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CO-INTEGRATION AND LEADERSHIP IN THE EUROPEAN OFF-SEASON FRESH FRUIT MARKET

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Abstract

This paper tests market co-integration, market leadership and price margins in the context of the recent development of European markets for imported off-season fresh fruit from countries in the southern hemisphere. The Engle-Granger and Johansen co-integration tests show that the main European markets for off-season fresh apples and table grapes were well integrated during the 1994-97 period. The vector autoregressive - error correction mechanism (VAR-ECM) model form is used to characterise the spatial co-integrating relationships among these markets during the same period. Statistical tests on meaningful restrictions on these VAR-ECM models show that the major import market of Rotterdam significantly leads the wholesale markets for table grapes in Germany down the supply chain but does not lead the wholesale markets in France and Germany for apples. They also show higher price margins between the import and wholesale markets for table grapes than for apples. The table grape variety imported from South Africa was consistently traded at a higher price during the 1994-98 period compared to the same variety from Chile. Using an industry survey, this paper discusses the econometric results and provides recommendations.

Keywords: co-integration, market leadership, off-season fresh fruits, European Union.

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1 Introduction

For the last ten years, new markets for off-season fresh fruit from a handful of countries in the southern hemisphere have rapidly developed in the European Union (EU). Between 1988 and 1997, Chile and South Africa increased their shipments of table grapes to the EU by 77% and 152% respectively (EUROSTAT, 1998). Over the same period, New Zealand has increased its shipments of apples by 108% and, since 1995, they have exceeded those from Chile and South Africa which have notwithstanding continued to increase their exports. Argentina has increased its shipments of pears by 82% while Chile and South Africa have increased theirs by 104% and 36% respectively. European imports of table grapes, apples and pears from these countries have increased by 115%, 34% and 68% respectively during the same period. These European markets for off-season fresh fruit have also become the major outlet for most of the exports of fresh fruit from these southern countries. For example, in 1997, 62% of Chile's pear exports, 50% of its apple exports and 30% of its grape exports were traded on these markets. Competition for these markets among exporting and importing firms has become increasingly fierce.

Recent surveys of these new markets indicate that importers and wholesalers in Europe are well informed of the demand from retailers and are capable of responding promptly to rapid change in this demand (Degand, Pirotte and Henry de Frahan, 1998). Although shipments of fresh fruit from the southern hemisphere are concentrated among a few ports of entry such as Rotterdam for produce from Chile and Argentina, Dover, Antwerp and, to a lesser extent, Hamburg for produce from South Africa and New Zealand, they are quickly dispatched all over the EU thanks to a well-organised marketing system and low transportation costs. Large volumes of these shipments end up in the final retail markets of Germany and the United Kingdom and, to a lesser extent, the Benelux countries, Spain and France. Surveys also indicate that competition in Europe for the best quality at the right time and location is strong among traders and retailers. Contractual arrangements among firms along the supply chain of these markets, as opposed to the use of physical markets, are the preferred way of conducting transactions. Product differentiation may exist depending on the country of origin. For example, produce from South Africa is generally traded at a higher price than that from Chile because of the produce's more homogenous quality. The South African marketing board for fresh produce with a monopsony on fresh exports until 1997, has actually played, until 1997, a key role in assembling and shipping volumes of a homogenous quality to the European markets.

With regard to the rapid development of these markets for off-season fresh fruit in the EU, this paper tests three propositions. First, the main European markets for off-season fresh fruit are well integrated, responding promptly to any price changes in other markets. Second, import markets determine prices for wholesale markets down the supply chain. Third, price differences persist in favour of produce originating from countries supplying more homogenous shipments. For each test, this paper also provides the algebraic relationships of co-integration among markets, speeds of market adjustment and differences among market prices. Possible explanations of the integration phenomenon based on interviews of importers, wholesalers and retailers located in Belgium, France, Germany, Italy, Spain, the Netherlands and the United Kingdom and producers and exporters in Chile made in 1997 are discussed.

This paper uses co-integration tests from Engle and Granger as well as Johansen and Error-Correction Mechanisms models (ECM models) to characterise the spatial relationships among the most important import and wholesale physical markets for off-season fresh fruits in the EU. Time-series are weekly price averages for specific fruit varieties that are the most commonly traded within these markets. Weekly price averages of these fruit varieties are calculated from the price quotations recorded two or three times per week on these markets. These time-series are converted and expressed in ecu per kilogram for a particular common packaging unit. Although most of the volume of the imported produce is not traded on these physical markets, price quotations recorded on these markets still reflect prices actually negotiated outside of these markets. For example, only about 10% of the Chilean fruit shipments unloaded in the port of Rotterdam are traded on the physical import market of Rotterdam while the other 90% are directly rerouted to different European markets. The limited availability of complete time-series have restricted the econometric tests on apple and grape prices for a small number of import and wholesale markets.

The next section reviews the econometric tests and models used in this paper emphasising the close relationship between the Engle-Granger and Johansen tests and the ECM models. The third section applies these tests and models to the available time-series, first to the price time-series of the Granny-Smith apples from Chile, second to the Thompson-Seedless grapes from Chile and third to the Thompson-Seedless grapes from Chile and South Africa. Explanations for the tested spatial relationships are also provided. The last section synthesises the econometric results and discusses the methodology.

2 Error Correction Mechanism models and co-integration issues

According to the Engle-Granger representation theorem (Engle and Granger, 1987), error correction mechanisms and co-integration are closely related. Once co-integration among time series is established, different forms of dynamic isomorphic models such as Vector Autoregressive (VAR), moving averages (MA) and Error Correction Mechanism (ECM) models can be estimated. In particular, ECM models combine in a convenient way the short and long-run dynamics implied by the co-integrating relationships while involving variables or group of variables that are stationary. As a result, "usual" statistical tests can be performed on the coefficients of the ECM models. This section briefly reviews issues such as testing for co-integration using the Engle-Granger and Johansen tests and formulating the ECM model related to co-integration. It focuses on models including two variables only.

2.1 ECM models and the Engle-Granger methodology

Introduced first by Sargan (1964) and popularized by Engle and Granger (1987) or Hendry (see for example Hendry and Ericsson, 1991, or Hendry, 1995, for a review of dynamical models), ECM models are closey related to co-integration between time series. Denote two time series by x_t and y_t. A natural way to link x_t to y_t is to specify a linear relationship between them and estimate

$$y_t = \beta_0 + \beta_1 x_t + \epsilon_t \tag{1}$$

where ϵ_t is assumed to be a white noise. If x_t and y_t are not stationary, this regression is likely to give spurious results in the sense of Granger and Newbold (1974)[1]. If x_t and y_t are integrated of first order[2], one solution to this problem is to differentiate x_t and y_t and estimate

$$\Delta y_t = \beta_0 + \beta_1 \Delta x_t + \epsilon_t \tag{2}$$

However, by differentiating the two series, all information about the level of the series is lost since expression (2) only gives information on the relationship between the changes in y_t and x_t. If x_t and y_t are co-integrated[3], then the regression of y_t on x_t is meaningful and the OLS estimator is super consistent (Stock, 1987). Because x_t and y_t are not stationary, the probability distributions appropriate to conduct the usual statistical tests on the coefficients of the model cannot be the usual Student or Fisher distributions, but are the modified distributions based on Wiener processes (Banerjee, Dolado, Galbraith and Hendry, 1993).

According to the Engle-Granger representation theorem, if x_t and y_t are two co-integrated series of order one, then an ECM model set in a VAR form (VAR-ECM model) can be written as follows

$$\Delta y_t = \alpha_1 + \alpha_y (y_{t-1} - \beta_0 - \beta_1 x_{t-1}) + \sum_{i=1}^{p} \alpha_{11}(i) \Delta y_{t-i} + \sum_{i=1}^{q} \alpha_{12}(i) \Delta x_{t-i} + \epsilon_{yt} \tag{3}$$

[1] For a discussion of dynamic regressions and how to deal with spurious regressions, see for example Hendry (1995) or Banerjee, Dolado, Galbraith and Hendry (1993).

