Causal relationship between wages and prices in R. Macedonia: VECM analysis

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ABSTRACT

In this paper the issue of causality between wages and prices in R.Macedonia has been tested. OLS relationship between prices and wages is positive; productivity is not significant in determination of prices or wages too. Engle-Granger test proved that variables of interest CPI and average real wage are cointegrated, i.e. there exists long run relationship between those variables, when first differenced. While their levels are not cointegrated. ARDL regression proved that between CPI and average real wage there exists almost significant long run relationship (tstat=1.60), and coefficient is of size 0.3353 at one lag. Unit root test showed that CPI and average real wage are I (1) variables. Johansen's test of cointegration showed that we cannot reject the null hypothesis of having rank 1 (rank=1) and therefore the number of cointegrating vectors is one. Optimal number of lags according for VARs and VECMs is 1. From the VECM model we can see which variable responds more if there is shock in the system, and it seems that average real wage responds more on the shock in the system.

Keywords: Granger causality, wages, prices, cointegration, VECM

JEL classification: C50, E31

Introduction

The issue of causality between wages and prices had been investigated extensively discussed in the literature. However, there is not being made clear consensus about the question what is cause and what is effect. David Hume (1739), argued that, in seeking to explain any object or event, we have evidence but not proof that its alleged cause produced and effect on it. Immanuel Kant, Hume's contemporary, also thought that the idea of causality is fundamental category of understanding, and a necessary condition for experience. In the economics science Haavelmo (1944)[1], was one of the first to contribute to the advancing the causality analysis, he formulated the economic relationships to be expressed in stochastic terms. But also stated that every theoretical relationship in economics can be tested empirically, as an example he took stochastic price-quantity relation.In economics, there exist different approaches to causality, one approach may emphasize structure, and other approach may emphasize structure[2].

Table 1 a summary of some studies, on causality issue

	Structural	**Process**
A priori	Cowles commission, Koopmans (1953), Hood and Koopmans (1953)	Zellner (1979)
Inferential	Simon (1953), Favero and Hendry (1992), Angrist, Krueger (2001)	Granger (1969) Vector autoregressions , Sims (1980)

Herbert Simon (1953) showed that causality could be defined in a structural econometric model, not only between exogenous and endogenous variables, but also among the endogenous variables themselves. The Cowles commission approach, related causality to the invariance properties of the structural model. This approach emphasized the distinction between endogenous and exogenous variables, and the identification and estimation of structural parameters. Zellner opposes Simon and sides with Granger: predictability is a central feature of causal attribution, which is why his is a process account. On the other hand, he opposes Granger and sides with Simon: an underlying structure (a set of laws) is a crucial presupposition of causal analysis, which is why his is an a priori account.

[1] Haavlemo T. (1944) '*The probability Approach in Econometrics'*, Econometrica, 12, Issue Supplement (July, iii-vi, 1-115.)

[2] Hoover, K.,(2008), Causality in economics and econometrics, From The New Palgrave Dictionary of Economics, Second Edition, 2008 Edited by Steven N. Durlauf and Lawrence E. Blume

Theoretical models of prices and wages review

A standard model in this framework is New Keynesian Philips Curve (NPKC), which has the following presentation: $\pi = \beta E(\pi_{t+1}) + \alpha(y - \bar{y})$ here π is inflation rate, π_{t+1} is expected inflation, and $\bar{y}$ is the natural output. Actually natural output represents the fitted values, this model is log-log functional form, to represent the percentage values of the variables. From a welfare point of view previous model implies that is best for welfare, to stabilize output and stabilize inflation (Blancard, Gali, 1988)[3]. And stabilizing inflation also stabilizes output gap. According to macroeconomic behavior $\bar{p}Y = M$, here $\bar{p}$ are average prices, M is money supply, and Y is output (Akerloff, Dickens,Perry, 2000)[4]. Because there exist n firms in the economy, that are monopolistically competitive, and they divide aggregate demand, $\frac{M}{\bar{p}}$ by $\frac{1}{n}$. So that aggregate demand for the output of a given firm is given as, $\frac{1}{n}\frac{M}{\bar{p}}\left(\frac{p}{\bar{p}}\right)^{\alpha}$ here p is the price charged by the firm on its own product. Now the relation between productivity, wages and unemployment is given by the following equation, $\Pr oductivity = -a + b\left(\frac{w}{w^r}\right)^{\alpha} + cu$, here w^r are the reference wages of the workers, and u is the unemployment rate. And, $0 < \alpha < 1$. Reference wage incorporates the following expression, $w^r = \overline{w}_{-1}(1 + \alpha\pi^e)$ so they do incorporate average wages from previous period, and expected inflation. The profit maximization for the firms is given by the following expression, $p_i = m\frac{w_i}{p_i}$, here m is the mark-up over wages and prices, and markup factor is $\left(\frac{\beta}{\beta - 1}\right)$. If we return to the expression, $\frac{1}{n}\frac{M}{\bar{p}}\left(\frac{p}{\bar{p}}\right)^{\alpha}$ here α is defined as $-\eta$, but so that $\eta > 1$. So that each firm has greater revenues as its price falls Akerloff, Yelen (1980)[5].

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[3]Blanchard, O.,Gali, J.(2005), Real wage rigidities and the New Keynesian model,NBER working paper

[4]. Akerlof,G, William T. Dickens & George L. Perry, (2000). "**Near-Rational Wage and Price Setting and the Long-Run Phillips Curve**,"Brookings Papers on Economic Activity, Economic Studies Program, The Brookings Institution, vol. 31(1), pages 1-60

[5] Akerlof, G. A. and J. L. Yellen (1985b). A near-rational model of the business cycle, with wage and price inertia, Quarterly Journal of Economics 100, 823—838 with wage and price inertia. Quarterly Journal of Economics 100, 823—838

Literature review

The debate on the direction of causality between wages and prices is one of the central questions surrounding the literature on the determinants of inflation. There have been many studies to test for the price-wage relationship. In the following tables are presented relevant studies on this relationship.

