ASSIMETRIA NA TRANSMISSÃO DE PREÇOS NO MERCADO DE CARNE SUÍNA: EVIDÊNCIAS EMPÍRICAS[1]

Asymmetry in price transmission in the pork meat market: empirical evidence

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Resumo: O objetivo deste artigo foi avaliar a transmissão de preços, em relação à assimetria entre os níveis produtor, atacado e varejo do mercado mais relevante de consumo de carne suína no Brasil, o Estado de São Paulo. Para atingir o objetivo proposto, foi utilizado o Modelo de Correção de Erro Assimétrico (ECM). A importância desse assunto deve-se à relevância do mercado doméstico de carne suína, dado o aumento da produção e a subsequente geração de emprego e renda e ainda ao caráter inovativo da aplicação dessa metodologia para o mercado de carne suína paulista. Os resultados mostram que a transmissão de preços de carne suína nesse mercado ocorre de maneira simétrica, indicando eficiência do mercado em relação à transmissão de preços.

Palavras-Chave: Modelo ECM; Estado de São Paulo; Brasil.

Abstract: the aim of this article was to evaluate the transmission of prices, in relation to asymmetry, between producer, wholesale and retail levels in the most relevant pork consumption market in Brazil, the State of São Paulo. To achieve the proposed objective, the Asymmetric Error Correction Model (ECM) was used. The importance of this subject is due to the relevance of the domestic pork market, given the increase in production and the subsequent generation of employment and income, as well as the innovative nature of the application of this methodology to the pork market in São Paulo. The results show that the transmission of pork prices in this market occurs symmetrically, indicating market efficiency in relation to price transmission.

Keywords: ECM Model; State of São Paulo; Brazil.

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1 INTRODUCTION

The main agents engaged in the production and sale of pork meat in the state of São Paulo, the largest Brazilian consumer market, are the producers, wholesalers and retailers. A peculiarity of pig farmers in the state of São Paulo is that they work independently, i.e., they are not necessarily associated with any given slaughterhouse or agroindustry (different than in the west of the state of Santa Catarina where, for example, the vertical integration system predominates), and have also specialized in the production of refrigerated meat for the local market or the preparation of canned goods. On the other hand, the main focus of slaughterhouses and processing plants is the sale of refrigerated meat on the state market. In this segment there is also the presence of certain traditional canned good manufacturers which are not nationally known. These agents prefer to operate only on the state market given the greater flexibility of the state inspection system in comparison to the federal system. In the retail sector, pork meat is sold at street markets, butcher shops, restaurants, bakeries, and supermarkets (BUENO, 2016).

The characteristics of the agents operating in the pork meat market in the state of São Paulo point to the hypothesis of the existence of an asymmetric price transmission (APT) up and down the entire chain, due to the fact that producers appear to be more susceptible to price variations on the market since they work independently, with no formal contracts with slaughterhouses and processors. Another relevant factor is having less access to information than the other agents operating in the system (fragmented market with small producers), which may lead to opportunistic behavior. On the other hand, wholesalers and retailers have more access to information and are able to anticipate price shocks more rapidly. In addition, pork meat is sold on a retail market comprised of supermarket chains that work via contracts, and since they are less affected by risk, are more concentrated, and thus capable of exerting market power (CASTRO, 2017).

This being said, this paper aims to evaluate price transmission asymmetry on the production, wholesale and retail levels in the pork market in the state of São Paulo. To attain the proposed objective, we used the Asymmetric Error Correction Model (ECM) proposed by Von Cramon-Taubadel (1998). This methodology has yet to be extensively used by Brazilian researchers, and the Houck approach, or one of its variants, is still the most used in the country (AGUIAR, 2011).

The importance of the pork meat market on a national level is reflected by the 55.8% increase in production between 2000 and 2019, reaching 3,983 thousand tons in 2019. Regarding *per capita* consumption, there has been timid growth over the years. Exports totaled 750 thousand tons in 2019, ranking the country fourth on the world market according to the Brazilian Animal Protein Association (ABPA, 2020).

In addition to the economic importance of the sector for the economy, this study may support the creation of public policies for the market, as the agents most susceptible to price variations, which are producers and consumers, may have part of their surplus captured by other agents, which would be evidence of inefficiency in the market.

