

Causality between Prices and Wages: VECM Analysis for EU-27¹

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The literature on causality as well as the empirical evidence clearly shows that there are two opposing groups of economists, who support different hypotheses with respect to the flow of causality in the price-wage causal relationship. The first group argues that causality runs from wages to prices, whereas the second argues that effect flows from prices to wages. Nonetheless, the literature review suggests that there is at least some consensus in that researcher's conclusions may be contingent on the type of data employed, applied econometric model, or even that relationship may alter with economic cycles. This paper empirically examines the price-wage causal relationship in EU-27, by using the OLS and VECM analysis, and it also provides robust evidence in support of a bilateral causal relationship between prices and wages, both in long-run as well as in the short-run. Prior to designing and estimating the econometric model we have performed stationarity tests for the employed price, wage and productivity variables. Additionally, we have also specified the model taking into account the lag order as well as the rank of co-integration for the co-integrated variables. Furthermore, we have also applied respective restrictions on the parameters of estimated VECM. The evidence resulting from model robustness checks indicates that results are statistically robust. Although far from closing the issue of causality between prices and wages, this paper at least provides some fresh evidence in the case of EU-27.

Keywords: *Causality, Co-integration, Granger, Determinants of Inflation,*

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*VECM*JEL Classifications: *C39, E31***Introduction**

The issue of causality between prices and wages has been intensively discussed in the literature. However, despite utmost empirical efforts to resolve the issue on who the cause is and who the effect is, the consensus is still far from being reached. Arguably, there have been two strands of economists. Whilst the first group argues that causality runs from wages to prices, the second one argues in favor of hypothesis that causality runs from prices to wages. The modern analysis of philosophical discussion of causality began in the 18th century with Hume (1739). He made the scientific hunt for causes possible, by freeing the concept of causality from the metaphysical chains that his predecessors had used to pin it down. Since Hume, the applicability of causality concept has been ever increasingly used in social sciences as well as in the field of economics. In addition to this, the analysis has been sophisticated by intensive use of mathematical and econometrical techniques, which have immeasurably increased the quality of economic analysis. Moreover, computing power and speed have tremendously increased also.

Nonetheless, all these significant advancements have not helped in completely resolving the issue of causality between the prices and wages. The evidence from literature is still conflicting and there is evidence in support of both hypotheses. The aim of this paper is to analyze and derive the pattern of causality for EU-27¹. This paper is organized as follows. *Section 2* reviews the literature on causality, in general, as well as that on causality between prices and wages, in particular. *Section 3* explains the methodology that has been utilized to

¹ Member states of EU-27 are: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxemburg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and the United Kingdom.

examine the causal relationship. *Section 4* describes the variables as well as the data that have been employed in our analysis. *Section 5*, is organized in two sub-sections and presents *Ordinary Least Squares (OLS)* and *Vector Error Correction Model (VECM)* regression results, from which the pattern of causality has been derived. Finally, *Section 6* concludes by summarizing the main findings of this paper.

2 Literature Review

The purpose of the literature review is to lay down some theoretical definitions, characteristics and arguments on causality, in general, and on the price-wage causal relationship, in particular. This summary of previous studies would not only be useful to derive some theoretical definitions of causality and critically assess them, but will also be the basis for the empirical analysis, which will be mainly focused on causality between wages and prices. First part reviews the causality literature from the theoretical perspective, whereas the second part focuses on the empirical studies that have specifically examined the causality between prices, wages and productivity. Causality is a relevant concept, both in natural and social sciences. As we have already emphasized, the modern analysis of philosophical discussion of causality began in the 18th century with Hume (1739). In his view, causality, as it is in the world, is a regular succession of event-types: one thing invariably following another.¹

However, it was the 20th century and especially its last decades, that saw its gained prominence in economics. Undoubtedly, Havlemo (1994) was one of the first to contribute in advancing the causality analysis. His view, which is almost universally acknowledged, is that economic theory must be always formulated in stochastic terms.

¹ His famous definition of causality runs as follows: "We may define a CAUSE to be 'an object precedent and contiguous to another, and where all the objects resembling the former are placed in like relations of precedency and contiguity to those objects, that resemble the latter'" (1978 ed., p. 170). <http://science.irank.org/pages/8538/Causality-Hume.html>

Certainly, one of the most prominent modern studies on causality analysis in economics was conducted by Granger in his seminal paper “*Investigating Causal Relations by Econometric Models and Cross Spectral Methods*” in 1969. An important follow-up analysis of causality was carried out by Ashley *et al.* 1980, who analyzed the causality between advertising and aggregate consumption. They argue that a universally acceptable definition of causality may well not be possible, but they put forward the following definition:

“Let Ω_n represent all the information available in the universe at time n . Suppose that at time n optimum forecasts are made of X_{n+1} using all the information in Ω_n and also using all of this information apart from the present values of Y_{n-j} , $j \geq 0$ of the series Y_t . If the first forecast, using all the information, is superior to the second, then the series Y_t has some special information about X_t not available elsewhere, and Y_t is said to cause X_t ”

It is well understood in economics that the existence of a relationship between two variables does not prove causality or the direction of influence. However, in the context of time series data, it may be possible to exploit the fact that time does not run backwards (so called “time arrow”). This relies on the assertion that the future cannot cause the past, and it is an *a priori* and fundamental feature of the way in which one orders its experience and not either an observed regularity or an analytic truth, (Gilbert, 2004). Table 2.1 provides a short summary of some studies that have examined in depth the causality issue in economics. Certainly, these studies can relatively encompass the developments in recent years.

Table 2.1 A summary of some studies on causality presented in chronological order

Studies	Title	Context/Method
Asshley, Granger and Schmalensee (1980)	Advertising and Aggregate Consumption	Granger causality; Box-Jenkins technique
Sims (1999)	Granger Causality	Definitions; causality and exogeneity.
Jung and Seldon (1995)	The Macroeconomic relation between Advertising and consumption	Granger causality, Error Correction Model;
Gilbert (2004)	Economic Causality	Economic causation, intervention and exogeneity; VAR modeling practice;
LeRoy (2004)	Causality in Economics	Formal analysis of causal relations; graphical analysis; definitions on causality.
Andersson (2005)	Testing for Granger Causality in the presence of measurement errors	Problems of Granger-tests; consequences on forecastability.

