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Measuring Price Transmission in the International Fresh Fruit and Vegetable Supply Chain: The Case of Israeli Grapefruit Exports to the EU

by

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Abstract:
We study vertical price transmission between Israel and the EU in the imperfectly competitive Israeli citrus export sector, which emerged after the former parastatal marketing board was liberalised in 1991. We find evidence of positive asymmetry in price transmission, implying that Israeli exporters' profits increase at the expense of grapefruit growers, and we argue that this is evidence that Israeli citrus exporters exert market power vis-à-vis Israeli citrus growers. This study is unique in investigating vertical price transmission in the international supply chain for fresh fruits and vegetables (FFV). International FFV trade is especially susceptible to the abuse of market power since transparency regarding the determination of the grower price is often very low. In our model approach we explicitly account for possible changes in exporters' pricing behaviour in the post-liberalization period. The analysis finds that exporters transmitted changes in EU import prices to Israeli growers asymmetrically in the volatile phase directly after liberalization, but symmetrically in the calm phase thereafter. Furthermore, results suggest that the measured asymmetry in price transmission is economically significant. Overall, our study demonstrates that liberalization improved the efficiency of Israel's international citrus marketing channel, although this took time and was probably accelerated by government market intervention.

1 Introduction

International fresh fruits and vegetables (FFV) trade is especially susceptible to the abuse of market power. FFV export sectors are often characterized by low competition. Transparency regarding grower price determination is also often very low. In particular, business in the international FFV supply chain is characterised by oral contracts. Typically, growers supply their produce to exporting companies on consignment and are thus not provided with information on the grower price until after the produce has been sold in the export market (e.g. KACHEL ET AL., 2003). Prices achieved in the export market are also influenced by the quality of the produce at the point of time of arrival in the export market. This is determined by on-site inspection which is beyond the growers' control. For small farmers, particularly in developing countries, to profit from the increasing international trade in FFV it is decisive that they are well integrated into the supply chain and equitably benefit from the profits achieved in international FFV trade (SWINNEN AND MAERTENS, 2007).

[1] This work was mainly done when Linde Goetz was a PhD student at the Department of Agricultural Economics and Rural Development, University of Goettingen, Germany.

This study is unique in investigating vertical price transmission in the international supply chain for FFV.[2] To cast light on the issue of market power we study vertical price transmission in international grapefruit trade from import markets in the EU to growers in Israel.

It is often hypothesised that imperfect competition will manifest itself in asymmetric price transmission (MEYER AND VON CRAMON-TAUBADEL, 2004; RAPSOMANIKIS ET AL., 2006). In most cases, it is predicted that market power will lead to positive asymmetric price transmission meaning that e.g. margin-squeezing price changes will be transmitted faster and more completely than margin-stretching changes.[3]

We test for asymmetric price transmission (APT) in the export chain for Israeli grapefruits as evidence of imperfect competition in the Israeli FFV export sector. Israeli grapefruit exports provide a case study that is well suited to isolating the link between market power and APT. First, as described in the following section, exports are in the hands of a few firms so imperfect competition is possible and might be reflected in APT. Second, since the grower price of the Israeli grapefruits exported to the EU is determined *ex post* only after the products are sold in the export market, and FFV products are highly perishable, several other factors that might cause APT such as adjustment and menu costs, caused by adjusting a firm's prices to a change in the price or quantity of inputs or outputs and inflation, can be disregarded. Furthermore, asymmetry in price transmission cannot result from market intervention by the EU since the EU entry price system does not apply to grapefruits.[4] Third, the post-liberalisation period that we study includes two important developments that may have changed exporters' pricing behaviour. These developments are the enforcement of the minimum price agreement in 1994/95, and the decrease of the EU import price by 30% in the time period underlying this analysis.

To take advantage of the opportunities offered by the Israel/EU grapefruit export case, we use weekly, firm-specific data of the three largest Israeli citrus exporters from 1991/92 to 1999/00 to test for APT between grower prices in Israel and import prices in France, and for possible structural changes in the nature of any APT that we find over the course of the 1990s.

[2] In contrast, previous studies of asymmetric price transmission in the FFV sector analyse price transmission within national marketing channels (e.g. WARD, 1982; PICK, KARRENBROCK AND CARMAN, 1990; BROOKER, EASTWOOD, CARVER AND GRAY 1997; WILLETT, HANSMIRE AND BERNARD, 1997; GIRAPUNTHONG, VANSICKLE AND RENWICK, 2003).

[3] There is a lack of theoretical models explicitly linking the exercise of market power to specific forms of asymmetric price transmission (MEYER AND VON CRAMON-TAUBADEL, 2004). MCCORRISTON ET AL. (1998), MCCORRISTON ET AL. (2001), WELDEGEBRIEL (2004) and LLOYD et al. (2006) develop models of vertical price transmission in the presence of market power and non-constant returns to scale. However, these models explore implications for long run elasticities of price transmission, and not for APT.

[4] For an overview on the EU entry price system see GOETZ AND GRETHE, 2007.

LLOYD ET AL. (2006) and LLOYD AND MORGAN (2007) point out that asymmetric price adjustment might result from an increase in marketing costs inducing a rise in the price spread even in a competitive market environment. In this study we observe relatively increasing marketing costs caused by the decline in the French import price during the underlying time period. We explicitly account for this by allowing for structural breaks in the cointegration regressions. Furthermore, the Israeli government's enforcement of a minimum price agreement in 1994/95 was designed to protect growers from the abuse of market power by Israeli exporters. This provides strong evidence that market power was indeed exerted by exporters in the first years after liberalization.