In addition to this brief introduction, the paper is divided into four more sections. In the second, we describe the theoretical scope of asymmetry in price transmission (APT); in the third, we present the methodology used to attain the objective proposed by the paper, and the ECM used as an alternative to the Houck (1977) model to the test for the presence of asymmetry; in the fourth section, the results are presented and discussed; and lastly, our concluding remarks are made regarding the study.

2 ASYMMETRY IN PRICE TRANSMISSION

According to Peltzman (2000), the study of asymmetry in the transmission of prices is important because it allows the detection of potential flaws in Economic Theory, since for this author,

the continuous recurrence of asymmetric price adjustments in the economy is more a rule than an exception. Meyer and Von Cramon-Taubadel (2004) argue that studying APT is relevant in terms of well-being and thus has policy implications. One may not be benefited by decreases (buyers) or increases (sellers) in price. Since this means that well-being would be allocated differently than in situations of symmetry, APT is therefore generally considered a flaw in the market.

Also, according to Meyer and Von Cramon-Taubadel (2004) asymmetry in a price transmission context may be classified according to three criteria. The first regards asymmetry related to the velocity or magnitude of the transmission of prices. Velocity concerns the time it takes for an adjustment in prices to take place. Magnitude is the amount of a shock that is transferred from one market to another. The second criterion is classifying APT as either positive or negative. Asymmetry is called positive when the price on a certain market level reacts more completely or rapidly to a decrease as opposed to an increase. The third criterion used to classify APT regards the vertical or spatial effect. APT is considered vertical when it refers to prices of the same good on different market levels (producers, wholesalers or retailers). It is spatial when it refers to prices of a good on a same level of market but at different locations.

Meyer and Von Cramon-Taubadel (2004) highlight two arguments regarding the causes vertical APT predominates in the literature: non-competitive markets and price adjustments. Market power has been frequently cited as the cause of APT, particularly in agricultural and livestock markets, given the frequent evidence of imperfect competition in the intermediate processes of the chain. It is generally expected that positive APT be detected for agricultural and livestock markets, since reductions in margins leading to input price increases are transmitted more rapidly or in greater intensity than changes that increase margins.

With regard to adjustments in costs, which increase when firms alter the quantity and/or price of inputs and/or products. If these costs were asymmetric in relation to increases or decreases in quantities or prices, then this would lead to asymmetry in the transmission of prices. Migliardo (2010) studied asymmetry in price-setting behavior in Italian companies, and the results showed that the setting of prices in the industrial sector is less rigid than in the services sector, given the lack of restrictions, such as menu costs, and price variation agility.

The differences between the two possible causes for APT highlighted by the authors is that both may produce asymmetry in the velocity of the transmission of prices, but only market power can lead to long-term asymmetries in the magnitude of the adjustment. Another difference is the actual extension of the adjustment in cost, since any asymmetry caused by it would not lead to effects of well-being that would justify governmental intervention (MEYER; VON CRAMON--TAUBADEL, 2004).

In addition to the causes listed by Meyer and Von Cramon–Taubadel (2004), Aguiar (2011) also selected certain common reasons for APT based on studies conducted on the theme. The first regards product characteristics: agents that market perishable products may hesitate to increase prices of products wary of the lower sales and greater waste, a situation also discussed by Ward (1982). Another reason listed concerns transitory variation in prices. In this case, the author cites the example of situations of chronic inflation, where agents are led to believe that a reduction in the price of a raw material may be transitory, and that a drop in price would not be transmitted in the same way as an increase in price.

Two other justifications are also mentioned as causes of APT: government intervention and the degree of organization of consumers. In the first case, agents may not believe that reduction in prices for producers are temporary as a result of government intervention, while increases would probably be permanent. In the case of fixed-price tables the opposite would happen, agents would not be able to increase prices, only reduce them. When consumers are highly organized, they may make if difficult for retailers to transmit price increases due to their greater demand capacity, thus leading to APT (AGUIAR, 2011).

In a spatial context, the transmission of prices may be considered asymmetric for four reasons, as highlighted by Bailey and Brorsen (1989). The first is the asymmetric adjustment of costs; the second market power; third, asymmetric information, and lastly, distorted price communication. In the spatial context, the adjustment costs may include the transportation costs of a certain good, either naturally or infrastructural asymmetric, spatial APT may increase if transportation costs vary according to the direction of the trade.

