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Asymmetric price transmission in the brazilian refined sugar market

This work evaluates the price relations and transmission patterns between producers and retail in the market for refined sugar in Sao Paulo, Brazil, its direction and magnitude. The results suggest that the transmission of shocks is bidirectional. Formal tests suggest that the symmetry in price transmission from retail to producer cannot be rejected in short and long-run. Therefore, positive and negative exogenous shocks of refined sugar at the retail impact producer's prices in the same magnitude. From producer to retail prices, the tests confirmed a negative asymmetry in price transmission. It means that a reduction in producer prices has a stronger impact in reducing retail prices than when a positive shock on producer prices is transmitted to increase retail prices.

1. Introduction

The dynamics of sugar prices in the Brazilian market is of particular interest, considering that the country is the main producer and exporter of the commodity.

Sugar is produced from sugarcane in Brazil. In the mid-1990s, the country became the greatest producer and exporter of the commodity. Since 2009 Brazil has been responsible for more than 20 percent of the world production of sugar and for 60% of the total export volume. About 70% of the Brazilian production is directed to the external market. The domestic market is therefore relevant to determine the surplus that will be directed to the international trade.

The work is applied to prices in the market of the state of Sao Paulo, given its importance on Brazilian sugar production and sugar exports. Sao Paulo has contributed with more than 60% of the overall Brazilian sugar production and has reached 70% of the countries' exports in 2016.

In a macro context, sugar is an important staple food product in Brazil and its prices affect the inflation rates. It is also an important component of the costs of many processed food, in particular of soft drinks.

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In general, evaluations about how price changes are transmitted between different market levels are relevant for players involved in production management, marketing, as well as for policymakers. With regard to production and marketing, it can help the planning of operations such as inventory loading, freight contract timing, among other logistic and production decisions. For policymakers, asymmetric price transmission (APT) analysis provides information about price dynamics in response to a specific shock, as well as determinants of short-term inflation with direct consequences for monetary and fiscal policies (Tripathi and Goyal, 2011). In this paper, we use econometric tests to evaluate if there is asymmetric price transmission (APT) within the refined sugar chain in the state of Sao Paulo (SP). To analyze the occurrence of APT between, for instance, the producer's price and retail price, we analyze how a shock in the producer's price affects the retail price and vice-versa (Meyer and von Cramon-Taubadel, 2004). This issue has triggered a vast amount of literature focusing agro-industrial markets (Aguiar and Santana, 2002; Goodwin and Holt, 1999; Weldesenbet, 2013; Silva Neto and Parré, 2012; Mattos, 2010; Capps and Sherwell, 2007; Santaremo and von Cramon-Taubadel, 2016; Santaremo and Cioffi, 2010; Kim and Ward, 2013; Serra and Goodwin, 2003; Goodwin and Harper, 2000 Azzam, 1999; Ward, 1982) and also applied to fuel markets (Canêdo-Pinheiro, 2012; Goodwin, 2006; Wlazlowski *et al.*, 2012).

The empirical observation of the data seems to indicate that there is APT from producers to consumers. Throughout the period from May 2003 to February 2015, the accumulated variation of the producer's price was 97%, equivalent to an increase of R$ 0.74 per kilogram, according to the *Centro de Estudos Avançados em Economia Aplicada* (CEPEA) refined sugar price indicator. The retail data for this same product, from the *Instituto de Economia Agricola* (IEA) shows that the accumulated variation, through the same period was slightly higher in absolute value of R$ 0.77 per kilogram, but lower in percentage terms (71%).

In addition, Rodrigues and Moraes (2007) found that consolidation of firms in the Brazilian refined sugar market has resulted in a relatively concentrated market structure due to entry barriers, such as high sunk costs with respect to the market size. These authors argued that despite the high market concentration, refined sugar producers have been unable to exploit this relative market power at the retail level. One possible explanation for that is that direct competition with crystal sugar produced in large scale in Brazil would result in high price elasticity of demand for refined sugar, such that an increase in its price would result in a more than proportional reduction in consumption, reducing revenue and creating opportunities for an expansion of crystal sugar consumption (Rodrigues and Moraes, 2007).

Since the 1990s, the Brazilian government deregulated the sugar and ethanol sector, forcing the development of self-management mechanisms. With this change, several adjustments became evident in the market and their products, fuel ethanol and sugar. This motivated an extensive literature on the ethanol fuel market (Barros, Bacchi and Burnquist, 2002; Alves and Bueno, 2003; Pontes, 2009; Serigati and Perosa, 2010; Gomez, 2010; Costa and Guilhoto, 2011; Farina *et al*., 2010; Freitas and Kaneko, 2011; Cardoso and Bittencourt, 2012; Santos, 2013). Despite the large number of studies on fuel ethanol, literature on refined sugar markets is still scarce, which justifies this analysis.

