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DYNAMIC INTERRELATIONSHIPS BETWEEN SPOT PRICES OF SOME AGRICULTURAL COMMODITIES ON RELATED MARKETS

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DYNAMIC INTERRELATIONSHIPS BETWEEN SPOT PRICES OF SOME AGRICULTURAL COMMODITIES ON RELATED MARKETS

A FIRST EXAMINATION

by

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Comments welcome

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1. INTRODUCTION

The idea in econometric modelling of specifying flexible dynamic short-run relationships between economic variables which have a constraint on a long-run equilibrium relationship is well-known. Many of these models have been specified and estimated as error-correction models. In these models, deviations of long-run equilibrium levels in the short run, are "corrected" in following periods. In more recent years the concept of cointegrated variables and its relationship to error-correction models has been developed. Engle and Granger (1987) elaborate this idea. Cointegrated variables have an error-correction representation. This will be discussed further in section 2.

Applications of these ideas of testing whether economic variables are cointegrated and can be modelled by an error-correction specification are found in recent econometric work. For example, Kunst (1988) applies this concept in a macro-economic system using Austrian data for six macro-economic variables. In the present paper the emphasis will be on commodity markets. In many econometric research on commodity markets, often the modelling of a single commodity market is encountered. However, if for instance an important reason for modelling a commodity market is to analyse the price formation of that particular commodity, one may wonder whether prices of related commodities are also important for the determination of the price level. In other words, circumstances on other but related markets influence the price too. This may concern price behaviour in the short run, or in the long run due to possible existing more or less (stochastic) long-run equilibrium levels between prices of the various commodities.

Examples of multivariate tackling of commodity markets for reasons to test various hypotheses, which make allowance for linkages among related markets can be found in recent econometric research on commodity markets; see for instance Durand and Blöndal (1988), Rausser and Walraven (1988) and Wolak and Kolstad (1988)[1]. First, some background information of these studies will be given in summary. Durand and Blöndal examined equilibrium

[1] These three papers have been presented on the Conference on International Commodity Market Modelling in Washington D.C., 24-26 October 1988.

relationships between the levels and changes of consumer and commodity prices to test the hypothesis that commodity prices are useful indicators of OECD price developments. They found no clear evidence of any equilibrium relationship between these price levels, although relations between changes in a number of commodity prices and consumer prices could be established. Rausser and Walraven notice in general that: "studies of futures market efficiency which search for single series martingale or random walk processes cannot be expected to classify markets correctly. Linkages among markets forces inefficiencies in one market to be transmitted to related markets." Rausser and Walraven analysed dynamic welfare effects of overreacting of futures market prices as a result of a monetary shock. They established a vector-ARMA model for an eight-market system (financial and commodity markets). Overshooting was found for all the futures markets, but for commodity markets to a much greater degree than the financial markets, however, the period length of the overreacting of agricultural commodity markets was much shorter. Lastly Wolak and Kolstad derived a model of homogeneous input demand under price uncertainty. They tested empirically the validity of the model for the imports of steam coal into Japan from five countries by analysing the five matched price series.