[2] A time series y_t is integrated of first order, or I(1), if its first difference ($\Delta y_t = y_t - y_{t-1}$) is stationary, or I(0).

[3] Two I(1) series x_t and y_t are co-integrated if there is a linear combination of the two series that is I(0), i.e., stationary. The series x_t and y_t are co-integrated of order one if both series are I(1) and $(y_t - \beta_0 - \beta_1 x_t)$ is stationary.

$$\Delta x_t = \alpha_2 + \alpha_x(y_{t-1} - \beta_0 - \beta_1 x_{t-1}) + \sum_{i=1}^{p} \alpha_{21}(i)\Delta y_{t-i} + \sum_{i=1}^{q} \alpha_{22}(i)\Delta x_{t-i} + \epsilon_{xt} \quad (4)$$

where $(y_{t-1}-\beta_0-\beta_1 x_{t-1})$ is the disequilibrium error from the long-run co-integrating relation and the sums over the Δx_{t-i} and Δy_{t-i} characterize the short-run dynamics of the model, with p and q such that the residuals ϵ_{yt} and ϵ_{xt} are not autocorrelated. The Engle-Granger methodology to analyze a system of two co-integrated variables x_t and y_t is summarized as follows:

a) Test for co-integration between the I(1) series x_t and y_t[4].

Testing for co-integration between the two I(1) series is staightforward. First, estimate the long run relationship

$$y_t = \beta_0 + \beta_1 x_t + \epsilon_t \quad (5)$$

Second, test the residuals $(\widehat{e}_t = y_t - \widehat{\beta}_0 - \widehat{\beta}_1 x_t)$ for stationarity with a modified Dickey-Fuller or Augmented Dickey-Fuller test using

$$\Delta \widehat{e}_t = \alpha_0 \widehat{e}_{t-1} + \sum_{i=1}^{q} \alpha_i \Delta \widehat{e}_{t-i} + u_t \quad (6)$$

with q such that the residuals u_t are not correlated. The null hypothesis H0: $\alpha_0 = 0$ is tested against the alternative hypothesis H1: $\alpha_0 < 0$. If H0 is rejected, then the residuals are stationary and x_t and y_t are co-integrated. Because of the strong downward bias in the estimation of α_0, the tables of MacKinnon (1991) are used instead of the usual Student tables.

b) Specify and estimate the VAR-ECM model.

Once co-integration between x_t and y_t is established, the VAR-ECM model (3) and (4) with $\widehat{e}_{t-1}$ instead of $y_{t-1}-\beta_0-\beta_1 x_{t-1}$ can be estimated by ordinary least squares, which allows to assess the short and long-run dynamics of the system. All variables and group of variables being stationary, the usual Student and Fisher tests can be conducted on the coefficients of the model. If for example the hypothesis H0: $\alpha_x = 0$ is not rejected, then the short-run dynamics of x_t is not affected by the past disequilibrium between x_t and y_t, i.e., not affected by its long-run dynamics. If x_t and y_t are co-integrated, the coefficient α_y must be different from zero and the short-run dynamics of y_t is determined by the past disequilibrium between x_t and y_t. In this case, x_t is said to lead y_t, or said otherwise, the stochastic trend in x_t is the common trend of x_t and y_t.

[4] That the series x_t and y_t are actually I(1) is first tested.

2.2 Johansen test

As an alternative to the Engle-Granger methodology, Johansen (1991) uses a co-integrating model set in a VAR form to test for co-integration. The co-integrated VAR model with two variables x_t and y_t is a dynamic system involving one stationary relation between the two variables and can be written in matrix notation as follows:

$$\Delta z_t = \sum_{i=1}^{q-1} \pi_i \Delta z_{t-i} + \pi z_{t-p} + u_t \tag{7}$$

where the vector $z_t = (x_t \quad y_t)'$, q is chosen such that the residuals u_t are not correlated and the rank of the matrix π is equal to one for one co-integrating relation. The matrix π can be rewritten as the product of two vectors α and β such that $\pi = \alpha\beta'$. The vector β corresponds to the co-integrating vector while α gives the weights of the co-integrating relationship in the equations of the VAR system, i.e., $\alpha = (\alpha_y \quad \alpha_x)'$ in (3) - (4). Expressing in this way the dynamic system is particularly well suited for conducting statistical tests on the coefficients of the long-run relationship (β) and the weights (α).

The Johansen's test is a likelihood ratio test. It involves the estimation of the unconstrained VAR system (i.e., without imposing constraints on the rank of π) and the test of the rank of a transformation of π. With two variables, if the rank of the transformation of π is zero, x_t and y_t are not co-integrated. It it is two, x_t and y_t are stationary, and thus not co-integrated. If the rank is one, x_t and y_t are co-integrated.

In this procedure, the test on the rank consists in identifying the number of characteristic roots of the transformation of π significantly different from zero. If there are T observations and the characteristic roots λ_i are ordered as $1 > \lambda_1 > \lambda_2 > 0$, the statistic

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{2} ln(1 - \lambda_i) \tag{8}$$

is used to test the null hypothesis that the number of co-integrating relations is less than or equal to r ($r = 0, 1$). This test statistic is compared with critical values given by Johansen (1995).

3 Co-integration, market leadership and margins in the European off-season fresh fruit market

The co-integration econometric tools introduced in the previous section are applied to the price series of the Granny-Smith variety of apple from Chile and the Thompson-Seedless variety of table grape from Chile and South Africa for the four European markets for which time-series are long enough to use these tools: Berlin, Hamburg, Rotterdam and Rungis. Berlin, Hamburg and Rungis, near Paris, along with Manchester, Liverpool and London New Covent Garden are among the largest European wholesale physical markets for off-season fresh fruit in the EU while Rotterdam and Brussels are the largest European physical import markets for off-season fresh fruit in the EU. Time-series are weekly price averages constructed from data from the weekly magazines ZMP (Germany), SNM (France), Tricop (The Netherlands) and Fresh Produce Journal (Great Britain)[5]. First, market co-integration and leadership are tested and discussed for the Chilean apple and grape price time-series and, second, market co-integration and price margin are tested and discussed for the Chilean and South African grape price time-series. For each set of time-series, the structure of the empirical work is as follows:

- conduct unit root tests on each time-series to establish that the available time-series are integrated of order one,
- use the Engle and Granger and Johansen tests to test for co-integration among the time-series that are integrated of order one,
- estimate the VAR-ECM models and test meaningful restrictions on their coefficients to determine market leadership, proportional relationship in the co-integration relations and significant price differences between time series.

Since tests and estimation procedures are similar for the three set of time-series, the methodology for only the first set is detailed below.

3.1 The market for the Granny-Smith apple from Chile

For this product, four price time-series of weekly data covering the four consecutive off-seasons from 1994 to 1997 are available for the import physical market of Rotterdam (*pcgro*) and for the wholesale physical markets of Berlin (*pcgbe*), Hamburg (*pcgha*) and Rungis (*pcgru*)[6]. Figure 1 presents the four price series and shows a possible presence of a strong common relationship among them.

3.1.1 Unit root tests

According to the Dickey-Fuller method, the unit root test is conducted for each available price series p_t using the following Augmented Dickey-Fuller equation:

$$\Delta p_t = \alpha_0 + \alpha_1 p_{t-1} + \sum_{i=1}^{q} \alpha_i \Delta p_{t-i} + u_t \tag{9}$$

[5]ZMP for Zentralen Markt und Preisberichtstelle fur Erzeugnisse der Landen and SNM for Service des Nouvelles des Marchés.

