WORKING PAPERS

N° 17-801

May 2017

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APPLICATION OF TIME SERIES TECHNIQUES IN RELEVANT MARKET DELIMITATION
The Brazilian experience

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ABSTRACT

A key issue in the analysis of mergers in antitrust is the relevant market definition. The application of time-series techniques can be useful in this process, since only prices are required for the analysis, allowing for relatively rapid estimates. The objective of this work is to make an overview of the main time-series techniques used in the delineation of the relevant markets and make a qualitative analysis of the votes and technical notes of the cases involving the discussion of the application of time series in the relevant market definition submitted to the Brazilian Antitrust Authority (CADE). In this analysis, despite of its importance, there is a clear need for a careful assessment so the model can deliver robust and believable results. In addition, the importance of the hypothetical monopolist test and simulation methodologies for merger impact analysis are hardly replaced by time series techniques accordingly to Cade's recent decisions.

JEL: K21; L40; C22

I. INTRODUCTION

A key question for merger analysis, recommended by the recent reviewed Horizontal Merger Guidelines[3] of the Brazilian Competition Authority (CADE), as well as by other jurisdiction, is the relevant market delimitation. It is the unit of analysis to assess the consequences of anticompetitive 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 effects of the merger.

Distinct methodologies are used to delineate relevant markets. The Department of Economic Studies (DEE) of Cade emphasizes the importance of the Hypothetical Monopolist Test (TMH) in which the relevant market is defined as the smallest group of products and the smallest geographic area necessary for an alleged monopolist to be able 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 research[4].

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. The objective of this work is to take a look at the main time series techniques and to make a qualitative analysis of three recent cases involving its application in Brazil. In spite of its importance, it is clear the necessity for a careful evaluation of the assumptions used in the models.

The work is divided as follows: second section resumes the main characteristics of the time series in the context of econometrics; third section presents the main time series techniques used in antitrust analysis in Brazil; fourth section presents three cases of concentration judged by CADE in which time series techniques played a central role; fifth section contains final comments and briefly discusses the main limitations with respect to these techniques.

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[2] The views expressed in this publication do not necessarily reflect the views of Cade.

[3] 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.

[4] 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.

II. TIME SERIES DATA

Wooldrigde (2002) assumes that econometrics is based on the development of statistical methods for estimating economic relations, testing theories and valuing public and private sector policies. This is a fairly broad definition and covers a number of methodologies that have been developed over time. However, it is possible to distinguish three groups with respect to the characteristics of data 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 of time, such as the National Survey of Household Sample (PNAD) and the Household Budget Survey (POF), both conducted by the Brazilian Statistics Institute (IBGE). Here, each unit of analysis constitutes an observation. By 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 of time. In this way, the observations vary according time and the unit of analysis.

Each of the aforementioned groups has its characteristics. 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), the analysis of time series 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. Observations are results of stochastic processes, that is, each value obtained in time is an embodiment of 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 (2009) describes two forms of stationarity. A time series is strictly stationary if its joint distribution function over time is invariant

$$F\left(y_{t_1}, y_{t_2}, y_{t_3}, \dots, y_{t_k}\right) = F\left(y_{t_1+h}, y_{t_2+h}, y_{t_3+h}, \dots, y_{t_k+h}\right), \text{ for all } h \in Z \quad (1)$$

This 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. A time series is weakly stationary if its mean, variance and covariance are constant in time, that is:

$$E(y_t) = \mu \quad (2)$$

$$E(y_t - \mu)^2 = \gamma_0 < \infty \quad (3)$$

$$E = (y_t - \mu)(y_{t-j} - \mu) = \gamma_j \quad (4)$$

Expression in (2) is the condition of constant mean, the expression in (3) is the condition of constant and finite variance and in (4) the covariance of the condition depends only on *j* lag, not *t*.

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. Consider the following regression:

$$y_t = \rho y_{t-1} + u_t \quad (5)$$

This will be a random walk (there is a unit root) if ρ=1. In this case:

$$y_t - y_{t-1} = u_t \quad (6)$$

The first difference is equal to the error term, which by definition is stationary because it is a white noise (zero mean, constant variance and not autocorrelated). Stationary series in first difference are commonly denoted as I (1), that is, integrated of order one. In the case of (5), it is a stationary process. Several tests were proposed in the literature, among them Dickey-Fuller, augmented Dickey-Fuller, Phillips-Perron and KPSS.

Stationarity is a fundamental condition for the analysis of univariate and multivariate series. An univariate model is based on a single data series and forecasts are modeled as a function of random shocks (moving averages (MA)) and lagged (auto regressive (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 or not to the same relevant market. The following are the main methods applied in this type of analysis. We separate the appropriate techniques for when series are stationary or non-stationary.

