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Long-run relationships between world vegetable oil prices†

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In the international edible oil markets, there is believed to be high substitutability between vegetable oils and fats produced under different conditions. In light of this, we consider the question: what is the nature of the long-run relationships between vegetable oil prices? Long-run co-movements among oil prices are analysed, based on a multivariate cointegration model. The empirical finding is that most co-movements are consistent with the predictions of market theory. Prices of oils tend to be grouped according to their different end-uses. Some policy implications of a buffer stock scheme are discussed.

1. Introduction

It is widely believed that in the international edible oil markets there is a high substitutability of a wide range of oils and fats originating under different production conditions. Oilseeds are produced all over the world and are important for the export performance of many developed and developing countries. The aim of this study is to determine patterns of co-movement of world oil prices and hence to gain a better understanding of how the world edible oil market operates. The study uses cointegration analysis, which helps in identifying any long-run relationships that may exist. It represents an improvement over the methods used in the literature.

Fortunately, world oil markets are highly competitive, being relatively free from the trade restrictions and price distortions that plague other agricultural products. Although taxes have been placed on vegetable oils by some countries to protect their domestic crushing and refining industries, they have generally not been very high and have been short-lived. Thus, in general, world prices of oil products are not greatly distorted.

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An understanding of the vegetable oil market is important for planning and policy-making. It would be interesting, for instance, to examine the impact that a large increase in the supply of one particular oil might have on the world oil market. For example, if the supply of palm oil increased faster than the supply of other oils, would the price of palm oil decrease? How would this affect prices of other oils? Furthermore, an understanding of the dynamics of edible oil markets is important for policy-making purposes. Policies regarding production and trade of vegetable oils in a particular country should take account of the world supply and demand situation since the prices of oilseed and oilseed products are important for the producers, crushers and exporters of oils.

There has been a significant amount of research in this area. Three basic approaches have been taken in the previous studies relating to world oilseeds and oil markets. First, some studies focus on how the world oils markets affect economic development in the vegetable oils exporting nations (Williams and Thompson 1984). Second, there are studies of how the world oil markets influence the vegetable oil consuming nations (Goddard and Glance 1989; Friedeberg 1989). The third category of study looks at how international commodity policies may improve such markets (Hwang 1990).

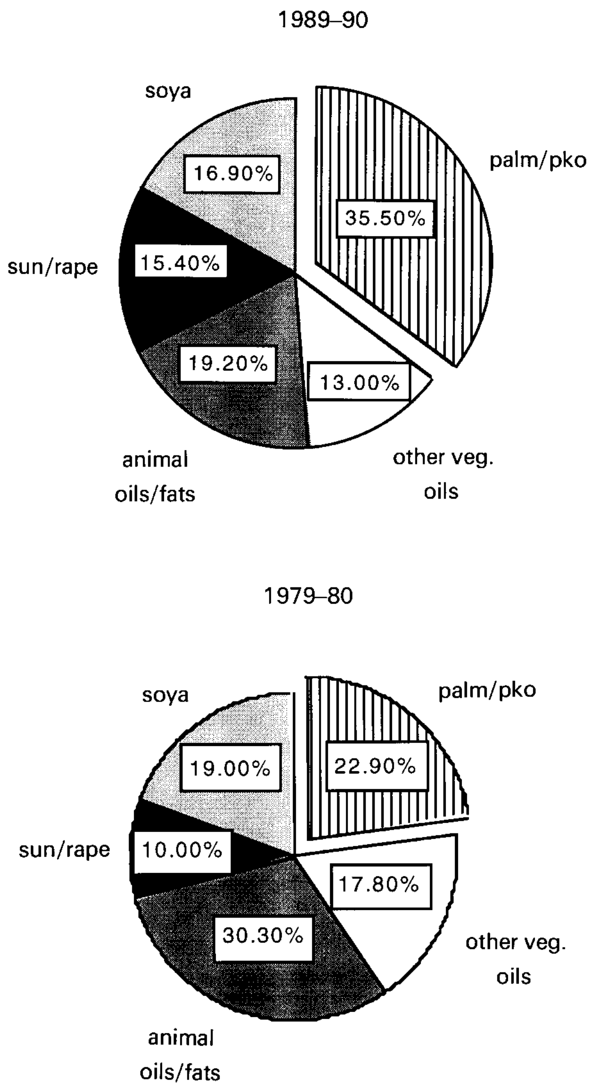
Given the high degree of substitutability among vegetable oils traded in the international market, the prices of these oils are not likely to diverge greatly from each other, at least in the long run. In this study, the world prices of eight vegetable oils, over a period from October 1976 to March 1990 are analysed in an attempt to establish the co-movements among oil prices, and to analyse the long-run relationships that may exist between the prices of these oils. A multivariate cointegration approach is used to examine the price behaviour of vegetable oils[1] with similar end-uses. Causal influences of one price on another can also be considered in this framework. Information about how a change in some oil prices may bring about changes in other oil prices will help the growers, crushers and refiners of oilseeds, as well as the countries involved in the oilseed trade. This will also help in deciding which oil or group of oils to include in a buffer stock of oils.

