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ABSTRACT: This paper examines the vertical price transmission of banana and orange prices in Finland using import and consumer price series from years 1998-2009. Considering the stationary behaviour of the price series, the dynamic relationship between import and consumer price is investigated by Autoregressive Distributed Lag (ADL) models and Error Correction Models (ECM). The results show that the vertical price transmission is symmetric both with banana and orange. However, the analysis concentrates on the speed of adjustment towards the equilibrium of prices. Due to linearity of the model it does not take into account the magnitude of the price change.
Key words: *Price transmission, autoregressive distributed lag model, error correction model, food markets.*

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TIIVISTELMÄ: Tässä tutkimuksessa tarkasteltiin vertikaalista hintasiirtymää Suomen elintarvikemarkkinoilla. Tutkimusaineistona käytettiin banaanin ja appelsiinin tuonti- ja kuluttajahintoja vuosilta 1998 - 2009. Hintasiirtymää tutkittiin aikasarja-ekonometrisin menetelmin käyttämällä dynaamisia ADL- ja virheenkorjausmalleja aineiston stationaarisuudesta johtuen. Tulokset osoittivat, että hintasiirtymä on symmetrinen sekä banaanin että appelsiinin tapauksessa. Huomionarvoista kuitenkin on, että valittu lähestymistapa tarkastelee hintasiirtymistä ajallisesti ja, että mallin lineaarisuuden vuoksi hintamuutoksen suuruutta ei huomioida.
Avainsanat: *Hintasiirtymä, ADL -malli, virheenkorjausmalli, elintarvikemarkkinat.*

YHTEENVETO

Tutkimuksesta saadut tulokset osoittavat, että tuontihedelmien hintojen muutokset siirtyvät kuluttajahintoihin samalla viiveellä riippumatta siitä, laskevatko vai nousevatko tuontihinnat. Tuontihinnassa tapahtuneen muutoksen vaikutusaika kuluttajahintaan on 4-5 kuukautta. Lyhyellä aikavälillä hedelmien tuontihinnan muutoksesta kuluttajahintaan siirtyy 20-30 %. Tämä tarkoittaa sitä, että esimerksiksi 10 sentin muutos tuontihinnassa saa aikaan 2-3 sentin muutoksen kuluttajahinnassa. Pitkällä aikavälillä tuontihinnan muutoksesta siirtyy kuluttajahintaan puolestaan 50-60 %.

Osittaista siirtymistä sekä lyhyellä että pitkällä aikavälillä selittää tuotteiden kausittaisuus. Lisäksi, kaupalle koituvat kustannukset hintamuutoksesta voivat olla hintamuutoksen tuomaa hyötyä suuremmat, jolloin tuontihinnan muutos ei välity kuluttajahintaan. Osittainen siirtyminen tarkoittaa kuitenkin vain sitä, että ns. hintamarginaali (kuluttajahinnan ja tuontihinnan erotus) vaihtelee ajan mukaan, ei sitä että se välttämättä kasvaisi. Esimerkkeinä olleista hedelmistä banaanin hintamarginaali on jopa pienentynyt ja appelsiinilla pysynyt suunnilleen samalla tasolla viimeisen kymmenen vuoden ajan.

Tämä tutkimus on osa PTT:n ja MTT:n laajempaa ruokamarkkinoiden tehokkuutta koskevaa tutkimushanketta, jolle on saatu rahoitus maatilatalouden kehittämisrahastosta. Hankkeessa tarkastellaan elintarvikeketjun horisontaalista ja vertikaalista hintaintegraatiota sekä hintamarginaaleja ja ketjun eri osien saamien osuuksien kehitystä.

Toimivien elintarvikemarkkinoiden edellytyksenä on, että hintamuutokset välittyvät täysimääräisesti ja samanaikaisesti riippumatta siitä, laskevatko vai nousevatko hinnat. Tässä tutkimuksen ensimmäisessä vertikaalista hintaintegraatiota tarkastelevassa työpaperissa banaani ja appelsiini valittiin tutkimuskohteiksi siksi, että niissä ei ole kilpailevaa kotimaista vaihtoehtoa tarjolla. Lisäksi niissä jalostavan teollisuuden (tai muiden väliportaiden) osuus ei ole kovin suuri. Tutkimuksen seuraavassa vaiheessa tarkastellaan kurkun ja tomaatin hintasiirtymiä, jotka tarjoavat mielenkiintoisen vertailukohdan appelsiiniin ja banaaniin, koska niissä on tarjolla sekä kotimainen että ulkomainen vaihtoehto.

Tutkimuksessa sovellettiin aikasarjaekonometrisia malleja kuvaamaan hintasiirtymisen viivettä tuontihinnasta kuluttajahintaan. Aineistona käytetyt hintasarjat (1998-2009) ovat hintasarjoina epätyypillisesti stationaarisia, joten yleensä hintasarjojen analysoinnissa käytettyjä yhteisintegroituvuusmenetelmiä ei tässä tutkimuksessa käytetty. Sen sijaan, hintojen välistä riippuvuutta mallinnettiin stationaarisille sarjoille sopivilla dynaamisilla ADL (*autoregressive distributed lag*) –malleilla sekä niistä johdetuilla virheenkorjausmalleilla (*error correction model*). Vertikaalista hintasiirtymistä kuvaava malli kuvaa hintasiirtymisen (a)symmetrisyyttä ajallisesti, eikä lineaarisuutensa vuoksi huomioi hintamuutoksen suuruuden vaihtelua.

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1 INTRODUCTION

The efficiency of food markets is one measure of a well-functioning society. Efficient food markets require that price changes on any level of the food chain are immediately reflected to other levels. In addition, an ideally working food chain reacts to consumers' preferences rapidly and without friction. In reality, however, the price transmission along the food chain is not perfect and thus provides an interesting scope to analyze the performance of the food markets which have a significant effect on society's welfare.

Agricultural policy has its benefits for stabilizing the markets and guarantees that production maintains at the level where it is still profitable. Still, policy actions distort markets through subsidies which affect price margins (Kuosmanen et al. 2009). In addition, different subsidies in the agricultural sector complicate the study of price transmission among agricultural products. In fact, Vavra and Goodwin (2005) find that the price asymmetry might be a cause of government interventions. In this paper, however, the examination concerns bananas and oranges which are imported into Finland and are not affected by the national agricultural policy. Thus, three interesting aspects arise: *First*, the fact that neither one of the fruits is produced in Finland offers a chance to explore whether agricultural policy has any effect on the price transmission. *Second*, both fruits imported are sold to consumers without processing.[1] *Third*, in Finland the retail firms in the food sector largely own the wholesale trade. Therefore, the import price of a fruit can be treated as a unit cost for the retail sector.

Price asymmetry arises when a change in an input price is not transmitted equally or coincidentally to the output price. Consumers often claim that retail prices rise more than costs rise and, respectively, they decrease less than costs do. The importance of price asymmetry has also been noticed among economists. For example, Frey and Manera (2007) report of 70 studies concerning the asymmetric price transmission. In addition, Meyer and Von Cramon-Taubadel (2004) offer an exhaustive selection of previous studies and methods concentrating on asymmetric price transmission in agricultural economics. Both surveys include various econometric models to detect asymmetric price transmission. The usefulness of these models depends on the properties of the data.

Usually price series exhibit non-stationary behaviour. Obvious reasons for this could be various weather conditions, changing technology or policy acts, for example. There are different estimation strategies depending on whether the time series data is stationary or

[1]Some portion of orange is processed into orange juice but the share is not significant compared to the total amount imported. Obviously, with banana this share is even less.

not. In the recent agricultural economics literature, cointegration based methods have been popular in examining the vertical price transmission. These methods are applied to non-stationary data when two time series are assumed to share an equilibrium in the long run. Error Correction Model (ECM) is widely used to characterize this relationship (see e.g., Conforti 2004; Von Cramon-Taubadel 1998). However, since the retail sector might not transmit minor price changes to the consumer price in the short run due to adjustment costs, different threshold approaches are used to study asymmetric price transmission. Error correction with threshold cointegration method can be investigated as an univariate case (Balke and Fomby 1997) or as multivariate with Threshold Vector Error Correction Models (TVECM) (Lo and Zivot 2001). The latter method is recently applied to study asymmetric price transmission in the meat markets (Ben-Kaabia and Gil 2007; Luoma et al. 2004).