III. TIME SERIES TECHNIQUES FOR ANTITRUST

A. Stationary time series techniques

1.1.1. Simple and parcial correlation

Correlation is a fairly widespread concept in statistics and can be useful in delineating relevant markets. The simple correlation between two variables x and y can be expressed by:

$$\rho_{xy} = \frac{cov(x,y)}{\sqrt{[var(x)\, var(y)]}} \qquad (7)$$

In the context of time series and following the notation proposed in Haldrup (2003), the simple correlation can be defined as:

$$\rho_{xy} = \frac{\sum_{t=1}^{T}(x_t-\bar{x})(y_t-\bar{y})}{\sqrt{[\sum_{t=1}^{T}(x_t-\bar{x})^2 \sum_{t=1}^{T}(y_t-\bar{y})^2]}} \qquad (8)$$

Where $\bar{x}$ and $\bar{y}$ are the mean values. The correlation coefficient, therefore, belongs to the interval [-1,1], indicating 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 degree of correlation between prices due to arbitrage. If there is a price increase in a relevant market in one region, consumers might prefer to buy from another region, which tends to reduce the price in the first one and raise 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 regarding correlation analysis: the first one 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. 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 their prices (assuming no collusion) and presents its own time series for the price of gasoline. However, the government decides to raise a tax on the commercialization of gasoline, so prices will be high in both stations without a direct or causal relationship between them. 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. Partial correlation, as defined by Haldrup (2003), would be the correlation between adjusted price series without the interference of external common factors.

Keeping the example of gasoline prices, it is possible to remove the effect of the government decision by means of the following regressions:

$$x_t = \hat{\beta}_0 + \hat{\beta}_1 D_t + \hat{u}_{1t} \qquad (9)$$

$$y_t = \hat{\beta}_2 + \hat{\beta}_3 D_t + \hat{u}_{2t} \qquad (10)$$

Where x_t and y_t are the price series of gas stations and D_t is a dummy that takes value 1 in the months when there was the tax increase. Residual $\hat{u}_{1t}$ and $\hat{u}_{2t}$ can be interpreted as the free price series of external influence, so a correlation analysis between these residues is a partial correlation analysis. As these last are white noise (with zero mean), the partial correlation would have the following form:

$$\rho_{xy}|_{D_t} = \frac{\sum_{t=1}^{T}\hat{u}_{1t}\hat{u}_{2t}}{\sqrt{[\sum_{t=1}^{T}(\hat{u}_{1t})^2 \sum_{t=1}^{T}(\hat{u}_{2t})^2]}} \qquad (11)$$

Possible external shocks should be analyzed with caution on a case-by-case basis. For the analysis of partial correlations it may be necessary to draw seasonal effects, government policies, external shocks among other factors. The idea is the same as the example analyzed.

Another problem pointed out by Davis and Garcés (2012) regarding the use of price correlations in the relevant market delimitation concerns the understanding of what is behind the price behavior of two differentiated products. This type of assessment is based on the assumption that the determinant of co-movement of prices is primarily consumer behavior, which replaces one product with another. However, there are other factors to be considered, not necessarily related to consumer behavior, which can generate false positives conclusions and spurious correlations.

1.1.2. Auto-regressive vectors (VAR)

According to Lutkepohl and Kratzig (2004), in the VAR models the variables are generally treated as endogenous. The series are modeled in terms of the lagged values themselves, constituting vectors of variables and matrices of coefficients to be estimated. It is possible to understand if one variable impacts others, very useful in delimiting relevant markets. In general, one VAR of order *p* and *k* variables can be represented by:

$$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \cdots + A_p Y_{t-p} + u_t \qquad (12)$$

Y_t is a vector containing $(Y_{1_t}, Y_{2_t}, \dots, Y_{k_t})$ stationary variables, A_i $(i = 1, \dots, p)$ are the coefficients matrix and $u_t = (u_{1_t}, u_{2_t}, \dots, u_{k_t})$ is the matrix that contains the error terms of each variable.

The model (12) is known as a VAR in its reduced (or unrestricted form) because it is a model that has no restrictions and relations based on economic theory. From an unrestricted VAR it is possible to obtain a structural VAR by means of orthogonalization of the error term. The matrix of variance and covariance of errors is a diagonal matrix, ie, the main diagonal would indicate the variances of the errors and there would be no covariance between contemporaneous errors. For instance, the variance and covariance matrix in (12) $\sum_u = E(u_t u_t')$ can be expressed. as a symmetric, positive and definite matrix. And there is a nonsingular matrix *P* such that $\sum_u = PDP'$ where D is a diagonal matrix. Therefore $P^{-1} \sum_u P'^{-1} = D$. One way to diagonalize the matrix of variance and covariance is to multiplie (12) by P^{-1} which results:

$$P^{-1} Y_t = P^{-1} A_1 Y_{t-1} + P^{-1} A_2 Y_{t-2} + \cdots + P^{-1} A_p Y_{t-p} + v_t \qquad (13)$$

v_t is the new vector of error terms defined by $v_t = P^{-1} u_t$. The new residual matrix of variance and covariance is $\sum_v = E(v_t, v_t') = P^{-1} E(u_t u_t') P'^{-1} = P^{-1} \sum_u P'^{-1} = D$ therefore a diagonal matrix. The model (13) is a structural or restricted VAR because the transformation carried out imposes a series of contemporary relations by P^{-1}[5].

The number of lags (*p*) in a VAR is usually defined by the selection criteria based on the maximum likelihood function where Akaike and Schwarz criteria is the most used. After defining the number of lags, we highlight the importance of autocorrelation tests between the residues since its presence may require the inclusion of a greater 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 in which 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). For illustration, consider a VAR (2) with two variables and in the non-matrix form:

$$y_t = \beta_1 y_{t-1} + \beta_2 y_{t-2} + \beta_3 x_{t-1} + \beta_4 x_{t-2} + \varepsilon_1 \qquad (14)$$

$$x_t = \beta_5 y_{t-1} + \beta_6 y_{t-2} + \beta_7 x_{t-1} + \beta_8 x_{t-2} + \varepsilon_2 \qquad (15)$$

Where β's are the coefficients related to each lag of each variable. The idea is to analyze the joint significance of the coefficients using the F test: if the variable x precedes y then the F test should reject the null hypothesis $\beta_3 = \beta_4 = 0$ in equation (14). Likewise, in order to y temporally precede x it is necessary that the null hypothesis $\beta_5 = \beta_6 = 0$ is rejected at (15). So the results are an one-way Granger causality (from x to y or the reverse), a bidirectional causality (both temporally precede it) or no causality at all. Clearly, attesting the presence of Granger's causality is an important indicator in the delineation of relevant markets.

Much of the interest in VAR models are in the residual. Given a stationary model, it is possible to predict how a shock in a lagged variable interacts with the model. 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

[5] Further details can be seen in Johnston and DiNardo (1997) and Lutkepohl and Kratzig (2004).

relevant market if the model is robust.[6] This type of analysis, the Impulse Response Function, can be illustrated as follows. Using the matrix notation a VAR (1) can be expressed as:

$$Y_t = A_1 Y_{t-1} + u_t \quad (16)$$

As the VAR (1) is stationary, the same goes for Y_{t-1}. Therefore:

$$Y_t = A_1(A_1 Y_{t-2} + u_{t-1}) + u_t \quad (17)$$

$$Y_t = A_1^2 Y_{t-2} + A_1 u_{t-1} + u_t \quad (18)$$

The same is true for Y_{t-2}, Y_{t-3} and so on. It is possible to observe that a stationary VAR can be inverted in an infinite moving averages model with the following specification:

$$Y_t = u_t + M_1 u_{t-1} + M_2 u_{t-2} + \dots \quad (19)$$

The matrices reflect the effects of shocks in the variables model where they can be obtained from the matrices previously defined. The analysis may also be made for the structural VAR with some peculiarities due to the diagonalization procedure of the variance matrix and the error covariance.

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 to other variables over time. According to Lutkepohl and Kratzig (2004), the *h* forecasted periods beginning in *T* can be expressed in a matrix form:

$$Y_{T+h}|_T = A_1 Y_{T+h-1}|_T + A_2 Y_{T+h-2}|_T + \dots + A_p Y_{T+h-p}|_T \quad (20)$$

The corresponding forecast error is given by:

$$Y_{T+h} - Y_{T+h}|_T = u_{T+h} + \Phi_1 u_{T+h-1} + \Phi_2 u_{T+h-2} + \dots + \Phi_{h-1} u_{T+1} \quad (21)$$

For the analysis of the variance decomposition of forecast errors it is necessary the model to be expressed in orthogonal errors. In orthogonal form:

$$Y_{T+h} - Y_{T+h}|_T = \Psi_0 v_{T+h} + \Psi_1 v_{T+h-1} + \Psi_2 v_{T+h-2} + \dots + \Psi_{h-1} v_{T+1} \quad (22)$$

If the *ij-th* element of Ψ_n and $\psi_{ij,n}$, the *k-th* prediction error vector element becomes:

$$Y_{k,T+h} - Y_{k,T+h}|_T = \sum_{n=0}^{h-1} (\psi_{k1,n}\, v_{1,T+h-n}, \dots, \psi_{kK,n}\, v_{K,T+h-n}) \quad (23)$$

Considering the properties of the orthogonal errors it is possible to specify the variance of the prediction error as:

$$\sigma_k^2(h) = \sum_{n=0}^{h-1} ({\psi^2}_{k1,n}, \dots, {\psi^2}_{kK,n}) = \sum_{j=1}^{k} ({\psi^2}_{kj,0}, \dots, {\psi^2}_{kj,h-1}) \quad (24)$$

$({\psi^2}_{kj,0}, \dots, {\psi^2}_{kj,h-1})$ is the contribution of variable *j* for the variance of the forecast error *h* periods ahead of the variable *k*. Dividing this term by $\sigma_k^2(h)$ we get this contribution in percentage terms.