2. World oil markets situation

Since World War II, world markets for fats, oils and high protein meals have grown in both value and complexity. Markets for some oils have grown more rapidly than others. In all cases, however, production and trade have

[1] Deaton and Laroque (1992) note that the prices of many agricultural products are governed by complicated non-linear stochastic processes. Certainly, the modelling of price behaviour of vegetable oils in a non-linear framework deserves future research.

expanded to meet the rising demand, stimulated by both population and income growth around the globe. The relative importance of individual oils and fats in world exports between 1979–80 and 1989–90 has been reported (figure 1). Palm and palm kernel oils as a group had the largest market share



Source: *Oil World Annual* (1990)

Figure 1 World export shares of all oils and fats by kind

Table 1 World production and trade of major oils (1988–89)

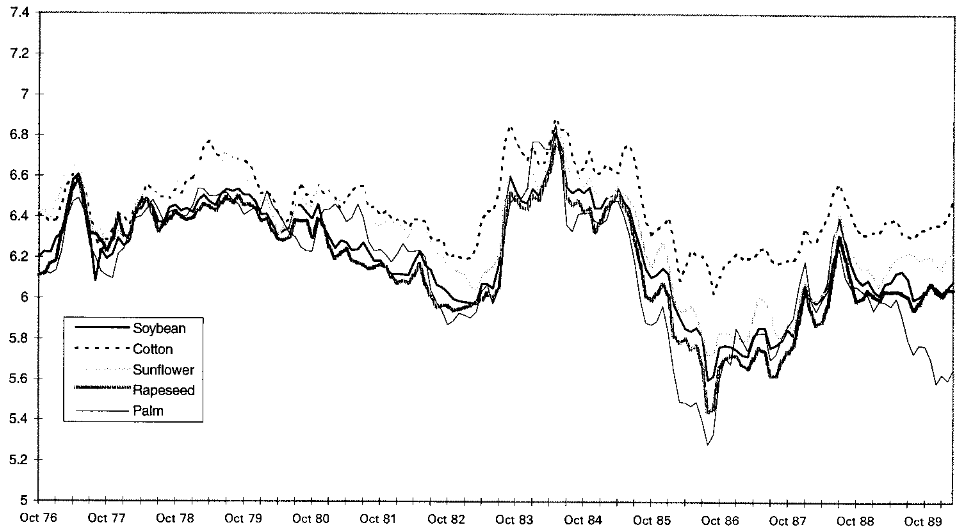
Oil	('000 tonnes) Production	Imports
Soybean	14695.1	3728.1
Cottonseed	3778.6	312.9
Groundnut	4237.4	375.9
Sunflower seed	7473.7	2257.4
Rapeseed	7765.9	1775.6
Palm	9744.7	7440.9
Palm kernel	1224.7	785.7
Coconut	2659.5	1244.7
Total of 8 oils	51579.6	17921.2
Total of all oils and fats	76107.0	25030.0
8 oils as percentage of all oils and fats	67.77	71.60

Source: *Oil World Annual* (1990)

in 1989–90, while they had the second position in 1979–80. Animal fats, on the other hand, had the second largest share in 1989–90, while they enjoyed the highest market share in 1979–80. Sunflower oil and rapeseed oil increased their share significantly from 1979–80 to 1989–90. Soybean oil retained its position over the period. It should be emphasised that the oils chosen for this study are important in terms of world trade. Table 1 shows their relative importance in terms of production and imports. From table 1, the eight oils under study constitute 68 per cent of the total world production, and 72 per cent of the world's imports. Soybean oil dominates world production, making up 28.5 per cent of the eight oils' production, while palm oil is the most traded of the oil products, accounting for 30 per cent of exports in 1988–89. Palm, soybean, sunflower and rapeseed oil have the highest production and trade. They are, therefore, more likely to influence the overall price situation in the world oil market. This question will be tested in the empirical analysis later.