Table 2 a summary of some studies, on price, wage and productivity relationship presented in chronological order

Studies	Title	Method
Moschos (1983)	**Aggregate price responses to wage and productivity changes: Evidence from the U.S.**	Productivity Changes: Evidence from U.S.
Strauss, Wohar (1994)	**The Linkage Between Prices, Wages, and Labor Productivity: A Panel Study of Manufacturing Industries**	Panel cointegration relationship
Erica L. Groshen Mark E. Schweitzer (1997)	**The Effects of Inflation on Wage Adjustments in Firm-Level Data: Grease or Sand?**	40-year panel of wage changes
Kawasaki, Hoeller, Poret, 1997	**Modeling wages and prices for smaller OECD countries**	Error correction mechanism
Gregory D. Hess and Mark E. Schweitzer (2000)	**Does Wage Inflation Cause Price Inflation?**	Granger Causality , panel econometrics
Raymond Robertson(2001)	**Relative Prices and Wage Inequality: Evidence from Mexico**	Ordered Logit Ordered Probit
Shik Heo(2003)	**The relationship between efficiency wages and price indexation in a nominal wage contracting model**	simple nominal wage contracting model
Peter Flaschel, Gäoran Kauermann, Willi Semmler (2005)	**Testing Wage and Price Phillips Curves for the United States**	Parametric and non-parametric estimation.
Pu, Flaschel and Chihying (2006)	**A Causal Analysis of the Wage-Price Spiral**	Granger causality. VAR (Vector Autoregressive) Model.
Goretti (2008)	**Wage-Price setting in New EU Member States**	ECM (Error Correction Model); and Panel Model.
Saten Kumar, Don J. Webber and Geoff Perry (2008)	**Real wages, inflation and labour productivity in Australia**	Cointegration; Granger causality
Dubravko Mihaljek and Sweta Saxena (2010)	**Wages, productivity and "structural" inflation in emerging market economies**	Empirical methods ,correlations

Methodology

The presence of bilateral causal relationship between two variables, makes more complex model building.OLS regressions produce highly significant parameters, but the presence of autocorrelation raises the question of whether OLS estimates are robust[6]. Next we use VECM model, which is usually applied in the examining models with more than one endogenous variable. About the theoretical relationship between prices, wages and productivity, policy makers and financial analyst cite wages pressures and productivity as leading factors in explaining inflation. Although cost push inflation has been examined by Mehra (1991, 1993, 2000), who shows that prices cause wages, but that rise in wages don't seems to explain the inflation. Hu and Trehan (1995), also reject the cost push view of inflation. Ghali (1999), using Granger-causality tests, finds that wage growth does help to predict inflation, supporting the cost-push view. The relationship between productivity and inflation, has been described in the theory but there are not many empirical studies to support this hypothesis, Straus (2004)[7]. Beside wages and productivity, other variables can be used on the models. But this big models, that include greater number of variables, have proven to be failure when trying to capture the dynamic relationship between the variables, due to loss of power. Lütkhepohl and Krätzig (2004), proved that the failure of this big models in explanation of the dynamic relationships, is their insufficient representation of the dynamic interactions in the systems of variables.

In the analyzing the causal relationship in this paper, we use two models OLS regression model and VECM model, in order to obtain statistically robust estimate. Prior to the estimation of this models we examine the respective model selection criteria, for determining the lag order/lagged differences so as the rank of cointegration.

Also there were applied Toda, Yamamoto test (1995), and Granger causality tests, as well as instantaneous causality test, in order to see the robustness of the causality results. VAR model was used to capture the short run relationship between the variables of interests.

[6]Although in the presence of autocorrelation the OLS estimators remain unbiased, consistent, and asymptotically normaly distributed, they are no longer efficient (Gujaraty, 2003).

[7] Straus, J.Wohar,E.,M., (2004), **The Linkage Between Prices, Wages, and Labor Productivity: A Panel Study of Manufacturing Industries,** Southern Economic Journal.

Data

For the empirical part of the price-wage causal relationship in Macedonia, we employ quarterly data covering the period from **2004 Q1**, to **2009 Q4**.Variables that we use are wages, which are represented by the wages (AVERAGE REAL WAGES), index number, quarterly data 2005=100.CPI (prices) consumer prices, index number, quarterly data 2005=100.Productivityis also represented by the quarterly index, (PROD).The sources of the data are IMF IFS and EconStats™[8]. Additionally in this section we have analyzed stationary properties of the time series data.

The plots for both level series of all three variables suggest a trending movement and little evidence of returning to a fixed mean value. Furthermore the plots are inconsistent with the series containing stochastic trends. In contrast, the plots for the differenced series suggest evidence of mean reversion and some evidence that the series may be stationary[9].

As the Table in the Appendix shows[10], the formal stationarity tests, Augmented Dickey –Fuller test (ADF), and Phillips Perron test (PPERRON), in all cases for wages and prices the null hypothesis that the series in levels contains unit root, we cannot reject. But for the productivity variable we accept that it is stationary even in levels, and that does not contain unit root.

In contrast all of the null hypothesis that the differenced series contain unit root is rejected in all cases for both series.

Therefore level series for wages and prices contain unit root, and appears to be characterized by the presence of stochastic trend.

Results

In the first sub-section we will examine the OLS results, whereas in the second sub-section we will analyze the VECM model.