Our results suggest that two of the three Israeli exporters transmitted changes in the French import market to Israeli growers asymmetrically in the heterogeneous, volatile price phase directly after liberalization, but symmetrically in the more homogeneous, calm phase thereafter. Further, we find the measured asymmetry in price transmission to be economically significant. In particular, the growers' losses amounted up to 4.0 % of growers' total revenues in one season.

This rest of this paper is structured as follows. Section two provides information on the liberalisation of the Israeli citrus export sector. Section 3 explains characteristic features of the data set and how they are accounted for in the empirical specification. The methodological concepts are explained in section 4 and empirical results are presented in section 5. Chapter 6 concludes und provides directions for future research.

2 Liberalisation of the Israeli parastatal marketing board

Prior to 1991, Israeli fresh citrus fruits were exported exclusively by the parastatal Citrus Marketing Board of Israel (CMBI). The goal of liberalising the Israeli citrus export sector was to increase the citrus growers' income and to strengthen the efficiency of the Israeli citrus export marketing channel by establishing competition between exporting companies. The CMBI's citrus export activities were mainly taken over by four large companies. In the first 10 years after liberalisation, these companies accounted for over 90% of all Israeli citrus exports. In contrast, Israel's citrus production was fragmented with about 630 citrus growers accounting for roughly 80% of the citrus growing area.

Tnuport, the largest grapefruit exporter in the nineties, and Mehadrin had own packing stations and provided packing services prior to liberalisation. After liberalisation Tnuport and Mehadrin started to engage in providing citrus export services as well. Mehadrin also owns citrus plantations and thus only partially buys citrus fruits from individual citrus growers. Agrexco, a company which had an export monopoly for fruit (other than citrus) and vegetables, started to engage in the export of citrus fruits after liberalisation of the citrus sector. The fourth largest citrus exporter is Pardess, a cooperative of citrus growers.

The restricted number of exporters provides only limited opportunities for the citrus growers to choose between exporters. This makes it possible for the exporters to exert market power vis-à-vis the Israeli citrus growers by paying a lower grower price. In addition, the consignment system of the former monopoly had been maintained. This induced the government, in 1993/94, to intervene in the newly liberalised market by establishing a minimum price agreement for oranges to protect growers against the abuse of market power by exporting companies. According to this agreement, exporters qualified for a government subsidy if they signed a written, standardised contract with growers, guaranteeing a minimum grower price and stating the timetable of payments and conditions triggering additional payments to the growers. The minimum price agreement was extended to include grapefruits over most of 1994/95 export season and part of 1995/96 (KACHEL, 2003).

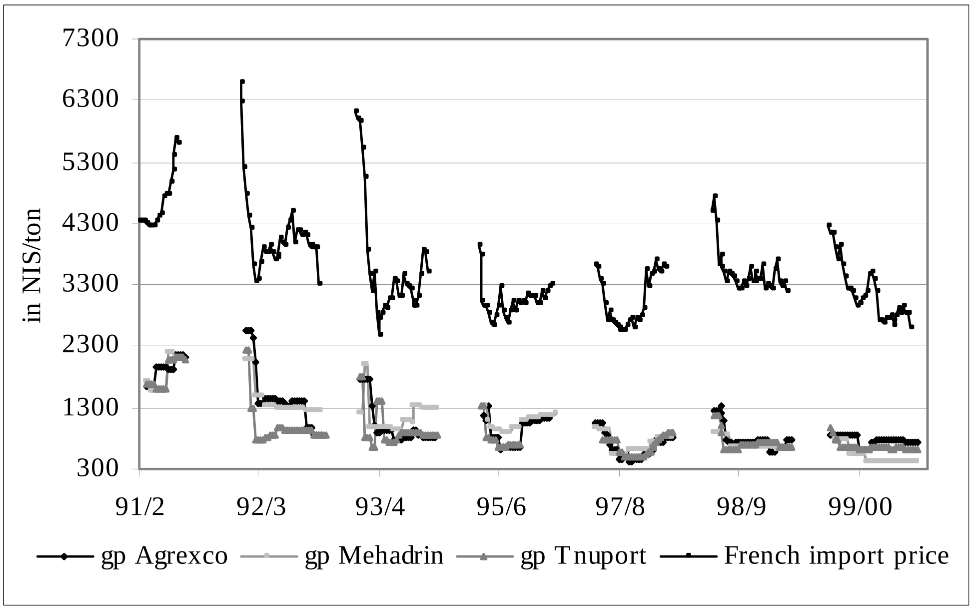
Government export marketing boards in the agricultural sector have been reformed or even abolished, particularly in many developing countries. Yet, the expected income gains to farmers did not accrue in many cases. For example, MATHER AND GREENBERG (2001) analyse the effects of privatisation of the citrus marketing board of South Africa in 1994 where new exporters entered the market in 1996. They find that liberalisation has shifted market power from the former export monopoly and cooperative packing stations to privately-owned large citrus enterprises. WILCOX AND ABBOTT (2004) use a conjectural variations approach and find evidence of market power in the post-liberalized cocoa bean market exerted by exporters and processors over growers in the Ivory Coast. For the cashew nut export sector in Mozambique MCMILLAN ET AL. (2002) find that the largest share of the benefits from removal of the export tax was captured by traders and little accrued to farmers. In their model of a concentrated developed country food market, SEXTON ET AL. (2007) show that even relatively small deviations from perfect competition can imply that the majority of the benefits from trade liberalisation accrue to the marketing companies and not to farmers.