The focus on sugar in the Brazilian market is particularly interesting given peculiar aspects in production and in the retail market. Sugar is both dependent on agricultural production and industrialization. In Brazil, it is obtained through an integrated vertical production chain where the major input, the sugarcane, is owned by the same industry that processed the cane and produced the refined sugar. In addition, the same industrialization process leads to the production of other types of sugar, such as crystal sugar and also bioethanol. This is a peculiar production setting where the input (sugarcane) can be allocated to produce more sugar at the expense of bioethanol and vice-versa. Producers can therefore respond to different market conditions.

Refined sugar in the country can be characterized as a non-perishable agro-industrial product with a relatively concentrated retail market. According to the literature, these conditions are expected to result in price increases transmitted more intensively than reductions (Aguiar and Santana, 2002). This study will evaluate if there are other characteristics both in the production process and market structure that should be considered in analyzes of price transmission for products integrated in a supply chain such as the refined sugar in Brazil.

The paper presents an overview of the refined sugar market in Brazil, providing general guidelines to investigate the efficiency in transmitting market changes to the prices. Next, a description of the concept of asymmetry in product and service transmission is presented and explained in terms of its relevance to evaluate market behavior. The methodology used for the evaluation of the price transmission is described at item 4, followed by the presentation and discussion of results, finalizing with the conclusions.

2. The refined sugar market in the state of Sao Paulo, Brazil

In Brazil, and specifically in the state of Sao Paulo, the sugar market is relatively complex, given the diversity in the supply chain and product characteristics. At first, there are at least eight different sugar types produced in Brazil,

and this situation affects the market of Sao Paulo, to which belongs the biggest share in the country sugar production. These different types of sugar correspond to: crystal sugar, classified crystal sugar, extra-fine-crystal sugar, crystal sugar mesh 30, granulated crystal sugar, amorphous crystal sugar, liquid sugar, inverted sugar, and raw sugar, which is classified into two categories; very high purity – VHP and very very high purity – VVHP (Guarani, 2015).

The amorphous refined sugar, which is this study's focus, is produced via crystal sugar purification, being composed of irregular shaped fine grains, with excellent whiteness and extremely hygroscopic, which easily blends in drinks and other preparations. It is highly used for direct human consumption and can be an ingredient in a large number of recipes, like desserts and bread rolls.

With the sector's consolidation process, the number of producers decreased in the last decades, as highlighted by Rodrigues and Moraes (2007). This consolidation process has affected particularly the refined sugar market, selected for the empirical analysis since it provides a suitable context for testing market performance with the characteristics of this commodity's vertical price transmission from producer to retail. This type of sugar is the consumer's favorite for direct consumption in the SP market, and other states of southeast and south Brazil as well.

Before the 1990s, government intervention in the Brazilian sugar-ethanol sector was relevant to explain the relation between competition through price and the market structure (Rodrigues and Moraes, 2007). Between 1969 and 1974, refined sugar prices had a falling trend. In turn, an intensification of the market structure concentration became evident. According to Rodrigues (2005), in the 1970s the industry concentration ratio – CR4 was 86%, and in 1974 it increased to 95%. Between 1975 and 1986, refined sugar prices experienced successive increases. During this period, besides the market structure becoming more concentrated, it suffered a slight fragmentation, mainly due to the entry of new mills (which used to belong to Copersucar) in isolate competition in the refined sugar market. From 1986 to 1999, prices were reduced, leading the sector to slowly restructure itself. Sector deregulation stimulated some mills to include product differentiation as a goal in self-management. With intensified competition in the 2010s, the companies took advantage of the product's good prices and made efforts to increase their market share.

Another relevant aspect in this period was the competition boost in the retail market (supermarkets), despite intensified concentration in the supermarket sector, when large groups with high negotiation power were opening new stores, certainly affecting product price levels (Barros and Claro, 2013 and DIEESE, 2013).

In addition to diversification of types of sugar, sugar and ethanol industrial units began to invest in differentiated logistics as an instrument to increase

competitiveness. Studies focusing on the sugar market in this period indicated that the main strategies adopted by sugar mills involved changes in business processes and operational activities (production and logistics), improving storage agility, transport and delivery of the product (Bianchini, 2006). These changes involved initiatives such as association for commercialization (consolidated with the creation of Crystalsev), company mergers and acquisitions, market diversification, just-in-time deliveries of sugar, and mills operating as trading companies (Bianchini, 2006). Rodrigues and Moraes (2007) emphasized the importance of identifying the evolution of market structure and competition level that developed throughout this process. Their study indicated that the market structure of the sugar refining industry in Brazil suffered from the effect of state regulation through price and trade control before the liberalization of the market in the 1990s.

