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Causal relationship between prices and wages: VECM analysis for Germany

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Abstract. 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, there is at least some consensus that researcher's conclusions may be contingent on the type of data employed, applied econometric model, or even that the relationship may vary through economic cycles. This paper empirically examines the price-wage causal relationship in Germany, by using OLS and VECM analysis, and it also provides robust evidence in support of a long-run unilateral causal relationship between prices and wages, running from wages to prices. In contrast, the evidence suggests that there is no statistically significant short-run relationship between prices and wages. 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 the 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 solid evidence for the case of Germany.

Keywords: Causality, Co-integration, Granger, Determinants of Inflation, VECM.

1 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. The first group argues that causality runs from wages to prices, whereas the second one argues 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 analyses have been continuously 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 econometric evidence in support of both hypotheses. The aim of this paper is to analyze and derive the pattern of causality for Germany. 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 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 this 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 subsequent 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.

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. 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 represent all the information available in the universe at time n. Suppose that at time n optimum forecasts are made of using all the information in and also using all of this information apart from the present values of of the series . If the first forecast, using all the information, is superior to the second, than the series has some special information about not available elsewhere, and is said to cause "

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 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 analysis. 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; implications on inference.
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 price-wage relationship, and most of them have employed US data. Table 2.2 presents a summary of relevant studies on this relationship.

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 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.

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 arguing that causation runs from wages to prices, while the second one studies arguing 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 econometrical 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 relationship economists very often use the "Granger-causality" by examining whether lagged values of one series (say wages) have significant in-sample explanatory power for another variable (say prices). Additionally, both variables may Granger-cause one another, in which case one can only conclude 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.

The matters may become more perplex 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, (Hess and Schweitzer, 2000).

Importantly, Emery and Chang (1996) empirically highlight the fact that the significance of Granger causal relation depends on the choice of price series, and it is relevant to any researcher to avoid data mining in designing models. It is appropriate to remind on 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 to contain essential information for forecasting future behavior of prices, and that needs to be considered as it may ultimately improve the robustness of the model. Above all, when analyzing the causality relation between wages and prices, it is also 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 Asimov 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 to analyze the price-wage relationship with different methods using the same data, in order to check on whether the causal relationship between prices and wages holds robustly.

Theoretical Relationship Between Prices, Wages and Productivity - This relation has been expressed in various 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 in this paper 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 with inclusion of greater number of variables it becomes more difficult to capture the dynamic and inter-temporal relations between relevant variables due to loss of power. As a matter of fact, in some forecast comparisons univariate time series models were found to outperform large scale econometric models. Lütkhepohl 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/lagged differences as well as the rank of co-integration. Due to space limitations there will only be a concise presentation of respective steps.

4 Data

For empirical analysis of the price-wage causal relationship in Germany 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 appropriateness of 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 for Germany will be denoted by 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 for Germany will be denoted by ; Productivity (Q) variable is represented by the quarterly index representing person based labor productivity, seasonally adjusted, Index 2000=100. Hereinafter, productivity variable for Germany will be denoted by . The source of data for the first two variables is EUROSTAT (www.ec.europa.eu/eurostat), whereas the source of data for productivity variable is Bundesbank (www.bundesbank.de).

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, (correlograms are not presented due to space limit). 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 when the level series of variables are utilized one may not reject the null hypothesis that autocorrelation is present in the residual. In contrast, when one uses the first differences of the levels, then the null hypothesis may be rejected according to the Breusch-Godfrey LM test. Now, one may raise the question on whether we can consider these OLS results as statistically robust. Certainly we cannot do that, due to the fact that simple OLS regression models are incapable of capturing the co-integration relationships that may exists between two or more variables. For this reason we need to utilize more sophisticated models that have better properties, such as VECM, in order to produce statistically, as well as theoretically robust models and estimates. Another problem is non-inclusion in the model of the lagged variables of respective series, which may potentially hide relevant information. Nonetheless, one has to agree that OLS models are a good start for any empirical analysis, as they provide 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 produce a better model. Complete OLS regression results are presented in Table 5.1.