Market power in a spatial context may be seen in the case of a firm that has local market power; in the absence of competitors within a certain radius, the firm may use this to pass on margin reductions more rapidly than increases. In relation to asymmetric information, it may be seen that prices on the central market tend to respond less to changes on the individual periphery markets than the contrary (MEYER; VON CRAMON-TAUBADEL, 2004).

Recent literature showcases applied research on APT, including Silva Neto and Parré (2012), Aguiar and Figueiredo (2012), Alves et al. (2013), Cunha and Wander (2014); Santos *et al.* (2015) and Souza *et al.* (2016). The progress made in recent years has regarded the method, particularly in econometrics, highlighting the work of Greb *et al.* (2013) who studied the fragilities of Threshold models used to analyse the transmission of prices, and proposed an alternative: a Bayesian estimator.

3 METHOD

3.1 The Asymmetric Error Correction Model (ECM)

The asymmetric error correction model resulted from the fact that previous models, such as Houck (1977), Wollfram (1971), and its variants, were not consistent enough to deal with cointegrated price series. The main problem with the specifications derived from the Houck approach is that they are based on a simple Vector Autoregressive Model. This is not an appropriate specification for cointegrated variables, for they do not take advantage of the information reflected on their levels. In addition, many of the applications of the Houck approach are characterized by the presence of first-order autocorrelation, which is frequently a symptom of spurious regression in analyses of non-stationary time series (VON CRAMON-TAUBADEL, 1998).

According to the ECM approach, if P_i and P_j ($P_i = P_j = P_P, P_W, P_R$) are cointegrated by way of the Engle–Granger representation theorem, it is possible to propose an alternative formulation to the analyse the transmission process:

$$\Delta P_{it} = a_0 + a_1 \Delta P_{jt} + a_2 ECT_{t-1} + a_3(L)\Delta P_{it-1} + a_4(L)\Delta P_{jt-1} + E_t \qquad (1)$$

Where $ECT_t = P_{it} - \beta_0 - \beta_I P_{jt}$ (deviations in relation to the cointegration between P_i e P_j) e $a_3(L)$ e $a_4(L)$ are polynomial lags related to series P_i amd P_j. E ΔP_{it} is the first difference of P_i for t = 1, 2 ... n.

The previous equation may be modified to include a segmentation of the ECT error correction term into positive and negative components:

$$\Delta P_{it} = a_0 + a_1 \Delta P_{jt} + a_2^{+} ECT_{t-1}^{+} + a_2^{-} ECT_{t-1}^{-} + a_3(L)\Delta P_{it-1} + a_4(L)\Delta P_{jt-1} + E_t \qquad (2)$$

where $ECT_{t-1}^{+} = ECT_{t-1}$ if $ECT_{t-1} > 0$ and equal to 0 otherwise and,

$ECT_{t-1}^{-} = ECT_{t-1}$ if $ECT_{t-1} < 0$ and equal to 0 otherwise.

According to Meyer and Von Cramon-Taubadel (2004) an F test in this case may be used to verify whether the coefficients $a_2^+ = a_2^-$, which would indicate symmetry between the transmission of P_i and P_j. The error correction term measures the deviations from the long term equilibrium between P_i e P_j, and therefore its inclusion in the model allows P_i not only to respond to changes in P_i, but also to correct any deviation from the long term equilibrium that may have been left from previous periods. A new specification may be considered so as to include the error correction term in a segmented manner, along with an exogenous change in price:

$$\Delta P_{it} = a_0 + a_1^+ \Delta P_{jt}^+ + a_1^- \Delta P_{jt}^- + a_2^+ ECT_{t-1}^+ + a_2^- ECT_{t-1}^- + a_3(L)\Delta P_{it-1} + a_4(L)\Delta P_{jt-1} + E_t \quad (3)$$

The variables ΔP_{jt}^+ and ΔP_{jt}^- are those defined by the Houck (1977) model, where the variable ΔP_{jt}^+ is the difference between $P_{jt} - P_{jt-1}$ for $P_{jt} > P_{jt-1}$ and zero otherwise. And the variable ΔP_{jt}^- is defined as the difference between $P_{jt} - P_{jt-1}$ if $P_{jt} < P_{jt-1}$ and zero otherwise The asymmetry test is thus: H_0: $a_1^+ = a_1^-$ and $a_2^+ = a_2^-$. Both hypothesis may be tested.