In this paper the price asymmetry is studied with Autoregressive Distributed Lag (ADL) models and Error Correction Models (ECM) which are the most used methods in studying the asymmetric price transmission (Frey and Manera 2007, 401). By economic theory it is reasonable to assume that import and consumer prices share an equilibrium. In theory, a change in the import price has both short and long term effects on the consumer price and the causality is assumed to go from import price to the consumer price. Both ADL and ECM models enable to examine the equilibrium concept between import and consumer price and how the process is adjusted back to the equilibrium after a price shock. These estimation methods also reveal the short and long-term effects of import price on consumer price.

This paper is organized as follows: After describing the causes of price asymmetry and Finnish import fruit markets in Section 2, in Section 3 the estimation methods for detecting the asymmetric price transmission are considered. Section 4 contains preliminary data analysis. The results are reported in Section 5 and Section 6 concludes.

2 PRICE ASYMMETRY

2.1 Types and Causes

Price asymmetry arises when a change in a price that is interconnected to the other price is not transmitted equally between them. Following Meyer and Von Cramon-Taubadel (2004) suppose the price that faces the change is denoted as p^i and the dependent price as p^d. The asymmetric price transmission (henceforth APT) may result in two ways. First, the change in p^i may not be transmitted with the same magnitude to the p^d. Second, it may take time for the change in the p^i to be equally transmitted to the p^d. Thus, the APT results in either or both ways. In addition, Peltzman (2000) classifies the APT into positive (negative) if p^d has a greater impact or adjusts more rapidly to an increase (decrease) in p^i than to a decrease (increase).

The APT may exist for many reasons, but the most unified opinion in literature is that the main cause is market power. Hence, increasing competition in every level of the processing chain could reduce the presence of APT. While competition sounds like an aid, it does not have any effect if there are only few firms competing against each other. Market concentration improves the possibilities of APT, for price level is easier to maintain at higher level when there are fewer competing firms in the market. Moreover, highly concentrated markets could reduce the competition and, in the worst case, set up an environment which encourages to a collusion. In case of a collusion firms keep higher prices as long as consumers do not change their consumption habits and until then the whole industry gains larger profits. However, market power affects only on the magnitude of APT and not on its speed. (Meyer and Von Cramon-Taubadel 2004.)

In the processing chain price changes always require some costs which are generally referred as adjustment or menu costs. If a firm considers these costs to be more than the obtained gain from the price change, it may keep the price at the current level. Thus, menu costs increase price rigidity which is generally a more acceptable reason for APT than market power. Nevertheless, menu costs are also a convenient explanation for a firm which has a market power to justify its actions (Meyer and Von Cramon-Taubadel 2004, 590).

In Finland, the price transmission in food products has recently been explicit. In 2007 prices of food products increased rapidly due to a global food crisis and rising producing costs. Afterwards, producing costs declined in 2008 but the food products in Finland maintained their high price level (Lehtinen 2009). This effect is known as *rockets and feathers* where prices rise instantly like a feather but fall very slowly (See, e.g. Tappata 2009).

2.2 Finnish Import Fruit Markets

In Finland the retail level in the food chain is highly concentrated. The two largest firms in retail sector had a 76% share of the markets in year 2008 (Karikallio et al. 2009). A majority of food products needs several stages in the chain before the final product is available to consume. Therefore, it is difficult to find the presence of APT. Banana and orange, however, concern only retail and consumer levels. The reason for this is that retail firms in Finland have their own wholesale trade as a subsidiary, and that neither one of the two fruits is produced in Finland.

Banana and orange are the two fruits with the largest volume imported to Finland. For example, the amount of bananas imported in 2009 was 53.300 tons, which was 21% of the total amount of fruits imported in that year. Respectively, the amount of oranges imported in 2009 was 25.400 tons, which was 10% of the total amount of fruits imported. The imports of banana and orange in years 1998-2009 are depicted in Figure 1. Figure 1 implies that the seasonal component is evident with orange but is not so explicit with banana. The import of orange decreases dramatically during the summer months, but the imported amount of banana is rather stabile during the whole year. The natural explanation can be found from the main crop of orange which is harvested in the autumn while production of banana is more regular.

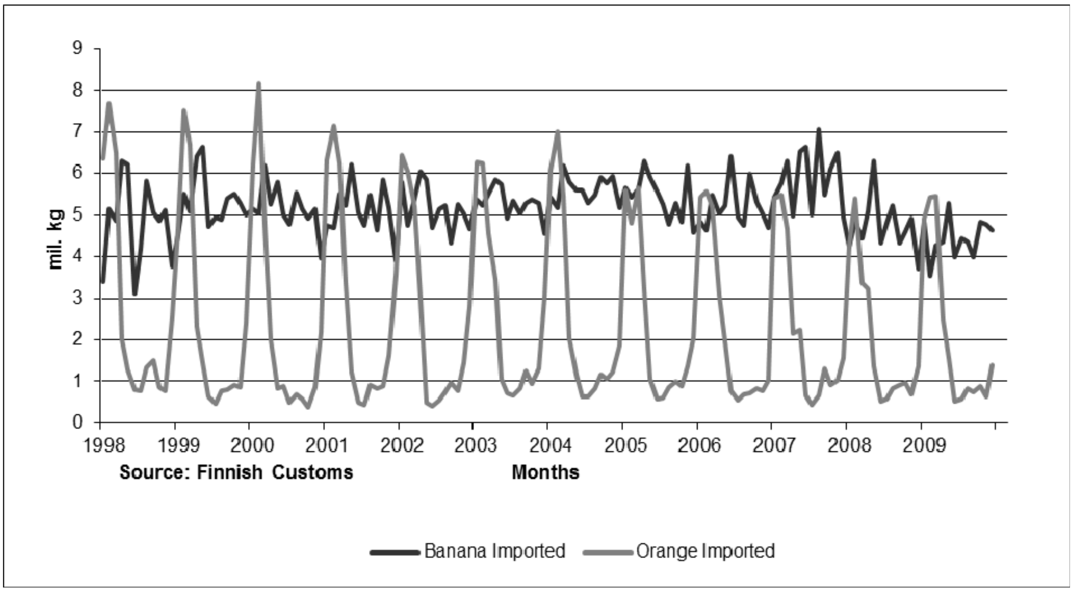

Figure 1: *Imports of banana and orange in years 1998-2009.*

Figure 2 shows the evolution of monthly average import price and consumer price of banana in years 1998-2009. Respectively, the monthly average import price and the consumer price of orange in years 1998-2009 are represented in Figure 3.