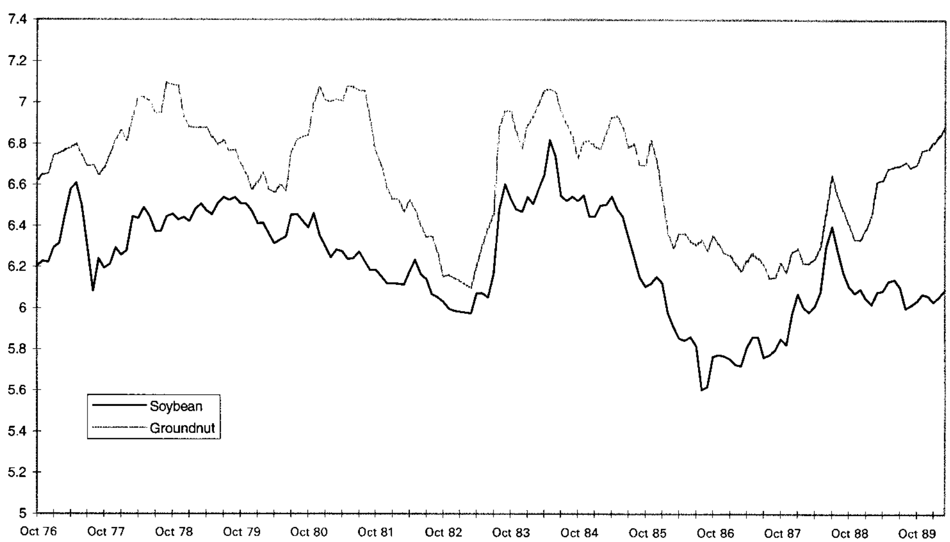
The eight oils which are selected in this study find similar end-uses in the food industry. For example, they are used to produce margarine, shortening and blended oil. Substitution can be made between all eight oils in the culinary, margarine and shortening trade. Vegetable oil price variables are thus expected to have co-movements in the long run because of the strong substitutability between various oils. The purist form of substitutability and interchangeability is in blending.

While all the eight oils are all close substitutes for margarine, shortening and blended oils, there are other differences in end-use. It will be helpful to classify the oils according to similar end-uses in the food industry. Based on the end-uses, the eight oils can be conveniently categorised into three groups:



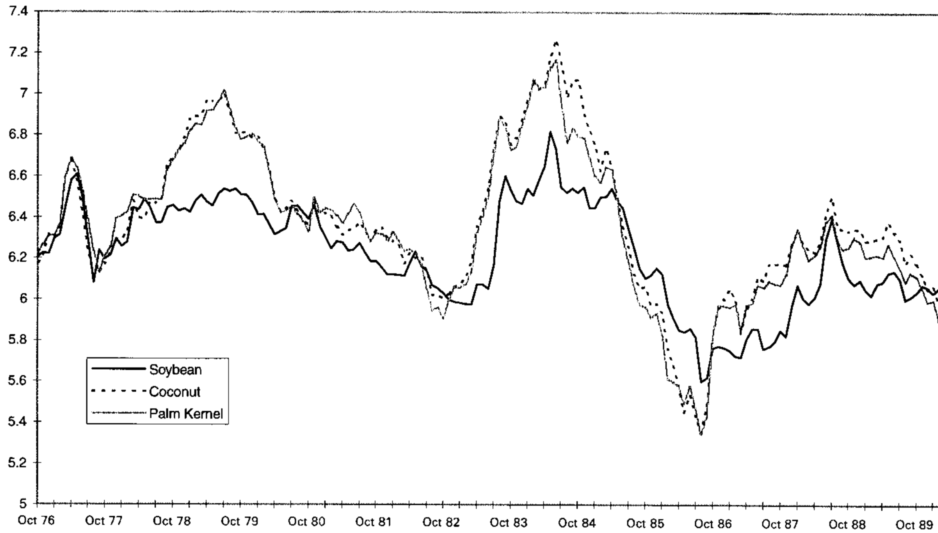
Source: *Oil World Annual* (1990)

Figure 2 Log of vegetable oil prices



Source: *Oil World Annual* (1990)

Figure 3 Log of vegetable oil prices



Source: *Oil World Annual* (1990)

Figure 4 Log of vegetable oil prices

(a) general oils (soybean, cotton, rapeseed, sunflower and palm); (b) groundnut; (c) coconut and palm kernel. We put soybean, cotton, rapeseed, sunflower and palm oils together for a number of reasons: (1) soybean is the largest single source of vegetable oil and protein meal. Soybean and sunflower are often called polyunsaturated oils and are preferred to other oils due to health consciousness, as saturated oil (coconut) is known to cause heart disease. (2) The mixture of soybean, rapeseed and sunflower oils are used to make margarine, accounting for 75 per cent of the vegetable oils used in the production of margarine. (3) The main retail products for cooking oils are low-cost blended products, such as soybean and rapeseed blend. (4) Palm, rapeseed and soybean oils are mostly used in compound fats. So, those five oils are very close substitutes for most end-uses (i.e., margarine, cooking oils and compound fats).

