Causal relationship between wages and prices in UK: VECM analysis and Granger causality testing

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Abstract

In this paper the issue of causality between wages and prices in UK has been tested. OLS relationship between prices and wages is positive; productivity is not significant in determination of prices or wages too. These variables from these statistics we can see that are stationary at 1 lag, i.e. they are I(1) variables, except for CPI variables which is I(2) variable. From the VECM model, If the log wages increases by 1%, it is expected that the log of prices would increase by 5.24 percent. In other words, a 1 percent increase in the wages would induce a 5.24 percent increase in the prices.About the short run parameters, the estimators of parameters associated with lagged differences of variables may be interpreted in the usual way.Productivity was exogenous repressor and it is deleted since it has coefficient no different than zero. The relation (causation) between these two variables is from CPI_log→ real_wage_log .Granger causality test showed that only real wages influence CPI or consumer price index that proxies prices, this is one way relationship, price do not influence wages in our model.

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

Introduction

In the literature from this area there two sides of economist one that thinks that causality runs from wages to prices and the second that thinks that causality runs from wages to prizes. The evidence in the literature has evidence in support to both hypotheses. Granger causality test is easy to be applied in economics.OLS techniques have been applied to data, and to estimate the long run relationship we apply VECM analysis.

Theoretical overview

In this theoretical review some basic concepts in the theory of wages and prices are outlined, to explain in some extent: what are determinants of wages and prices from neo-classical and neo-keynesian perspective.

The Issue of Time Consistency

New Classical Analysis makes a distinction between anticipated and unanticipated changes in money supply.There exists superiority of fixed policy rules, low inflation requires monetary authorities to commit themselves to low-inflation policy. Government cannot credibly commit to low inflation policy if retain the right to conduct discretionary policy (Kydland,Prescott,1977). The model of optimal policy is as follows:

Let $\pi = (\pi_1, \pi_2, \ldots \pi_T)$ be a sequence of policies for periods 1 to T and

$x = (x_1, x_2 \ldots x_T)$ be the corresponding sequence of economic agents' decisions.

Assume an agreed social welfare function:

$$S\,(x_1, x_2 \ldots x_T, \pi_1, \pi_2, \ldots \pi_T) \qquad (1)$$

And that agents' decisions in period t depend on all policy decisions and their own past decisions:

$$x_t = X_t\,(x_1, x_2 \ldots x_{t-1}, \pi_1, \pi_2, \ldots \pi_T) \qquad (2)$$

An optimal policy is one which maximises (1) subject to (2).The issue of time consistency is: A policy π is time consistent if for each t, π_t maximises (1) taking as given previous economic agents' decisions and that future policy decisions are taken similarly.Optimal policies are time inconsistent

- therefore lack credibility
- discretionary policies lead to inferior outcomes

– need credible pre-commitment

Consider a two period model in which π_2 is selected to maximise:

$S(x_1, x_2, \pi_1, \pi_2)$ (3)

subject to:

- $x_1 = X_1(\pi_1, \pi_2)$ and
- $x_2 = X_2(x_1, \pi_1, \pi_2)$ (4)

For the policy to be time consistent π_2 must maximise (3), given x_1 and π_1 and given constraint (4). Now we are going to eliminate inflatory bias:Low inflation rule not credible if government retains discretionary powers

- need to gain a reputation for maintaining a low inflation policy mix
  - benefits from cheating < punishment costs
- or need to pre-commit to a low inflation policy goal
  - central bank independence, 'golden rule' for fiscal policy
  - but danger of democratic deficit?

Sources of price rigidity

New Keynesians suggest that small nominal price rigidities may have large macro effects

– incomplete indexing of prices in imperfectly competitive goods, labour and financial markets may be costly in terms of output instability

In goods market small 'menu costs' + unsynchronised price adjustments lead to staggered price adjustments

– fear that rapid price adjustments costly in decision-making time and cause excessive loss of existing customers

Sources of wage rigidity

Efficiency wages

Economy of high wages – productivity and non-wage labour costs may be endogenous in the wage-fixing process, even given excess supply of labour firms may not lower wages because their unit labour costs may rise → persistent unemployment.This repeals law of supply and demand, if the relationship between wages and productivity/non-wage costs varies across industry repeals law of one price. Version of efficiency wage model is:

A representative firm seeks to maximise its profits:

$\pi = Y - wL$ (1)

where Y firm's output and wL its wage costs and:

$Y = F(eL) \quad F'>0\ , F''<0 \qquad (2)$

where e is workers' effort and:

$e = e(w) \qquad e'>0 \qquad (3)$

there are L^o identical workers who each supply 1 unit of labour inelastically

The problem of the firm is to:

$\max_{Lw} F(e(w)L - wL \qquad (4)$

when there is unemployment the first order conditions for L and *w* are:

$F'(e(w)L)e(w) - w = 0 \qquad (5)$

$F'(e(w)L)Le'(w) - L = 0 \qquad (6)$

rewriting (5) gives:

$F'(e(w)L) = w / e(w) \qquad (7)$

substituting (7) into (5) gives:

$we'(w) / e(w) = 1 \qquad (8)$

From (8) at the optimum, the elasticity of effort with respect to wage is 1, i.e. the efficiency wage (w^*) is that which satisfies (8) and minimises the cost of effective labour

With N firms each hiring L* (the solution to (7), then total employment is NL* and as long as $NL^* < L^+$ we observe an efficiency wage (w^*) and unemployment

Literature overview

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.We selected ten studies as to see what method they use in explanation of this relationship, most of the studies use panel methods but some use VECM model just like ours too.