This study investigates whether the newly established companies in the Israeli citrus export sector have exerted market power over the citrus growers by asymmetric price transmission implying short-run additional revenues to the exporters and losses to the citrus growers.

3 Dataset and critical issues

The analysis is based on weekly[5] grower price data for each of the three largest Israeli grapefruit exporting firms (Tnuport, Mehadrin and Agrexco), and the corresponding French import price for red 'Sunrise' grapefruits in the seasons 1991/92 to 1999/00 (Figure 1).[6] Over the study period, Tnuport was Israel's largest red grapefruit exporter with a market share of 38%, followed by Mehadrin (28%) and Agrexco (26%). The EU is Israel's primary export market for grapefruits. Between 1991 and 2000, the EU accounted for 75% to 90% of total Israeli red grapefruit exports, and France alone accounted for between 20% and 40% (C.L.A.M., various years).

Figure 1: Firm-level Israeli grower prices (gp) for the three largest Israeli exporting companies and the French import price 1991/92 to 1999/00 (real NIS/t)



Source: Citrus Growers' Association of Israel; CMBI.

The Israeli firm-level grower prices for red grapefruits for export and the corresponding French import prices are weighted averages of the prices for different fruit sizes.[7] The Israeli grower prices and the French import prices are stated in New Israeli Shekel (NIS) per ton and deflated with the Israeli monthly consumer price index (2000=100; CBS Israel). The data set is balanced by including only those weeks for which grower price data is available for all three exporters, and contains altogether seven seasons with a total of 205 observations. In the

[5] BROOKER ET AL. (1997) point out that due to the perishability of FFV and the high volatility of supply, the planning horizon in the fresh produce marketing channel is short and pricing strategies can change several times per month. Therefore, at least weekly data is required to adequately capture price transmission in the FFV sector.

[6] The Israeli firm-level grower prices were surveyed by the Citrus Growers' Association of Israel. The French import prices were collected by a large French fruit import company by a telephone survey of the major fruit importers in France.

[7] The Israeli grower prices are weighted with a standard size distribution for each season.

context of this study, weekly data is sufficient to fully capture price transmission since fresh grapefruits are delivered from Israel to the EU once a week by ship during the harvest season.

We identify three empirical particularities which are explicitly accounted for in our estimation approach:

1. It is likely that the pricing behaviour of the citrus exporting companies changed in the post-liberalisation period. The French grapefruit import prices decreased significantly over the period of this analysis. From Table 1 it becomes evident that the mean French import price weighted by the actual export quantity of each season fell by 30% from 4547 NIS/ton in season 1991/92 to 3165 NIS/ton in season 1999/00. All exporters will have attempted to pass decreased French import prices on to the growers, but firm-specific strategies and the scope for passing this on may have varied depending *inter alia* on each firm's market power.

Table 1: Weighted mean French import price for grapefruits, by season (NIS/t)

Season	1991/92	1992/93	1993/94	1995/96	1997/98	1998/99	1999/00
Mean French import price	4547	4135	3579	3028	3076	3483	3165

Source: Own calculations.

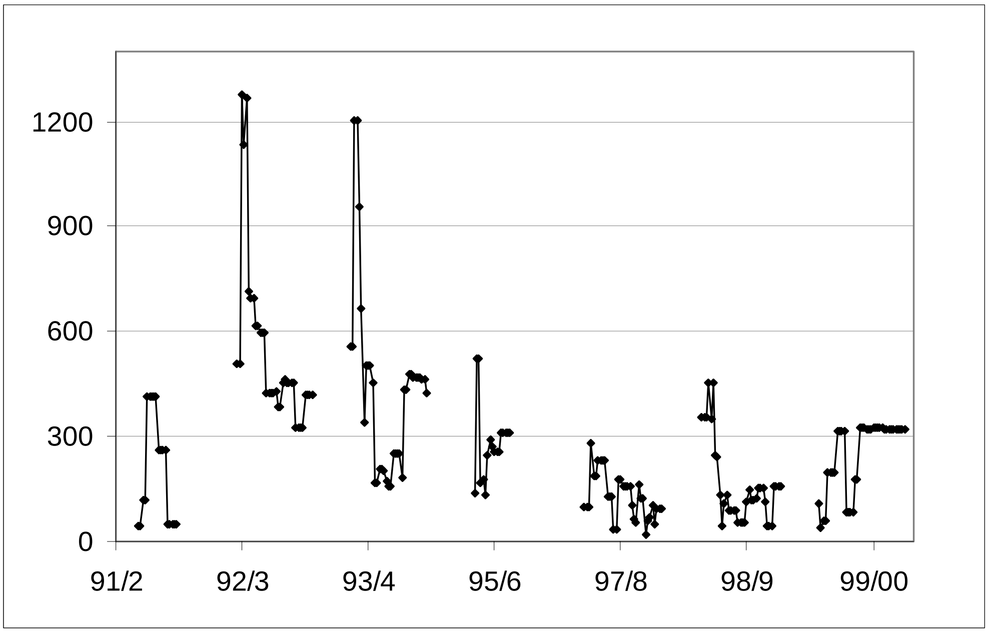
Furthermore, exporters might have adjusted their long-run pricing strategy following the minimum price agreement imposed by the government particularly in 1994/95 which signalled that the government was willing and able to intervene in response to what were perceived as unfair pricing practices by the exporting firms. The data indicate that the homogeneity of grower prices increased over time, which may be evidence of increasing competition. In particular, the difference between the maximum and minimum grower price (price spread) of the three major exporters decreased significantly over the 1990s (Figure 2). The mean spread of the three grower prices was 400 NIS/t in 91/92-95/96, and fell to 180 NIS/t in 97/98-99/00. This indicates that grower price volatility decreased, suggesting that exporters' pricing behaviour changed between 95/96 and 97/98.

