TRADE SPECIALIZATION IN LIGHT VEHICLE FUELS BETWEEN BRAZIL AND OTHER AMERICAN COUNTRIES:
An analysis through the intra-industry trade viewpoint

By

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ABSTRACT

This paper analyzes the specialization in light vehicle fuels trade – including alcohol and gasoline – between Brazil and the other American countries; the latter being analyzed as a group. The analysis has two stages. Brazilian export supply and import demand functions are first estimated as transfer function models. Then, the Grubel and Lloyd index (GLI) is calculated, based on inside sample forecasts for the period between 2000 and 2005, and on projections for the years 2006 and 2007. The verification of the models performance suggests that, although the predicted index apparently overestimates the intra-industry trade, its behavior is coherent with the one identified through the observed data, indicating specialization on imports between 2000 and 2003, as well as diversification in the two years following it. In three different scenarios for the domestic income variation, the resulting GLI suggests export specialization for 2006 and 2007, highlighting the paradigm change in this trade flow.

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1 INTRODUCTION

Since the 1990s, lower interventionist policies have been adopted in the Brazilian economy, leading many productive sectors to an increasing market exposure. Among them, the sugar cane and the fuel chains stand out: their productive and commercial activities are undergoing significant changes due to the Government deviations from its previous coordination functions.

The petroliferous sector in Brazil, as well as sugar cane's, used to be characterized by a high level of government intervention. Production, commercialization and price control were tightly linked to economic, energetic, social and tributary questions. The opening of the sugar cane market in Brazil started with the extinction of the Sugar and Ethanol Institute (*Instituto do Açúcar e do Álcool*) in 1990 and with a gradual price liberalization in the sector. In 2002, the petroliferous sector also started a transition stage for its operation in a deregulated market. Since then, planning and execution of productive and trade activities have become private management responsibilities, raising new possibilities for activities delimitation in these sectors (Marjotta-Maistro, 2002).

In this new context, the sectors' agents started to pay attention to factors that could increase their competitiveness. Among these factors, information about the trading of products and the market performance can be highlighted, justifying the efforts on researches to understand the market's mechanisms and its most important variables.

The anhydrous alcohol is used mixed with gasoline and the hydrated alcohol is a fuel for the ethanol-propelled car fleet. Decisions about the proportion in which anhydrous alcohol is added to gasoline are taken considering the ethanol production expectancy or its availability, frequently seeking price stability.

This article aims to analyze the trade flow in light vehicle fuels (ethanol and gasoline) between Brazil and other American countries, in order to identify the specialization pattern observed in this market. Also, it intends to evaluate the impact of domestic income over the intra-industry trade through Grubel and Lloyd's Index estimation and projection.

A better comprehension of intra-industry trade is essential for the definition of the best commercial policy strategy in a world with strong trade groups and where the trade flows are increasingly characterized by this type of trade.

2 INTRA-INDUSTRY TRADE

2.1 Definition and determinants

The intra-industry trade consists on simultaneously exporting and importing products from the same industry. On the other hand, in the inter-industry trade, the countries export and import products from different industrial sectors.

Unlike the inter-industry trade, the intra-industry trade is not consistent with the traditional theory of international trade. Some hypotheses for the explanation of this phenomenon can be found only in recent literature. In general, such hypotheses are related to the characteristics of the industries and the countries involved in the trade.

Krugman and Obstfeld (2001) associate the existence of intra-industry trade to the occurrence of market failures and economies of scale. Considering an industry on monopolistic competition, the products from many firms inside the same industry can't be taken as identical, though they are seen as close substitutes by the consumers. Then, one might expect a positive relation between the intra-industry trade and the level of product differentiation inside each industry. Considering the existence of economies of scale in the production of various goods inside the industry, it would be much more helpful for a country to specialize in the production of only a limited set of products and establishing interchange for the achievement of the other goods also demanded, but which are not produced domestically. Then, the economies of scale would avoid all the countries to produce all set of products, increasing the intra-industry trade.

Besides the economies of scale and the market failures, Hidalgo (1993) also considers trade liberalization and economic integration among countries as factors that stimulate the growth of intra-industry trade. On the other hand, trade restrictions (either tariff or non-tariff), transportation costs and the distance between countries impose limits to this type of trade. So, one might expect that countries with common borders present a higher intra-industry interchange flow.