A summary of some studies on the price, wage and productivity relationship

Studies	Title	Method
Strauss, Wohar (2004)	**The Linkage Between Prices, Wages, and Labor Productivity: A Panel Study of Manufacturing Industries**	panel unit root and panel cointegration procedures
Saten Kumar, Don J. Webber and Geoff Perry (2008)	**Real wages, inflation and labour productivity in Australia**	Cointegration; Granger causality
Dubravko Mihaljek and Sweta Saxena	**Wages, productivity and "structural" inflation in emerging market economies**	Empirical methods ,correlations
Erica L. Groshen Mark E. Schweitzer (1997)	**The Effects of Inflation on Wage Adjustments in Firm-Level Data: Grease or Sand?**	40-year panel of wage changes
Kawasaki, Hoeller, Poret, 1997	**Modeling wages and prices for smaller OECD countries**	Error correction mechanism
Peter Flaschel, GÄoran Kauermann, Willi Semmler (2005)	**Testing Wage and Price Phillips Curves for the United States**	parametric and non-parametric estimation.
SHIK HEO(2003)	**THE RELATIONSHIP BETWEEN EFFICIENCY WAGES AND PRICE INDEXATION IN A NOMINAL WAGE CONTRACTING MODEL**	simple nominal wage contracting model
John B. Taylor(1998)	**STAGGERED PRICE AND WAGE SETTING IN MACROECONOMICS**	time-dependent pricing, staggered price and wage setting
Gregory D. Hess and Mark E. Schweitzer	**Does Wage Inflation Cause Price Inflation?**	Granger Causality , panel econometrics
Raymond Robertson(2001)	**Relative Prices and Wage Inequality: Evidence from Mexico**	Ordered Logit Ordered Probit

This table shows that there exist theoretical and empirical models for prices and wages .This si a small sample of ten studies that study the relationship between wages, prices and productivity.

Data and the methodology

We use time series data here for UK industry. Three variables are selected for the model. **LRW** is the log of real wage. This variable represents Real Hourly Compensation in Manufacturing, CPI Basis, in the United Kingdom. The data are from 1960 to 2009 although in our regressions we use data only from 1960 to 2007, because from 2008 financial crisis started which in terms of econometrics represents a huge structural break. This variable is indexed and as base is chosen 2002=100. Second variable is **LCPI** which represents logarithm of consumer price index in UK for all items from 1960 to 2009, we use 1960-2007, and it is indexed 2005=100. **LPROD** is logarithm of productivity for UK manufacturing industry**,** this variable was calculated on a basis of average working hours in manufacturing industry and total output of manufactured goods, second variable was divided by first, and then logarithms were put. OLS and time series methods like VECM and co-integration are going to be applied for this series of data.

OLS regressions

I model: Price as a function of wages and productivity

$$CPI = f(RW, PRODUCTIVITY)$$

II model: Wage is function of price and productivity.

$$RW = f(CPI, PRODUCTIVITY)$$

This functional form is being applied on our data.

Ordinary least squares regressions are presented in the next page[1]:

[1] For detailed output see Appendix 1 OLS regressions

Variables	$CPI = f(RW, PRODUCTIVITY)$			$RW = f(CPI, PRODUCTIVITY)$	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
log	LRW	0.42**	**log**	LCPI	0.21**
	LPROD	-0.017		LPROD	0.06
	CONST	5.81***		CONST	3.33***
	AC test	0.001***		AC test	0.794***
	Ramsey test	0.019*		Ramsey test	0.178***
Δlog	ΔLRW	0.15	**Δlog**	ΔLCPI	0.17
	ΔLPROD	-0.0051		ΔLPROD	0.038
	CONST	0.053		CONST	0.017
	AC test	0.000		AC test	0.000
	Ramsey test	0.943***		Ramsey test	0.943***

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

Here OLS relationship between prices and wages is positive, also and between productivity and prices and productivity and wages except for the fact that these relationships are not significant. These models in column 1 can be represented in a form:

$\hat{lcpi} = \beta_1 lrw + \beta_2 lprod + \beta_0$, where β_0 is intercept, β_1 and β_2 are elasticities that measure elasticity of wages to prices and productivity to prices respectively. Second model in this column is: $\Delta \hat{lcpi} = \beta_1 \Delta lrw + \beta_2 \Delta lprod + \beta_0$, this is the case of first differences of the variables.

Autocorrelation in the models from column I is a serious problem, OLS time series do suffer from serial correlation. Functional form significant at all conventional levels of significance. Finally the estimated coefficients on wages to prices (and vice versa) are positive. This notion is not confirmed with Granger causality test, except for the case that Log of real wages causes LCPI at 5% level of significance.[2]

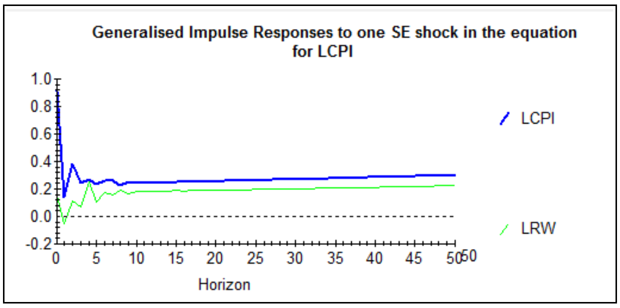
[2] See Appendix 2 Granger causality test

	Log-levels	First-differences
NON-CAUSAL VARIABLES	LR stat	LR stata
LCPI	0.316	0.801
LRW	0.049**	0.133

Note 1: *** - significant at 1% level of significance; ** - significant at 5% level of significance; * - significant at 10% level of significance.

Impulse response graph

On the next graph is given impulse Response for a shock of variables, prices and wages.