We account for these possible changes by testing for structural breaks in the cointegration regressions. In addition, and based on the results of these tests, we distinguish a heterogeneous, volatile phase in 91/92, 92/93, 93/94 and 95/96 from a more homogeneous, stable phase in 97/98, 98/99 and 99/00, and estimate separate ECMs for these two phases (referred to as SUBSET 1 and SUBSET 2 in the following).

2. The data set is characterised by gaps resulting from seasonal interruptions in grapefruit

production and trade. This implies that for the first observations in each season, no or only incomplete information on the preceding observations is available, so that a complete set of lagged variables cannot be created. How many observations are lost in this manner depends on the chosen lag specification. WARD (1982) introduces additional dummy variables for those observations for which lags are missing in his model to ensure that each observation can be included in the estimation. We take the alternative course of omitting observations for which the required lags cannot be constructed. Our approach leads to a loss of degrees of freedom whereas Ward's approach may lead to estimation bias. Given the often very large differences in our data between the last observation of one season and the first observation of the next (see Figures 1 and 2), we are more concerned about bias than degrees of freedom.

Figure 2: Spread of the weekly grower prices of Agrexco, Mehadrin and Tnuport (NIS/t)



Source: Own calculations.

3. We account for the lag between the week in which the grower price is recorded, and the week in which the corresponding French import price is determined. The grower price represents the value of the produce at the point of time of its delivery to the packing station, while the French import price is determined at the border to France. According to the consignment system, the grower price is determined *ex post*, i.e. after the produce is sold in the French import market. The minimum time lag between those two points in the transport chain is seven to nine days. Since delays may occur at several points, this lag is stochastic. Simplifying, we assume a transport lag of two weeks for all models.[8]

[8] We estimated the model for lags of 1 to 3 weeks, but coefficients did not differ substantially.

4 Methods

4.1 Identifying asymmetry in price transmission

To estimate the ECM we follow the Engle and Granger (1987) two-step approach which requires the time series to be cointegrated. First, the long-run equilibrium relationship between the Israeli grower price p_{it} and the French import price p_{jt} for Israeli grapefruits is estimated as:

(1) $p_{it} = \alpha_0 + \alpha_1 * p_{jt} + \upsilon_t$ with t = 1,…,T.

The data are in logarithms, so α_1 corresponds to the price transmission elasticity, indicating the percentage price change in p_{it} if p_{jt} changes by 1%. If prices changes are transmitted completely, then α_1 =1. If there is no price transmission, α_1 is not significantly different form zero. The residual vector υ_t represents the short-run deviations from this long-run equilibrium. The actual grower price may be higher or lower than its long-run equilibrium value in any given period, thus υ_t might be greater or smaller than zero, respectively. The estimated residuals are lagged by one period and enter the ECM as the error correction term (ECT), where $ECT_{t-1} = p_{it-1} - \alpha_0 - \alpha_1 * p_{jt-1}$:

(2) $\Delta p_{it} = \sum_{n=0}^{K} \beta_{1n} \Delta p_{jt-n} + \sum_{m=1}^{L} \beta_{2m} \Delta p_{it-m} + \phi ECT_{t-1} + \varepsilon_t$.

In this model, $\sum_{n=0}^{K} \beta_{1n} \Delta p_{jt-n}$ captures contemporaneous and previous change effects of p_{jt} on p_{it} up to lag K, and $\sum_{m=1}^{L} \beta_{2m} \Delta p_{it-m}$ accounts for autocorrelation up to order L. ϕ indicates the speed at which deviations from the long-run equilibrium in the previous period are corrected, and is referred to as the adjustment parameter.

To allow for APT, contemporaneous and lagged effects caused by price increases are distinguished from those caused by price decreases by splitting the respective variables into positive and negative components in the ECM. The ECT is included as a split variable as well. ECT^+ contains the positive, and ECT^- the negative lagged residuals from equation (1). Thus, positive and negative error correction behaviour can be identified separately:

(3)

$$\Delta p_{it} = \sum_{n_1=0}^{K_1} \beta_{1n_1}^{+} D_{1t}^{+} \Delta p_{jt-n_1} + \sum_{n_2=0}^{K_2} \beta_{1n_2}^{-} D_{1t}^{-} \Delta p_{jt-n_2} + \sum_{m=1}^{L} \beta_{2m} \Delta p_{it-m} + \phi_1 D_{2t}^{+} ECT_{t-1} + \phi_2 D_{2t}^{-} ECT_{t-1} + \varepsilon_t$$

with $D_{1t}^{+}=1$ if Δp_{jt-n_1} >0 and 0 otherwise, $D_{1t}^{-}=1$ if Δp_{jt-n_2} <0 and 0 otherwise, $D_{2t}^{+}=1$ if ECT_{t-1} >0 and 0 otherwise, and $D_{2t}^{-}=1$ if ECT_{t-1} <0 and 0 otherwise.

This model structure allows for differing numbers of lags for the positive and negative short-run effects. APT is present if the null hypothesis that the estimated coefficients of the respective positive and negative variable are equal is rejected by an F-test.