[8]The web site for this citation is : http://www.econstats.com/ifs/NorGSc_Mac2_Q.htm
[9]See Appendix 1 section 1
[10]See Appendix 1 section 2

OLS estimates

In the next Table are presented the results of the OLS estimates. In the columns (2) and (3), prices are regressed on wages and productivity in a log-log functional form, and then also are provided first difference estimates. In the column (6) and (7) wages are regressed on productivity and also in the second part of the columns (denoted in the beginning with **Δlog**symbol)**,** are provided first differenced results. Also from each model are reported autocorrelation tests results, and functional form test results.

Table 3 OLS estimates

Variables	Prices=f(wages, productivity)				Wages=f(prices,productivity)		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
	LRW	0.35***	0.96***		LCPI	2.31***	1.04***
	LPROD	0.015	-0.11***		LPROD	0.002	0.107**
log	CONST	3.032***	n.a.	**log**	CONST	-6.038***	n.a.
	LM test	0.0024	0.0027		LM test	0.0018	0.0013
	Ramsey test	0.0000			Ramsey test	0.9804	
	ΔLRW	-0.034	0.091		ΔLCPI	-0.19	0.75
	ΔLPROD	-0.0036	-0.002		ΔLPROD	-0.0037	0.021
	CONST	0.0076***	n.a.		CONST	0.025***	n.a.
Δlog	LM test	0.3792***	0.1021	**Δlog**	LM test	0.3524***	0.0431
	Ramsey test	0.0750*			Ramsey test	0.2290***	

Note 1: *** - significant at 1% level of significance; ** - significant at 5% level of significance; * - significant at10% level of significance.The LM tests indicate the p-value of the Breusch-Godfrey LM test for autocorrelation with H_0: no serial correlation and H_a: H_0 is not true.The OLS regression in column 2 can be represented in a form: $\hat{lcpi} = \beta_1 lrw + \beta_2 lprod + \beta_0$, where β_0 is intercept, β_1 and β_2 are elasticities that measure elasticity of wages to prices and productivity to prices respectively. Second model in this column is: $\Delta\hat{lcpi} = \beta_1 \Delta lrw + \beta_2 \Delta lprod + \beta_0$ this is the case of first differences of the variables. Autocorrelation in the log modelfrom column I is a serious problem, OLS time series do suffer from serial correlation. While in the second model

form this column, first difference model does not suffer from serial autocorrelation. Functional form in this column is better when first differenced model. That is the change of the variables model is better than their levels model. Models form column (6) can be presented as $\hat{lrw} = \beta_1 lcpi + \beta_2 lprod + \beta_0$, and the second model in this column is, $\Delta \hat{lrw} = \beta_1 \Delta lcpi + \beta_2 \Delta lprod + \beta_0$,first mode in this column do suffer from autocorrelation but the OLS estimates give the predicted *apriori* relationship between the variables of interest. Except that the productivity does not influence the level wages not even their changes (first differences). Models without constant in columns 3 and 7 are also tested. And in this models same as log-log OLS models autocorrelation is a problem, while in a first difference models autocorrelation seems not to be a problem. Now we shall draw some conclusion for the causality based on the OLS estimation;

Table 4 the pattern of causality in R.Macedonia based on OLS model

Model	Log-log	First-differences
Intercept	$cpi \Leftrightarrow realwages$	$cpi - realwages$
No intercept	$cpi \Leftrightarrow realwages$	$cpi - realwages$

Note 2: $\Leftrightarrow$ indicates bilateral causality, while – indicates absence of causality.

This evidence suggests that there is bilateral causal relationship between prices and wages in our models, but not in first difference models. But in log-log models serial correlation was serious problem, and that harms the reliability of the OLS estimates. Nonetheless, we must agree that OLS estimates are a good start, as they provide first insight when testing different relationships. On a basis of Ramsey's RESET test it appears the when prices are function of wages, first differenced model appears to be better, while when wages are function of prices and productivity level model and first differenced model, according to Ramsey's RESET test appear to be well specified. Productivity seems to be significant only in level models, and not in first differenced models. According to the LM test, Breusch-Godfrey test, for autocorrelation, autocorrelation seems to be a problem in a level's models while not when first differenced models[11]. This raises the question whether OLS estimates are statistically robust.

[11]Null hypothesis in this test is H_0:no serial correlation and H_a: there exists serial correlation in the residuals

Toda and Yamamoto test (1995)

Toda and Yamamoto (1995) developed a test, alternative to Granger causality test, irrespective of whether Y_t and X_t are are I(0),I(1),I(2), cointegrated or not cointegrated of an arbitrary order. This is widely known as Toda and Yamamoto (1995) augmented Granger causality. Toda and Yamamoto test is based on the following two equations.

$$LCPI_t = \alpha + \sum_{i=1}^{h+d} \beta_i LCPI_{t-i} + \sum_{j=1}^{k+d} \gamma_j LRW_{t-j} + u_{yt} \qquad \textbf{(I)}$$

$$LRW_t = \alpha + \sum_{i=1}^{h+d} \theta_i LRW_{t-i} + \sum_{j=1}^{k+d} \delta_j LCPI_{t-j} + u_{xt} \qquad \textbf{(II)}$$

For the first equation;

Null hypothesis is $H_0 : \sum_{j=1}^{k} \gamma_j = 0$ or X_t does not cause Y_t, alternative hypothesis is, $H_1 : \sum_{j=1}^{k} \gamma_j \neq 0$,or X_t does cause Y_t .For the second equation null hypothesis is; $H_0 : \sum_{j=1}^{k} \delta_j = 0$ or Y_t does not cause X_t, alternative hypothesis is, $H_1 : \sum_{j=1}^{k} \delta_j \neq 0$,or Y_t does cause X_t. Here d is the maximal order of integration, h and k are optimal lag length from the information criteria. In our case optimal lag length is 4. From the estimated VAR model[12].In a small and finite samples like ours and like other researchers they too use, F-test is the most appropriate statistics, when doing a Wald tests. The unrestricted models are:

$$LCPI_t = \alpha + \sum_{i=1}^{h} \beta_i LCPI_{t-i} + u_{yt} \qquad \textbf{(III)}$$

$$LRW_t = \alpha + \sum_{i=1}^{h} LRW_i X_{t-i} + u_{xt} \qquad \textbf{(IV)}$$

Now we calculate the F-statistics for the models. The results are presented in the following sections

