

APPLICATION OF TIME SERIES TECHNIQUES IN RELEVANT MARKET DELIMITATION – THE BRAZILIAN EXPERIENCE

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ABSTRACT *This work aims to make an overview of the main time-series techniques used in the relevant market definition and make a qualitative analysis of the votes and technical notes of important cases involving the discussion of time series by the Brazilian Antitrust Authority (CADE). Time-series techniques can be useful in relevant market definition since only prices are required for the analysis, allowing relatively rapid estimates. Despite their importance and relevance, there is a clear need for a careful assessment so these techniques can deliver robust and credible results. CADE's recent decisions indicate that time series techniques hardly replace the hypothetical monopolist test and simulation methodologies.*

SUMMARY 1. Introduction. 2. Time Series Data and Techniques. 2.1 Stationary time series techniques. 2.2 Technics with non-stationary series. 3. Time series models and market definition debates in Brazil. 3.1 Braskem-Quattor. 3.2 Braskem-Solvay. 3.3 Videolar and Innova. 4. Final Remarks

KEY-WORDS & JEL CLASSIFICATION CODES time series techniques; relevant market definition; CADE; Brazil. K21; L40; C22

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1. INTRODUCTION

A key question for merger analysis, recommended by the reviewed Horizontal Merger Guidelines¹ of the Brazilian Competition Authority (CADE) and other jurisdictions, is the relevant market delimitation. It is the unit of analysis to assess the consequences of anti-competitive practices. In other words, it defines the frontier of competition between firms in both geographic and product aspects. Its incorrect delimitation can compromise the estimates of the consequences of a merger/acquisition. For example, a very narrow definition would likely result in overestimated market shares. On the other hand, a very broad definition includes local products that should not be considered in the relevant market, underestimating market shares and possible merger effects.

Distinct methodologies are used to delineate relevant markets. For example, the Department of Economic Studies (DEE) of CADE emphasizes the importance of the Hypothetical Monopolist Test (TMH). In TMH, the relevant market is defined as the smallest group of products and the smallest geographic area necessary for an alleged monopolist to impose a small but significant and non-transitory price increase. Besides TMH, DEE also highlights other methods, including the diversion ratio (consider the degree of substitution or competition between two or more products), the shipment test (considering the significant volume of trade), event studies, and qualitative research².

The application of time series techniques can be useful in this process, provided they are well applied. The main advantage of these techniques is that only price series are necessary, allowing for relatively quick and useful estimations. This work aims to look at the main time series techniques and make a qualitative analysis of three recent cases involving its application in Brazil. Despite its importance, it is clear the necessity for a careful evaluation of the assumptions used in the models.

The work is divided as follows: the second section resumes the main characteristics of the time series in the context of econometrics; the third section presents the main time series techniques used in the antitrust analysis in

1 CADE's new Horizontal Mergers Guidelines was published in July 2016. Despite its recognition for the relevant market analysis, it also highlights the importance of simulations and counterfactuals, for instance, which may assess the impacts of a merger without necessarily having to stress a specific market.

2 Some concrete cases of mergers in Brazil and its respective methodologies are described in "Delimitação de Mercado Relevante – Versão pública" (in Portuguese). Available at http://www.Cade.gov.br/acesso-a-informacao/publicacoes-institucionais/dee-publicacoes-anexos/delimitacao_de_mercado_relevante.pdf.

Brazil; the fourth section presents three cases of concentration judged by CADE in which time series techniques played a central role; the fifth section contains final comments and briefly discusses the main limitations concerning these techniques.

2. TIME SERIES DATA AND TECHNIQUES

Wooldridge (2002) assumes that econometrics is based on developing statistical methods for estimating economic relations, testing theories, and valuing public and private sector policies. Thus, econometrics is a broad definition covering several methodologies that have been developed over time. However, it is possible to distinguish three groups based on data characteristics in the econometric models: cross-section, time series, and panel data. An econometric model in cross-section occurs when all the variables related to the units of analysis are the same period, such as National Surveys of Household Sample, and each unit of analysis constitutes one observation. On the other hand, time series are data where the unit of analysis is monitored over time, so the number of observations is equal to the time in the sample, such as the evolution of the nominal interest in the last ten years. Finally, a panel is a junction of both: several units of analysis are tracked for a period. In this way, the observations vary according to time and the unit of analysis.

Each of the groups has its characteristics. For example, time-series models study the dynamics or temporal structure of data through models capable of interpreting, predicting, and testing data-related hypotheses. According to Enders (2009), time series analysis focuses on the relationship between a variable of interest and its lagged values, other explanatory variables, and random components.

Some concepts are fundamental for the analysis of time series. First, observations result from stochastic processes; each value obtained in time embodies a random process. Hence comes the term “stationary.” Stationary time series are realizations of stationary stochastic processes in which the probabilistic characteristics are not changed over time. Time series must be stationary, so their estimates and forecasts are possible.

Bueno (2008) describes two forms of stationarity. First, a time series is strictly stationary if its joint distribution function over time is invariant. Strict stationarity is a difficult concept to check in practice because it is very restrictive. For this reason, the most usual is to work with the definition of weak stationarity. Second, a time series is weakly stationary if its mean, variance,

and covariance are constant in time. The verification of the stationarity condition is usually done through unit root tests. In general, these tests aim to understand if a series behaves like a random walk. Several tests were proposed in the literature, including Dickey-Fuller, augmented Dickey-Fuller, Phillips-Perron, and KPSS.

Stationarity is a fundamental condition for the analysis of univariate and multivariate series. A univariate model is based on a single data series, and forecasts are modeled as a function of random shocks – moving averages (MA) – and lagged autoregressive (AR) values. However, univariate models are not used to delineate relevant markets precisely because the idea is to verify the degree of integration among different products and locations, resulting in more than one dataset. In mergers analysis, we usually work with multivariate models, which consist of analyzing two or more series and concluding whether they belong to the same relevant market. The following are the main methods applied in this type of analysis. First, we separate the appropriate techniques for when series are stationary or non-stationary.

2.1. Stationary time series techniques

a. Simple and partial correlation

Correlation is a widespread concept in statistics is discussed in different jurisdictions on their role in delineating relevant markets. The simple correlation between two variables, x , and y , expresses how they move together, both in direction and strength. The correlation coefficient, belonging to the interval $[-1,1]$, indicates a perfect negative relation at the lower end and a perfect positive association at the upper end. Intuitively, a relevant market (geographic or product) tends to present a high correlation between prices due to arbitrage. For example, if there is a price increase in a relevant market in one region, consumers might prefer to buy from another region, reducing the price in the first one and raising it in the second. In the same way, suppliers will sell their products in the region where the price is higher, resulting in the equalization of prices over time.