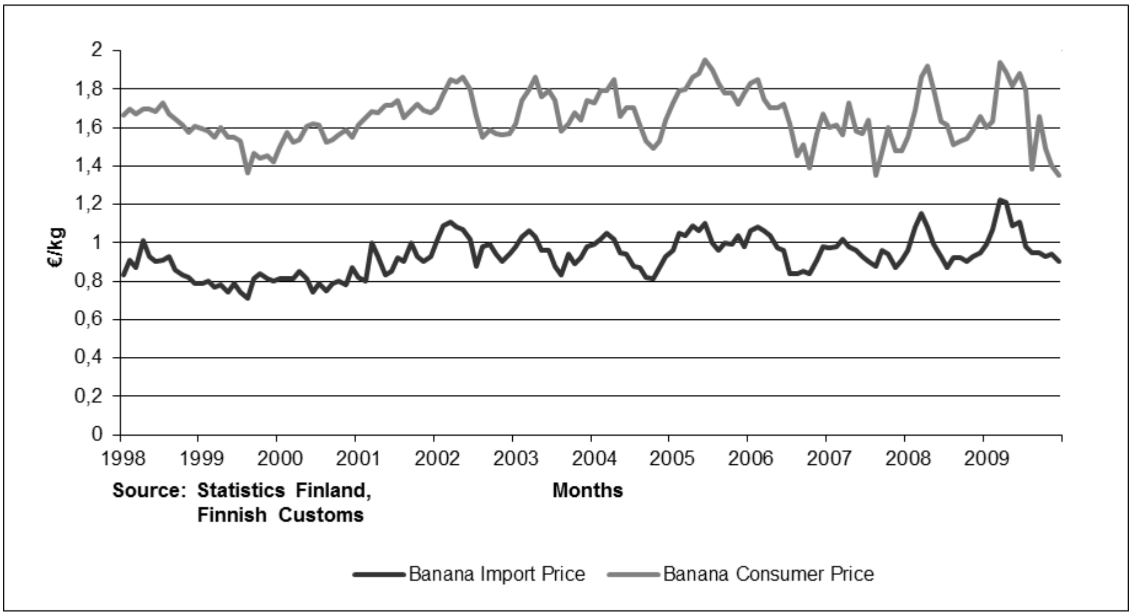

Figure 2: *Import and consumer prices of banana in Finland in years 1998-2009.*

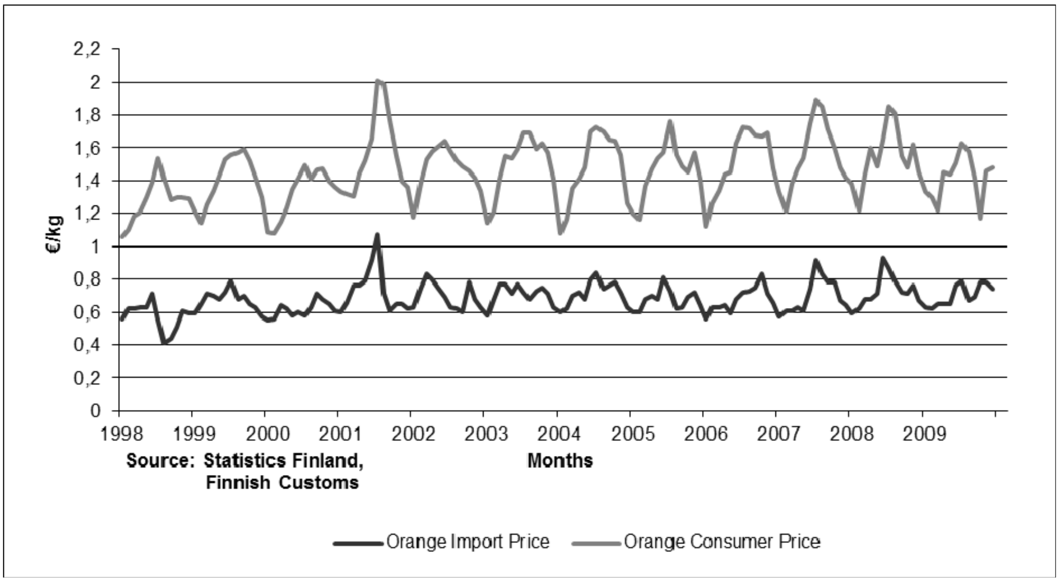

Figure 3: *Import and consumer prices of orange in Finland in years 1998-2009.*

A rather surprising observation is that both prices of banana have stayed approximately at the same level during the time period. This same notion applies also to orange. However, real prices have not changed either (Appendix A). From Figures 2 and 3 one can draw a preliminary conclusion that the price series are stationary since the mean is the same during the whole time period and also the variance is finite. In both cases the consumer price varies more with respect to the import price. Moreover, the seasonal component is evident with the price series of orange but not with the price series of banana.

The evolution of a price margin of banana is depicted in Figure 4(a) in absolute values and in 4(b) as percentages of import price. The marginal has a decreasing trend both in absolute and relative terms.

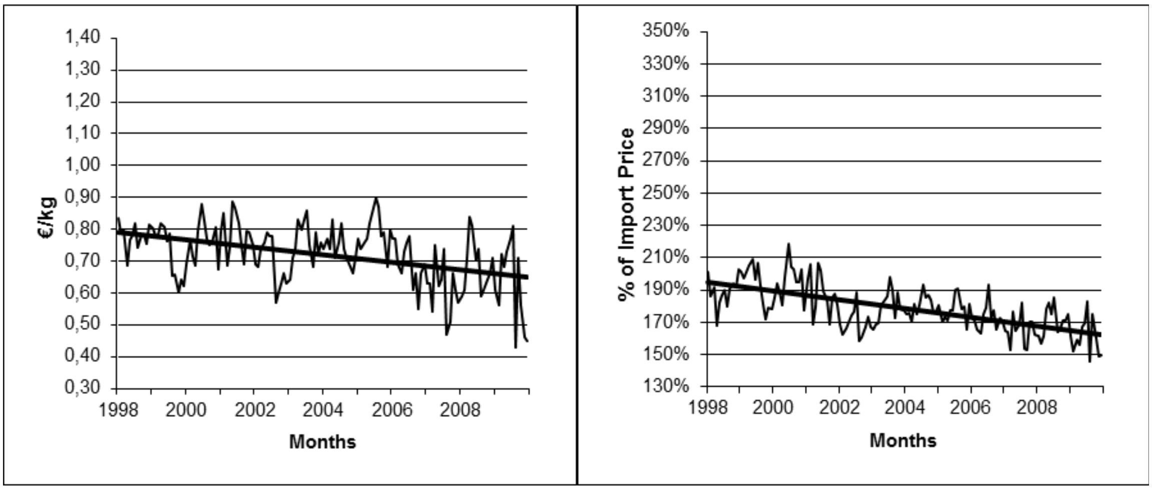

Figure 4: *Price margin of banana in (a) absolute values and (b) as a percentage of import price.*

Respectively, the evolution of the price margin of orange is plotted in Figures 5(a) and 5(b). In this case, the margin has remained at the same level in both ways measured. However, the percentage share of import price is significantly larger than with banana. In addition, the orange price margin has more variation than the banana price margin and its peak is clearly in the summer. This variation can be explained by the change in consumer price which indicates that the demand of orange exceeds its supply.

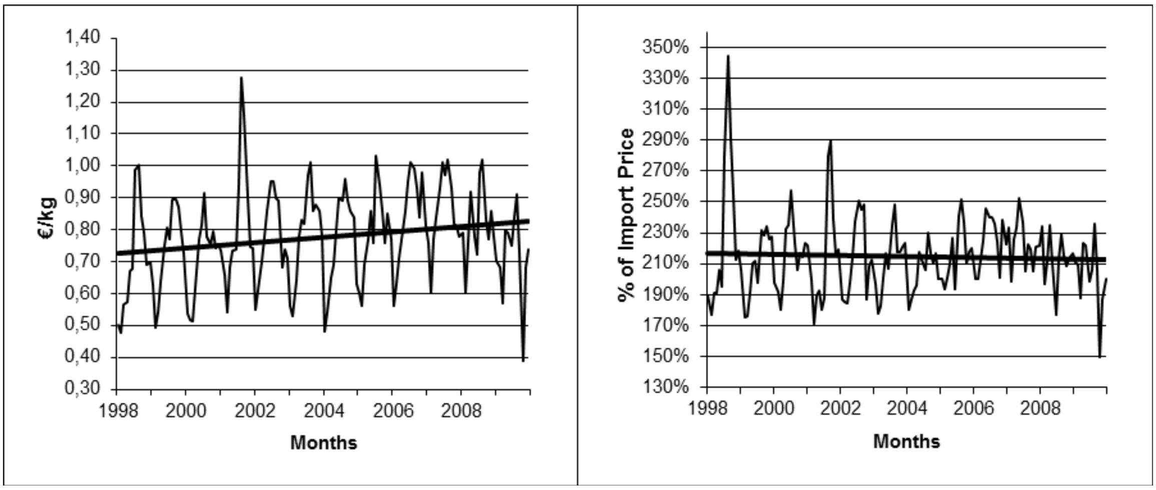

Figure 5: *Price margin of orange in (a) absolute values and (b) as a percentage of import price.*

