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COMPARATIVE WAGE-PRICE SPIRAL ANALYSIS IN THE EUROZONE: A VECTOR AUTOREGRESSION APPROACH

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In this paper I investigate the wage-price spiral dynamics of three Eurozone countries and compare them with the entire Eurozone and the United States. Using Granger Causality tests and impulse response analysis I find that the Netherlands and Italy are especially vulnerable to wage-price spirals due to their respective Granger causalities and impulse response functions, while pointing out some new findings in wage-price spirals mechanisms.

KEYWORDS: Phillips curve, Wage Inflation, Cost push inflation, Wage price spiral.

1. INTRODUCTION

During times with a lot of macro economic uncertainty there are all kinds of inflationary forces at play which can influence and shock the economy. Some of these economic shocks are challenging to model and largely seen as stochastic (Lenza & Primiceri, 2020). Take for example the recent Ukraine war, with Ukraine playing a relatively small part in the European and global economy, some academics (Conlisk et al, 2022) are expecting significant increases in inflation in coming months, directly because of the Ukraine war. Why is that the case?

This has everything to do with the war which led to Russia being excluded from the global economy and with the Russian federation being home to the world's largest gas supplies and being a big oil exporter, energy prices soared in the few days after the invasion when the unprecedented western sanctions against Russia were put in place (Macchiarelli et al, 2022). Then there was a delayed effect with Ukraine being a big grain exporter which came to a near halt in its exporting abilities, so wheat prices soar and afterwards food prices in general started to increase (Kammer et al, 2022). This in itself led to inflationary pressures worldwide with levels of inflation not seen since the oil crises of the 1970s and 1980s in western countries.

In addition, there is price inflation reaching elevated levels before the Ukraine invasion began and an impactful labour shortage (Arnold & Romei, 2022) which started developing after the end of the worldwide covid lockdowns and the return to the office. This led to more wage bargaining power for ordinary employees which could lead to inflationary pressures (Haaland et al, 2021).

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This leads one to wonder whether a wage-price spiral is developing or if the economy will recover naturally as energy and food prices settle down. Hence the research question I will investigate is: To what extent can we model and observe a wage-price spiral in the Netherlands, Austria and Italy?

Throughout the rich history of inflation analysis in macro economics the Phillips curve (Phillips & Alban, 1958) has been a hot topic. The inverse relationship between inflation and the unemployment rate has been a useful tool for many institutions around the world to analyze inflation. However now with recent price surges and wage inflation lagging price inflation by a lot, there has been a shift of focus for people which started to wonder whether wage increases, commonly referred to as wage inflation is next. To address these worries, an analysis will be done using a Vector AutoRegression (VAR) on historical values of price and wage inflation, which has the advantage over univariate models because it can capture two shocks in both directions simultaneously. This will help by giving a clear picture on the dynamics of wage-price spirals.

The analysis will be done on three different countries in particular, namely the Netherlands, Austria and Italy. The analysis covers three completely different countries in the Eurozone, with the Netherlands being an industrial powerhouse of Europe (Loog et al, 2021), Italy being a southern European country with its own economic problems due to being hit exceptionally hard by the covid pandemic and Austria, a stable economy which has close and arguably problematic economic relations with eastern Europe (Marin, 2016). These three different but interlinked economies should give an indication on how inflationary pressures will develop throughout the entire Eurozone, which will be analyzed as well.

The estimated vector autoregressions, from now on referred to as VARs, have the goal of painting a picture as to how historical interactions of price and wage inflation can be modelled into the present day and even projected unto future time periods. This could be of great importance because according to Galati (2021) may wage inflation increase too much then the Eurozone could see the start of a new wage-price spiral, which would be detrimental for the whole economy.

The rest of this thesis goes as follows. In section 2 the literature relevant to the thesis will be discussed. In section 3 the results of the conducted analysis will be presented. Finally in section 4 the results will be discussed and the research question shall be answered.

2. LITERATURE REVIEW

To fully understand the background of the analysis done on wage-price spirals in the Eurozone, we need to start with an overview of inflationary forces in Europe. First, ever since the global financial crisis of 2008 and the European debt crisis of 2009, the expectation was that inflation would surge because of the various monetary measures taken such as bailouts and low interest rates (Bonam et al, 2019). Surprisingly, the opposite happened and inflation kept decreasing beyond the European Central Bank's (ECB) 2 percent long term inflation target. This led the ECB to further lower interest rates until the ECB put the interest rate on 0 percent in 2016, which still holds to the time of writing this paper. Later research by Bonam et al (2019) finds evidence that this downward trend in price inflation started all the way in 1985, which may question the ECB's handling of price inflation even further. Nevertheless, there were no new inflationary developments until the world was faced with an unexpected pandemic.