Unit root tests[3]

Unit root tests statistics are given in a Table below

Variables tested for unit roots	Test statistic	Decision
real_wage_log	-1.4627	Series is non-stationary
real_wage_log_d1	-3.5693**	Series is stationary
CPI_log	-1.1164	Series is non-stationary
CPI_log_d1	-2.3459	Series is non-stationary
CPI_log_d1_d1_d1	-7.0234***	Series is stationary

Critical values for the test at	1%	5%	10%
	-3.96	-3.41	-3.13

Note 1: *** - significant at 1% level of significance; ** - significant at 5% level of significance; * - significant at 10% level of significance.

[3] See Appendix 3 Unit root tests

These variables from these statistics we can see that are stationary at 1 lag, i.e. they are I(1) variables, except for CPI variables which is I(2) variable. These variables are graphically presented as non-stationary and their differences as stationary in the unit root section Appendix 3.

Johansen Trace test (co-integration test)[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.

Cointegration rank

On the next table is summarized the decision fro with how many lags to continue testing.

Variables	Deterministic trend	Johansen trace test		
CPI_log and Real_wage_log		Lag order	LR-stat	p-value
	Constant	1	2.65	0.6540
	Constant and a trend	1	4.97	0.6072

We reject the null for zero lags and we cannot reject the r=1, so we will accept 1 cointegrating vector.

Estimated cointegrating vector

Next we are going to present the estimation for cointegrating vector. This estimation does not include intercepts and does not include trends.

[4] See Appendix 4 test for cointegration

Chosen order =1
44 observations from 1964 to 2007

	Vector 1
LRW	.24600
	(-1.0000)
LCPI	-.18411
	(.74839)

List of variables included in the cointegrating vector:
LRW LCPI

These vectors are normalized in brackets.

Estimated long run coefficient using ARDL approach

Long run coefficient between logarithm of real wages and logarithm of prizes is positive and statistically significant.

Estimated Long Run Coefficients using the ARDL Approach
ARDL(1,0) selected based on Schwarz Bayesian Criterion
Dependent variable is LRW
44 observations used for estimation from 1964 to 2007

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
LCPI	.74158	.030294	24.4796[.000]

VECM model

VECM model is presented in the matrix form below

Coefficient matrix

$$\begin{bmatrix} d(CPI\_\log)(t) \\ d(real\_wage\_\log)(t) \end{bmatrix} = \begin{bmatrix} -0.105 \\ -0.031 \end{bmatrix} \begin{bmatrix} 1.000 & -5.246 \end{bmatrix} \begin{bmatrix} CPI(\log(t-1) \\ real\_wage\log(t-1) \end{bmatrix} + \begin{bmatrix} 15.325 \end{bmatrix} \begin{bmatrix} CONST \end{bmatrix}$$

$$+ \begin{bmatrix} -0.010 \\ -0.003 \end{bmatrix} \begin{bmatrix} TREND(t) \end{bmatrix} + \begin{bmatrix} u1(t) \\ u2(t) \end{bmatrix}$$

VECM output consists of coefficients. **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

***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 our case loading coefficients have t-ratios [-12.616] [-3.907] respectively. Thus, based on the presented evidence, it can be argued that co-integration relation resulting from normalization of cointegrating vector enters significantly.Table of t-stat matrix is given below.

t-stat matrix

$$\begin{bmatrix} d(CPI\_\log)(t) \\ d(real\_wage\_\log)(t) \end{bmatrix} = \begin{bmatrix} -12.616 \\ -3.907 \end{bmatrix} \begin{bmatrix} [\ldots \quad -10.401] \begin{bmatrix} CPI(\log(t-1) \\ real\_wage\log(t-1) \end{bmatrix} + [8.779] \quad [CONST] \end{bmatrix}$$
$$+ \begin{bmatrix} -10.933 \\ -3.068 \end{bmatrix} [TREND(t)] + \begin{bmatrix} u1(t) \\ u2(t) \end{bmatrix}$$

Co-integration vectors –The model we can arrange as follows

$$ec^{fgls} = CPI\_\log - 5.246 real\_wage\_\log$$

(-10.401)

If we rearrange

$$CPI\_\log = 5.246 real\_wage\_\log + ec^{fgls}$$

(-10.401)

If the log wages increases by 1%, it is expected that the log of prices would increase by 5.24 percent. In other words, a 1 percent increase in the log wages would induce a 5.24 percent increase in the log of prices.

Short-run parameters - The estimators of parameters associated with lagged differences of variables may be interpreted in the usual way.Productivity was exogenous regressor and it is deleted since it has coefficient no different than zero.

Deterministic Terms –Trend term has statistically significant though very small impact in the two equations.

Conclusion

In our paper we made several conclusions about the relationship between prices and wages. First there exist positive and significant relationship between the two variables and causation is from real wages to CPI. As our Vector Error correction model (VECM) showed on average 1% increase in log of real wages induces by 5.3% increase in CPI for all items in UK, i.e. this means that increase in wages causes inflation in UK, this notion was confirmed with the Granger causality test. The relation (causation) between these two variables is from CPI_log→ real_wage_log .