Empirical facts on the price, wage and productivity relationship

- 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. The purpose of this review is to identify the key theories, concepts or ideas explaining the causality issue between prices and wages. Besides, it seems sensible to assess what has been

addressed so far on the relevant questions and problems related to the analysis of the relationship between prices and wages. There have been a number of studies that have analyzed the price-wage relationship, and in fact most of them have employed US data. Table 2.2 presents a summary of relevant studies on this relationship.

The available studies focusing on the price-wage causality use various methodologies and can be broadly divided into two categories. The *first strand* of studies focuses on estimation of the effect of wages on prices using data from various economic sectors, whereas the *second strand* estimates the effect of wages on inflation by using the aggregate (national) level data. Alternatively, empirical studies on the price wage causality can be divided into two categories with regard to the direction of effect. The *first category* of studies provides evidence in favor of hypothesis that causation runs from wages to prices, whereas the *second* one suggests that causation runs from prices to wages.

A common feature of most of these studies is that many researchers have applied the Granger-causality concept described above, which as we have already emphasized, is easily applicable in economics. Regarding the econometric models applied in examining the long-run relationship between prices and wages, the *Error Correction Models (ECM)* appear to dominate the alternative econometric methods. While it is commonly acknowledged in the academic literature that prices and wages move strongly together, Hess and Schweitzer (2000) argue that there is a sharp division amongst economists on whether wages cause prices or vice-versa. In order to explain such a causal relation, economists very often use the “Granger-causality” by examining whether the lagged values of one series (say wages) have a significant in-sample explanatory power for another variable (say prices). Additionally, both variables may Granger-cause one another, in which case one can conclude only that both economic series are determined simultaneously. If this is the case, the researcher may be unable to infer that one series has independent causal effect on the other.

Table 2.2 A summary of some studies on the price, wage and productivity relationship presented in chronological order

Studies	Title	Context/Method
Moschos (1983)	Aggregate Price Responses to Wages and Productivity Changes: Evidence from U.S.	Error Correction Model (ECM); Instrumental Variable (IV);
Emery and Chang (1996)	Do Wages Help Predict Inflation?	Granger causality ECM (Error Correction Model)
Palley (1999)	The U.S. Inflation Process: Does Nominal Wage Inflation cause Price Inflation, Vice-versa, or neither	Granger Causality;
Hess and Schweitzer (2000)	Does Wage Inflation Cause Price Inflation	Granger causality; ECM (Error Correction Model)
Garcia and Restrepo (2001)	Price and Wage inflation in Chile	ECM (Error Correction Model)
Jonsson and Palmqvist (2004)	Do higher wages Cause Inflation?	Two Sector Dynamic General Equilibrium (DGE) Model
Strauss and Wohar (2004)	The linkage between, prices wages and productivity: a panel study of manufacturing industries	Granger Causality; Panel Model;
Lemos (2004)	The Effect of Minimum Wage on Prices	Review of empirical research
Pu, Flaschel	A Causal Analysis of the	Granger causality

and Chihying (2006)	Wage-Price Spiral	VAR (Vector Autoregressive) Model
Goretti (2008)	Wage-Price setting in New EU Member States	ECM (Error Correction Model); and Panel Model;

The matters may become more puzzling if the series in question are co-integrated, which is the case when the levels of the series move together over the long-run, even though the individual series are best modeled in growth terms. In that case, the researcher must be careful to include the “error correction terms” in Granger-causality tests so as to allow the series to catch up with one another. The significance of the ECM terms in the Granger-causality tests simply reflects the fact that the series in question are driven to return to a long-run equilibrium relationship that it is non-causal. In addition to this, the researchers conclusions on the causal relationship often depend on the sample length, the number of explanatory variables used (including the number of lags of each variable) and in particular the measure of prices used,¹ (Hess and Schweitzer, 2000).

Importantly, Emery and Chang (1996) empirically highlight the fact that significance of Granger causal relation depends on the choice of price series, and it is relevant to any researcher to avoid data mining whilst designing models. Also, it is important to emphasize Palley (1999) argument that the relation also varies by business cycles, i.e. causality order between prices and wages may alter over time. A fundamental reason why there has been a lack of evidence in favor of hypothesis that wages cause prices may well be the fact that, as Lemos (2004) acknowledges, the international literature has mainly utilized the data from the US where price effects are small. The selection of different variables may also play a significant role on the strength of results as well. For example, money supply indicators are often found

¹ See Emery and Chang (1996).

to contain essential information for forecasting the future behavior of prices, and that needs to be considered as it may ultimately improve the robustness of model. Above all, when analyzing the causality relation between wages and prices, it is relevant to control for labor productivity, i.e. supply effects.

3. Methodology

Without a doubt the crux of the matter in empirical research is to design a model which truly represents a certain DGP or economic phenomena. The presence of a bilateral causal relationship between two or more variables not only complicates, but certainly it makes more complex and challenging the process of model building. Although OLS regressions may produce highly significant parameters, it is the regression diagnostics, in particular the presence of autocorrelation that raises serious doubts on the robustness of simple OLS models. Often, it is this limitation in remedying autocorrelation that necessitates the application of more sophisticated models that are able to analyze more thoroughly complex relationships, such as that between prices and wages. Certainly, the VECM models are frequently applied in examining models with more than one endogenous variable. As Isaac Asimov¹ has pointed out, “though science can cause problems, it is not by ignorance that we will solve them.” In this spirit, the aim of this paper is not to rely only on derivative output of other studies, or put differently to blindly accept one hypothesis and reject or ignore the other one, but to thoroughly analyze the price-wage relationship with different methods by using the same data, in order to check whether the causal relationship between prices and wages holds and how much robust it is in fact.

¹ Quoted in Dunleavy P. (2003), ‘Authoring a PhD’, Palgrave, 2003.

