Tests for Interest Rate Convergence and Structural Breaks in the EMS

Stilianos Fountas[1] Jyh-lin Wu[2]

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Department of Economics
University College Galway
Ireland

http://www.ucg.ie/ecn/

[1]Department of Economics, University College Galway, Ireland. email: `steve.fountas@ucg.ie`

[2]Institute for International Economics, National Chung Cheng University, Chia-Yi, Taiwan, ROC.

Abstract

We use a new test for cointegration that allows for structural breaks in the cointegrating relationship to test for bilateral interest rate convergence in the European Monetary System. Contrary to previous studies that employed standard cointegration tests, we find strong evidence for convergence between German nominal interest rates and interest rates in four other EMS countries in the 1979–1995 period.

Keywords: convergence, structural breaks

JEL Classification: F3, F4

1 Introduction

The issue of monetary policy coordination and convergence has been in the forefront of the European Monetary System (EMS). The successful operation of the Exchange Rate Mechanism (ERM) necessitates monetary policy coordination among the member countries. Policy coordination and the resulting monetary policy convergence would be necessary for the implementation of the last stage of the process towards a monetary union, i.e., the introduction of a common currency. Developments in the econometrics of nonstationary time series have allowed researchers to test for interest rate convergence between ERM member countries. Examples include Karfakis and Moschos (1990), Katsimbris and Miller (1993) and Edison and Kole (1994). The bilateral convergence tests performed by these authors[1] have considered Germany as the base country given its significance in the system and have tested for cointegration between the German interest rate and interest rates in other ERM countries. A finding of cointegration would be consistent with a long-run comovement between German and other ERM members' interest rates and, hence, long-run German dominance as it would imply that German and other ERM rates have fully converged, i.e., they share a common stochastic trend.

Surprisingly, this literature has produced some unexpected results. For example, in most cases a lack of bivariate cointegration obtains between Germany and most of the other ERM countries (Karfakis and Moschos, 1990, Katsimbris and Miller, 1993). Some authors (e.g., Katsimbris and Miller, 1993) have speculated that possible structural breaks in the cointegrating relationship, due to exchange rate realignments, for example, could justify the finding of no cointegration. In other words, the presence of structural breaks biases cointegration tests in favour of acceptance of the null of no cointegration. The objective of this paper is to test for bilateral cointegration using, in addition to standard tests, a test that allows for an endogenously-determined structural break in the cointegrating vector. This break could be due to exchange rate realignments, institutional changes like changes in the existing restrictions on capital movements or asymmetric interest rate changes due to asymmetric adjustment in the stance of monetary policy in the two countries. Our tests that cover a longer period than previous studies and include data up to the end of 1995, provide strong evidence for bilateral cointegration in four out of the six countries included in our sample. The structure of this paper is as follows: section 2 discusses the methodology, section 3 presents the results and section 4 concludes.

[1] Multilateral convergence tests deal with a separate issue as they can be used to test for the degree of convergence among the interest rates of all the EMS member countries. Hafer and Kutan (1994) and Bredin and Fountas (1996) follow this approach.

2 Methodology

2.1 Theory

According to the uncovered interest rate parity (UIP) theory, interest rate differentials reflect imperfect substitution between domestic and foreign assets that is due to "country barriers" and "currency barriers". "Country barriers" include capital controls and differential tax treatment and "currency barriers" include expected exchange rate changes and the exchange risk premium. Let

$$i_t - a - ci_t^* \quad = \quad \mathrm{E}_t s_{t+1} - s_t + pr_t \tag{1}$$

where i_t and i_t^* are the domestic and German interest rates, respectively, s_t is the spot exchange rate, pr_t is the exchange risk premium, and a and c are parameters. E_t is the expectations operator. Stationarity of the expected depreciation and the risk premium would imply that the linear combination between the two interest rates is stationary. Hence,

$$i_t \quad = \quad a + ci_t^* + e_t \tag{2}$$

where e_t is stationary or, equivalently, i_t and i_t^* are cointegrated. Nominal interest rate equalization would imply that $a = 0$ and $c = 1$. In particular, if c equals unity, the link between domestic and foreign interest rates would be perfect. However, because of "country barriers", a and c can differ from their hypothesized values. In addition, the cointegrating relation between i_t and i_t^* might change over time because of changes in the intercept and/or slope of equation (2). These changes can arise from exchange rate realignments, changes in the regime of capital controls, or asymmetric changes in monetary policy in the two countries. To account for this possibility, we need to use a test that allows for shifts in the cointegrating relation.