For Ruffin (1999), while the existence of differences between countries is the basic cause of the inter-industry trade, the importance of their intra-industry trade relies on their similarities. In this way, Hidalgo (1993) highlights some of the countries' characteristics, such as income and size of the economy, as determinant factors of the intra-industry trade. The theory suggests that the intra-industry trade is directly related to the average per capita income and domestic market size. But, the intra-industry trade is expected to be inversely proportional to the difference on their per capita income and to the differences on the size of their economies.

According to Kenen (1998), an increase in the countries' income might have a positive effect on the intra-industry trade: the consumers tend to spend an increasing proportion of their income on sophisticated industrialized products, which tend to be highly differentiated.

The importance of intra-industry trade, according to Krugman and Obstefeld (2001), relies on the fact that it produces additional international trade earnings, higher than the comparative advantage gains, once it enables the countries to benefit from larger markets. With the growth on the intra-industry trade, the country is able to, simultaneously, reduce the number of goods it produces and increase the variety available for the domestic consumption. Producing fewer varieties, the country can produce each good in a larger scale, with higher productivity and lower costs, at the same time that consumers benefit from increases in their options. Besides that, Ruffin (1999) points out that the intra-industry trade stimulates the innovation and the development of new technologies, but it doesn't cause the distortions associated to the inter-industry trade over the production factors – once the factors' reallocation occurs inside the same industry, and not between capital or labor intensive industries.

2.2 The Grubel and Lloyd index

The Grubel and Lloyd intra-industry trade index (Grubel & Lloyd, 1975) seeks to reflect the value of an industry export that is exactly compensated by the imports of the same industry, and it can be represented as:

$$GL_i = \frac{(X_i + M_i) - | X_i - M_i |}{(X_i + M_i)}, \quad \text{with} \quad 0 \leq GL_i \leq 1 \tag{1}$$

where:

X_i = export value from industry *i;*

M_i = import value from industry *i;*

$(X_i + M_i)$ = trade flow from industry *i*;

$| X_i - M_i |$ = inter-industry trade;

$(X_i + M_i) - | X_i - M_i |$ = intra-industry trade.

The index varies from zero to one. If the index is equal to 1, then $X_i = M_i$. In this case, the trade is perfectly balanced, which means that it's all intra-industry. On the other hand, if the index is zero, the trade is unilateral (which means that $X_i = 0$ or $M_i = 0$. In this case, all the trade is inter-industry.

2.3 Empirical evidences for the Brazilian economy

Many papers analyze the intra-industry trade in the Brazilian economy through the measurement of the Grubel and Lloyd index (from now on, GLI). Among them, some results from Hidalgo (1993), Vasconcelos (2003) and Campos & Hidalgo (2004) will be presented in this section.

Hidalgo (1993) analyzed the pattern of intra-industry trade in Brazil for the period between 1978 and 1987. These results showed an increasing participation of intra-industry trade, reaching 40% of the total trade on manufactured products by the end of the period, which is equivalent to the rate observed in countries with recent industrialization. About the determinants of the intra-industry trade, the results confirm that this trade is more frequent with more differentiated products and where there are fewer barriers. On the other hand, the bilateral intra-industry trade tends to increase with the level of economic development and with the size of the markets. A significant intra-industry trade between Brazil and the developed countries or the main trade partners from Latin America was observed, while this type of trade with most the other developing countries was insignificant.

Vasconcelos (2003) tries to analyze the contribution of intra-industry trade in the growth of the Brazilian trade flows inside Mercosur during the 90s. The results obtained emphasize that the growth in the trade interchange between Brazil and the other Mercosur countries occurred basically due to an increment on the intra-industry trade flow. Regarding the contribution of the intra and extra group trade flow for the growth on the multilateral Brazilian intra-industry trade, it was considered expressive and with an increasing trend, confirming the hypothesis that commercial liberalization (in this case, through the implementation of Mercosur) increases the intra-industry trade indexes.

On their article, Campos & Hidalgo (2004) investigate the impacts of the trade opening and the intra-industry over wages inequalities between qualified and “less-qualified” workers in the Brazilian process industry. The results enabled to conclude that the intensification of the intra-industry trade was responsible for the increase in the income inequalities between the groups of workers analyzed.