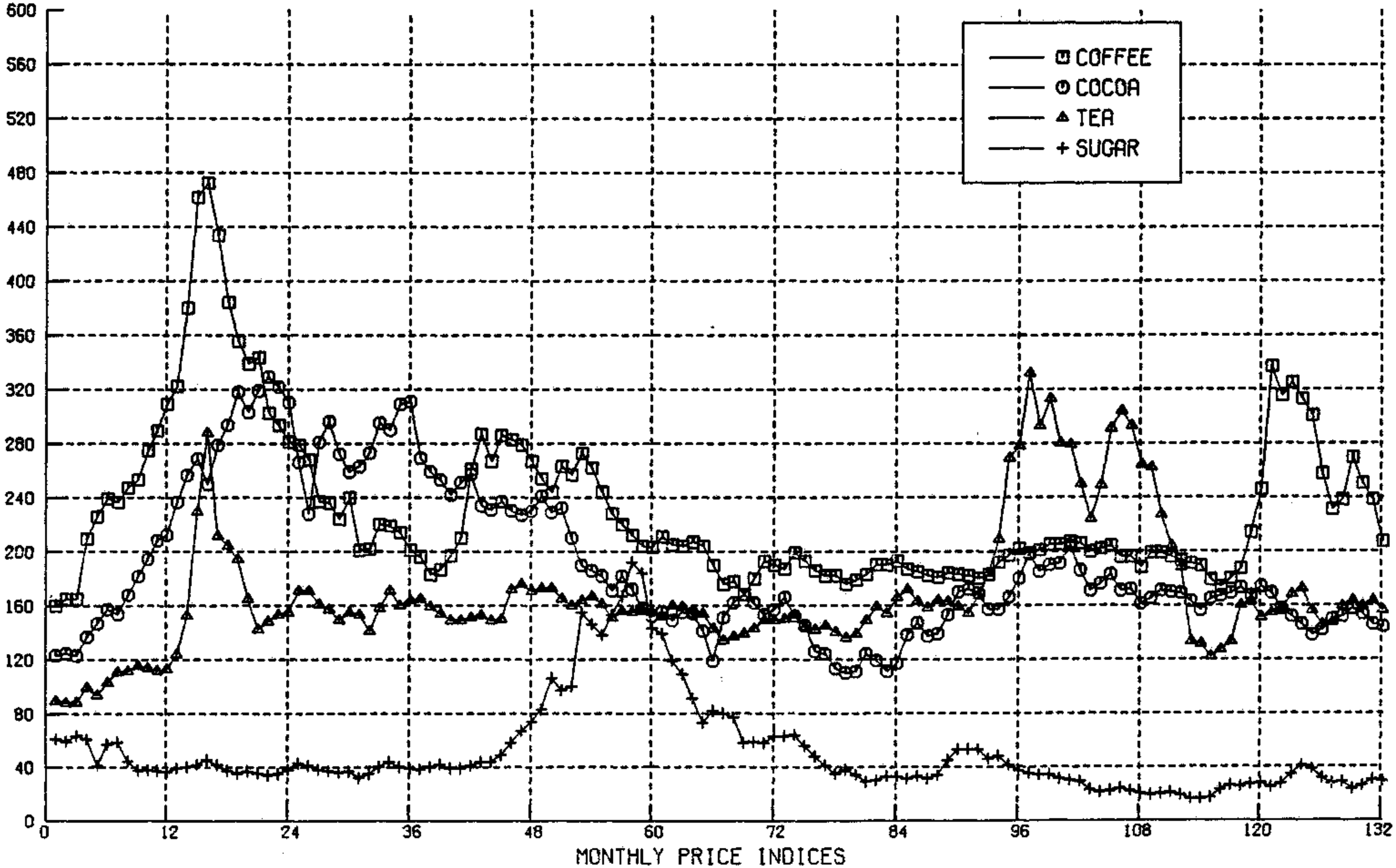
In the present paper, the hypothesis is examined that various related commodity prices deviate in the short run from long-run stochastic equilibrium levels. Commodity prices which have been formed on various related markets are influenced by common factors, which causes similar price trends. This hypothesis stems from the observation that important events on one market do not only influence the price of that particular commodity, but also prices of related commodities, while in the absence of such events prices develop in a comparable way. So, the basic idea is that some stochastic equilibrium relationship exists between the prices of more or less related commodities. Prices have their own short-term movements, but have also the tendency to return to a steady state. A distinction can be made between the hypothesis that such a steady state exists for the price levels or for proportional changes in the price levels. We return to this remark in the next section. The intention of this paper is to present results of a first examination of a group of related commodity prices by using recently developed statistical techniques.

The commodity prices which have been investigated in this paper are the spot-market prices for coffee, cocoa, tea and sugar[2]. It concerns monthly price indices from the period 1976 - 1986, which are plotted in Figure 1. Looking at the figure, a more or less similar price trend in the commodity prices can be noticed, of course besides specific price movements of the particular commodities. For instance, the high prices for all the commodities in 1976 and 1977 have been caused by occurrences on the coffee market, while at the end of this sample period some particular price movements and their return to the trend of coffee and tea can be observed.

This paper proceeds as follows. The statistical methodology which will be used for testing the hypothesis, is briefly summarized in section 2. In section 3, the empirical results for the four commodity prices will be presented and discussed. In the last section conclusions and possible sequels to this 'first-round analysis' are formulated.

[2] World export price indexes of primary commodities and non-ferrous base metals, Monthly Bulletin of Statistics, U.N.