According to Meyer and Von Cramon-Taubadel (2004) the short and long term effects for the effects of increases and decreases in P_j on P_i may also be seen in the ECM model:

$$\Delta P_{it} = a_0 + \sum_{l=1}^{M1} a_1 \Delta P_{i\,t-l} + a_2^+ \Delta P_{jt-l}^+ + \sum_{l=1}^{M2} a_3^+ \Delta P_{jt-l}^+ + a_4^- \Delta P_{jt-l}^- + \sum_{l=0}^{M3} a_5^- \Delta P_{jt-l}^- + a_6^+ ECT_{t-1}^+ + a_7^- ECT_{t-1}^- + E_t \quad (4)$$

The asymmetric error correction model adopts to the Houck (1977) model when the number of lags is the same. Thus, if any of the coefficients a_6^+, a_7^-, a_1 were statistically different than zero, the asymmetric error correction model is superior to the Houck model. Cunha and Wander (2014) identified that the ECM approach is more robust than the Houck approach in relation to the transmission of prices in bean market in the state of São Paulo. In addition, Capps-Jr and Sherwell (2007) showed that both the Houck and the ECM approaches were statistically indistinguishable when studying the transmission of prices of milk in the United States. The results indicated asymmetry in the transmission of prices from the producer to the retailer for both the Houck approach and the ECM model.

Von Cramon-Taubadel (1998) applied the error correction model to the German pork meat market. Using prices on the producer and wholesale levels, the author found that the negative portion of the error correction term induces a greater change in the wholesale price than the positive portion. Thus, indicates that the wholesale price is too low in relation to the producer price, i.e., that the margin is lower than the long-term equilibrium value, suggesting that the wholesale prices react more rapidly when the margin is lower than when it is higher. And represents the correction of the margin when it is increased. In this case, Von Cramon-Taubadel (1998) found that is statistically equal to zero, that there was no correction when the margins increased, and thus the prices could not be cointegrated.

3.2 Data

The price series used refer to the average monthly prices of pork for slaughter, received by producers when selling to the first buyer on the commercial chain. Also used was the price of pork half carcasses on the wholesale market. Here, processing, industrializing, preparation, conditioning, and transportation costs, as well as commissions and taxes are included, up until their purchase by other companies. Lastly, the average monthly price of pork meat on the retail market was used, collected at supermarkets, street markets, butcher shops and bakeries. The data were obtained from the São Paulo Agricultural Economics Institute (IEA) database and deflated based

in the General Price Index – Domestic Availability (IGP-DI) calculated by the FGV, based on September of 2020. The producer, wholesaler and retailer prices refer to the processes in the state of São Paulo, the metropolitan region of São Paulo, and the city of São Paulo, respectively, and cover the period between January of 2000 and September of 2020, totaling 249 observations. Descriptive statistics associated with these respective price series are exhibited in Table 1.

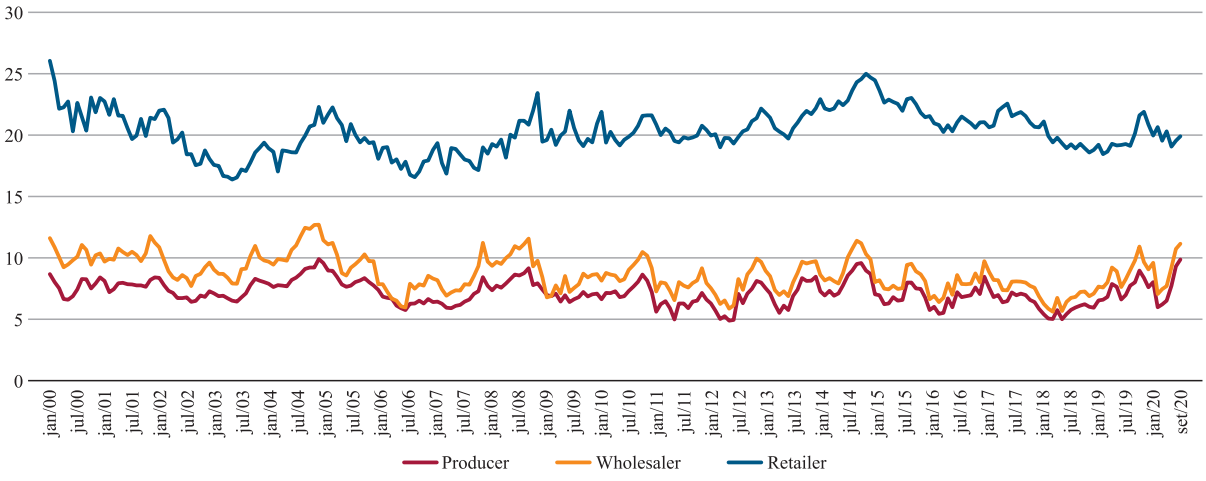
Table 1 – Descriptive Statistics of producer, wholesaler and retailer prices

