Stability of price premiums for wool

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Abstract

The objective of this study was to determine whether long-run relationships existed between price premiums for wools with different fibre diameters. Based on cointegration analysis using monthly data from 1976.8 to 1999.10, the results showed that price premiums, in relative price terms, for fibre diameters between 19 and 23 micron were cointegrated. Furthermore, the price premiums for 19, 20 and 21 micron were found to be weakly exogenous. The latter result suggested that price premiums for finer wools tended to be more stable, compared with coarser wools which appeared to bear the burden of price adjustments. The implication is that wool producers would enjoy more stable prices, and hence income, by focusing on finer wools.

Key words: cointegration, error correction model, reserve price scheme, wool marketing.

Introduction

Wool is one of Australia's largest export commodities, bringing in around $4 billion in export earnings annually. However, the livelihood of Australian wool producers has been at stake in recent years because of falling demand and low prices (IWS 1997). As the problem persisted, a review of the Australian wool industry was conducted in 1999. One of the recommendations from the review was that the industry needs to become more cost competitive and market-oriented (Wool Taskforce 1999). Increasing supply of finer wools to suit increasing demand for casual wear is a key step towards meeting changing customer needs. However, not all farms are suitable for producing finer wools. Moreover, because such an endeavour involves changing flock and management practices, the benefits (price premiums) must outweigh the costs to provide an incentive for change. An analysis of the price relationships over time between wools of different fibre diameters would help evaluate potential benefits of producing finer wools. It can also provide useful information concerning the effectiveness of cross-hedging for reducing price risk (Lubulwa et al. M. 1997). Therefore, the main objective of this research is to determine the linkages between price premiums for wools of different fibre diameters based on cointegration analysis. In the process, the study also examines the effects on linkages of government intervention, particularly the reserve price scheme, in the marketing system.

The paper begins with a description of the wool market and preliminary analysis of the data. It then provides a brief introduction of the main concepts involved in cointegration analysis, particularly the relationships between vector autoregression, error correction models and cointegration. In the next section, an error correction model is used to test for unit roots and cointegration, based on the Johansen procedure. Discussion of the results is then provided, followed by areas for further research and concluding remarks.

Factors determining wool prices

Wool is not a homogeneous product. Therefore, the price for a specific bale (typically around 500 kg clean) or lot (comprising 5-10 bales of similar wools) is determined primarily by quality characteristics such as fibre diameter, fibre strength, fibre length, fibre colour, and vegetable matter content (Gleeson, Lubulwa and Beare 1993). Among these physical attributes of wool, fibre diameter is by far the most important, accounting for about 60 percent of the price variation. Fibre diameter is important because it affects the spinning capacity, strength and texture of the yarns, which in turn determines the fabric quality. For example, finer wools are softer and less prickly than coarser wools. As such, there are price premiums for wools with smaller micron.

However, the price premiums associated with fibre diameter, as well as other quality attributes, do change over time, as a result of changes in demand and supply conditions of related products, including various types of wool and other substitute fibres such as cotton and synthetics. It has been observed that price differentials between finer and coarser wools have increased in recent years (Griffith 1999). The main reason is the recent fashion changes from traditional and formal wear (suits, coats and trousers) to casual wear and lighter, softer and easier care fabrics. This shift in trend is in favour of finer wools at the expense of coarser wools. Since traditionally the Australian wool industry had concentrated on supplying wool for formal wear, the increasing demand for finer wools has resulted an increase in premiums for finer wools over coarser wools.

But because fibre of different diameters are, to varying degrees, potential substitutes (Beare and Meshios 1990), a price change in one market will cause necessary adjustments in related markets. Therefore, if the market is efficient, one would expect a strong linkage between related price series, particularly in the long run. The existence of an equilibrium relationship between related series means, in econometric terminology, that the series are co-integrated. In cases where a market is not efficient, as a result of market imperfection, the price linkage may be weakened and the equilibrium relationship may not exist and the related price series will not be cointegrated. For example, the reserve price scheme for Australian wool, instituted in the early 1970s until its demise in February 1991, may have caused a break down in such price relationships because of distorted market signals.