4.2 Tests for structural breaks in a cointegration regression

Standard tests for cointegration (e.g. the residual-based ENGLE AND GRANGER (1987) test) require that the cointegrating vector be time-invariant. If the cointegrating vector changes during the sample period, the results of these tests might be misleading (GREGORY AND HANSEN, 1996). In GREGORY AND HANSEN's (1996) cointegration test, the null hypothesis of no cointegration is tested against the alternative hypothesis of cointegration allowing for the presence of a structural break at an unknown point of time according to the following three model frameworks:

a) Level shift

(4) $p_{it}=\alpha_{01}*\varphi_{t\tau}^{1}+\alpha_{02}*\varphi_{t\tau}^{2}+\alpha_{1}*p_{jt}+\upsilon_{t}$;

b) Level shift with trend

(5) $p_{it}=\alpha_{01}*\varphi_{t\tau}^{1}+\alpha_{02}*\varphi_{t\tau}^{2}+\alpha_{1}*p_{jt}+\alpha_{2}*t+\upsilon_{t}$; and

c) Regime shift

(6) $p_{it}=\alpha_{01}*\varphi_{t\tau}^{1}+\alpha_{02}*\varphi_{t\tau}^{2}+\alpha_{11}*\varphi_{t\tau}^{1}*p_{jt}+\alpha_{12}*\varphi_{t\tau}^{2}*p_{jt}*\varphi_{t\tau}+\upsilon_{t}$.

In all three cases, $\varphi_{t\tau}^{1}=1$ if $t\le[n\tau]$, $\varphi_{t\tau}^{1}=0$ if $t>[n\tau]$, $\varphi_{t\tau}^{2}=0$ if $t\le[n\tau]$, and $\varphi_{t\tau}^{2}=1$ if $t>[n\tau]$, where $\tau\in(0,1)$.

In this test, the residuals of the individual cointegration regressions in (4)-(6) for all possible breakpoints are tested for the existence of a unit root by an Augmented Dickey Fuller (ADF) test.[9] If the standard ADF test does not reject the null hypothesis of no cointegration, but the ADF statistic of the GREGORY-HANSEN test does, this is interpreted as evidence of a structural break in the cointegration regression. The timing of the structural break corresponds to the break point of the cointegration regression for which the ADF statistic is lowest. Critical values are non-standard and are tabulated in GREGORY AND HANSEN (1996). In previous studies of price transmission, this approach has been applied by BAKUCS AND FERTÖ (2006), GUILLOTREAU, GREL AND SIMIONI (2005) and TIFFIN AND DAWSON (2000).[10] GREGORY AND HANSEN (1996) point out that this test is not a test for the existence of a regime shift, but rather a test for cointegration which allows for the existence of a regime shift.

[9] This procedure is followed for all model frameworks in (4) to (6). Estimates and their standard errors are compared and additional information, if available, is utilized to select the model framework which fits best.

[10] In a multivariate setting, BARASSI AND GOSHRAY (2007) detect an unknown break-point by employing a testing procedure proposed by BARASSI AND TAYLOR (2004) for a change in the cointegration rank.

5 Empirical Results

5.1 Price transmission analysis

We begin by determining the order of integration of the data series by the ADF test and the KPSS test of KWIATOWSKI ET AL. (1992). We find the French import price (p_{jt}) to be I(0) according to the ADF test, but I(1) according to the KPSS test. The Israeli grower price series for all three exporters are I(1) according to the ADF as well as the KPSS.

We utilize the residual-based test by ENGLE AND GRANGER (1987) to test for cointegration between the French import price (p_{jt}) and the Israeli grower price (p_{it}) of each of the three exporters. The consignment system strongly suggests that the Israeli grower price is the dependent variable and the French import price the independent variable. The results in Table 2 indicate cointegration between the French import price and the Israeli grower price for Agrexco (5% significance level) alone.

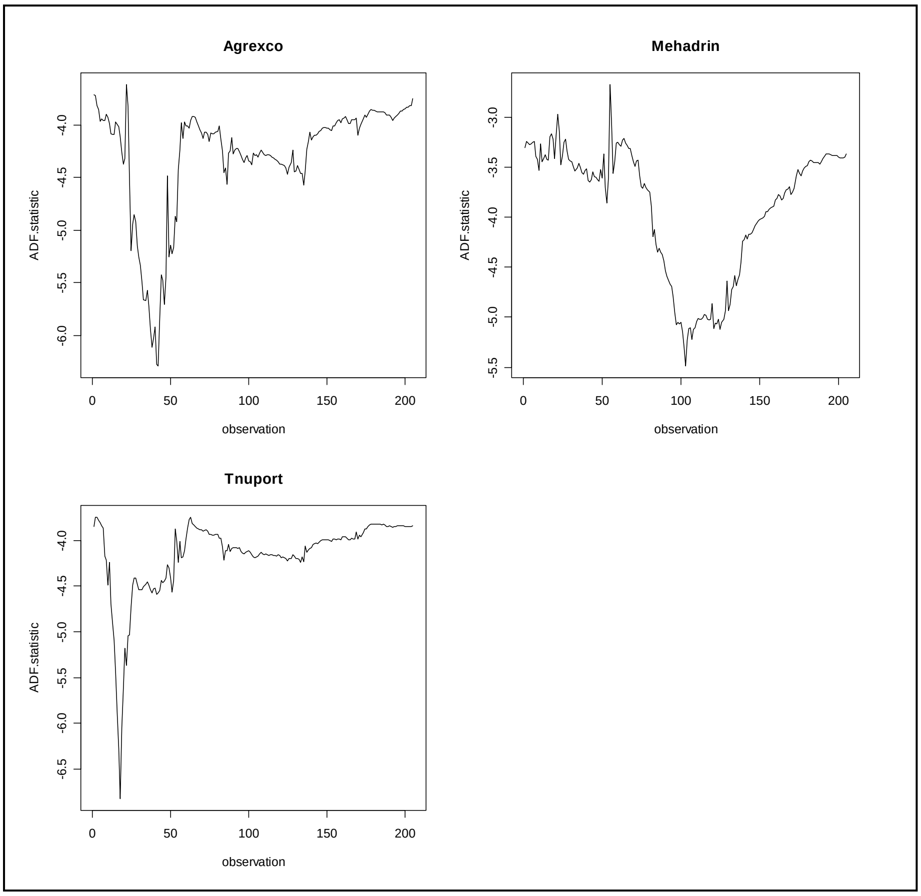
Table 2: Results of the residuals-based tests for cointegration between the French import price and the individual Israeli grower prices