After the COVID-19 virus spread to Europe and fear really started to kick in with consumers, consumer spending drastically decreased and the world economy came to a stand still, which could have led to businesses going bankrupt if governments had not assisted them through various compensations and tax cuts. This fiscal policy problem came hand in hand with another monetary problem called deflation, more specifically, the threat of deflation due to reduced economic activity (Jackson, 2020). Because interest rates were already at 0 percent and government bonds priced above par value, lowering the interest rate even more, which is the classical way to tackle economic downturns could not be done. So the remaining monetary options left on the table were various quantitative easing measures in the fashion of Eggertsson (2004). These measures accomplished their task and according to official inflation measures, deflation during the pandemic barely took place (see Appendix A).

When the world started recovering from the covid pandemic, the demand for goods and services started to blossom, however inflation also started blossoming. This can be attributed to multiple simultaneous occurrences such as disturbances in supply chains, soaring commodity prices and the sudden release of pent-up demand (Galati, 2021). The exact scope of current galloping inflation is still unclear and whether current inflation is transitory or more permanent remains a hot debate (Ireland & Levy, 2021). Nevertheless recent HICP inflation measurements in multiple eurozone countries show inflation topping 10 percent.

A little inflation is generally considered desirable, however history, more specifically the 1970's, demonstrates that sudden high inflation bursts can trigger wage-price spirals (Perry et al, 1978). Meaning price inflation leading to employees requiring higher wages from their employers, which leads to employers needing more money to pay out their employees, which in turn leads to an increase in their prices, and repeat. This naturally leads to the importance of knowing whether wage inflation will follow current price inflation, such that the catastrophic consequences of such a wage-price spiral can be prevented in time.

To investigate the research question a vector autoregression will be fit, with the wage Phillips curve as described by Phillips (1958) as a foundation of the inflation dynamics. In a nutshell this Phillips curve is a simple OLS regression taking wage inflation as the dependent variable and unemployment rate as the explanatory variable. This kind of Phillips curve estimation is generally regarded as oversimplified and through the years new innovations expanded the use and specifications of the Phillips curve. Calvo (1983) expanded the textbook Phillips curve by taking into account excess demand in his staggered wage model which gave birth to the New Keynesian (NK) Phillips curve attempting to estimate inflation as a function of excess demand over time. Various innovations in the Phillips curve also include adding lagged inflation variables or adding short and long term inflation expectations into the equation (Galí (2011), Bulligan & Viviano (2017)).

While the Phillips curve has many applications, the standard Phillips curve is generally used to estimate price inflation. The estimation of wage inflation which was the original goal of Phillips (1958) has been gradually taking a smaller share of inflation literature, with the price Phillips curve taking the spotlight. Recently however the wage Phillips curve has had a small revival. With Leduc and Wilson (2017) suggesting that the Phillips wage curve might become steeper through time. Bulligan and Viviano (2017) show that since the global financial crisis the Phillips wage curve in the euro area still remains strong except for Germany where it has remained relatively weak.

Both the price and wage Philips curves can be seen as a single equation framework of the wage-price VAR model. Another relation between the two types of models is that vector autoregressions can be used to test and analyze structural models such as the wage or price Philips curve. This practice has been gaining momentum since the paper of Montfort and Rambemananjara (1990), where they demonstrate with their wage-price spiral modelling how well it is able to test their structural model. The VAR model is however quite extraordinary for the fact that it has so many use cases, mainly for multivariate modelling. Thus, VARs have become a common practice for macro economists to show relations between productivity, prices and wages (Baffoe & Gyapon (2012), Gallí & Gambetti (2019))

For this paper my goal is to accurately express wage-price spirals mechanisms, through historical data from different countries and other entities. This will be done using a Vector Autoregression (VAR) model with two endogenous variables, wage and price inflation, representing both directions of the wage-price spiral. The model will be fit on the Eurozone countries of the Netherlands, Austria and Italy and will be analyzed such that it will give a comparative picture of the results and performance of the models. Additionally the model will be fit on the entire Eurozone and the United States to confirm or contest the results.

3. METHODOLOGY

3.1. *Data*

The data set used for modelling has been composed out of various different sources, ranging from St. Louis FED for monthly oil price and hourly wage data, the OECD for monthly unemployment rate data and finally Eurostat was consulted for all other metrics. The aim was to make a comparative data set using different metrics mostly regarding inflation, with data collected from the Netherlands, Austria and Italy, as well as the Eurozone and the US.

Most crucial is the monthly data of wage inflation and price inflation, with the former being measured as the change in hourly wage rate of manufacturing in a given economy, which is a measure of the short-term development of the labour cost, meaning the total cost on an hourly basis of employing labour. While there are multiple measures available for wage inflation, the change in hourly wage rate is a common measure in VAR literature (Moore & Pentecost, 2006). The measure of price inflation is called Harmonized Index of Consumer Prices or HICP inflation. This measure of price inflation is the standard for all Eurozone countries and thus very useful to fairly compare price inflation in the Eurozone. Note that in these price inflation measures food and energy prices will be excluded to filter out the aforementioned shocks in these commodities, also will it help to maintain the exogeneity of the oil price variable. For price inflation in the US and Eurozone country data from before the establishment of the Euro and HICP measures, CPI inflation will be used.