Appendix 1 OLS regressions

```
  Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is LRW
 48 observations used for estimation from 1960 to 2007
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 C                          3.3245            1.0646              3.1228[.003]
 LCPI                       .20940            .10131              2.0670[.045]
 LPROD                     .055376           .036035              1.5367[.131]
*******************************************************************************
 R-Squared                    .13049   R-Bar-Squared                   .091842
 S.E. of Regression           .87654   F-stat.    F(  2,  45)    3.3766[.043]
 Mean of Dependent Variable   6.0656   S.D. of Dependent Variable      .91980
 Residual Sum of Squares     34.5748   Equation Log-likelihood       -60.2352
 Akaike Info. Criterion     -63.2352   Schwarz Bayesian Criterion    -66.0420
 DW-statistic                 2.0656
*******************************************************************************
```

```
                               Diagnostic Tests
*******************************************************************************
*    Test Statistics  *        LM Version        *         F Version          *
*******************************************************************************
*                     *                          *                            *
* A:Serial Correlation*CHSQ(   1)=  .068405[.794]*F(   1,  44)=  .062794[.803]*
*                     *                          *                            *
* B:Functional Form   *CHSQ(   1)=   1.8114[.178]*F(   1,  44)=   1.7256[.196]*
*                     *                          *                            *
* C:Normality         *CHSQ(   2)=  21.5106[.000]*       Not applicable       *
*                     *                          *                            *
* D:Heteroscedasticity*CHSQ(   1)=  .066142[.797]*F(   1,  46)=  .063473[.802]*
*                     *                          *                            *
* E:Predictive Failure*CHSQ(   2)=   .72414[.696]*F(   2,  45)=   .36207[.698]*
*******************************************************************************
   A:Lagrange multiplier test of residual serial correlation
   B:Ramsey's RESET test using the square of the fitted values
   C:Based on a test of skewness and kurtosis of residuals
   D:Based on the regression of squared residuals on squared fitted values
   E:A test of adequacy of predictions (Chow's second test)
```

Test for autocorrelation

```
  Test of Serial Correlation of Residuals (OLS case)
*******************************************************************************
 Dependent variable is LRW
 List of variables in OLS regression:
 C               LCPI            LPROD
 48 observations used for estimation from 1960 to 2007
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 OLS RES(- 1)             -.038067            .15191             -.25059[.803]
*******************************************************************************
 Lagrange Multiplier Statistic    CHSQ( 1)=  .068405[.794]
 F Statistic                   F(  1,  44)=  .062794[.803]
*******************************************************************************
```

```
    Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is LCPI
 48 observations used for estimation from 1960 to 2007
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 C                          5.8088             1.4061             4.1311[.000]
 LRW                        .41409             .20033             2.0670[.045]
 LPROD                   -.016950             .051925            -.32643[.746]
*******************************************************************************
 R-Squared                    .087020   R-Bar-Squared                  .046443
 S.E. of Regression            1.2326   F-stat.    F(  2,  45)    2.1446[.129]
 Mean of Dependent Variable    7.9939   S.D. of Dependent Variable      1.2623
 Residual Sum of Squares      68.3711   Equation Log-likelihood       -76.5990
 Akaike Info. Criterion      -79.5990   Schwarz Bayesian Criterion    -82.4058
 DW-statistic                  .99136
*******************************************************************************


                               Diagnostic Tests
*******************************************************************************
*    Test Statistics  *        LM Version        *         F Version          *
*******************************************************************************
*                     *                          *                            *
* A:Serial Correlation*CHSQ(   1)=  11.9751[.001]*F(   1,  44)=  14.6262[.000]*
*                     *                          *                            *
* B:Functional Form   *CHSQ(   1)=   5.5049[.019]*F(   1,  44)=   5.6998[.021]*
*                     *                          *                            *
* C:Normality         *CHSQ(   2)=  12.6934[.002]*      Not applicable        *
*                     *                          *                            *
* D:Heteroscedasticity*CHSQ(   1)=   .98073[.322]*F(   1,  46)=   .95947[.332]*
*                     *                          *                            *
* E:Predictive Failure*CHSQ(   2)=   1.1090[.574]*F(   2,  45)=   .55449[.578]*
*******************************************************************************
   A:Lagrange multiplier test of residual serial correlation
   B:Ramsey's RESET test using the square of the fitted values
   C:Based on a test of skewness and kurtosis of residuals
   D:Based on the regression of squared residuals on squared fitted values
   E:A test of adequacy of predictions (Chow's second test)
```

Test for autocorrelation

```
Test of Serial Correlation of Residuals (OLS case)
*******************************************************************************
 Dependent variable is LCPI
 List of variables in OLS regression:
 C              LRW              LPROD
 48 observations used for estimation from 1960 to 2007
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 OLS RES(- 1)               .51226             .13395             3.8244[.000]
*******************************************************************************
 Lagrange Multiplier Statistic    CHSQ( 1)=  11.9751[.001]
 F Statistic                   F(  1,  44)=  14.6262[.000]
*******************************************************************************
```