	ADF (H_0 : x and y are not cointegrated)	
	Test-statistic	Conclusion
Agrexco	|-3.922|>|-3.37| (5%)	reject H_0 at the 5% level; variables are cointegrated
Mehadrin	|-2.398|<|-3.37| (5%)	*cannot* reject H_0; variables are not cointegrated
Tnuport	|-3.172|<|-3.37| (5%)	*cannot* reject H_0; variables are not cointegrated

Source: Own estimation.

The failure to find cointegration for the other exporters may be due to structural breaks as outlined above. Hence, we next test for cointegration allowing for the existence of a structural break using the GREGORY-HANSEN test. For Agrexco, Mehadrin and Tnuport a regime shift is identified at the 1% level of significance in March 1993, (observation 42), October 1997, (observation 103), and October 1992 (observation 19), respectively (Figure 3). Note that the structural break is earliest for Tnuport, the exporter with the largest market share and thus probably the largest degree of market power. The estimated coefficients of the long-run equilibrium regression according to equation (6) for each exporter are presented in Table 3. In all cases α_{11} is higher than α_{12}. This decrease in the slope coefficient can be attributed to the decrease in the French import price resulting in relatively higher marketing costs and reducing the share of the Israeli grower price in the French import price. α_{12} is lowest by far for Tnuport, the largest exporter with the potentially largest market power.

Figure 3: ADF-values obtained by the Gregory-Hansen test for different break-points of the disaggregated grower price for Agrexco, Mehadrin and Tnuport



Source: Own estimation

Table 3: Estimated coefficients of the cointegration regression for the three exporters

Coefficient	α_{01}	α_{11}	α_{02}	α_{12}
Agrexco	-261.29	0.456	-184.11	0.295
Mehadrin	-27.054	0.378	-54.74	0.258
Tnuport	-1157.0	0.577	287.0	0.138

Source: Own estimation.

The identified break-points of the cointegration regressions for Agrexco, Mehadrin and Tnuport are accounted for in the estimation of the cointegration residuals, which enter the ECM (equation 3) as ECT terms. An ECM is estimated for each of the three exporters individually based on the COMPLETE data set comprising observations from all 7 marketing seasons and accounting for the specified break point in the cointegration regression (Table 4).

Lag-lengths K_1 and K_2 are chosen according to the Bayesian Information Criteria (BIC)[11]. The BIC indicated that the lag-lengths K_1 and K_2 should not be greater than one in any model, with the exception of the model for Tnuport (COMPLETE), and in some cases it indicates that no lag should be included. Lag-length L is adjusted to account for autocorrelation, which is detected by the Breusch-Godfrey test. If the Breusch-Pagan test identifies the presence of heteroscedasticity, White's heteroscedasticity consistent standard error is estimated.

For the COMPLETE data series, the F-test confirms that the estimates of ϕ_1 and ϕ_2 for Agrexco are significantly different at the 1% significance level, suggesting strong asymmetry in the error correcting behaviour. The identified asymmetry is of the kind that is beneficial to exporters but reduces growers' revenues. For example, when the import price falls, implying that the grower price lies above its long-run equilibrium level and squeezing Agrexco's margin, the grower price is reduced by 42.4% of this "error" in the next week. If, on the other hand, the import price increases so that the grower price falls below its long-run equilibrium level and Agrexco's margin is stretched, the grower price increases only by 8.3% in the next week. However, results for the COMPLETE data series suggest that the short-run adjustment to the long-run equilibrium is symmetric for Mehadrin and Tnuport since the respective estimates for ϕ_1 and ϕ_2 do not differ significantly. Though, the observed contemporaneous previous price changes are transmitted is asymmetrically for Tnuport.

To test whether the exporters' price transmission behaviour may have changed, we estimate separate ECMs for the phase with heterogeneous grower prices in the first years after liberalisation (SUBSET 1) and the subsequent phase with more homogeneous grower prices (SUBSET 2). Again, the break points in the individual cointegration regressions are accounted for. The results are reported in Table 4. We find asymmetry in the error correcting behaviour for Agrexco and Tnuport in SUBSET 1. In particular, deviations from the long-run equilibrium are corrected faster if the grower price is above its long-run equilibrium level, and slower if the grower price is below. In the case of Tnuport the estimated coefficient for ϕ_2 is positive. This would indicate that if the grower price is below its equilibrium level, price adjustment implies that the grower price drops even more below its equilibrium level. However, this coefficient is not significantly different from zero. The results suggest that price transmission is symmetric in SUBSET 2 for Agrexco and Tnuport. For Mehadrin, price transmission is found to be symmetric in both SUBSET 1 and SUBSET 2.