The wool price reserve scheme (RPS) was introduced in the early 1970s with an aim of stabilising wool prices (Bardsley, 1994). Under the scheme, wool was bought and stored as buffer stock when the price was considered to be too cheap; the stock was then put on the market when the price improved. The scheme appeared to work well in the early years. However, when the exchange rate was floated in the early 1980s, it became increasingly difficult to manage the scheme due to exposure to the international financial market. Moreover, when the price-setting process was taken over by the Australian Wool Council (AWC), which represented woolgrowers' interest, the minimum price was boosted to a level far above what buyers were willing to pay. Under the authourity of the AWC, the market indicator (the weighted average price) for wool was increased from 508 cents/kg clean in 1986/87 to 645 cents/kg clean in 1987/88, then to 870 cents/kg clean in 1988/89 -- a rise of over 70 percent in two years (Malcolm, Sale and Egan 1996). As sales plummeted in response to the steep price increase, AWC purchases grew rapidly. So did the stockpile. In May 1990, the minimum price dropped to 700 cents/kg clean. However, with no improvement in demand, the scheme collapsed. In March 1991, the RPS was abandoned and free market sales of wool was re-introduced.

Because the objective of the scheme was to stabilize prices, the effectiveness of the RPS is evaluated by examining the variability of wool prices associated with different fibre diameters. Price variability, as measured in terms of standard deviation and coefficient of variation (COV), is presented in Tables 1 and 2. It can be seen that wool prices had become more variable under the RPS than without the RPS. For example, the standard deviation for wool with 19 micron (M19) was 586 cents/kg clean with the RPS while it was 219 cents/kg clean without the RPS (see Table 1). The corresponding COVs are 0.63 and 0.23, respectively (Table 2). This is true for all wool types. Further, price variability in wool prices also increased with increases in fibre diameter.

Variability in price premiums is presented in Tables 3 and 4. Again based on standard deviation and COV, wool price premiums for adjacent fibre diameters were more variable with the RPS than without the RPS. For example, the standard deviation for price premium for M19 over M20 (M19-20) was 152 cents/kg clean with the RPS while it was 81 cents/kg clean without the RPS (see Table 3). Moreover, price premiums for finer wools (M19 – M22) appeared to have increased after the demise of the RPS while price premiums for wools of 23 to 25 micron had decreased. The latter result is consistent with Griffith's finding that an increase in demand for finer wools has accentuated the price differentials between finer and coarser wools. It also shows that when the free market was allowed to operate, prices (premiums) reflected better the demand/supply conditions for wools.

The RPS was also found to have created artificial price linkages between prices and between price premiums. As can be seen from Table 5, with the RPS, coefficients of correlation between wool prices of different fibre diameters are above 0.95, with only few exceptions. Even the correlation between M19 (fine apparel wool) and M30 (carpet wool) is as high as 0.97. By comparison, without the RPS, correlation between finer wools and coarser wools is greatly reduced (Table 6). Moreover, it appears that M23-25 are closer related with one another than M19-M21. In particular, the correlation between M19 and M30 has reduced from 0.97 with the RPS to 0.36 without the RPS. Similar results are found with price premiums (Tables 7-8), except that some price premiums have moved in opposite directions after the demise of the RPS, as indicated by negative correlation of coefficients (Table 8). Based on these results, it is evident that the RPS had resulted in an increase in variability of price and price premiums of Australian wool rather than stabilising them, as was intended by the Scheme. Another unintended effect of the RPS is the artificial linkages among wool prices and among price premiums.