Two major caveats to be stressed regarding correlation analysis: the first is that the series must be stationary. Otherwise, there will be a high probability of obtaining spurious correlations. This problem occurs when a high coefficient of correlation is obtained without any theoretical or logical reasons. Second, statistically, the problem is related to the behavior of the series: a non-stationary series varies in time in its first three moments (mean, variance,

and covariance) and presents a random walk behavior. According to Forni (2004), this implies that the long-term forecasts of the series are not equal to the mean, and the variance tends to grow unlimited. Therefore, a high degree of correlation between two series would be a statistical coincidence, not a causal co-movement relationship over time.

The second one is about the impact of other factors on the time series. Suppose the goal is to delineate the relevant gasoline market in a city with two gas stations. Each of them determines its prices (assuming no collusion) and presents its time series for the price of gasoline. However, the government decides to raise a tax on the commercialization of gasoline so that prices will be high in both stations without a direct or causal relationship between them. As a result, the correlation between prices will have increased due to an external shock. Ideally, external factors should be removed from the correlation analysis so that the market is defined only by the actions of consumers and suppliers through integration and arbitration. As defined by Haldrup (2003), the partial correlation would be the correlation between adjusted price series without the interference of common external factors.

Another problem pointed out by Davis and Garcés (2010) regarding the use of price correlations in the relevant market delimitation concerns the understanding of the price behavior of two differentiated products. This type of assessment assumes that the determinant of co-movement of prices is primarily consumer behavior, which replaces one product with another. However, other factors are not necessarily related to consumer behavior, which can generate false positives conclusions and spurious correlations.

b. Auto-regressive vectors (VAR)

VAR models are used to capture the relationship of multiple variables simultaneously, meaning they are treated as endogenous – each one of them influences one another. The series is modeled in terms of the lagged values themselves, constituting vectors of variables and matrices of coefficients to be estimated. In general, a VAR model is defined by its number of lags (order) p and k variables. The number of lags (p) is usually defined by the selection criteria based on the maximum likelihood function, such as the Akaike and Schwarz method. Therefore, it is important to proceed to autocorrelation tests between the residues to test for the number of lags. The Ljung-Box and Breusch-Godfrey tests are commonly used for this purpose.

Based on VAR models, three types of analyzes are commonly used. The first is the Granger Causality test. Causality is seen as temporal precedence,

meaning that a variable precedes another one (if lagged values are related to the current value of the other variables). The results could point to a one-way Granger causality, a bidirectional causality, or no causality at all. Attesting the presence of Granger's causality in a VAR model could indicate the delineation of relevant markets.

Much of the interest in VAR models are in the residual. If the model is stationary, it is possible to predict how a shock in a lagged variable interacts with the others. For example, for the relevant market delimitation, one can analyze how a shock in the price of one market (or region/product) affects the other, thus indicating that both are in the same relevant market if the model is robust.³ This type of analysis is called the Impulse Response Function.

A third interesting analysis from the VAR is the variance decomposition of the forecast errors. This is used to verify which proportion of the prediction error variance is due to itself or other variables over time. We did not find many applications of this type of analysis in discussing relevant market delimitation, though.

2.2. Technics with non-stationary series

When two or more time series are not stationary, they can cointegrate, i.e., both series may have a long-term relationship. Two or more integrated series of the same order⁴ are cointegrated if they present a stochastic tendency in common and at least one stationary linear combination. This characteristic is important to relevant market definition since prices of different products and locations following the same path could indicate integration of that markets and, in some sense, that they are part of the same relevant market. According to Forni (2004), economic intuition arises from arbitrage. If products are substitutes both on the demand side and on the supply side, prices will not disperse over time since consumers and producers will choose between them, so the more expensive product may face price reductions, and the cheaper ones face an increase in prices.

Several cointegration tests are proposed in the literature. Following is a brief review of the most commonly used.

³ As in the correlation example, one variable can impact the other not because they are in the same relevant market but because they were affected by another price movement, such as raise in costs.

⁴ Generally, with one unitary root $I(1)$ for most economic data.

a. Engle-Granger

The test proposed by Engle and Granger (1987) aims to find only one cointegration relation between two or more variables. For example, suppose having two variables, y , and x . The first step is to verify if the series is not stationary and integrated in the same order. If both are integrated of 1 order – $I(1)$ – the second step is to run an Ordinary Least Squares (OLS) test to estimate their long-term relationship. There is no criterion for determining which variable will be the explanatory one, which will be the dependent one. The analyst must make this definition.

One of the main criticisms related to Engle-Granger methodology relates to the unique cointegrating relation, regardless of the number of variables. In theory, there may be several linear stationary combinations resulting from the existence of several cointegration vectors. If there are k variables, it is possible to exist $k-1$ linearly independent cointegrating vectors, one cointegration relation each. Another important criticism is the arbitrariness in the definition of the dependent variable and the explanatory variables.

An interesting approach is provided by Forni (2004) regarding this type of test to relevant market delimitation. The author argues that a series $I(1)$ does not necessarily present a constant mean or an increasing variance over time since shocks are permanent. Thus, if the difference between the two series is $I(1)$, both can diverge from each other over time. Otherwise, they walk through time in a common trajectory. Forni (2004) suggests using the increased Dickey-Fuller and KPSS tests to verify the stationarity condition. If there is one unit root, the products do not belong to the same relevant market (and vice-versa).

b. Johansen Cointegration Test

Johansen cointegration test's main advantage compared to Engle-Granger is that it allows multiple cointegrating vectors. In addition, the test is based on a VAR model, so variables are treated as endogenous in a dynamic scenario. Therefore, there is no need to define a priori the dependent variable and the explanatory variables.

A restricted VAR can be used when variables are not level stationary and cointegrated, also known as the error correction model (VECM). The VECM models are widely used in time series, allowing for analyses of impulse response functions and decomposition of forecast error variance. As discussed in the VAR context, these two techniques are good indicators of market integration.

Regardless of the number of variables, attesting for the existence of at least one cointegration vector is sufficient to conclude that markets are integrated. For antitrust analysis, this could indicate that distinct markets may behave as parts of the same relevant market since series have the same long-term trajectory and, at least, one linear combination. But, again, a caveat in the application of cointegration tests for relevant market definition is, if the economic theory behind the equation is not well defined, false positives are well possible.