B. Technics with non-stationary series

When two or more time series are not stationary they can cointegrate, ie, indicates that both series may have a long-term relationship. Two or more integrated series of the same order (generally I (1) in the case of economic data) are cointegrated if they present a stochastic tendency in common and at least one stationary linear combination. This is an important issue to relevant market definition since prices of different products and/or 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.

1. Engle-Granger

[6] 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.

The test proposed by Engle and Granger (1987) aims to find only one cointegration relation between two or more variables. Suppose two variables y_t and x_t. The first step is to verify if the series are not stationary and if they are integrated in the same order. Suppose that both are I (1).The second step is to run an OLS to estimate the long-term relationship. There is no criterion for determining which variable will be the explanatory one neither which will be the dependent one though. This definition must be made by the analyst. Assuming y_t a vector of the dependent and x_t a vector of the explanatory the long-term relationship is given by:

$$y_t = \beta_0 + \beta_1 x_t + u_t \qquad (25)$$

After estimating (25) by OLS we obtain the residual term. Thus, the following linear combination is obtained:

$$\hat{u}_t = y_t - \beta_0 - \beta_1 x_t \qquad (26)$$

Finally we test for unit root in the residual. If it does not point to unit root it is possible to conclude that the series y_t and x_t are cointegrated.

One of the main criticisms related to Engle-Granger methodology relates to the unique cointegrating relation, regardless 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, each denoting one cointegration relation. 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). The author argues that a series I (I) does not necessarily present a constant mean or an increasing variance over time since shocks are permanent. Thus, if the difference between two logarithmized series is I (1), both series actually diverge from each other over time. Otherwise they walk through time in a common trajectory. Forni (2004) suggests the choice of the increased Dickey-Fuller and KPSS tests to verify the stationarity condition. If there is a presence of one unit root the products do not belong to the same relevant market (and vice-versa).

2. Johansen Cointegration Test

Johansen cointegration test (Johansen (1988) and Johansen and Juselius (1990)) has a main advantage in comparison to the Engle-Granger one for its allowance for the existence of multiple cointegrating vectors. The test is based on a VAR model, so variables are treated as endogenous in a dynamic scenario. There is no need to define a priori the dependent variable and the explanatory variables.

Johansen's cointegration test can be illustrated as follows. Assume an autoregressive process in matrix form as in (12):

$$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \cdots + A_p Y_{t-p} + u_t \qquad (27)$$

With some algebraic manipulation the following expression is obtained:

$$\Delta Y_t = \sum_{i=1}^{p-1} \tau_i \Delta Y_{t-1} + \pi Y_{t-1} + u_t \qquad (28)$$

On what:

$$\pi = -\left(I - \sum_{i=1}^{p} A_i\right) \qquad (29)$$

$$\tau_i = \sum_{j=i+1}^{p} A_j \qquad (30)$$

Expression (28) is a restricted VAR used when variables are not level stationary and cointegrated, also known as error correction model (VECM). The VECM models are widely used in the context of time series. They allow the Impulse Response Functions and the Decomposition of Forecast Error Variance analyses. As discussed in the VAR context, these two techniques are good indicators of market integration. Once variables are I (1) and cointegrated, the matrices τ_i represent the short-term coefficients while π contains the long-term coefficients and its cointegrating vectors.

The key issue is the rank of the π matrix, since this contains the exact number of cointegrating vectors. If the *rank=0* the variables are not cointegrated. But if *rank=n* the process is stationary. For intermediate cases the rank is the number of cointegrating vectors, as πX_{t-1} is the error term correcting factor. Enders (1995) affirms the number of different cointegrating vectors is obtained by the significant roots terms of π.Thus, π estimates and its number of feature roots are calculated in (31) and (32):

$$\lambda_{traço}(r) = -T\sum_{i=r+1}^{n} \ln(1-\hat{\lambda}_i) \quad (31)$$

$$\lambda_{max}(r, r+1) = -T ln(1-\hat{\lambda}_{r+1}) \quad (32)$$

$\hat{\lambda}$s are the estimated values of the characteristic roots, *r* is the number of cointegrating vectors and T is the number of observations. The first is the trace test and its null hypothesis is that the number of different vectors should be less or equal to *r*. The second test is the test of the maximum eigenvalue and it tests the null hypothesis that the number of cointegrating vectors is *r* against the alternative hypothesis of *r+1* vectors.

