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Price Analyses of the Brazilian Citrus Supply Chain

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Abstract: The Brazilian citrus chain is comprised by an upstream farm sector, made up of numerous heterogeneous (by size and technology) farm units serviced by input suppliers, and a downstream segment consisting of a small number of processing industries. Our study examines the behavior of citrus pricing along this supply chain, focusing on the relationship between orange juice prices established in international markets and orange fruit prices paid to Brazilian farmers. Results indicate that the price of orange fruit is fundamentally linked to the price of its juice, regardless of data source considered for testing. Evidence was found indicating that there is asymmetry of price transmission within the Brazilian orange sector, with juice price increases being transmitted to the farmer in smaller proportions than juice price decreases. The results of our study did not give a particularly strong indication of the cause of this price asymmetry.

Key words: Orange sector, Brazil, price transmission, asymmetry conditions.

1. Problem Statement

In general, prices in any productive chain tend to reflect supply and demand fundamentals and market structure, with the market structure often distorting pricing pressures applied by actual supply and demand conditions. Market structure is determined by the number and size of firms within the chain and their degree of interdependence such as buyers, sellers, and decision makers, the legal setting, and numerous other factors. If the structure is not balanced, supply and demand conditions may not be the sole determinant of prices paid to the chain's members.

The Brazilian citrus chain is unbalanced. Market and pricing power in the chain are concentrated in its downstream industrial segment. In turn, this industrial segment is dominated by three orange processors in the state of São Paulo. These processors control over 90% of Brazil's total crushing capacity and are a major force in the international market for frozen concentrated orange juice (FCOJ). There is a concern that prices paid to chain members may be unduly influenced by the industrial segment rather than by actual supply and demand conditions. This situation has generated frequent conflicts between growers and processors, causing Brazilian orange growers to doubt that the market prices they really receive reflect actual supply and demand conditions.

In 1995, a Cessation of Practice Agreement (TCC) originating with Brazil's antitrust agency (CADE) was signed by the processing companies—this agreement is usually signed by companies engaged in anticompetitive practices. In 2004, Federal Police conducted raids on the offices of orange juice processing companies. Operation Fanta, as it was called, seized evidence alleged to show that the processors while working together had continued to fix prices paid to orange growers [1]. Hoping to resolve conflicts, growers and processing industry representatives met in 2011 and 2012 to create a new negotiating platform, the Council of Orange Producers

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and Orange Juice Industries (Consecitrus); but discussions broke down and the initiative failed [2].

The vertical integration process of the citrus industry chain has increased the asymmetry of information between producers and processing companies, turning this imbalance into a major source of conflict between agents while carrying out contracts. This asymmetry of information is mainly related to the technological and financial resources of the companies and used to obtain information affecting contract price, for example, forecasts regarding the volume and quality of crop. The growers, in turn, work with little information and thus with reduced bargaining power, and within sufficient information, growers do not have the knowledge needed about to act. This scenario allows the processing companies to benefit almost exclusively from contracts that will ensure them lower industrial risks.

The lack of market equality between agents within the Brazilian citrus supply chain might result in lower production and raw material prices as well as higher consumer prices. It has been suggested that reformatting the chain abetter balance intra-segment bargaining power would contribute to being greater economic efficiency, fairer distribution of generated income, and also lead to more social stability.

This study presents an analysis of the relationship between orange juice prices established in international markets and orange fruit prices paid to farmers in Brazil. The analysis was undertaken to determine if price transmission in Brazil's citrus chain is asymmetrical, if farmers are systematically losing their share of these prices, and to support the agents involved in the possible structural reorganization of the sector. We have to point out that Barros [3] found that even in a competitively balanced market, price changes at the raw materials level tend to be greater than the ones at the processing level.

2. Data and Methodology

2.1 Data

Monthly spot market prices received by Brazilian orange growers for the 1995/96 crop through to the 2012/13 crop were obtained from the Center for Advanced Studies in Applied Economics (CEPEA/USP). The data for this sprice series come mainly from small and medium sized production units which can not market their production through long-termcontracts (multiyear contracts) and that are more dependent on the Brazilian spot market.