Groundnut oil stands alone in terms of end-use, as it has more limited use in the culinary, margarine and shortening trade, because groundnut oil is better for frying purposes. In the catering sector, higher performance specifications such as groundnut oil and palmolein are necessary for frying oils. For group (c), we put coconut and palm kernel as a separate group because palm kernel and coconut oils are together called lauric oils. Lauric oil (coconut and palm kernel oils) are better suited for soap making and have advantages over other vegetable oils in this field. Owing to their special uses, demand for these lauric acid oils is more price-inelastic than demand for other oils and relatively sharper price changes are required for demand to adjust to changes in supply.

Based on the above market characteristics, the prices of the oils are graphed in these three groups (figures 2, 3, and 4). Price of soybean oil is plotted in each one to be able to compare across graphs. It is seen from figure 2 that the soybean, cotton, rapeseed, sunflower and palm display similar but not identical patterns. The five oil price variables exhibited marked upward (late 1983) and downward (early 1982 and 1986) trends during the period of 1976:10 to 1990:3. Observe also that sunflower and cotton oil prices are always slightly higher than the soybean price over the period, due to the fact that sunflower oil is highly valued on account of its high content of unsaturated fatty acids, while it appears that cotton oil prices are slightly higher due to a higher cost of production relative to the low-cost soybean product.

From figure 3, notice that the price movement of groundnut is clearly different from that of soybean and other mainstream oil prices for reasons given above. In figure 4 notice that coconut and palm kernel oil differ from the mainstream oils, but are connected closely to each other. It is clear from figure 4 that coconut oil and palm kernel oil appear to show very strong co-movement in the long run.

In each graph, there are a few periods of sharp movement in some series which could suggest one-off behaviour that needs to be modelled with outlier dummies, for example. However, observe that almost always the sharp movements occur with several series, not just one, so cointegration analysis should eliminate this behaviour from the linear combinations of series obviating the need for dummy variables.

Categorising the eight oils in the above three groups implies that three common trends should exist among the eight variables, one for each group. Conversely, five cointegrating vectors should also exist. Inspection of figure 2 suggests, however, that the five oil prices may not be adequately described by one common trend. There is indication of an excessive diversity of price movements. The empirical analysis to follow will address this question.

The remainder of this article is organised as follows. In section 3 we describe our main methodology, Johansen's maximum likelihood for cointegrated vector autoregressive models. Section 4 contains the empirical results on the number of common trends tests of restrictions on the cointegrating relationships, and weak exogeneity tests. Section 5 contains concluding comments.

3. Johansen's test procedure

Johansen (1988) and Johansen and Juselius (1990) set out a maximum likelihood procedure for the estimation and testing of the cointegrating vectors in a VAR system. Suppose the vector of p-variables,

$Z_t = (Z_{1t}, \dots Z_{pt})'$, is generated by the k-order vector autoregressive process with Gaussian errors

$$Z_t = A_1 Z_{t-1} + \dots A_k Z_{t-k} + \mu + \Psi D_t + \varepsilon_t, t = 1, \dots, T \quad (1)$$

where Z_t is a $p \times 1$ vector of stochastic variables, $\varepsilon_1, \dots, \varepsilon_T$ are i.i.d. $N_p(0, \Sigma)$ and D_t are centred seasonal dummies, and μ is a vector of constants. Since we want to distinguish between stationarity by linear combinations and by differencing, this process may be rewritten in error correction form as

$$\Delta Z_t = \Gamma_1 \Delta Z_{t-1} + \dots + \Gamma_{k-1} \Delta Z_{t-k+1} + \Pi Z_{t-k} + \mu + \Psi D_t + \varepsilon_t, t = 1, \dots, T \quad (2)$$

The matrix Π contains the long-run information in the system and is analogous to the error-correction representation of Engle and Granger (1987). Information about the number of cointegrating vectors is found in the rank of Π. Denote the rank of Π as $r < p$; there exists a representation of Π such that $\Pi = \alpha\beta'$ where α and β are both $p \times r$ matrices. The matrix β is called the cointegrating matrix and has the property that $\beta' Z_t \sim I(0)$, where $I(d)$ indicates 'integrated of order d'. Thus we can interpret the relations of $\beta' Z_t$ as the stationary relations among potentially nonstationary variables, i.e. as cointegrating relations. Johansen (1988) and Johansen and Juselius (1990) develop a maximum likelihood estimation procedure for μ, Γ_i, α, β and ε and also provide tests for the number of cointegrating vector. Since Johansen's test procedure is well known, a description of the specific details is omitted here for the sake of brevity.