Although standard deviation, COV and coefficient of correlation are useful statistics for understanding the basic characteristics, such as variability and linear association, of random variables, they are meaningful only when the underlying random variables are stationary, ie having constant mean and variance. However, many economic time series do not have a constant mean or variance, ie they are non-stationary (Myers 1994). This is true for the prices and price premiums that are under investigation in this research. As such, in the following sections, cointegration techniques are used to determine the dynamics and long-run equilibrium relationships between wool premiums, taking into account the impact of the RPS.

Methodology

The principal analytical tool to be used in this study is cointegration, as proposed by Johansen and Juselius (1990). In essence, the cointegration technique will determine whether a long-run stationary relationship exists among a set of non-stationary series based on the error correction model (ECM).

Vector autoregressive (VAR) models, error correction models (ECMs) and cointegration are related concepts in time series analysis used to characterise the relationships among the series being studied. In essence, it can be shown that, with re-parameterisation, the ECM is a standard VAR in first differences augmented by error correction terms. Moreover, according to the Granger Representation theorem, an ECM representation for a set of variables which are integrated of order one implies cointegration among the variables and vice versa (Engle and Granger 1987).

A standard VAR with lag length p, VAR(p), can be written as:

(1) $$x_t = A_0 + A_1 x_{t-1} + ... + A_p x_{t-p} + B D_t + C S_t + v_t, \quad t = 1,...,T,$$

where

p = lag length;

x_t = an (n x 1) vector of endogenous variables;

A's = (n x n) matrices of unknown parameters;

x_{t-j} = an (n x 1) vector of the jth lagged value of x_t;

D_t = a set of centred seasonal dummies;

S_t = a set of dummy variables representing structural changes; and

v_t = white-noise disturbance terms which may be contemporaneously correlated.

An ECM with lag length p, ECM(p), can be derived from the above VAR(p) by re-parameterisation. That is, simply by term manipulation, an ECM of the form can be obtained:

(2) $$\Delta x_t = \Pi_0 + \Pi_1 \Delta x_{t-1} + ... + \Pi_{p-1} \Delta x_{t-(p-1)} + \Pi x_{t-p} + B D_t + C S_t + v_t$$

$$= \Pi_0 + \sum_{i=1}^{p-1} \Pi_j \Delta x_{t-j} + \Pi x_{t-p} + B D_t + C S_t + v_t,$$

where

$\Pi_0 = A_0$,

$\Pi_j = - (I - \sum_{i=1}^{j} A_i)$, j = 1, 2, ..., p - 1;

$\Pi = - (I - \sum_{i=1}^{p} A_i)$; and

Δx_{t-j} = an (n by 1) vector of x_{t-j} in first differences, j = 1, 2, ..., p - 1.

Other variables are as previously defined. Therefore, without any loss of information, the ECM(p) in equation (2) is a transformation of the VAR(p) in equation (1) expressed in first differences augmented by the error correction term, Πx_{t-p}. For detailed derivations, see Enders (1995, pp. 389-90).

The Π matrix in equation (2), which is termed the long-run impact matrix of the ECM, is of primary importance. Firstly, the rank of Π provides the basis for determining the existence of cointegration or the long run relationship among the variables. According to Johansen (1988), there are three possibilities with regard to the rank of Π :

Case 1. If rank(Π) is zero, then the variables are not cointegrated and the model is equivalent to a VAR in first differences;

Case 2. If $0 < \text{rank}(\Pi) < n$, then the variables are cointegrated; and

Case 3. If rank(Π) = n , then the variables are stationary and the model is equivalent to a VAR in levels.

Secondly, the Π matrix can be decomposed into the product of matrices α and β, ie $\Pi = \alpha ß'$. α is the matrix of speed of adjustment coefficients, which characterises the long-run dynamics of the system, while ß is the matrix representing the cointegrating relations in which $ß'x_t$ (the disequilibrium error) is stationary (Johansen and Juselius 1990). A large (small) value of α means that the system will respond to a deviation from the long run equilibrium with a rapid (slow) adjustment. On the other hand, if the αs are zero for some equations, it implies that the corresponding variables do not respond to the disequilibrium error and, hence, may be weakly exogenous.