[6]Because some weekly data were missing for some markets and seasons, the number of observations available per *pair* of markets varies, and amounts to 66 for the Rotterdam-Berlin relationship, 68 for Rotterdam-Hamburg and 56 for Rotterdam-Rungis.

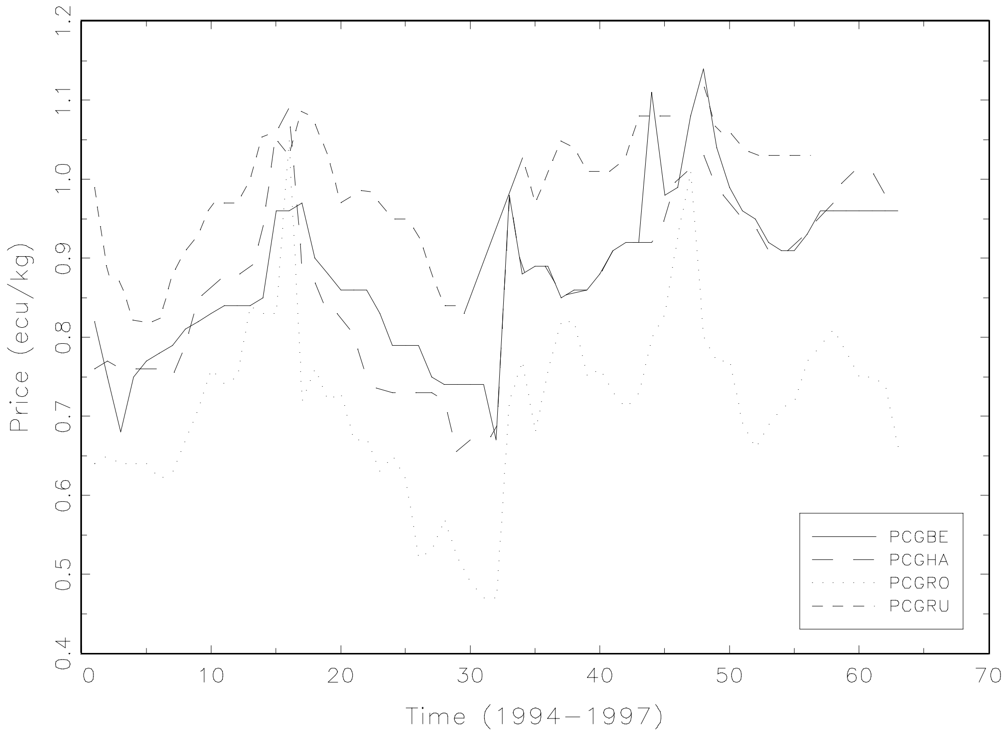

Figure 1: Prices of Granny-Smith apples from Chile in four European markets: Berlin (*pcgbe*), Hamburg (*pcgha*), Rotterdam (*pcgro*) and Rungis (*pcgru*)

where q is chosen such that the residuals u_t are not correlated. The null hypothesis of non stationarity is integration (H0: $\alpha_1 = 0$), and the alternative hypothesis is stationarity (H1: $\alpha_1 < 0$). Not rejecting H0 implies that p_t is I(1)[7]. The non stationarity hypothesis is also tested by a Fisher[8] test where the null hypothesis is H0: $\alpha_0 = \alpha_1 = 0$.

Table 1 reports that each of the four price series is clearly an I(1) process at the five percent level. Unit root tests conducted on the first difference of each series rules out the possibility that these series are integrated of an order greater than one. Since the price series under study are integrated of the same order, co-integration tests are conducted.

[7]The usual t-statistic can be used, but the critical values are not given by the Student tables as the distribution of α_1 is skewed to the left. Instead the Dickey-Fuller tables are used.

[8]In this case, modified Fisher tables given by Dickey-Fuller are used.

Table 1: Unit root tests
(Granny-Smith apples from Chile)

	t-stat	F-stat
pcgro	-2.74	2.49
pcgha	-2.06	2.69
pcgbe	-2.46	2.37
pcgru	-2.25	3.40

Unit root tests for the price series of Granny-Smith apples. t-stat is the test statistic for H0: $\alpha_1 = 0$ in equation (9), while F-stat is the statistic for H0: $\alpha_0 = \alpha_1 = 0$ in equation (9). At the five percent level, the critical values from the Dickey-Fuller tables are -2.93 for the t-stat and 4.86 for the F-stat. For all unit root tests, $q = 1$ in (9).

3.1.2 Co-integration tests

Testing for co-integration between price series is equivalent to testing for long-run relationships between prices and integration between the different markets under study. Table 2 reports the Engle and Granger and Johansen tests for co-integration between the four price series grouped two by two. Expressions (26) to (31) in the appendix give the long-run relationships[9]. The results of the co-integration tests indicate that:

- all six pairs of market prices are co-integrated at the five percent level (at this significance level, the residuals of the co-integrating relations are stationary, while $r = 1$ against $r = 0$ is not rejected);
- market integration is strong for most pairs of markets (five out of six pairs are integrated at a level less than three percent);
- both Engle and Granger and Johansen tests lead to the same conclusions.

[9]Because the coefficients of the long-run relationships given by the co-integrating regressions can be biased for a small number of observations (see for example Banerjee, Dolado, Galbraith and Hendry, 1993), no emphasis is given on these coefficients. The use of dynamic regressions such as the VAR-ECM model is more appropiate to estimate the coefficients of the co-integrating relationship.

Table 2: Co-integration tests
(Granny-Smith apples from Chile)

	Engle and Granger	Johansen	
Rotterdam-Berlin	0.029	r=0	0.016
		r≤1	0.138
Rotterdam-Hamburg	0.042	r=0	0.092
		r≤1	0.356
Rotterdam-Rungis	0.009	r=0	0.003
		r≤1	0.177
Berlin-Hamburg	0.003	r=0	0.011
		r≤1	0.280
Berlin-Rungis	0.002	r=0	0.021
		r≤1	0.356
Hamburg-Rungis	0.014	r=0	0.041
		r≤1	0.494

Co-integration tests (Engle and Granger, Johansen) for the prices of Granny-Smith apples on four European markets: Rotterdam, Berlin, Hamburg and Rungis. The second column gives the p-value for the Engle and Granger stationarity test on the residuals, while the third column gives the p-values of Johansen trace test for each null hypothesis.

3.1.3 Market leadership and margin tests

Price series being co-integrated, a VAR-ECM model is used to analyse the dynamics of the model. One particular question is whether prices in the import market of Rotterdam lead prices in the wholesale markets of Berlin, Hamburg and Rungis. Is the market of Rotterdam a market leader in the formation of prices of imported off-season apples in the other markets? For pairs of markets involving Rotterdam, the following VAR-ECM models are estimated:

$$\Delta x_t = a_1(x_{t-1} - \beta_0 - \beta_1 y_{t-1}) + a_{11}\Delta x_{t-1} + a_{12}\Delta y_{t-1} + \epsilon_{xt} \tag{10}$$

$$\Delta y_t = a_2(x_{t-1} - \beta_0 - \beta_1 y_{t-1}) + a_{21}\Delta x_{t-1} + a_{22}\Delta y_{t-1} + \epsilon_{yt} \tag{11}$$

with x_t and y_t being co-integrated price series. The short-run dynamics is limited to the first order, for which ϵ_{xt} and ϵ_{yt} of the model are not correlated. With this model, the following four constraints are tested:

- Is there a market leader, i.e., is the speed of adjustment a_1 or a_2 zero for one market?
- Is it possible to simplify further the short-run dynamics of the model, i.e., are the coefficients of the short-run dynamics not significantly different from zero?
- Is there a pure proportional relationship between the price series of pairs of markets, i.e., is the constant β_0 of the model not significantly different from zero?
- Is there a significant price difference between pairs of markets , i.e., is the coefficient β_1 significantly different from one? This hypothesis is also tested with a joint test on β_0 and β_1, i.e., that the null hypothesis H0: $\beta_0 = 0$ and $\beta_1 = 1$ can be rejected.