Monthly orange juice prices received by the processing industry between 1995 and 2013 came from the following sources:

(a) The Food News agency (FN): price (Frozen Concentrate Orange Juice—FCOJ), in Europe;

(b) The Brazilian Foreign Trade Secretariat (SECEX): Price (FCOJ and Free on Board—FOB) calculated by the ratio of the value ($) and volume (ton) exported to Europe and the United States;

(c) New York Stock Exchange (NYSE): Future sprices of orange juice (FCOJ) at the ICE.

2.2 Methodology

The elasticity of price transmission was used as a measure of the impact of a shock (change) in prices at one market level (dependent variable) on prices at another market level. If the elasticity of transmission is one, the initial shock on prices is transmitted equally between market levels; and the shock's impact is proportional. Elasticity greater or less than one indicates that the shock's impact on one market level is disproportionately transmitted to another market level.

Tests were conducted to determine if there was asymmetric transmission between orange fruit prices received by the growers and orange juice prices received by the processing companies. Peltzman [4], Meyer and Cramon-Taubadel [5] argue that economic theory has little, if anything, to say about price asymmetry, although most studies affirm its existence and relate this asymmetry to a lack of competition. Cramon-Taubadel and Meyer [6] reported that methods typically used to test asymmetry tend to

indicate the existence of excessive asymmetry.

Data were analyzed using the statistical and econometric methods and methodology summarized below:

Step (1): A Pearson Correlation was used to study the contemporary correlations between a series of the international orange juice prices and Brazilian orange prices.

Step (2): The Granger causality test [7] was used to examine the relationship between the prices of orange juice and oranges and among juice prices from different market sources to determine if change in price of one variable caused a predictable change in price of another variable. The Granger test is based on two premises: (a) that the relationship between cause and effect is temporal in the sense that the cause cannot arise before effect; and (b) that predictability is analogous to causality. According to Zhang, Dufour and Galbraith [8], the Granger [7] introduced the concept of causality in terms of predictability at one horizon of (vector) variable X from its own past, the past of another (vector) variable Y, and possibly a vector Z of auxiliary variables.

Causality relationships are indicated if price changes at one market level anticipate price changes on another level. This information may be used as a predictive indicator, but the fact that a price change at one market level anticipates price change in another need not imply that any level is the price maker. The following situations imply causality relationships:

(a) in a competitive market, changes in supply and demand conditions at any market level initiate a price change that is then passed to another market level;

(b) in a non-competitive market, a market level (processing industries, for example) may impose changes on the price of its raw materials (orange, for example) in anticipation of changes in market conditions where its products are sold.

Step (3): Following Enders [9], our analysis of causality relationships involved two main steps:

1st, we tested for the presence of a unit root[1] and, confirming that the series are non-stationary and integrated of the same order, performed cointegration analysis and the Granger causality test [7].

2nd, after studying the direction of causality, we analyzed price transmission attempting to identify stable, long-term price relationships between variables as opposed to short-term deviations. Any identified relationships served as guide to estimateof future price adjustments.

The methodology adopted for use in this step was based on the Johansen method [10] of cointegration analysis as presented by Enders [9]. The Johansen method employs maximum likelihood estimators to test for the presence and number of cointegrating vectors through analysis of the rank of a matrix and its characteristic roots.

In our analysis, a Vector Error Correction (VEC) model, included in Johansen's methodology, was used to verify the existence of a stable long term relationship between prices in different segments while error variance decomposition was used to check the direction and intensity of a price shock on different segments.

Step (4): The last step tested for asymmetry in price transmission between processing industries and the farm. If two different price transmission elasticites are detected, one for increasing prices and one for decreasing prices, price transmission asymmetry is indicated. This test was performed using Houck's model [11], which estimates the intensity of price changes among segments. A detailed description of this method can be found in Refs. [2, 12, 13].

