
Forecasting the Level of Unemployment, Inflation and Wages: The Case of Sweden*

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Abstract:

Purpose: In the macroeconomic theory and analyses there are a number of studies focused on three crucial phenomena, namely unemployment, inflation, and wages. As a result, the term called 'Phillips curve' was introduced in order to illustrate a negative correlation between inflation and the unemployment rate. This paper is to establish the relationship between unemployment, inflation, and wages in Sweden, and to forecast their value using.

Design/Methodology/Approach: The Vector Autoregression (VAR) model has been used for the analysis. The analysis applies the values of the unemployment rate, the level of the minimum wage and the value of inflation in the period of 2002 - 2017 on a quarterly basis.

Findings: Results from the analysis show that (1) the unemployment rate and the level of wages do not explain well enough inflation developments in Sweden and (2) as in many previous empirical studies on this topic, there are no significant changes in employment resulting from the increase in the minimum wage.

Practical Implications: This study is of great importance especially for the policy makers who can apply the presented analysis tools to predict further tendencies in shaping value of the main economic indicators and make appropriate decisions to avoid possible recession and its negative consequences. Therefore, the outcomes of this paper can increase efficiency of the economic policy in numerous countries.

Originality/Value: This research checks the suitability of the widely known tool to evaluate dependencies and predict further situation of the main economic indicators in Sweden. Moreover, the analysis shows that the real relationships between unemployment rate, minimum wages and inflation are not always the same as these, which appear in the literature.

Keywords: VAR modelling, unemployment rate, inflation, minimum wage rate.

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Paper type: Research article.

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1. Introduction

The relation of unemployment with inflation and the level of wages is one of the main aspects considered in macroeconomic analyses. Phillips (1958) observed a negative correlation between money wage changes and unemployment in Great Britain in the period of 1861-1957. Then, Samuelson and Solow (1960) placed this way of thinking into more generalized form. They made a clear link between inflation and unemployment as follows: when the level of inflation is high, unemployment rate is low, and the other way around. In addition to this, Samuelson was the one who popularised this phenomenon by giving it a term 'Phillips curve' (Blaug, 1997; Bochenek, 2016). More than once, in later studies, deviations from his theory were noted. Phelps (1967) in his work proved that this relationship is only short-lived, because the rise in inflation is followed by the increase in nominal wages, which causes their illusory rise. Illusory because its purchasing power does not change. The society, succumbing to the "deceived" increase in wages, takes up a job, causing a drop in unemployment.

After some time, when they become convinced that they are wrong about wage increases, unemployment returns to its original level. Moreover, even with rising inflation, employers tend to ignore it and refrain from increasing wages for employees. Wages, and in particular the ratio of the minimum wage to the level of social benefits, are one of the most important determinants of the unemployment level. Studies on changes in the minimum wage indicate the possibility of both an increase and a decrease in employment as a result of its increase (De Fraja, 1999; Neumark *et al.*, 2004). This is related to changes in marginal productivity.

According to the classical theory of employment, if an increase in the minimum wage followed by an increase in wages for the remaining group of employees does not cause changes in marginal productivity, then due to higher labour costs, employers dismiss employees whose marginal product value is below the minimum wage (Evans-Pritchard, 1985). However, according to the effective wage theory, under certain conditions, one can even expect an increase in employment (Raff and Summers, 1987; Bradley, 2007). Many studies show a weak relationship between the increase in the minimum wage and the reduction of poverty (Burkhauser and Sabia, 2007; Gindling, 2018). The reason is that in many poor families nobody works so changes in the minimum wage do not matter to them. The prevailing view in research is that changes in the minimum wage level do not affect employment, but only reduce wage inequalities.

The aim of the study is to exhibit the relationship between the processes of unemployment, inflation, and wages, based on the example of Sweden, and to forecast their value using the Vector Autoregression (VAR) model. The analysis used the values of the unemployment rate, the level of the minimum wage and the value of inflation (change compared to the previous period) in the period 2002: 01-

2017: 01 (due to the lack of availability of data on wages in the later period) on a quarterly basis. On the basis of the estimated model, forecasts of the unemployment rate and the minimum wage were made for seven periods ahead (until the end of 2018) and their admissibility was assessed, and in the case of the unemployment rate, also their accuracy.