Another important factor concerns the sector's pricing mechanism. Since it is product also traded in the international market, it is expected that its market will be influenced by the price of refined sugar traded on the London Stock Exchange, as well as by the values of sugar marketed in the international market of New York and its respective premium of polarization. Thus, it is believed that the sugar price formed in the foreign market – whether raw or white – should influence price formation in the domestic market. In addition, the supermarket sector identified by Rodrigues and Moraes (2007) as being highly concentrated, can exert power with refined sugar producers. The analysis associating price level and market structure allows us to conclude that, despite the State's regulation of the product, the market structure was strongly related to price levels, demonstrating a positive relationship between price level and market concentration.

3. Theoretical reference for Asymmetric price transmission (APT)

The literature about vertical price linkages has concentrated on evaluations of the relation between farm, wholesale and retail prices. These relations are typically characterized by the magnitude, speed and nature of the adjustments through the supply chain to market shocks generated at different levels of the marketing process (Vavra and Goodwin, 2005). Recent research has recognized that underlying aspects of price transmission may cause asymmetric adjustments to shocks.

The literature about APT has presented several contributions for empirical analysis, with particular emphasis for agricultural products. Meyer and von Cramon-Taubel (2004) and Peltzman (2000) stand out for their theoretical approach, providing an interesting analytical framework about these con-

cepts. The former presents a broad discussion about the nature and plausible reasons why asymmetric price transmission arises. They observe that asymmetric price transmission can imply that consumers are not benefiting from a price reduction at the producers' level, nor are producers benefitting from a price increase at the retail level. This, in turn, can modify the welfare effects across levels and among agents following shocks to a market relative to the case of symmetric price transmission. Peltzman (2000) considers asymmetric price transmission as a rule, and not exception, such that standard economic theory that does not take this into account might not be accurate. According to Peltzman (2000), consumers notice this asymmetry by the way costs are incorporated in the price of final goods in several markets. This perception can be noticed in the petrol market, for instance, where there is an intense consumption frequency and an unusual price transparency in other market levels (Perdiguero-Garcia, 2013).

Asymmetric price transmission (APT) has been associated with a number of reasons to explain asymmetries and imperfect pass-through of prices: market power, adjustment costs, inventory management, government interventions, asymmetric information and perishability of the good (Aguiar and Santana, 2002; Santeramo and von Cramer-Taubadel, 2016). Other authors also consider that aspects such as high inflation scenario and use of price strategies (Bakucs, Falkowski and Ferto, 2013) can cause asymmetric price transmission. When one of these conditions occurs in the market, it is expected to reflect some asymmetry in price transmission.

Borenstein Cameron and Gilbert (1997) and Perdiguero-Garcia (2013) show a set of reasons where asymmetry can occur in a competitive market. Peltzman (2000) highlights that studies focus on petrol (Karrenbrock, 1991; Borenstein, Cameron and Gilbert, 1997).

Several evaluations show that the price transmission for agricultural products is such that price increases are more rapid and fully transmitted than price decreases (Kinnucan and Forker, 1987; Aguiar, 1990; Karrenbrock, 1991; Goodwin and Harper, 2000; Kim and Ward, 2013). Additionally, various existing research has found that price changes tend to flow from the farm to wholesale and retail markets.

However, a generalization of these results is somewhat difficult to make, since there are studies that detected asymmetries in price adjustments at different market levels, although the extent of asymmetry is generally small.

Azzam (1999) has demonstrated that when retailers incur in repricing costs, there is a range of farm price change that does not change the retail price. Results obtained by Goodwin and Harper (2000) confirm the findings of other research where the transmission of shocks appears to be unidirectional with information flowing up the marketing channel from farm to wholesale

to retail markets but not in the opposite direction. However, they have also determined that farm markets do adjust to wholesale market shocks. The effects of retail market shocks, however, are largely confined to retail markets. In addition, minor asymmetries are present in the response of farm prices to farm and wholesale shocks in the earlier period. Serra and Goodwin (2003) studied price transmission between producer and retail in the Spanish dairy sector subject to government intervention through a system of quotas. They observed that price decreases were transmitted more fully than price increases. In principle, scarcity of milk could lead to competition among processors to increase both their access to milk quota and their retail market share resulting in higher prices to producers. However, the resulting farm level price increase was not fully transmitted to the retail level.

An overall evaluation of the results presented in the related literature suggests that these have not been conclusive regarding which factors determine the exact direction and magnitude of price transmission, but have resulted in a progressively organized framework to approach the issue. This seems to indicate that there is a need to proceed to empirical analysis to identify if asymmetries occur, as well as its nature, direction and speed. It is important, however, to use adequate procedures for the analysis.