[12] See Appendix 2

FOR THE EQUATION (I) AND (III) [13]

$$F = \frac{\left(R_{UR}^2 - R_R^2\right)/k}{R_{UR}^2\,/\left(n-k\right)}m = \frac{(0.015-0.011)/2}{0.015\,/(20-2)} = \frac{0.001}{0.000083} = 12.04$$

Here R_{UR}^2 are the residual sum of squares of the unrestricted model (I), and R_R^2 are the residual sum of squares of the restricted model (III). The F-stats for 2 and 18 degrees of freedom is 6.013 .so we reject the null hypothesis that LRW_t does not influence $LCPI_{t,}$ and we accept the alternative that LRW_t does influence $LCPI_t$.

FOR THE EQUATION (II) AND (IV)

$$F = \frac{\left(R_{UR}^2 - R_R^2\right)/m}{R_{UR}^2\,/\left(n-k\right)} = \frac{(0.022-0.013)/2}{0.022\,/(19-2)} = \frac{0.009}{0.0013} = 6.92$$

The F-stats for 2 and 17 degrees of freedom is 6.12, so 6.93>6.12, we reject the null hypothesis that $LCPI_t$ does not cause LRW_t, and $LCPI_t$ does weakly cause LRW_t. Next we introduce the estimated VAR model. A *p*th-order VAR is also called a **VAR with *p* lags**.Following Gordon (1988)[14], we specify the following wage and price equations that constitute the VAR model:

$$\Delta LCPI = \alpha_0 + \sum_{s=1}^{k} \alpha_{1s}\Delta LCPI_{t-s} + \sum_{s=1}^{k} \alpha_{2s}\Delta LRW_{t-s} + \sum_{s=1}^{k} \alpha_{3s}\Delta X_t + \sum_{s=1}^{k} \alpha_{4s}\Delta Z_t + \varepsilon_t^{CPI} \qquad \textbf{(V)}$$

$$\Delta LRW = \beta_0 + \sum_{s=1}^{k} \beta_{1s}\Delta LCPI_{t-s} + \sum_{s=1}^{k} \beta_{2s}\Delta LRW_{t-s} + \sum_{s=1}^{k} \beta_{3s}\Delta X_t + \sum_{s=1}^{k} \beta_{4s}\Delta Z_t + \varepsilon_t^{RW} \qquad \textbf{(VI)}$$

This equations constitute two equation non-structural vector autoregressive system, (VAR) that can be used to study the short run dynamics of the relationship between prices and wages inflation. But since the series appear to be cointegrated which is late shown in the following tests cointegration tests we will incorporate the long run information in the model that was removed by first differencing the variables. The result is Vector Error correction (VEC) model. This is a common approach to include the lost information, by including the levels of the variables LCP_{t-1} and LRW_{t-1}, by which on would obtain VEC unrestricted model Nourzad,.(2008)[15].

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[13] In the F-stat formula, *m* is the number of imposed restrictions

[14] Gordon, Robert J. (1998) "The Role of Wages in the Inflation process," *American Economic Review*, 78, 276-283

[15] Nourzad,F.(2008), Assessing the Predictive Power of Labor-Market Indicators of Inflation, Applied economic Letters

TABLE 5 VAR MODEL: LCPI LRW, LAGS (4)

LCPI	Coefficient	z	P>|z|
L4.LCPI	-0.46	-1.38	0.17
L4.LRW	0.79	4.48	0.00
CONSTANT	3.08	3.96	0.00
LRW	**Coefficient**	**z**	**P>|z|**
L4.CPI	1.69	3.67	0.00
L4.LRW	0.75	3.06	0.00
CONSTANT	-6.58	-6.13	0.00

Next, we report Wald tests of the hypothesis that the endogenous variables at the given lag are jointly zero for each equation and for all equations jointly.

Equation: LCPI

lag	χ^2	df	p > χ^2
4	142.4237	2	0.000

Equation: LRW

lag	χ^2	df	p > χ^2
4	629.6134	2	0.000

Equation: All

lag	χ^2	df	p > χ^2
4	766.7447	4	0.000

So we reject the null hypothesis that all endogenous variables at the given lag are zero, because the probability of making Type I error is zero. In the standard VAR process framework the instantaneous causality is being tested by using Wald test for zero restrictions. Granger defines instantaneous causality where current as well past values of x are used to predict y_t[16]. That there is instantaneous causality, it was proven by the JMULTI test, where pvalue is 0.0760. The granger causality testing otherwise where not in favor of the causal relationship[17].

[16] Schwert, W.G.(1977), Tests of causality the message of innovations, Rochester University

[17] See Appendix 3

VECM estimates

By analyzing the results from the optimal lag length criteria, according to all of the info criteria, Akaike information criteria (AIC), Hannan-Quinn (HQ) criteria, and optimal lag length is 4 lags[18].