2. Methodology

Three decades ago, Sims (1980) introduced a new macro econometric tool called Vector Autoregression (VAR) model, which is a n-equation, n-variable linear model. In this model, each variable is explained by its own lagged values and in addition it contains present and past values of the remaining n-1 variables. Stock and Watson (2001) described a VAR as a simple framework that “provides a systematic way to capture rich dynamics in multiple time series, and the statistical toolkit that came with VARs was easy to use and interpret”.

In this paper, a VAR model is applied in order to determine the linkages between unemployment, inflation, and wages in Sweden, and to forecast their value. In order to determine the relationship between the given processes, the form VAR model was estimated:

$$\begin{bmatrix} Y_{1,t} \\ Y_{2,t} \\ Y_{3,t} \end{bmatrix} = \begin{bmatrix} \alpha_{11,1} & \alpha_{12,1} & \alpha_{13,1} \\ \alpha_{21,1} & \alpha_{22,1} & \alpha_{23,1} \\ \alpha_{31,1} & \alpha_{32,1} & \alpha_{33,1} \end{bmatrix} \cdot \begin{bmatrix} Y_{1,t-1} \\ Y_{2,t-1} \\ Y_{3,t-1} \end{bmatrix} + \begin{bmatrix} \alpha_{10} & \beta_{11} & \beta_{12} & \beta_{13} & \beta_{14} & \beta_{15} \\ \alpha_{20} & \beta_{21} & \beta_{22} & \beta_{23} & \beta_{24} & \beta_{25} \\ \alpha_{30} & \beta_{31} & \beta_{32} & \beta_{33} & \beta_{34} & \beta_{35} \end{bmatrix} \cdot \begin{bmatrix} 1 \\ t \\ Q_1 \\ Q_2 \\ Q_3 \\ Q_4 \end{bmatrix} + \begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \\ \varepsilon_{3,t} \end{bmatrix} \quad (1)$$

where: Y_1 – minimum wage value, Y_2 – inflation value, Y_3 – unemployment rate, t – time variable, Q_1, Q_2, Q_3, Q_4 – zero-one seasonal variables, ε - random component.

For the statistical verification of the model, the Student's t-test was used to verify the significance of the structural parameters of the model, the Jarque-Ber test to check the consistency of the distribution of residuals with the normal distribution, the Ljung-Box test for the presence of autocorrelation in the residual component and the VAR model stability test. The impulse response was also analysed, and the forecasts of the unemployment rate and minimum wages were assessed based on the model results.

3. Empirical Results

First, the time structure of each of the analysed processes was examined. Preliminary structure analysis showed the presence of an important component of the trend in the case of the minimum wage and the unemployment rate. Seasonality, on the other hand, plays an important role in shaping only the value of wages. In the case of inflation, none of the components of the trend-seasonal structure was significant. As for at least one of the above-mentioned processes, trend-seasonal components are important, they were also included in the estimation of the VAR model.

Then, the selection of the delay order of the vector autoregression model, the results of which are presented in Table 1. All information criteria (AIC, BIC and HQC) take the lowest value for the delay equal to one. Therefore, such a delay order was chosen to estimate the VAR model for the formation of the above-mentioned processes in Sweden.

Table 1. Values of information criteria for selecting the delay order of the VAR model

Time lag	loglik	p(LR)	AIC	BIC	HQC
1	-257,253		10,613334*	11,505542*	10,956434*
2	-249,722	0,08925	10,66877	11,89556	11,14053
3	-246,856	0,76631	10,90022	12,46158	11,50065
4	-241,417	0,28424	11,03462	12,93056	11,76371

Source: Own calculations using Gretl software.

After selecting the delay order, the VAR model was estimated (1). The results of model estimation and verification are presented in Table 2, while Table 3 presents the results of the analysis of the autocorrelation occurrence in the rest of the VAR model equations. The unemployment rate significantly affects the minimum wage process. During the entire period of this study, the increase in the unemployment rate resulted in a decrease in the minimum wage *ceteris paribus*.

Moreover, there are noticeable regularities in the trend-autoregressive structure. Both the time variable and the seasonal component as well as the autoregressive parameter are statistically significant. In the case of the inflation analysis, a significant impact of the minimum wage and the trend-autoregressive structure were noted. In the analysed period, the relationship between inflation and wages is negative. The unemployment rate, on the other hand, depends on the level of inflation and seasonal and autoregressive parameters.