This has generated another research line that focuses on the different estimation methods to identify the characteristics of price transmissions between different market levels. A comprehensive review of estimating and testing for asymmetric price transmission can be found in Meyer and von Cramon Taubadel (2004).

According to Vavra and Goodwin (2005), von Cramon Taubadel and Fahlbusch (1994) were among the first to incorporate the concept of cointegration into models of asymmetric price transmission, having suggested that in the case of cointegration between non-stationary time series, it becomes more adequate to use an error correction model (ECM) extended by incorporating asymmetric adjustment terms as a better procedure. This approach has been adopted for this analysis.

Estimates of asymmetric price transmission using threshold error correction model are also common. Santeramo (2015) adopts this approach to provide estimates of transaction costs and speeds of price transmission among spatially separated markets.

Goodwin (2006) highlights that the vertical relation among prices is frequently used as an important index for structure-conduct-performance in the markets analyzed, or to exercise market power more directly.

Summarizing, it is important to resort to formal tests to demonstrate the existence and categorize which type of asymmetry is happening. For the analysis proposed about the Brazilian refined sugar market, it is useful to classify

the different asymmetric price transmission types and respective causes (Meyer and von Cramon-Taubadel, 2004). Thus, the possible causes of asymmetric price transmission, as well as a description of the econometric proceedings and their results are shown in this paper.

In the refined sugar case, after these analyses, it should be possible to suggest policy direction and/or strategies to improve market performance. This is the objective of this paper.

The basis of the price theory assumes that consumers and suppliers have direct interaction leading to a balance, which corresponds to the intersection between supply and demand slopes. Hardly ever the producer-received price is the same of consumer-paid prices (Tomek and Robinson, 1972), this difference is called marketing margin, a useful concept to highlight what must be taken into account to analyze the price relation among different market levels. These differences could arise from three sources; value-added, storage, and transport (Barros, 2012). Several analyses in vertical asymmetric price transmission try to answer questions such as: Is the marketing margin too high? Why is this margin not homogenous among the goods? Do margin values change over time? Is there any association between margin value and market structure? As answers based on the marketing theory were presented for these questions, the asymmetry in the transmission of prices came to dominate the analysis of the behavior of prices and margin.

For the analysis proposed, it is useful to classify the different asymmetric price transmission types and causes (Meyer and von Cramon-Taubadel, 2004). Thus, the possible causes of asymmetric price transmission, as well as a description of the econometric proceedings and their results are shown in this paper.

4. Methodology and Data

4.1 Error Correction Model

For the empirical analysis, an error correction model (ECM) basis is used to obtain the price transmission between two refined sugar market levels (producer and retail). This procedure requires the price series to be cointegrated, and, in this case, the ECM is preferred instead of the procedure described by Houck (1977). Therefore, before estimating an ECM, it is necessary to test for cointegration and then it is useful to perform a Granger causality test, in order to predict the causality direction. Once the condition of cointegration is satisfied, a model proposed by Von-Cramon-Taubadel and Loy (1999), with the modification adopted by Canêdo-Pinheiro (2012), is imple-

mented as in equation 1, where the change in retail prices is an endogenous variable:

$$\Delta p_{r_t} = \alpha + \sum_{J=0}^{J^+} \beta_j^+ \Delta p_{f\,t-j}^+ + \sum_{J=0}^{J^-} \beta_j^- \Delta p_{f\,t-j}^- + \sum_{k=1}^{K^+} \gamma_j^+ \Delta p_{r\,t-j}^+ + \sum_{k=1}^{K} \gamma_j^- \Delta p_{r\,t-j}^- + \theta^+ ETC_{t-1}^+ + \theta^- ETC_{t-1}^- + \varepsilon_t, \quad (1)$$