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

Variables	**Prices = F (Wages, Productivity) (a)**				**Wages = F (Prices, Productivity) (b)**		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
log	*ln w*	0.07	***-0.77	***log***	*ln p*	0.04	***-0.30
	ln q	***0.69	***1.75		*ln q*	***1.08	***1.30
	const	***1.02	n/a		*const*	***-0.55	n/a
	AC Test	***0.00	***0.00		AC Test	***0.00	***0.00
	Ramsey Test	***0.00			Ramsey Test	***0.00	
Δ*log*	*Δln w*	-0.15	*0.27	**Δ*log***	*Δln p*	-0.12	*0.26
	Δln q	-0.15	**0.33		*Δln q*	-0.09	***0.58
	const	***0.00	n/a		*const*	***0.00	n/a
	AC test	0.19	0.70		AC test	0.40	0.99
	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 $H_a: H_0$ is not true. The OLS regression in columns (3) and (7) can be expressed as: $\widehat{LP}_t = \beta_1 LW_t + \beta_2 LQ_t + \beta_0$; 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: $\widehat{LP}_t = \beta_1 LW_t + \beta_2 LQ_t$; where parameters β_1 and β_2 are interpreted in the same way as above. In the case of first differences only the letter D 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).

For example the results are interpreted as follows: the coefficient of wages for the levels in column (4) is statistically significant at 1 percent level and it indicates a negative impact of wages on prices measuring -0.77 percent (which is theoretically incorrect), i.e. if wages increase by one percent, on average and ceteris paribus, the prices will decrease by 0.77 percent. Otherwise, this coefficient measures the elasticity of prices on wages. Likewise, all other regression coefficients may be interpreted. Unfortunately, according to the Breusch-Godfrey test, it appears that one may firmly reject the null hypothesis of no serial correlation with test statistic being high and value zero. On the basis of Ramsey's RESET test one may exclude the intercept from model, as it results in a better representation of DGP, in both cases when log-levels and first differences of the respective series are utilized. Finally, the estimated coefficients suggest that there is a negative bilateral causal relationship running from wages to prices and vice-versa, which certainly contradicts a priori theoretical assumptions. This fact raises serious doubts on the appropriateness of OLS models. Additionally, the Table 5.2 presents the pattern of causality for Germany.

Again, the evidence suggests that potentially there is a bilateral causal relationship between prices and wages for both log-level and differenced series, significant at least at 10 percent level, though only when intercept is excluded.

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 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 potentially there is evidence in support of 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.

Table 5.2 The pattern of causality in Germany based on OLS model

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

Note: ↔ indicates bilateral (feedback) causality; ← or → indicates unilateral causality; — no causality.
* indicates that relationship is significant at 10 percent level

5.2 VECM Estimates

Based on the relevant information criteria, the optimal number of lagged differences for endogenous variables is . 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 . Notice that owing to one observation lost when the first differences of the variables were taken, only the data from 1996:Q2–2007:Q4 are actually used as sample values, thus the actual sample size is T= 47. 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.2).

Rank of co-integration) – the co-integration were performed between and . The results of all the tests are summarized in Table 5.3. On the basis of Johansen Trace Test one would continue analysis with a model containing one co-integration relation, though only when constant is included in the co-integration test, whilst the test statistic in this case is significant at 1 percent level. In contrast when trend or orthogonal trend are included the test statistics suggest that there is insufficient evidence to reject the null hypothesis that , in favor of alternative hypothesis that . Similarly, the Saikkonen and Lütkhepohl (1997) test suggests the same results as the Johansen Trace Test. Although the presented evidence is not very convincing in favor of alternative hypothesis that , one can still engage in analyzing the relationship with one co-integration relation, i.e. use , in the VECM model. Possibly, this may well be a result of the fact that co-integration relationship is present only in one of the equations of the VECM system, or it is not present at all.