Theoretical Relationship Between Prices, Wages and Productivity

- This relation has been expressed in various functional forms, i.e. different causal ordering. *First*, the wage can be expressed as a function of price and productivity. *Second*, the price can be expressed as a function of wage and productivity. *Thirdly*, real wage (wages/prices) can be expressed as a function of productivity. The relations that are subject matter of this paper and which will be analyzed here are only the first two causal orderings. Besides, there are numerous studies that have explicitly studied price wage causal relationship, (see for example Moschos (1983); Emery and Chang (1996); Palley (1999); Hess and Schweitzer (2000); DeGrauwe (2003); Strauss and Wohar (2004)). Other variables may also be considered and included in the model. Nevertheless, increasing the number of variables and equations does not necessarily lead to a better model because by including greater number of variables it becomes more difficult to capture the dynamic and inter-temporal relations between relevant variables due to the loss of power. As a matter of fact, in some forecast comparisons univariate time series models were found to outperform large scale econometric models. Lütkepohl and Krätzig (2004) suggest that a possible reason for the failure of larger models is their insufficient representation of the dynamic interactions in a system of variables.

Applied econometric methods – in analyzing the causal relationship we will utilize two methods. *First*, we will use basic OLS regression model, with the purpose of examining the relationship. *Second*, we shall apply the VECM in order to derive statistically robust estimates. Prior to estimation of the latter models one should also examine the respective model selection criteria for determining the lag order and/or lagged differences as well as the rank of co-integration. Due to space limitations there will only be a brief presentation of respective steps.

4. Data

For empirical analysis we will employ quarterly data covering period 1996:Q1-2007:Q4. Unfortunately, due to the unexpected events of global recession and its consequences, the author has been forced to exclude the data for 2008-9, which in econometric terms represents a significant structural break. Thus inclusion of data for that period may significantly raise questions on the applicability of VECM. The following variables have been selected for empirical analysis: **Price (P)** variable is represented by the *Harmonized Index of Consumer Prices (HICP)*, Monthly data, 2005=100. The quarterly data were obtained by taking three month average of monthly data. Hereinafter, price variable will be denoted by **PEU27**; **Wage (W)** variable is represented by the *Labor Cost Index (LCI)* quarterly data, i.e. wages and salaries in industry and services (excluding public administration), nominal value, seasonally adjusted and adjusted data by working days, Index 2000=100. Hereinafter, wage variable will be denoted by **WEU27**; **Productivity (Q)** variable is represented by the quarterly index representing *person based labor productivity* for total economy at constant prices (fixed composition), seasonally adjusted, not working day adjusted, total, ECU/euro, index. Hereinafter, productivity variable will be denoted by **QEU27**. The source of data for all three variables is EUROSTAT (www.ec.europa.eu/eurostat). The list of all variables has been presented in Table C.1.

Additionally, in this section we have thoroughly analyzed the 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, (Figure C.1). Additionally the correlograms for the level series of all three variables appear to have a long memory and the decay rate appears slow with persistence up to the 12th lag. This tentatively suggests that both series

could be characterized by a stochastic trend where shocks persist. In an opposite manner, the correlograms for the differenced series tend to decay much more rapidly. This could be taken to suggest that shocks do not persist. As Table C.2 shows, the formal stationarity tests, the Augmented Dickey Fuller (ADF) and Phillips-Perron tests, in all cases the null hypothesis that the series in levels contain a unit root cannot be rejected by the data. In contrast, the null hypothesis that the differenced series contain a unit root is rejected in all cases for both series. This implies that all series require differencing just once to render them stationary. Therefore, all levels series contain a unit root and appear to be characterized by the presence of a stochastic trend, (see Table C.2).

5. Results

In the first sub-section we will examine the OLS results, whereas in the second sub-section we will analyze the VECM model. All the tests and results are presented in Appendix E.

5.1 OLS Estimates

The OLS regressions were subject to autocorrelation tests, on the basis of which it is evident that the inability of simple OLS models to remedy the problem of autocorrelation, in particular, necessitates the utilization of more sophisticated models, in order to produce statistically robust models as well as estimates. Certainly, this may well be a result that the lagged variables of respective series were not included in the model. Furthermore, the simple OLS regressions models are incapable of capturing the co-integration relationships that may exist between two or more variables. Nonetheless, OLS models are a good start for any empirical analysis, as it gives us the first insights when testing different relationships. In our initial OLS empirical analysis, we have also compared the models with intercept,

and without intercept. On the basis of the Ramsey's RESET test it appears that intercept is not present at all in the price-wage relationship, hence its exclusion would certainly produce a better model. The complete OLS results are presented in Table 5.1.

Table 5.1 OLS Regression results for EU-27 using level, log-level, first differences and first differences of the log-level

Variables	prices = F(wages, productivity) (a)			Variables	wages = F (prices, productivity) (b)		
	(2)	(3)	(4)		(6)	(7)	(8)
log	<i>lnw</i>	0.08	***0.72	log	<i>lnp</i>	0.08	***1.28
	<i>lnq</i>	***1.90	***0.25		<i>lnq</i>	***2.37	***0.24
	<i>const</i>	***-4.64	n/a		<i>const</i>	***6.62	n/a
	AC Test	***0.00	***0.00		AC Test	***0.00	***0.00
	Ramsey Test	***0.00			Ramsey Test	***0.00	
Δlog	Δ <i>lnw</i>	0.47	***0.72	Δlog	Δ <i>lnp</i>	0.04	***0.42
	Δ <i>lnq</i>	0.39	0.43		Δ <i>lnq</i>	0.02	***1.00
	<i>const</i>	0.00	n/a		<i>const</i>	***0.00	n/a
	AC test	0.48	0.50		AC test	**0.02	***0.00
	Ramsey Test	***0.00			Ramsey Test	***0.00	

Note 1: *** - significant at 1% level of significance; ** - significant at 5% level of significance; * - significant at 10% level of significance. The AC tests indicate the p-value of the Breusch-Godfrey LM test for autocorrelation with H_0 : no serial correlation and H_1 : H_0 is not true. The

OLS regression in columns (3) and (7) can be expressed as: $\Delta \ln P_t = \beta_0 + \beta_1 \Delta \ln W_t + \beta_2 \Delta \ln Q_t + \epsilon_t$; where β_0 is intercept, β_1 is the slope coefficient which measures the elasticity of prices on wages, and β_2 is slope coefficient which measures the elasticity of prices on productivity. In contrast, when intercept is excluded, columns (4) to (8) the OLS regression may be expressed as follows: $\Delta \ln P_t = \beta_1 \Delta \ln W_t + \beta_2 \Delta \ln Q_t$; where parameters β_1 and β_2 are interpreted in the same way as above. In the case of first differences only the letter Δ is added in front of variables, whereas the formulas are identical.