Long run relationship

We use ARIMA approach, autoregressive integrated moving average, we use ARIMA (0, 0, 1), that is series is moving average. This model in general form is presented as follows:

$$X_t = \mu + \varepsilon_t + \psi_1 \varepsilon_{t-1} + ... + \psi_n \varepsilon_{t-n} \qquad \textbf{(VII)}$$

Here μ is the average of the time series, $\psi_1, ..., \psi_n$ are the parameters in the model, $\varepsilon_t, \varepsilon_{t-1}$ are the white noise errors, the value of n is the order of the MA model. Thus a moving average model is conceptually a linear model[19].The results are presented in the following table.

TABLE 6 ARMA model (0, 0, 1)

Dependent variable LCPI	Coefficient	pvalue
LRW	0.3086	0.000
Constant	3.199	0.000
MA	1	

From the table we can see that the variables of interest are positively and significantly correlated.

Engle Granger method

According to Engle and Granger (1987)[20], a series with no deterministic component, which has stationary , ARMA representation, after differencing *n* times, is said to be integrated of order n, denoted $x_t \sim I(n)$ .If x_t and y_t are both $I(n)$, variables than generally it is true that a linear combination like :

$$z_t = x_t - \alpha y_t \qquad \textbf{(VIII)}$$

[18] See Appendix 6

[19] Random shocks in the MA model are propagated to the future values only, ε_{t-1} appears directly on the right hand side of the equation. And the shock in MA model affects the X_t values in the current period, but also in the n periods in the future.

[20] Engle, Robert F., Granger, Clive W. J. (1987) "***Co-integration and error correction: Representation, estimation and testing***", *Econometrica*, 55(2), 251-276.

Will also be $I(n)$. In the previous expression z_t is the equilibrium error, and α is the co-integrating vector[21]. The results of the test are presented in the following table:

Table 7 Engle-Granger cointegartion test

Test procedure/variables	Predicted residuals form OLS regression prices on wages ,when first differenced
ADF	-4.794

Critical value at 5% is -3.000

So the saved equilibrium residuals from the previous, proved that are stationary, from the first differenced regression between prices and wages. So that is used as an evidence for co-integrating relationship between the two variables.

The Johansen test for co-integration of the rank and Saikkonen and Lütkhepohl test

The cointegration tests were performed between $LCPI$ and LRW. On the basis of the Johansen trace test we would continue our analysis with one co-integrating relationship. This applies only when constant is included in the cointegration test, whilst the test statistic is significant at 1%. , clearly indicating that there is sufficient evidence that the rank of cointegration is zero i.e. $rc(\Pi) = 0$, and accept the alternative hypothesis that $rc(\Pi) = 1$. While in contrast when there is trend and orthogonal trend in the cointegration test, there is insufficient evidence to reject the null hypothesis of $rc(\Pi) = 0$, against the alternative $rc(\Pi) = 1$ .Same results applies when we use Saikkonen and Lütkhepohl (1999) test[22]**,** and this test suggests that rank of one is appropriate.

Table 8 Johansen test for co-integration of the rank and Saikkonen and Lütkhepohl test

Variables	Deterministic term	**Johansen Trace test**			**Saikkonen and Lütkhepohl**		
		Lag Order	LR-stat	Pvalue	Lag Order	LR-stat	Pvalue
LCPI LRW	Constant	1	13.89	0.0051	1	3.44	0.0758
	Constant and trend	1	4.91	0.6152	1	1.14	0.7554
	Orthogonal trend	1	10.10	0.2784	1	8.98	0.0720

[21] Co-integrating vector such as: $\hat{\alpha} = \sum_{t=1}^{T} X_t Y_t (\sum_{t=1}^{T} X_t^2)^{-1} = \alpha + \sum_{t=1}^{T} X_t e_t (\sum_{t=1}^{t} X_t^2)^{-1}$

[22] Saikkonen, P. and Lütkhepohl, H. (1999), 'Local power of likelihood ratio tests for the cointegrating rank of a VAR process', Econometric Theory 15:50-78.

Hence there is sufficient evidence to continue the analysis with one cointegrating relationship $r = 1$. The VECM model was estimated using the *Two Stage procedure (S2S)*, with *Johansen Procedure* being used in the first stage and Feasible Generalized Least Squares (*FGLS) procedure* being used in the second stage[23].This estimations were conducted with JMulTi software, generating output of all related loading matrix, co-integration matrix and short-run parameters. From the model have been eliminated coefficients with $t < 2$, t statistics lower than two. This is in accordance with the recommendations by Lütkhepohl and Krätzig, 2004[24]; Lütkhepohl and Krätzig, 2005[25].About the ***Loading coefficients,*** their t ratios can be interpreted in the usual way, as being conditional on the estimated co-integration coefficients, (Lütkhepohl and Krätzig, 2004; Lütkhepohl and Krätzig, 2005,).In this case the loading coefficient of the first equation and in the second equation are significant. Their t ratios are respectively 3.973 for the first equation, and 2.398 for the second equation. Thus, based on the presented results, we can argue that co-integration relation resulting from normalization of cointegrating vector enters significantly in the two equations. About the ***Co-integrating vectors***, by selecting $LCPI_t$ as the first variable in the model, it means that the coefficient of this variable in the cointegration relation will be normalized to 1 in the maximum likelihood estimation procedure. Nevertheless, by looking at p-value of the coefficient looks like there is sufficient evidence to suggest that $LCPI_t$ and LRW_t are cointegrated. The model takes this form:

$$ec_t^{EGLS} = LCPI_t - \underset{(0.000)}{1.012}\ \mathrm{LRW}_t \qquad \textbf{(IX)}$$

The number in parentheses is pvalue, when previous equation has been rearranged, the new expression takes this form:

$$LCPI_t = \underset{(0.000)}{1.012}\ \mathrm{LRW}_t + ec_t^{EGLS} \qquad \textbf{(X)}$$

Considering that the logs of variables have been used, the relation in previous expression expresses the elasticity of prices on wages, hence the coefficient of 1.012 is the estimated price elasticity. If the log wages increases by 1%, it is expected that the log of prices would increase

[23] See Appendix 4 for the estimated results

[24] Lütkhepohl, H. and Krätzig, M. (2004), '*Applied Time Series Econometrics*', Cambridge University Press, October 2004, ISBN 0521 54787 3.