For the three pairs of markets Rotterdam-Berlin, Rotterdam-Hamburg and Rotterdam-Rungis, Table 7 in the appendix reports the estimated VAR-ECM models. Table 8 in the appendix gives the likelihood ratio tests corresponding to the null hypotheses H0: $\beta_0 = 0$ (no constant in the co-integrating relation) and H0: $a_{11} = a_{12} = a_{21} = a_{22} = 0$ (no short-run dynamics) and the Student tests corresponding to the null hypotheses H0: $a_1 = 0$, H0: $a_2 = 0$ (the coefficient of adjustment speed is not significant) and H0: $\beta_1 = 1$ (no significant difference between the level of the two price series[10]). These tests allow to simplify the VAR-ECM models as follows:

Rotterdam-Berlin

$$\Delta pcgbe_t = -0.19^*(pcgbe_{t-1} - 1.24^* pcgro_{t-1}) \tag{12}$$
$$\Delta pcgro_t = 0.18(pcgbe_{t-1} - 1.24^* pcgro_{t-1}) \tag{13}$$

Rotterdam-Hamburg

$$\Delta pcgha_t = 0.01(pcgha_{t-1} - 1.22^* pcgro_{t-1}) \tag{14}$$
$$\Delta pcgro_t = 0.37^*(pcgha_{t-1} - 1.22^* pcgro_{t-1}) \tag{15}$$

Rotterdam-Rungis

$$\Delta pcgru_t = -0.09(pcgru_{t-1} - 1.37^* pcgro_{t-1}) \tag{16}$$
$$\Delta pcgro_t = 0.37^*(pcgru_{t-1} - 1.37^* pcgro_{t-1}) \tag{17}$$

[10] As indicated above, this hypothesis is also tested with a joint likelihood ratio test for the null hypothesis H0: $\beta_0 = 0$ and $\beta_1 = 1$. For the three pairs of markets Rotterdam-Berlin, Rotterdam-Hamburg and Rotterdam-Rungis, this hypothesis is clearly rejected as the test statistic is equal to 15.27, 13.96 and 21.32 respectively.

where the index $*$ denotes a coefficient significant at the five percent level.

From all three sets of models, the short-run dynamics can be disregarded since their coefficients are not significantly different from zero at the five percent level. For all three pairs of markets, the constant β_0 of the co-integration relation is not significantly different from zero at the five percent level, which implies a direct proportional relationship between the price series. The coefficient β_1 of the long-run relationship is significantly greater than one at the five percent level, which indicates that prices in Rotterdam are persistently lower than the prices in the other three markets. With a coefficient of adjustment speed a_2 not significant, the import market of Rotterdam can be considered a market leader for prices of the Chilean Granny-Smith apple only with the wholesale market of Berlin. As shown below, this result is in sharp contrast with the results for the Thompson-Seedless grapes, where Rotterdam's leadership is easily accepted, also with respect to the wholesale market of Hamburg.

3.1.4 Interpretation of the results

The Engle and Granger and Johansen co-integration tests show that markets for the Chilean Granny-Smith apple in Berlin, Hamburg, Rotterdam and Rungis are strongly integrated. Prices in these markets not only move together but also in the same direction. These econometric results confirm the information gathered from interviews conducted with key agents in the fresh fruit supply chain. Importers and wholesalers are well informed about trade opportunities in Europe and are organised to respond promptly to these opportunities. Particularly those traders with large market shares have access to many diverse sources of information and appropriate logistic support to react almost instantaneously to any trade opportunity in any European market. Transport costs within the European Union have become so negligible compared to the value of the shipment that the location of the port of entry with respect to the final destination of the produce does not affect market integration. Available physical facilities and contractual agreements to use these facilities rather than distance to final consumer markets determine the use of one port of entry versus another one in the European Union.

Student tests on the coefficient of speeds of adjustment of the VAR-ECM models show that the import market of Rotterdam can only be considered a market leader for prices of the Chilean Granny-Smith apple with respect to Berlin, but not with respect to Hamburg and Rungis. Surprisingly, these tests also show that Hamburg and Rungis can be both considered as market leaders with respect to Rotterdam. Releases of European apple stocks on the market during the off-season are likely to affect the spatial relationships among the European markets for off-season imported fresh apples and, hence, may explain these mixed econometric results. In contrast, for off-season fresh fruit markets not disturbed by such releases, like the market for off-season imported table grapes, the import market of Rotterdam is the market leader as shown below.

Prices in the wholesale markets of Berlin and Hamburg are systematically higher than in the import market of Rotterdam, respectively 24 % and 22 %. Prices in the wholesale market of Rungis are even higher than in Rotterdam. Rotterdam is an import market from which wholesalers from markets in Hamburg and Berlin and, to a lesser extent, Rungis get a large part of their supply of imported apples during the off-season. Price differences between Rotterdam and these wholesale markets correspond to a market margin that includes the handling, re-packaging, storage, spoilage and transport costs.

3.2 The market for the Thompson-Seedless grapes from Chile

For this product, three price time-series of weekly data covering the four consecutive off-seasons from 1994 to 1997 are available for the import market of Rotterdam (*pctro*) and the wholesale markets of Berlin (*pctbe*) and Hamburg (*pctha*)[11]. Figure 2 presents the three price series and apparently indicates the possible presence of a strong common relationship among them.

3.2.1 Unit root tests

Following the same method used to test unit roots on the price series of the Granny-Smith apple, the Augmented Dickey-Fuller test is conducted on each available price series. Table 3 reports that each of the three price series is an I(1) process at the five percent level according to the Student test but at the one percent level according to the Fisher test. Since the price series under study are integrated of the same order, co-integration tests are conducted.

3.2.2 Co-integration tests

Table 4 reports the Engle and Granger and Johansen tests for co-integration between the three price series grouped two by two. Expressions (32) to (34) in the appendix give the long-run relationships. The results of the co-integration tests indicate that:

- according to the Engle and Granger test the three pairs of markets are co-integrated at the one percent level; Johansen test gives the same results, but at the ten percent level for Berlin-Rotterdam and Hamburg-Rotterdam;

- the integration between the markets of Hamburg and Berlin is particularly strong, as the co-integration is accepted at a level less than one tenth of a percent. This result is not surprising as it involves two wholesale markets in the same country.

[11] The number of observations available per pair of markets amounts to 62.