Regardless 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 indicates 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. Again, it is necessary to make a caveat in the application of cointegration tests for relevant market definition since, independently of how good the provided analytical instruments are, if the economic theory behind the equation is not well defined it is still possible to deliver false positives.

IV. TIME SERIES MODELS AND MARKET DEFINITION RECENT DEBATS IN BRAZIL

Here we illustrate three cases in which the debate about the application of time series to 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.

A. Braskem-Quattor

1. Time series techniques used by the parties

In 2010, Braskem, a giant company at the petrochemical sector in Brazil, sought CADE's approval for Quattor acquisition. Both companies produced thermoplastic resins such as polyethylene (PEAD, PEBD, PEBDL[7]) and polypropylene (PP) – so the operation would create a giant monopoly in the production of such resins. Assets consolidation would position Braskem as the largest petrochemical company in the Americas. The geographical size of this market was the most controversial point, since previous jurisprudence generally considered the relevant market as international[8].

The parties presented an economic study to test for relevant geographic market[9]. 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 domestic market, for international markets and for naphtha (as the cost shifter) for the polyethylene resins PEBD, PEBDL, PEAD and PP[10].

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.

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[7] Portuguese acronyms for High-density polyethelene, low-density polyethelene, linear, linear low-density polyethelene.

[8] 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 Vilias Cueva - it was not be possible to reach, "with a high degree of certainty, a conclusive definition of the geographical dimension".

[9] Merger Act No. 08012.001205/2010-65.

[10] PEBD: low density polyethylene; PEBDL: linear low density polyethylene; PEAD: high density polyethylene; PP: polypropylene.

Table 1. Johansen cointegration – trace and maximum eigenvalue

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

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

Deviations (), *t* statistics []. Source: Braskem/ Consultoria Tendências. Note: adjusted coefficents are significant considering only the results for the domestic market, being an 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 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	71.17	2.27	25.75	3.42

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

2. *SSNIP test*

In line with the Horizontal Merger Guidelines, the Reporting Commissioner asked for the parties a document presenting the SSNIP[11] test. The estimated equation for the demand elasticities was as follows:

$$\ln q_t = \alpha + \beta_1 \ln pbr_t + \beta_2 \ln pint_t + \beta_3 \ln y_t + \varepsilon_t \quad (33)$$

Pbr=log of the domestic prices for PP,PEBD, PEBDL and PEAD
Pint= log of the foreign prices
Y= log of the demand shock
Q= log of the total quantity sold of PP,PEBD, PEBDL and PEAD in the domestic market

The authors used 3 estimating methodologies in which the presented instruments were the lagged price for the naphta, both in level and in first difference. The first GMM estimations showed demand elasticies 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 summary, the authors reached a formal conclusion that the relevant market should include resins imports, depending on the period.

Table 5. Critical loss

	ΔPrice	Demand	Critical elasticities
Profit maximization	5%	Linear	-2.27
		Constant elasticie	-2.68
	10%	Linear	-1.85
		Constant elasticie	-2.50

Source: Braskem/ Consultoria Tendências.

3. *The role of the Department of Economic Studies*

The Department of Economic Studies (DEE) stressed that simply correlation between domestic and foreign markets would not imply in relevant market definition because this could simply reflect firms precification strategy. Regarding the methodologies, the Department also identified inconsistencies in the granger causality and in the variance decomposition. First, the chosen model was a VAR in first difference without structural break, but the most

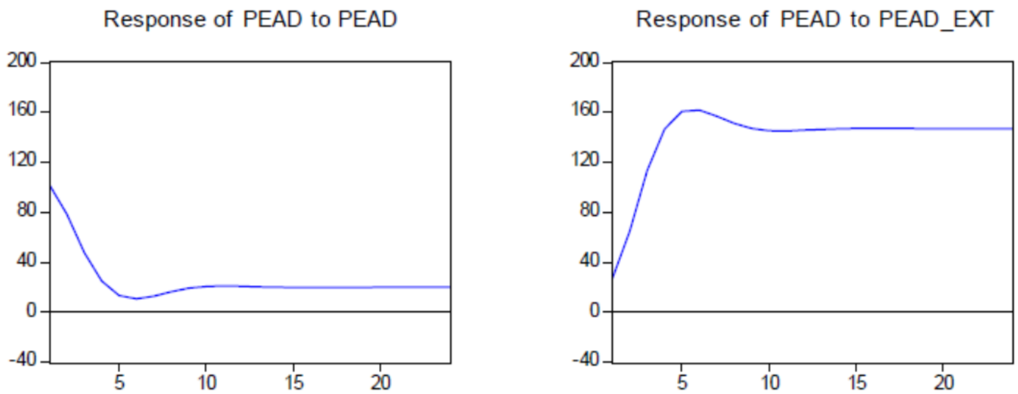
[11] Small but significant and non-transitory increase in price.

suitable one for interpretations should be the VEC with structural break. In this case, Granger causality of foreign to domestic price was not verified.