[25] Lütkhepohl, H. and Krätzig, M. (2005), '*VECM Analysis in JMulTi*', 2005, www.jmulti.de

by 1.012 percent. In other words, a 1 percent increase in the log wages would induce a 1.012 percent increase in the log of prices. In addition to this the value of standard deviation is very low, indicating a high efficiency for the estimated parameter. Now, the ***Short-run parameters*** can also be interpreted in the usual way. The estimators of parameters associated with lagged differences of variables may be interpreted in the usual way. Here t ratios are asymptotically under this conditions. The coefficient of productivity does not have a statistically significant impact on wages, neither on prices. About the ***Deterministic Terms***, seasonal dummies do not appear to have significant impact neither on first, neither on second equation. In the next table are presented the results for the diagnostic test performed on the VECM model[26].Testing the model robustness - most of tests rely on the residuals of final VECM, with some applying to the residuals of individual equations and others are based on the full residual vectors, the VECM model statistic indicates that one may not reject the null hypothesis that restricted model has a better representation of Data generating process, compared to unrestricted model. The value is 0.8356 which provides sufficient evidence that no information is lost if restrictions are in some of the short run parameters. ARCH-LM test prove that there is no problem with serial autocorrelation. Non-normality test gives ambiguous results, Lütkepohl (1993) test[27] proves normality in the residuals, whilst Dornik and Hansen (1994) test proves opposite[28].

Table 9 VECM Diagnostic Tests

Type of test	p-value	VECM
VECM model statistics	0.8356	√
LM Autocorrelation Test	0.5611	√
Non normality test		
Dornik and Hansen (1994)	0.0000	x
Lütkepohl (1993)	0.5506	√
ARCH-LM		
u1	0.9505	√
u2	0.6531	√

Note: √ - test indicates no problems with diagnostic criteria; x – indicates that there is some problems with the diagnostic criteria.

[26] See Appendix 4

[27] Lütkepohl (1993), Introduction to Multiple Time Series Analysis, 2ed

[28] Doornik, J.K. and, Hansen, H., 1994, A practical Test for Univariate and Multivariate Normality, Discussion Paper, Nuffield College.

Finally, based on the evidence, one can argue that and are not so strongly co-integrated, and furthermore co-integration relation enters significantly only in the first equation of the system. Put differently, there is sufficient evidence in support of a unilateral causal relationship between prices and wages, running from wages to prices only.

Conclusion

In this literature there are two groups of economists, one that argue that causality runs from wages to prices, and the second group of economists that argue that causality runs in opposite direction. In our paper there is clear evidence that causality runs from wages to prices.

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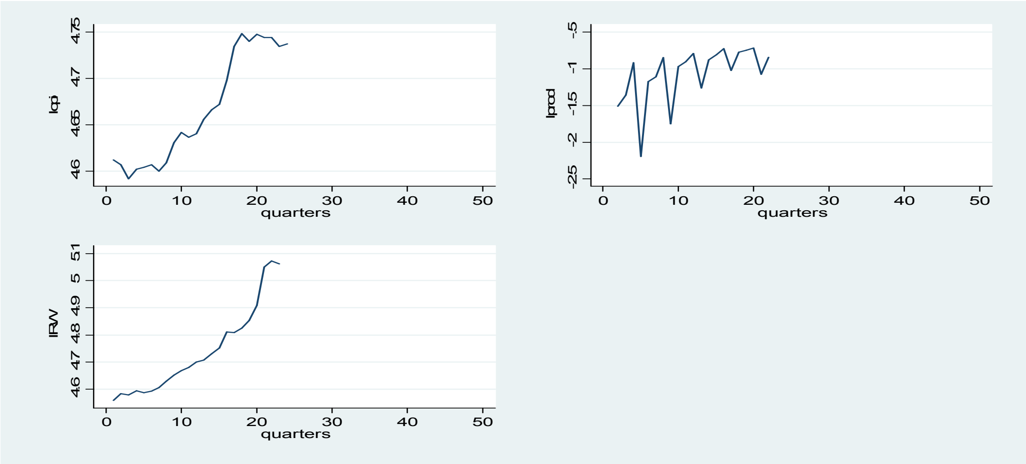
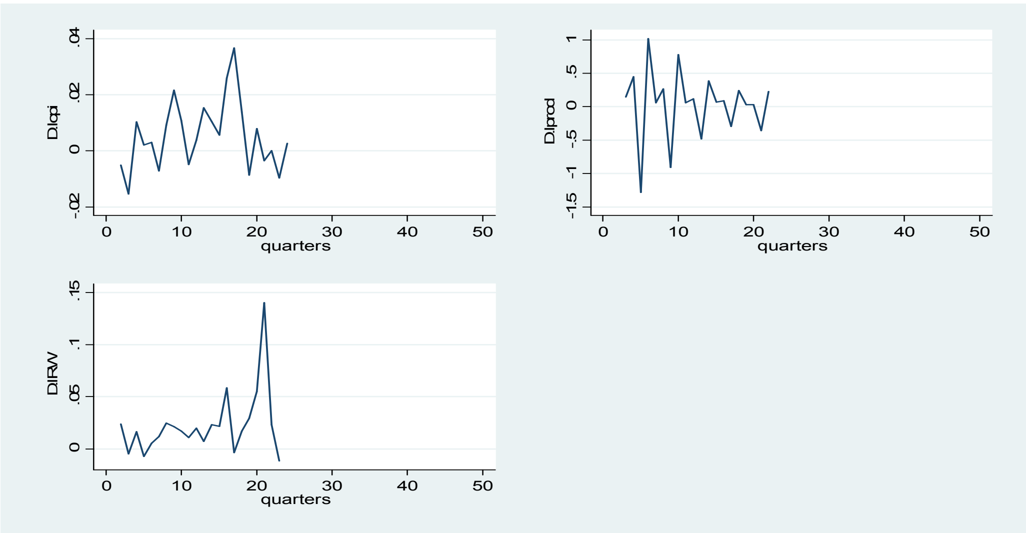
Appendix 1