Series	Mean	Median	Standard deviation	Minimum	Maximum
Producer	7.1724	7.0824	1.0150	4.8878	9.9039
Wholesaler	8.7311	8.5939	1.4617	5.6066	12.690
Retailer	20.289	20.195	1.7655	16.374	26.044

Source: Prepared by the authors with study data.

Figure 1 shows the behavior of the price series received by the swine producer in the state of São Paulo, as well as the prices practiced in the wholesale and retail market between the years 2000 and 2020. Producer prices are the lowest, followed by wholesale prices and retail prices. There is also a large distance in the graph between wholesale and retail prices, suggesting higher sales margins in this last market level.

Figura 1 – Evolução dos preços reais de suínos (R$) no âmbito do produtor, atacado e varejo no estado de São Paulo de 2000 a 2020



Source: Prepared by the authors with study data.

The Regression Analysis of Time Series – RATS version 9.0 software package was used for the econometric procedures and tests.

4 RESULTS

Table 2 shows the result of the Kwiatkowski, Phillips, Schmidt and Shin (KPSS) test for the unit root. The null hypothesis of the KPSS (1992) test allows a series to be stationary. Thus, at a 5% significance level, the null hypothesis must be rejected for producer, wholesaler and retailer price series in level, and first difference series must be used, which are not stationary. This condition is also consistent with the criterion of the cointegration test, which requires the series to be differentiated on the first order.

Table 2 – Unit root test

KPSS Test						
Series	**Producer**	**Wholesaler**	**Retailer**	**1%**	**5%**	**10%**
Level	0.40902	0.86184	0.43271	0.739000	0.463000	0.348000
First Difference	0.05888	0.05270	0.06886	0.739000	0.463000	0.348000

Source: Prepared by the authors with study data.

In order to verify whether the transmission of prices takes place in a symmetric or asymmetric manner along the three levels of the pork meat market chain in the state of São Paulo, equation 4 was estimated and is presented in section 3.1 in three manners. The first two verify the presence of asymmetry in relation to variables constructed by increases and decreases in prices received by producers in relation to wholesale and retail prices. The third model relates increases and decreases in wholesale prices in relation to retail prices.

The aim of estimating the ECM consists in verifying whether the transmission of prices between each level of market takes place in an asymmetric manner or not. The hypothesis test is performed on the coefficients of the variables constructed from increases and decreases both in prices and the error correction term (ECT). The null hypothesis suggests that the coefficients of increases are equal to the coefficients of decreases, i.e., symmetry. Rejection of the null hypothesis suggests asymmetry in the transmission of prices. The hypotheses may be verified by an F test performed on the restrictions of the estimated coefficients, as suggested by Meyer and Von Cramon-Taubadel (2004).

The idea behind the rise of the ECM lies in finding a better model than the Houck (1977) approach, above all in relation to the autocorrelation problem and the lack of consistency with cointegrated variables. Analysing Tables 3, 4 and 5, it may be perceived that in the three cases, the increase and/or decrease variables of the error correction term are significant, meaning that the ECM is superior to the Houck (1977) approach. In relation to the auto-correlation problem commonly highlighted in the Houck approach, the LM test indicated the absence of autocorrelation for the last two cases estimated with the ECM at a 5% level of significance.

The residuals of the three models are not normally distributed. This deficiency was also detected by Von Cramon-Taubadel (1998) where the set of residuals were fat-tailed for both the symmetric and asymmetric versions of the ECM. However, this characteristic was lower in the asymmetric version. Non-normality implies that results of subsequent tests should be interpreted with caution.