Despite the initial observation of the trend in the level of the unemployment rate, the time variable is not statistically significant. In the case of the first and third equations, the determined coefficient of determination R^2 indicates a high degree of explanation of the variability of the dependent variable by the model. A low value

was shown only for the inflation process that is difficult to model. This means that the unemployment rate and the level of wage unsatisfactorily explain inflation in developments in Sweden. Only in the case of the equation for the level of wages is the distribution of residuals compatible with the normal distribution. In the second and third equations, the lack of normal residual distribution is undoubtedly their weakness.

Table 2. The results of the estimation and verification of the VAR model for the wages, inflation, and unemployment processes in Sweden

Equation 1 - for the minimum wage					
Parameter	Estimate	Standard Error	t	p-value	Significance
α_{10}	1209,44	333,894	3,622	0,0007	***
$\alpha_{11,1}$	0,574231	0,120775	4,755	1,62E-05	***
$\alpha_{12,1}$	2,31035	6,62912	0,3485	0,7289	
$\alpha_{13,1}$	-8,22939	4,48768	-1,834	0,0724	*
β_{12}	-22,9391	9,32185	-2,461	0,0172	**
β_{13}	34,545	8,22564	4,2	0,0001	***
β_{14}	-71,645	13,3053	-5,385	1,77E-06	***
β_{11}	9,50002	2,69146	3,53	0,0009	***
R ²	0,997144				
DW	1,978815				
JB	p = 0,483474				
Equation 2 - for inflation					
Parameter	Estimate	Standard Error	t	p-value	Significance
α_{20}	13,7864	6,41073	2,151	0,0362	**
$\alpha_{21,1}$	-0,00476247	0,002319	-2,054	0,045	**
$\alpha_{22,1}$	0,366599	0,127278	2,88	0,0058	***
$\alpha_{23,1}$	-0,119868	0,086163	-1,391	0,1701	
β_{22}	-0,708308	0,178978	-3,958	0,0002	***
β_{23}	0,300798	0,157931	1,905	0,0624	*
β_{24}	-0,427656	0,255461	-1,674	0,1001	
β_{21}	0,103872	0,051676	2,01	0,0496	**
R ²	0,531277				
DW	1,959688				
JB	p = 0,034185				
Equation 3 - for unemployment rate					
Parameter	Estimate	Standard Error	t	p-value	Significance

α_{30}	6,17156	4,75465	1,298	0,2	
$\alpha_{31,1}$	-0,00194475	0,00172	-1,131	0,2633	
$\alpha_{32,1}$	-0,303786	0,094399	-3,218	0,0022	***
$\alpha_{33,1}$	0,851189	0,063904	13,32	2,16E-18	***
β_{32}	0,213219	0,132743	1,606	0,1143	
β_{33}	0,124234	0,117133	1,061	0,2938	
β_{34}	0,334	0,189468	1,763	0,0838	*
β_{31}	0,0412852	0,038326	1,077	0,2864	
R ²			0,920345		
DW			1,697461		
JB			p ~ 0		

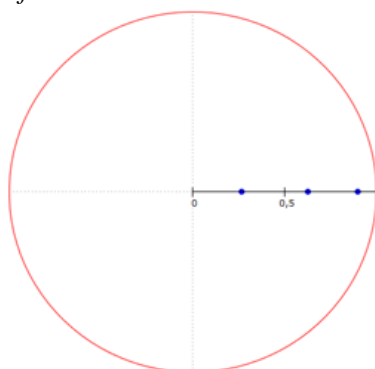
Source: Own calculations using Gretl software.

Undoubtedly, the advantage of each of the equations is the lack of autocorrelation in the residuals. Based on the value of the partial autocorrelation coefficient (PACF) and the results of the Ljung-Box test, it should be concluded that the autocorrelation coefficient is not significant. Moreover, Figure 1 shows that all the roots of the characteristic equation are less than one, which proves the stability of the estimated VAR model in the case of data for Sweden. Thus, the VAR model is suitable for practical use - the determined responses to the impulse do not create non-stationary processes with an explosive course.

Table 3. The results of testing the occurrence of autocorrelation in the residuals of the VAR model

Time lag	ACF	PACF	Ljung-Box Q	p-value
Equation 1				
1	0,0024	0,0024	0,0004	0,985
2	-0,07	-0,07	0,3142	0,855
3	0,0469	0,0475	0,4579	0,928
4	0,1406	0,1363	1,7717	0,778
Equation 2				
1	0,0113	0,0113	0,0081	0,928
2	-0,0417	-0,0419	0,1198	0,942
3	0,0902	0,0913	0,6505	0,885
4	-0,0473	-0,0521	0,799	0,939
Equation 3				
1	0,1423	0,1423	1,2759	0,259
2	0,1642	0,147	3,0058	0,222
3	0,1697	0,1344	4,8844	0,18
4	-0,0418	-0,1058	5,0006	0,287

Source: Own calculations using Gretl software.