Appendix 1 section 1





Appendix 1 section 2

Test procedure/variables	CPI	LCPI	DCPI	DLCPI
ADF	-0.181	-0.185	-3.137	-3.173
Phillips-Perron	-0.332	-0.328	-3.075	-3.106

Critical value at 5% is -3.000

Test procedure/variables	RW	LRW	D.RW	DLRW
ADF	1.350	1.287	-3.208	-3.353
Phillips-Perron	1.525	1.487	-3.180	-3.330

Critical value at 5% is -3.000

Test procedure/variables	PROD	LPROD	D.PROD	DLPROD
ADF	-4.338	-4.130	-8.113	-8.148
Phillips-Perron	-4.398	-4.140	-10.904	-11.854

Critical value at 5% is -3.000

Appendix 2

VAR MODEL

```
. var  lcpi laveragewage,lags(4)

Vector autoregression

Sample:  5 - 23                                   No. of obs      =        19
Log likelihood =  90.77785                        AIC             = -8.923984
FPE            =  4.59e-07                        HQIC            = -8.873509
Det(Sigma_ml)  =  2.43e-07                        SBIC            =  -8.62574

Equation           Parms      RMSE     R-sq      chi2     P>chi2
----------------------------------------------------------------
lcpi                  3     .020596   0.8823   142.4237   0.0000
laverageWage          3     .028407   0.9707   629.6134   0.0000
----------------------------------------------------------------

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
lcpi         |
        lcpi |
         L4. |  -.4583469   .3331472    -1.38   0.169    -1.111303    .1946096
             |
laveragewage |
```

```
         L4. |   .7963654   .1778083     4.48   0.000     .4478674    1.144863
             |
       _cons |   3.079201   .7781019     3.96   0.000      1.55415    4.604253
-------------+----------------------------------------------------------------
laveragewage |
        lcpi |
         L4. |   1.687134   .4594884     3.67   0.000     .7865533    2.587715
             |
laveragewage |
         L4. |   .7507831   .2452396     3.06   0.002     .2701224    1.231444
             |
       _cons |  -6.580546   1.073186    -6.13   0.000    -8.683951    -4.47714
```

Appendix 3

```
Granger causality test
*** Tue, 26 Feb 2013 00:15:16 ***
TEST FOR GRANGER-CAUSALITY:
H0: "laveragewage" do not Granger-cause "lcpi"

Test statistic l = 1.8438
pval-F( l; 1, 20) = 0.1896

TEST FOR INSTANTANEOUS CAUSALITY:
H0: No instantaneous causality between "laveragewage" and "lcpi"

Test statistic: c = 3.1481
pval-Chi( c; 1) = 0.0760

  Granger causality Wald tests
  +------------------------------------------------------------------+
  |          Equation           Excluded |   chi2     df Prob > chi2 |
  |--------------------------------------+---------------------------|
  |              lcpi       laveragewage |   .3338     2    0.846    |
  |              lcpi               prod |  15.683     2    0.000    |
  |              lcpi                ALL |  26.369     4    0.000    |
  |--------------------------------------+---------------------------|
  |      laveragewage               lcpi |  3.2753     2    0.194    |
  |      laveragewage               prod |  .89394     2    0.640    |
  |      laveragewage                ALL |  3.8084     4    0.433    |
  |--------------------------------------+---------------------------|
  |              prod               lcpi |  4.2023     2    0.122    |
  |              prod       laveragewage |  9.4541     2    0.009    |
  |              prod                ALL |  20.248     4    0.000    |
  +------------------------------------------------------------------+
```