2.2 Econometric tests

Gregory and Hansen (1996) have developed residual-based cointegration tests in models of regime shifts where the timing of the regime shift is not known *a priori* but is determined by the data. Gregory and Hansen (1996) consider four models of a regime shift depending on whether the shift affects the intercept, or the slope and whether a trend is included in the cointegrating regression. A level shift model (model 2 in Gregory and Hansen) takes the form

$$y_t = a + bD_t + cx_t + u_t, \; t = 1, \ldots, n \tag{3}$$

$$\text{and } \mathrm{D_t} = \begin{cases} 0 & \text{if } t \leq [n\tau] \\ 1 & \text{if } t > [n\tau] \end{cases}$$

where $\tau \in (0,1)$ is an unknown parameter denoting the timing of the change point and [] denotes integer part. The use of the dummy variable D_t allows one to test for a structural change or regime shift. In equation (3) above, a is the intercept before the shift and b is the change in the intercept due to the shift. Models (3) and (4) in Gregory and Hansen (1996) add a trend and slope dummy to model (2), respectively.

To test for cointegration between y_t and x_t with structural change, i.e., stationarity of u_t in equation (3), Gregory and Hansen (1996) suggest the use of three tests. These tests are modifications of the test statistics Z_α and Z_t (suggested by Phillips (1987)) and the ADF statistic. These statistics are defined as:

$$\begin{aligned} Z_\alpha^* &= \inf_{\tau \in T} Z_\alpha(\tau) \\ Z_t^* &= \inf_{\tau \in T} Z_t(\tau) \\ \mathrm{ADF}^* &= \inf_{\tau \in T} \mathrm{ADF}(\tau) \end{aligned}$$

where $Z_\alpha(\tau), Z_t(\tau)$ and $\mathrm{ADF}(\tau)$ correspond to the choice of change point τ. The set T can be any compact subset of $(0,1)$. Gregory and Hansen (1996) suggest that a reasonable choice is $T = (0.15, 0.85)$. Following Gregory and Hansen we compute the test statistic for each break point in the interval $([0.15n], [0.85n])$. According to the definition of Z_α^*, Z_t^*, and ADF* we are interested in the smallest values of $Z_\alpha(\tau), Z_t(\tau)$ and $\mathrm{ADF}(\tau)$ across all possible break points since small values of the statistics are required to reject the null hypothesis. Gregory and Hansen (1996) derive asymptotic critical values for alternative models. Their Table 1 lists the critical values. Based on Monte Carlo evidence for the model with structural break in the intercept, they also find that Z_t^* has the largest power and Z_α^* the lowest power (Gregory and Hansen, 1996, p. 114).

3 Results

We use overnight money market interest rates for Belgium, Denmark, France, Germany, Ireland, Italy and Netherlands. Quarterly data are taken from the *International Financial Statistics* published by the IMF[2] and cover the 1979Q2 to 1995Q4 period. The beginning of our sample coincides with the launch of the EMS. Our interest rate data are shown in Figure 1.

Table 1 lists the unit root tests. As it is usually done in the literature, we report the value of ADF(k), where k is the minimum lag for white errors. According to Table 1, all interest rates are I(1). Having established that all series are I(1) we can now proceed to cointegration tests. We first test for cointegration without allowing for a structural break. We decided to apply the Engle and Granger (1987) methodology rather than the Johansen tests. The rationale is that the application of the Gregory and Hansen (1996) tests, that represents the major contribution of our study, is a direct extension to the Engle and Granger (1987) tests. Table 2 lists the Engle and Granger (1987) cointegration tests where the order of the ADF statistic is the minimum necessary for white errors. We clearly cannot reject the null of no cointegration at 5%. In the case of the Netherlands, the t-statistic is marginally smaller than the critical value.