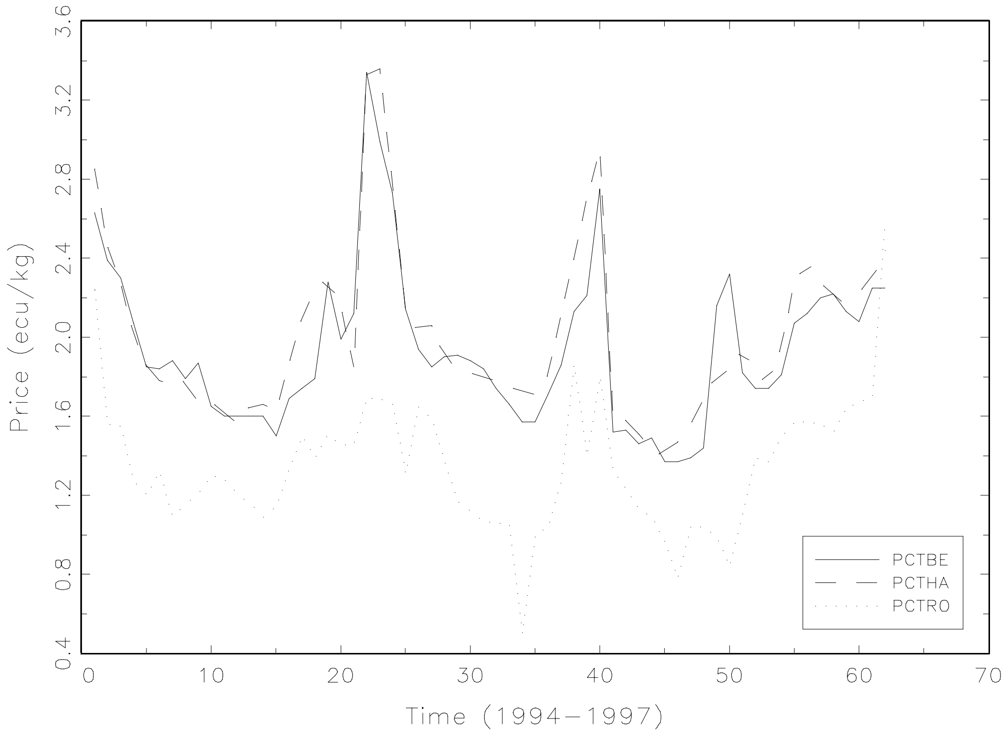

Figure 2: Prices of Thompson-Seedless grapes from Chile in three European markets: Berlin (*pctbe*), Hamburg (*pctha*) and Rotterdam (*pctro*)

3.2.3 Market leadership and margin tests

Price series being co-integrated, VAR-ECM models as given by (10) and (11) are estimated to analyse the dynamics of the model. Whether prices in the import market of Rotterdam lead and are significantly different from prices in the wholesale markets of Berlin and Hamburg are hypotheses that are tested with the VAR-ECM model. For the three pairs of markets Rotterdam-Berlin, Rotterdam-Hamburg and Berlin-Hamburg, Table 9 of the appendix reports the estimated VAR-ECM models while Table 10 of the appendix gives the likelihood ratio tests corresponding to the null hypothesis H0: $\beta_0 = 0$ (no constant in the co-integrating relation), H0: $a_{11} = a_{12} = a_{21} = a_{22} = 0$ (no short-run dynamics) and the Student tests corresponding to the null hypothesis H0: $a_1 = 0$, H0: $a_2 = 0$ (the coefficient of adjustment speed is not significant) and H0: $\beta_1 = 1$ (no significant difference between the level of the two price series[12]). These tests allow to simplify the VAR-ECM

[12] As indicated in Section 3.1.3, this hypothesis is also tested with a joint likelihood ratio test for the null hypothesis H0: $\beta_0 = 0$ and $\beta_1 = 1$. For the three pairs of markets Rotterdam-Berlin, Rotterdam-Hamburg and Berlin-Hamburg, this hypothesis is clearly rejected as the test statistic

Table 3: Unit root tests
(Thompson-Seedless grapes from Chile)

	t-stat	F-stat
pctbe	-2.95*	5.70*
pctha	-2.78	5.39*
pctro	-2.81	1.06

Unit root tests for the price series of Thompson-Seedless grapes. t-stat is the test statistic for H0: $\alpha_1 = 0$ in equation (9), while F-stat is the statistic for H0: $\alpha_0 = \alpha_1 = 0$ in equation (9). At the five percent level, the critical values from the Dickey-Fuller tables are -2.93 for the t-stat and 4.86 for the F-stat. A * denotes the statistics that are significant at the five percent level. For all unit root tests, $q = 1$ in (9).

models as follows:

Rotterdam-Berlin

$$\Delta pctbe_t = -0.24^*(pctbe_{t-1} - 1.41^* pctro_{t-1}) \tag{18}$$
$$\Delta pctro_t = 0.15(pctbe_{t-1} - 1.41^* pctro_{t-1}) \tag{19}$$

Rotterdam-Hamburg

$$\Delta pctha_t = -0.59^*(pctha_{t-1} - 0.75^* - 0.93^* pctro_{t-1}) + 0.37^* \Delta pctha_{t-1} - 0.29 \Delta pctro_{t-1} \tag{20}$$
$$\Delta pctro_t = 0.0002(pctha_{t-1} - 0.75^* - 0.93^* pctro_{t-1}) + 0.17 \Delta pctha_{t-1} - 0.34^* \Delta pctro_{t-1} \tag{21}$$

Berlin-Hamburg

$$\Delta pctbe_t = -0.52^*(pctbe_{t-1} - 0.94^* pctha_{t-1}) + 0.33^* \Delta pctbe_{t-1} - 0.22 \Delta pctha_{t-1} \tag{22}$$
$$\Delta pctha_t = 0.16(pctbe_{t-1} - 0.94^* pctha_{t-1}) + 0.17 \Delta pctbe_{t-1} + 0.12 \Delta pctha_{t-1} \tag{23}$$

where the index $*$ denotes a coefficient significant at the five percent level.

For Rotterdam-Berlin and Berlin-Hamburg, the constant β_0 of the co-integration relation is not significantly different from zero at the five percent level, which implies a direct proportional relationship between the pairs of price series. The

is equal to 11.73, 16.22 and 15.89 respectively.

Table 4: Co-integration tests
(Thompson-Seedless grapes from Chile)

	Engle and Granger	Johansen	
Berlin-Rotterdam	0.009	r=0	0.089
		r≤1	0.335
Rotterdam-Hamburg	0.007	r=0	0.081
		r≤1	0.436
Berlin-Hamburg	0.00009	r=0	0.0011
		r≤1	0.2093

Co-integration tests (Engle and Granger, Johansen) for the prices of Thompson-Seedless grapes on three European markets: Rotterdam, Berlin and Hamburg. The second column gives the p-value for the Engle and Granger stationarity test on the residuals, while the third column gives the p-values of Johansen trace test for each null hypothesis.

coefficient β_1 of the long-run relationship is significantly different from one, which indicates that prices are significantly different from one market to the other[13]. For the Rotterdam-Hamburg market pair, the constant β_0 is significantly different from zero. To test H0: $\beta_1 = 1$, the VAR-ECM model is reestimated without the constant β_0. H0 is rejected, with the consequence that prices are significantly different from one market to the other. With a coefficient of adjustment speed a_2 not significant, the import market of Rotterdam is a market leader for prices of the Chilean Thompson-Seedless grapes with respect to Berlin and Hamburg.

3.2.4 Interpretation of the results

The Engle and Granger and Johansen co-integration tests show that markets for the Chilean Thompson-Seedless grapes in Berlin, Hamburg and Rotterdam are integrated. Like prices in the Chilean Granny-Smith apple markets, prices in the Chilean Thompson-Seedless grape markets move together in the same direction. This result is not surprising since importers and wholesalers involved in handling and trading imported apples are also involved in handling and trading imported grapes. They benefit from the same efficient information network and logistical

[13]While the price equality between the Berlin and Hamburg markets is rejected, the price difference is very small (6 percent) compared to the price difference between the Berlin and Rotterdam markets (41 percent).

support to react almost instantaneously to any trade opportunity in any European market.

In contrast to the off-season imported apple markets, Student tests on the coefficient of speed of adjustment of the VAR-ECM models systematically show that the import market of Rotterdam can be considered the market leader for prices of the Chilean Thompson- Seedless grape with respect to Berlin and Hamburg. Rotterdam is by far the port of entry for grapes from Chile, which has been the most important supplier of off-season grapes in Europe. Traders in the supply chain of off-season grapes consider the market of Rotterdam as providing the most reliable indication of the off-season grape market in Europe and often use prices in Rotterdam as the floor prices for trading off-season grapes elsewhere. Because grapes from European production cannot be stored, the European markets for off-season imported grapes in this case is not disturbed by European stock releases and are, therefore, directly influenced by the import market of Rotterdam.