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

Variables	Deterministic terms	Johansen Trace Test			Saikkonen and Lütkhepohl		
		Lag order	LR-stat	p-value	Lag order	LR-stat	p-value
$LPDE$ and $LWDE$	Const	1	86.71	0.0000	1	56.84	0.0000
	Const and Trend	1	14.33	0.6353	1	4.14	0.9324
	Orthogonal trend	1	7.16	0.5658	1	2.24	0.7601

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 the JMulTi software generating 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 Brügeman and Lütkhepohl (2001) and Lütkhepohl and Krätzig (2004) the Sequential Elimination of Regressors (SER) has been utilized 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, (Lütkhepohl and Krätzig, 2004; Lütkhepohl 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, (Lütkhepohl and Krätzig, 2004; Lütkhepohl and Krätzig, 2005,). In this case the loading coefficient of the first equation has a t ratio of -2.125, which is significant at 5 percent level, whereas the loading coefficient for the second equation has statistically insignificant t ratio and its coefficient has been restricted to zero. Thus, based on the presented evidence, it can be argued that co-integration relation resulting from normalization of co-integrating vector enters significantly only in the first equation, whereas it is insignificant in the second equation.

***Co-integration vectors* –** by selecting $LPDE_t$ 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 $LPDE_t$ 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 $LPDE_t$ is co-integrated with $LWDE_t$. Consequently the model takes the form,

$$ec_t^{EGLS} = LPDE_t - 1.50\, LWDE_t \quad (5.2.1)$$
$$(-18.07)$$

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

$$LPDE_t = 1.50\, LWDE_t + ec_t^{EGLS} \quad (5.2.2)$$
$$(-18.07)$$

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 1.5 is the estimated price elasticity. If the log wages increases by 1%, it is expected that the log of prices would increase by 1.5 percent. In other words, a 1 percent increase in the log wages would induce a 1.5 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, (Lütkhepohl and Krätzig, 2004). The coefficient of productivity has a statistically significant impact on wages, whereas the true impact is very small in terms of magnitude.

Deterministic Terms – seasonal dummies and trend term have statistically significant though very small impact only in the first equation, whereas in the second equation all deterministic terms have statistically insignificant impact, thus have been restricted to zero.

Table 5.4 VECM Diagnostic Tests

Type of Test	p-value	VECM
VECM Model statistic	0.97	√
LM Autocorrelation Test	0.68	√
Non-normality test		
Dornik and Hansen (1994)	0.93	√
Lütkepohl (1993)	0.95	√
ARCH-LM		
u_1	0.83	√
u_1	0.81	√
Plots of Residuals	n/a	√
ACF and PAC	n/a	√
Cross-correlations	n/a	√

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

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, (see table 5.4). Graphical tools may also enlighten 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 value is 0.97 which provides sufficient evidence that no information is lost if restrictions are in some of the short run parameters. It is worth mentioning that the loading coefficient for the wages equation has also been restricted to zero. 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.

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. In addition to the long-run relationship, one can also argue that short-run parameters also indicate no statistically significant causal relationship. This means that in the long-run wages affect prices only. Furthermore, the robustness checks firmly indicate that VECM model is well designed and does not suffer from any econometric problem.

6 Conclusion

As we have seen there are two groups of economists that are divided 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 researcher's conclusions on the causal relationship may be contingent on a number of elements such as sample length, 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. The statistically robust evidence emerging from this study clearly supports the view that causality runs from wages to prices.

The OLS regression results strongly support the case of bilateral causality, though these results are scientifically questionable due to the fact that OLS regression coefficients have theoretically incorrect sign, which raises serious doubts on the scientific validity of such results. Nonetheless, the most significant findings emerging from OLS estimations are potential presence of causal relationship and non-presence of intercept in that relationship. On the other hand, VECM model has been specified by taking into account various information criteria as well as respective co-integration tests, which were carefully performed and analyzed. However, only the parsimonious model has been presented. Based on the VECM coefficients one can firmly argue in favor of a long-run unilateral causal relationship, running from wages to prices. In contrast, the evidence suggests that there is no statistically significant short-run causal relationship between prices and wages. 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 Germany. Certainly, an analysis taking into account larger group of countries may be more fruitful in delivering a clearer answer hence, efforts in that direction would be very productive in answering or decomposing some open issues related to causality between prices and wages.