Table 3 includes the results of the Gregory and Hansen (1996) cointegration tests that allow for an endogenously-determined structural break in the cointegrating relationship. There is strong evidence that cointegration applies for Belgium, Denmark and Ireland (at 1%) and some evidence for the Netherlands (at 10%).[3] No evidence in favour of cointegration is found for France and Italy. The break points are estimated to be in 1988Q3 or 1992Q1 (for Denmark), 1986Q2, 1986Q3 or 1986Q4 (Belgium), 1982Q1, 1987Q3 or 1987Q4 (Ireland) and 1984Q2 or 1992Q3 (Netherlands). Our interpretation of some of these break dates is as follows: The Belgian Franc was devalued by 2% against the DM in a realignment during the second quarter of 1986. Hence, this realignment could be responsible for the shift in the cointegrating vector in 1986Q2. The break point for Ireland in the second half of 1987 could be attributed to the second fiscal stabilization that led to a sharp gradual reduction in Irish interest rates. Figure 1 shows that, after the end of 1987, the gap between Irish and German interest rates narrows which is consistent with our finding of a change in the cointegrating relationship

[2]Due to unavailability of Irish data in the *International Financial Statistics*, Irish data are 3-month interbank rates taken from the Quarterly Bulletin of the Central Bank of Ireland.

[3]When using the Gregory and Hansen (1996) tests we consider also 10% significance levels whereas under the Engle and Granger (1987) approach we only report 5% significance levels. The difference in the approach is because the Gregory-Hansen (1996) tests use much higher critical values and hence have low power as the break date is unknown *a priori* (Banerjee and Urga, 1995).

following this break period. Finally, the break date for the Netherlands in the second quarter of 1984 can be justified by the divergence, for the first time, of Dutch and German exchange rate policies following the March 1983 realignment. As Gros and Thygesen (1992, p. 77) report, this divergence led to a positive differential between Dutch and German interest rates that lasted for approximately five years.

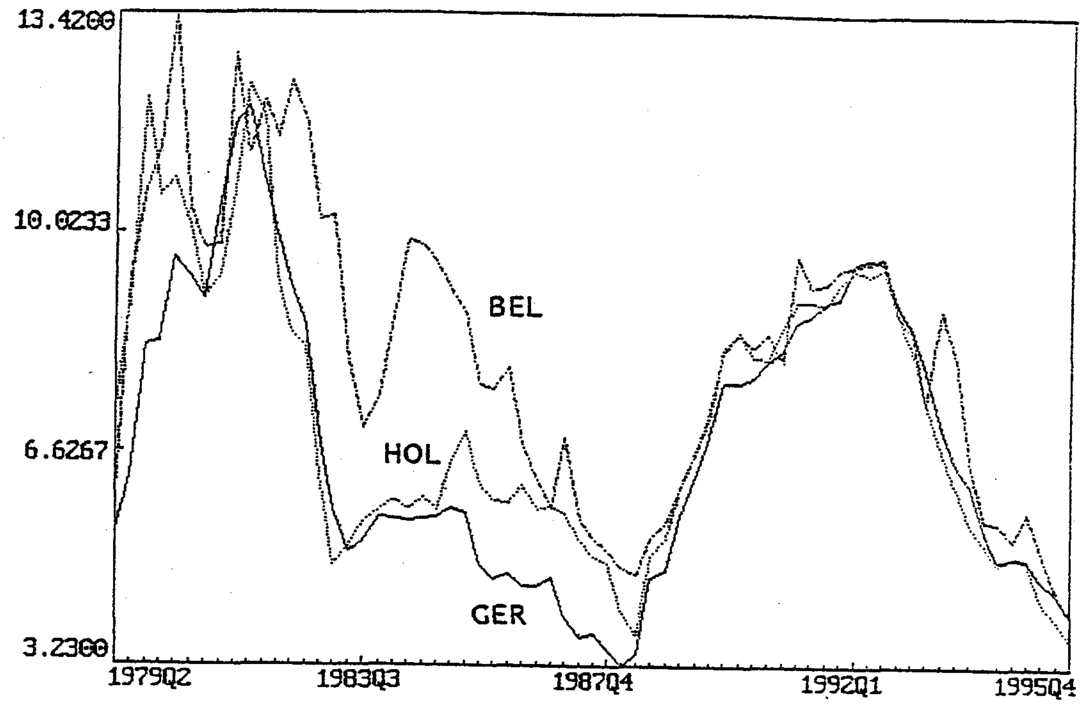
Based on these cointegration test results, we estimate the cointegrating regressions applying the procedure of dynamic OLS (DOLS) suggested by Stock and Watson (1993). This method provides more efficient estimators than other existing approaches (e.g., West, 1988). The results, using the break points suggested by the cointegration tests, are shown in Table 4. Perfect link between German and other EMS countries' rates would imply that $c = 1$. Tests of this hypothesis imply that we cannot reject the null for Denmark (break point 1988Q3) and Ireland (all break points) at 5%. In the cases of Belgium and the Netherlands, our estimates of c are significantly less than one implying that, even though interest rates in these countries tend to move together with German rates, the link is less than perfect.[4]