3. TIME SERIES MODELS AND MARKET DEFINITION DEBATES IN BRAZIL

Here we illustrate three cases in which the debate about applying time series to the relevant market definition was used in Brazilian jurisprudence. The first case concerns the merger of Quattor and Braskem in 2010. The second case reports the discussion presented at the proposed acquisition of Solvay by Braskem in 2014; Finally, we present the debate in Innova SA / Videolar SA case, approved with remedies in 2014.

3.1. Braskem-Quattor

a. Time-series techniques used by the parties

In 2010, Braskem, a giant company in Brazil's petrochemical sector, sought CADE's approval for the Quattor acquisition. Both companies produced thermoplastic resins such as polyethylene (PEAD, PEBD, PEBDL⁵) and polypropylene (PP) – so the operation would create a giant monopoly in producing such resins. In addition, assets consolidation would position Braskem as the largest petrochemical company in the Americas. However, the geographical size of this market was the most controversial point since previous jurisprudence generally considered the relevant market as international.⁶

5 Portuguese acronyms for High-density polyethelene, low-density polyethelene, linear, linear low-density polyethelene.

6 Decisions in the Merger Acts 08012.005473 / 1997-45; 08012.006452 / 2000-86 and 08012.005799 / 2001-92. CADE considered the relevant geographic market as Mercosur for polyethylene and polypropylene. Merger Act 08012.005598 / 2005-19 assessed the impacts of polyethylenes and polypropylenes market both in international and national relevant markets, because – according to the Commissioner Ricardo Boas Villias Cueva – it was not possible to reach, “with a high degree of certainty, a conclusive definition of the geographical dimension”.

The parties presented an economic study to test for the relevant geographic markets.⁷ Johansen cointegration, VECM, Granger Causality, and Decomposition of Forecast Error Variance were used. The database presented had monthly price information from 2000 to 2010 for the domestic market, international markets, and naphtha (as the cost shifter) for the polyethylene resins PEBD, PEBDL, PEAD, and PP.⁸

In summary, the study concluded that there was a long-run relationship between prices (i.e., trace and maximum eigenvalue tests showed positive and significant results for cointegration). Table 1 reproduces the results for Johansen trace and eigenvalue tests. Table 2 presents the estimated cointegrating equation, and Table 3 exhibits the VECM model.

Table 1. Johansen cointegration – trace and maximum eigenvalue

Product	Model choice	Number of cointegrating vectors					
		Trace			Max. Eigenvalue		
		None	1	2	None	1	2
PEBD	One lag, no intercept, and no trend	0.0000	0.2088	0.8742	0.0000	0.1538	0.8742
PEBDL	One lag, no intercept, and no trend	0.0000	0.2038	0.8377	0.0000	0.1511	0.8377
PEAD	One lag, no intercept, and no trend	0.0000	0.2963	0.9309	0.0000	0.2255	0.9309
PP	One lag, no intercept, and no trend	0.0000	0.4131	0.8418	0.0000	0.3349	0.8418

P-values by Mackinnon-Haug-Michelis (1999). Endogenous variables: national GDP, world GDP, NAFTA NW Europe CIF.
Source: Braskem/ Consultoria Tendências.

⁷ Merger act No. 08012.001205/2010-65.

⁸ PEBD: low density polyethylene; PEBDL: linear low-density polyethylene; PEAD: high density polyethylene; PP: polypropylene.

Table 2. Cointegrating vector estimations

Cointegration	PEBD	PEBDL	PEAD	PP
Domestic market (-1)	1.000000	1.000000	1.000000	1.000000
Foreign market (-1)	-0.806902	-0.981948	-0.950488	-0.718256
	(0.06772)	(0.07072)	(0.06754)	(0.09203)
	[-11.9155]	[-13.8841]	[-14.0730]	[-7.804336]
Nafta Europe (-1)	-0.655702	-0.252285	-0.383822	-1.053653
	(0.20779)	(0.20298)	(0.19393)	(0.26457)
	[-3.15564]	[-1.24289]	[-1.97916]	[-3.98258]

Endogenous variables: NAFTA NW Europe CIF, world GDP, and Brazilian GDP. Deviations (), t statistics []. Source: Braskem/ Consultoria Tendências.

Table 3. VECM

	D. (Domestic market)	D. (Foreign market)	D. (NaftaNWCIF)
CointEq1	-0.259191	0.011968	0.015826
PEBD	(0.03748)	(0.07466)	(0.03748)
	[-6.91482]	[0.16030]	[0.44554]
CointEq1	-0.259132	0.065418	0.026500
PEBDL	(0.03598)	(0.07073)	(0.03598)
	[-7.20122]	[0.92491]	[0.69629]
CointEq1	-0.296703	0.075192	0.025346
PEAD	(0.03994)	(0.06842)	(0.03727)
	[-7.42812]	[1.09903]	[0.68013]
CointEq1	-0.203034	-0.037785	0.010575
PP	(0.03090)	(0.06393)	(0.03090)
	[-6.57140]	[-0.59107]	[0.32813]

Deviations (), t statistics []. Source: Braskem/ Consultoria Tendências. Note: adjusted coefficients are significant considering only the results for the domestic market, being a piece of evidence for integration between domestic and foreign prices.

The presented study also tested for the direction of causality, concluding that international prices caused home prices, despite the common control value (naphtha). Regarding the choice of ordering foreign price and the naphtha price to the domestic one (the exogeneity order of variables),

variance decomposition suggested price of foreign resin explained by largely the price of the domestic one (Table 4). Parties concluded, therefore, that a merger between Braskem and Quattor would have little impact on prices due to the internationalization of the resins market.

Table 4. Variance decomposition of forecast errors.