In order to verify the null hypotheses for asymmetry, the F test was used to test the restrictions on the coefficients of the regression, as indicated by Von Cramon-Taubadel (1998) and Meyer, and Von Cramon-Taubadel (2004). The results for the first case (Table 3) indicated that the null hypothesis for symmetry could not be rejected, with the F statistic equal to 0.48, and P-value equal to 0.6197. In other words, the transmission of prices for the producer level to the wholesale level takes place in a symmetric manner in the São Paulo pork meat market. In the second case (Table 4) the results showed that the null hypothesis of symmetry could not be rejected at a 5% of significance, with the F statistic equal to 2.32 and the P-value equal to 0.0999. Thus, the transmission of prices from the producer level to the retail level is symmetric. And, in the third case (transmission from wholesale to retail) illustrated in Table 5 symmetry is also suggested, with a P-value equal to 0.6484, and F statistic equal to 0.43.

For the upstream models, which deal with the transmission of prices from wholesale to producer (Table 6) and from retail to producer (Table 7), the F test results showed that the transmission of prices in these cases is also symmetric. Thus, the pork market in São Paulo is considered efficient at three market levels: producer, wholesale and retail. There is no significant distinction in the way in which increases or decreases are transferred to different market levels.

Table 3 – Result of the ECM for the transmission of prices from Producer (P_P) to Wholesaler (P_W)

Variables	Dependent variable: ΔP_W			
	Coefficient	Std.-Error	T Statistic	P-value
Constant	-0.0021	0.0053	-0.3978	0.6911
ΔP_{Wt-1}	-0.1428	0.0636	-2.2440	0.0258
ΔP_{Pt}^{+}	0.1509	0.0079	19.1800	0.0000
ΔP_{Pt-1}^{+}	0.0021	0.0123	0.1709	0.8645
ΔP_{Pt}^{-}	0.1459	0.0081	18.0100	0.0000
ΔP_{Pt-1}^{-}	0.0140	0.0119	1.1770	0.2403
ECT_{t-1}^{+}	-0.1316	0.0756	-1.7410	0.0829
ECT_{t-1}^{-}	-0.2448	0.0778	-3.145	0.0019
R^2	0.8300		Adjusted R^2	0.8251
F statistic[a]	0.4795		p-value	0.6197
LM test for autocorrelation	2.0062		p-value	0.0247
Normality test of residuals	123.7240		p-value	0.0000

[a]Constraint set: $\Delta P_{Pt}^{+} - \Delta P_{Pt}^{-} = 0$ and $ECT_{t-1}^{+} - ECT_{t-1}^{-} = 0$

Source: Prepared by the authors with study data.

Table 4 – Result of the ECM for the transmission of prices from Producer (P_P) to Retailer (P_R).

Variables	Dependent variable: ΔP_R			
	Coefficient	Std.-Error	T Statistic	P-value
Constant	-0.0066	0.0061	-1.0930	0.2756
ΔP_{Rt-1}	-0.2315	0.0602	-3.8480	0.0002
ΔP_{Pt}^{+}	0.0221	0.0079	2.7630	0.0062
ΔP_{Pt-1}^{+}	0.0194	0.0081	2.3930	0.0175
ΔP_{Pt}^{-}	-0.0032	0.0084	-0.3862	0.6997
ΔP_{Pt-1}^{-}	0.0022	0.0085	0.2603	0.7948
ECT_{t-1}^{+}	-0.2000	0.0679	-2.9460	0.0035
ECT_{t-1}^{-}	-0.0895	0.0588	-1.5210	0.1295
R^2	0.1997		Adjusted R^2	0.1762
F statistic[a]	2.3251		p-value	0.0999
LM test for autocorrelation	1.2344		p-value	0.2604
Normality test of residuals	7.1422		p-value	0.0281

[a]Constraint set: $\Delta P_{Pt}^{+} - \Delta P_{Pt}^{-} = 0$ and $ECT_{t-1}^{+} - ECT_{t-1}^{-} = 0$

Source: Prepared by the authors with study data.

Table 5 – Result of the ECM for the transmission of prices from Wholesaler (P_W) to Retailer (P_R).

Variables	Dependent variable: ΔP_R			
	Coefficient	Std.-Error	T Statistic	P-value
Constante	-0.0022	0.0061	-0.3633	0.7167
ΔP_{Rt-1}	-0.2440	0.0602	-4.0550	0.0000
ΔP_{Wt}^{+}	0.0075	0.0061	1.2300	0.2200
ΔP_{Wt-1}^{+}	0.0181	0.0062	2.9450	0.0036
ΔP_{Wt}^{-}	0.0078	0.0060	1.2910	0,1981
ΔP_{Wt-1}^{-}	0.0034	0.0061	0.5684	0.5703
ECT_{t-1}^{+}	-0.1591	0.0642	-2.4770	0.0140
ECT_{t-1}^{-}	-0.0635	0.0565	-1.1240	0.2621
R^2	0.1931		Adjusted R^2	0.1695
F statistic[a]	0.4341		p-value	0.6484
LM test for autocorrelation	1.5161		p-value	0.1193
Normality test of residuals	9.1577		p-value	0.0103

[a]Constraint set: $\Delta P_{Wt}^{+} - \Delta P_{Wt}^{-} = 0$ and $ECT_{t-1}^{+} - ECT_{t-1}^{-} = 0$

Source: Prepared by the authors with study data.