Note 2: Ramsey RESET Tests check whether the model without intercept better represents the DGP between prices and wages, compared to the model with intercept, (Maddala, 1999, Gujarati, 2002; Wooldridge 2003; etc).

Table 5.2 The pattern of causality in EU-27 based on OLS model

Country		Log-Levels	First differences
(1)	(2)	(3)	(4)
EU-27	Intercept	$P \rightarrow W$	$P \rightarrow W$
	no intercept	$P \leftrightarrow W$	$P \leftrightarrow W$

Note: \leftrightarrow indicates bilateral (feedback) causality; \leftarrow or \rightarrow indicates unilateral causality; - no causality. Sign * indicates that relationship is significant at 10 percent level

Finally, one may ask whether we can draw a firm conclusion from the causality tests that are presented in Table 5.1. Without a doubt, one has to concede that the presence of autocorrelation harms the reliability of the OLS estimates, if not destroys them. However, the purpose of the OLS analysis was to test the existence of the price-

wage relationship, as well as the uniqueness of causal orderings, and to get some useful insight, even if no conclusive evidence emerges from these analyses. Certainly, one has to concede that there is solid evidence in support of a strong causal relationship, and that the causal ordering in this relationship is not unique. Even so, let's leave to VECM analysis to deliver the final verdict on this issue.

5.2 VECM Estimates

On the basis of information criteria, the optimal number of lagged differences for endogenous variables is $(p - 1) = 4$. Whereas the Akaike Information Criterion (AIC) tends to overestimate the optimal lag order, the Hannan–Quinn information criterion (HQ) provides the most consistent estimates, thus it will be considered as the most reliable criterion. By analyzing the lag order for exogenous variables and statistical significance of coefficients, the optimal lag order for exogenous variable is $q = 3$. Notice that owing to four lagged differences and additional observation lost when the first differences of variables were taken, only the data from 1997:Q2–2007:Q4 are actually used as sample values, thus the actual sample size is $T = 43$. Notably, choosing the order too small can lead to size distortions for the tests. Conversely, selecting an order which is too large may imply the reduction in the power of tests. It is exactly this fact that makes so critical the issue of choice of the number of lagged differences, (Appendix E.1).

Rank of co-integration ($rk(\Pi)$) – the co-integration tests were performed between $LPEU27$ and $LWEU27$. The results of all tests are summarized in Table 5.3. On the basis of Johansen Trace Test one would proceed analysis with a model containing one co-integration relation, since in all cases the test statistic is significant at 1 percent level, hence, clearly indicating that there is sufficient evidence to reject the null hypothesis that $rk(\Pi) = 0$, in favor of alternative hypothesis that $rk(\Pi) = 1$. Similarly, the Saikkonen and Lütkepohl (1997) test

suggests that one clearly finds the rank of one being appropriate, as in all cases the test statistic is significant at least 5 percent level. Hence, there is sufficient evidence to proceed the analysis with one co-integration relation, i.e. use $r = 1$, in the VECM model.

Table 5.3 Specification of the co-integration rank by co-integration tests

Variables	Deterministic terms	Johansen Trace Test			Saikkonen and Lütkepohl		
		Lag order	LR-stat	p-value	Lag order	LR-stat	p-value
LPEU27 and LWEU27	Const	4	25.20	0.0082	4	21.50	0.0009
	Const and Trend	8	54.60	0.0000	8	17.13	0.0292
	Orthogonal trend	8	21.44	0.0048	8	11.44	0.0249

Estimation - 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. The estimated results are presented in Appendix E, with JMulTi software generating the output of all related loading matrix, co-integration matrix and short-run parameters. The standard t ratios and F tests retain their usual asymptotic properties if they are applied to short-run parameters in VECM. Hence, when appropriate, it is a good idea to impose restrictions on the VECM parameters. As a replacement for the statistical testing procedures, restrictions for individual parameters or groups of parameters in VECM may also be based on the model selection criteria. In the view of this, as proposed by Brüggeman and Lütkepohl (2001) and Lütkepohl and Krätzig

(2004) the Sequential Elimination of Regressors (SER) has been utilized in order to delete those regressors that lead to the largest reduction of the model selection criteria, (in this case HQ criterion), until no further reduction is possible, (Lütkepohl and Krätzig, 2004; Lütkepohl and Krätzig, 2005). All the coefficients with t ratios lower than two have been eliminated or restricted to zero.

Loading coefficients - even though they may be considered as arbitrary to some extent due to the fact that they are determined by normalization of co-integrating vectors, their t ratios may be interpreted in the usual way as being conditional on the estimated co-integration coefficients, (Lütkepohl and Krätzig, 2004; Lütkepohl and Krätzig, 2005). In this case the loading coefficient of the first equation has a t ratio of -8.216, which is significant at 1 percent level, whereas the loading coefficient for the second equation has a t ratio of 2.955 and is also significant at 1 percent level. Hence, based on the presented evidence, it can be firmly argued that co-integration relation resulting from normalization of co-integrating vector enters significantly in both equations.

Co-integration vectors – by selecting $LPEU27_t$ 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. This normalization is tricky if $LPEU27_t$ is not actually present in the co-integration relation here, and hence, it has a coefficient equal to zero. Nevertheless, taking into account the t test it looks that there is sufficient evidence to suggest that $LPEU27_t$ is strongly cointegrated with $LWEU27_t$. Consequently the model takes the form,

$$ec_t^{OLS} = LPEU27_t - 0.98LWEU27_t \quad (5.2.1)$$

(-521.50)

where the numbers in parenthesis represent t ratios. When (5.2.1) is arranged, the new expression takes the form,

$$LPEU27_t = 0.98 LWEU27_t + \varepsilon_t^{PEU} \quad (5.2.2)$$

(-521.50)

considering that the logs of variables have been used, the relation in (5.2.2) expresses the elasticity of prices on wages, hence the coefficient of 0.98 is the estimated price elasticity. If the log wages increases by 1%, it is expected that the log of prices would increase by 0.98 percent. In other words, a 1 percent increase in the log wages would induce a 0.98 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.

Short-run parameters - The estimators of parameters associated with lagged differences of variables may be interpreted in the usual way. All coefficients with values that are not different from zero have been eliminated. The t ratios are asymptotically normal under these assumptions. In contrast, this may not be true for parameters associated with deterministic terms, which t ratios are just given for completeness, (Lütkepohl and Krätzig, 2004).