[11] In a simulation study on various criteria for estimating the order of a vector autoregressive process, Luetkepohl (1985) finds that the BIC criterion chooses the correct autoregressive order most often.

Table 4: Estimated ECM coefficients based on disaggregated data for the complete data set and data subsets
(Theoretical F-values are given for the 5% significance level; * indicates 1% significance level)

	COMPLETE						SUBSET 1						SUBSET 2					
	Agrexco		Mehadrin		Tnuport		Agrexco		Mehadrin		Tnuport		Agrexco		Mehadrin		Tnuport	
Coef./ test stat.	Estim. value	stand. error (t-val.)	Estim. value	stand. error (t-val.)	Estim. value	stand. error (t-val.)	Estim. value	stand. error (t-val.)	Estim. value	stand. error (t-val.)	Estim. value	stand. error (t-val.)	Estim. value	stand. error (t-val.)	Estim. value	stand. error (t-val.)	Estim. value	stand. error (t-val.)
β_{11}^{+}					0.013	0.052 (0.238)	0.189	0.069 (2.742)	0.002	0.138 (0.017)							0.007	0.044 (0.157)
β_{11}^{-}					0.251	0.128 (1.963)	0.051	0.085 (0.603)	0.145	0.078 (1.871)							0.137	0.137 (0.038)
β_{12}^{+}					0.165	0.092 (1.793)												
β_{12}^{-}					-0.189	0.165 (-1.14)												
β_{21}	0.116	0.078 (1.486)											0.058	0.076 (0.755)			0.219	0.096 (2.286)
ϕ_1	-0.424	0.105 (-4.04)	-0.062	0.100 (-0.62)	-0.131	0.116 (-1.68)	-0.438	0.121 (-3.63)	-0.034	0.087 (-0.40)	-0.180	0.076 (-2.38)	-0.408	0.184 (-2.24)	-0.012	0.070 (-0.17)	0.025	0.084 (0.297)
ϕ_2	-0.083	0.035 (-2.34)	0.032	0.170 (0.188)	-0.014	0.080 (-0.17)	-0.009	0.089 (-0.10)	-0.061	-0.061 (-0.60)	0.258	0.208 (1.244)	-0.106	-0.047 (-2.27)	-0.061	0.074 (0.822)	-0.063	0.038 (-0.16)
Breusch-Godfrey test (p-value)	0.101		0.959		0.528		0.053		0.801		0.443		0.069		0.981		0.266	
Breusch-Pagan test (p-value)	<0.001		<0.001		<0.001		0.006		0.019		0.329		0.005		0.371		0.163	
Emp. & theor. F-val. (sym. cont. p.t.) $\beta_{11}^{+} = \beta_{11}^{-}$					6.397>3.891		1.476<3.939		0.714<3.939								3.918<3.938	
Emp. & theor. F-val. (sym. cont. p.t.) $\beta_{12}^{+} = \beta_{12}^{-}$					11.230>6.769*													
Emp. & theor. F-val. (sym. error corr. beh.) $\phi_1 = \phi_2$	11.913>6.765*		1.352<3.889		3.856<3.890		6.728>3.939		0.714< 3.939$_c$		3.940>3.939		1.942<3.934		0.513<3.935		0.827<3.938	

5.2 Welfare implications

MEYER AND VON CRAMON-TAUBADEL (2004) stress the importance of supplementing the statistical detection of APT by analysing its economic implications and relevance. Based on the results documented in Table 4, we estimate the revenue that Israeli grapefruit growers have foregone as a result of asymmetric price transmission in the study period.

The calculation of the welfare implications of asymmetric price transmission in the Israeli grapefruit export chain is confined to Tnuport and Agrexco, and to the seasons 1991/92, 1992/93, 1993/94 and 1995/96 since APT is only found for these firms and seasons (SUBSET 1). To calculate the grower price under APT, the estimated coefficients of the asymmetric ECM are utilized to calculate the grower price in period t+1 (p_{it+1}^{as}) as the grower price in the previous period t (p_{it}^{as}) plus the changes in the grower price in period t+1:

$$(7)\quad p_{it+1}^{as} = p_{it}^{as} + \sum_{n_1=0}^{K_1} \beta_{1n_1}^{+} D_{1t+1}^{+} \Delta p_{jt+1-n_1} + \sum_{n_2=0}^{K_2} \beta_{1n_2}^{-} D_{1t+1}^{-} \Delta p_{jt+1-n_2} + \sum_{m=1}^{L} \beta_{2m} \Delta p_{it+1-m}$$
$$+ \phi_1 D_{2(t+1)}^{+} ECT_{(t+1)} + \phi_2 D_{2(t+1)}^{-} ECT_{(t+1)}$$

For Agrexco $K_1 = K_2 = L = 1$ and for Tnuport $K_1 = K_2 = L = 0$. For Tnuport we assume $\phi_2 = 0$ in the estimation of $p_{i(t+1)}^{as}$ since the estimated coefficient for ϕ_2 is positive and not statistically significant (more details are given in the previous section).

To calculate the grower price ($p_{i(t+1)}^{s}$) under the assumption of symmetric price transmission, we assume that the speed of adjustment for positive and negative price changes is equal ($\phi_1 = \phi_2$). The estimated coefficient for ϕ_1, which exceeds ϕ_2, is utilized for Agrexco and Tnuport, on the assumption that if such rapid transmission is possible in one direction, equally rapid transmission should be possible in the other as well. The quantitative effect of price asymmetry (qe^{as}) for one season with t=v and t=w corresponding to the beginning and the end of a season, respectively, equals:

$$(8)\quad qe^{as} = \sum_{t=v}^{t=w} (p_{it}^{s} - p_{it}^{as}) * q_{it},$$

with q_{it} equal to the amount of products exported in time period t.