3. Results

3.1 Descriptive Analysis and Correlations

Fig. 1 shows the annual evolution of the analyzed orange and orange juice prices between 1995/96 and 2012/13. The series is arranged to reflect the Brazilian

[1]The methodology adopted for the unit root tests can be seen in Refs. [14-16].

orange harvest, which goes from June to January. Orange juice prices received by the Brazilian processing industry are presented according to their source: the New York Stock Exchange (NYSE), Food News (FN), and the Brazilian Department of Foreign Trade (SECEX). Fig. 1 also shows Brazilian orange prices. Monthly spot market prices received by Brazilian orange growers were obtained from the Center for Advanced Studies in Applied Economics (CEPEA/USP). We observed that juice and orange prices follow common long-term trends; although in the short-term, changes inprice differential between the two commodities can be significant.

FN and NYSE juiceprices present similar levels and variations, with changes in the quoted NYSE price slightly anticipating FN prices. Juice prices from SECEX also show some similarities with the other juice market prices in level and variation; however, there is no clear pattern of anticipation.

In Fig. 2, we show the margin of processing industry as the difference between the juice selling price and the orange spot price (both in tons) from July 2000 to March 2010. The values of orange processing by products were not included. It was found that prices quoted at the NYSE and in the FN are more closely related to one another than they are

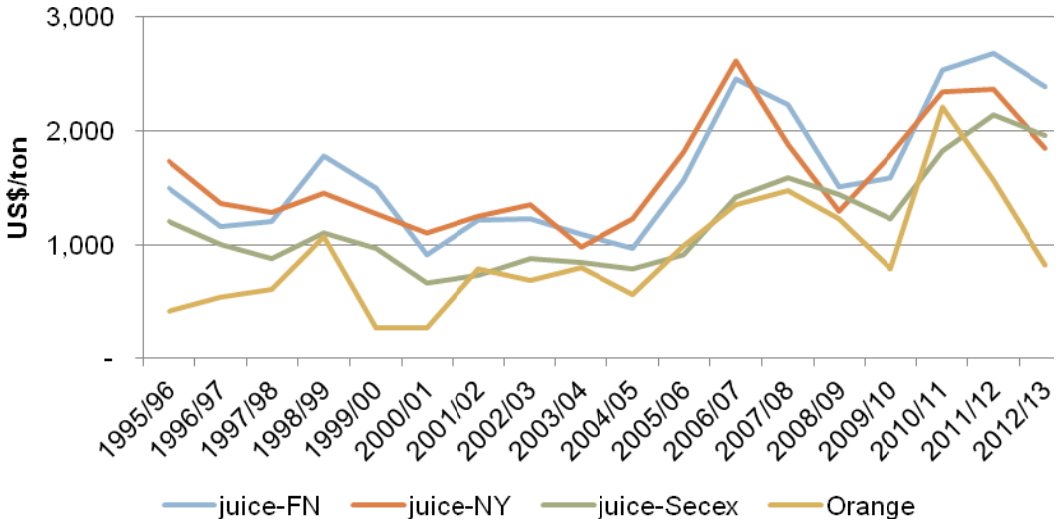

Fig. 1 Juice & orange prices, 1995/96 to 2012/13 crops.
Sources: CEPEA/USP, NYSE, SECEX, FN.