Testing the model robustness - most of checks 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. Graphical tools may also shed light on potential defects of the model and, thus, provide a useful insight on the robustness of the model. The *VECM model statistic* indicates that one may not reject the null hypothesis that restricted model has a better representation of DGP, compared to unrestricted model. The F value is 0.95 which provides sufficient evidence that no information is lost when restrictions are imposed in some of the short run parameters. Likewise, autocorrelation, non-

normality tests as well as ARCH test indicate no problem with the model with diagnostic test statistics firmly not rejecting the robustness of VECM model. This impression is also supported by the visual inspection of graphical tools, such as plots of residuals, AC, PAC and cross correlations.

Table 5.4 VECM Diagnostic Tests

Type of Test	p-value	VECM
VECM Model statistic	0.95	√
LM Autocorrelation Test	0.29	√
Non-normality test		
Dornik and Hansen (1994)	0.31	√
Lütkepohl (1993)	0.27	√
ARCH-LM		
u_t	0.21	√
u_t	0.85	√
Plots of Residuals	n/a	√
ACF and PAC	n/a	√
Cross-correlations	n/a	√

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

Finally, based on the evidence, one can argue that $LPEU27_t$ and $LWEU27_t$ are strongly co-integrated, and furthermore the co-integration relation

enters significantly in both equations of the system. Put differently, there is sufficient evidence of bilateral causality between prices and wages. In addition to long-run relationship, one can also argue that short-run parameters also indicate a statistically significant bilateral causal relationship. More importantly, the robustness checks firmly indicate that VECM model is well designed and that it does not suffer from any econometric problem.

6. Conclusion

As we have seen there are two groups of economists that are split with regards to the direction of causality between prices and wages. *First*, those who argue that wages cause prices, and *second*, those economists who argue that prices cause wages. Agreeing with Lemos (2004) we can also suggest that the researcher's conclusions on the causal relationship may be contingent on a number of elements such as sample length, the number of explanatory variables used (including the number of lags of each variable), particular measure of prices used etc., or as Palley (1999) suggests, the causal relationship may also change with economic cycles. Despite most of the studies usually providing support in favor of one way causality, this study of the price-wage causal relationship in EU-27 provides statistically robust evidence and supports the case of bilateral or feedback causality between prices and wages.

The OLS regression results strongly support the case of bilateral causality, though these results are scientifically questionable due to the presence of high autocorrelation in the residuals of estimated OLS models. Nonetheless, the most significant findings emerging from OLS estimations are potentially strong causal relationship and non-presence of intercept in the relationship. The VECM model has been specified by taking into account various information criteria and co-integration tests, which were carefully performed and analyzed, though only the results of parsimonious model have been presented. Based on

the VECM coefficients one can firmly argue in favor of a strong bilateral causal relationship, both in long-run as well as in the short-run. Furthermore the robustness checks indicate no problems with the designed model, hence one may not reject the null hypothesis that model is correctly specified. Although, far from completely resolving the issue of causality, this article provides a modest analysis in the case of EU-27. Without a doubt, an analysis taking into account larger group of countries may be more productive in delivering a more accurate answer, hence future efforts in that direction would be very fruitful and would greatly facilitate in decomposing the complexity and dilemma of the price-wage causality puzzle.

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APPENDICES

Table C.1 Description of the price, wage and productivity variables for EU-27

Variable		Description of variables
Software	Statistical	
TREND	t	Trend variable
PEU27	P_t^{EU27}	Prices for EU-27
LPEU27	$\ln P_t^{EU27}$	Log of P for EU-27
1DPEU27	ΔP_t^{EU27}	First Difference of P for EU-27
1DLPEU27	$\Delta \ln P_t^{EU27} = \hat{P}_t^{EU27}$	First Difference of the log of P for EU-27
WEU27	W_t^{EU27}	Wages for EU-27
LWEU27	$\ln W_t^{EU27}$	Log of W for EU-27
1DWEU27	ΔW_t^{EU27}	First Difference of W for EU-27
1DLWEU27	$\Delta \ln W_t^{EU27} = \hat{W}_t^{EU27}$	First Difference of the log of W for EU-27
QEU27	Q_t^{EU27}	Productivity for EU-27
LQEU27	$\ln Q_t^{EU27}$	Log of Q for EU-27
1DQEU27	ΔQ_t^{EU27}	First Difference of Q for EU-27
1DLQEU27	$\Delta \ln Q_t^{EU27} = \hat{Q}_t^{EU27}$	First Difference of the log of Q for EU-27

Table C.2 Formal Unit Root Tests for individual series of price, wage and productivity variable

Test Procedure/Variables	<i>PEU27</i>	<i>LPEU27</i>	<i>DPEU27</i>	<i>DLPEU27</i>
ADF	-2.260	-2.718	-6.716	-5.621
Phillips-Perron	-2.725	-2.967	-6.728	-5.657

	<i>WEU27</i>	<i>LWEU27</i>	<i>DWEU27</i>	<i>DLWEU27</i>
ADF	-0.993	-0.896	-3.953	-4.869
Phillips-Perron	-1.568	-1.296	-4.154	-5.089

	<i>QEU27</i>	<i>LQEU27</i>	<i>DQEU27</i>	<i>DLQEU27</i>
ADF	-1.720	-1.571	-4.914	-4.482
Phillips-Perron	-2.019	-1.822	-4.891	-4.836

Note: Critical values are as follows: a) levels series, 0.05 = -3.512; b) differenced series, 0.05 = -2.941.

Figure C.1A Plots of price, wage and productivity variables: a) levels and b) first difference of levels.