Prices in the wholesale markets of Berlin and Hamburg are systematically higher than in the import market of Rotterdam, respectively by 41 % and 47 %. Prices in Hamburg and Berlin are relatively close, with prices in Berlin being 6 % lower than in Hamburg. The price differences between the market leader and the other markets are larger in the case of off-season grapes than in the case of off-season apples. Because of the greater fragility and perishability of grapes compared to apples, the handling, packaging, spoilage and transport costs are higher for grapes than for apples. In addition, competition in the off-season market for grapes is likely to be not as fierce as in the off- season market for apples because of the absence of carry-over stocks. The greater fragility and lower competition for off-season grapes compared to apples explain the larger price differences between the import and wholesale markets for off-season grapes compared to those for off-season apples.

3.3 The market of the Thompson-Seedless grapes from Chile and South Africa

For this product but from different origins, two price time-series covering the consecutive off-seasons from 1994 to 1998 are available for the Thompson-Seedless grapes from Chile (*pctbe*) and South Africa (*patbe*) in the wholesale market of Berlin. Each price series has data for the same weeks within the same off-season and includes 50 observations in total. Figure 3 shows the two price series and indicates a strong common relationship between them as well as a possibly constant price difference.

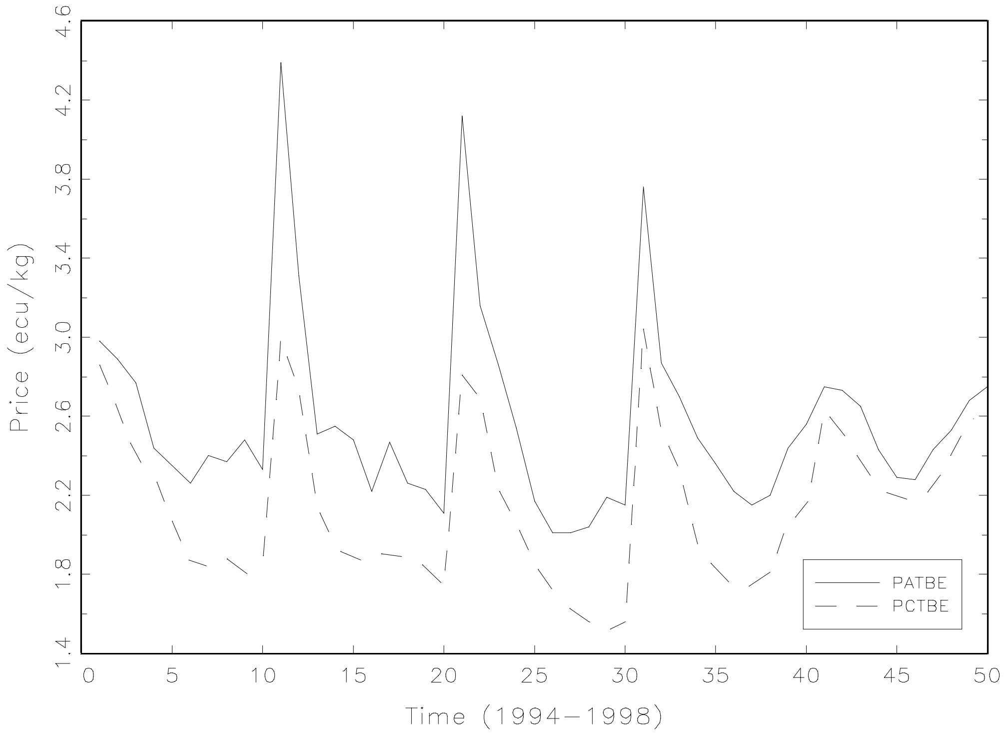

Figure 3: Prices of Thompson-Seedless grapes from Chile (*pctbe*) and South Africa (*patbe*) in Berlin

3.3.1 Unit root tests

Because of the strong seasonal pattern in the data as shown in Figure 3, the data need first to be deseasonalized[14]. Since each season includes ten observations, each price series is deseasonalized applying a lag operator of ten and is renamed *pd*10*atbe* and *pd*10*ctbe* accordingly. Table 5 reports that the seasonally differenced price series are I(1) processes at the five percent level according to the Dickey-Fuller t-test.

Since the price series *pctbe* and *patbe* considered in this case are not I(1) processes, regressing *patbe* on *pctbe* using a least squares regression model such as $patbe_t = \beta_0 + \beta_1 pctbe_t + \epsilon_t$ is meaningful. The estimated model is

$$patbe_t = 1.19 pctbe_t$$

[14]Unit root tests conducted on the two price series *pctbe* and *patbe* reject the unit root hypothesis at the five percent level. The price series *pctbe* is different from the one used in Section 3.2 as the dataset is different.

Table 5: Unit root tests
(Thompson-Seedless grapes from South Africa and Chile)

	t-stat
*pd*10*atbe*	-2.91
*pd*10*ctbe*	-2.07

Unit root tests for the seasonally differenced price series of Granny-Smith apples from South Africa (*pd*10*atbe*) and Chile (*pd*10*ctbe*) in Berlin. t-stat is the test statistic for H0: $\alpha_1 = 0$ in equation (9). At the five percent level, the critical value from the Dickey-Fuller tables is -2.93.

and indicates that the prices of the Thompson-Seedless grape variety from South Africa are 19 % higher than prices of the same grape variety but from Chile[15]. At the five percent level, the price difference is significantly different from zero.

As indicated by Figure 3, the price difference appears to be narrowing down in the last off-season (1998). This can be formally tested by first estimating the model on the two sub-periods 1994-1997 and 1998, and then testing the structural change hypothesis using a Fisher test. Estimating the model on the two sub-periods gives

$$patbe_t = 1.23 pctbe_t$$

for 1994-1997, and

$$patbe_t = 1.07 pctbe_t$$

for 1998. The Fisher test for the null hypothesis H0: $\beta_1 = \delta_1$ is equal to 26.9 and is distributed as a $F(1, 48)$.[16] The structural change in the level of the prices is significant at the five percent level.

3.3.2 Co-integration and origin leadership tests

Table 6 reports the Engle and Granger and Johansen tests for co-integration between the two seasonally differenced price series *pd*10*atbe* and *pd*10*ctbe*. Expression (35) in the appendix gives the long-run relationship. At the five percent level, the two seasonally adjusted differenced price series are co-integrated.

Table 11 of the appendix reports the estimation of the VAR-ECM model for the two seasonally differenced series *pd*10*atbe* and *pd*10*ctbe*. Table 12 of the appendix

[15] Because the constant is not significant at the five percent level, the model is estimated without it.

[16] The estimated model is $patbe_t = \beta_1 pctbe_t + \epsilon_t$ for 1994-1997 and $patbe_t = \delta_1 pctbe_t + \epsilon_t$ for 1998.

Table 6: Co-integration tests
(Thompson-Seedless grapes from South Africa and Chile)

	Engle and Granger	Johansen	
Berlin market	0.00001	r=0	0.009
		r≤1	0.158

Co-integration tests (Engle and Granger, Johansen) for the seasonnaly differenced prices of Thompson-Seedless grapes from South Africa and Chile in Berlin (*pd*10*atbe* and *pd*10*ctbe*). The first column gives the p-value for the Engle and Granger stationarity test on the residuals, while the second column gives the p-values of Johansen trace test.

gives the likelihood ratio tests corresponding to the null hypotheses H0: $\beta_0 = 0$ (no constant in the co-integrating relation) and H0: $a_{11} = a_{12} = a_{21} = a_{22} = 0$ (no short-run dynamics), and the Student tests corresponding to H0: $a_1 = 0$ and H0: $a_2 = 0$ (the coefficient of adjustment speed is not significant). These tests allow to simplify the VAR-ECM model as follows:

$$\Delta pd10atbe_t = -0.80^{*}(pd10atbe_{t-1} - 0.27^{**}pd10ctbe_{t-1}) \quad (24)$$

$$\Delta pd10ctbe_t = -0.08(pd10atbe_{t-1} - 0.27^{**}pd10ctbe_{t-1}) \quad (25)$$

where the index $*$ denotes a coefficient significant at the five percent level, while the index $**$ denotes a coefficient that is significant at the ten percent level but not at the five percent level.