It’s important to say that a paper related to intra-industry trade, specifically for the fuel sector, was not found in the Brazilian literature. Also, there isn’t any paper evaluating GLI answers to changes in the domestic income. Therefore, the analysis developed in this article differentiates from the previous ones.

3 METHODOLOGY

3.1 Theoretical model for the export function

Analogously to the model proposed by Barros et al (2002), it can be said that:

$$Q^x = Q^s - Q^d \qquad (2)$$

or, putting it into words, the exported quantity (Q_x) equals the domestically supplied amount (Q_s) that is not absorbed by the Brazilian demand (Q_d).

From the literature, it's known that the demanded quantity (q^d) is directly proportional to the domestic income level (or to its proxy per capita income - rpc) but inversely proportional to the domestic price level (p). So, it can be written like that:

$$q_t^d = \alpha + \beta p_t + \theta rpc_t + \upsilon_t \qquad \beta > 0,\ \theta < 0 \tag{3}$$

where υ_t is a random error. Regarding the amount supplied by the domestic producers (q^s), only the effect of domestic price was considered. Then:

$$q_t^s = \gamma + \delta p_t + \nu_t \qquad \delta > 0 \tag{4}$$

with ν_t also being a random error.

From the substitution of equations (3) and (4) on equation (2) it can be written that:

$$q_t^x = \gamma + \delta p_t + \nu_t - (\alpha + \beta p_t + \theta rpc_t + \upsilon_t) \tag{5}$$

or, even after some algebraic simplifications:

$$q_t^x = (\gamma - \alpha) + (\delta - \beta) p_t - \theta rpc_t + (\nu_t - \upsilon_t) \tag{6}$$

Since $\beta < 0$ and $\delta > 0$ (from the initial model specification), the logarithm of the exported quantity (q^x) is expected to be inversely proportional to the logarithm of the domestic price level (p). Also according to the equation (6), exports are expected to be inversely proportional to changes on the per capita income.

As in Barros et al (2002), international prices can be represented like:

$$p_t - p_t^x = m_t \tag{7}$$

where p^x is the international price (in local currency) and m_t is the export margin (which can be expressed as a proportion of the domestic price level: μp_t). But international prices are expressed in US$, so:

$$p_t^x = cr_t + \left(p_t^x\right)^* \tag{8}$$

where cr_t is the real effective exchange rate and $(p_t^x)^*$ is the international price level (both on their logarithms). Substituting (8) and the margin value as a function of domestic prices into (7) results in:

$$p_t = cr_t + \left(p_t^x\right)^* + \mu p_t \tag{9}$$

which, on its turn, substituting the domestic price level in (6) and adding dummy variables to filter seasonality, achieves the econometric model used representing the export function (and whose parameters had to be estimated for the GLI projection):

$$q_t^x = \rho + \varphi cr_t + \eta\left(p_t^x\right)^* + \lambda p_t + \theta rpc_t + \sum_{i=1}^{11} \kappa_i D_{it} + e_t \tag{10}$$

with D_i being dummy variables to represent different months (December was considered the reference month) and $\varphi > 0$, $\eta > 0$, $\lambda < 0$, $\omega < 0$ and $\theta < 0$.

The assumption of homogeneity between the exchange rate, the international price and the domestic price implies that the same magnitude variation on cr, $(p^x)^*$ or p must have the same impact over the exported quantity and, then, the following linear restriction must be imposed to the parameters:

$$\varphi = \eta = -\lambda \tag{11}$$

So equation (10) is reduced to:

$$q_t^x = \rho + \varphi rel + \theta rpc_t + \sum_{i=1}^{11} \kappa_i D_{it} + e_t \tag{12}$$

where:

$$rel = cr_t + \left(p_t^x\right)^* - p_t \tag{13}$$

3.2 Theoretical model for the import function

According to Blanchard (2001), the imports depend basically on the general level of the domestic demand and on the real exchange rate. Then, it can be written that:

$$m = m(Y, \lambda) \tag{14}$$

where: m is the import quantity;
Y is the real income;
λ is the real exchange rate;

with $\frac{\partial m}{\partial Y} > 0$ and $\frac{\partial m}{\partial \lambda} < 0$. In words, the increase in the real income level leads to growth on imports, while the increase in the real exchange rate reduces it.