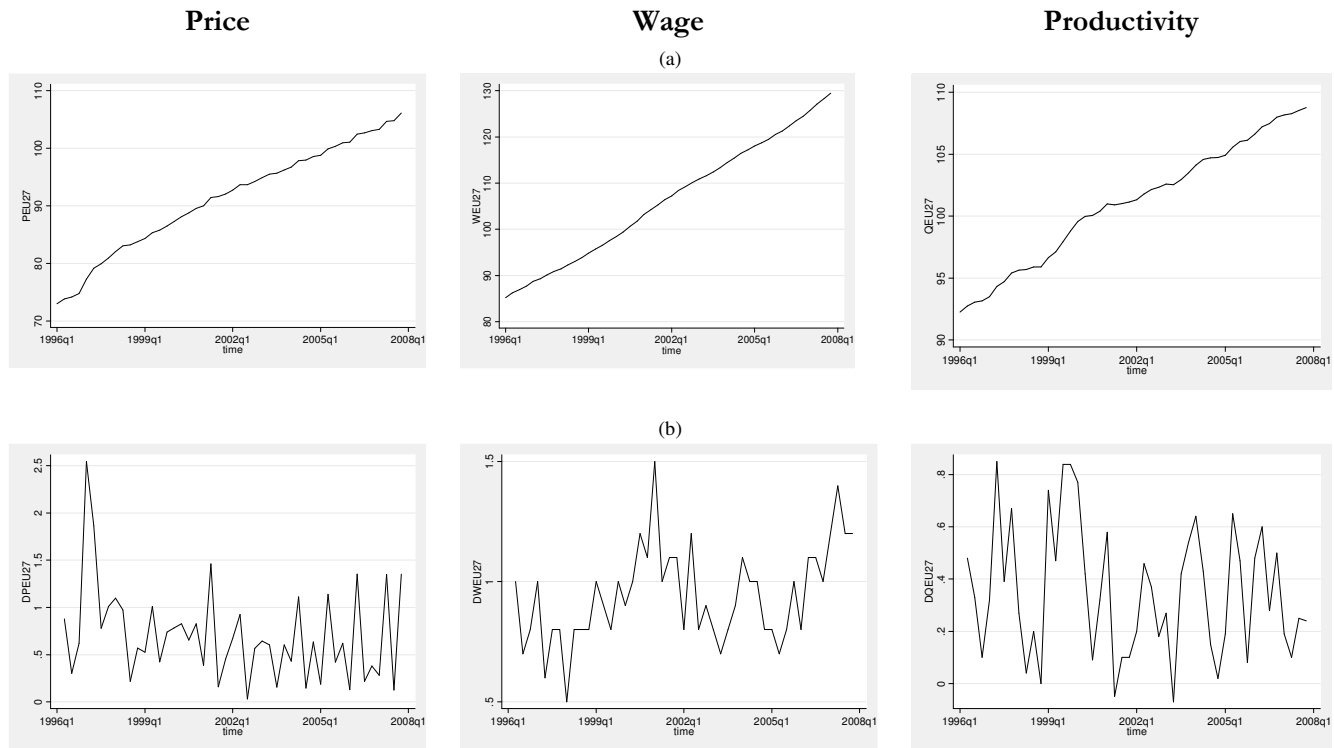


Figure C.1B Plots of price, wage and productivity variables: a) log-levels and b) first difference of log-level.

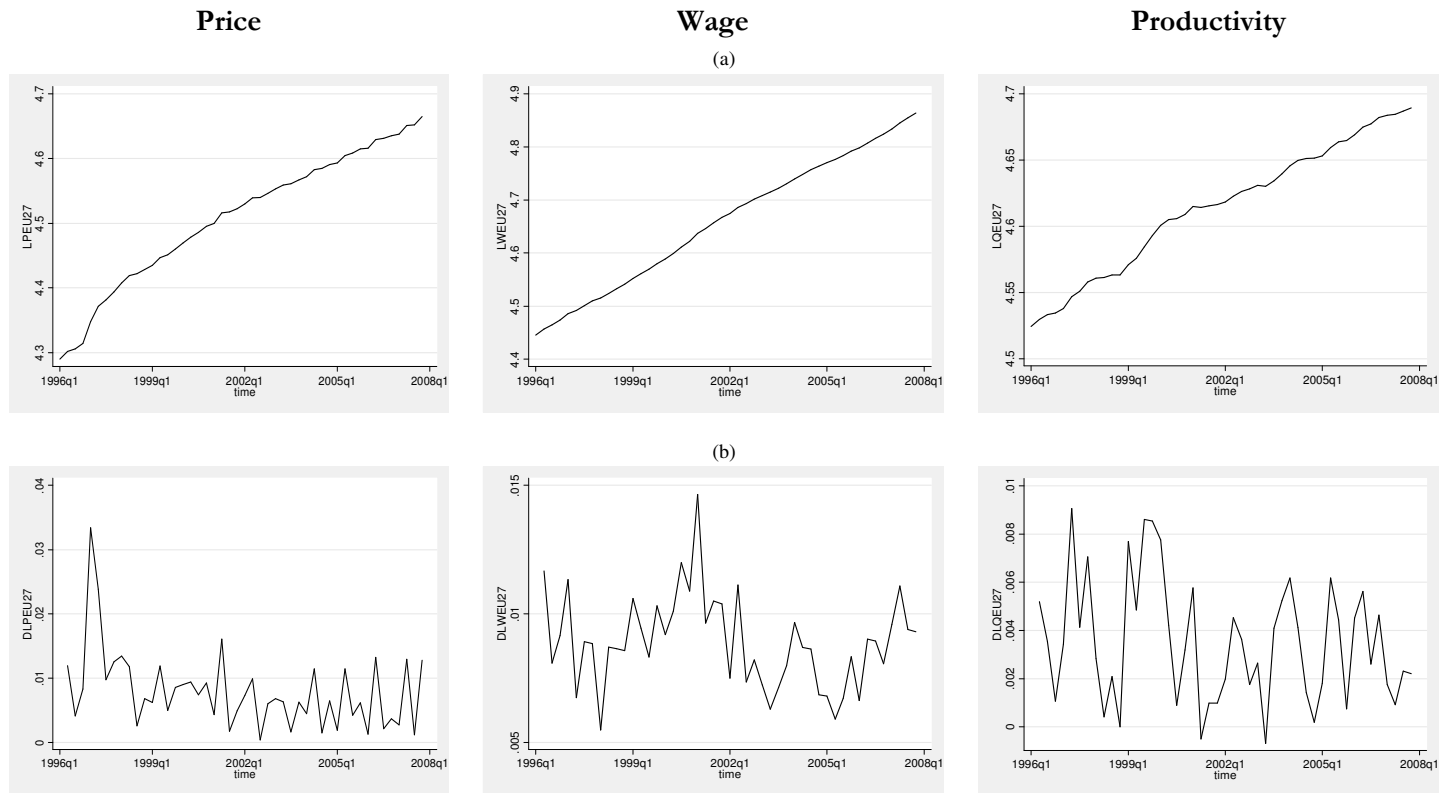


Table C.2 Formal Unit Root Tests for individual series of price, wage and productivity variable