Appendix 4

```
*** Mon, 25 Feb 2013 22:43:53 ***
OPTIMAL ENDOGENOUS LAGS FROM INFORMATION CRITERIA

endogenous variables:     lcpi laveragewage
exogenous variables:      prod
exogenous lags (fixed):   0
deterministic variables:  CONST S1 S2 S3 TREND
sample range:             [2004 Q4, 2007 Q2], T = 11

optimal number of lags (searched up to 10 lags of 1. differences):
Akaike Info Criterion:    1
Final Prediction Error:   1
Hannan-Quinn Criterion:   1
```

```
Schwarz Criterion:        1


*** Mon, 25 Feb 2013 21:19:08 ***
VEC REPRESENTATION
endogenous variables:     lcpi laveragewage
exogenous variables:      prod
deterministic variables:  S1 S2 S3 TREND
endogenous lags (diffs):  0
exogenous lags:           0
sample range:             [2004 Q2, 2009 Q2], T = 21
estimation procedure:     Two stage. 1st=Johansen approach, 2nd=EGLS



Current and lagged exogenous term:
==================================
           d(lcpi)  d(laveragewage)
------------------------------------
 prod(t)|   -0.008     0.025
        |   (0.008)   (0.023)
        |   {0.339}   {0.274}
        |  [-0.955]   [1.093]
------------------------------------



Loading coefficients:
=====================
           d(lcpi)  d(laveragewage)
------------------------------------
ec1(t-1)|    0.057     0.098
        |   (0.014)   (0.041)
        |   {0.000}   {0.016}
        |   [3.973]   [2.398]
------------------------------------

Estimated cointegration relation(s):
====================================
                 ec1(t-1)
---------------------------
lcpi        (t-1)|    1.000
                 |   (0.000)
                 |   {0.000}
                 |   [0.000]
laveragewage(t-1)|   -1.012
                 |   (0.009)
                 |   {0.000}
                 | [-116.567]
S1(t-1)          |   -0.128
                 |   (0.052)
                 |   {0.014}
                 |  [-2.458]
S2(t-1)          |   -0.283
                 |   (0.055)
                 |   {0.000}
                 |  [-5.188]
S3(t-1)          |   -0.020
                 |   (0.054)
                 |   {0.716}
                 |  [-0.364]
```

```
TREND(t-1)       |    0.025
                 |   (0.003)
                 |   {0.000}
                 |   [7.567]
---------------------------


VAR REPRESENTATION

modulus of the eigenvalues of the reverse characteristic polynomial:
|z| = ( 1.0000     1.0446     )

Legend:
=======
              Equation 1   Equation 2  ...
------------------------------------------
Variable 1 | Coefficient          ...
           | (Std. Dev.)
           | {p - Value}
           | [t - Value]
Variable 2 |         ...
...
------------------------------------------


Lagged endogenous term:
=======================
                      lcpi  laveragewage
-----------------------------------------
lcpi        (t-1)|    1.057     0.098
                 |   (0.000)   (0.000)
                 |   {0.000}   {0.000}
                 |   [0.000]   [0.000]
laveragewage(t-1)|   -0.058     0.900
                 |   (0.000)   (0.000)
                 |   {0.000}   {0.000}
                 |   [0.000]   [0.000]
-----------------------------------------

Current and lagged exogenous term:
==================================
              lcpi  laveragewage
---------------------------------
 prod(t)|   -0.008     0.025
        |   (0.008)   (0.023)
        |   {0.339}   {0.274}
        |  [-0.955]   [1.093]
---------------------------------

Deterministic term:
===================
                  lcpi  laveragewage
-------------------------------------
S1(t-1)    (t)|   -0.007    -0.013
              |   (0.000)   (0.000)
              |   {0.000}   {0.000}
              |   [0.000]   [0.000]
S2(t-1)    (t)|   -0.016    -0.028
              |   (0.000)   (0.000)
              |   {0.000}   {0.000}
              |   [0.000]   [0.000]
```

```
S3(t-1)   (t)|   -0.001    -0.002
             |   (0.000)   (0.000)
             |   {0.000}   {0.000}
             |   [0.000]   [0.000]
TREND(t-1)(t)|    0.001     0.002
             |   (0.000)   (0.000)
             |   {0.000}   {0.000}
             |   [0.000]   [0.000]
-------------------------------------
```

Appendix 5

```
VECM MODEL STATISTICS
sample range:   [2004 Q2, 2009 Q2], T = 21

Log Likelihood:       1.152024e+02
Determinant (Cov):    3.403084e-08

Covariance:   8.137386e-05 -1.423625e-04
             -1.423625e-04  6.672651e-04

Correlation:  1.000000e+00 -6.109477e-01
             -6.109477e-01  1.000000e+00


WALD TEST FOR BETA RESTRICTIONS (using Johansen ML estimator)
R*vec(beta'(K-r))=r; displaying R and r:
 0.0000  0.0000  1.0000  1.0000  1.0000  1.0000           1.0000

test statistic:           0.0430
 p-value:                 0.8356
 degrees of freedom:      1.0000


*** Mon, 25 Feb 2013 21:52:20 ***
TESTS FOR NONNORMALITY

Reference: Doornik & Hansen (1994)
joint test statistic:     36.7077
 p-value:                 0.0000
degrees of freedom:       4.0000
skewness only:            12.5031
 p-value:                 0.0019
kurtosis only:            24.2045
 p-value:                 0.0000

Reference: Lütkepohl (1993), Introduction to Multiple Time Series Analysis, 2ed, p. 153
joint test statistic:     3.0431
 p-value:                 0.5506
degrees of freedom:       4.0000
skewness only:            2.0074
 p-value:                 0.3665
kurtosis only:            1.0357
 p-value:                 0.5958

*** Mon, 25 Feb 2013 21:52:21 ***
JARQUE-BERA TEST

variable        teststat   p-Value(Chi^2)  skewness   kurtosis
u1              0.4820     0.7859         -0.1716     3.6580
u2              47.6022    0.0000          2.0079     9.1868
```

```
*** Mon, 25 Feb 2013 21:52:21 ***
ARCH-LM TEST with 1 lags

variable        teststat   p-Value(Chi^2)  F stat     p-Value(F)
u1              0.0039     0.9505          0.0039     0.9511
u2              0.2020     0.6531          0.2041     0.6568

*** Mon, 25 Feb 2013 21:52:21 ***
MULTIVARIATE ARCH-LM TEST with 1 lags

VARCHLM test statistic:   7.7349
 p-value(chi^2):          0.5611
 degrees of freedom:      9.0000
```

Appendix 6

Lag selection –order criteria

Selection-order criteria

Sample: 5 - 23 Number of obs = 19

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	52.1921				.000017	-5.28338	-5.26655	-5.18396
1	98.3569	92.33	4	0.000	2.1e-07	-9.72178	-9.6713	-9.42353
2	102.711	8.7088	4	0.069	2.0e-07	-9.75908	-9.67495	-9.262
3	106.74	8.0569	4	0.090	2.1e-07	-9.76207	-9.6443	-9.06617
4	120.518	27.556*	4	0.000	8.3e-08*	-10.7913*	-10.6399*	-9.8966*

Endogenous: lcpi laveragewage
Exogenous: _cons