The error-correction formulation (2) can be used as the basis for testing for weak exogeneity among variables. In this article, a weak exogeneity testing procedure is applied to investigate which are the exogenous variables among the several oilseed price variables. The idea of defining exogeneity for a given set of parameters of interest is central for the concept of exogeneity proposed by Engle, Hendry and Richard (1983). Generally, a variable X_t can be regarded as weakly exogenous for a set of parameters of interest, say Ψ, if the marginal process for X_t contains no useful information for the estimation of Ψ; that is, if inference for Ψ can be efficiently made conditionally on X_t alone and its marginal process contains no relevant information. The concept can also be formulated in reverse. That is, X_t is weakly exogenous for the parameters of interest Ψ, if knowledge of Ψ is not required for inference on the marginal process of X_t (see Spanos 1986, pp. 376 and 421–2).

To understand the nature of exogeneity testing in this context, we start with equation 2. Following Juselius (1991), let us partition the vector $Z_t = (Y_t, X_t)'$, where Y_t denotes the endogenous variables and X_t denotes the potential set of weakly exogenous variables, and rewrite equation 2 in this form, assuming for simplicity that $k = 2$.

$$\begin{bmatrix} \Delta Y \\ \Delta X \end{bmatrix}_t = [\Gamma_1] \begin{bmatrix} \Delta Y \\ \Delta X \end{bmatrix}_{t-1} + \begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{bmatrix} \begin{bmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \end{bmatrix} Z_{t-1} + \begin{bmatrix} \mu_1 \\ \mu_2 \end{bmatrix} + \Psi D_t + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \end{bmatrix} \tag{3}$$

Based on equation 3, we can infer that the condition for $\{X_t\}$ to be weakly exogenous for β is that $\alpha_{2\bullet} = (\alpha_{21} = \alpha_{22}) = 0$, implying that the equations for ΔX_t do not contain information about the long-run parameters β or, to put it differently, the long-run parameters β can be estimated efficiently without the equation for ΔX_t. Testing for weak exogeneity of a particular variable thus boils down to testing whether the corresponding row of α is zero. The results of this testing for each variable will be discussed in section 4.

Finally, note that the variables in the Johansen method need not all be $I(1)$. Johansen's method allows us to perform cointegration analysis using a mixture of $I(1)$ and $I(0)$ variables. Suppose, for example, that Z_{1t} were $I(0)$. This would show up in the analysis as a cointegrating relationship with a 'cointegrating vector' given by $(1, 0, 0, \ldots, 0)'$. For this reason, we do not present the results of the univariate unit root test prior to undergoing the cointegration analysis.[2]

4. Empirical results: data

It is common to use natural logarithms with price data as movements in price are generally understood to be stable in percentage terms rather than absolute terms. A logarithm transformation thus gives us a set of variables where approximating their relationships in a linear way is appropriate.

We consider the natural logarithms of eight vegetable oil price variables. The study uses monthly data of vegetable oil prices from October, 1976 to March, 1990. Prices are taken from various issues of *Oil World Weekly* and *Oil World Annual, 1990* published by the Information Service for Statistical Analysis of the World Markets of Oilseeds, Oilmeals, Vegetable, Animal and Marine Oils and Fats (ISTA), Mielke Gmbh, Hamburg. During the period under study, from 1976 to 1990, there have not been dramatic changes in the structure of the world oil market, which means that there should not be any major anomalies in the results obtained. All the prices used in the study are border prices, free on board (f.o.b.) and cost, insurance and freight (c.i.f.) prices in terms of US$ per 1000 tonnes. Prices will thus reflect

[2] Johansen's procedure as used in this article would not be valid if the variables were $I(2)$. Preliminary unit root tests clearly rejected this possibility against the alternative of $I(1)$. We do not report the results here for the sake of brevity.

somewhat movements in the US dollar, but this is of no concern since we are only interested in relative movements in prices. Prices taken are at the various ports of the world. For example, soybean oil prices are Dutch, f.o.b., ex mill prices, while groundnut oil prices are Rotterdam, c.i.f. prices. Being the major trade centres, the prices at these places are most representative. The major portion of vegetable oils traded in the international market are crude vegetable oils, which do not have significant quality differences. There are two main reasons for limited trade in refined vegetable oils. There are technical problems involved in exporting refined vegetable oils with regard to transportation. The importing countries also prefer not to import refined oils, because of extra costs involved.