Inferences on how the price margin changes relative to import and consumer prices are difficult to do based on Figures 4 and 5. Hence, the following approach from Ben-Kaabia and Gil (2007) is used to examine the price asymmetry separately when the price margin is decreasing and when it is increasing. Three conclusions based on Figure 6 are that (i) in both cases, changes in marketing margins are consequence of variation in the consumer price, especially with orange, (ii) with banana in average the negative changes equal positive changes while with orange positive changes are in average greater than negative changes and (iii) the import price in both cases is more rigid than the consumer price.

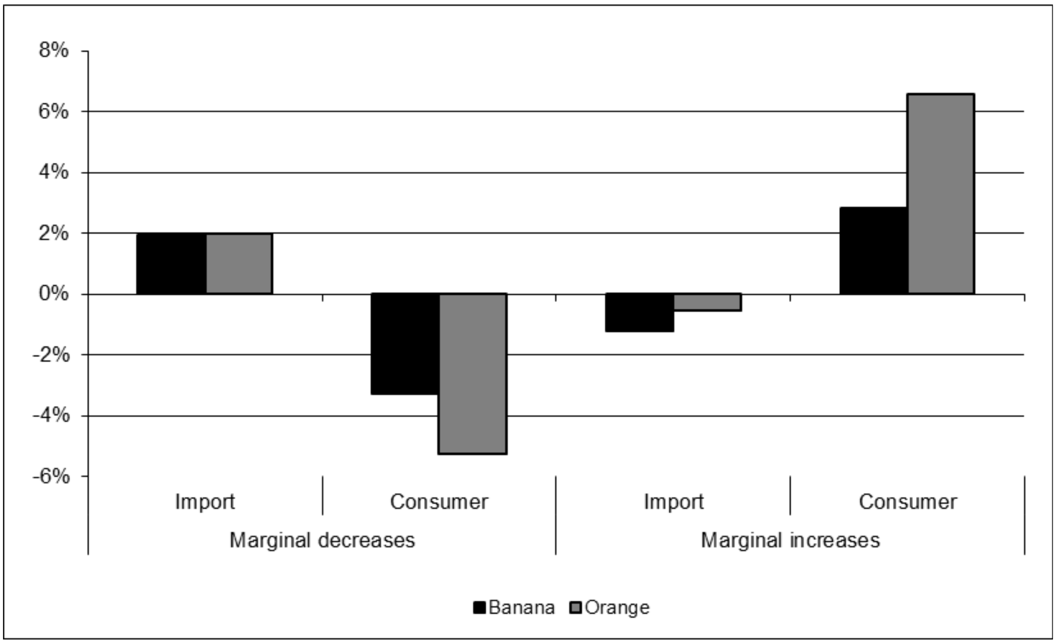

Figure 6: *Percentage change of import and consumer prices when marginal is either decreasing or increasing.*

The conclusion based on the original price series, the price margins and their interaction is that orange differs from banana. With orange the price margin is greater than with banana, and it also shows stronger seasonality.

3 ESTIMATION METHOD

By economic theory it is reasonable to assume that a change in the import price affects the consumer price. In the case of banana and orange, this argument is validated by the fact that there are no intermediaries since neither one of the fruits is produced in Finland. Considering the dynamic relation between the prices, it is rational to presume that the import price has both short and long term effects on the consumer price and, at least in the long run, they share an equilibrium. Furthermore, a prior view is that the causality goes from the import price to the consumer price. Under these assumptions, suppose that the relationship between consumer and import price is characterized as

$$P_t^c = AP_t^i \tag{1}$$

where P^c and P^i denote the consumer and import price, respectively. A is the factor of proportionality. The logarithmic form of Eq. (1) is

$$p_t^c = a + p_t^i. \tag{2}$$

where $\ln \mathrm{P}_t^c = p_t^c$, $\ln \mathrm{A} = a$ and $\ln \mathrm{P}_t^i = p_t^i$. Then, suppose that the Eq. (2) is estimated assuming that the disturbances follow a first-order autoregressive, AR(1) process. The model is then written as

$$\begin{aligned} p_t^c &= \beta_0 + \beta_1 p_t^i + \varepsilon_t, \\ \varepsilon_t &= \rho\varepsilon_{t-1} + u_t, \qquad t = 1,\ldots,\mathrm{T}. \end{aligned} \tag{3}$$

The above model could be estimated with Feasible Generalized Least Squares (FGLS) but a modern econometric analysis prefers to examine the dynamic relationship between variables. The autocorrelation is being treated as a cause of model misspecification (Hendry 1995; Mizon 1995). Therefore, suppose that the disturbance process in Eq. (3) is inserted into the regression model and then written as

$$p_t^c = \beta_0 + \rho p_{t-1}^c + \beta_1 p_t^i + \beta_2 p_{t-1}^i + u_t \tag{4}$$

where $\beta_2 = \rho\beta_1$. The Eq. (4) is referred as Autoregressive Distributed Lag model, ADL(p,q) where p refers to the number of lags of dependent variable and q to the number of lags of independent variable, respectively. Thus, the model in Eq. (4) is denoted as ADL(1,1). ADL model can be estimated efficiently with OLS as long as the assumption of spherical disturbances holds.

Usually price series exhibit non-stationary behaviour. There are different estimation methods available for characterizing the equilibrium between variables depending on whether price series are stationary or not. According to the Granger Representation Theorem (Engle and Granger 1987), Error Correction mechanism with non-stationary series is isomorphic to the cointegration. However, with stationary series Error Correction is isomorphic to the ADL(p,q) model. Hence, it is possible to derive an Error Correction Model (ECM) from ADL(p,q). In particular, this model selection is justified by two reasons. First, it characterizes the equilibrium concept between the import price and consumer price. In addition, ECM allows one to analyze both short and long run effects. Second, it is possible to circumvent the non-stationarity assumption with single-equation ECM (Keele 2005). Suppose that Eq. (4) is manipulated by adding and subtracting to obtain a single-equation ECM form as

$$\Delta p_t^c = \beta_0 + \beta_1 \Delta p_t^i - \phi_1 (p_{t-1}^c - \phi_2 p_{t-1}^i) + \varepsilon_t \tag{5}$$

where $\phi_1 = \rho - 1$ and $\phi_2 = \beta_1 + \beta_2$ and Δ denotes the first difference. Now, the long-run equilibrium between the import price and the consumer price can be characterized as

$$p_t^c = \alpha_1 + \alpha_2 p_t^i \tag{6}$$

where $\alpha_1 = \frac{\beta_0}{\phi_1} = \frac{\beta_0}{\rho - 1}$ and $\alpha_2 = \frac{\phi_2}{\phi_1} = \frac{\beta_1 + \beta_2}{\rho - 1}$. The previous model assumes symmetric price transmission. However, since the objective is to examine the asymmetric price transmission it is possible to calculate residuals as

$$p_t^c - \hat{\alpha}_1 - \hat{\alpha}_2 p_t^i = e_t \tag{7}$$

and then divide the residuals into positive and negative terms (Granger and Lee 1989) as $e_t = e_t^+ + e_t^-$, $e_t^+ = \max(e_t, 0)$, $e_t^- = \min(e_t, 0)$ to construct an ECM as

$$\Delta p_t^c = \beta_0 + \beta_1 \Delta p_t^i + \gamma_1 e_{t-1}^+ + \gamma_2 e_{t-1}^- + \varepsilon_t \tag{8}$$

To detect the asymmetric price transmission, a null hypothesis $\gamma_1 = \gamma_2$ is tested. The residuals terms in Eq. (8) enable to observe whether the correction towards the equilibrium is the same if we are above or below the long run equilibrium. However, the correction in Eq. (8) is linear so a constant proportion of the deviation is corrected regardless of the size of this deviation (Meyer and Von Cramon-Taubadel 2004, 597). Hence, this estimation strategy concentrates only on the speed of adjustment towards the equilibrium and not on the magnitude.