o

```
  Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is DLRW
 47 observations used for estimation from 1961 to 2007
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 C                         .016183             .18532            .087324[.931]
 DLCPI                      .16411             .15873             1.0340[.307]
 DLPROD                    .037112            .035729             1.0387[.305]
*******************************************************************************
 R-Squared                    .046583   R-Bar-Squared                   .0032454
 S.E. of Regression            1.2690   F-stat.    F(  2,  44)    1.0749[.350]
 Mean of Dependent Variable   .026783   S.D. of Dependent Variable      1.2711
 Residual Sum of Squares      70.8578   Equation Log-likelihood       -76.3375
 Akaike Info. Criterion      -79.3375   Schwarz Bayesian Criterion    -82.1127
 DW-statistic                  2.9188
*******************************************************************************


                               Diagnostic Tests
*******************************************************************************
*    Test Statistics  *        LM Version        *         F Version          *
*******************************************************************************
*                     *                          *                            *
* A:Serial Correlation*CHSQ(   1)=  10.4302[.001]*F(   1,  43)=  12.2642[.001]*
*                     *                          *                            *
* B:Functional Form   *CHSQ(   1)=   .86120[.353]*F(   1,  43)=   .80261[.375]*
*                     *                          *                            *
* C:Normality         *CHSQ(   2)=   .16722[.920]*       Not applicable       *
*                     *                          *                            *
* D:Heteroscedasticity*CHSQ(   1)=   .39955[.527]*F(   1,  45)=   .38583[.538]*
*                     *                          *                            *
* E:Predictive Failure*CHSQ(   2)= .0011216[1.00]*F(   2,  44)= .5608E-3[1.00]*
*******************************************************************************
   A:Lagrange multiplier test of residual serial correlation
   B:Ramsey's RESET test using the square of the fitted values
   C:Based on a test of skewness and kurtosis of residuals
   D:Based on the regression of squared residuals on squared fitted values
   E:A test of adequacy of predictions (Chow's second test)

Test for autocorrelation
Test of Serial Correlation of Residuals (OLS case)
*******************************************************************************
 Dependent variable is DLRW
 List of variables in OLS regression:
 C               DLCPI           DLPROD
 47 observations used for estimation from 1961 to 2007
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 OLS RES(- 1)              -.48305             .13793            -3.5020[.001]
*******************************************************************************
 Lagrange Multiplier Statistic    CHSQ( 1)=  10.4302[.001]
 F Statistic                   F(  1,  43)=  12.2642[.001]
*******************************************************************************
```

```
                       Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is DLCPI
 47 observations used for estimation from 1961 to 2007
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 C                         .052526             .17375            .30230[.764]
 DLRW                       .14454             .13979            1.0340[.307]
 DLPROD                 -.0051790             .033930           -.15264[.879]
*******************************************************************************
 R-Squared                    .023721   R-Bar-Squared                 -.020655
 S.E. of Regression            1.1909   F-stat.    F(  2,  44)    .53455[.590]
 Mean of Dependent Variable   .056205   S.D. of Dependent Variable      1.1788
 Residual Sum of Squares      62.4047   Equation Log-likelihood       -73.3522
 Akaike Info. Criterion      -76.3522   Schwarz Bayesian Criterion    -79.1274
 DW-statistic                  3.0912
*******************************************************************************


                               Diagnostic Tests
*******************************************************************************
*    Test Statistics  *        LM Version         *         F Version          *
*******************************************************************************
*                     *                           *                            *
* A:Serial Correlation*CHSQ(   1)=  14.1529[.000]*F(   1,  43)=  18.5274[.000]*
*                     *                           *                            *
* B:Functional Form   *CHSQ(   1)= .0050795[.943]*F(   1,  43)= .0046477[.946]*
*                     *                           *                            *
* C:Normality         *CHSQ(   2)= 156.5101[.000]*       Not applicable       *
*                     *                           *                            *
* D:Heteroscedasticity*CHSQ(   1)=   .37556[.540]*F(   1,  45)=   .36248[.550]*
*                     *                           *                            *
* E:Predictive Failure*CHSQ(   2)= .0010102[1.00]*F(   2,  44)= .5051E-3[1.00]*
*******************************************************************************
   A:Lagrange multiplier test of residual serial correlation
   B:Ramsey's RESET test using the square of the fitted values
   C:Based on a test of skewness and kurtosis of residuals
   D:Based on the regression of squared residuals on squared fitted values
   E:A test of adequacy of predictions (Chow's second test)

Test of Serial Correlation of Residuals (OLS case)
*******************************************************************************
 Dependent variable is DLCPI
 List of variables in OLS regression:
 C               DLRW            DLPROD
 47 observations used for estimation from 1961 to 2007
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 OLS RES(- 1)              -.55190             .12822           -4.3043[.000]
*******************************************************************************
 Lagrange Multiplier Statistic    CHSQ( 1)=  14.1529[.000]
 F Statistic                   F(  1,  43)=  18.5274[.000]
*******************************************************************************
```