The data from the individual Eurozone countries as well as the US will be analyzed from January 1970 until April 2022, this is because hourly wage data from before 1970 was unavailable in most of these countries. As with the Eurozone, which was officially founded in 1999, reliable monthly data of any kind only started being collected in 1993 and thus the analysis done on the Eurozone will exclude the 1970-1992 era.

Besides inflation also unemployment rate and interest rate data will be used for a few VAR estimations. Unemployment rate will be seasonally adjusted using a different dummy variable for each month, this will be done because of common swings in employment throughout the year, e.g. employees tend to get fired at the end of a business cycle and hired at the start. The interest rate data will be measured as ten year bond or treasury prices.

The data for wage and price inflation has been transformed using log first differences to render them stationary, while also addressing some other issues. As for the transformation, firstly the natural logarithm of the observations were taken and after first differences of these measures were applied (1).

$$\pi_t^* = log(\pi_t) - log(\pi_{t-1}) = \Delta log(\pi_t) \tag{1}$$

Taking first differences means that the VAR model will be fitted for month over month changes in inflation. Taking the log over the observations means that outliers of the data will be smaller and thus easier to capture in the model, also is it aiming to reduce heteroskedasticity and improve stationary (see Appendix C). To filter out seasonality and check the performance of the model also year over year changes in inflation will be investigated, which are non stationary.

To confirm that the transformations of the data mentioned above remove unit roots from the time series, an Augmented Dickey-Fuller T-test (Fuller, 1976) was conducted on each transformed time series. This Augmented Dickey fuller test included a trend and drift term, With the null hypothesis that the variable has a unit root and is thus not stationary.

3.2. *The model*

The VAR(p) model will be used to capture both directions of the wage-price spiral, where p stands for the number of lagged values included in the model. For example, a VAR(1) model can be formulated as a bidirectional autoregression using the following matrix notation.

$$\begin{bmatrix} \pi_t^p \\ \pi_t^w \end{bmatrix} = c + \begin{bmatrix} \alpha \ \beta \\ \gamma \ \delta \end{bmatrix} \begin{bmatrix} \pi_{t-1}^p \\ \pi_{t-1}^w \end{bmatrix} + \phi L_t + \epsilon_t$$

Where c is a vector of constants and ϵ_t is a vector of error terms. An important property of the VAR model to check is whether π_t^p and π_t^w have any sort of Granger causality, which in this VAR(1) model boils down to whether β and γ are different from zero. Successful Granger causality tests are a strong indication for a wage-price spiral as it tests for whether past values of price inflation contain information about current values of wage inflation and vice versa, which is part of the definition of a wage-price spiral. To test for Granger causality in a situation where p > 1 two standard Granger Causality F-tests will be implemented, one for each direction. These Granger causality tests have all been carried out using R, see Appendix F for details.

Furthermore the impulse response functions will be calculated according to $\frac{\partial \pi_t^p}{\partial \epsilon_{1,t-k}}$ and $\frac{\partial \pi_t^w}{\partial \epsilon_{2,t-k}}$ with $t, k \subseteq \mathbb{N}$, these are the responses of variables to a one-unit increase of its own respective error after k periods, while holding all other subsequent errors at zero (Stock & Watson, 2001). We will make use of so called orthogonal impulse response functions (2)

$$\Theta_t^o = \Phi_i P \tag{2}$$

Where Φ_i is the coefficient matrix of lag i and the P matrix is the Choleski decomposition of variance-covariance matrix of the estimated ϵ_t vector, $\Sigma = PP^T$, where P is a lower triangular matrix with positive diagonal elements. For this bivariate model it means that we restrict the top right element to be zero at all times, resulting in a ceteris paribus condition (Stock & Watson, 2001). These orthogonal impulse response functions are essential as they represent to what extent the change of wage or price inflation in Eurozone countries reacts to a shock in the other, which makes it a key measure to capture wage-price spiral dynamics from historical data. Besides orthogonal also forecast error impulse response functions (FEIR) in the fashion of Pesaran and Shin (1998) will be fitted on the VAR model as a robustness check.

Note that the p parameter, also called memory, will be chosen for each model separately using four model selection criteria. These criteria will each give a preferred value for p, if these values differ from another, the value which gets chosen most often will be the one used. If there is no clear majority choice then the memory chosen will be based on the criterion with lowest outcome of p. The four criteria include: Akaike information criterion, Hannan Quinn criterion, Schwarz criterion and Final prediction error. Please consult Appendix B for the specifications.

Wrapping up the technical details of the VAR(p) model, L_t will act as a nx1 matrix which adds n different variables to the equation, additionally L_t includes 12 monthly dummies which are supposed to capture the seasonality across different months. ϕ acts as the coefficient matrix with dimension 2xn. Additionally through the L_t matrix it will be possible to validate whether the variables behave according to macroeconomic and Philips curve theory, which helps to improve the validity of the model.

The research will be conducted in the following way, first all VAR(p) model will be fitted using the appropriate value for p with their respective impulse response functions. Then a comparison will be given among the different eurozone countries to confirm or contest the analysis done. Lastly a comparison will be given with previous wage price spirals and finally the research question will be answered.