Products	Period	Domestic prices/ Foreign prices	Foreign prices/ Domestic prices	Domestic prices/naphta	Foreign prices/ naphta
PEBD	1 year	71.1	0.69	23.01	7.87
	2 years	72.57	0.44	24.51	7.33
PEBDL	1 year	79.97	1.23	12.45	7.4
	2 years	82.23	1.3	13.41	7.26
PEAD	1 year	78.33	1.19	14.03	6.66
	2 years	80.47	1.42	15.08	6.22
PP	1 year	69	3.64	24.67	4.17
	2 years	1.17	2.27	25.75	3.42

Endogenous variables: NAFTA NW Europe CIF, world GDP, and Brazilian GDP. Deviations (), t statistics []. Source: Braskem/ Consultoria Tendências.

b. SSNIP test

In line with the Horizontal Merger Guidelines, the Reporting Commissioner asked the parties for a document presenting the SSNIP⁹ test. As a result, the estimated equation for the demand elasticities was as follows:

$$\ln q_t = \alpha + \beta_1 \ln PBr_t + \beta_2 \ln Pint_t + \beta_3 \ln y_t + \varepsilon_t \quad (1)$$

Pbr is the domestic prices for PP, PEBD, PEBDL, and PEAD, $Pint$ is the foreign prices, y is the demand shock, and q is the total quantity sold of PP, PEBD, PEBDL, and PEAD in the domestic market. All variables are expressed in logarithm. The authors used three estimating methodologies in which the presented instruments were the lagged price for the naphtha, both in level and in first difference. The first GMM estimations showed demand elasticities around 1%. In linear estimation using a rolling regression, the authors concluded that the elasticities change over time, ranging from -2% to -4%, higher than the critical loss proposed by the monopolist test (table 5). In

9 Small but significant and non-transitory increase in price.

summary, the authors reached a formal conclusion that the relevant market should include resins imports, depending on the period.

Table 5. Critical loss

	Δ Price	Demand	Critical elasticities
Profit maximization	5%	Linear	-2.27
		Constant elasticities	-2.68
	10%	Linear	-1.85
		Constant elasticities	-2.50

Source: Braskem/ Consultoria Tendências.

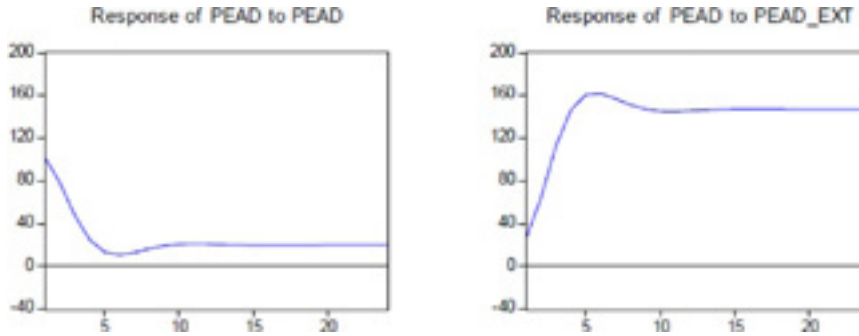
c. The role of the Department of Economic Studies

The Department of Economic Studies (DEE) stressed that simply a correlation between domestic and foreign markets would not imply relevant market definition because this could reflect firms' price strategy. Regarding the methodologies, the Department also identified inconsistencies in the granger causality and the variance decomposition. First, the chosen model was a VAR in the first difference without a structural break, but the most suitable one for interpretations should be the VEC with a structural break. Second, in this case, the Granger causality of foreign to domestic price was not verified.

Second, DEE highlighted the misinterpretation of the price order. Cost prices (i.e., naphtha) also anticipated the movement of foreign prices in the VEC and the Granger test. In this case, there would be no reason to believe in the ordination naphtha causing foreign price, then causing domestic price, finding little explanation for the variance decomposition (Table 4).

DEE simulated unilateral price increases in domestic prices to check whether they would be significant and permanent through impulse response. As a result, for domestic price shocks, it was identified a short-run price augmentation. However, considering a foreign price shock, this effect lasted for a longer period, pointing to a possible international market definition (Figure 1).¹⁰

¹⁰ The note DEE, however, also points out more than once the need for a test beyond the correlation of prices and to understand profitability with an increase in prices, as in the loss Critical and Elasticity criticism.

Figure 1. Impulse response for PEAD prices.

Note: Shocks are standard price deviations. Source: Braskem/ Tendências.

Despite methodological differences, the vote of Reporting Commissioner Carvalho (2010) made the following considerations: i) it was verified the existence of cointegration between domestic and international prices and the long-term trend between them; ii) other correlation tests also indicated that the variance in international prices explained variance in domestic prices; iii) finally, critical loss test showed no strong evidence against the international market hypothesis. Thus, it ruled for an understanding of the international geographic market. However, the case was approved with behavioral remedies. The new company had to report the monthly imported quantity for each resin and any importing contract signed between foreign and national industries.

3.2. Braskem- Solvay

At the end of 2013, Braskem proposed acquiring its competitor Solvay, located in Brazil and Argentina¹¹. Following the market consolidation, which had begun with the acquisition of Quattor, the company strategy was to strengthen its plastic resin production in Mercosur. In the previous operation, the main product markets involved producing polyethylenes and propylenes—the current operation target PVC¹², commercialized as suspension (PVC-S) or emulsion (PVC-E).

¹¹ Merger act N° 08700.000436/2014-27.

¹² Polyvinyl chloride.

a. Time series used to push through an international geographic market

Parties presented an analysis of price cointegration for the PVC market. The main argument was that imports could impede domestic production and block any attempt of market abuse from the new company. The database contained average monthly price information for domestic¹³ and foreign prices of PVC-S¹⁴ between January 2008 and July 2013. In addition, the authors included a dummy during an antidumping period when US imports were overtaxed by 16%. Another dummy was added to cover the financial crisis between 2008 and 2009. Finally, for cost control, naphtha and ethane prices were also included.

The study presented trace statistics for the null hypothesis of non-cointegration, replicated in Tables 6 and 7 below. Results pointed to the rejection of the null hypothesis, meaning for a long-run relationship between domestic and internal prices.

Table 6. Trace statistics using ethane as cost

Model	Number of cointegrating vectors			
	0	1	2	
Trace statistics				
Domestic PVC + US GULF	no intercept, no trend	32,09	16,29	3,44
Domestic PVC + SE ÁSIA	no intercept, no trend	35,91	13,06	0,97
PVC INTERNO + NE ÁSIA	no intercept, no trend	35,72	13,54	0,77
PVC INTERNO + NEW	no intercept, no trend	30,55	11,72	0,55

Source: Braskem, Solvay/ Tendências. Critical values based on Johansen, Mosconi, and Nielsen (2000).

¹³ Average price of Solvay and Braskem.

¹⁴ Average PVC-S price from US-Gulf, South Asia, Northeast Asia and Northwest Asia, the main origins of Brazilian PVC imports.

Table 7. Trace statistics using naphtha as cost

	Model	Number of cointegrating vectors		
		0	1	2
		Trace statistics		
Domestic PVC + US GULF	with intercept, no trend	31,46	10,15	3,58
Domestic PVC + SE ÁSIA	no intercept, no trend	41,51	8,62	1,35
PVC INTERNO + NE ÁSIA	no intercept, no trend	38,58	8,62	1,01
PVC INTERNO + NEW	no intercept, no trend	30	7,42	1,05

Source: Braskem, Solvay/ Tendências. Critical values based on Johansen, Mosconi, and Nielsen (2000).