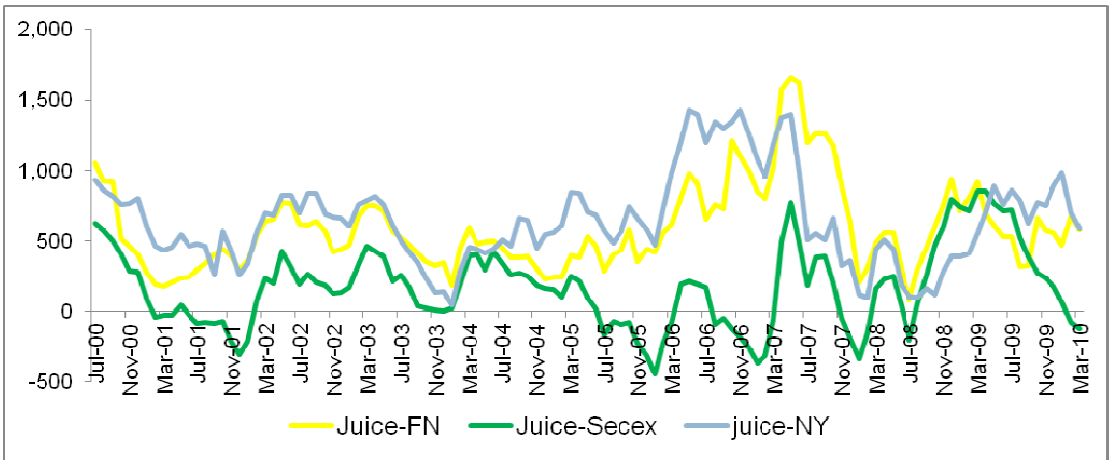

Fig. 2 Monthly processor margin (juice price-orange price) from NYSE, FN, SECEX, CEPEA/USP, July 2000 to March 2010.
Source: Authors.

to SECEX prices. SECEX juice prices tend to be lower than those from the NYSE and FN since transportation costs are not included in SECEX prices, which occasionally leads to a negative differential between the SECEX juice price and the Brazilian orange spot price.

Table 1 shows the calculated coefficients of variation in orange and orange juice prices over the duration of all series. It was found that the price of oranges was more volatile than the price of juice and that juice prices quoted in the FN were the most volatile of all juice prices.

Table 2 shows the calculated correlation coefficients (Pearson correlation) between the price of oranges and the price of orange juice from ourdata sources. All juice price series were shown to be positively correlated with the price of orange, indicating that the variables generally move in the same direction.

Juice prices given in the FN were found to be the most correlated with orange spot prices, 0.84, indicating an immediate and intense interaction between these prices. In contrast, the smallest contemporary correlation was found between orange spot prices and the price given by SECEX; yet this correlation is significant (0.73).

Table 3 shows the statistical correlations among juice prices from the three different juice price data sources. The contemporary correlation coefficient between juice prices given in the FN and those at the NYSE and SECEX were very similar, and significant (0.854 and 0.852, respectively). The contemporary correlation between NYSE juice prices and SECEX juice prices was less significant (0.681), which is an indicative of the lower connectivity. These results can be explained by tight integration between these price sources due to the use of the latest communication technologies.

3.2 Causality Relationship Analysis

Augmented Dickey-Fuller tests were applied to the logarithms of all juice prices and orange prices and their first differences. The lags included in the model were chosen according to Akaike-Schwarz and Hannan-Quinn information criteria (AIC & HQC). Test results (not reported) gave evidence that these price series at the logarithmic level are non-stationary and that the corresponding first differences were all stationary. We therefore modeled the first difference following a logarithmic transformation in each case and then performed a Granger test to determine the causal relationship between changes in the price of oranges and juice from each data source.

The Granger test results for causality in the price relationship between Brazilian orange prices and international juice are shown in Table 4.

The test results rejected the hypothesis of no-causality in the flow of price changes from the NYSE juice price to the one of Brazilian oranges, while the hypothesis of a no-causality in the opposite directionis not rejected. The model then examined the relationship between FN juice and orange prices and produced the same results. In contrast, the Granger test neither rejected the no-causality hypothesis in the flow of price changes from the SECEX exchange to the price of oranges nor was it rejected in the opposite

Table 1 Coefficients of variation juice and orange prices.

	Juice prices			Orange price
	FN	SECEX	NYSE	Spot
Coefficients of variation	37%	31%	33%	47%

Source: authors.

Table 2 Correlation between orange and juice prices.

	FN	SECEX	NYSE
Orange	0.84	0.73	0.77

Source: authors.

Table 3 Correlation coefficients between juice prices.

	FN	SECEX	NYSE
FN	1		
SECEX	0.852	1	
NYSE	0.854	0.681	1

Source: authors.

Table 4 Granger causality test between orange price and juice prices.