4.1 Cointegration among vegetable oil prices

In this section, we estimate the number of cointegrating relationships contained in the logarithms of vegetable oil prices. We first establish an eight-variable VAR model. In choosing the specification of the VAR model, it is necessary to select the number of lags in the autoregressive specification. We begin by estimating the unrestricted VAR model (1) with the vector of stochastic variables.

$$Z_t = [sb, co, gn, su, ra, cc, pk, pm]'_t \quad t = 1976:10, \ldots, 1990:3$$

where $sb, co, gn, su, ra, cc, pk, pm$ are the logarithms prices of soybean, cotton, groundnut, sunflower, rapeseed, coconut, palm kernel, and palm price, respectively. The effective sample size is 162, from 1976:10 to 1990:3. A constant and eleven monthly dummies are included in the regression, although seasonal effects seem to be very small.

After some experimentation, a lag length for the VAR of $k = 3$ was settled upon. We sought to obtain a lag's length as small as possible, whilst seeking to pass as many diagnostic tests on the residuals as possible. The diagnostic statistics for the residuals of this model are presented in table 2. From this table, we can infer that the assumed stochastic specification of the basic model seems adequate in all equations. Several of the Jarque-Bera statistics are quite high, particularly for groundnut, but little improvement could be achieved with different values of k. A few sharp movements in prices in the sample period appear to be the cause of this problem. The main consequence of this problem is that the null distributions of the test statistics which follow are not likely to be well approximated by the asymptotic distributions tabulated by Johansen and others. This needs to be borne in mind in the treatment of the results that follow.

The next step of the analysis is to 'estimate' r, the number of cointegrating relationships.

Table 2 Diagnostic statistics for unrestricted VAR($k = 3$)

Equation	B–P.Q[a]	ARCH[b]	Skew[c]	Ex.kurt[d]	J–B. Norm[e]
sb	20.84	0.68	0.34	1.20	12.77
co	24.60	1.94	0.39	0.11	4.18
gn	26.90	2.84	0.78	1.68	35.05
su	18.28	0.07	0.49	1.06	14.06
ra	20.87	1.42	0.12	0.29	1.01
cc	40.41	1.62	0.45	0.37	6.31
pk	28.47	1.59	0.56	0.87	13.47
pm	35.97	0.36	0.17	0.69	3.96

Notes: Critical value at 95% level $\chi^2(2) = 5.99$, $\chi^2(3) = 7.81$, $\chi^2(33) = 47.37$
[a] The Box–Pierce Q statistics sums 36 autocorrelations, and the degrees of freedom is given by the number of autocorrelations summed minus the order of the AR (3) process, namely 33.
[b] ARCH (f) is a test statistic for autoregressive heteroscedasticity approximately distributed as $\chi^2(f)$, where $f = 3$ in this case.
[c] Skew is the third moment around the mean.
[d] Ex.kurt is the fourth moment around the mean.
[e] J–B Norm is the Jarque–Bera test statistic for normality distributed as $\chi^2(2)$.

In table 3, the likelihood ratio test statistics for the rank of Π are presented, along with the 95 per cent quantiles of the appropriate limiting distributions. Two versions of the test procedure are reported in table 3. The first is based on the trace and the second on the maximum eigenvalue. We begin with $H_0 : r = 0$ and moving sequentially up until a non-rejection is found. With the λ_{max} test we cannot reject $H_0 : r \leq 1$, suggesting a choice of $r = 1$. The trace test, in contrast, leads to a choice of $r = 5$. Note that for both tests, however, several of the test statistics are close to the critical values.

To aid inference regarding r, the cointegrating disequilibrium variables are all plotted. The maximum likelihood procedure estimates the columns of β, the cointegrating vectors, in some priority order. That is, β_1 corresponds

Table 3 Testing the cointegrating rank

H_0	Trace	Trace (0.95)	λ_{max}	λ_{max} (0.95)
$r \leq 7$	2.34	3.84	2.35	3.84
$r \leq 6$	9.62	12.53	7.27	11.44
$r \leq 5$	21.81	24.31	12.18	17.89
$r \leq 4$	41.81	39.89	20.00	23.80
$r \leq 3$	66.23	59.46	24.42	30.04
$r \leq 2$	96.23	82.49	30.00	36.36
$r \leq 1$	130.20	109.99	34.00	41.51
$r = 0$	182.30	141.20	52.02	47.99

Note: Critical values are taken from Osterwald–Lenum (1992).

to the largest eigenvalue and hence to the linear combination of Z_t which is 'most stationary' and β_8 to the combination which is 'least stationary'. Although the graphs of cointegrating disequilibrium terms are not reported here, they inclined to select $r = 4$. Results which follow will be based on this choice.