7 References

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APPENDICES

Table C.1 Description of the price, wage and productivity variables for EU-12

Variable	Description of variables

Software	Statistical	
TREND	t	Trend variable
PDE	P_t^{DE}	Prices for Germany
LPDE	lnP_t^{DE}	Log of P for Germany
1DPDE	ΔP_t^{DE}	First Difference of P for Germany
1DLPDE	$\Delta lnP_t^{DE} = \dot{P}_t^{DE}$	First Difference of the log of P for Germany
WDE	W_t^{DE}	Wages for Germany
LWDE	lnW_t^{DE}	Log of W for Germany
1DWDE	ΔW_t^{DE}	First Difference of W for Germany
1DLWDE	$\Delta lnW_t^{DE} = \dot{W}_t^{DE}$	First Difference of the log of W for Germany
QDE	Q_t^{DE}	Productivity for Germany
LQDE	lnQ_t^{DE}	Log of Q for Germany
1DQDE	ΔQ_t^{DE}	First Difference of Q for Germany
1DLQDE	$\Delta lnQ_t^{DE} = \dot{Q}_t^{DE}$	First Difference of the log of Q for Germany

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

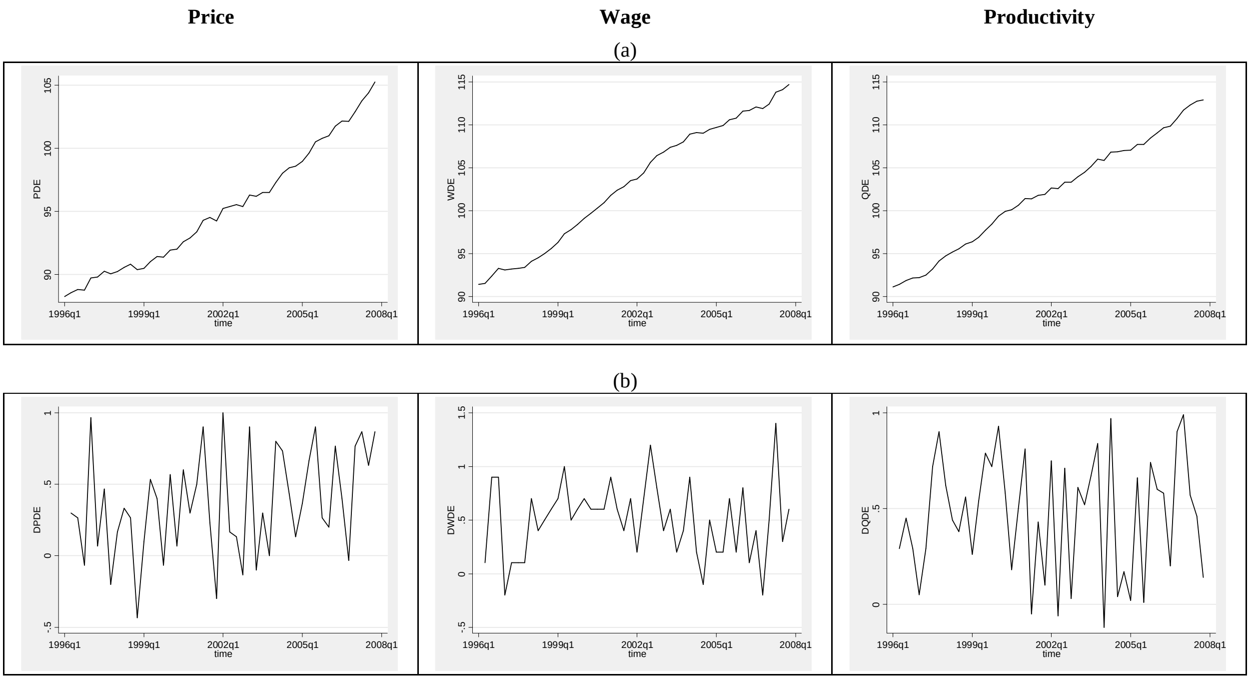


Figure C.1 Plots of price, wage and productivity variables: c) log-levels and d) first difference of log-level.