From the VAR-ECM model, the short-run dynamics can be disregarded since their coefficients are not significantly different from zero at the five percent level. The constant β_0 of the co-integration relation is not significantly different from zero at the five percent level, which implies a direct proportional relationship between the seasonally adjusted differenced prices of the same variety but from different origins. The coefficient β_1 of the long-run relationship is significantly different from zero only at the ten percent level. This is probably due to the small number of observations (40 observations since 10 others had to be removed from the original data to compute the seasonally differenced series) combined with the use of the seasonally-differenced data. The market of the grape variety from Chile can be considered the market leader with respect to the market for the same variety but from South Africa.

3.3.3 Interpretation of the results

The Engle and Granger and Johansen co-integration tests show that markets for the Thompson-Seedless grape from Chile and South Africa in Berlin are integrated. Prices on the Chilean and South African Thompson-Seedless grape markets move together in the same direction.

The Thompson-Seedless grape variety from South Africa is traded in Berlin at a significantly higher price than the same grape variety but from Chile. On this particular market, the price difference is 19 % higher. According to the traders interviewed, this price difference is attributable to a greater homogeneity in the shipments from South Africa compared to those from Chile. The South African sole marketing board Capespan imposes strict quality standards on their South African suppliers and is very careful in shipping batches of grapes that are homogenous in grade, appearance, colour and packaging. In addition, this board hires salespersons in the European import and wholesale markets to promote and sell directly their produce to European retailers at prices set in direct relation with the prices of the previous week. As a result, because of the large volume of produce under its control and its reputation for good and consistent quality shipments, Capespan acts more like a price-maker in the European markets and, hence, is capable of selling its produce at a higher price than its direct competitors. Since the 1998 off-season, this board no longer holds the monopsony in assembling and shipping fresh produce out of South Africa. Because other South African traders are now allowed to deal directly with European traders and, as a consequence, shipments from South Africa are not as homogenous as before, the price difference between South African and Chilean grapes has narrowed to 7 % in 1998.

On the Chilean side, however, exporters compete with each other for European markets and have not developed a common strategy for imposing quality standards and negotiating prices with their European buyers. While constituting an oligopsony in Chile, they act more like price-takers in the European markets.[17] In addition, shareholders of the large Chilean exporting companies have additional stakes in the freighting business, an interest which tends to lead to the shipping of frequent large volumes to the detriment of the quality of these shipments. All traders interviewed in the European markets agree that a greater homogeneity in the shipments from Chile could significantly increase their market value. For example, traders in Germany estimate that withdrawing 10 to 15% of Chile's lowest quality export shipments could result in a greater homogeneity in quality and significantly reduce the price difference with respect to shipments from South Africa. Conflicting interests in Chile have until now prevented such a strategy. Meanwhile, some large retailers in the EU, in particular in the United Kingdom, are increasingly bypassing European importers and wholesalers (and even large Chilean exporters) to identify directly in Chile producers and small exporters able to supply large volumes of homogenous high quality produce.

[17] The economic concentration ratio is 36% for the first four exporting firms and 53% for the first ten exporting firms in 1997 (Villarroel, 1998).

4 Conclusion

The Engle and Granger and Johansen co-integration tests confirm that the main physical European markets for off-season fresh fruit for which price time-series are available are statistically integrated. That these markets are not compartmentalised and are actually part of a single European market is certainly good news for the performance of this industry. This market integration results from the efficiency of the marketing and shipping system used by traders, which allows them to respond promptly to market signals. Traders interviewed during the 1997 industry survey emphasised their ability to have near perfect market information and act accordingly. Market integration for grapes may, however, also reflect the ability of the South African sole marketing board to act like a price-maker and set prices in the off-season market for grapes where its market share reached 51 % in 1997 exceeding by 7 percent points the market share of the exporting firms from Chile. With the loss of the South African marketing board's monopsony power, whether market co-integration is declining for this specific market is a proposition that could be tested. Because New Zealand, with a share of 30 % of the imported off-season apple market in 1997, is also deregulating its fresh produce exports from the grip of a sole marketing board, this proposition could also be tested for this market.

The statistical significance of the coefficient of adjustment speed found for the VAR-ECM models between the price series of the import market of Rotterdam and the available price series of the wholesale markets confirms that this import market can be considered a market leader for off-season grapes with respect to the wholesale markets. The leadership of the import market of Rotterdam over the wholesale markets for off-season grapes is an interesting result for traders located not only in Europe but also in the exporting countries in search of synthesised information on the development of the European market for off-season grapes. Even if this market handles only 10 % of the grape shipments unloaded in the port of Rotterdam, which in turn may represent 2.5 % of the volume of imported grapes in Europe, the monitoring of this specific market may provide valuable information for these traders to plan their transactions and negotiate prices. The volume of produce traded on this physical import market is, however, declining and soon may no longer reflect changes in the development of the European market for off-season grapes. As expected, the import market of Rotterdam cannot be considered a market leader for the off-season imported apple prices with respect to the wholesale markets because of the concomitant releases of European apple stocks which impact wholesale prices.

The co-integration tests as well as the statistical significance of the coefficients of the long-run dynamics of the VAR-ECM models confirm a persistent proportional price difference between the import market of Rotterdam and the wholesale markets for both the Granny-Smith apple variety and the Thompson Seedless grape variety. As expected, the econometric results show a larger price difference between markets down the supply chain for the grape variety than for the apple variety as a result of higher transaction costs for the former.

The same tests and models confirm that the Thompson-Seedless grape variety from South Africa is constantly traded in Berlin at a higher price than the same variety but from Chile. A greater homogeneity in the grape shipments from South Africa compared to those from Chile explains this price difference. This price difference is, however, beginning to narrow as a result of the deregulation of the South-African fresh produce exporting system. Enforcing higher minimum quality standards on exports of fresh produce in Chile is also likely to narrow further this price difference.

Because of data constraints, the econometric results apply for a limited number of markets. Since the Granny-Smith apple variety and Thompson-Seedless grape variety are also extensively traded in some other European markets, an extension of the econometric analysis would be to include these other markets as data become available. While focussing on these varieties, this analysis could also be extended to other varieties and off-season fresh fruits such as pears.

With respect to the econometric analysis conducted on the available time-series, the estimated VAR-ECM models are "self-contained" in the sense that the regressors included in the models are the lagged or differenced regressands. These models could be extended by including additional explanatory variables that affect prices, particularly those variables that affect supply and demand at any given time. Weather conditions, European carry-over stocks, country-of-origin productions, exchange rates and market shares are all potential explanatory variables. Such extensions could not only ascertain the evidence of market integration and leadership in the fresh off-season fruit market but help develop forecasting models. Another possible extension would be to test for co-integration in a multivariate framework, i.e., conduct multivariate co-integration tests on the three of four markets under study. However, this requires the availability of a relatively large number of "common" data for all markets. At this stage this condition is not met, but the database could be improved and extended in further work as more data become available.