3.3 Econometric procedures

3.3.1 Unit root and co-integration tests

To verify if a time series is stationary, Augmented Dickey-Fuller (ADF) tests – developed in Fuller (1976) and Dickey & Fuller (1979 and 1981) – were performed, following the procedure suggested by Enders (1995). This test is used to verify the integration order of a time series, namely Y_t, pointing out the existence (or not) of a unit root through the following regression model:

$$Y_t = \beta_1 + \beta_2 t + \rho Y_{t-1} + e_t \quad \text{or} \quad \Delta Y_t = \beta_1 + \beta_2 t + \gamma Y_{t-1} + e_t \tag{15}$$

where t is a deterministic trend, e_t is a random error and $\gamma = \rho - 1$.

The ADF test also incorporates on equation (15) lagged values from the dependent variable (ΔY_t) in order to eliminate autocorrelation problems.

According to Gujarati (2000), the ADF test statistics have the same asymptotic distribution as simple Dickey & Fuller statistics do, so the same critical values can be used.

Using the methodology proposed by Enders (1995) to establish the inclusion of deterministic terms (constant and/or trend), equations (16) to (18) must be sequentially estimated, under the null hypothesis that $\gamma = 0$.

$$\Delta Y_t = \beta_1 + \beta_2 t + \gamma Y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta Y_{t-1} + e_t \tag{16}$$

$$\Delta Y_t = \beta_1 + \gamma Y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta Y_{t-1} + e_t \tag{17}$$

$$\Delta Y_t = \gamma Y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta Y_{t-1} + e_t \tag{18}$$

It's worthy to say that $m = p - 1$, where p corresponds to the order of the autoregressive model adjusted with the original series, which were determined according to Akaike and Schwarz information criterion, respecting the assumption of autocorrelation absence indicated by Ljung Box's Q test. The p value can also be obtained using the systematic described in Moraes (2002), quoting Campbell & Perron (1991): starting with the most complete specification, if the coefficient of the last term is not significant, the model order should be reduced until the coefficient of the term with the higher lag becomes significant. If none of the coefficients is significant, then $p = 1$.

In (16) and (17), when the coefficient estimated for the constant and for the trend is significant, $\gamma = 0$ can be evaluated through the normal distribution. Otherwise, τ statistics should be used. The $\tau_{\beta\tau}$ and $\tau_{\alpha\mu}$ statistics are used to evaluate, respectively, the trend's coefficient in (16) and the constant in (17). The critical values for such statistics can be found in Dickey & Fuller (1981). If H_0 is not rejected, the variables are called integrated; otherwise, the variables are stationary, I(0). It must be noticed that, in the events where the unit root hypothesis is not rejected, new tests have to be performed with the variable on successive differences until the results indicate that the series becomes stationary. In a general way, if a series is stationary only on its *n*-th difference, it's called integrated of order *n*-1, or, I(*n*-1).

When the series are not I(0) but they are integrated of the same order, the co-integration existence between/among them must be tested. The idea of co-integration is related to the existence of a long-run relation between the variables. As proposed by Engle & Granger (1987), given equation (19), the series of deviations (e_t) is estimated. This series is used to estimate equation (20), under the null hypothesis of $\lambda_1=0$.

$$Y_t = \theta_0 + \theta_1 X_t + e_t \quad \text{or} \quad e_t = Y_t - \theta_0 - \theta_1 X_t \tag{19}$$

$$\Delta\hat{e}_t = \lambda_1 \hat{e}_{t-1} + \varepsilon_t \tag{20}$$

Based on the critical values tabulated by Engle & Granger (1987), the existence of a unit root in the residual series is tested. If the null hypothesis is rejected, the series of deviations are stationary and, therefore, the variables are co-integrated. Once co-integration is identified, the model should include an error correction term, actually, the equation's (19) residual series lagged in one period.

3.3.2 Box-Jenkins methodology

Box-Jenkins objective is to identify and to estimate an autoregressive integrated moving average model – ARIMA(*p,d,q*) – which properly represents the data-generating process. This method consists of four steps:

1st) Identification: to discover the appropriate *p*, *d* and *q* values through the correlograms derived from the series' autocorrelation and partial autocorrelation functions.

2nd) Estimation: to calculate the coefficients of the autoregressive and moving average terms included on the model.