where Δp_r is the retail price variation, Δp_f is the variation on the producer's price, *ETC* is the error correction term, ε is a random error, the subscript t represents time and the superscript (+) and (-) indicate whether the variation has positive (otherwise they assume a zero value), or negative values (otherwise, equals zero), respectively. The *ETC* was obtained from an auxiliary regression, with their predicted residuals, i.e. $ETC_t = p_{r_t} - \delta - p_{f_t}$, representing a long-term relation between prices. In a model where price transmission occurs in the direction from retail to producers, one should only substitute Δp_r for Δp_f and vice versa. From equation (1) it is possible to implement the following asymmetry tests (Pinheiro, 2012; Weldesenbet, 2013): (i) contemporaneous impact asymmetry (COIA), if $\beta_0^+ \neq \beta_0^-$; (ii) distributed lag effect asymmetry (DLEA), if $\beta_j^+ \neq \beta_j^-$ for a j $\in$ [0, max(J^+,J^-)]; (iii) cumulated impact asymmetry (CUIA) until lag *J*, if $\Sigma_{j=J}^{J^+} \neq \Sigma_{j=J}^{J^-}$, where j $\in$ [0, min(J^+,J^-)];(iv) total cumulated impact asymmetry (TCIA) if $\Sigma_{j=J}^{J^+} \neq \Sigma_{j=J}^{J^-}$; (v) equilibrium adjustment path asymmetry (EAPA) if $\theta^+ \neq \theta^-$, i.e. if the convergence "speed" depends on whether the retail price is above ($ETC_{t-1} \geq 0$) or under ($ETC_{t-1} < 0$) the long-term price balance. All these tests can be performed as an F test. Note that COIA, DLEA, CUIA and TCIA test for a short-run asymmetric behavior, comparing the positive and negative impact of p_r on p_f in a given period; while EAPA tests for long-term asymmetry.

The Stata and Eviews softwares have been used for the model estimates and related econometric test.

4.2 Data

This study used monthly price series of amorphous refined sugar paid to the producer and paid by the retail consumer. Both series start in May of 2003[1] and end in February of 2015. For the value paid to the producer, a

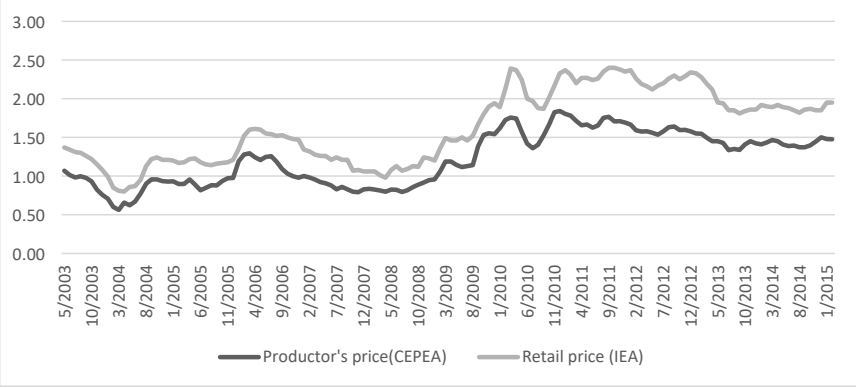
[1] The series beginning being in May of 2003 is due to the beginning of CEPEA refined sugar price index.

monthly average was calculated from the daily indicator series of the Center for Advanced Studies in Applied Economics (CEPEA) for refined sugar prices. As for the retail price, it was obtained from the Institute of Agricultural Economics (IEA) database, where the monthly price series of white sugar packaged in 1kg sacks is published, which corresponds to the amorphous refined sugar sold in the retail market. Both price series for 1kg of refined amorphous sugar are presented in Figure 1. It is demonstrated that prices had a significant rise in the period from April 2008 to April 2010. After this period, even if there were price changes, it is noted that these are maintained at higher levels and that there is an increase in the marketing margin[2], a fact that changes from 2013 onwards when prices decrease. However, the price reduction is more intense in retail than in the producer's level.

Apparently, the price series shown in Figure 1 do not have fixed averages over time, and they also seem to share the same trajectory over time, that is, they have the same stochastic tendency, with cointegration between the series. There is also greater variation in prices in the period from the end of 2008 to 2010.

In Figure 2 it is possible to visually infer that both price series became stationary after the first difference.

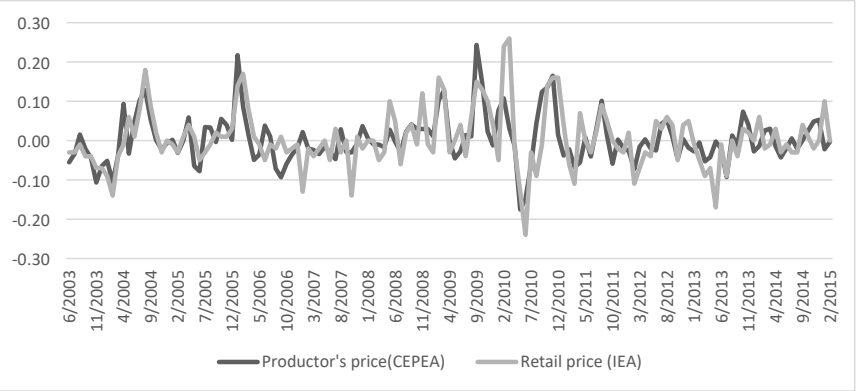
Fig. 1. Refined sugar prices in Brazilian Real at producer and retail price levels.