Table 6 – Result of the ECM for the transmission of prices from Wholesaler (P_W) to Producer (P_P).

Variables	Dependent variable: ΔP_P			
	Coefficient	Std.-Error	T Statistic	P-value
Constante	−0.0041	0.0051	−0.8034	0.4225
ΔP_{Pt-1}	−0.1063	0.0639	−1.6620	0.0978
ΔP_{Wt}^{+}	0.0993	0.0057	17.5100	9.85e-045
ΔP_{Wt-1}^{+}	0.0180	0.0086	2.0930	0.0374
ΔP_{Wt}^{-}	0.0860	0.0055	15.5500	3.89e-038
ΔP_{Wt-1}^{-}	0.0145	0.0081	1.7970	0.0737
ECT_{t-1}^{+}	0.1734	0.0719	2.4120	0.0166
ECT_{t-1}^{-}	0.1779	0.0733	2.4260	0.0160
R^2	0.8103		Adjusted R^2	0.8047
F statistic[a]	0.9998		p-value	0.3695
LM test for autocorrelation	2.2741		p-value	0.0096
Normality test of residuals	24.8375		p-value	4.04217e-006

[a]Constraint set: $\Delta P_{Wt}^{+} - \Delta P_{Wt}^{-} = 0$ and $ECT_{t-1}^{+} - ECT_{t-1}^{-} = 0$

Source: Prepared by the authors with study data.

Table 7 – Result of the ECM for the transmission of prices from Retailer (P_R) to Producer (P_P).

Variables	Dependent variable: ΔP_P			
	Coefficient	Std.-Error	T Statistic	P-value
Constante	−0.0020	0.0118	−0.1693	0.8657
ΔP_{Pt-1}	−0.0919	0.0674	−1.3630	0.1742
ΔP_{Rt}^{+}	0.0241	0.0119	2.0250	0.0440
ΔP_{Rt-1}^{+}	0.0146	0.0120	1.2190	0.2239
ΔP_{Rt}^{-}	0.0056	0.0109	0.5161	0.6062
ΔP_{Rt-1}^{-}	0.0130	0.0104	1.2510	0.2121
ECT_{t-1}^{+}	−0.1217	0.1439	−0.8458	0.3985
ECT_{t-1}^{-}	−0.0277	0.1201	−0.2311	0.8175
R^2	0.0438		Adjusted R^2	0.0158
F statistic[a]	0.5536		p-value	0.5756
LM test for autocorrelation	3.2803		p-value	0.0002
Normality test of residuals	38.1476		p-value	5.20415e-009

[a]Constraint set: $\Delta P_{Rt}^{+} - \Delta P_{Rt}^{-} = 0$ and $ECT_{t-1}^{+} - ECT_{t-1}^{-} = 0$

Source: Prepared by the authors with study data.

The analysis of the asymmetric transmission of prices with the use of the ECM show that the transmission of prices from the producer to the wholesaler takes place in a symmetric manner, i.e., the increases and decreases in prices for producers are transmitted in the same manner by wholesalers. This evidence may be explained by the low margins verified on this level of the market, given the small differences in prices between the two levels.

Similar results may be observed for transmission from wholesalers to retailers. The increases and decreases verified in prices on the wholesale level are passed on in the same manner by the retailers. Even with higher sales margins, retailers asymmetrically transmit changes in prices to the wholesale level, given the proximity between agents in the system, with information being exchanged more rapidly, facilitating the transmission process.