3rd) Diagnose checking: to verify if the chosen model is reasonably well adjusted to the data, because it's possible that another ARIMA model presents the same performance. This can be made through an analysis of the estimated residues: if they are white noise, this specific adjustment may be accepted; if they're not, the researcher should return to step one. So, Box-Jenkins methodology is an interactive process.

4th) Forecasting: to perform predictions using the final model.

In the event of a transfer function, like the ones in this paper, the explanatory variables might be included in the second step. After the model estimation, the contribution of such variables for the model's predictive performance must be checked.

3.3.3 Determination of explanatory variables' lag in the transfer function

The cross correlation function (CCF) between an explanatory variable X_t and the dependent variable Y_t measures the correlation between the series in different time periods and it's an important analytic tool for the identification of transfer function models. In (21), γ_{xy} is the cross covariance of X_t and Y_t, and in (22), ρ_{xy} is the cross correlation function of X_t and Y_t. In both, $k = 0, \pm 1, \pm 2 ...$, μ_x and μ_y are the averages, and σ_x and σ_y are the standard deviations of the stationary series X_t and Y_t.

$$\gamma_{xy}(k) = \mathrm{E}\left[(X_t - \mu_x)(Y_{t-k} - \mu_y)\right] \tag{21}$$

$$\rho_{xy}(k) = \frac{\gamma_{xy}(k)}{\sigma_x \sigma_y} \tag{22}$$

Positive values of k denote lag periods and negative values correspond to lead periods. If Y_t, in the current period, is influenced by X_{t+2}, $\gamma_{xy}(2)$ is different from zero. Then, $\gamma_{xy}(-k) = \gamma_{yx}(k)$. The cross-covariance points out both the extension and the direction in the variables' relation. The cross correlation function $\rho_{xy}(k)$ is not symmetric and has to be calculated for both positive and negative k values. The significant correlations for each $k > 0$ value indicate that Y_t is a predictor of X_t, the inverse occurring if the significant values are related to $k < 0$ values (Vandaele, 1983).

The time series methodology indicates that the cross correlation function should be estimated with previously filtered series, in order to eliminate the autoregressive behavior of the series (which could result in spurious relations). The occurrence of significant values in the CCF indicates the existence of causality between the variables, as well as the direction in which it occurs.

For samples from two independent white noise series, the standard deviation of the cross correlation is approximately given by the formula (23).

$$DP\left[r_{xy}(k)\right] = \frac{1}{\sqrt{N}} \tag{23}$$

Considering a 95%-confidence interval on *t*-Student's distribution, significant values for the cross correlation should respect the condition expressed in (24).

$$\left|r_{xy}(k)\right| \geq \frac{1{,}96}{\sqrt{N}} \tag{24}$$

Once the direction of the causal relation between the series is known, the transfer function can be specified. The number of explanatory variables lags included is determined by the higher significant lag on the CCF.

3.4 Data source

In order to analyze the Brazilian light vehicle fuels (alcohol and gasoline) exports and imports, six series of monthly data were used, deflated by the IGP-DI from Fundação Getúlio Vargas (if the series were in R$) or by the CPI from United States Bureau of Labor and Statistics (if the series were in US$).

The exported and imported amounts were represented by the FOB values, in US$, obtained in the Sistema de Análise das Informações de Comércio Exterior via Internet (ALICEWEB)[2]. The ethanol international price was calculated dividing the FOB value by its respective amount, expressed in net kilograms, also available at ALICEWEB. The considered ethanol domestic price was the monthly average of anhydrous alcohol producer prices in Sao Paulo State (published by

[2] For calculating these series, four products (of eight digits) from Mercosur Common Nomenclature (NCM) were considered, namely: 2207.10.00 and 2207.20.10 to represent alcohol flows; 2710.11.59 and 2709.00.10 to represent gasoline flows. The ratio of 2/3 was adopted for the conversion of the imported oil into gasoline available for consumption.

It's also important to say that, during the period analyzed, the Brazilian exports on light vehicle fuels for other American countries were actually constituted of ethanol. There was no gasoline being exported for these countries and, therefore, the prices used in the export transfer function represented only the alcohol market.