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Appendix

Co-integrating relations for the Granny-Smith apples from Chile

Rotterdam-Berlin

$$pcgbe_t = 0.397 + 0.685 pcgro_t \tag{26}$$

Rotterdam-Hamburg

$$pcgha_t = 0.274 + 0.831 pcgro_t \tag{27}$$

Rotterdam-Rungis

$$pcgru_t = 0.581 + 0.571 pcgro_t \tag{28}$$

Berlin-Hamburg

$$pcgbe_t = 0.186 + 0.799 pcgha_t \tag{29}$$

Berlin-Rungis

$$pcgbe_t = -0.106 + 0.993 pcgru_t \tag{30}$$

Hamburg-Rungis

$$pcgha_t = -0.118 + 0.990 pcgru_t \tag{31}$$

Co-integrating relations for the Thompson-Seedless grapes from Chile

Berlin-Rotterdam

$$pctbe_t = 0.928 + 0.751 pctro_t \tag{32}$$

Rotterdam-Hamburg

$$pctha_t = 0.768 + 0.921 pctro_t \tag{33}$$

Berlin-Hamburg

$$pctbe_t = 0.288 + 0.814 pctha_t \tag{34}$$

Co-integrating relation for the Thompson-Seedless grapes from Chile and South Africa

Berlin

$$pd10atbe_t = -0.031 + 0.611 pd10ctbe_t \tag{35}$$

Table 7: VAR-ECM (Granny-Smith apples from Chile)

	Rotterdam-Berlin	Rotterdam-Hamburg	Rotterdam-Rungis
a_1	-0.17 (0.09)	-0.19 (0.13)	-0.26 (0.12)
a_2	0.21 (0.12)	0.19 (0.17)	0.29 (0.19)
β_0	0.05 (0.17)	0.18 (0.11)	0.39 (0.12)
β_1	1.17 (0.24)	0.97 (0.15)	0.83 (0.16)
a_{11}	-0.28 (0.13)	0.29 (0.17)	0.16 (0.14)
a_{12}	0.12 (0.12)	-0.23 (0.14)	-0.01 (0.09)
a_{21}	-0.22 (0.16)	0.33 (0.22)	0.09 (0.23)
a_{22}	0.13 (0.15)	-0.35 (0.17)	-0.24 (0.16)

Estimated coefficients for the ECM-VAR (Granny-Smith apples). The estimated system is (10) and (11), with $x_t = pcgbe_t$ and $y_t = pcgro_t$ (Rotterdam-Berlin), $x_t = pcgha_t$ and $y_t = pcgro_t$ (Rotterdam-Hamburg) and $x_t = pcgru_t$ and $y_t = pcgro_t$ (Rotterdam-Rungis). Standard errors are given in parenthesis.

Table 8: Restriction tests on the VAR-ECM
(Granny-Smith apples from Chile)

Rotterdam	-Berlin	-Hamburg	-Rungis
H0: $a_{11} = a_{12} = a_{21} = a_{22} = 0$	5.24	3.02	3.48
H0: $\beta_0 = 0$	0.57	0.09	2.00
H0: $a_1 = 0$	-2.42	0.15	-1.35
H0: $a_2 = 0$	1.81	3.07	3.69
H0: $\beta_1 = 1$	7.62	8.61	12.65

Likelihood ratio tests (for H0: $\beta_0 = 0$ and H0: $a_{11} = a_{12} = a_{21} = a_{22} = 0$) and Student tests (for H0: $a_1 = 0$, H0: $a_2 = 0$ and H0: $\beta_1 = 1$) on the VAR-ECM (Granny-Smith apples). The estimated system is (10) and (11), with $x_t = pcgbe_t$ and $y_t = pcgro_t$ (Rotterdam-Berlin), $x_t = pcgha_t$ and $y_t = pcgro_t$ (Rotterdam-Hamburg) and $x_t = pcgru_t$ and $y_t = pcgro_t$ (Rotterdam-Rungis). At the five percent level, the critical values are $\chi^2(4) = 9.49$, $\chi^2(1) = 3.84$ and $t(60) = 2$.

Table 9: VAR-ECM (Thompson-Seedless grapes from Chile)

	Rotterdam-Berlin	Rotterdam-Hamburg	Berlin-Hamburg
a_1	-0.52 (0.14)	-0.59 (0.15)	-0.73 (0.17)
a_2	0.05 (0.12)	0.0002 (0.11)	-0.005 (0.18)
β_0	0.82 (0.32)	0.75 (0.29)	0.22 (0.10)
β_1	0.82 (0.24)	0.93 (0.22)	0.84 (0.04)
a_{11}	0.18 (0.15)	0.37 (0.15)	0.45 (0.16)
a_{12}	-0.43 (0.19)	-0.29 (0.20)	-0.29 (0.16)
a_{21}	0.01 (0.12)	0.17 (0.12)	0.25 (0.17)
a_{22}	-0.26 (0.15)	-0.34 (0.15)	0.03 (0.16)

Estimated coefficients for the ECM-VAR (Thompson-Seedless grapes). The estimated system is (10) and (11), with $x_t = pctbe_t$ and $y_t = pctro_t$ (Rotterdam-Berlin), $x_t = pctha_t$ and $y_t = pctro_t$ (Rotterdam-Hamburg) and $x_t = pctbe_t$ and $y_t = pctha_t$ (Berlin-Hamburg). Standard errors are given in parenthesis.

Table 10: Restriction tests on the VAR-ECM (Thompson-Seedless grapes from Chile)

	Rot.-Berlin	Rot.-Hamburg	Berlin-Hamburg
H0: $a_{11} = a_{12} = a_{21} = a_{22} = 0$	5.87	9.45	15.81
H0: $\beta_0 = 0$	1.50	5.51	2.77
H0: $a_1 = 0$	-1.97	-4.1	-3.21
H0: $a_2 = 0$	1.66	0.001	0.97
H0: $\beta_1 = 1$	5.91	-	-4.89

Likelihood ratio tests (for H0: $\beta_0 = 0$ and H0: $a_{11} = a_{12} = a_{21} = a_{22} = 0$) and Student tests (for H0: $a_1 = 0$, H0: $a_2 = 0$ and H0: $\beta_1 = 1$) on the VAR-ECM (Thompson-Seedless grapes). The estimated system is (10) and (11), with $x_t = pctbe_t$ and $y_t = pctro_t$ (Rotterdam-Berlin), $x_t = pctha_t$ and $y_t = pctro_t$ (Rotterdam-Hamburg) and $x_t = pctbe_t$ and $y_t = pctha_t$ (Berlin-Hamburg). At the five percent level, the critical values are $\chi^2(4) = 9.49$, $\chi^2(1) = 3.84$ and $t(60) = 2$.

Table 11: VAR-ECM
(Thompson-Seedless grapes from Chile and South Africa)

	Berlin market
a_1	-0.94 (0.19)
a_2	-0.09 (0.20)
β_0	-0.07 (0.04)
β_1	0.33 (0.19)
a_{11}	0.13 (0.09)
a_{12}	-0.15 (0.21)
a_{21}	0.18 (0.07)
a_{22}	-0.32 (0.15)

Estimated coefficients for the ECM-VAR on seasonnaly differenced prices (Thompson-Seedless grapes from Chile and South Africa). The estimated system is (10) and (11), with $x_t = pd10atbe_t$ and $y_t = pd10ctbe_t$. Standard errors are given in parenthesis.

Table 12: Restriction tests on the VAR-ECM
(Thompson-Seedless grapes from Chile and South Africa)

	Berlin market
H0: $a_{11} = a_{12} = a_{21} = a_{22} = 0$	3.67
H0: $\beta_0 = 0$	2.41
H0: $a_1 = 0$	-5.96
H0: $a_2 = 0$	-0.75

Likelihood ratio tests (for H0: $\beta_0 = 0$ and H0: $a_{11} = a_{12} = a_{21} = a_{22} = 0$) and Student tests (for H0: $a_1 = 0$ and H0: $a_2 = 0$) on the VAR-ECM (Thompson-Seedless grapes). The estimated system is (10) and (11), with $x_t = pd10atbe_t$ and $y_t = pd10ctbe_t$. At the five percent level, the critical values are $\chi^2(4) = 9.49$, $\chi^2(1) = 3.84$ and $t(60) = 2$.