The authors estimated a VEC equation for both relationships and, as their estimated adjustment coefficients were negative, they corroborated their analysis for a long run and stable cointegration between domestic and foreign prices.

Table 8. Adjustment coefficients

	Ethane		Naphtha			
	Domestic market	Foreign market	Ethane	Domestic market	Foreign market	Naphtha
Gulf	-0,001225	0,024062	-0,049246	-0,096192	0,054021	-0,187144
	(0,00959)	(0,01932)	(0,02433)	(0,04154)	(0,0799)	(0,06011)
	[-0,127741]	[1,24569]	[-2,02410]	[-2,31557]	[0,67610]	[-3,11316]
SEA	-0,108645	-0,017643	-0,366983	-0,115896	0,10212	-0,246395
	(0,04187)	(0,0738)	(0,11723)	(0,05027)	(0,08662)	(0,0786)
	[-2,59496]	[-0,23907]	[-3,13055]	[-2,30544]	[1,17893]	[-3,13497]
NEA	-0,189646	0,061923	0,34901	-0,162484	-0,033598	-0,214785
	(0,04689)	(0,08514)	(0,14016)	(0,04931)	(0,08498)	(0,07817)
	[-4,04424]	[-0,72727]	[-2,49003]	[-3,29509]	[-0,39538]	[-2,74735]
NWE	-0,062559	0,213736	-0,134371	-0,086755	0,260762	-0,081268
	(0,04669)	(0,099909)	(0,12788)	(0,05242)	(0,10595)	(0,07956)
	[-1,34001]	[2,15709]	[-1,05079]	[-1,65512]	[2,50618]	[-1,02151]

Source: Braskem, Solvay/ Tendências. P-values in (), t-statistics in [].

For the variance decomposition, the study observed a long-run relationship (over 12 months). The foreign price explained the domestic price (around 70% using ethane as cost control and 60% using naphtha). So, claimants' economists corroborated the correlation hypothesis between domestic and foreign prices. To complement, they also proceeded to impulse-response function analysis. The shock of foreign prices on the domestic ones caused a long-run impact on domestic prices, not reversible in the short run. The only exception was the prices from US-Gulf origins, pointing towards the greater influence of the Asian prices. The authors concluded that the market should have been considered as international geographically speaking.

b. DEE review's strike again

On reviewing the parties' study, DEE followed the Haldrup (2003) methodology to analyze the cointegration between series. Controlling domestic and international prices by common factors such as the ethane and naphtha, the Department unit root tests did not point to I (1) series because there were two cointegrating equations and only two endogenous variables be interpreted as stationary. DEE applied the correlation analysis for domestic and foreign prices, finding a strong relationship between domestic and US-Gulf prices. This finding contradicted the impulse response results presented by the parties.

Considering seasonal and common factors, DEE preceded the VAR model and the Granger causality test. Their results are shown in Tables 9, 10, and 11. The Department reached a similar conclusion to the claimants' study, i.e., that foreign prices caused domestic prices. However, the interpretation observed the strongest effect from the US-Gulf prices, like the correlation analysis.

Table 9. Granger Causality – Ethane

Direction of Causality			X test 2	Freedom Degrees	Decision
<i>Brazil</i>	Not Granger-cause	Gulf (USA)	0.57	2	accepted
<i>Brazil</i>		NE Asia	0.91	2	accepted
<i>Brazil</i>		SE Asia	1.53	2	accepted
<i>Brazil</i>		Europe NWE	1.70	2	accepted
Gulf (USA)		<i>Brazil</i>	6.67	2	Rejects 5%
NE Asia		<i>Brazil</i>	3:49	2	accepted
SE Asia		<i>Brazil</i>	0.31	2	accepted
Europe NWE		<i>Brazil</i>	4.07	2	accepted
ALL		<i>Brazil</i>	10.96	4	Rejects 5%

Source: Merger act 08700.000436/2014-27 vol. 13, pp. 144-200.

Table 10. Causality Granger – Naphtha

Direction of Causality			X test 2	Freedom Degrees	Decision
<i>Brazil</i>	Not Granger- cause	Gulf (USA)	0.99	2	accepted
<i>Brazil</i>		NE Asia	1.58	2	accepted
<i>Brazil</i>		SE Asia	2.99	2	accepted
<i>Brazil</i>		Europe NWE	2.86	2	accepted
Gulf (USA)		<i>Brazil</i>	7.17	2	Rejects 5%
NE Asia		<i>Brazil</i>	3.17	2	accepted
SE Asia		<i>Brazil</i>	0.18	2	accepted
Europe NWE		<i>Brazil</i>	4.09	2	accepted
ALL		<i>Brazil</i>	13.63	4	Rejects 1%

Source: Merger act 08700.000436/2014-27 vol. 13, pp. 144-200.

DEE preceded the hypothetical monopolistic test for the PVC market, following the methodology proposed by Werden (2003). Using quantity and price data for PVC imported and locally produced, controlling for energy costs, labor costs, and seasonal dummies, the Department estimated demand elasticities using two stages OLS, GMM, and MLE. The obtained elasticities

ranged from -0,5 to -0,8, much lower than the critical elasticity. The results for the estimations and the critical values are reported in tables 12 and 13.

Table 12. Estimated elasticities

	Estimation types					
	1	2	3	4	5	6
lnP	-0.502** (0.212)	-0.587*** (0.196)	-0.0545** (0.225)	-0.530*** (0.164)	0.783*** (0.250)	-0.640*** (0.191)
lnEthane	0.068 (0.089)	0.101 (0.081)	0.074 (0.090)	0.115* (0.068)	0.157* (0.084)	0.131* (0.073)
IBC-Br (GDP)	0.000 (0.005)	0.002 (0.004)	0.001 (0.005)	-0.001 (0.004)	0.002 (0.008)	-0.001 (0.004)
Constant	14.646*** (1.616)	14.914*** (1.663)	14.933*** (1.696)	14.721*** (1.272)	16.078*** (2.323)	15.477*** (1.452)
Number of observations	65	65	65	65	65	65
Rsquared	0.804	0.786	0.800	0.890	0.615	0.879
Monthly dummies	yes	yes	yes	yes	yes	yes
Year dummies	yes	yes	yes	yes	yes	yes
Outliers	yes	yes	yes	yes	yes	yes
Methodology	2OLS	GMM	ML	2OLS	GMM	ML
Kleibergen-Paap rk (p-valor)	0.00	0.00	0.00	0.00	0.00	0.00
Cragg-Donald F statistics	4.34	5.32	4.34	4.11	5.05	4.11
Sargan (j statistics)	0.57		0.57	0.19		0.21

Note: quantity monthly sold by Solvay and Braskem in logarithm. The international ethane price controls estimations. IBC-BR index is a proxy for aggregated demand, estimated by Brazilian Central Bank. Instruments: first and second lags for labor costs, ethane costs, and energy costs. Outliers' dummies in January 2009, October 2011, and July 2013. Standard errors (). ***p<0.01. **p<0.05. *p<0.1.