4. RESULTS

First and foremost it was checked whether all time series are stationary after the first difference log transformation. This was done using the Augmented Dickey-Fuller T-test. All ten tests (View Appendix E for details) resulted in a p-value of 0.01 or 0.03, rounded at 2 decimals. This means that the hypothesis that the transformed time series have a unit root has been rejected and stationary can be assumed.

Next, the order of the VAR(p) models were estimated using the aforementioned four criteria (see Appendix B), resulting in VAR(12) models for the Netherlands and Italy and VAR(13) for Austria. While the Eurozone got a VAR(5) model and the US a VAR(9). It can be seen that the AIC and FPE often result in higher indications for the memory. This makes sense as those criteria have the softest punishments for dimensionality. However since we want to decrease the chances of overfitting, the memories chosen tend to have lower dimensions.

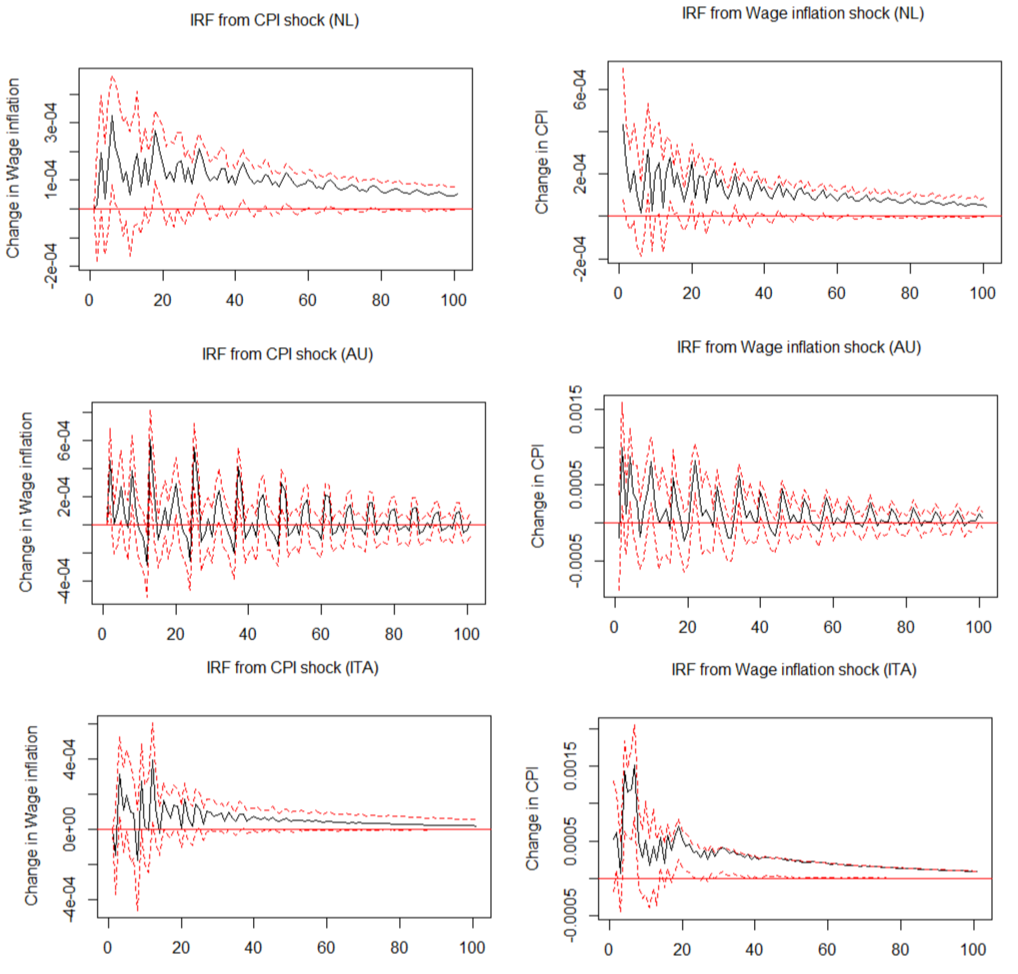
Memory tests results				
Entity name	AIC	HQ	SC	FPE
Netherlands	12	12	12	12
Austria	87	56	13	70
Italy	95	12	12	95
Eurozone*	100	16	5	29
US	9	9	5	9

$*$Eurozone data is starting at 1993

While the memories all gave somewhat similar outcomes, the Granger causality directions differed by a lot. Important to remember for the Granger causality tests is that the null hypothesis always states that there is no Granger causality. By taking a significance level of $\alpha = 0.05$*