The Granger causality (Granger 1969) testing is a common procedure with dynamic model specification. In particular, it helps to make inferences about the exogeneity of variables. Within this context, the Granger causality testing is done by means of testing our strong assumption rising from the theory that only the import price has an effect on the consumer price and not vice versa. The hypotheses to be tested are

$$p_t^c = \beta_0 + \sum_{i=1}^{p} \rho_i p_{t-i}^c + \sum_{i=1}^{p} \beta_i p_{t-i}^i + \varepsilon_t^1 \tag{9}$$

$$H_0^I : \beta_1 = \beta_2 = \ldots = \beta_p = 0$$

and

$$p_t^i = \delta_0 + \sum_{i=1}^{q} \gamma_i p_{t-i}^c + \sum_{i=1}^{q} \theta_i p_{t-i}^i + \varepsilon_t^2 \tag{10}$$

$$H_0^{II} : \gamma_1 = \gamma_2 = \ldots = \gamma_q = 0$$

The appropriate lag length is found when both disturbances are $NID(0, \sigma_\varepsilon^2)$. A prior view is that the first hypothesis is rejected and the second is not so the import price Granger cause the consumer price.

4 DATA AND PRELIMINARY ANALYSIS

The data is collected from Statistics of Finland and Finnish Customs. It contains the monthly averages of import and consumer prices of banana and orange in years 1998-2009. The import price of orange is a combination of two price series since Finnish Customs has changed the classification during the time period. The variables are expressed in natural logarithms so the interpretation is in proportional terms. Note that seasonal adjustments were not performed to avoid the loss of information.

Often price series exhibit nonstationary behavior indicating a presence of a unit root. Considering the seasonality of the fruits, the HEGY test procedure (Hylleberg et al. 1990) was used to detect the presence of seasonal unit roots. The test regression specification and results can be found from Appendix B. HEGY test results indicate that the hypothesis of an unit root is rejected in all frequencies but not with zero. This argument is supported by following Beaulieu and Miron (1993) that i) even though joint hypothesis is rejected, a sufficient condition is that at least other *t*-test is rejected, ii) the last test specification with an intercept and seasonal dummy variables is the most appropriate and iii) using a seasonal difference filter is likely to lead to misspecification problems. Therefore, the appropriate method to handle seasonality is to include seasonal dummies to the regression models.

Due to stationary behaviour of price series, on the contrary to the widely used cointegration analysis, the models to be considered here will be dynamic ADL(p,q) and ECM discussed in the previous section. For ADL models the lag length selection procedure was performed as general to simple and selection criterias were minimum AIC value, R^2 with residual diagnostics checking. After the preliminary analysis the chosen model specifcation is ADL(1,1) for both fruits. Consequently, it is possible to derive error correction representations which model the asymmetric price transmission.

5 RESULTS

5.1 Banana

The results from differenced version of ADL(1,1) regression with seasonal dummies $\sum_{i=1}^{11} DS_i$ for banana are represented in Table 1.

Table 1. *Regression on* $\Delta\ p_t^c$

Variable	Estimate	Std. Error	*t*-value	P>|*t*|
intercept	0.207	0.0382	5.40	0.000
$\Delta\ p_t^i$	0.299	0.0696	4.30	0.000
p_{t-1}^c	-0.389	0.0724	-5.37	0.000
p_{t-1}^i	0.197	0.0484	4.07	0.000
DS_1	0.006	0.0173	0.34	0.738
DS_2	0.019	0.0172	1.13	0.259
DS_3	0.013	0.0175	0.73	0.469
DS_4	0.024	0.0177	1.35	0.180
DS_5	0.007	0.0187	0.35	0.725
DS_6	0.018	0.0178	1.00	0.321
DS_7	0.018	0.0185	0.9	
0.339				
DS_8	-0.071	0.0180	-3.95	0.000
DS_9	0.008	0.0169	0.47	0.642
DS_{10}	-0.010	0.0172	-0.60	0.548
DS_{11}	-0.012	0.0169	-0.73	0.467
N=143,	R^2 =0.52,	$\bar{R}^2$ =0.47,	s=0.0413	
F=10.00,	LM^a =1.86,	Q^b =46.48		

[a]Breusch-Godfrey statistic [b]Box-Pierce statistic

All coefficients of price variables are significant and only August has significant effect on all seasonal dummies when December is the baseline. The results indicate that the short-run effect of import price on the consumer price is approximately 0.3. This means that the proportional change in the consumer price is only 30 % of the proportional change in the import price. Thus, the consumer price is lagging behind the import price and this creates a disequilibrium. Mostly, this lagging effect of consumer price is explained by menu costs for a firm in retail level would suffer a greater loss than it might gain if it adjusted the selling price too often. The short-run effect could also be explained by the quality of the data. The data on monthly basis may be too aggregate since price changes could happen in weeks. Since both coefficients of lagged variables are statistically significant, the error correction mechanism is assured. The single equation ECM form from the estimated model is derived as

$$\Delta p_t^c = \underset{(0.0382)}{0.207} + \underset{(0.0696)}{0.299}\Delta p_t^i - \underset{(0.0724)}{0.389}(p_{t-1}^c - \underset{(0.0365)}{0.507}\, p_{t-1}^i) + u_t \tag{11}$$

where the standard error of the long-run multiplier is calculated with Bewley transformation using fitted values of Δp_t^c as instruments (Banerjee et al. 1993, 62). Now, in the long-run the proportional change in the consumer price is 51 % of the proportional change in the import price. The error correction value is negative -0.389, which implies that the correction is towards the equilibrium as it should be. The error-correction of 39 % per month is considered as slow convergence. This means that adjustment time back to the equilibrium is five months.[2] The long-run relationship between the consumer and the import price is characterized as

$$p_t^c = 0.531 + 0.507\, p_t^i + e_t \tag{12}$$

Since this 0.531 is the logarithm of the proportional term, the exponential of it reveals the true relationship between the consumer price and the import price. It follows that the consumer prices are approximately 1.70 greater than the import prices in the long-run. This 70 % share over the import price includes the marketing and transactions costs for retail as well as their profit from banana. With the help of the long-run equilibrium it is possible to construct ECM that captures the asymmetric price transmission. The results are listed in Table 2:

Table 2. *Regression on* $\Delta\ p_t^c$

Variable	Estimate	Std. Error	*t*-value	P>|*t*|
intercept	-0.005	0.0130	-0.40	0.693
$\Delta\ p_t^i$	0.288	0.0676	4.25	0.000
e_{t-1}^+	-0.235	0.1563	-1.51	0.135
e_{t-1}^-	-0.495	0.1201	-4.12	0.000
DS_1	0.007	0.0172	0.38	0.706
DS_2	0.019	0.0169	1.15	0.253
DS_3	0.013	0.0170	0.75	0.456
DS_4	0.025	0.0171	1.44	0.152
DS_5	0.005	0.0184	0.27	0.786
DS_6	0.016	0.0177	0.88	0.382
DS_7	0.014	0.0186	0.77	0.441
DS_8	-0.075	0.0182	-4.10	0.000
DS_9	0.005	0.0170	0.31	0.760
DS_{10}	-0.010	0.0171	-0.59	0.558
DS_{11}	-0.014	0.0169	-0.82	0.416
N=143	R^2=0.53	$\bar{R}^2$=0.48	s=0.0411	
F=10.18	LM=1.12	Q=43.75		

[2]The correction of 51 % towards the equilibrium proceeds in stages in future periods so that at time *t*, the correction is 19 %, *t*+1: 12 %, *t*+2: 7 %, *t*+3: 5 % and *t*+4: 3 % so after five periods it no longer has significant effect.