Appendix 2 Granger causality test

```
Granger causality
LR Test of Block Granger Non-Causality in the VAR
*******************************************************************************
 Based on 46 observations from 1964 to 2009. Order of VAR = 4
 List of variables included in the unrestricted VAR:
 LCPI            LRW
 Maximized value of log-likelihood = -117.7206
*******************************************************************************
 List of variable(s) assumed to be "non-causal" under the null hypothesis:
 LCPI
 Maximized value of log-likelihood = -120.0863
*******************************************************************************
 LR test of block non-causality, CHSQ(  4)=   4.7314[.316]
*******************************************************************************
 The above statistic is for testing the null hypothesis that the coefficients
 of the lagged values of:
 LCPI
 in the block of equations explaining the variable(s):
 LRW
 are zero. The maximum order of the lag(s) is 4.
*******************************************************************************
```

```
LR Test of Block Granger Non-Causality in the VAR
*******************************************************************************
 Based on 46 observations from 1964 to 2009. Order of VAR = 4
 List of variables included in the unrestricted VAR:
 LCPI            LRW
 Maximized value of log-likelihood = -117.7206
*******************************************************************************
 List of variable(s) assumed to be "non-causal" under the null hypothesis:
 LRW
 Maximized value of log-likelihood = -122.4993
*******************************************************************************
 LR test of block non-causality, CHSQ(  4)=   9.5574[.049]
*******************************************************************************
 The above statistic is for testing the null hypothesis that the coefficients
 of the lagged values of:
 LRW
 in the block of equations explaining the variable(s):
 LCPI
 are zero. The maximum order of the lag(s) is 4.
*******************************************************************************
```

```
LR Test of Block Granger Non-Causality in the VAR
*******************************************************************************
 Based on 45 observations from 1965 to 2009. Order of VAR = 4
 List of variables included in the unrestricted VAR:
 DLCPI           DLRW
 Maximized value of log-likelihood = -118.4812
*******************************************************************************
 List of variable(s) assumed to be "non-causal" under the null hypothesis:
 DLCPI
 Maximized value of log-likelihood = -119.3015
*******************************************************************************
 LR test of block non-causality, CHSQ(  4)=   1.6406[.801]
*******************************************************************************
 The above statistic is for testing the null hypothesis that the coefficients
 of the lagged values of:
 DLCPI
 in the block of equations explaining the variable(s):
 DLRW
 are zero. The maximum order of the lag(s) is 4.
*******************************************************************************

LR Test of Block Granger Non-Causality in the VAR
*******************************************************************************
 Based on 45 observations from 1965 to 2009. Order of VAR = 4
 List of variables included in the unrestricted VAR:
 DLCPI           DLRW
 Maximized value of log-likelihood = -118.4812
*******************************************************************************
 List of variable(s) assumed to be "non-causal" under the null hypothesis:
 DLRW
 Maximized value of log-likelihood = -122.0135
*******************************************************************************
 LR test of block non-causality, CHSQ(  4)=   7.0647[.133]
*******************************************************************************
 The above statistic is for testing the null hypothesis that the coefficients
 of the lagged values of:
 DLRW
 in the block of equations explaining the variable(s):
 DLCPI
 are zero. The maximum order of the lag(s) is 4.
*******************************************************************************


LR Test of Block Granger Non-Causality in the VAR
*******************************************************************************
 Based on 45 observations from 1965 to 2009. Order of VAR = 4
 List of variables included in the unrestricted VAR:
 DLRW            DLPROD
 Maximized value of log-likelihood = -185.0739
*******************************************************************************
 List of variable(s) assumed to be "non-causal" under the null hypothesis:
 DLPROD
 Maximized value of log-likelihood = -187.5924
*******************************************************************************
 LR test of block non-causality, CHSQ(  4)=   5.0369[.284]
*******************************************************************************
 The above statistic is for testing the null hypothesis that the coefficients
 of the lagged values of:
 DLPROD
 in the block of equations explaining the variable(s):
 DLRW
 are zero. The maximum order of the lag(s) is 4.
*******************************************************************************
```

```
LR Test of Block Granger Non-Causality in the VAR
******************************************************************************
 Based on 46 observations from 1964 to 2009. Order of VAR = 4
 List of variables included in the unrestricted VAR:
 LRW            LPROD
 Maximized value of log-likelihood = -185.4792
******************************************************************************
 List of variable(s) assumed to be "non-causal" under the null hypothesis:
 LPROD
 Maximized value of log-likelihood = -188.4135
******************************************************************************
 LR test of block non-causality, CHSQ(  4)=   5.8688[.209]
******************************************************************************
 The above statistic is for testing the null hypothesis that the coefficients
 of the lagged values of:
 LPROD
 in the block of equations explaining the variable(s):
 LRW
 are zero. The maximum order of the lag(s) is 4.
******************************************************************************
```

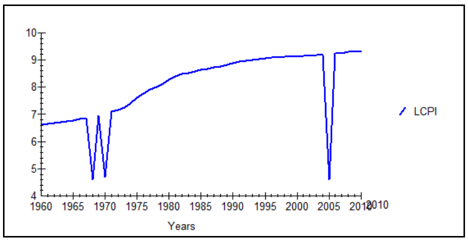
Appendix 3 Unit root tests

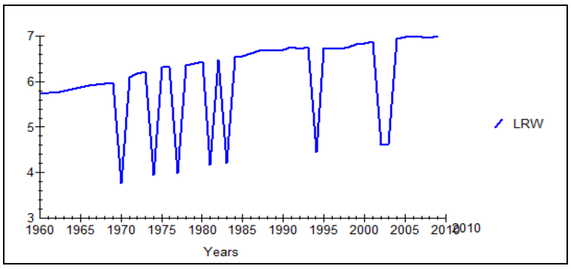
```
Unit root tests

ADF Test for series:      real_wage
sample range:             [1963, 2009], T = 47
lagged differences:       2
intercept, time trend
asymptotic critical values
reference: Davidson, R. and MacKinnon, J. (1993),
"Estimation and Inference in Econometrics" p 708, table 20.1,
Oxford University Press, London
 1%         5%         10%
-3.96      -3.41      -3.13
value of test statistic: -2.5859
regression results:
---------------------------------------
variable      coefficient   t-statistic
---------------------------------------
 x(-1)        -0.2824       -2.5859
dx(-1)         0.2446        1.6202
dx(-2)         0.0087        0.0537
constant       21.0595       2.8098
trend          0.4809        2.5718
RSS            131.2881

OPTIMAL ENDOGENOUS LAGS FROM INFORMATION CRITERIA

sample range:             [1971, 2009], T = 39

optimal number of lags (searched up to 10 lags of 1. differences):
Akaike Info Criterion:    1
Final Prediction Error:   1
Hannan-Quinn Criterion:   0
Schwarz Criterion:        0
```