In relation to the transmission of prices from the producer level to the retail level, the results show evidence of symmetry, meaning that increases and decreases in prices received by producer are transmitted of symmetric manner by retailers. This result is pertinent with some empirical studies, as exemplified by Usman and Haile (2017) who found no convincing asymmetry in major grain producing markets of Ethiopia; Yami *et al.* (2020) who found absence of positive asymmetric price transmission in wholesale white maize markets in Ethiopia and, Pozo *et al.* (2020) who found similar results when analysing the price transmissions among farm, wholesale and retail U.S. beef markets. The results by Pozo *et al.* (2020) show that in general, farm, wholesale, and retail beef prices respond symmetrically to price changes at each market level. This reveals an efficient market where price signals transmit vertically in a symmetric fashion up and down the beef value chain.

This result of symmetry in the transmission of prices between producers and retailers is somewhat intriguing and perhaps a peculiarity of the São Paulo market, where the sales structure between these agents seems to be moving towards something more competitive. Producers are small and act independently; the slaughterhouses are specialized in the production of chilled meat for the state market (the perishability requires quick sale). And chilled meat is best sold at fairs, butchers and local markets, precisely the peculiarity of the São Paulo market. In large supermarkets and hypermarkets the preference (on the supply side) is processed meat.

Table 8 presents the short-term and long-term price transmission elasticities for rising and falling prices in the pork market. As in Capps-Jr and Sherwell (2007), the short-run elasticity of price transmission was calculated as the average of all observations corresponding to $a_{sr} * P_{it}/P_{jt}$ conditional on $\Delta P_{it} > 0$. Likewise, the short-run negative elasticity of price transmission was calculated as the average of all observations corresponding to $a_{sr} * P_{it}/P_{jt}$ conditional on $\Delta P_{it} < 0$. On the other hand, the long-run elasticities of price transmission were derived by replacing a_{sr} by $\sum_{i=0}^{M_1} a_i$ and $\sum_{i=0}^{M_2} a_i$ by and .

Table 8 – Elasticities of Price Transmission.

	Producer to Wholesaler	Producer to Retailer	Wholesaler to Retailer	Wholesaler to Producer	Retailer to Producer
EPT_POS_SR[a]	0.1247	0.0078	0.0032	0.1206	0.0693
EPT_POS_LR[b]	0.0017	0.0069	0.0078	0.0219	0.0419
EPT_NEG_SR[c]	0.1205	-0.0011	0.0034	0.1045	0.0161
EPT_NEG_LR[d]	0.0116	0.0008	0.0015	0.0176	0.0374

[a]EPT_POS_SR short-run elasticity of price transmission for rising prices in the pork meat market
[b]EPT_NEG_SR short-run elasticity of price transmission for falling prices in the pork meat market
[c]EPT_POS_LR long-run elasticity of price transmission for rising prices in the pork meat market
[d]EPT_NEG_LR long-run elasticity of price transmission for falling prices in the pork meat market

The estimated price transmission elasticities are all inelastic and are higher in the short run for both increases and decreases in prices. the greatest elasticity found is the transmission of prices from producer to wholesale in the short run in relation to price increases (0.1247). The agent with the greatest price transmission elasticity to the producer in the short run is the wholesaler, but in the long run it is the retailer. This means that in the short term the prices received by the producer are more affected by price variations at the wholesale level, but in the long term this role passes to the retail.

5 CONCLUDING REMARKS

The aim of this study was to evaluate the transmission of prices, in relation to asymmetry, on the production, wholesale and retail levels of the pork meat market in the state of São Paulo. Toward this end, the Asymmetric Error Correction Model (ECM) proposed by Von Cramon-Taubadel (1998) was used to verify the hypothesis of asymmetry between the three market levels.

The results show that the transmission of pork meat prices in the state of São Paulo takes place in an symmetric manner, indicating that pork meat prices generally respond similarly to downstream market price increases and decreases, and consumer pork meat prices respond similarly symmetric to upstream price changes.

Thus, the transmission of prices in pork meat market in São Paulo is efficient. This indicates that price signals transmit vertically in a symmetric fashion up and down the pork meat value chain.

Among the political implications are a structural change in the São Paulo pork market, given the strong growth observed in the large groups of meatpackers that have a different dynamic from that observed in São Paulo. With greater concentration, smaller refrigerators will face survival difficulties and still, will generate high unemployment in the segment.

For future research, it is suggested that studies be made to determine whether the behavior detected in the state of São Paulo is also present in the other metropolitan regions, particularly those in the Southern states of the country, for having a production process different than that of São Paulo. Other markets, such as fruit, vegetables and produce should also be studied given the lack of empirical applications in these segments.

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