Test Procedure/Variables	<i>PEU27</i>	<i>LPEU27</i>	<i>DPEU27</i>	<i>DLPEU27</i>
ADF	-2.260	-2.718	-6.716	-5.621
Phillips-Perron	-2.725	-2.967	-6.728	-5.657

Test Procedure/Variables	<i>WEU27</i>	<i>LWEU27</i>	<i>DWEU27</i>	<i>DLWEU27</i>
ADF	-0.993	-0.896	-3.953	-4.869
Phillips-Perron	-1.568	-1.296	-4.154	-5.089

Test Procedure/Variables	<i>QEU27</i>	<i>LQEU27</i>	<i>DQEU27</i>	<i>DLQEU27</i>
ADF	-1.720	-1.571	-4.914	-4.482
Phillips-Perron	-2.019	-1.822	-4.891	-4.836

Note: Critical values are as follows: a) levels series, 0.05 = -3.512; b) differenced series, 0.05 = -2.941.

Appendix E.1 Determination of the Number of Lagged Differences

*** Sat, 20 Jun 2009 02:21:31 ***

OPTIMAL ENDOGENOUS LAGS FROM INFORMATION CRITERIA

endogenous variables: **LPEU27 LWEU27**
 exogenous variables: **LQEU27**
 exogenous lags (fixed): **3**
 deterministic variables: **TREND**
 sample range: **[1998 Q2, 2007 Q4], T = 39**

optimal number of lags (searched up to 8 lags of 1. differences):
 Akaike Info Criterion: 7
 Final Prediction Error: 4
Hannan-Quinn Criterion: 4
 Schwarz Criterion: 0

Appendix E.2 Complete Results

*** Sat, 20 Jun 2009 02:24:36 ***

VEC REPRESENTATION

endogenous variables: **LPEU27 LWEU27**
 exogenous variables: **LQEU27**
 deterministic variables: **TREND**
 endogenous lags (diffs): **4**
 exogenous lags: **3**
 sample range: **[1997 Q2, 2007 Q4], T = 43**
 estimation procedure: **Two stage.**
1st=Johansen approach,
2nd=EGLS

Lagged endogenous term:		()	()
=====		{ }	{ }
==		[]	[]
	d(LPEU27)	d(LWEU27)	d(LWEU27)(t-2) --- 0.394
-----		()	(0.113)
d(LPEU27)(t-1)	-0.242	---	{ } {0.000}
	(0.074)	()	[] [3.488]
	{0.001}	{ }	d(LPEU27)(t-3) -0.198 ---
	[-3.263]	[]	(0.064)
d(LWEU27)(t-1)	0.664	0.283	{0.002} { }
	(0.198)	(0.117)	[-3.082]
	{0.001}	{0.016}	d(LWEU27)(t-3) --- 0.217
	[3.344]	[2.414]	() (0.115)
d(LPEU27)(t-2)	---	---	{ } {0.060}

```

| [ ] [1.879]
d(LPEU27)(t-4)| 0.344 ---
| (0.067) ( )
| {0.000} { }
| [5.162] [ ]
d(LWEU27)(t-4)| --- -0.432
| ( ) (0.118)
| { } {0.000}
| [ ] [-3.662]

```

Current and lagged exogenous term:

```

=====
=====

```

d(LPEU27) d(LWEU27)

```

-----
LQEU27(t) | 0.227 0.001
| (0.068) (0.000)
| {0.001} {0.000}
| [3.321] [3.618]

```

LQEU27(t-1) | --- ---

```

| ( ) ( )
| { } { }
| [ ] [ ]
LQEU27(t-2)| --- ---
| ( ) ( )
| { } { }
| [ ] [ ]
LQEU27(t-3)| -0.227 ---
| (0.069) ( )
| {0.001} { }
| [-3.306] [ ]

```

Deterministic term:

```

=====
=====
d(LPEU27) d(LWEU27)
-----

```

```

TREND(t) | -0.001 0.000
| (0.000) (0.000)
| {0.000} {0.013}
| [-7.796] [2.485]

```

Loading coefficients:

```

=====
d(LPEU27) d(LWEU27)
-----

```

```

ec1(t-1) | -0.413 0.068
| (0.050) (0.023)
| {0.000} {0.003}
| [-8.216] [2.955]

```

Estimated cointegration relation(s):

```

=====
=====

```

ec1(t-1)

```

-----
LPEU27(t-1) | 1.000
| (0.000)
| {0.000}
| [0.000]
LWEU27(t-1) | -0.981

```

<pre> (0.002) {0.000} [-521.500] ----- </pre>	<pre> Variable 2 ----- Lagged endogenous term: ===== == LPEU27 LWEU27 ----- LPEU27(t-1) 0.345 0.068 (0.000) (0.000) {0.000} {0.000} [0.000] [0.000] LWEU27(t-1) 1.069 1.216 (0.000) (0.000) {0.000} {0.000} [0.000] [0.000] LPEU27(t-2) 0.242 0.000 (0.000) (0.000) {0.000} {0.000} [0.000] [0.000] </pre>	<pre> LWEU27(t-2) -0.664 0.112 (0.000) (0.000) {0.000} {0.000} [0.000] [0.000] LPEU27(t-3) -0.198 0.000 (0.000) (0.000) {0.000} {0.000} [0.000] [0.000] LWEU27(t-3) 0.000 -0.178 (0.000) (0.000) {0.000} {0.000} [0.000] [0.000] LPEU27(t-4) 0.542 0.000 (0.000) (0.000) {0.000} {0.000} [0.000] [0.000] LWEU27(t-4) 0.000 -0.648 (0.000) (0.000) {0.000} {0.000} [0.000] [0.000] LPEU27(t-5) -0.344 0.000 </pre>
<p>VAR REPRESENTATION</p> <p>modulus of the eigenvalues of the reverse characteristic polynomial: $z = \begin{pmatrix} 0.9957 & 1.2116 & 1.2116 \\ 1.2386 & 1.2386 & 1.0000 & 1.2338 \\ 1.2338 & 1.4042 & 1.4042 & \end{pmatrix}$</p> <p>Legend: =====</p> <p style="text-align: center;">Equation 1 Equation 2 ...</p> <p>-----</p>		
<pre> Variable 1 Coefficient ... (Std. Dev.) {p - Value} [t - Value] </pre>		