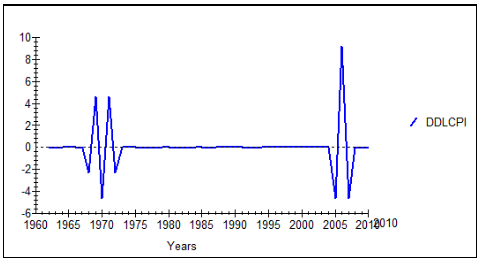
```
ADF Test for series:      real_wage_log_d1
sample range:             [1964, 2009], T = 46
lagged differences:       2
intercept, time trend
asymptotic critical values
reference: Davidson, R. and MacKinnon, J. (1993),
"Estimation and Inference in Econometrics" p 708, table 20.1,
Oxford University Press, London
 1%        5%        10%
-3.96      -3.41      -3.13
value of test statistic: -3.7255
regression results:
---------------------------------------
variable      coefficient   t-statistic
---------------------------------------
 x(-1)        -0.9770       -3.7255
dx(-1)         0.0500        0.2382
dx(-2)        -0.0796       -0.5092
constant       0.0253        3.1793
trend         -0.0007       -2.1044
RSS            0.0279

OPTIMAL ENDOGENOUS LAGS FROM INFORMATION CRITERIA

sample range:             [1972, 2009], T = 38

optimal number of lags (searched up to 10 lags of 1. differences):
Akaike Info Criterion:    0
Final Prediction Error:   0
Hannan-Quinn Criterion:   0
Schwarz Criterion:        0


ADF Test for series:      CPI_log
sample range:             [1964, 2009], T = 46
lagged differences:       2
intercept, time trend
asymptotic critical values
reference: Davidson, R. and MacKinnon, J. (1993),
"Estimation and Inference in Econometrics" p 708, table 20.1,
Oxford University Press, London
 1%        5%        10%
-3.96      -3.41      -3.13
value of test statistic: -1.1182
regression results:
---------------------------------------
variable      coefficient   t-statistic
---------------------------------------
 x(-1)        -0.0173       -1.1182
dx(-1)         0.8453        5.6073
dx(-2)        -0.0500       -0.3167
constant       0.0759        1.3566
trend          0.0006        0.5225
RSS            0.0260

OPTIMAL ENDOGENOUS LAGS FROM INFORMATION CRITERIA

sample range:             [1972, 2009], T = 38

optimal number of lags (searched up to 10 lags of 1. differences):
Akaike Info Criterion:    6
Final Prediction Error:   1
Hannan-Quinn Criterion:   1
Schwarz        Criterion:                                                        1
```

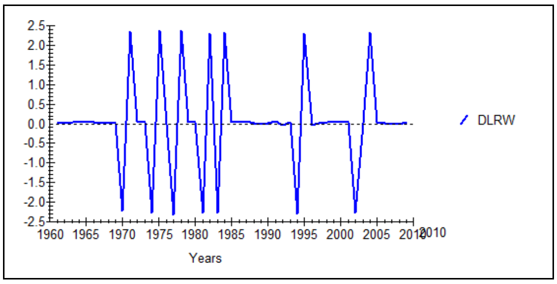
```
DF Test for series:      CPI_log_d1
sample range:             [1964, 2010], T = 47
lagged differences:       2
intercept, time trend
asymptotic critical values
reference: Davidson, R. and MacKinnon, J. (1993),
"Estimation and Inference in Econometrics" p 708, table 20.1,
Oxford University Press, London
 1%        5%        10%
-3.96      -3.41      -3.13
value of test statistic: -2.4032
regression results:
---------------------------------------
variable      coefficient   t-statistic
---------------------------------------
 x(-1)        -0.2326       -2.4032
dx(-1)         0.1002        0.6746
dx(-2)        -0.0687       -0.4624
constant       0.0133        2.0231
trend         -0.0005       -1.7227
RSS            0.0269

OPTIMAL ENDOGENOUS LAGS FROM INFORMATION CRITERIA

sample range:             [1972, 2010], T = 39

optimal number of lags (searched up to 10 lags of 1. differences):
Akaike Info Criterion:    6
Final Prediction Error:   6
Hannan-Quinn Criterion:   0
Schwarz Criterion:        0

ADF Test for series:      CPI_log_d1_d1_d1
sample range:             [1966, 2009], T = 44
lagged differences:       2
intercept, time trend
asymptotic critical values
reference: Davidson, R. and MacKinnon, J. (1993),
"Estimation and Inference in Econometrics" p 708, table 20.1,
Oxford University Press, London
 1%        5%        10%
-3.96      -3.41      -3.13
value of test statistic: -7.0234
regression results:
---------------------------------------
variable      coefficient   t-statistic
---------------------------------------
 x(-1)        -2.4764       -7.0234
dx(-1)         0.8551        3.2501
dx(-2)         0.3935        2.6904
constant      -0.0005       -0.0947
trend          0.0000        0.0928
RSS            0.0408

OPTIMAL ENDOGENOUS LAGS FROM INFORMATION CRITERIA

sample range:             [1974, 2009], T = 36

optimal number of lags (searched up to 10 lags of 1. differences):
Akaike Info Criterion:    3
Final Prediction Error:   3
Hannan-Quinn Criterion:   3
Schwarz Criterion:        3
```