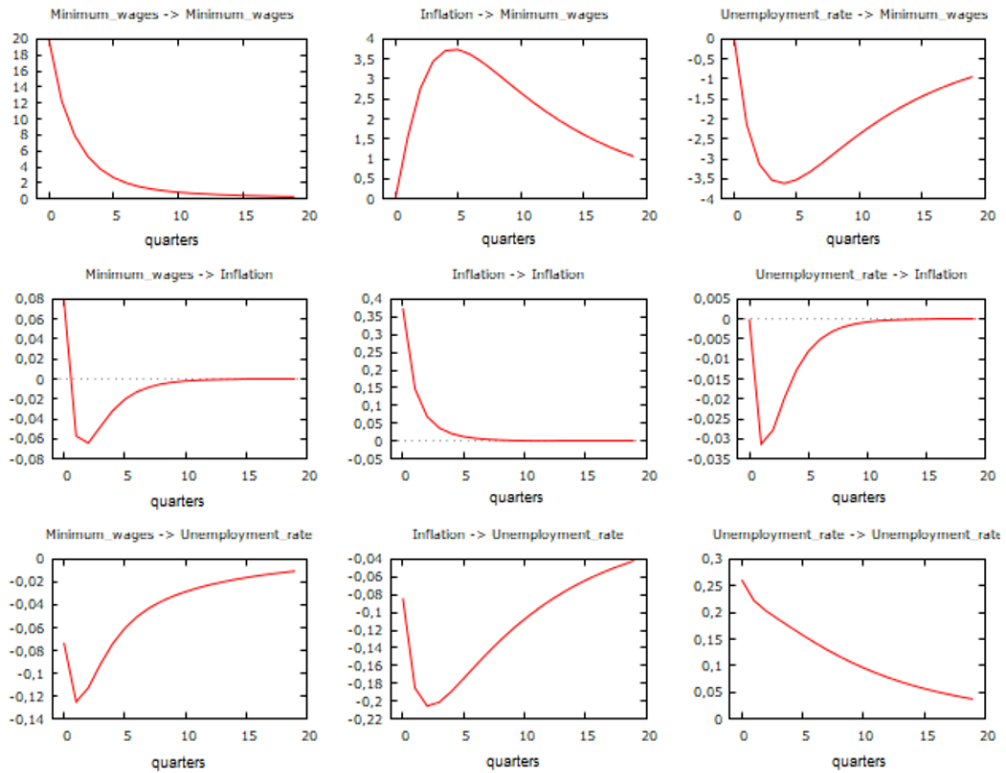
Figure 1. Stability testing of the VAR model

Source: Own elaboration with the use of Gretl software.

The results of the aforementioned analysis of the response to the impulse are shown in Figure 2. The minimum wage impulse at time t causes inflation to rise initially, then it immediately declines and returns to the pre-impulse level after about 8 quarters. On the other hand, in the process of unemployment, a decrease in its rate caused by the wage impulse is observed, followed by a slow approach to the level before the impulse. The impact of the inflation impulse causes the minimum wage to rise and the unemployment rate to decline, which last for 4 and 2 quarters, respectively. In the later period, there is a return to the value from before the impulse, while in the course of 20 quarters, both processes do not reach it. The impulse from unemployment in time t causes the minimum wage to decline for the first year, followed by a slow increase towards the base value, which it does not reach in 5 years. On the other hand, there is an almost immediate decline in inflation, which returns to the base value within approximately 2 years after the impulse.

Table 4 shows the results of the minimum wage and unemployment rate forecasts in Sweden until the end of 2018. The limit for the acceptability and accuracy of forecasts was adopted at the level of 8%. Both in the third quarter of 2017 and 2018, the value of both economic processes is forecasted to decline compared to the previous quarter. In the remaining quarters, the reverse trend is observed (except for the unemployment rate in the fourth quarter of 2018, where there is also a slight decrease - however, according to the adopted limit value, this is not an acceptable forecast). In the case of the minimum wage, forecasts for all quarters ahead are acceptable (the values of the relative prediction error are less than 0.08), which cannot be stated for the unemployment rate. There, one should only pay attention to the forecasts until the end of 2017, which at the same time turned out to be accurate (the values of the relative forecast error are less than 0.08). Moreover, the unemployment rate forecasts turned out to be slightly overestimated. Figure 3 shows the forecasted values of the analysed processes. As it should be noted, the projected minimum wage values continue the earlier trend, which is the result of very good prognostic properties of the first equation of the VAR model (1) for Sweden.