Source: Merger act 08700.000436/2014-27vol. 13, pp. 144-200.

Table 13 Critical elasticities

	Cmg -Proxy				Cmg(estimated)			
	Linear		Isoelastic		Linear		Isoelastic	
SSNIP	5%	10%	5%	10%	5%	10%	5%	10%
Breakeven	2.61	2.31	2.86	2.75	2.16	1.95	2.34	2.27
Profit Max.	2.31	1.87	2.74	2.54	1.95	1.63	2.26	2.14

Source: Merger act 08700.000436/2014-27 vol. 13, pp. 144-200.

The Department concluded that there was a high probability for a non-transitory profitable price increase of more than 10% for the monopolist in the PVC market. This result indicated that other products would not rival the domestic production of PVC in other geographical regions. Therefore, the relevant market of this product would have a national geographic dimension.

c. Diff-diff estimations

Given the controversy and debate between claimants and CADE, DEE held a difference-in-differences test, such as the analysis made in Ineos Group Limited and Kerling ASA¹⁵ merger in the UK. Considering plants' interruptions effect in the Brazilian PVC market, DEE sought to determine whether there was an increase in imports, their main origins, and their impacts on domestic resin prices. Regression's equation contained information on the quantity (Y) sold in Brazil by domestic production and imports (i) in each month (t), controlling for PVC prices and costs (X). T is the dummy variable for the treatment plants (with interruptions), and t the time dummy. Interaction Tt aimed to capture the imported product effect on the domestic market, as it follows:

$$Y_{it} = \alpha X_{it} + \gamma T_{it} + \rho t_{it} + \beta(T_{it}t_{it} + \varepsilon_{it}) \quad (2)$$

Data for this experiment included the imported quantity of polystyrene (PS) as the control group because both firms did not produce this type of resin. Hence, an imported quantity change of PS could not have been the result of a shock production. Importing trends between PS and PVC were quite similar during the analyzed period (January 2008- July 2013, 72 periods). Not

¹⁵ Operation notified to the European Commission on 17 July 2007. For details, see Amelio; De La Mano & Godinho (2008).

programmed plant interruptions were frequent during this period, and the loss of production was around 26% of installed capacity.

DEE estimations using 2OLS were based on the regressions between the first difference of the logarithm quantities with lagged controls variables (1) and with the differences between national and imported prices (2) for each exporting region (South America, North America, Asia, and Europe). Tables 14, 15, 16, and 17 show the results.

Table 14. “diff-in-diffs” South American imports

	1	2	1	2	1	2
PVC * Treatment (t: t+1)	0.472***	0.897***				
	[0.0563]	[0.0701]				
PVC * Treatment (t: t+2)			0.299***	0.30***		
			[0.0238]	[0.0297]		
PVC * Treatment (t: t+3)					0.157***	0.0737***
					[0.00949]	[0.00070]

Source: Merger act 08700.000436/2014-27vol. 16, pp 6-30. Standard errors [].***p<0.01. **p<0.05. *p<0.1.

Table 15. “diff-in-diffs” North American imports

	1	2	1	2	1	2
PVC * Treatment (t: t+1)	0.0879***	0.125				
	[0.00841]	[0.0795]				
PVC * Treatment (t: t+2)			0.302***	0.175***		
			[0.0197]	[0.0419]		
PVC * Treatment (t: t+3)					0.375***	0.286***
					[0.0173]	[0.0812]

Source: Merger act 08700.000436/2014-27vol. 16, pp 6-30. Standard errors [].***p<0.01. **p<0.05. *p<0.1.

Table 16. “diff-in-diffs” Asian imports

	1	2	1	2	1	2
PVC * Treatment (t: t+1)	0.0563	0.138***				
	[0.0507]	[0.0273]				
PVC * Treatment (t: t+2)			0.0435***	0.00738		
			[0.00198]	[0.0172]		
PVC * Treatment (t: t+3)					-0.0712***	-0.0867
					[0.0121]	[0.0]

Source: Merger act 08700.000436/2014-27vol. 16, pp 6-30. Standard errors [].***p<0.01. **p<0.05. *p<0.1.

Table 17. “diff-in-diffs” European imports

	1	2	1	2	1	2
PVC * Treatment (t: t+1)	0.279***	0.00815				
	[0.108]	[0.0569]				
PVC * Treatment (t: t+2)			(-0.951)***	0.649***		
			[0.0656]	[0.0243]		
PVC * Treatment (t: t+3)					-0.339***	0.0267
					[0.0914]	[0.0507]

Source: Merger act 08700.000436/2014-27vol. 16, pp 6-30. Standard errors [].***p<0.01. **p<0.05. *p<0.1.

The Department concluded that the relevant geographic market should be understood as broader than Brazil, including South America and eventually North America. Coefficients from both regions were positive and significant, despite the small impact of this last region. Asia and the European Union did not seem to belong to the same relevant market since results were negative and not significant, contradicting the cointegration analysis presented by claimants. DEE also asked for a qualitative analysis of stocks and antidumping measures, impacting econometric evaluations.

In his opinion, Reporting Commissioner Araujo (2014) concluded the relevant geographic market as South America, with a moderate degree of rivalry in North America. As a result, companies dropped the case, and no merger was concluded. Later in 2016, Unipar Carbocloro, the country’s main

caustic soda producer, acquired Solvay Indulpa, creating the 2nd largest producer of PVC behind Braskem.