Null hypothesis (H_0)	Lags	F test	Critic value (5%)	Decision
NY and orange				
H_0: NYSE to Orange, no Granger-cause	1	3.84013	3.920	Reject H_0
H_0: Orange to NYSE, no Granger-cause	1	1.04864	3.920	No reject H_0
FN and orange				
H_0: FN to orange, no Granger-cause	1	0.71770	3.920	Reject H_0
H_0: Orange to FN, no Granger-cause	1	3.37743	3.920	No reject H_0
SECEX and orange				
H_0: SECEX to orange, no Granger-cause	1	0.29537	3.92	No Reject H_0
H_0: Orange to SECEX, no Granger-cause	1	1.79620	3.92	No reject H_0

Source: authors.

Table 5 Granger causality test between juice prices and taken from the NYSE, SECEX and FN.

Null hypothesis (H_0)	Lags	F test	Critic value (5%)	Decision
NYSE and SECEX				
NYSE to SECEX, no Granger-cause	2	3.53902	3.072	Reject H_0
SECEX to NYSE, no Granger-cause	2	0.81247	3.072	No reject H_0
FN and SECEX				
FN to SECEX, no Granger-cause	3	6.67866	2.696	Reject H_0
SECEX to FN, no Granger-cause	3	0.48157	2.696	No reject H_0
FN and NYSE				
FN to NYSE, no Granger-cause	3	1.30836	2.696	No reject H_0
NYSE to FN, no Granger-cause	3	2.78575	2.696	Reject H_0

Source: authors' analysis.

direction. From these results we conclude that changes in juice prices found at NYSE or in the FN influence and precede the formation of Brazilian orange prices.

Table 5 shows results from the Granger causality test examining the relationships among the three different juice price sources.

According to these results, the hypothesis that NYSE juice prices do not affect SECEX juice prices is rejected: change in juice prices at the NYSE causes (predate) change in SECEX juice prices. On the other hand, the idea that SECEX juice prices do not affect NYSE juice prices was not rejected: SECEX prices do not affect NYSE prices. This unilateral causality was also found in the relationship between FN juice prices and SECEX juice prices. Granger test results rejected the hypothesis that FN juice prices do not affect SECEX juice prices while indicating that non-causality in the opposite direction was a possibility: SECEX prices do not affect FN prices. Results of causality test also rejected the null hypothesis in regard to the effect of price changes at NYSE on FN juice prices while that hypothesis in regard to FN juice prices affecting NYSE juice prices was not rejected.

Fig. 3 summarizes the overall results of Granger causality test. The arrows indicate the probable direction of causality.

Fig. 3 shows the importance of NYSE orange juice prices as having temporal precedence over all other juice prices over the period analyzed. By extension, changes in the NYSE juice price also indicate the direction of future Brazilian orange fruit prices. Juice

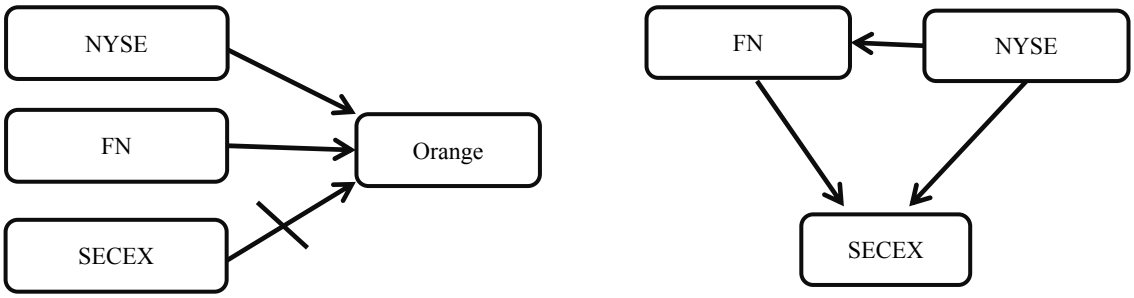

Fig. 3 Summary of Granger causality test between juice and orange prices and among juice price sources.
Source: authors.

price changes shown in the FN had a similar relationship with orange fruit prices, although not on NYSE juice prices. The SECEX price indicator was the only one that did not show prices presaging the formation of orange prices over the period of study, as graphically represented in Fig. 3 with a slash cutting the direction the arrow.