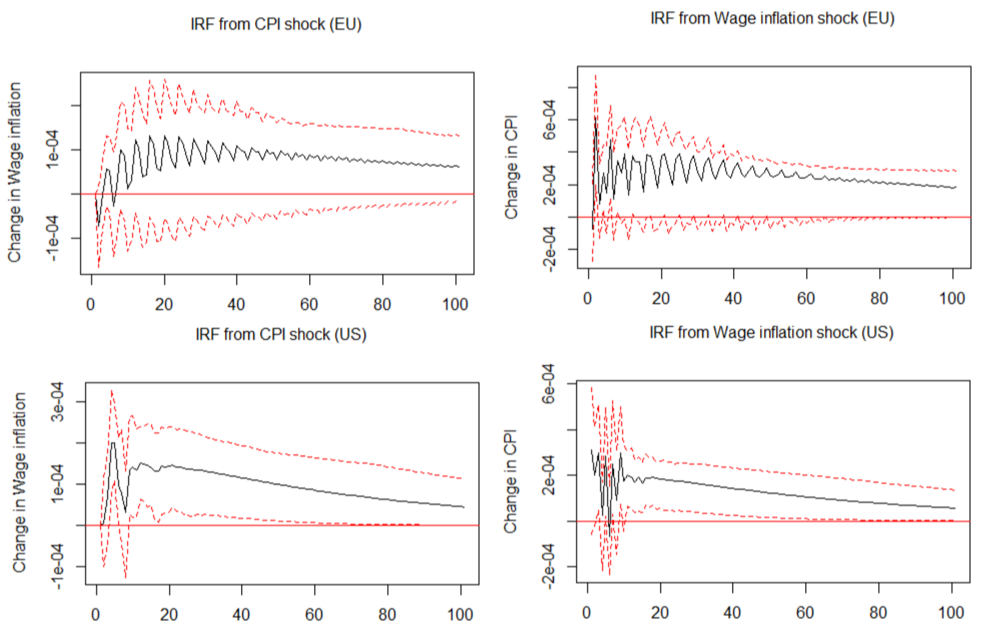
Granger Causality tests, p-values		
Entity name	Price inflation does not cause Wage I.	Wage inflation does not cause Price I.
Netherlands	F-Test=1.307, p-value = 0.208	F-Test=2.478, p-value = 0.003*
Austria	F-Test=4.826, p-value = 2.99e-08*	F-Test=5.087, p-value = 7.817e-09*
Italy	F-Test=8.529, p-value = 1.11e-15*	F-Test=2.300, p-value = 0.007*
Eurozone	F-Test=5.266, p-value = 9.502e-05*	F-Test=1.278, p-value = 0.272
US	F-Test=2.850, p-value = 0.003*	F-Test=2.013, p-value = 0.035*

The Granger causality tests show that in most instances price inflation Granger causes wage inflation and vice versa. The two exceptions being that in the Netherlands we accept the null hypothesis that price inflation does not Granger cause wage inflation and that in the Eurozone wage inflation does not Granger cause price inflation.



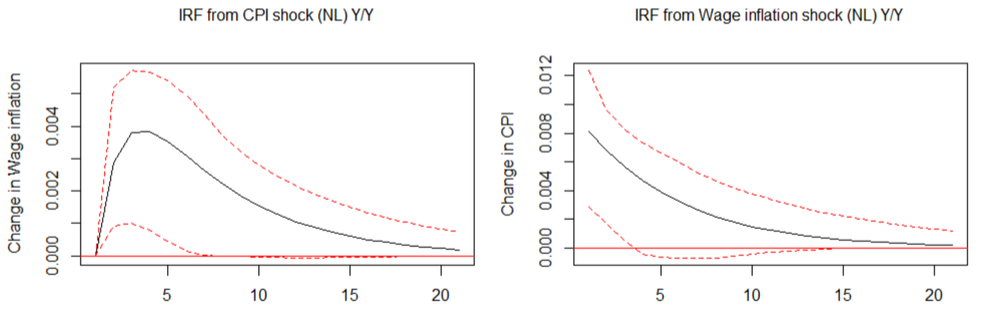
From the Orthogonal (Cholesky identified) Impulse Response Functions, it is seen that they vary from region to region. Out of the three Eurozone countries it can be seen that Austria has the least predictability from past shocks, while the Netherlands and Italy both show a clear positive response to past shocks. Most notably Italy showing strong responses to shocks in wage inflation, with changes in CPI getting up to 0.0015. even though the lower bound of the 95% confidence interval at early lags sometimes gets under the zero line.

Below the IRFs for the Eurozone and the US are given. These picture the same painting as the IRFs of the Netherlands and Italy. A positive shock in either wage or price inflation after a few periods always leads to increases in the other. An interesting observation is that The IRFs tend to have less seasonality than the country IRFs and that the US lower bound of the 95% confidence interval converges to zero from above the zero line.



Selected variable estimates for CPI autoregression (with p-values)			
Entity name	Oil	Bonds	Unemployment
Netherlands	7.207e-06 (0.177919)	1.306e-04 (0.016618)*	-4.260e-05 (0.434173)
Austria	7.660e-06 (0.207117)	8.378e-05 (0.202813)	6.960e-06 (0.983350)
US	4.359e-06 (0.12356)	6.762e-05 (0.03109)*	-1.141e-04 (0.00385)**

At the table above we get to see that in our VAR estimation the exogenous variables added some interesting insights to the equation. The unemployment rate has a very significant negative relation with CPI inflation, this is in line with aforementioned Philips curve theory of a negative relation between unemployment and CPI. Also higher oil prices turns out to correlate with higher CPI, which is in line with oil price spillover theory (Chen, 2009). Please consult Appendix D for the same selected results of wage inflation autoregression.