The results indicate that the price asymmetry does not exist since the coefficients of the residuals do not statistically differ from each other, F(1,128)= 1.22 and P > F=0.27. However, the negative residuals have a significant indirect effect on the change in consumer price meaning that the speed of adjustment to an increase in prices has a greater effect than a decrease. Still, there is no evidence of asymmetria since the coefficients of residuals are not statistically different. The Granger causality test with *p*=2 and *q*=5 implies that H_0^I is rejected $(F(2,137) = 17{,}88, P > F = 0.00)$ and H_0^{II} is not rejected $(F(5,128) = 0.50, P > F = 0.77)$. Consequently, the test result supports the theory that the import price has forecasting power to the consumer price.

The results indicate that banana exhibits no asymmetric price transmission so the changes in the import price are transmitted to the consumer price simultaneously regardless of the direction of the change. Note, however, that the correction towards the equilibrium does not depend on the size of this deviation. Hence, this analysis concentrates only on the speed of the adjustment, not on the magnitude.

5.2 Orange

The results of estimated ADL(1,1) model for orange are represented in Table 3. The results indicate that in the short term the proportional change in the consumer price is only 20% of the proportional change in the import price, which is a third less than in the case of banana. Again, the coefficients of price variables are all significant, which assures that the error correction mechanism exists. The coefficients of seasonal dummies reveal that the seasonality of orange is stronger than that of banana. In the summer, scarcity of orange raises the consumer price.

Table 3. Regression on $\Delta\ p_t^c$

Variable	Estimate	Std. Error	*t*-value	P>|*t*|
intercept	0.249	0.0441	5.65	0.000
$\Delta\ p_t^i$	0.204	0.0595	3.43	0.001
p_{t-1}^c	-0.501	0.0684	-7.33	0.000
p_{t-1}^i	0.295	0.0500	5.90	0.000
DS_1	-0.062	0.0223	-2.79	0.006
DS_2	-0.009	0.0252	-0.35	0.724
DS_3	0.055	0.0258	2.12	0.036
DS_4	0.077	0.0232	3.33	0.001
DS_5	0.076	0.0217	3.49	0.001
DS_6	0.110	0.0243	4.53	0.000
DS_7	0.135	0.0225	5.99	0.000
DS_8	0.091	0.0225	4.03	0.000
DS_9	0.061	0.0233	2.64	0.009
DS_{10}	0.036	0.0232	1.53	0.128
DS_{11}	0.056	0.0216	2.57	0.011
N=143	R^2=0.69	$\bar{R}^2$=0.66	s=0.052	
F=20.73	LM=0.03	Q=48.70		

The single-equation ECM for orange is the following:

$$\Delta p_t^c = \underset{(0.0441)}{0.249} + \underset{(0.0595)}{0.204}\,\Delta p_t^i - \underset{(0.0684)}{0.501}(p_{t-1}^c - \underset{(0.0425)}{0.589}\, p_{t-1}^i) + u_t \tag{13}$$

The speed of return to the equilibrium is 50% which is an average convergence. At this convergence rate the process returns to the equilibrium after four months so the adjustment is faster than with banana. The faster adjustment compared to banana is a cause of greater variation in prices which is due to the seasonality of orange. Next, the long-run equilibrium for orange is characterized as

$$p_t^c = 0.497 + 0.589\,p_t^i + e_t \tag{14}$$

The long-run relationship shows that in the case of orange the import price explains only 59% of the change in the consumer price which is approximately at the same level as in the case of banana. The proportional term now equals 1.64, which is quite close to the proportional term of banana. This means that there is no significant difference to the retail sector as to which fruit it is selling in the long-run. To examine the price asymmetry in the case of orange the results from ECM are the following:

Table 4. *Regression on* $\Delta\ y_t$

Variable	Estimate	Std. Error	*t*-value	P>|*t*|
intercept	-0.004	0.0188	-0.23	0.819
$\Delta\ p_t^i$	0.201	0.0561	3.58	0.000
e_{t-1}^{+}	-0.467	0.0832	-5.60	0.000
e_{t-1}^{-}	-0.612	0.1791	-3.42	0.001
DS_1	-0.061	0.0219	-2.79	0.006
DS_2	-0.010	0.0245	-0.39	0.694
DS_3	0.054	0.0255	2.11	0.037
DS_4	0.077	0.0231	3.34	
0.001				
DS_5	0.077	0.0217	3.54	0.001
DS_6	0.111	0.0241	4.59	0.000
DS_7	0.135	0.0217	6.20	0.000
DS_8	0.088	0.0225	3.92	0.000
DS_9	0.058	0.0238	2.42	0.017
DS_{10}	0.034	0.0231	1.47	0.145
DS_{11}	0.054	0.0216	2.49	0.014
N=143	R^2 =0.70	$\bar{R}^2$ =0.66	s=0.052	
F=20.83	LM=0.19	Q=48.68		

The results from ECM imply that the asymmetric price transmission is not present since the coefficients of positive and negative lagged residuals do not differ $(F(1,128) = 0.45, P > F = 0.50)$. Hence, the speed of adjustment towards the equilibrium is the same whether prices are increasing or decreasing. Thus, the result is the same as with banana. However, the level of residual coefficients with orange is higher than in the case of banana. The reason for this arises from the seasonality of orange which increases the variability of prices. The Granger causality test for orange with p=2 and q=5 indicates that H_0^I is rejected $(F(2,137) = 17.12, P > F = 0.00)$ and H_0^{II} is not rejected $(F(5,128) = 0.46, P > F = 0.81)$ so the conclusion is that the import price Granger cause the consumer price.

To summarize, there is no evidence that the changes in consumer prices adjust at different speed depending on whether import prices are decreasing or increasing. Therefore, the vertical price transmission in the Finnish fruit markets is symmetric based on findings from banana and orange which constitute a major share of fruit markets in Finland. In addition, the seasonality of the product does not affect the adjustment process. However, the price transmission is rather slow for both fruits since it took from four to five months to return to the long-run equilibrium.

6 CONCLUSIONS

In this paper the price asymmetry was investigated among import fruits which are not produced in Finland. The chosen fruits, banana and orange provided an interesting scope for econometric analysis concerning the price asymmetry. Both are independent of national agricultural policy and include no processing. Taking into account the concentration of the Finnish retail sector, import price can be treated as a unit cost to the retail firms.

The asymmetric price transmission was examined with ECMs which were conducted from appropriate dynamic ADL models. The short-run effect varies from 0.2-0.3, which implies that a 10 cent change in the import price causes a 2-3 cent change in the consumer price. Respectively, the long-run effect is between 0.5-0.6. These effects can be explained by the seasonality of fruits. Furthermore, the retail firms might not transmit small price changes to consumer prices due to menu costs. The results also showed that asymmetric price transmission is not present with either of the fruits. Hence, there is no evidence that changes in the import prices are transmitted to the consumer prices differently depending on whether they are increasing or decreasing. After a price change, the adjustment time to the equilibrium lasts from four to five months. The performed analysis, however, examines the speed of asymmetric price transmission and does not take into account the magnitude of price change due to linearity of the model.

Further analysis with different food products is needed to obtain more reliable conclusions on how Finnish food markets operate. Also, a comparison between Finland and other European markets could be a starting point for the vertical price asymmetry analysis. Finally, a minor shortcoming arises from the quality of the data. If the data had been in weeks rather than in months during the time period analysed, it would have been possible to emphasize the short term effects more accurately since price adjustments may result in weeks.