3.3. Videolar and Innova

In July 2013, Videolar SA asked for clearing its acquisition of Innova SA. Videolar was the only polystyrene (PS) producer in the north of Brazil where it benefited from a series of tax reductions and subsidies applied in the Free Area of Manaus¹⁶. Innova was a state-owned enterprise in the Rio Grande do Sul state. The main commercialized product was imported PS, acrylonitrile-butadiene-styrene (ABS), styrene-acrylonitrile (SAN), and styrene. With no other national producers of PS, the new company would become a monopoly. The main argument from the parties was that ABS and PP would be perfect substitutes for PS since it is an older resin being replaced by the former. However, during the process analysis, the General Superintendence did not agree on that definition because PP was a type of thermoplastic resin while ABS was the one applied in construction, differently from the applications of the ABS¹⁷.

a. International relevant market and ABSxPS substitution

The parties presented a series of correlation and cointegration tests among polystyrene (PS) prices in Brazil, the United States, and Asia to verify if these regions would belong to the same relevant market. They also presented price results for ABS, PP, and PS to broaden product market analysis. Data ranged from January 2003 to May 2013 for PS prices in Brazil, in the US, in the European Union, and Asia, as well prices for ABS and PP for the same period in Asia.

The study tested for Engle-Granger cointegration and causality tests. The first tested for a unit root presence on the residual of the OLS equation using only prices as dependent and independent variables. Tables 18 and 19 report the results, where significance means the presence of unit root and, accordingly to the parties, cointegration. The study pointed to the existence of cointegration among prices in Brazil and all international prices of PS and a long-term relationship among these and ABS/PP prices.

¹⁶ In Portuguese, Zona Franca de Manaus. Taxes exemptions to industries are given to those who were installed in the region, in order to promote the development of the Amazonic states.

¹⁷ ABS's is used in manufacturing products such as pipe systems, musical instruments, automotive trim components, medical devices for blood access et al. because of its light weight. It is not produced in Brazil.

Table 18. Cointegration tests

	No constant	Constant
PSBRA / PSUSA	-0,440847 (0,0005237)	-0,369077 (0,02876)
PSBRA / PSEUR	-0,28808 (0,01747)	-0,312921 (0,07531)
PSBRA / PSASI	-0,475036 (0,0001371)	-0,458478 (0,003776)
PSBRA / ABSASI	-0,221364 (0,06717)	-0,121361 (0,7051)
PSBRA / PPASI	-0,271132 (0,01854)	-0,133897 (0,6367)

p values (). Source: Merger act 08700.009924/2013-19, vol. 04, pp. 173-205.

Table 19. Cointegration tests

Null hypothesis		Constant F test	No constant F test
PS Brazil	PS USA	5,3072	6,9037
PS USA	P5 Brazil	2,3374	1,8773
PS Brazil	PS Europe	0,1266*	0,3859*
P5 Europe	PS Brazil	14,689	10,952
PS Brazil	PS Asia	0,3297*	1,4853*
PS Asia	PS Brazil	17,153	15,368
PS Brazil	ABS Asia	0,0057*	0,4462*
ABS Asia	PS Brazil	3,5052	3,8991
PS Brazil	PP Asia	0,0964*	0,0965*
PP Asia	P5 Brazil	6,5374	6,5374

*Accepts the null hypothesis. Source: Merger act 08700.009924/2013-19, vol. 04, pp. 173-205.

b. DEE's cointegration analyses

The Department of Economic Studies replicated the cointegration test using the Johansen methodology. However, it reached a different conclusion: while the PS price in Brazil (PSBRA) would still cointegrate with prices in the US

(PSUSA), Europe (PSEUR), and Asia (PSASI), the same could not be sustained for ABS and PP prices in Asia (ABSASI and PPASI). DEE observed that the conclusion obtained from the former analysis would be sensitive to methodological changes with these modifications. Results showed no relationship between Asian prices of ABS and PP concerning the price of domestic PS. So even if the price of polystyrene in Brazil continued to cointegrate with international PS prices, the conclusion that companies in Brazil would be price takers in this market was not verified. In other words, there would be no causal relationship between domestic and foreign polystyrene prices. Results are illustrated in Tables 20 and 21.

Table 20. Johansen cointegration test run by DEE

	Is there cointegration with PSBRA?			
	eigenvalue		trace	
	No constant	Constant***	No constant	Constant***
PSUSA*	Yes	Yes	Yes	Yes
PSEUR*	Yes	Yes	Yes	Yes
PSASI*	Yes	Yes	Yes	Yes
ABSASI*	No	No	No	No
PPASI**	No	No	No	No

Source: Merger act 08700.009924/2013-19, vol. 17, pp. 167-206.

*One lag. **two lags. ***considering the same model used in the parties' study.

Table 21. Granger causality (no constant)

Methodology			Chi2	p-value	Conclusion
VEC	PS Brazil	PS USA	4,97	2,6%	Rejects
VEC	PS USA	PS Brazil	4,47	3,4%	Rejects
VEC	PS Brazil	PS Europe	4,92	2,6%	Rejects
VEC	PS Europe	PS Brazil	6,44	1,1%	Rejects
VEC	PS Brazil	Not Granger-Causality PS Asia	6,24	1,2%	Rejects
VEC	PS Asia	PS Brazil	2,39	12,2%	Accepts

Methodology			Chi2	p-value	Conclusion
VAR	PS Brazil	ABS Asia	0,44	50,5%	Accepts
VAR	ABS Asia	PS Brazil	3,96	4,7%	Rejects
VAR	PS Brazil	PP Asia	14,74	0,1%	Rejects
VAR	PP Asia	PS Brazil	12,01	0,2%	Rejects

Source: Merger act 08700.009924/2013-19, vol. 17, pp. 167-206.

c. Hypothetical Monopolist Test (TMH)

Dropping the hypothesis that ABS and PP would be part of the same product market of PS, the Department proceeded with the TMH comparison. Claimants presented an elasticity of demand of -1.08% for domestic PS but did not compare this result with the estimated margins of critical loss. Consequently, the following regression was estimated:

$$\ln Qv_i^M = \alpha_{0,i}^M + \alpha_{1,i}^M \ln P_i^M + \sum_{k=1} \gamma_{k,i}^M X_{k,i}^M + \varepsilon_i^M$$

Qv is the sold quantity of PS, P is its sold price, X_k is a matrix of controlling variables such as income (proxied by IBC-BR) and dummies for seasonal effects. As instruments, energy and labor costs were used in the production of PS and the lagged price series. The estimated price-cost margins were already high (25%-37%), making it difficult to accept the imports substitution hypothesis for domestic supply. Table 22 shows the calculated critical loss. Table 23 shows the estimated elasticities range from -0.858 to -1.285 (domestic prices), thus indicating a profitable price augmentation up to 25% for a hypothetical monopolist. Reporting Commissioner Oliveira Junior (2014) agreed on DEE's opinion and defined the geographical polystyrene market as national. Claimants presented behavioral remedies to get the merger cleared, including keeping the same production level in the north and south plants, styrene, and polystyrene patents licensing, adopting a compliance program, and not acquiring any further resin plan for the next five years. The Court agreed on the remedies' agreement, and the case was cleared in October 2014.