The year over year (Y/Y) VAR models show the model is able to capture the IRFs with barely any seasonality, it is also clearly seen that both variables react positively to impulses. These results are nearly identical for other Eurozone countries (see Appendix G). However since almost all Y/Y data turned out to be non stationary, it is not wise to draw empirical conclusions just from these charts. Nevertheless it is a good sign for the model that the Y/Y IRFs as well as the FEIRs (see Appendix F) show clear positive responses to shocks.

5. CONCLUSION AND DISCUSSION

In this paper we looked at the dynamics of wage-price spirals in the Netherlands, Austria and Italy and compared it with the Eurozone as a whole and the United States. It is found that out of all the three countries, Austria is not very susceptible to wage-price spirals. For Italy there are strong indications that a potential wage-price spiral might be more extreme, having strong responses to price and wage inflation shocks, in line with the general thought of Italy being a less "resilient" economically (Biscaro, 2016).

Another interesting finding is that wage inflation in the Eurozone shows not to Granger cause price inflation, this could be the case because EU and Eurozone data only started being collected at 1993, which means that the wage price spirals of the 1970's, were not captured by that VAR model while the 1990's and 2000's were part of the model. This period is known for wage increases without price inflationary forces (see Appendix A, Hess & Schweizer (2000)). This theory is supported by the US showing consistency with the observed wage-price dynamics.

A disappointing occurrence of these VAR models is that the seasonality was not totally filtered out by the individual month dummies, as seen in the IRFs. While being a bit of a nuisance, this was made up by the IRFs displaying clear behaviour which can be read disregarding the little bumps as well as Y/Y IRFs showing similar results with no seasonality. An interesting next step of comparative wage-price analysis could be to fit a TAR or STAR model on Eurozone wage-price data to explain specifications on the occurrence or absence of wage-price spirals even further.

Finalizing the discussion, we found out that in most of the Eurozone countries there is potential for a wage-price spiral if wage inflation continues to increase to current price inflation levels. Thus it is important for policy makers to keep a close eye on wage inflation and act accordingly before it spirals out of control.

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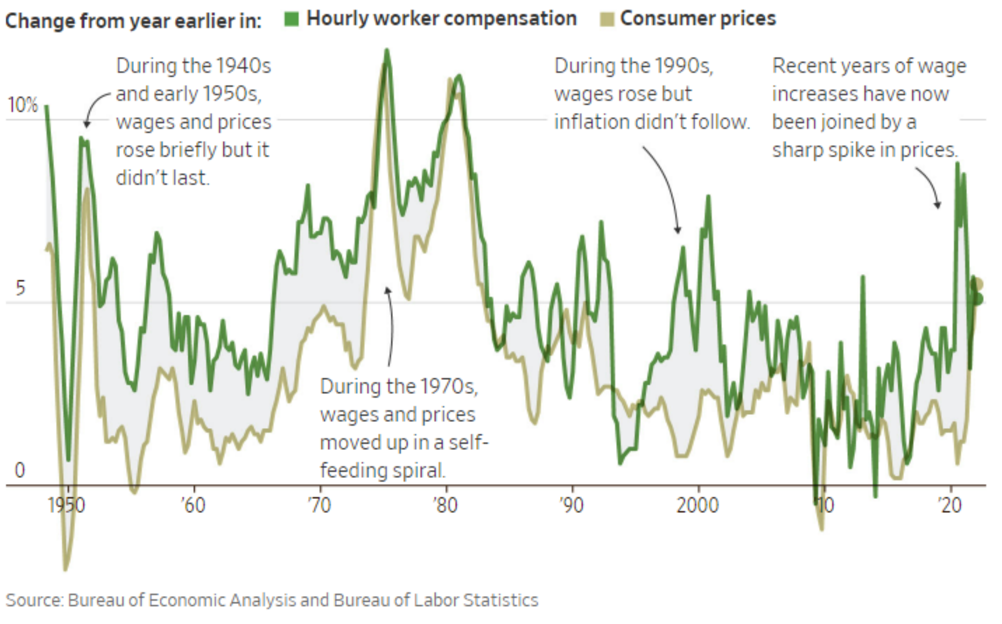
APPENDIX A