	(0.000) (0.000)	LQEU27(t) 0.227 0.001	{0.001} { }
	{0.000} {0.000}	(0.068) (0.000)	[-3.306] []
	[0.000] [0.000]	{0.001} {0.000}	-----
LWEU27(t-5) 0.000 0.432	[0.000] [0.000]	[3.321] [3.618]	
	(0.000) (0.000)	LQEU27(t-1) --- ---	Deterministic term:
	{0.000} {0.000}	() ()	=====
	[0.000] [0.000]	{ } { }	LPEU27 LWEU27
-----		[] []	-----
		LQEU27(t-2) --- ---	TREND(t) -0.001 0.000
Current and lagged exogenous term:		() ()	(0.000) (0.000)
=====		{ } { }	{0.000} {0.000}
=====		[] []	[0.000] [0.000]
LPEU27 LWEU27		LQEU27(t-3) -0.227 ---	-----
-----		(0.069) ()	

Appendix E.3 Model Statistics

*** Sat, 20 Jun 2009 02:26:39 ***

VECM MODEL STATISTICS

sample range: [1997 Q2, 2007 Q4], T = 43

Log Likelihood: 4.210925e+02

Determinant (Cov): 6.707615e-12

Covariance: 5.086197e-06 4.260302e-07

4.260302e-07 1.354473e-06

Correlation: 1.000000e+00 1.623150e-01

1.623150e-01 1.000000e+00

LR-test (H1: unrestricted model): 5.8040

p-value(chi²): **0.9530**

degrees of freedom: 13.0000

Appendix E.4 Analysis of residual

*** Sat, 20 Jun 2009 02:52:21 ***

PORTMANTEAU TEST is not implemented if exogenous variables are in the model.

*** Sat, 20 Jun 2009 02:52:21 ***

LM-TYPE TEST FOR AUTOCORRELATION with 5 lags

LM statistic: 23.0128

p-value: **0.2882**

df: 20.0000

*** Sat, 20 Jun 2009 02:52:21 ***

TESTS FOR NONNORMALITY

Reference: Doornik & Hansen (1994)

joint test statistic: 4.7805

p-value: **0.3106**

degrees of freedom: 4.0000

skewness only: 3.1805

p-value: 0.2039

kurtosis only: 1.6000

p-value: 0.4493

Reference: Lütkepohl (1993), Introduction to Multiple Time Series Analysis, 2ed, p. 153

joint test statistic: 5.1748

p-value: **0.2698**

degrees of freedom: 4.0000
 skewness only: 3.3597
 p-value: 0.1864
 kurtosis only: 1.8150
 p-value: 0.4035

MULTIVARIATE ARCH-LM TEST with 5 lags

VARChLM test statistic: 40.5469
 p-value(chi²): **0.6609**
 degrees of freedom: 45.0000

*** Sat, 20 Jun 2009 02:52:21 ***

JARQUE-BERA TEST

variable	teststat	p-Value(Chi ²)	skewness	kurtosis
u1	0.0184	0.9909	-0.0249	2.9119
u2	3.7031	0.1570	0.6054	3.7751

*** Sat, 20 Jun 2009 02:52:21 ***

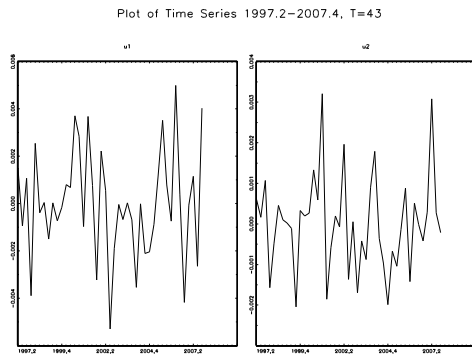
ARCH-LM TEST with 16 lags

variable	teststat	p-Value(Chi ²)	F stat	p-Value(F)
u1	20.3383	0.2054	5.1519	0.0061
u2	10.2912	0.8510	1.0394	0.4912

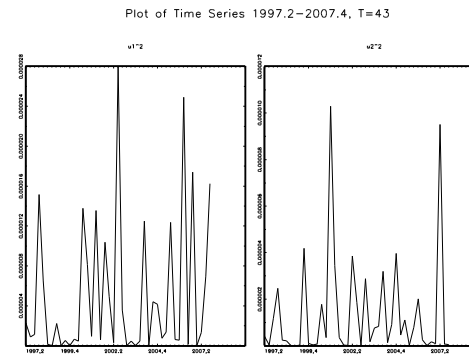
*** Sat, 20 Jun 2009 02:52:21 ***

Figure E.5 Diagnostic Checks

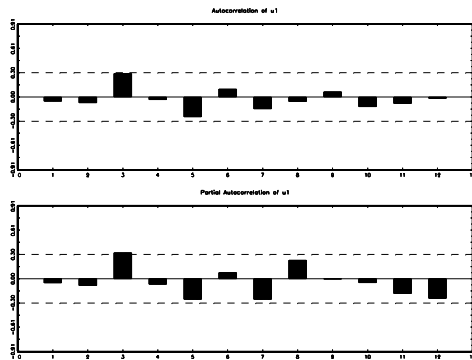
Plot of Residual u_t



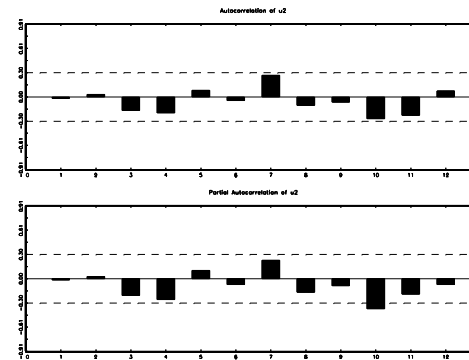
Plot of Squared Residual u_t^2



Plot of Autocorrelation (AC) of Residual



Plot of Partial Autocorrelation (PAC) of Residual



Cross-correlation between u_{1t} and u_{2t}

Crosscorrelations