In summary, results from the Granger causality test are:

(1) Changes in orange juice prices at the NYSE tend to initiate and determine the direction of price changes reported by Foodnews and SECEX;

(2) Changes in prices reported by Foodnews tend to anticipate changes in prices reported by SECEX;

(3) Changes in prices at the NYSE and those reported in Foodnews tend to anticipate changes in prices paid to orange growers.

3.3 Johansen Cointegration Analysis

With the direction of price causality now reasonably established, methodology devised by Johansen was used to study the structure of orange market as defined by the long-term price relationship between its segments. Generally, when there is a concentrated industrial structure and fragmented group of product consumers and raw material suppliers, it is expected that the price of the industrial products (in this case, juice) generates changes in the raw material prices (in this case, oranges), rather than visa versa. The direction of price change among the Brazilian orange product market can be seen as a reflection of this type of markets structure: concentrated power in the industrial segment with fragmentation in the raw material inputs segment.

Results from the use of the Johansen cointegration test to evaluate the long-term equilibrium price relationship between juice and orange prices are shown in Table 6. SECEX juice prices were not employed in these calculations since the Granger test showed that a change in the SECEX price does not cause a change in orange prices while prices at the NYSE and in FN do affect orange fruit prices.

The Johansen cointegration test was conducted with the series in the first difference. Furthermore, the cointegrating relationship was tested from the trace statistics, and the number of lags was defined through residual correlogram analysis and both Akaike-Schwarz and Hannan-Quinn information criterion (AIC & HQC).

Based on the results shown in Table 6, the null hypothesis was rejected indicating that there is a cointegration relationship ($r = 0$) between the orange price series and NYSE and FN orange juice prices. In both cases, the trace statistics (λ trace) indicated the existence of one vector cointegration at a 5% significance level.

A Vector Error Correction Model (VEC) was formulated to verify the existence of a stable long-term relationship between juice and orange prices and included in each vector autoregression (VAR) estimate. VEC modeling also made it possible to infer the speed at which the variables converge to a long-term equilibrium. The VEC model was constructed with the orange and juice price series in the first difference

Table 6 Results from Johansen Cointegration Test.

Variables	Null hypothesis	Alternative hypothesis	λ trace	Critic values 5%
Orange	r ≤ 1	r > 1	1.952	3.841
FN juice	r = 0	r > 0	21.999	15.408
Orange	r ≤ 1	r > 1	2.472	3.841
NYSE juice	r = 0	r > 0	20.414	15.408

Source: authors' analysis.

because the augmented Dickey-Fuller test showed that both series were non-stationary but that the corresponding first differences were all stationary.

Eqs. (1) and (2) were used to calculate the long-term formation of orange prices based on the juice price and estimated VEC values. The variables are in logarithmic form.

Considering the orange juice prices with source in Food News we have:

$$Orange_t = 1{,}035FN_t + \cdots + \mu_t \quad (1)$$

(7,602)

Considering the orange juice prices with source in NYSE we have

$$Orange_t = 1{,}062NY_t + \cdots + \mu_t \quad (2)$$

(5,684)

where:

$Orange_t$ = logarithm of the orange prices in month t;

FN_t = logarithm of FN orange juice prices in month t;

NY_t = logarithm of NYSE orange juice prices in month t.

For both Eqs. (1) and (2), the long-term elasticity calculated using cointegration was one or a bit moreand with a positive signal. This means that changes in international orange juice prices are, in average, transmitted proportionally to domestic orange fruit prices.

We also calculated the variance decomposition of forecast errors monthly priced of oranges in order to evaluate the origin of price variations. Results from the calculations are shown in Table 7.

The variance decomposition analysis revealed that the largest share of shock in orange prices came from changes within the orange fruit production segment itself rather than changes in international juice prices. It was found that from approximately 0% to 11% of any monthly change in the price of orange fruit was a reflection of a change in juice prices shown in the FN and approximately 10% to 21% a reflection of a change in juice prices quoted at the NYSE. Over our study period, approximately 80% to 100% of any monthly change in the variance decomposition price of oranges came from within the orange producer segment.