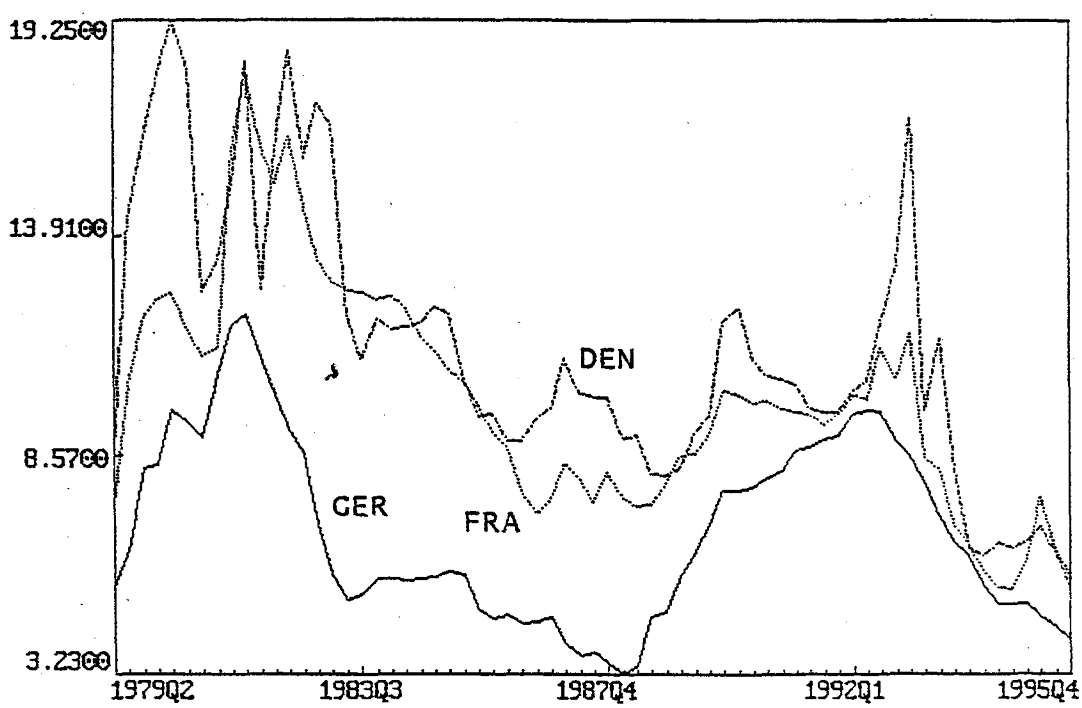
4 Conclusions

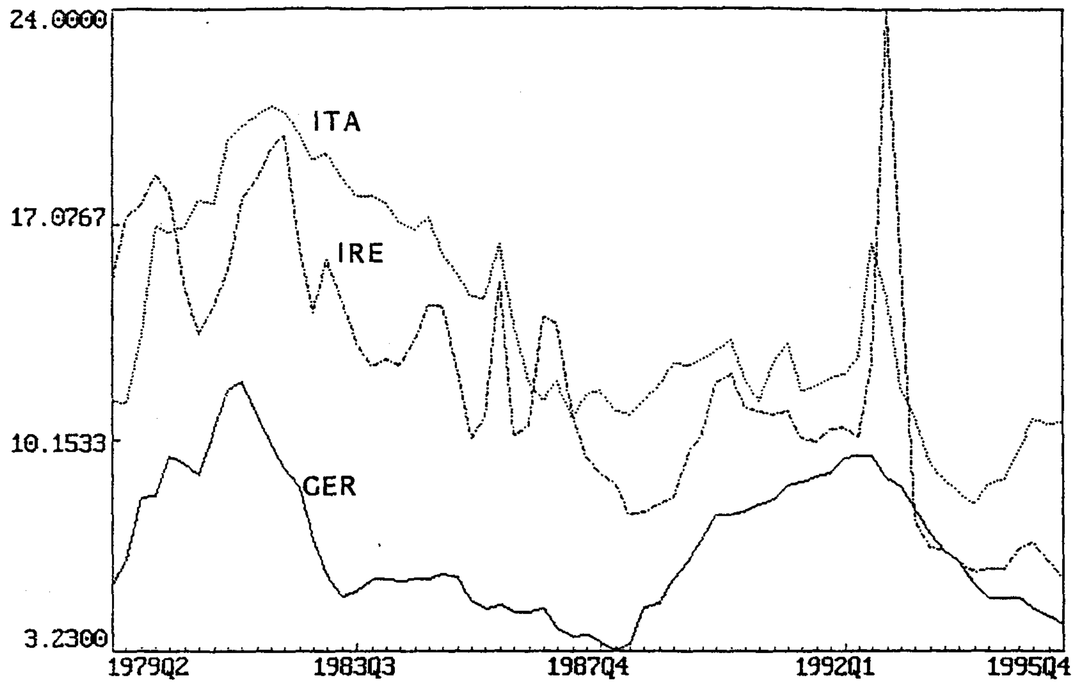
We have provided evidence in support of bilateral interest rate convergence between German rates and interest rates in four other ERM-member countries using a cointegration test that allows for a change in the cointegrating vector at an endogenously-determined date. Our finding of cointegration with structural break could possibly imply that results based on standard Engle and Granger cointegration tests are biased towards a result of no cointegration and, hence, might explain the lack of support for cointegration in previous studies that used standard Engle-Granger tests. Our result is also intuitively appealing as it would be expected that monetary policy coordination in the EMS over the past sixteen years has led to interest rate convergence between Germany and other ERM-member countries.

[4]The result for the Netherlands seems surprising as it is well known that Dutch monetary authorities have followed closely Germany's monetary policy. In light of this, and our result of the Engle and Granger cointegration test that rejected cointegration