1976 - 1986 (1975=100)



2. STATISTICAL METHODOLOGY

In this section a brief summary of the statistical tools and their use in analysing multivariate time series is given. It has already been mentioned in the introduction that these methods, which will be used to test the presence of long-run equilibrium relationships between economic variables, are related to error-correction models (ECM) and the concept of cointegrated variables. In this paper only the possible cointegration of the commodity prices will be examined. Engle and Granger (1987) discuss thoroughly the relationship between these two econometric items and survey a number of test statistics. Their approach will be followed in this paper. The theory of cointegrated time series makes it possible to study long-run steady-state properties of related time series. Variables which are cointegrated can be represented by an ECM. A necessary condition for time series to be cointegrated is that they have similar intertemporal properties, i.e they are integrated of the same order. Two variables can have a long-run equilibrium relationship if they are both integrated of first order (notation $x_i \sim I(1)$, $i \in \{1,2\}$). In that case the series are stationary after first differencing. I(1)-variables which are cointegrated will have an equilibrium error that is I(0), which implies that it is stationary. The hypothesis that a series is I(1) can be determined by testing whether that series have a unit root. A survey of unit-root tests are given in the above mentioned article of Engle and Granger. Most applied work has been done for bivariate systems. For systems with more than two variables the procedure becomes rather complicated. This will be left for future research. In this paper we will use the Cointegrating Regression Durbin Watson test (CRDW) the Dickey-Fuller (DF) and the Augmented-Dickey-Fuller (ADF) test. The null hypothesis that a series x_t is integrated of first order can be tested, for example in the following manners.

a. CRDW

Run the regression $x_t = \alpha + \varepsilon_t$, and compute the DW-statistic which is zero under the null. Tables for this statistic can be found in Sargan and Bhargava (1983).

b. DF

Run the regression $\nabla x_t = \phi x_{t-1} + \varepsilon_t$, and compute the t-statistic for β. Also a constant term can be inserted. The null is not rejected if the t-statistic is below its table value. Tables can be found in Fuller (1976), see also Dickey and Fuller (1979).

c. ADF

Run the regression $\nabla x_t = \phi x_{t-1} + \sum_{i=1}^{p} \beta_i \nabla x_{t-i} + \varepsilon_t$, and test in the same way as before with the t-statistic of ϕ.

According to Engle and Granger the ADF-test allows for more dynamics in the regression and will be overparametrized in the first order case but is correctly specified in the higher order cases. For that reason the CRDW and the ADF-tests may give different results. The results of the three mentioned unit-root tests will be presented in the next section. When the null hypothesis of a first order integrated variable has not been rejected the same test statistics can be used to test for a unit root in the first differences, i.e. test the H_0: $x_t \sim I(1)$ against the alternative that $x_t \sim I(2)$. The CRDW-test is than applied on ∇x_t, and the DF and ADF-test on $\nabla^2 x_t$.

If the null hypothesis of I(1) variables cannot be rejected, cointegration tests can be performed for each pair of variables. The same test statistics are used on the residuals of the cointegrating regression. The cointegrating regression is just the linear regression between the two variables. When testing for cointegration, Engle and Granger recommend the ADF-test as an appropriate test, as the critical values of the CRDW-test are very sensitive to the particular parameters within the null hypothesis, although the CRDW-test is useful for a quick check because of its simplicity. If the assumption can be made that the steady-state between the variables is in levels, all the tests are carried out for the levels of the variables. However, in many cases economic variables might be in equilibrium concerning a relationship in proportionate rates of changes, which implies that the tests will be carried out for the logarithms of the variables. The critical values of Dickey-Fuller-cointegration tests are different from those for testing for unit roots in the variables as the cointegrating vector is unknown and has to be estimated. Engle and Granger (1987) computed critical values for the bivariate case and a sample size of 100 by means of a Monte Carlo simulation.

3. EMPIRICAL RESULTS FOR FOUR COMMODITY PRICES

The test statistics of the previous section have been used to test the hypothesis that the commodity prices of coffee, cocoa, tea and sugar are cointegrated. The choice has been made rather arbitrary, and might quite well be adjusted in future research. This analysis was called in the introduction a "first-round-analysis" to see whether possible steady-state relationships exist between related agricultural commodity prices. As we will assume that prices may be in equilibrium in percentage changes, all tests have been performed for the logged variables.

Firstly, the results of the unit roots tests will be presented. In Table 1 the outcomes of the CRDW-test are reported, and in Table 2 those from the DF and the ADF-test. The results of the ADF-test which are reported have been carried out for p = 1. Regressions have been done for $p \in \{1,\ldots,4\}$, but p=1 turned out to be an appropriate value, seen the t-values of the parameters β_i and the value of the Durbin-Watson statistic.