US Price inflation vs Wage inflation



APPENDIX B

Criteria used for determining VAR memory

$$AIC(n) = \log\ \det(\hat{\Sigma}_\epsilon(n)) + \frac{2}{T} nK^2$$

$$HQ(n) = \log\ \det(\hat{\Sigma}_\epsilon(n)) + \frac{2\log(\log(T))}{T} nK^2$$

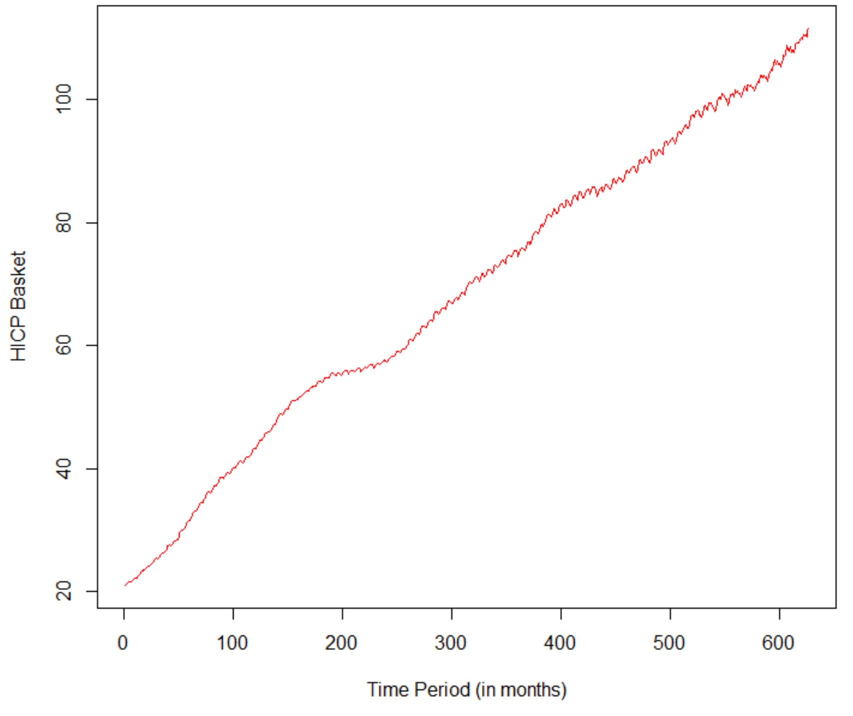
$$SC(n) = \log\ \det(\hat{\Sigma}_\epsilon(n)) + \frac{\log(T)}{T} nK^2$$

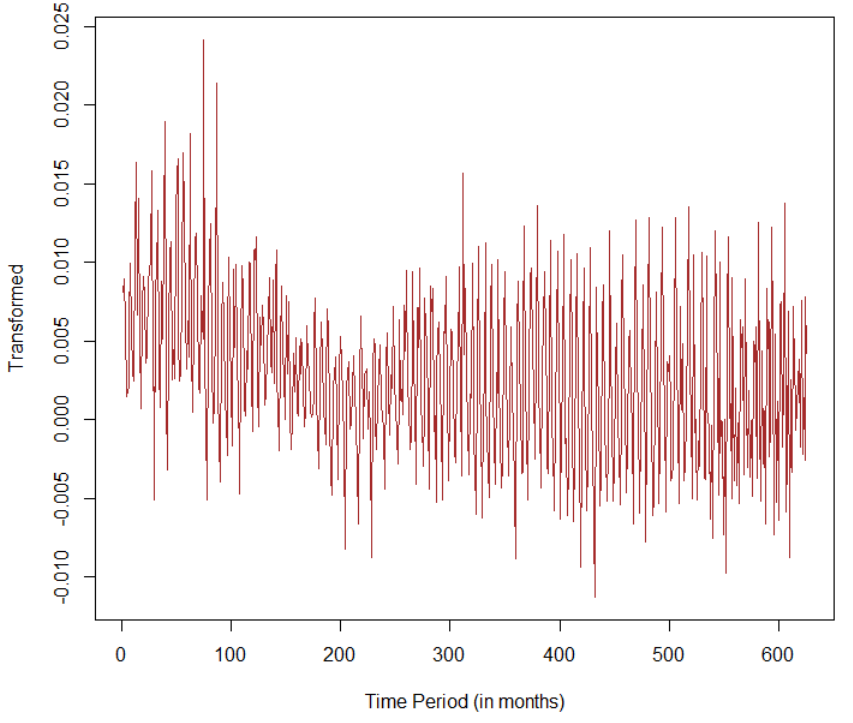
$$FPE(n) = \left(\frac{T+n^*}{T-n^*}\right)^K \log\ \det(\hat{\Sigma}_\epsilon(n))$$

Sources in order:
(Akaike, 1969)
(Hannan & Quinn, 1979)
(Schwarz, 1978)
(Akaike, 1974)

APPENDIX C

Inflation variable transformation





APPENDIX D

Estimates for wage inflation autoregression

Selected variable estimates for wage inflation autoregression (with p-values)			
Entity name	Oil	Bonds	Unemployment
Netherlands	-3.442e-06 (0.6068)	-4.292e-05 (0.5284)	-8.228e-05 (0.2275)
Austria	-4.339e-06 (0.782938)	2.496e-04 (0.143878)	5.440e-04 (0.529802)
US	-1.488e-05 (0.005605)**	-1.436e-04 (0.015665)*	-2.945e-05 (0.692680)

APPENDIX E

Unit root checks

Augmented Dickey Fuller test p-values		
Entity name	wage inf	price inf
Netherlands	0.03	0.01
Austria	0.01	0.01
Italy	0.01	0.01
Eurozone	0.01	0.01
US	0.01	0.01