marginally, we estimated the cointegrating regression without allowing for a structural break using DOLS. The estimated coefficient for c is 0.766, which is statistically different from unity.

FIGURE 1: Time Series of Interest Rates







24.0000
17.0767
10.1533
3.2300
ITA
IRE
GER
1979Q2
1983Q3
1987Q4
1992Q1
1995Q4

Table 1: Unit root tests

Levels

	ADF(k)				k
	τ_μ		τ_τ		
Belgium	−1.64		−2.90		0
Denmark	−2.30		−4.35	*	0
France	−1.38		−3.26		0
Germany	−1.84		−1.97		1
Ireland	−2.40		−3.91	*	0
Italy	−1.24		−3.32		0
Netherlands	−1.18		−1.60		0

First Differences

	ADF(k)				k
	τ_μ		τ_τ		
Belgium	−8.58	*	−8.54	*	0
Denmark	−9.68	*	−9.61	*	0
France	−7.11	*	−7.09	*	0
Germany	−4.62	*	−4.62	*	0
Ireland	−8.26	*	−8.20	*	1
Italy	−6.58	*	−6.64	*	0
Netherlands	−6.14	*	−6.08	*	0

Note: The 5% critical values for τ_μ and τ_τ are −2.89 and −3.45, respectively (Fuller, 1976). A * indicates significance at 5%.

Table 2: Engle-Granger Cointegration Tests

	ADF(k)	k
Belgium	−2.87	0
Denmark	−2.98	0
France	−1.77	0
Ireland	−3.12	0
Italy	−1.41	0
Netherlands	−3.416	3

Note: The 5% critical value is −3.43 and is determined using Table 1 in MacKinnon (1991).