The discussion in section 2 suggests that we might expect there to be five cointegrating vectors. This is clearly not supported by the data. It is of interest to consider where the analysis has departed from what was expected in our current understanding of the market. This can be examined by testing some hypotheses about the cointegrating space. What has been obtained is an $8 \times r$ matrix β (where $r = 4$) whose columns form a basis of the cointegrating space. We can test whether certain vectors are contained in the cointegrating space. Table 4 presents the hypotheses to be tested and the results of the tests.

Recall that in section 2 we grouped the variables into three groups (a), (b) and (c). The variables within each group are expected to be cointegrated in the form that the difference between one and the other is stationary. For example, prices of soybean oil (Z_{1t}) and sunflower oil (Z_{4t}) are both part of group (a), so we wish to test whether $Z_{1t} - Z_{4t}$ is stationary. This is equivalent to testing whether the cointegrating space contains the vector $\beta_0 = (1, 0, 0, -1, 0, 0, 0, 0)'$.

Consider first the tests of the five group (a) variables. Four pairwise tests of the form described above find cointegration between soybean oil and sunflower oil, and between sunflower oil and rapeseed, as expected. However, the remaining two tests lead to rejection. The test involving soybean oil and palm oil appears to show a stationary disequilibrium term for most of the sample, except the last ten observations, where the variable shows rapid growth. In fact, the test is accepted if these observations are omitted. Returning to figure 2, the source of this strange behaviour is a dramatic drop in the price of palm oil at the end of the sample. Further inquiry into this phenomenon has revealed a considerable increase of world palm oil output and a fall in the output of soybean oil at the end of the sample period. For

Table 4 Test of restrictions on the cointegrating space

Price differential	(a) $sb - su$	(a) $su - ra$	(a) $sb - pm$	(a) $sb - co$	(a) – (b) $sb - gn$	(c) $cc - pk$
LR test ($\chi^2(r)$)	9.36(*)	5.65(*)	10.78	20.43	13.71	13.88

Note: The null hypothesis in each case is that the difference in the price of the given pair of oils is stationary.
* Critical value at 5 per cent level $\chi^2(4) = 9.49$.

example, world palm oil production rose by 13 per cent in 1989[3] and an expanding output of palm products has contributed to the improved supply situation and helped to lower the palm oil price. In contrast, world soybean production in 1989 fell by 9 per cent to 96 million tons. Even so, world trade in the soybean complex, after declining in 1988, dropped further in 1989, despite the stock withdrawals in the United States. Given the lower output of soybean oil and the expanded production of palm products in 1989, particularly marked changes occurred in oil price relationships. The palm oil price reduction relative to soybean oil induced the consumption shift from oils in shorter supply. All of these changes are reflected in figure 2. Although the graphs of the cointegrating disequilibrium ($\beta_i' R_{Kt}$) and restricted cointegrating disequilibrium terms ($\beta_o' R_{Kt}$) are not reported here for the sake of space limitation, the disequilibrium term shows a gradual downward drift throughout the sample, consistent with a steady increase in the price of cotton oil relative to soybean oil (see figure 2). It seems the explanation for this failure of co-movement lies with general economic factors. First, note that cotton oil is a by-product of cotton and is less traded and the production of cotton is directly dependent on the demand for cotton. Therefore, the output of cotton oil is determined partly by the changes in lint prices. Second, cotton oil has an advantage as a salad oil. Owing to this special use, demand for cotton oil is relatively more price-inelastic than demand for soybean. Third, and perhaps most importantly, a steady decrease in the soybean oil price relative to that of cotton oil reflected ample overall supplies of soybean relative to import demand. The considerable increases in output of both oils, soybean and cotton, are 67 per cent and 21 per cent respectively, during the period 1977–88. In these circumstances, soybean oil and cotton oil prices are not likely to move together in the long run.

We now turn to the two oils in group (c), coconut oil and palm kernel oil. Recall from figure 4 that these two variables follow an almost identical pattern. It thus comes as a surprise that the test is rejected. This reveals that although there seems to be substantial co-movement in prices of these two oils, the price of coconut oil has been gradually moving ahead of that of palm kernel oil throughout the sample. Although the movement is small, it is significant and suggests a long-run factor yet to be included in the model is at work. An explanation for the failure of co-movement between coconut oil and palm kernel oil prices may be as follows. During the sample period 1973:10–1990:3, world export and production of coconut oil grew less

[3] Continuing area expansion resulted in production increases in Indonesia (19 per cent) and in Malaysia where production increased by 15 per cent as yields also increase. As Malaysia and Indonesia account for 90 per cent of world exports, world trade was higher in 1989 and helped to press downward on palm oil price.