APPENDIX E

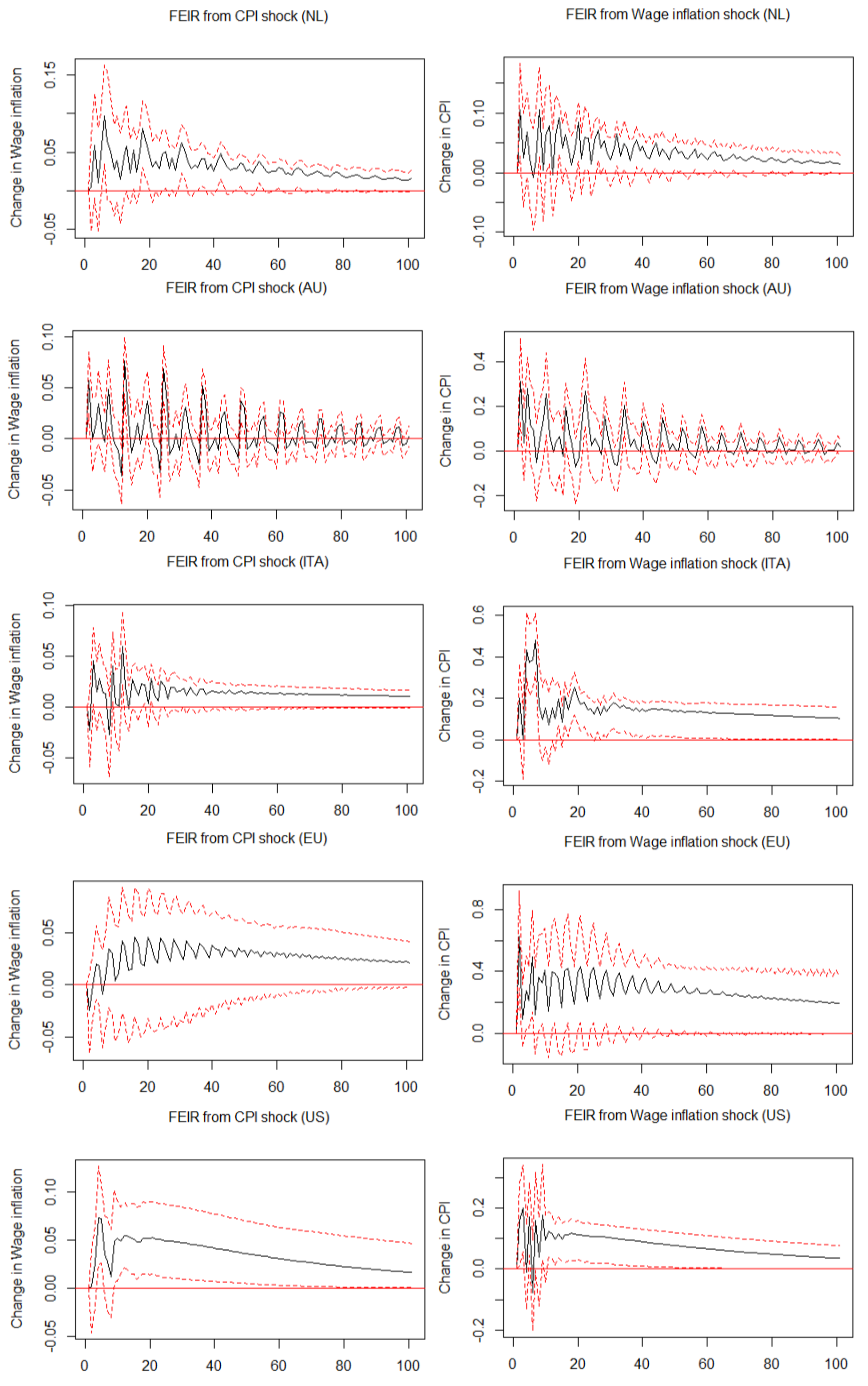
R-packages details

For this research the R-package called 'vars' has been used. The package designed by Pfaff (2008) allows to clearly and concisely plot and analyze time series data, but mostly it is known for fitting VECM, structural and ordinary VAR models. Additionally it was used to investigate Granger causality and conduct impulse response analysis.

To check for unit roots a different R-package was consulted called 'urca' (Pfaff, 2016). This package offers a variety of unit root tests, such as the augmented dickey fuller test, which will help determine stationarity of the data.

APPENDIX F

Forecast Error Impulse Response functions


FEIR from CPI shock (NL)
FEIR from Wage inflation shock (NL)
FEIR from CPI shock (AU)
FEIR from Wage inflation shock (AU)
FEIR from CPI shock (ITA)
FEIR from Wage inflation shock (ITA)
FEIR from CPI shock (EU)
FEIR from Wage inflation shock (EU)
FEIR from CPI shock (US)
FEIR from Wage inflation shock (US)
Change in Wage inflation
Change in CPI

APPENDIX G

Year over Year IRFs