3.4 Asymmetric Price Transmission Analysis

Table 8 summarizes the results of the analysis of asymmetric price transmission between orange juice prices established in international markets and orange fruit prices paid to farmers in Brazil. Estimations were the result of an application of Houck's model [11].

The results show that the transmission of prices from juice to orange differs according to whether juice prices are increasing or decreasing. A decrease in listed juice prices, whether from the Food News or the

Table 7 Orange fruit prices variance decomposition.

Month	Orange fruit	FN-juice	Orange fruit	NY-juice
1	99.77	0.23	89.77	10.23
5	89.87	11.23	79.27	20.73
10	89.88	11.22	79.26	20.74

Source: authors.

Table 8 Price transmission—Summary.

	Impact on orange prices after 2 months*		
	Juice price Δ:+1	Juice price Δ:-1	F test
FN-juice	0.595	-0.699	2.279
NYSE-juice	1.097	-1.712	3.994

*period to complete price transmission.

Source: authors.

Table 9 Elasticities frequency of transmission from juice to orange price.

	Variations in FN-juice		Variations in NY-juice	
Elasticity (E)	Positive	Negative	Positive	Negative
E > 1	56%	57%	33%	35%
0 < E < 1	22%	14%	27%	23%
E < 1	22%	29%	40%	42%

Source: authors' analysis.

Obs.: frequency observed in the sample data.

NYSE, was transmitted to orange prices with greater intensity than juice price increase. Over a period of two months, a 10% decrease in the price of juice quoted in the FN was accompanied by a fall of 6.99% in Brazilian orange prices while the same juice price decrease at the NYSE was accompanied by a 17.12% decrease in Brazilian orange prices. On the other hand, over two months, a 10% increase in juice prices quoted in the FN was accompanied by a 5.9% increase in Brazilian orange prices while the same juice price increase at the NYSE was accompanied by a 10.97% increase in Brazilian orange prices.

In Table 9, we present the frequency percentage of three possible types of price transmission: (1) transmission is greater than unity, which means that the change in juice price has been transmitted to orange prices more than proportionally in the same direction; (2) transmission is between zero and unity, which means that the juice price change was transmitted less than proportionally but in the same direction to orange price; (3) transmission is less than zero, which means that the change in juice price was transmitted to orange prices in the opposite direction.

In the case of monthly variation in juice prices at the NYSE, we found that that price transmission occurred more frequently in the opposite direction (negative elasticities). Transmission in the same direction and more than proportionally (elasticity > one) accounted for about a third of the cases while transmission in the same direction and less than proportionally (elasticity between zero and one) occurred in about a quarter of the cases.

In the case of monthly juice price variation shown in the FN, we found that the transmission in the same direction and more than proportionally occurred in 57% of the months, transmission in the opposite direction (negative elasticity) occurred in 29% of the months, and transmission in the same direction but less than proportionally (elasticities between zero and one) occurred in approximately 14% of the months.

Overall, we conclude that the transmission of monthly juice price changes, regardless of price source, is volatile and rather unpredictable. The large variation in the direction and impact of juice price changes on orange prices is an indication of weak market transparency.

4. Conclusions

This survey analyzed the relationship between international orange juice and orange fruit prices paid to Brazilian farmers to determine if price transmission in this sector is asymmetrical and if Brazilian farmers are systematically losing their share of these prices.

Results indicated that the price of orange fruit is

fundamentally linked to the price of its juice, regardless of which juice price data source is considered and in the long-term, international juice prices are transmitted to farmers. Juice prices at the NYSE were found to be the most important determinant of international juice prices and the strongest external predictor of orange fruit prices in Brazil. Evidence was found indicating that there is asymmetry of price transmission within the Brazilian orange sector, with short-term juice price increases being transmitted to the farmer in smaller proportions than juice price decreases. An examination of the historical record of monthly price transmission did show that Brazilian orange fruit price volatility is high and transparency is low. Study results did not give a particularly strong indication of the cause of this price asymmetry, whether it is the result of externalities, a systematic sectoral problem, or manipulation.

The results of this survey can be of benefit to those negotiating prices between independent Brazilian citrus farmers and the country's citrus processing industry to establish a more balanced, less confrontational trading pattern.

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