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APPENDICES

Appendix A. Real Prices of Banana and Orange

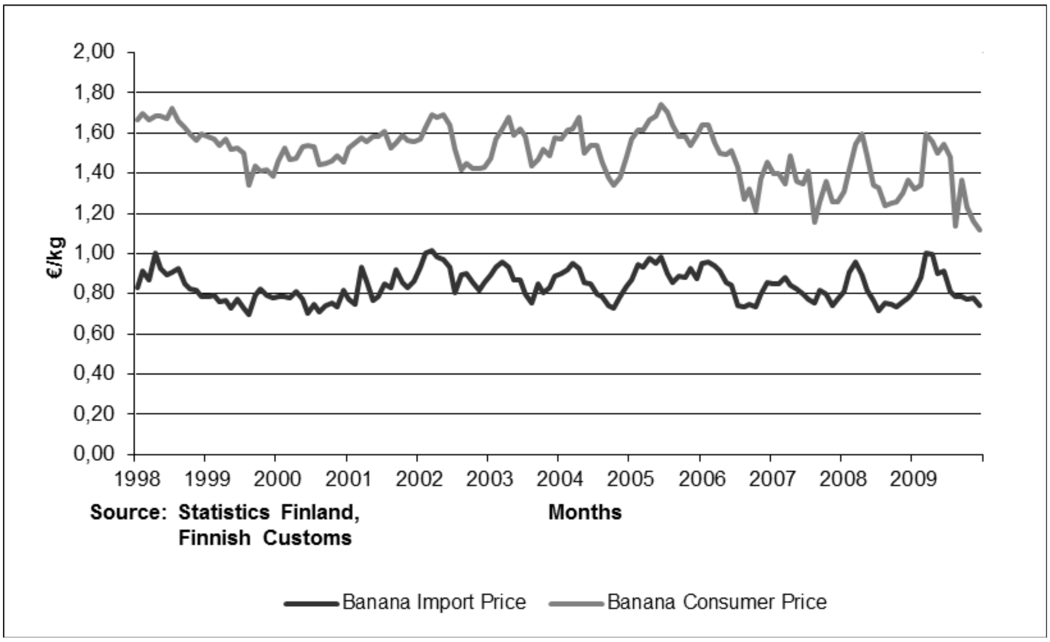

Figure 7: *Real import and consumer price of banana.*

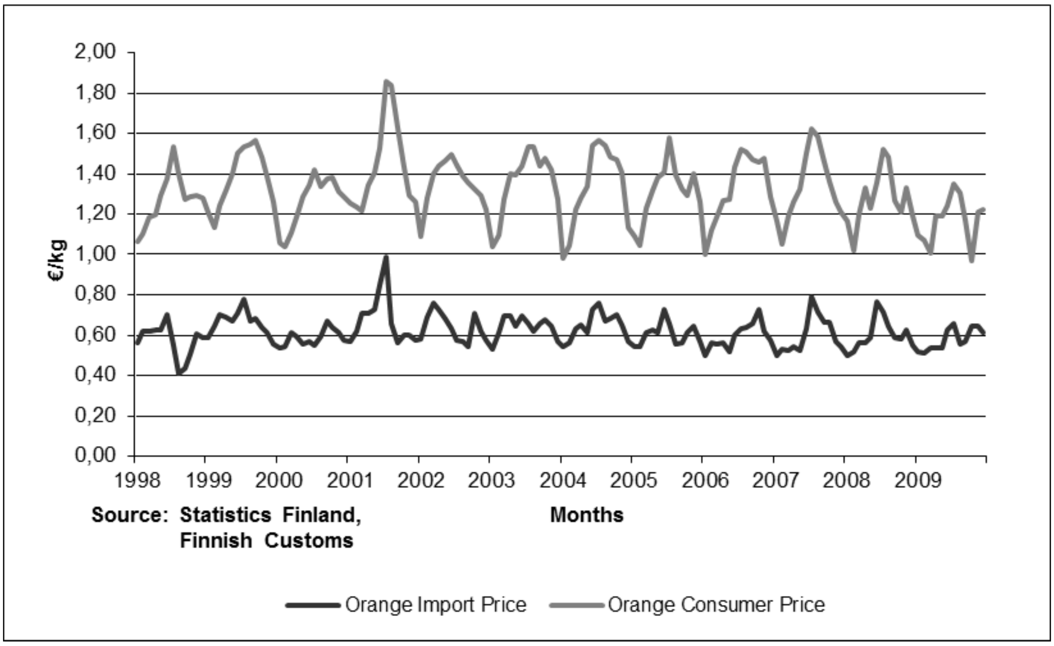

Figure 8: *Real import and consumer price of orange.*

Appendix B. Seasonal Unit Root Tests

Following Hylleberg et al. (1990) and Beaulieu and Miron (1993), the monthly price series is assumed to follow an autoregressive process of order p-12 (AR(p-12)) as

$$\varphi_{p-12}(B)y_t = \mu_t + \varepsilon_t \tag{15}$$

where $\varphi_{p-12}(B)$ is AR polynomial of order p-12, μ_t contains deterministic terms and ε_t is a white noise process. The process in Eq. (15) has peaks at 12 seasonal frequencies. The objective is to discover whether the roots of $\varphi_{p-12}(B)$ polynomial lie on a unit circle indicating that the series is integrated at seasonal frequencies. For monthly data, the objective is to discover the roots for $\Delta_{12}\mathrm{B} = (1-B^{12})$ polynomial which all lie on the unit circle. These roots, their frequencies and cycles are reported in Table 5.

Table 5. *Seasonal unit roots for monthly series*

Root	Frequency	Cycles/Year
-1	π	6
i	$\pi/2$	3
-i	$-\pi/2$	9
$-(1+\sqrt{3}\,i)/2$	$-2\pi/3$	8
$-(1-\sqrt{3}\,i)/2$	$2\pi/3$	4
$(1+\sqrt{3}\,i)/2$	$\pi/3$	2
$(1-\sqrt{3}\,i)/2$	$-\pi/3$	10
$-(\sqrt{3}\,i+1)/2$	$-5\pi/6$	7
$-(\sqrt{3}\,i-1)/2$	$5\pi/6$	5
$(\sqrt{3}\,i+1)/2$	$\pi/6$	1
$(\sqrt{3}\,i-1)/2$	$-\pi/6$	11

To test whether the roots of $\varphi_{p-12}(B)$ lie on a unit circle, the HEGY (Hylleberg et al. 1990) procedure was used. Let $\varphi_{p-12}(B)$ be defined with the help of Lagrange proposition as:

$$\varphi_{p-12}(B) = \sum_{k=1}^{12}\lambda_k\Delta_{12}(B)\frac{1-\delta_k(B)}{\delta_k(B)} + \Delta_{12}(B)\varphi^*(B), \tag{16}$$

where

$$\delta_k(B) = 1-\frac{1}{\theta_k}B, \qquad \lambda_k = \frac{\varphi(\theta_k)}{\prod_{j\neq k}\delta_j(\theta_k)}, \qquad \Delta_{12}(B) = \prod_{k=1}^{12}\delta_k(B).$$

θ_k refers to 11 seasonal unit roots plus one zero frequency unit root. Respectively, $\varphi^*(B)$ denotes the remainder with roots outside the unit circle. If $\Delta_{12}(B)$ is decomposed into

$$\Delta_{12}(B) = (1-B)(1+B)(1+B^2)(1+B+B^2)(1-B+B^2) \times(1+\sqrt{3}B+B^2)(1-\sqrt{3}B+B^2) \tag{17}$$

and inserted into Eq. (16) with roots listed in Table 5, we are able to replace $\varphi_{p-12}(B)$ in