In summary, cointegration of a set of time series implies that long-run stationary relationships exist among the component nonstationary series. Because these series are linked by common stochastic trends, they do not move independently of each other and there are systematic co-movements among the series.

Data

Monthly prices for wools with fibre diameters, ranging from 19 micron to 25 micron for the period August 1976 to October 1999 (a total of 279 observations), are used for the current analysis. The price series, published in the AWEX Eastern Market Indicator and Micron Price Guide, are collated by the Wool International. The original price series includes the Eastern Market Indicator (EMI) and prices (cents/kg clean) for fibre diameters ranging from 19 micron to 26 micron, as well as 28 micron, 30 micron and 32 micron. Similar information is also available on a weekly basis.

This study focuses on wools range from 19 to 25 micron because together these wool types account for about 83 percent of total wool production in Australia, based on the 1993/4 data compiled by Stanton and Coss (1995). Among them, the 22 micron wool is the most commonly produced, accounting for 19.1 percent of total Australian wool production. The second most commonly produced wool is 21 micron (16.5 percent), followed by 23 micron (16.2 percent), 24 micron (10.2 percent), 20 micron (10.2 percent), 25 micron (5.6 percent) and 19 micron (4.8 percent). The remaining 17 percent are made up by wools with superfine wools of 15 to 18 micron (less than 2 percent), medium wools of 26 to 30 micron (about 12 percent) and coarser wools of 31 to 41 micron (about 3 percent).

Empirical model and estimated results

In this section, an ECM is developed to test the hypothesis that long-run relationships exist among Australian wool premiums based on the Johansen procedure. The Johansen procedure, as suggested in Enders (1995, pp. 396-400), includes the following four steps:

Step 1. Pre-test the order of integration and determine the lag length for the ECM based on a standard VAR.

Step 2. Estimate the ECM and determine the rank of Π.

Step 3. Analyse the cointegrating vector(s) and the speed of adjustment coefficients.

Step 4. Perform innovation accounting and causality tests on the ECM.

In Step 1, the order of integration of wool price premiums (expressed in relative prices) for different fibre diameters is tested based on the augmented Dickey-Fuller (DF) tests. Although the Johanson test can detect differing orders of integration, it is important not to mix variables with different orders of integration. As such, the pre-test employed here is to ensure that all variables are of the same order of integration.

Unit root in a time series indicates nonstationarity that has implications for economic theory and modelling (White 1997). In this study, both the augmented Dickey-Fuller test and Phillips-Perron test were used to test for unit roots using SHAZAM (Version 8, 1997). The results concludes that the null hypothesis of a unit root cannot be rejected for all price premiums. The same tests were performed on the first differences of these series and the rejection of the null hypothesis of a unit root verified that all price premiums are integrated of order one I(1).

After confirming that the price series under consideration are I(1), the next task is to determine the proper lag length for the ECM. The testing procedures involve making pair-wise comparisons between two standard VARs, each having a different lag length. The tests can be done based on the likelihood ratio (LR) tests or the Akaike information criterion (AIC) (Enders 1995, pp. 312-315). Applying the wool data to the standard VAR(p) specified in Equation (1), the variables are defined as follows:

> $x_t = [M19_t, M20_t, M21_t, M22_t, M23_t]'$ = a vector of price premiums, expressed in relative prices using M25 as numeraire;
>
> $x_{t-i} = [M19_{t-i}, M20_{t-i}, M21_{t-i}, M22_{t-i}, M23_{t-i}]'$ for i = 1, 2, 3,...,p;
>
> $S_t = 1$ for the period between 1976.8 to 1991.2 when the RPS was in operation; and $S_t = 0$, otherwise;
>
> D_t = monthly seasonal dummies, using December as the base period; and
>
> A's, B and C = unknown parameters to be estimated.

Other variables are as previously defined. S_t is included in the VAR model to reflect the existence of the reserve price scheme before March 1991.

