment; instead, he purely proves that it is indeed harder for workers to find jobs after a negative productivity shock. This phenomenon can also be explained by the reduction in recruiting activities.

Some other discussions on wage rigidity may cover the government intervention and union-based bargaining. Swedish government indeed took several methods during pandemic period to alleviate the loss of employers and employees, such as subsidizing for those who reduced working hours due to sickness, however, no proof can be found that it was related with the rigidity of hourly earnings in a specific industry. Labour unions also play an important role in wage bargaining; however, "wage rigidity" and "unemployment volatility" appeared in both Sweden and the U.S., even though these two countries have different wage bargaining settings. Therefore, it is difficult to link the union-based bargaining with wage elasticity.

6 Concluding remarks

This literature tries to explore the associations among wage rate, labour productivity and labour market tightness, as well as how the industry-level aggregate wage is adjusted by the fluctuation of productivity and market tightness in Sweden over 2019-2021. By applying an OLS estimation strategy, I find that between-industry wage gap can be partially explained by the inter-industry differences on labour productivity and labour market tightness, while the with-industry wage fluctuation over time cannot be explained well by productivity growth and market tightness change. After including industry and time fixed effects, the coefficients of both labour productivity and labour market tightness become not significant at 5% level; excluding the sample after the outbreak of coronavirus can still not make the coefficients significant. These results are against my hypothesis that wage rate is positively influenced by labour productivity and market tightness.

Capital deepening, capacity utilization, transfer payment and compensation may explain why the wage rate is so rigid. But the most convincing explanation is that employers are reluctant to cut their staff's wages during recessions, due to the consideration of fairness.

Hall and Milgrom (2008) critically point out employers would put fewer resources into recruiting in future rather than cut employees' wages, when there comes recession. To verify whether Hall and Milgrom's statement is true, I investigate how the labour market of Swedish hospitality industry

perform during 2019-2021, as this industry was the most severely affected during the pandemic period. I find that the total production of hospitality industry in Sweden experienced a great reduction after two pandemic shocks, as a result of lower labour productivity and fewer working hours. Although the aggregate wage level of hospitality industry did not drop sharply, the number of newly generated vacancies was substantially reduced in the future periods. By applying VAR model and plotting impulse response function, I find that the number of newly generated vacancies is positively driven by the productivity-wage gap, and it takes over half an year to recover to its original level, while the worker outflow responds negatively and less radically. This means despite the reduction in labour productivity during recession, employers may take most of the loss themselves instead of cutting employees' wages, but they would transfer the productivity loss to future workers as they spend less on recruiting new employees in the next several months or years.

I also do VAR tests on other industries during the same period, but find less significant results. The possible reason is that the spread of COVID-19 had only limited negative impact on Swedish economy, and the recession in many industries is mostly caused by the reduction in working hours instead of labour productivity drop.

In summary, my findings suggest that industry-level aggregate wage rate is insensitive to the productivity shock and labour market tightness fluctuations. Wage rate resists the shock from reduced labour productivity during recession, but the opportunity cost to maintain the wage rigidity is the high volatility of unemployment in a long time period. Employers would transfer the loss caused by negative productivity shock to the future workers by lowering recruiting intensity; while the aggregate wage of current employees is still stable.

However, there still remains some problems unsolved. The data I collected is at industry-level. Apparently the industry-level data is more specified and detailed than the national-level one, but this is based on the assumption that labour force normally would not move across industries. When I calculated labour market tightness, there was no information about the number of unemployed workers in a specific industry, because unemployment rate is usually only available at region-level or nation-level. The only way to get such industry-level information is to use worker outflow of a industry as its unemployment. However, the question is, would this unemployed worker still remain in the same industry he or she has worked before? This method for calculating v/u ratio would fail if the assumption did not hold, which is also the problem that many other economists are facing while analysing industry-level labour market.

One more limitation for this literature is that aggregate wage rate might not be a suitable response variable. The elasticity of wage rate for permanent workers may be smaller than the one for tem-

porary workers; graduates' wages may be more easily affected by labour market tightness than the aged workers, because the latter group of people accumulate more working experience during lifetime and their salaries are not likely to be affected by the labour supply, and most importantly, they are not likely to be dismissed during recession.

Therefore, future research may focus on more disaggregated data such as firm-level or region-level. Entry-level salary for graduates could be appropriate response variable when analyzing how it is influenced by the supply and demand of labour, however, usually there are not much information about this in database. Instead, issuing questionnaires is a more reasonable way to get such data.

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