Price **Wage** **Productivity**

(c)

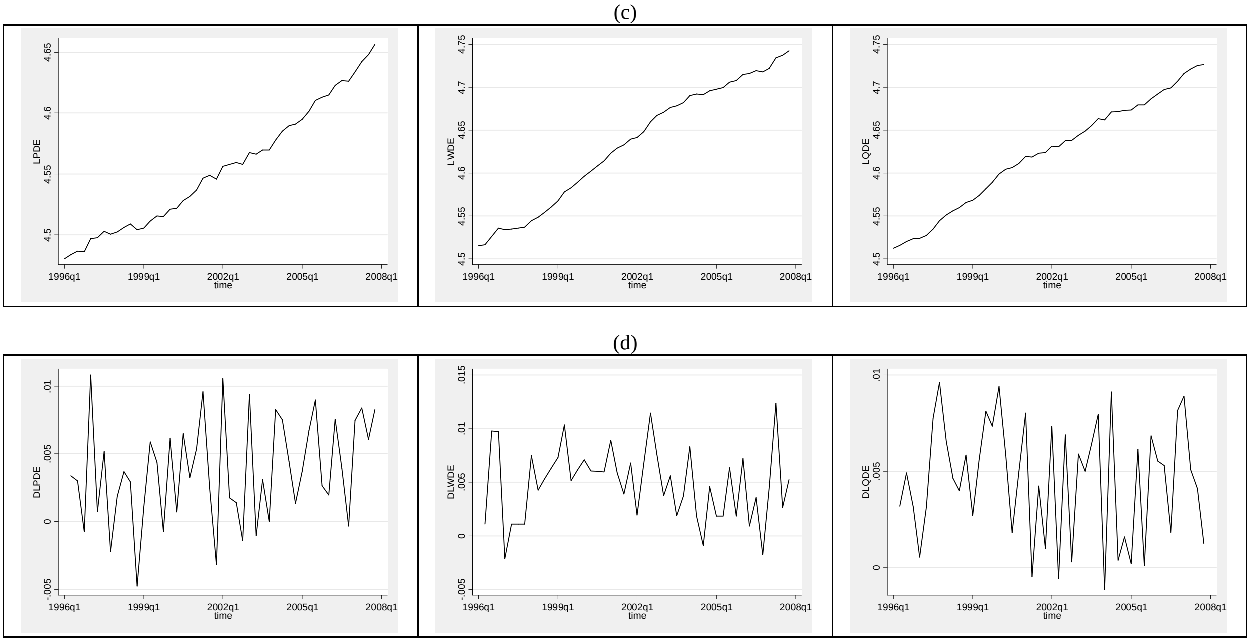


Table C.2 Formal Unit Root Tests for individual series of price, wage and productivity variable

Test Procedure/Variables	*PDE*	*LPDE*	*DPDE*	*DLPDE*
ADF	-0.652	-1.070	-7.367	-7.785
Phillips-Perron	-0.077	-0.453	-7.383	-7.861

Test Procedure/Variables	*WDE*	*LWDE*	*DWDE*	*DLWDE*
ADF	-1.429	-0.988	-6.329	-6.114
Phillips-Perron	-1.584	-1.149	-6.338	-6.137

Test Procedure/Variables	*QDE*	*LQDE*	*DQDE*	*DLQDE*
ADF	-2.210	-1.790	-7.719	-7.494
Phillips-Perron	-2.319	-1.829	-7.682	-7.468

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 03:31:39 ***
OPTIMAL ENDOGENOUS LAGS FROM INFORMATION CRITERIA

endogenous variables:     LPDE LWDE
exogenous variables:      LQDE
exogenous lags (fixed):   0
deterministic variables:  S1 S2 S3 TREND
sample range:             [1998 Q2, 2007 Q4], T = 39