Graphic presentation of the variables









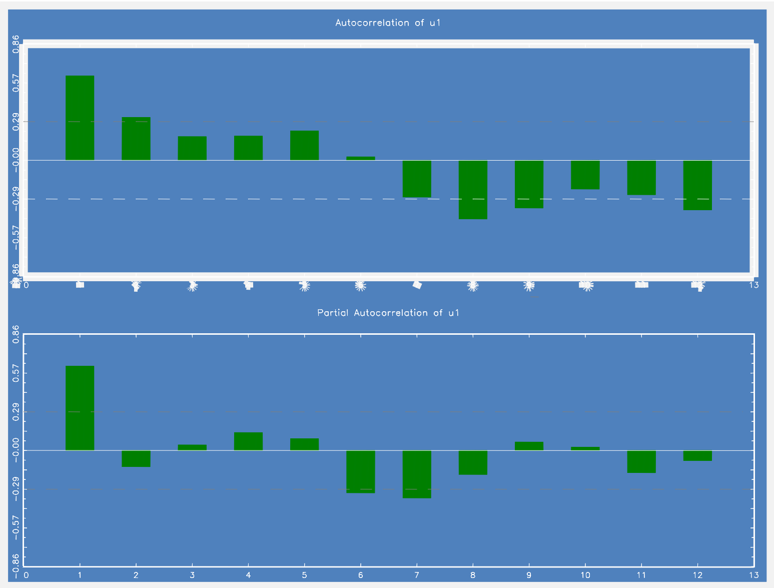
Appendix 4 Test for cointegration

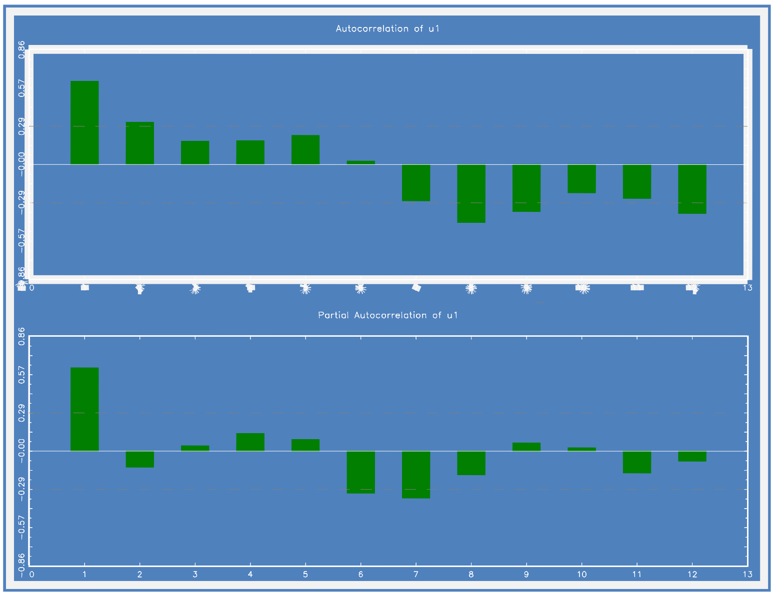
```
Johansen Trace Test for:  CPI_log real_wage_log
sample range:             [1961, 2009], T = 49
included lags (levels):   1
dimension of the process: 2
intercept included
response surface computed:
-----------------------------------------------
 r0  LR       pval     90%      95%      99%
-----------------------------------------------
 0   71.27    0.0000   17.98    20.16    24.69
 1   2.65     0.6540   7.60     9.14     12.53

OPTIMAL ENDOGENOUS LAGS FROM INFORMATION CRITERIA

sample range:             [1961, 2009], T = 49

optimal number of lags (searched up to 1 lags of levels):
Akaike Info Criterion:    1
Final Prediction Error:   1
Hannan-Quinn Criterion:   1
Schwarz Criterion:        1

*** Tue, 11 Oct 2011 23:20:41 ***
Johansen Trace Test for:  CPI_log real_wage_log
sample range:             [1961, 2009], T = 49
included lags (levels):   1
dimension of the process: 2
trend and intercept included
response surface computed:
-----------------------------------------------
 r0  LR       pval     90%      95%      99%
-----------------------------------------------
 0   50.61    0.0000   23.32    25.73    30.67
 1   4.97     0.6072   10.68    12.45    16.22

OPTIMAL ENDOGENOUS LAGS FROM INFORMATION CRITERIA

sample range:             [1961, 2009], T = 49

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

```
VEC REPRESENTATION
endogenous variables:     CPI_log real_wage_log
exogenous variables:      productivity_log
deterministic variables:  CONST TREND
endogenous lags (diffs):  0
exogenous lags:           0
sample range:             [1961, 2009], T = 49
estimation procedure:     One stage. Johansen approach



Deterministic term:
===================
          d(CPI_log)  d(real_wage_log)
---------------------------------------
TREND(t)|   -0.010    -0.003
        |   (0.001)   (0.001)
        |   {0.000}   {0.002}
        | [-10.933]  [-3.068]
---------------------------------------


Loading coefficients:
=====================
          d(CPI_log)  d(real_wage_log)
---------------------------------------
ec1(t-1)|   -0.105    -0.031
        |   (0.008)   (0.008)
        |   {0.000}   {0.000}
        | [-12.616]  [-3.907]
---------------------------------------

Estimated cointegration relation(s):
====================================
                   ec1(t-1)
----------------------------
CPI_log      (t-1)|    1.000
                  |   (0.000)
                  |   {0.000}
                  |   [0.000]
real_wage_log(t-1)|   -5.246
                  |   (0.504)
                  |   {0.000}
                  | [-10.401]
CONST             |   15.325
                  |   (1.746)
                  |   {0.000}
                  |   [8.779]
----------------------------



VAR REPRESENTATION

modulus of the eigenvalues of the reverse characteristic polynomial:
|z| = ( 1.0000     0.9478     )

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

```
...
------------------------------------------


Lagged endogenous term:
=======================
                    CPI_log  real_wage_log
-------------------------------------------
CPI_log      (t-1)|    0.895    -0.031
                  |   (0.008)   (0.008)
                  |   {0.000}   {0.000}
                  | [107.021]  [-3.907]
real_wage_log(t-1)|    0.553     1.161
                  |   (0.044)   (0.041)
                  |   {0.000}   {0.000}
                  |  [12.616]  [28.251]
-------------------------------------------


Deterministic term:
===================
           CPI_log  real_wage_log
----------------------------------
TREND(t)|   -0.010    -0.003
        |   (0.000)   (0.000)
        |   {0.000}   {0.000}
        |   [0.000]   [0.000]
CONST   |   -1.616    -0.469
        |   (0.000)   (0.000)
        |   {0.000}   {0.000}
        |   [0.000]   [0.000]
----------------------------------
```

Residual analysis in VECM





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