Source: CEPEA and IEA databases

[2] In this case, the market margin is the difference between the retail and producers' prices.

Fig. 2. Refined sugar prices in Brazilian Real in first difference at producer and retail price level.



Source: CEPEA and IEA databases.

5. Results and Discussion

5.1 Unit root test

Within a cointegration context, the first step is to make sure that the series is non-stationary; to do this it is usual to perform some unit root tests in the time series. Therefore, three unit root tests were used in this analysis; the Dickey-Fuller Generalized Least Squares (DF-GLS), Phillips Perron (PP) and Kwiatkowski, Phillps, Schmidt, and Shin (KPSS).

The results of these tests can be found in Table 1. The results indicate that both price series are non-stationary in level, but became stationary after the first differentiation, an indication that they are first order integrated.

5.2 Cointegration

With both time series being first order integrated, we can test for cointegration using the Johansen test, we chose to use the third equation of the Johansen test, and the results of the tests are in Table 2. Both the trace and maximum eigenvalue tests indicate the presence of a cointegration vector between prices. This leads to the conclusion that the variables are cointegrated, which enables the use of error correction models.

Tab. 1. Unit root tests' results.

	Variables in level		
	No constant and trend	No constant	Constant and trend
Producer price			
PP	0.113	-1.221	-2.239
DF - GLS	-	-1.255	-2.035
KPSS	-	1.042 ***	0.13
Retail price			
PP	0.138	-1.212	-2.048
DF - GLS	-	-1.26	-2.157
KPSS	-	0.984 ***	0.134

Note: ***1% of statistical significance, **5% of statistical significance e *10% of statistical significance.
Source: authors analysis.

Tab. 2. Johansen test for cointegration results.

Test	Hypothesis (n. of vectors)	Trace statistics	p-value
Trace	None	27.994	0
	At maximum 1	1.965	0.161
Max Eigenvalue	None	26.029	0.001
	1	1.964	0.161

Source: authors results and p-value by MacKinnon-Haug-Michelis (1999).

5.3 Granger causality

Granger causality is a temporal causality, in an error-correction model context, causality is associated to short-term, while the causality among variables associated with error correction represents the long-term causality.

Another important aspect about Granger causality is that it is sensitive to the number of lags used. For this reason, tests were performed for different numbers of lags, in addition to the optimal number of lags found previously for the Johansen procedure. The results of the Granger causality tests are shown in Table 3.

Tab. 3. Granger causality test results.

Null Hypothesis	Chi^2	Probability	Number of lags
Producer price does not	13.042	0.002 ***	2
Granger-cause	12.851	0.012 **	4
Retail price	15.152	0.019 **	6
	15.142	0.056 *	8
Retail price does not	8.333	0.002 ***	2
Granger-cause	8.422	0.077 *	4
Producer price	12.604	0.05 **	6
	13.587	0.093 *	8

Note: Null hypothesis rejection at ***1%, **5% and *10% of statistical significance.
Source: author's own calculations.

The Granger causality results indicate that there is a bi-causality between prices at producer and retail levels, suggesting that both respond to changes in each other's prices. Thus, an exogenous change in producer prices will reflect in retail prices, just as an exogenous shock in retail prices will affect prices at the producer level. These results are important for this research by indicating which equations we should estimate. In the case of bi-causality, we chose to estimate two equations, one considering retail prices as an endogenous variable and the other considering producer prices as a variable being explained by the lagged prices themselves and the lagged prices of consumer prices.

5.4 Error-correction model

According to the previous item's test results, we estimate two error correction equations; one referring to the retail price response to a shock occurred in producer prices; another refers to the response of price shocks at the retail level with repercussions on producer prices. These expressions are estimated separately and each presents the best number of lags according to selection criteria (Akaike and Bayesian), and a total of 625 models were tested for each equation. Another relevant point to note is that, generally, when considering a chain that starts at the producer level and ends at the retail level, the asymmetry in price transmission deals with downstream shocks causing upstream impacts. However, Barros (2012) argues that an upward change in prices may

impact downstream prices. This possibility has been confirmed for refined amorphous sugar prices and will be treated by the second equation shown in this section.

For asymmetric price transmission analysis of shocks occurring in producer prices, here adopting the notation (p_f) impacting retail prices (p_r), an error correction model was estimated according to Equation 1, choosing the optimal number of lags based on the information criteria cited. This model and the results of its estimation are shown in Table 4 and are consistent with the expected, negative and significant error correction terms. Some price estimates with lags have negative values, which would mean that the above (below) equilibrium prices are expected to decrease (increase) (Weldesenbet, 2013). Another point to be highlighted is that the estimates of producer price parameters and the error correction term represent a decrease in absolute values higher than the values of the respective parameters referring to an increase.