Table 3: Gregory-Hansen Cointegration Tests

	ADF*		Z_t^*		Z_α^*	
Belgium						
Model (2)	−4.45*	(0.45)	−5.81***	(0.43)	−44.18**	(0.46)
Model (3)	−4.43	(0.45)	−5.90***	(0.43)	−43.89*	(0.43)
Model (4)	−4.86*	(0.45)	−6.25***	(0.43)	−47.43**	(0.43)
Denmark						
Model (2)	−4.16	(0.58)	−5.13***	(0.57)	−37.87*	(0.57)
Model (3)	−4.67	(0.78)	−6.02***	(0.78)	−44.29*	(0.78)
Model (4)	−4.17	(0.58)	−5.15**	(0.57)	−38.05	(0.57)
France						
Model (2)	−3.27	(0.37)	−4.09	(0.37)	−23.49	(0.37)
Model (3)	−3.76	(0.16)	−4.62	(0.16)	−32.05	(0.16)
Model (4)	−3.14	(0.37)	−3.97	(0.37)	−22.54	(0.37)
Ireland						
Model (2)	−6.16***	(0.52)	−5.19***	(0.52)	−40.64**	(0.52)
Model (3)	−6.25***	(0.18)	−5.25**	(0.51)	−41.88	(0.51)
Model (4)	−6.34***	(0.52)	−5.32**	(0.52)	−42.13*	(0.52)
Italy						
Model (2)	−4.33	(0.39)	−3.77	(0.40)	−19.64	(0.40)
Model (3)	−4.63	(0.39)	−3.89	(0.40)	−19.16	(0.40)
Model (4)	−4.17	(0.39)	−3.64	(0.40)	−18.73	(0.40)
Netherlands						
Model (2)	−4.41*	(0.81)	−3.38	(0.79)	−20.75	(0.18)
Model (3)	−4.90*	(0.31)	−3.88	(0.37)	−25.50	(0.37)
Model (4)	−4.41	(0.81)	−4.17	(0.18)	−29.31	(0.18)

Note: ***, **, and * imply significance at 1%, 5%, and 10%, respectively. The numbers in parentheses are break points expressed as a percentage of the sample size.

Table 4: Dynamic OLS

(a) Model(2): $i_t = a + bD_t + ci_t^*$

		a	b	c
Belgium	(0.43)	5.137	−2.037	0.631
		(11.672*)	(−9.368*)	(−4.454*)
Belgium	(0.45)	4.961	−2.004	0.650
		(11.464*)	(−9.321*)	(−4.181*)
Belgium	(0.46)	4.680	−1.925	0.680
		(10.579*)	(−8.615*)	(−3.730*)
Denmark	(0.57)	6.386	−3.668	0.951
		(6.769*)	(−7.066*)	(−0.211)
Ireland	(0.52)	8.519	−4.471	0.823
		(6.815*)	(−6.691*)	(−0.747)
Netherlands	(0.81)	1.986	−0.539	0.766
		(0.969)	(−3.343*)	(−4.192*)

(b) Model(3): $i_t = a + bD_t + ci_t^* + d$ (trend)

		a	b	c	d
Belgium	(0.43)	5.258	−1.581	0.638	−0.014
		(11.681*)	(−3.592*)	(−4.313*)	(−1.189)
Denmark	(0.78)	10.676	0.468	0.612	−0.121
		(9.389*)	(0.508)	(−2.045*)	(−5.889*)
Ireland	(0.18)	8.999	3.009	0.762	−0.159
		(4.459*)	(1.998*)	(−1.247)	(−7.389*)
Ireland	(0.51)	11.692	−0.701	0.600	−0.115
		(7.441*)	(−0.465)	(−1.852)	(−2.733*)
Netherlands	(0.31)	1.813	0.626	0.808	−0.021
		(5.605*)	(2.353*)	(−2.850*)	(−3.609*)

(c) Model(4): $i_t = a + bD_t + ci_t^* + d(D_t i_t^*)$

		a	b	c	d
Belgium	(0.43)	6.048	−3.544	0.568	0.212
		(0.290)	(−4.911*)	(−5.063*)	(1.884)
Belgium	(0.45)	5.755	−3.408	0.542	0.194
		(9.437*)	(−4.951*)	(−4.571*)	(1.655)
Denmark	(0.57)	6.235	−4.189	0.967	0.051
		(5.420*)	(−2.080*)	(−0.134)	(0.122)
Ireland	(0.52)	9.054	−7.198	0.741	0.329
		(5.933*)	(−3.381*)	(−1.528)	(1.399)

Note: The numbers in parenthesis below a, b, and d are t-statistics for the null hypothesis that the corresponding coefficients are zero. The number in parenthesis under c is the t-statistic for the null that $c = 1$. The t-statistics follow a Student's t distribution asymptotically. * denotes significance at 5%.

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Enquiries:

Department of Economics
University College Galway
Ireland

Telephone	+353-91-524411 ext 2177
Fax	+353-91-524130
Email	claire.noone@ucg.ie
World Wide Web	http://www.ucg.ie/ecn/