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

Appendix E.2 Complete Results

```
*** Sat, 20 Jun 2009 03:41:18 ***
VEC REPRESENTATION
endogenous variables:     LPDE LWDE
exogenous variables:      LQDE
deterministic variables:  S1 S2 S3
TREND
endogenous lags (diffs):  0
exogenous lags:           0
sample range:             [1996 Q2,
2007 Q4], T = 47
estimation procedure:     Two stage.
1st=Johansen approach, 2nd=EGLS

Current and lagged exogenous term:
==================================
           d(LPDE)   d(LWDE)
-----------------------------
 LQDE(t)|      ---     0.001
        |     (   )   (0.000)
        |     {   }   {0.000}
        |     [   ]   [9.940]
-----------------------------

Deterministic term:
===================
           d(LPDE)   d(LWDE)
-----------------------------
S1   (t)|   0.006       ---
        |  (0.001)     (   )
        |  {0.000}     {   }
        |  [5.129]     [   ]
S2   (t)|   0.005       ---
        |  (0.001)     (   )
        |  {0.000}     {   }
        |  [3.981]     [   ]
S3   (t)|   0.004       ---
        |  (0.001)     (   )
        |  {0.000}     {   }
        |  [3.719]     [   ]
TREND(t)|   0.000       ---
        |  (0.000)     (   )
        |  {0.017}     {   }
        |  [2.390]     [   ]
-----------------------------


Loading coefficients:
=====================
           d(LPDE)   d(LWDE)
-----------------------------
ec1(t-1)|  -0.001       ---
        |  (0.000)     (   )
        |  {0.034}     {   }
        | [-2.125]     [   ]
-----------------------------


Estimated cointegration relation(s):
====================================
          ec1(t-1)
------------------
LPDE(t-1)|    1.000
         |   (0.000)
         |   {0.000}
         |   [0.000]
LWDE(t-1)|   -1.500
         |   (0.083)
         |   {0.000}
         | [-18.066]
------------------

VAR REPRESENTATION
```

```
modulus of the eigenvalues of the
reverse characteristic polynomial:
|z| = ( 1.0008     1.0000     )

Legend:
=======
              Equation 1   Equation 2

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



Lagged endogenous term:
=======================
              LPDE      LWDE
-----------------------------
LPDE(t-1)|   0.999     0.000
         |  (0.000)   (0.000)
         |  {0.000}   {0.000}
         |  [0.000]   [0.000]
LWDE(t-1)|   0.001     1.000
         |  (0.000)   (0.000)
         |  {0.000}   {0.000}
         |  [0.000]   [0.000]
-----------------------------

Current and lagged exogenous term:
==================================
              LPDE      LWDE
-----------------------------
 LQDE(t)|      ---     0.001
        |     (   )   (0.000)
        |     {   }   {0.000}
        |     [   ]   [9.940]
-----------------------------

Deterministic term:
===================
              LPDE      LWDE
-----------------------------
S1   (t)|    0.006     0.000
        |   (0.000)   (0.000)
        |   {0.000}   {0.000}
        |   [0.000]   [0.000]
S2   (t)|    0.005     0.000
        |   (0.000)   (0.000)
        |   {0.000}   {0.000}
        |   [0.000]   [0.000]
S3   (t)|    0.004     0.000
        |   (0.000)   (0.000)
        |   {0.000}   {0.000}
        |   [0.000]   [0.000]
TREND(t)|    0.000     0.000
        |   (0.000)   (0.000)
        |   {0.000}   {0.000}
        |   [0.000]   [0.000]
---------------------------
```

Appendix E.3 Model Statistics

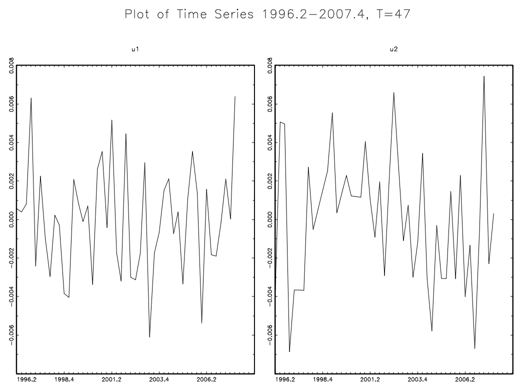
```
*** Sat, 20 Jun 2009 03:41:18 ***
VECM MODEL STATISTICS
sample range:   [1996 Q2, 2007 Q4], T = 47

Log Likelihood:       4.022139e+02
Determinant (Cov):    8.715645e-11

Covariance:   8.033218e-06 -1.379535e-06
             -1.379535e-06  1.108641e-05

Correlation:  1.000000e+00 -1.461815e-01
             -1.461815e-01  1.000000e+00

LR-test (H1: unrestricted model):   1.3327
 p-value(chi^2):                    0.9698
 degrees of freedom:                6.0000
```