CEPEA-ESALQ/USP). The real effective exchange rate adopted was the one informed by IPEA and the per capita income was represented by the per capita GDP, calculated through the division of BCB's monthly GDP estimates by IBGE's monthly Brazilian population. To simplify the result exhibition, the following nomenclature will be used to represent these six series: q^x, q^m, $(p^x)^*$, p, cr and rpc, respectively, besides rel – as described in (13).

The period considered in the analysis ranged from January 2000 to October 2006, summing up 82 observations. The econometric tests were performed with the software RATS (Regression Analysis of Time Series).

4 RESULTS

Figures 1 to 6 show the set of series used. The visual inspection of exported value FOB series (Figure 1) indicates that it doesn't have a constant average during the analyzed period, fact that has to be considered in the prediction model. The inclusion of two dummy variables, one to mark the period from May 2004 to June 2006 and another to the months starting in July 2006 on, will take into account such variation. From Figure 2, it can be observed that the fuel import series also presents wide oscillations, mainly in the beginning and at the end of the analyzed period, anticipating the discovery of an adequate prediction model in the adjustment.

As it can be observed on Figure 3, the international price for fuel alcohol could not be estimated in September and October 2000, once Brazil didn't export this product for the other American countries during these months. So, a price lightly higher than the ones observed in the months immediately before and after was adopted, considering that such price would imply in a restriction to the exports and also marking them with a dummy variable.

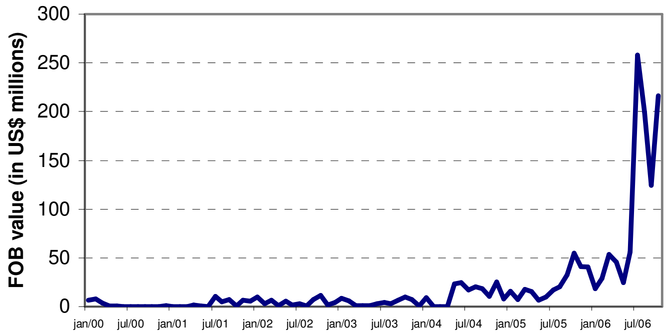

Figure 1 – Evolution of the Brazilian exports on light vehicle fuels for the America – real FOB value (in US$ million) – from Jan/2000 to Oct/2006.

Source: ALICEWEB data.

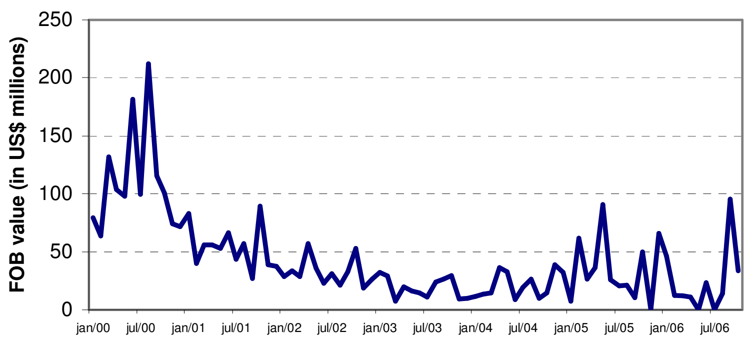

Figure 2 – Evolution of the Brazilian imports on light vehicle fuels for the America – real FOB value (in US$ million) – from Jan/2000 to Oct/2006.

Source: ALICEWEB data.

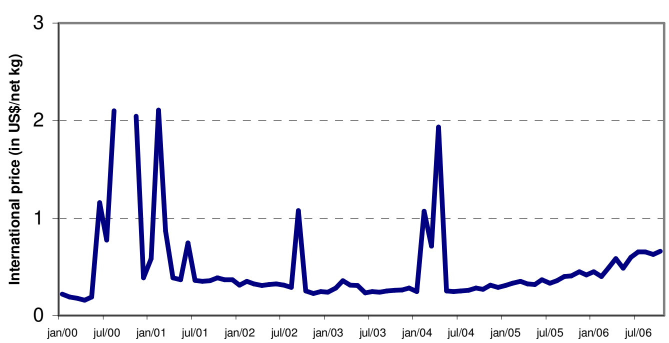

Figure 3 – Evolution of fuel alcohol real international price (in US$ by net exported kilogram) – from Jan/2000 to Oct/2006.