Table 22. Critical loss

Linear	<i>m</i> =25%				<i>m</i> =37%			
	Isoelastic		Linear		Isoelastic		Linear	
	5%	10%	5%	10%	5%	10%	5%	10%
SSNIP	5%	10%	5%	10%	5%	10%	5%	10%
Breakeven	3.3	2.83	3.69	3.49	2.34	2.10	2.56	2.46
Profit Max.	2.83	2.21	3.46	3.11	2.1	1.73	2.47	2.31

Source: Merger act 08700.009924/2013-19, vol.21 pp. 153-170.

Table 23. Demand estimations

	1	2	3
lnP	-0.858*** [0.282]	-1.285** [0.562]	-0.902*** [0.259]
lnP (imports)		-0.196 [0.132]	-0.244** [0.110]
IBC-Br	0.0276*** [0.00588]	0.0248*** [0.00517]	0.0240*** [0.00479]
Dummies (year)	YES	YES	YES
Dummies (month)	YES	YES	YES
R2	0.82	0.82	0.84
Overidentification		0.02	0.00
F statistics		3.07	40.36
Hansen (p-value)		0.81	0.16

Source: Merger act 08700.009924/2013-19, vol.21 pp. 153-170.

4. FINAL REMARKS

CADE's latest decisions regarding using time series methods in relevant market definition have gone in the direction placed by main references in the antitrust literature. Despite its importance, it is clear the need for a detailed assessment of the assumptions used in the models, so they are the most credible possible. Moreover, it is clear the supremacy of the results obtained by TMH in comparison with those from cointegration tests, for example. Often results from these methods assume determinants of the co-movement of prices as primarily from consumer behavior, ignoring other factors such as cost shocks.

This study, therefore, aimed to present the main time series techniques used in the definition of relevant markets. The idea was to present an overview and

key statistical data of different analyses used by the Brazilian Competition Authority in the last years. As stressed in this paper, time-series techniques are useful if used with caution because it is a relatively fast and simple analysis, most often relying only on price data. Thus, it can be considered “quick and dirty” (on the one hand, there is the advantage of speed, on the other, there is the disadvantage of lack of reliability and robustness). Ideally, these analyses complement other tests more appropriate for antitrust analysis, such as the hypothetical monopolist test.

BIBLIOGRAPHY

- AMELIO, A; de LA MANO, M. & GODINHO, M.
 2008 “Ineos/Kerling Merger: An Example of Quantitative Analysis in Support of a Clearance Decision”, in *Competition Policy Newsletter*, n.º 1, pp. 65-69
- BUENO, Rodrigo de Losso da Silveira
 2008 *Econometria de séries temporais*, São Paulo: Cengage Learning
- CADE (Brazil)
 2010 *Delimitação de Mercado Relevante*, Available at http://www.Cade.gov.br/acesso-a-informacao/publicacoes-institucionais/dee-publicacoes-anexos/delimitacao_de_mercado_relevante.pdf
- 2016 *Guia para Análise de Atos de Concentração Horizontal*, Available at http://antigo.cade.gov.br/acesso-a-informacao/publicacoes-institucionais/guias_do_Cade/guia-para-analise-de-atos-de-concentracao-horizontal.pdf/@@download/file/Guia%20para%20An%C3%A1lise%20de%20Atos%20de%20Concentra%C3%A7%C3%A3o%20Horizontal%20julho-2016.pdf.
- 2010 Merger n.º 08012.001205/2010-65, *Braskem-Quattor*, Commissioner Carvalho Report
- 2014a Merger n.º 08700.000436/2014-27, *Braskem-Solvay*, Commissioner Araujo Report
- 2014b Merger n.º 08700.009924/2013-19, *Videolar-Innova*, Oliveira Júnior Commissioner Report
- 2014c Nota Técnica n.º 07/2014/DEE
- 2016a Nota Técnica n.º 17/2014/DEE
- 2016b Nota Técnica n.º 18/2014/DEE
- 2016c Nota Técnica n.º 24/2014/DEE

- DAVIS, P. & GARCÉS, E.
2010 *Quantitative Techniques for Competition and Antitrust Analysis*, Princeton University Press, cap. 4
- ENDERS, W.
2009 *Applied econometric time series*, 3rd ed., New York: John Wiley
- ENGLE, R. F. & GRANGER, C. W. J.
1987 “Cointegration and error correction: representation, estimation, and testing”, in *Econometrica*. v. 55, n.º 2, pp. 251-276
- FORNI, M.
2004 “Using stationarity tests in antitrust market definition”, in *American Law and Economics Review*, v. 6, n.º 2, pp. 441-464
- HALDRUP, N.
2003 “Empirical analysis of price data in the delineation of the relevant geographical market in competition analysis”, in *University of Aarhus, Economics Working Paper*, n.º 2003-09
- JOHANSEN, S.
1988 “Statistical analysis of cointegration vectors”, in *Journal of Economic Dynamics and Control*, v. 12, issues 2-3, pp. 231-254
- JOHANSEN, S. & JUSELIUS, K.
1990 “Maximum likelihood estimation and inference on cointegration: with application to the demand for money”, in *Oxford Bulletin on Economics and Statistics*, v. 52, n.º 1, pp. 169-210
- JOHANSEN, S., MOSCONI, R. & NIELSEN, B.
2000 “Cointegration analysis in the presence of structural breaks in the deterministic trend” in *Econometrics Journal*, vol. 3, issue 2, pp. 216-249
- JOHNSTON J. & DINARDO, J.
1997 *Econometric methods*, London: McGraw-Hill International Edition
- LÜTKEPOHL H. & KRÄTZIG, M.
2004 *Applied time series econometrics*, Cambridge: Cambridge University Press
- MACKINNON, J. G.; HAUG, A. A. & MICHELIS, L
1999 “Numerical distribution functions of likelihood ratio tests for cointegration”, in *Journal of applied Econometrics*, v. 14, n.º 5, pp. 563-577
- WERDEN, G
2003 “The 1982 Merger Guidelines and the Ascent of the Hypothetical Monopolist Paradigm”, in *Antitrust Law Journal* v. 71, n.º 1, pp. 253-275
- WOOLDRIDGE, J. M.
2002 *Introductory Econometrics: A Modern Approach*, 2.º edition, South-Western College Pub