Eq. (15) with r.h.s of Eq. (16) to obtain an expression as

$$\varphi^*(B)\Delta_{12}y_t = \mu_t + \sum_{k=1}^{12}\pi_k y_{k,t-1} + \varepsilon_t, \tag{18}$$

where

$$\begin{aligned}
y_{1t} &= (1+B+B^2+B^3+B^4+B^5+B^6+B^7+B^8+B^9 \\
&\quad +B^{10}+B^{11})y_t, \\
y_{2t} &= -(1-B+B^2-B^3+B^4-B^5+B^6-B^7+B^8-B^9 \\
&\quad +B^{10}+B^{11})y_t, \\
y_{3t} &= -(B-B^3+B^5-B^7+B^9-B^11)y_t, \\
y_{4t} &= -(1-B^2+B^4-B^6+B^8-B^{10})y_t, \\
y_{5t} &= -\frac{1}{2}(1+B-2B^2+B^3+B^4-2B^5+B^6-B^7-2B^8 \\
&\quad +B^9+B^{10}-2B^{11})y_t, \\
y_{6t} &= \frac{\sqrt{3}}{2}(1-B+B^3-B^4+B^6-B^7+B^9-B^{10})y_t, \\
y_{7t} &= \frac{1}{2}(1-B-2B^2-B^3+B^4+2B^5+B^6-B^7-2B^8 \\
&\quad -B^9+B^{10}+2B^{11})y_t, \\
y_{8t} &= -\frac{\sqrt{3}}{2}(1+B-B^3-B^4+B^6+B^7-B^9-B^{10})y_t, \\
y_{9t} &= -\frac{1}{2}(\sqrt{3}-B+B^3-\sqrt{3}B^4+2B^5-\sqrt{3}B^6-B^7 \\
&\quad -B^9+\sqrt{3}B^{10}+2B^{11})y_t, \\
y_{10t} &= \frac{1}{2}(1-\sqrt{3}B+2B^2-\sqrt{3}B^3+B^4-B^6-\sqrt{3}B^7-2B^8 \\
&\quad +\sqrt{3}B^9-B^{10})y_t, \\
y_{11t} &= \frac{1}{2}(\sqrt{3}+B-B^3-\sqrt{3}B^4-2B^5-\sqrt{3}B^6-B^7 \\
&\quad +B^9+\sqrt{3}B^{10}+2B^{11})y_t, \\
y_{12t} &= -\frac{1}{2}(1+\sqrt{3}B+2B^2+\sqrt{3}B^3+B^4-B^6-\sqrt{3}B^7-2B^8 \\
&\quad -\sqrt{3}B^9-B^{10})y_t.
\end{aligned} \tag{19}$$

The null hypothesis of seasonal integration implies that the coefficients for π_k (k=1, ..., 12) are equal to zero. The seasonal unit root tests were implemented with R and the contributed package uroot. Monthly integration was tested with HEGY method using function HEGY.test(). The used HEGY test regressions were

$$\Delta_{12}y_t = \sum_{k=1}^{12}\pi_k y_{k,t-1} + \sum_{k=1}^{q}\delta_k \Delta_{12}y_{t-1} + \varepsilon_t \tag{20}$$

$$\Delta_{12} y_t = \pi_0 + \sum_{k=1}^{12} \pi_k y_{k,t-1} + \sum_{k=1}^{q} \delta_k \Delta_{12} y_{t-1} + \varepsilon_t \tag{21}$$

$$\Delta_{12} y_t = \pi_0 + \sum_{k=1}^{12} \pi_k y_{k,t-1} + \sum_{i=1}^{11} \beta_i DS_{i,t} + \sum_{k=1}^{q} \delta_k \Delta_{12} y_{t-1} + \varepsilon_t \tag{22}$$

where y_k (k=1, ..., 12) are defined as in Eq. (19) and DS_i (i=1, ..., 11) refer to seasonal dummies. The test results are tabulated in Table 6.

Table 6. *HEGY test results for seasonal unit roots* [a]

Variable	Regression	$t:\pi_1$	$t:\pi_2$	$t:\pi_3$	$t:\pi_4$	$t:\pi_5$	$t:\pi_6$	$t:\pi_7$	$t:\pi_8$	$t:\pi_9$	$t:\pi_{10}$
Banana Import	None	-2.25**	-4.47**	-6.13**	-3.30**	-2.81**	-0.68	-2.05**	-1.34*	-3.34**	2.19
	Intercept	-1.94	-4.43**	-6.11**	-3.26**	-2.81**	-0.68	-2.02**	-1.34*	-3.34**	2.20
	Intercept, Seas.dum.	-2.18	-3.61**	-4.60**	-1.86**	-5.32**	2.23	-2.47	-2.09**	-4.46**	1.46
Orange Import	None	-1.36	-1.70*	-1.07	-0.55	-1.61*	0.98	-2.66**	-1.47*	-2.54**	2.71
	Intercept	-2.23	-1.75*	-1.20	-0.52	-1.65*	0.84	-2.70**	-1.50*	-2.51**	2.73
	Intercept, Seas.dum.	-1.75	-3.33**	-5.29**	-4.66**	-6.12**	3.18	-4.61**	-2.92**	-5.46**	2.69
Banana Consumer	None	0.04	-0.04	-2.95**	-1.97**	-2.46**	0.87	-3.02**	-1.22	-3.11**	1.66
	Intercept	-2.59*	0.56	-2.07**	-0.77	-0.87	-0.97	-4.08**	1.57	-1.87*	1.26
	Intercept, Seas.dum.	-2.33	-0.94	-4.91**	-2.18**	-3.67**	3.13	-2.60	-1.24	-3.85**	1.75
Orange Consumer	None	0.31	-3.08**	0.11	-0.58	-3.15**	4.66	0.82	-1.99**	-1.99**	0.95
	Intercept	-2.35	-3.26**	0.14	-0.52	-3.33**	4.62	0.62	-1.93**	-2.00**	1.00
	Intercept, Seas.dum.	-2.39	-3.94**	-2.37	-0.50	-2.28	4.84	-1.21	-2.39**	-3.57**	2.41

Table 6. continued

Variable	Regression	$t: \pi_{11}$	$t: \pi_{12}$	$F: \pi_3 \cap \pi_4$	$F: \pi_5 \cap \pi_6$	$F: \pi_7 \cap \pi_8$	$F: \pi_9 \cap \pi_{10}$	$F: \pi_{11} \cap \pi_{12}$
Banana Import	None	0.65	-1.05	24.23**	4.20**	3.32**	9.48**	0.81
	Intercept	0.63	-1.08	23.91**	4.19**	3.28**	9.49**	0.82
	Intercept, Seas.dum.	-1.27	-3.53**	12.99**	16.36**	5.67*	11.45**	6.70**
Orange Import	None	-1.52	-0.83	0.73	1.63	4.65**	7.35**	1.49
	Intercept	-1.77*	-0.50	0.85	1.59	4.80**	7.31**	1.70
	Intercept, Seas.dum.	-3.05*	-0.41	22.39**	21.18**	15.68**	18.55**	4.97
Banana Consumer	None	0.54	-0.71	6.91**	3.32**	5.39**	6.22**	0.41
	Intercept	0.59	-0.20	2.56*	0.90	9.53**	2.57*	0.19
	Intercept, Seas.dum.	-0.71	-2.96**	13.93**	11.50**	4.22	9.75**	4.82
Orange Consumer	None	-0.84	-0.63**	0.17	16.65**	2.33	2.68*	0.55
	Intercept	-0.81	-0.54	0.14	17.13**	2.06	2.75*	0.47
	Intercept,Seas.dum.	-3.91**	-1.66*	2.93	16.26**	3.75	8.80**	9.77**

[a]For critical values see Beaulieu and Miron (1993) or Franses and Hobijn (1997).

[*]Significant at the 10 % level.

[**]Significant at the 5 % level

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