Using RATS (Version 4, 1995), paired comparisons, each with different lag lengths, are made to determine the relevance of the dummy variables and the appropriate lag length for the

ECM. The LR test results suggest that neither seasonality nor the RPS had an impact on the price relationships. As such, they were removed from the model and the test for appropriate lag length was redone. Further LR tests suggest that 16 months to be an appropriate lag for the model, ie p = 16. The latter test result is presented in Table 9.

With the lag length of the ECM being determined, an ECM(16) is applied to the wool data. Based on the results obtained from Step 1, the ECM for wool premiums is specified as:

$$(3) \qquad \Delta x_t = \Pi_0 + \sum_{i=1}^{15} \Pi_j \, \Delta x_{t-j} + \Pi \, x_{t-16} + v_t,$$

where

$\Delta x_t = [\Delta M19_t, \Delta M20_t, \Delta M21_t, \Delta M22_t, \Delta M23_t]'$ = price premiums in first differences;

$\Delta x_{t-i} = [\Delta M19_{t-i}, \Delta M20_{t-i}, \Delta M21_{t-i}, \Delta M22_{t-i}, \Delta M23_{t-i}]'$ for i = 1, 2, ..., and 15;

$x_{t-16} = [M19_{t-16}, M20_{t-16}, M21_{t-16}, M22_{t-16}, M23_{t-16}]'$;

Π_i's = (5 by 5) matrices of unknown parameters representing the short-run dynamics;

$\Pi = \alpha ß'$ = the matrix of unknown parameters representing the long-run dynamics; and

v_t = white noise disturbance terms which may be contemporaneously correlated.

Other variables are as previously defined.

Two versions of the ECM(16), Models A and B, are estimated based on the Johansen procedure using CATS in RATS (Doran 1994). Model A is the unrestricted model where the constant term is incorporated in the equation. Model B is the restricted model where the constant term is incorporated in the cointegrating vectors. The estimated results regarding the rank of Π, r, for both versions are presented in Table 10.

As can be seen in Table 10, the maximal eigenvalue statistics (λ_{max}) and the trace statistics (λ_{trace}) indicated that the rank of Π is one for both Model A and Model B. This meant that the three wool premiums are cointegrated with one cointegrating relation. To discriminate between Models A (with a trend drift) and B (with a constant term in the cointegrating vector), the test statistic LR_λ, which is suggested in Enders (1995, pp. 393), is used. The LR_λ is defined as:

$$(4) \qquad LR_\lambda = - T \sum_{i=r+1}^{n} [\ln(1 - \lambda_i^*) - \ln(1 - \lambda_i)],$$

where λ_i^* and λ_i are estimated eigenvalues of the matrix Π for the restricted (Model B) and unrestricted (Model A) models, respectively ; r is the number of cointegrating vectors in the unrestricted model; and n is the number of endogenous variables.

Given that $n = 5$ and $r = 1$, the computed value for LR_λ is 0.92, which is much smaller than the critical value of 9.49 with four degrees of freedom at the 5 per cent significance level (bottom of Table 3). Therefore, Model B (the restricted version) is not rejected and it is concluded that the ECM could be specified with the constant term being restricted in the cointegrating relation.

As indicated in Table 11, the estimated cointegrating relation or long-run equilibrium relationship, normalised by the β associated with the price premium for 19 micron wool, can be written as:

$$(5) \qquad M19 - 6.33 - 7.55\ M20 + 20.50\ M21 - 25.50\ M22 + 18.23\ M23 = 0.$$

since the five series are shown to be cointegrated, the system can be expected to return to the equilibrium after being perturbed by exogenous shocks. The estimated speed of adjustment, which is indicated by the magnitude of the adjustment coefficients, to the disequilibrium errors is shown in the bottom half of Table 11. It can be seen that the α coefficients associated with M19 - M21 are statistically insignificant while they are statistically significant for M22 and M23. This result suggests that the price premiums for 19, 20 an 21 micron wools may be weakly exogenous to the system.