Considering the estimates shown in Table 4, the asymmetry tests proposed in the methodology section, using the respective acronyms adopted, are performed and shown in Table 5.

It should be noted that, since the model presents only one producer price lag, both in the case of positive and negative variations, the tests for CUIA and TCIA will be the same. The results shown in Table 5 indicate that the null hypothesis of long-term and short-term price transmission symmetry should be rejected at 5% and 1% of statistical significance, respectively, except for the short-term test of contemporary asymmetry that did not reject the hypothesis of symmetry. Results suggest there is asymmetry in the transmission of refined sugar prices from producer to retail and that this asymmetry is negative, that is, decreases in producer prices reduce retail prices more intensely than increases in producer prices raise prices in retail.

The second equation estimated is associated with the producer price response, due to changes in retail prices, following the same procedure as the previous equation, being estimated based on equation 1, but with the change from p_r to p_f and vice versa, being described in Table 6.

The asymmetry tests performed based on the results shown in Table 6 are shown in Table 7, where in all the four performed tests, we could not reject the hypothesis that there is symmetry in the transmission of prices both short and long terms, i.e. it is not statistically rejected that positive or negative exogenous shocks in the prices of refined sugar at retail impacting producer prices have the same magnitude.

The results for the lags of both positive and negative retail price changes were not statistically significant, but the same retail price changes were statistically significant for the contemporary period, i.e. for period t.

Tab. 4. Error correction model (Δp_r).

Variable	Estimated coefficient	T statistic
Constant	0.016	1.87 *
Δp^+_{ft}	0.3	1.24
Δp^+_{ft-1}	-0.707	-2.93 ***
Δp^-_{ft}	0.741	4.8 ***
Δp^-_{ft-1}	0.225	1.21
Δp^+_{rt-1}	0.33	3.34 ***
Δp^+_{rt-2}	-0.345	-3.68 ***
Δp^-_{rt-1}	0.004	0.03
ETC^+_{t-1}	-0.205	-2.48 **
ETC^l_{t-1}	-0.54	-6.76 ***
R^2	0.637	
DW	1.951	
AIC	-448.775	
BIC	-419.43	
Cointegration regression		
	Estimated coefficient	t-statistic
Constant	-0.021	-0.67
p_f	1.349	55.51 ***

Note: ***1%, **5% and *10% of statistical significance.
Source: author's analysis.

Tab. 5. Asymmetric price transmission from p_r to p_f.

Test acronym	F statistic	p-value
COIA	2.31	0.1307
DLEA (1 lag)	9.95	0.002 ***
CUIA = TCIA	13.87	0.0003 ***
EAPA	6.36	0.0129 **

Note: ***1%, **5% and *10% of statistical significance.
Source: author's analysis.

Tab. 6. Error correction model (Δp_r).

Variable	Estimated coefficient	T statistic
Constant	0.003	0.46
$\Delta p^{+}_{r_t}$	0.664	6.27 ***
$\Delta p^{+}_{r_{t-1}}$	-0.081	-0.82
$\Delta p^{-}_{r_t}$	0.42	3.51 ***
$\Delta p^{-}_{r_{t-1}}$	0.064	0.52
$\Delta p^{+}_{f_{t-1}}$	0.26	1.82 *
$\Delta p^{-}_{f_{t-1}}$	0.316	1.8 *
ETC^{+}_{t-1}	-0.356	-2.96 ***
ETC^{l}_{t-1}	-0.185	-1.51
R^2	0.488	
DW	1.917	
AIC	-462.535	
BIC	-436.06	
Cointegration regression		
	Estimated coefficient	t-statistic
Constante	0.068	3.12 ***
p_{fr}	0.709	55.44 ***

Note: ***1%, **5% and *10% of statistical significance.
Source: Author's analysis.

Tab. 7. Asymmetric price transmission from p_r to p_f.

Test	F statistic	p-value
COIA	1.96	0.1639
DLEA (1 lag)	0.68	0.4125
CUIA = TCIA	0.16	0.6858
EAPA	0.79	0.377

Note: ***1%, **5% and *10% of statistical significance.
Source: Author's analysis.

6. Conclusions

Several studies about agro-industrial price transmission are designed to explain why primary producers' returns are low when consumers pay values that can be considered high. In this paper, we evaluated the dynamics of refined sugar, a staple product in the Brazilian economy, which is relevant in the definition of inflation and returns to cane producers.

Aguiar and Santana (2002) had linked the high inflation rate, evidenced in Brazil before 1994, with their founds of APT for several agricultural products in Sao Paulo - Brazil, pointing out that a high inflation rate could have led the expectations of consumers to accept naturally positive APT.