The estimated values for the growers' losses are presented in Table 5. For growers delivering to Agrexco, the seasonal losses vary between about 5,000 NIS and 330,000 NIS, corresponding to between 0.17% (in 1995/96) and 3.95% of seasonal revenues (in 1992/93). For Tnuport the seasonal losses add up to between about 52,000 NIS and 580,000 NIS. These losses correspond to between 0.36% and 3.50% of the seasonal revenues and are highest in 1991/92.

As growers' profits are only about 20% of their total revenues (own calculation based on REGEV AND MAOZ, 1996)[12], the losses in grower profits due to the revenue effects of APT outlined in Table 5 are likely very relevant.

Table 5: Growers' losses due to asymmetry in price transmission

	Growers' losses	1991/92	1992/93	1993/94	1995/96
Agrexco	in NIS	17,157	331,530	23,649	5,237
	in % of revenue	0.421%	3.945%	0.359%	0.167%
Tnuport	in NIS	579,620	55,060	158,376	52,164
	in % of revenue	3.496%	0.358%	1.480%	1.553%

Source: Own calculations.

6 Conclusions

The analysis of price transmission based on firm-specific grower price data suggests that the price transmission behaviour of Israelis citrus exporters changed in the post-liberalisation period after 1991. We attribute these changes to two external factors, i.e. the government market intervention in favour of citrus growers, and the substantial decrease in the French import price. The latter reduced the difference between the grapefruit growers' reservation price and the maximum import price which EU importers are willing pay. As a result, the prices paid to growers became more homogeneous, and exporters ceased transmitting prices asymmetrically.

In our model approach we distinguish a period with more volatile grower prices from a phase with more homogeneous pricing. We find that two Israeli exporters, Agrexco and Tnuport, transmitted grapefruit price changes in the EU import market asymmetrically to Israeli citrus growers in the phase with heterogeneous pricing in the first years after liberalisation, while Mehadrin transmitted prices symmetrically. Mehadrin might have had less motivation or scope for exerting market power over the citrus growers since it also markets citrus produce from its own plantations.

We also find that the identified asymmetry in price transmission by Tnuport and Agrexco in the first years after liberalisation was economically significant. This is consistent with the

[12] Further details on the calculation are available from the authors upon request.

hypothesis that the observed asymmetry in price transmission was caused by Israeli exporters exerting market power over Israeli citrus growers. Our results indicate that growers' seasonal losses resulting from asymmetric price transmission amounted to as much as 4.0% of citrus growers' total revenues, and presumably a much larger share of their profits.

Finally, our results suggest that price transmission by all three exporters was symmetric in the subsequent phase (second half of the 1990s) characterized by more homogeneous pricing. This suggests that the efficiency of Israel's international citrus marketing channel improved in the aftermath of liberalisation. It is highly probable that the government's imposition of a minimum price agreement on the grapefruit sector effective in the seasons 1994/95 and partially 95/96 contributed to this development. Altogether, our findings are in line with the results of earlier studies that highlight the risk that new export companies that emerge in the aftermath of liberalisation will be in a position to exert market power.

As an area for future research, price transmission in the international FFV supply chain should be investigated, particularly between export prices in developed country markets and grower prices obtained by small farmers in developing countries under different supply chain governance structures. As pointed out above, although APT might result from many different causes, in the context of international trade in FFV, grower prices are generally determined *ex post* by the consignment system. In this setting, thus causes of APT related to menu and adjustment costs are not relevant and it is possible to focus on market power as the most likely cause.

However, analysing price transmission in international FFV trade faces particular challenges regarding data requirements. First, we used an aggregated price as the EU import price for grapefruits. Of course, different exporters might achieve different prices for their produce in the same market, particularly since the quality of fresh produce can vary sharply with the maturity of the fruits at the time of picking, or with the time required to move the produce from the farm gate to the ship. The higher the variability in product quality between growers, the higher the distortions that result from utilizing aggregated import prices will be. If exporter-specific import prices are not available (which is likely to be the rule), analysis should concentrate on products originating in countries which exhibit low variability of quality.

Second, to exactly measure the weekly average export price achieved by an exporter, export price data for all markets served by this exporter is required. However, our analysis is based on price data for exports to the EU (France) alone. The more diverse the export markets that are served, the more data is required to exactly measure the average export price achieved by exporters. Data requirements for exports that are concentrated on one or a few markets are lower and thus more suitable for this kind of analysis.

Finally, frequency of the data set has to be chosen adequately, depending e.g. on how often fresh products are delivered from the exporting to the importing country. High frequency price data might be gathered by means of telephone surveys of the primary importers of the product in question.

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7.08 Zvi Lerman – Agricultural Development in Uzbekistan: The Effect of Ongoing Reforms.

8.08 Iddo Kan, Ofira Ayalon and Roy Federman – Economic Efficiency of Compost Production: The Case of Israel.

9.08 Iddo Kan, David Haim, Mickey Rapoport-Rom and Mordechai Shechter – Environmental Amenities and Optimal Agricultural Land Use: The Case of Israel.

10.08 Goetz, Linde, von Cramon-Taubadel, Stephan and Kachel, Yael - Measuring Price Transmission in the International Fresh Fruit and Vegetable Supply Chain: The Case of Israeli Grapefruit Exports to the EU.