Second, DEE highlighted the misinterpretation of the price ordering. Cost prices (i.e. naphta) also anticipated the movement of foreign prices in the VEC, as well as in the Granger test. In this case, there would be no reason to believe in the ordination naphtha → foreign price → domestic price, in which there is 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. For domestic price shocks it was identified a short run price augmentation. Considering a foreign price shock, however, this effect lasted for a longer period, pointing to a possible international market definition (Figure 1)[12].

Figure 1. Impulse reponse for PEAD prices.



Note: Shocks are price standard 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 variance in domestic prices were explained by the variance in international prices; iii) Finally, critical loss test showed no strong evidence against the international market hypothesis. Thus, it ruled for an understanding for the international geographic market. The case, though, was approved with behavioral remedies in which the new company had to report the monthly imported quantity for each resin and any importing contract signed between foreign and national industry.

B. Braskem- Solvay

At the end of 2013, Braskem proposed the acquisition of its competitor Solvay, located in Brazil and Argentina[13]. 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 the production of polyethylenes and propylenes. This time, the main resin involved was PVC[14], which can be commercialized as suspension (PVC-S) or emulsion (PVC-E).

1. 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. Database contained average monthly price information for domestic[15] and foreign prices of PVC-S[16] between January 2008 and July 2013. The authors included a dummy during an antidumping period when US imports were overtaxed on 16%. Another dummy was added to cover the financial crisis between 2008 and 2009. For cost control, naphtha and ethane prices were also included.

[12] 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.

[13] Merger Act No. 08700.000436 / 2014-27.

[14] Polyvinyl chloride

[15] Average price of Solvay and Braskem

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

For the null hypothesis of non-cointegration, the study presented trace statistics, 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/ Tendencias. Critical values accordingly to Johansen, Mosconi and Nielsen (2000).

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/ Tendencias. Critical values accordingly to 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/ Tendencias. P-values in (), t-statistics in [].

For the variance decomposition, the study observed a long run relationship (over 12 months) for which the foreign price explained the domestic price (around 70% using ethane as a cost control and 60% using naphtha). So claimants' economists corroborated the correlation hypothesis between domestic and foreign prices. To complement they also proceeded to an impulse-response function analysis. The shock of foreign prices on the domestic ones caused a long-run impact on domestic prices, not reversible in 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.

2. 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 since there were 2 cointegrating equations and only 2 endogenous variables the series should be interpreted as stationary. Using a simply correlation analysis for domestic and foreign prices, the strongest relation was found between domestic and US-Gulf price, contradicting 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 price caused domestic prices. In the interpretation, however, it observed the strongest effect from the US-Gulf prices, similar to the correlation analysis.

Table 9 - Granger Causality – Ethane

Direction of Causality			X test ^{2}	Degrees of freedom	Decision
Brazil		Gulf (USA)	0.57	2	accepted
Brazil		NE Asia	0.91	2	accepted
Brazil		SE Asia	1.53	2	accepted
Brazil		Europe NWE	1.70	2	accepted
Gulf (USA)	Not Granger-cause	**Brazil**	6.67	2	Rejects 5%
NE Asia		**Brazil**	3:49	2	accepted
SE Asia		**Brazil**	0.31	2	accepted
Europe NWE		**Brazil**	4.07	2	accepted
ALL		**Brazil**	10.96	4	Rejects 5%

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

Table 10 - Causality Granger – Naphtha

Direction of Causality			X test ^{2}	Degrees of freedom	Decision
Brazil		Gulf (USA)	0.99	2	accepted
Brazil		NE Asia	1.58	2	accepted
Brazil		SE Asia	2.99	2	accepted
Brazil		Europe NWE	2.86	2	accepted
Gulf (USA)	Not Granger-cause	**Brazil**	7.17	2	Rejects 5%
NE Asia		**Brazil**	3.17	2	accepted
SE Asia		**Brazil**	0.18	2	accepted
Europe NWE		**Brazil**	4.09	2	accepted
ALL		**Brazil**	13.63	4	Rejects 1%