Discussion of results

The main result from the cointegration test suggests that price premiums for 19 to 23 micron wools are cointegrated. This means that an equilibrium relationship exists between price premiums for these five types of wool. Moreover, it was found that price premiums for 19 -21 micron wools are weakly exogenous. This means that price premiums for these wools (19 - 21 micron) do not adjust if the market is in disequilibrium. As such, the long-run equilibrium in the Australian wool market, after an exogenous shock, is restored by adjustments made by wools with 22 to 23 micron. Although the price premiums for finer wools do not respond to disequilibrium, they do adjust through the short-run dynamics of the system. Therefore, they still play a role in restoring the equilibrium of the system despite being weakly exogenous.

The full results from the ECM, which are not reported here to save space, are available from the authors for interested readers.

Conclusion

Using Johansen's procedure, the cointegration analysis shows that the five types of wools, with fibre diameter ranging from 19 to 23 micron are integrated of order one and they are cointegrated. This means that they are non-stationary but tend to move together over time and respond to the same exogenous shocks to the system. However, there is no clear evidence that either the reserve price scheme or seasonality had any impact on the equilibrium relationship. Furthermore, wools with 19 to 21 micron were found to be weakly exogenous. The latter result suggested that price premiums for finer wools were more stable, compared with coarser wools which appeared to bear the burden of price adjustments. The implication is that wool producers would enjoy more stable prices, and hence income, by focusing on finer wools.

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Table 1. Average prices and standard deviations for wool of different fibre diameters in different time period

	August 1976 – Feb 1991 (under RPS)	March 1991 – November 1999 (without RPS)	August 1976 – November 1999 (whole sample)
M19	951 (596)*	936 (219)	945 (483)
M20	813 (460)	785 (168)	802 (372)
M21	688 (326)	674 (136)	683 (267)
M22	648 (274)	612 (111)	634 (225)
M23	589 (226)	543 (93)	571 (187)
M24	546 (183)	527 (93)	538 (154)
M25	491 (152)	504 (92)	497 (132)
M30	392 (121)	444 (71)	413 (107)
EMI	689 (288)	659 (109)	677 (234)

*Figures in parentheses are standard deviations.

Table 2. Coefficients of variation (COV) for wool prices of different fibre diameters in different time period

	August 1976 – Feb 1991 (with RPS)	March 1991 – November 1999 (without RPS)	August 1976 – November 1999 (whole sample)
M19	0.63	0.23	0.51
M20	0.57	0.21	0.46
M21	0.47	0.20	0.39
M22	0.42	0.18	0.35
M23	0.38	0.17	0.33
M24	0.34	0.18	0.29
M25	0.31	0.18	0.27
M30	0.31	0.16	0.26
EMI	0.42	0.17	0.35

[a] COV = standard deviation/mean.

Table 3. Average price premiums and standard deviations for wools of different fibre diameters in different time period

	August 1976 – Feb 1991	March 1991 – November 1999	August 1976 – November 1999
M19-20	138 (152)	151 (81)	143 (129)
M20-21	125 (139)	111 (75)	119 (118)
M21-22	40 (60)	62 (49)	49 (57)
M22-23	59 (52)	69 (36)	63 (46)
M23-24	43 (47)	16 (12)	32 (39)
M24-25	54 (33)	23 (9)	42 (31)

Table 4. Coefficients of variation for price premiums between wools of different fibre diameters in different time period

	August 1976 – Feb 1991	March 1991 – November 1999	August 1976 – November 1999
M19-20	1.10	0.54	0.90
M20-21	1.12	0.67	0.99
M21-22	1.51	0.78	1.17
M22-23	0.88	0.52	0.73
M23-24	1.09	0.74	1.22
M24-25	0.61	0.41	0.74

Table 5. Correlation between wool prices, under the RPS

	M19	M20	M21	M22	M23	M24	M25	M30
M19	1.							
M20	0.99178	1.						
M21	0.98255	0.99507	1.					
M22	0.97462	0.98625	0.99446	1.				
M23	0.96826	0.97675	0.98632	0.99680	1.			
M24	0.95553	0.96304	0.97514	0.98839	0.99588	1.		
M25	0.95045	0.95732	0.96953	0.98332	0.99194	0.99743	1.	
M30	0.92954	0.95651	0.96265	0.96301	0.95189	0.93278	0.92506	1.