Figure 2. Summary plot of impulse response based on the estimated VAR model



Source: Own elaboration with the use of Gretl software.

On the other hand, in the case of the unemployment rate, its stabilization is visible, resulting from the waning downward trend in the previous quarters. As shown by the results of the ex post analysis, the stabilization according to the VAR model took place too quickly.

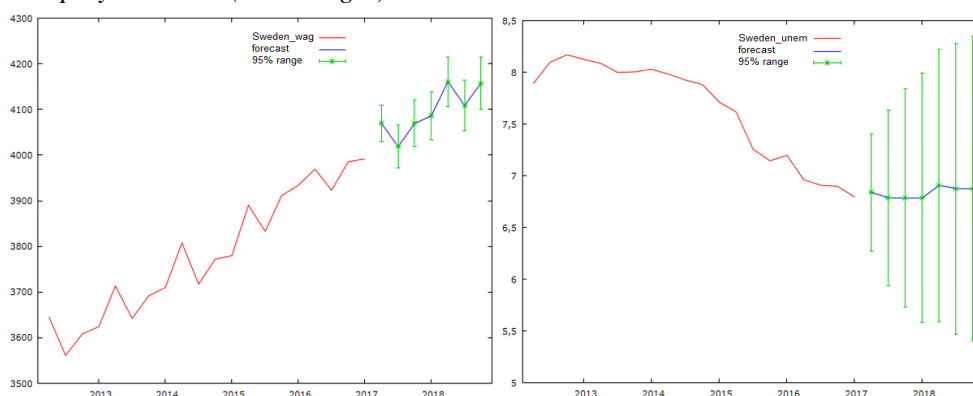
Table 4. Forecasts of the minimum wage and the unemployment rate based on the VAR model

Quarter	Minimum wage		
	Forecast	Prediction error	Relative prediction error
2017:02	4069,46	19,9243	0,004896055
2017:03	4018,55	23,5265	0,005854475
2017:04	4069,1	25,1717	0,006186061
2018:01	4085,87	26,1965	0,006411486
2018:02	4160,95	26,9595	0,006479169
2018:03	4108,18	27,5729	0,006711707
2018:04	4157,65	28,0777	0,006753262
Quarter	Unemployment rate		

	Forecast	Prediction error	Relative prediction error	Forecast error	Relative forecast error
2017:02	6,839426	0,283722	0,041483	0,058274	0,008594
2017:03	6,787357	0,423994	0,062468	0,06406	0,009528
2017:04	6,78343	0,525171	0,07742	0,206419	0,031385
2018:01	6,785056	0,599766	0,088395	0,46963	0,074362
2018:02	6,907301	0,656169	0,094996	0,473111	0,073531
2018:03	6,876379	0,699624	0,101743	0,537183	0,08474
2018:04	6,874761	0,733534	0,1067	0,503369	0,079005

Source: Own calculations using Gretl software.

Figure 3. Development of the projected minimum wage (on the left) and the unemployment rate (on the right)



Source: Own elaboration with the use of Gretl software.

4. Conclusions

Modelling the processes of the minimum wage, inflation and the unemployment rate in Sweden showed the relationships between them. However, with the use of the vector autoregression model for the analysed period, due to poor prognostic properties, the inflation process should not be forecasted, while in the case of the unemployment rate, only short-term forecasts are correct. Only the values of minimum wages can be forecasted in a long-term perspective using only the impact of inflation and the unemployment rate, for the remaining processes, the explanation of their value is not sufficient. Based on the results of the estimation of the VAR (1) model for Sweden, it can be concluded that there are several important relationships.

However, there are no significant changes in employment resulting from the increase in the minimum wage what is also underlined by conclusions from many previous studies on this topic. In order to increase the prognostic value of the VAR model, it would be necessary to supplement, first of all, the equations of inflation and the

unemployment rate with the influence of other processes not included in the study, or to apply a different approach to modelling these processes.

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