The results showed that in the refined amorphous sugar market of the state of Sao Paulo, changes in prices are transmitted in both directions, from producers to retail and vice-versa. However, these transmissions occur in different forms with regard to the asymmetry of price transmission. We could not reject the hypothesis that it is symmetrical when retail prices are subject to a shock which is passed on to the producer. The symmetry hypothesis was rejected, however, for shocks starting at the producer and passed on to the retailer. Next, this shock transmission from producer to retail was identified as a negative APT.

These results are important to better understand a relatively complex market such as the refined sugar market in Brazil. In general, a positive asymmetric behavior is expected for less perishable goods when there is market power such as monopolistic market structures. Oligopolistic structures allow for both, positive and negative asymmetric transmission. Therefore, the results are according to the related literature, since there is an increasing firm concentration in the supermarket sector.

The Granger causality results indicated bi-causality of price transmission between producers and retailers. Since the transmission is expected to be, in general, from producers to retail, a possible explanation for the bi-causality can actually be the high concentration of supermarkets, such that the big retailers negotiate and affects the price of producers. In fact, the results show that changes in producer prices have a larger impact on retail prices when these are negative.

Another important aspect is that the negative APT was evidenced in a farm-retail price orientation, and some could argue that this price transmission orientation is not according to the exercise of market power by the supermarkets. However, if we consider that Granger causality, as well the symmetry tests performed are based on time lags only, this does not exclude the possibility of a previous negotiation, where the supermarkets negotiate lower prices with the producers and then reduce shelve prices.

Kim and Ward (2013, p. 234) state that "prices higher in the vertical system respond quicker to rising than falling prices, again, except for the most perishables." However, there might be other situations where even non-perishable products respond more to price decrease than to rising prices. The study results suggest that there might be other situations where even non-perishable products respond more to price decrease than to rising prices. In this paper, the production chain under analysis is vertically integrated, such that the sugar mills produce, harvest and process their own sugarcane to obtain refined sugar. In addition, the same industrialization process leads to the production of other types of sugar, such as crystal sugar and also bioethanol. In this context, the negative asymmetry suggests that increasing market share is more important for the limited number of mills that produce refined sugar and which is a non-differentiated product (refiners can only resort to brands to differentiate their products). Therefore, they will not be willing to pass along cane price increases to the retail, although lower prices can be strategically explored to increase market shares. The result suggests that an increase in input price might be compensated in the markets of other co-products of the sugarcane sector, where the prevailing market conditions are more competitive, such as bioethanol and crystal sugar.

From a consumer perspective, since sugar is a staple food product that affects inflation, the evidence that positive shocks on producer prices will be passed on to consumers less intensely than negative shocks suggests that there is no need to policy intervention in the short-run. In addition, there seems to be reasons to expect that reduction in taxes levied upon sugarcane producers, both direct and indirect, would be passed on to the retail level, benefiting final consumers.

A problem that might evolve through time, however, and to which policymakers should be aware, is regarding the progression of competition for increasing market share at the retail level. As a high concentration is reached by few retailers, a change in price transmission behavior could be expected such that price increases would be explored in a sufficiently concentrated market.

As previously highlighted herein and in the related literature, the methodology used does not enable to identify the reasons that explain what has actually occurred. However, others plausible explanations to be proven by future analyses can include the following: (i) being a product of the Brazilian staple food, refined sugar presents a more inelastic demand than its supply, hence a tax exemption on retail prices may result in a greater drop in prices charged by retailers than those by producers; (ii) the change of habits of Brazilians and campaigns against refined sugar consumption (these explanations, (i) and (ii), are not complementary); (iii) the increase in concentration and competition of retailers over the period of the analysis may have caused a decline in re-

fined sugar prices to the consumer; (iv) as a strategy to increase market concentration, it may have occurred the reverse of the most expected price behavior when there is abuse of market power, in an alternative to that raised in item (i), i.e. if it would be valid that the demand for refined sugar is not so inelastic as assumed in the argument above; (v) another possibility is that it has become more elastic over time, given a likely increase in the supply of competing products, such as ground crystal sugar, which has a lower production cost; (vi) an increase in the consumption of foods with higher added value that use other types of sugars in detriment of foods made at home that use refined amorphous sugar, and even the reduction of its consumption due to campaigns to reduce consumption of this type of sweetener, such as campaigns for type 2 diabetes prevention, such as in (ii). Thus, suggestions for future research would be to verify the evolution of the price elasticity of demand for refined sugar in Brazil and especially in south-central regions, where this type of sugar is most consumed, in order to validate possible explanations for price shock behavior.

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