Table 5 Tests for weak exogeneity

Variable	*sb*	*co*	*gn*	*su*	*ra*	*cc*	*pk*	*pm*
LR Test ($\chi^2(r)$)	10.06	5.27(*)	2.26(*)	6.96(*)	14.14	9.54	4.91(*)	9.79
P-Value	0.04	0.26	0.69	0.14	0.01	0.05	0.30	0.04

Note: * Critical value at 5 % level $\chi^2(4) = 9.49$ and weak exogeneity of cotton, groundnut, sunflower and palm kernel is accepted

rapidly than those of palm kernel oil. Particularly, the drastic increase in output of palm kernel oil in 1985–1990, along with palm oil, contrasts with a drop in coconut oil production.[4] It seems there is loyalty by at least some end-users to coconut oil, the relative supply changes thus bringing about the observed (small) movement in relative prices.

The last test to be included in table 4 is a comparison of the prices of soybean oil and groundnut oil. This is included to confirm expectations that the price of groundnut oil behaves somewhat differently to the other oils, consistent with its qualitatively different end-use.

4.2 Weak exogeneity testing

We will now continue with testing for weak exogeneity using the VAR with $k = 3$ and maintaining four cointegrating vectors. The test considered can be interpreted as a test that certain rows of α are zero. Since $\alpha_{i\bullet} = 0$ implies that the cointegration relations $\beta_j' X_t$ do not enter equation i, this is in fact a test of weak exogeneity of Z_{it} when the parameters of interest are the long-run parameters β. The exact form of the test statistic can be found in Juselius (1991).

From table 5, it can be concluded that cotton, groundnut, sunflower and palm kernel are weakly exogenous for the long-run parameters of interest but soybean, rapeseed, coconut and palm oil are not weakly exogenous. These weak exogeneity test results provide further insight into the markets. Specifically, since previous testing revealed that groundnut oil was excluded from any cointegrating relationship with other variables, one would not

[4] For example, in 1985 output of palm kernels reached record levels and in 1986 output of palm kernels with palm oil again reached record levels. In 1987, world output of both palm oil and palm kernels increased 5 per cent reaching new records of, respectively, 8.5 and 2.9 million tons. In 1987, the related fall in production of coconut oil is partly offset by increased production of the other main lauric oil – palm kernel oil, reflecting continuing growth of palm kernel production. World production of lauric acid oil (coconut oil) declined by 5 per cent in 1988, reflecting higher palm kernel output and lower price of palm kernels. In 1989, world production of lauric acid oils increased by 4 per cent, almost entirely because of the 12 per cent growth in palm kernels (see FAO, *Commodity Outlook*, various issues).

expect this variable to respond to any disequilibria. It ought thus to be exogenous for β and the test statistic clearly supports this expectation. Considering the two group (c) oils – coconut and palm kernel – the tests reveal that palm kernel oil is the exogenous variable with the price of coconut oil responding. This is consistent with the increasing share that palm kernel oil has in the production of lauric oils, and hence the tendency for the price of palm kernel oil to 'lead' that of coconut oil. One would also expect that at least one of the five variables in group (a) should be exogenous, and table 5 suggests that cotton oil and sunflower oil prices are both weakly exogenous variables in that group.

5. Concluding remarks

There is a high degree of substitutability among the vegetable oils traded on the international market. The market prices of these oils are, therefore, not likely to diverge greatly from each other, at least in the long run. In the present study, the world prices of eight vegetable oils, over a period of time, are scrutinised in an attempt to establish an understanding of the long-run co-movements. The study utilises the multivariate cointegration framework for the analysis. It was found that there were four cointegrating vectors in an eight-variable model. Co-movements amongst oils are found by various tests based on the cointegrating space. The key empirical findings are that there exists cointegration or a long-run relationship between sunflower and soybean and sunflower and rapeseed, reflecting thus the extent of substitution among them. Not all results went according to expectations. It seems that whilst the oils can be grouped according to similar end-uses, even within each group there seems to be small differences in end-use or quality of the products. Changes in relative production thus lead to movements in relative prices. The weak exogeneity test results are generally consistent with *a priori* expectations. The information provided by these tests is likely to be useful in deciding which oils should be in any international buffer stock designed to control wide fluctuations in oil prices.

Finally, the policy implications for a buffer stock scheme appears straightforward, since the majority of oils are highly substitutable, it may be relatively easy to control or 'manage' the whole oils sector by stabilising the prices of just one or two of the major oils. Since prices would be highly interdependent, the stabilisation effect of the managed oil would spread to the whole constellation of oil prices. However, if the substitution relationships are relatively weak, then it may be more difficult to manage these markets by buffer stocks as oil prices would behave independently. In our case, groundnut, coconut, and palm kernel oils are not recommended for use in a buffer stock scheme.

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