Table 6. Correlation between wool prices, without the RPS

	M19	M20	M21	M22	M23	M24	M25	M30
M19	1.0000							
M20	0.94586	1.0000						
M21	0.75007	0.89887	1.0000					
M22	0.53864	0.72478	0.94137	1.0000				
M23	0.37689	0.55566	0.82515	0.95350	1.0000			
M24	0.36599	0.53533	0.80516	0.93227	0.99204	1.0000		
M25	0.36778	0.52978	0.80125	0.92190	0.98202	0.99495	1.0000	
M30	0.35775	0.54011	0.82383	0.91901	0.93274	0.93391	0.93999	1.

Table 7. Correlation between wool price premiums, under the RPS

	PD1920	PD2021	PD2122	PD2223	PD2324	PD2425
PD1920	1.0000					
PD2021	0.88154	1.0000				
PD2122	0.74037	0.87942	1.0000			
PD2223	0.75874	0.91156	0.88825	1.0000		
PD2324	0.80845	0.91704	0.81600	0.93677	1.0000	
PD2425	0.79155	0.86397	0.75318	0.86530	0.88048	1.0000

Table 8. Correlation between wool price premiums, without the RPS

	PD1920	PD2021	PD2122	PD2223	PD2324	PD2425
PD1920	1.0000					
PD2021	0.78417	1.0000				
PD2122	0.56292	0.74366	1.0000			
PD2223	0.20684	0.39804	0.74138	1.0000		
PD2324	-0.09825	0.07478	0.05816	0.35642	1.0000	
PD2425	-0.17212	0.02628	-0.11175	0.09009	0.38059	1.0000

Table 9. Summary of test statistics for determining the lag length in standard VARs

Lag length		Calculated χ^2(df)	Test results
Unrestricted model	Restricted model		
18	16	37.56 (50)	fail to reject H_0, p-value = 0.90
16	14	66.41 (50)	reject H_0, p-value = 0.06

Table 10. Summary of rank tests on matrix Π of the ECM

Model A. Incorporating the trend drift in the ECM		
	Estimated λ	λ_{trace}
λ_1	0.1459	78.58 (64.74)
λ_2	0.0636	37.11 (43.84)
λ_3	0.0405	19.83 (26.70)
λ_4	0.0257	8.97 (13.31)
λ_5	0.0080	2.11 (2.71)
Model B. Restricting the constant in the cointegrating vector		
	Estimated λ	λ_{trace}
λ_1*	0.1460	79.56 (71.66)
λ_2*	0.0636	38.05 (49.92)
λ_3*	0.0406	20.76 (31.88)
λ_4*	0.0277	9.86 (17.79)
λ_5*	0.0093	2.47 (7.50)
LR_λ =0.92 < 9.49 (df = 4; α = 5%)		

[a] The figures in parentheses are critical values for λ_{trace} statistics at the 10 per cent significance level.

Table 11. Estimated long-run parameters, αs and βs, r = 1

	M19	M20	M21	M22	M23	CONSTANT
βs	1.00 (--)[a]	-7.55 (--)	20.50 (--)	-25.50 (--)	18.23 (--)	-6.33 (--)
αs	-0.012 (-0.40)[b]	0.033 (1.69)	0.019 (1.45)	0.033 (3.70)	0.018 (3.20)	

[a] t-ratios for β coefficients are not calculated.

[b] Figures in parentheses are t-values.