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

Table 11 - Granger causality test results for the model without constant

Method	Direction of Causality			Chi2 test	p-value	Decision
VEC	PS Brazil	Not Granger-cause	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		PS Asia	6.24	1.2%	rejects
VEC	PS Asia		PS Brazil	2.39	12.2%	accepted
VAR	PS Brazil		ABS Asia	0.44	50.5%	accepted
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 08700.000436/2014-27vol. 13, pag. 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 2 stage 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**	_0.587***	_0545**	_0.530***	0.783***	_0.640***
	(0.212)	(0.196)	(0.225)	(0.164)	(0.250)	(0.191)
lnEthane	0.068	0.101	0.074	0.115*	0.157*	0.131*
	(0.089)	(0.081)	(0.090)	(0.068)	(0.084)	(0.073)
IBC-Br (GDP)	0.000	0.002	0.001	-0.001	0.002	-0.001
	(0.005)	(0.004)	(0.005)	(0.004)	(0.008)	(0.004)
Constant	14.646***	14.914***	14.933***	14.721***	16.078***	15.477***
	(1.616)	(1.663)	(1.696)	(1.272)	(2.323)	(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. Estimations controlled by the international ethane price. 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, pag. 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, pag. 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 domestic production of PVC would not be rivaled by other products in other geographical regions. The relevant market of this product would have national geographic dimension.

3. 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 ASA[17] merger in the UK. Considering plants' interruptions effect in the Brazilian PVC market, DEE sought to determine whether there was an increase of imports, their main origins and their impacts on domestic resin prices. Regressions 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:

$$\boldsymbol{Y_{it} = \alpha X_{it} + \gamma T_{it} + \rho t_{it} + \beta(T_{it} t_{it}) + \varepsilon_{it}} \quad (34)$$

Data for this experiment included imported quantity of polystyrene (PS) as the control group because this type of resin was not produced by both firms. 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 programmed plant interruptions were frequent during this period[18] and the loss of production was around 26% of installed capacity.

DEE estimations using 2OLS were based on the regressions between 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 * Tratamento (t: t+1)	O.472***	O.897***				
	[0.0563]	[0.0701]				
PVC * Tratamento (t: t+2)			0.299***	0.308***		
			[0.0238]	[0.0297]		
PVC * Tratamento (t: t+3)					0.157***	0.0737***
					[0.00949]	[0.000703]

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

[17] Operation notified to the European Commission on 17 July 2007. For details, see Amelio A .; De La Mano, M. and Godinho, M. (2008).

[18] Confidentiel information.

Table 15 - "diff-in-diffs" North American imports

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

Source: Merger act 08700.000436/2014-27vol. 16, pag. 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 * Tratamento (t: t+1)	0.0563	0.138***				
	[0.0507]	[0.0273]				
PVC * Tratamento (t: t+2)			0.0435***	0.00738		
			[0.00198]	[0.0172]		
PVC * Tratamento (t: t+3)					-0.0712***	-0.0867
					[0.0121]	[0.0]

Source: Merger act 08700.000436/2014-27vol. 16, pag. 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 * Tratamento (t: t+1)	0.279***	0.00815				
	[0.108]	[0.0569]				
PVC * Tratamento (t: t+2)			(-0.951)***	0.649***		
			[0.0656]	[0.0243]		
PVC * Tratamento (t: t+3)					0.339***	0.0267
					[0.0914]	[0.0507]

Source: Merger act 08700.000436/2014-27vol. 16, pag. 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 but only 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. The Department also stressed the importance of qualitative analysis, such as the presence of stocks and anti-dumping measures applied to other countries, which distorted the results of econometric evaluations.

In his opinion, Reporting Commissioner Araujo (2014) concluded the relevant geographic market as South America, with moderate degree of rivalry in North America. 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.

C. Videolar and Innova

In July 2013, Videolar SA asked for the clearing of 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 Manaus[19]. Innova was a stated owned enterprise in Rio Grande do Sul state whose main product was PS but who also commercialized acrylonitrile-butadiene-styrene (ABS), styrene acrylonitrile (SAN) and styrene through imports. With no other national producers of PS, the new company would become a monopoly. The

[19] 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.

main argument from the parties was that ABS and PP would be perfect substitutes of PS, since it is an older resin being actually replaced by the former. However, during the process analysis, the General Superintendence did not agreed 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 ABS[20].

1. *International relevant market and ABSxPS substitution*

The parties presented a series of correlation and cointegration tests among the prices of polystyrene (PS) in Brazil, in the United States and in Asia to verify if products in 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 in 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. Table 18 reports the results, where significance mean presence of unit root and, accordingly to the parties, cointegration.

Table 18 – Cointegration tests

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

P values ().Source: Merger act 700.009924/2013-19, vol. 04, pages: 173-205.