Table 1: CRDW-test values, H_0: prices are I(1)

Commodity	levels	first differences
Coffee	.0998	1.3443
Cocoa	.0606	1.7037
Tea	.1204	1.4349
Sugar	.0557	1.6485

Critical value at the 5% level: .22

The critical value of .22 has been roughly determined by extrapolating the values of Table 1 in Sargan and Bhargava (1983)

Table 2: The DF and ADF-test values, H_0: prices are I(1)

Commodity	levels		1st differences	
	DF	ADF	DF	ADF
Coffee	-.26	-.32	8.24	10.94
Cocoa	-.18	-.19	9.72	14.40
Tea	.29	.11	8.16	11.22
Sugar	-.67	-.69	8.22	12.00

Critical value at the 5% level: 2.24, see Fuller (1976)

These results clearly show that the Durbin-Watson and Dickey-Fuller test statistics do not reject the null hypothesis of first-order integrated price series, both against the hypothesis of I(0) and against I(2) series. Although only the results for the logged variables have been tabulated, it can also be reported that the results for the levels, which also have been computed, do hardly differ from the results which have been presented for the logged variables.

Now it has been established that all the series are I(1), cointegration tests for all pairs of variables have been computed. By using the augmented Dickey- Fuller test, p = 2 appeared in this case to be an appropriate choice. All the results are given in Table 3.

Although the results do not show spectacular cointegrated variables, they are encouraging for continuing this research. According to the CRDW and the DF test statistic values the null hypothesis of non-cointegration can not be rejected. However, the results of the augmented Dickey-Fuller test are different. Significant values are found for tea and coffee, tea and cocoa, and tea and sugar. Referring to the remarks of Engle and Granger, cited in section 2 of this paper, concerning the performances of the various test statistics for testing for cointegration, it can be remembered that the ADF-test was recommended as the most appropriated approach. Therefore we set more value on the outcomes of the ADF-test than to the other test statistics.

Table 3: Cointegration-test values between pairs of commodity prices
H_0: variables are non-cointegrated

	Cocoa	Tea	Sugar	Test
Coffee	.1205	.1150	.0556	CRDW
	2.0435	2.7437	1.1790	DF
	2.1016	3.4893	1.2529	ADF
Cacao		.1245	.0554	CRDW
		2.7053	1.1703	DF
		3.4093	1.2568	ADF
Tea			.1389	CRDW
			2.9308	DF
			3.7757	ADF

Critical values at the 5% level are for the CRDW-test statistic . 386, for the DF-statistic 3.37, and for the ADF statistic 3.17, see Engle and Granger (1987)

Again it is worth mentioning that the tests have also been applied on the price levels, and just as before, the results are rather similar.

The implication of these results is that the conclusion may be drawn that the price of tea plays a particular role within this group of commodity prices. Therefore it seems acceptable to state that the development of the price of tea can be considered as important for the long-run development of the prices of the other commodities involved in this analysis. These prices deviate in the short run from each other but have the tendency to return to a steady state relationship with the price of tea. It looks surprising that, in this analysis, it is the price of tea which determines a steady state relationship, and not e.g. the price of such an important commodity like coffee, which often seems to carry away other commodity prices with its sometimes heavy fluctuations. So this effect of the coffee price must be a short-run effect on the other commodity prices.

4. CONCLUSIONS AND SUGGESTIONS FOR FURTHER RESEARCH

The conclusion of this first analysis of possible cointegrating commodity prices is that a long-run relationship between related agricultural commodity prices may exist, although the price series themselves are non-stationary. Within the group of coffee, cocoa, tea and sugar the analysis of this paper indicates that the development of the price of tea plays a central role in a possible long-run equilibrium relationship. Results have been reported for percentage changes of the prices, but even a relationship in levels is not out of the question. Maybe, it will also be clarifying to split up the sample and apply the same analysis for both sub samples, as the behaviour of the prices in the first and last years of the sample is somewhat different.

Therefore it seems appropriate to perform such an analysis of cointegrating commodity prices for a larger group of commodities. If an obvious indication is obtained for a steady state relationship among these prices, various interesting items can be elaborated, like the application of causality tests and the estimation of error-correction models or vector-ARMA models for such relationships. These models will give more insight in a larger structure of various but related agricultural commodity prices with respect to short-run and long-run properties of their interrelationships.

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