Appendix E.4 Analysis of residual

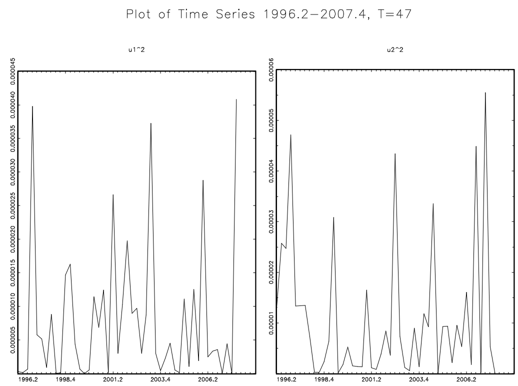
```
*** Sat, 20 Jun 2009 03:44:28 ***
PORTMANTEAU TEST is not implemented if exogenous variables are in the model.

*** Sat, 20 Jun 2009 03:44:28 ***
LM-TYPE TEST FOR AUTOCORRELATION with 5 lags

LM statistic:            16.5128
 p-value:                0.6843
 df:                     20.0000

*** Sat, 20 Jun 2009 03:44:28 ***
TESTS FOR NONNORMALITY

Reference: Doornik & Hansen (1994)
joint test statistic:     0.8829
 p-value:                 0.9270
degrees of freedom:       4.0000
skewness only:            0.2707
 p-value:                 0.8734
kurtosis only:            0.6123
 p-value:                 0.7363

Reference: Lütkepohl (1993), Introduction to Multiple Time Series Analysis, 2ed, p. 153
joint test statistic:     0.7319
 p-value:                 0.9473
degrees of freedom:       4.0000
skewness only:            0.3233
 p-value:                 0.8508
kurtosis only:            0.4086
 p-value:                 0.8152

*** Sat, 20 Jun 2009 03:44:28 ***
JARQUE-BERA TEST

variable        teststat   p-Value(Chi^2)  skewness   kurtosis
u1              0.3693     0.8314          0.1707     2.7316
u2              0.4125     0.8136          0.0422     2.5489

*** Sat, 20 Jun 2009 03:44:28 ***
ARCH-LM TEST with 16 lags

variable        teststat   p-Value(Chi^2)  F stat     p-Value(F)
u1              17.9642    0.3260          2.6700     0.0358
u2              14.3498    0.5727          1.6698     0.1705

*** Sat, 20 Jun 2009 03:44:28 ***
MULTIVARIATE ARCH-LM TEST with 5 lags

VARCHLM test statistic:   54.3367
 p-value(chi^2):          0.1605
 degrees of freedom:      45.0000
```

Figure E.5 Diagnostic Checks

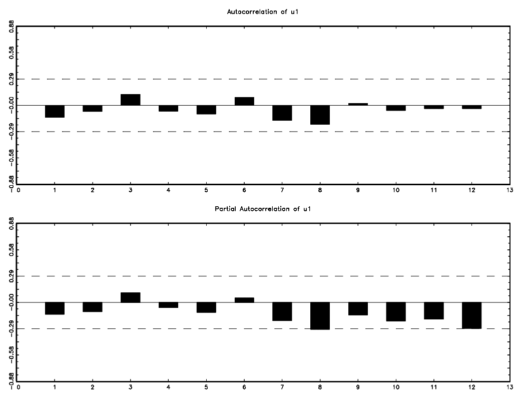
Plot of Residual u_t



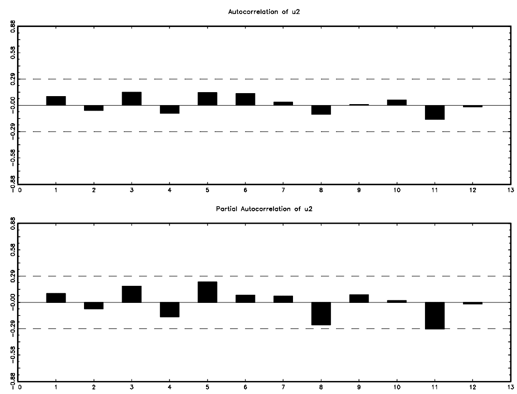
Plot of Squared Residual u_t^2



Plot of Autocorrelation (AC) of Residual



Plot of Partial Autocorrelation (PAC) of Residual



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