Table 19 – Causality tests

Null hypothesis			Constant	No constant
			F test	F test
PS Brasil	does not Granger Cause	PS USA	5,3072	6,9037
PS USA		P5 Brasil	2,3374	1,8773
PS Brasil		PS Europa	0,1266*	0,3859*
P5 Europa		PS Brasil	14,689	10,952
PS Brasil		PS Ásia	0,3297*	1,4853*
PS Ásia		PS Brasil	17,153	15,368
PS Brasil		ABS Ásia	0,0057*	0,4462*
ABS Ásia		PS Brasil	3,5052	3,8991
PS Brasil		PP Ásia	0,0964*	0,0965*
PP Ásia		P5 Brasil	6,5374	6,5374

*accepts the null hypothesis. Source: Merger act 700.009924/2013-19, vol. 04, pages: 173-205.

The study pointed for the existence of cointegration among prices in Brazil and all international prices of PS, as well as a long-term relationship among these and ABS/PP prices.

2. *DEE's cointegration analyses*

[20] 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.

The Department of Economic Studies replicated the cointegration test using the Johansen methodology and reached a different conclusion illustrated in Table 20: 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).

Table 20 – Johansen cointegration test run by DEE

	Is there cointegration with PSBRA?			
	eigenvalue		trace	
	No constante	Constante***	No constante	Constante***
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 700.009924/2013-19, vol. 17, pages: 167-206.
*One lag. **two lags. ***considering the same model used in the parties' study.

For the Granger causality, DEE tested a VEC model for variables in differences since they were not stationary.

Table 21 – Granger causality (no constant)

Methodology				**Chi2**	**p-value**	**Conclusion**
VEC	PS Brasil	Não Granger-Causa	PS USA	4,97	2,6%	Rejects
VEC	PS USA		PS Brasil	4,47	3,4%	Rejects
VEC	PS Brasil		PS Europa	4,92	2,6%	Rejects
VEC	PS Europa		PS Brasil	6,44	1,1%	Rejects
VEC	PS Brasil		PS Ásia	6,24	1,2%	Rejects
VEC	PS Ásia		PS Brasil	2,39	12,2%	Accepts
VAR	PS Brasil		ABS Ásia	0,44	50,5%	Accepts
VAR	ABS Ásia		PS Brasil	3,96	4,7%	Rejects
VAR	PS Brasil		PP Ásia	14,74	0,1%	Rejects
VAR	PP Ásia		PS Brasil	12,01	0,2%	Rejects

Source: Merger act 700.009924/2013-19, vol. 17, pages: 167-206.

With these modifications, DEE observed that conclusion obtained from former analysis would be sensitive to methodological changes. Results showed no relationship between Asian prices of ABS and PP in relation to 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.

3. *Hypothetical Monopolist Test (TMH)*

Dropping the hypothesis that ABS and PP would be part of the same product market of PS, the Department proceeded 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.

The following regression was estimated:

$$lnQv_i^M = \alpha_{0,i}^M + \alpha_{1,i}^M lnP_i^M + \sum_{k=1} \gamma_{k,i}^M X_{k,i}^M + \varepsilon_i^M \qquad (35)$$

Where Qv is the sold quantity of PS, P is its sold price, Xk is a matrix of controlling variables such as income (proxied by IBC-BR) and dummies for seasonal effects. As instruments, it was used energy and labor costs used in the production of PS and the lagged price series. The estimated price-cost margins were already high (25%-37%) which would already make 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.

Table 22 – Critical loss

	m=25%				*m*=37%			
	Linear		Isoelastic		Linear		Isoelastic	
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 700.009924/2013-19, vol.21 pag. 153-170.

Table 23 – Demand estimations

	1	2	3
lnP	-0.858***	-1.285**	-0.902***
	[0.282]	[0.562]	[0.259]
lnP (imports)		-0.196	-0.244**
		[0.132]	[0.110]
IBC-Br	0.0276***	0.0248***	0.0240***
	[0.00588]	[0.00517]	[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 700.009924/2013-19, vol.21 pag. 153-170.

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 level of production in the north and south plants, styrene and polystyrene patents licensing, adoption of a compliance program and not acquiring any further resin plan for the next 5 years. The Court agreed on the remedies agreement and the case was cleared in October 2014.

V. FINAL REMARKS

Cade's latest decisions regarding the use of time series methods in relevant market definition have gone in the direction placed by main references in the antitrust literature: in spite of 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 analysis used by the Brazilian Competition Authority in 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 as "quick and dirty" (on one hand there is the advantage of speed, on the other there is the disadvantage of lack of reliability and robustness). Ideally, these types of analyzes are complementary to other tests more appropriate for antitrust analysis, such as the hypothetical monopolist test.

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