Source: calculated based on ALICEWEB data.

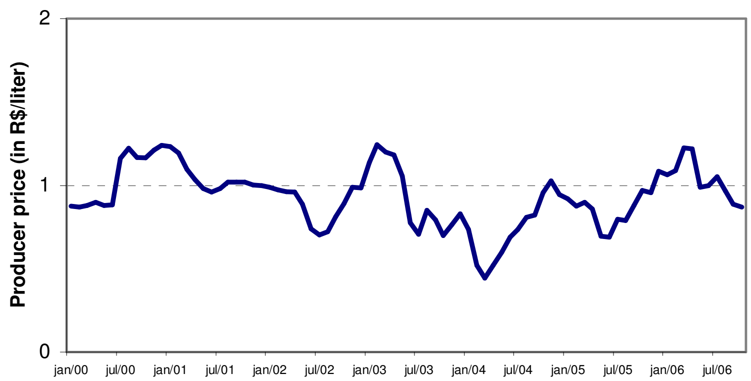

Figure 4 – Evolution of fuel alcohol real domestic price (in R$ by liter) – Sao Paulo State – from Jan/2000 to Oct/2006.

Source: CEPEA-ESALQ/USP data.

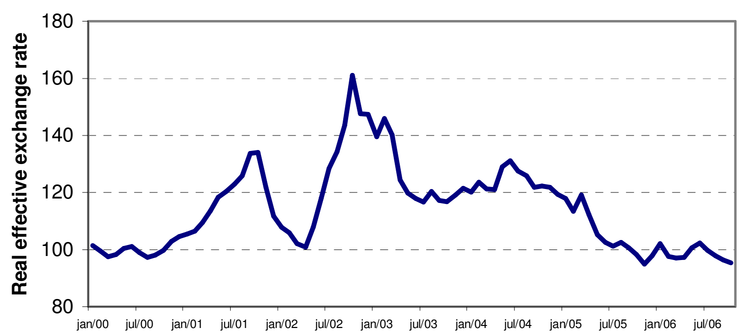

Figure 5 – Evolution of the real effective exchange rate – from Jan/2000 to Oct/2006.

Source: IPEA data.

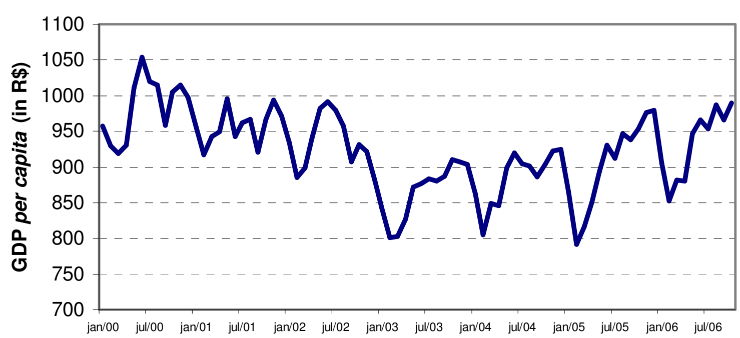

Figure 6 – Evolution of the per capita Gross Domestic Product – from Jan/2000 to Oct/2006.

Source: IBGE and BCB data.

Tables 1 and 2 summarize the results of the unit root tests. On Table 1, the variables are expressed on their first differences. It can be checked that, until a significance level of 10%, only q^m, cr and rpc are not stationary. On Table 2, the variables are expressed on their second differences and the estimated statistics indicate that these series are I(1).

Table 1 – Unit Root Test Results

Series	Lags (p - 1)	Statistics				
		τ_τ	$\tau_{\beta\tau}$	τ_μ	$\tau_{\alpha\mu}$	τ
q^x	5	-3.917**	2.893**	-	-	-
q^m	2	-1.860	-0.530	-2.090	1.380	-1.610
$(p^x)^*$	0	-4.287*	-0.573	-	-	-
p	3	-3.363***	-1.101	-	-	-
cr	6	-1.814	-1.783	-1.600	1.597	-0.162
rpc	12	-0.825	0.626	-1.690	1.690	-0.095
rel	0	-4.682*	-0.429	-	-	-

* Significant until 1% probability level.

** Significant until 5% probability level.

*** Significant until 10% probability level.

Table 2 – Unit Root Identification Test Results

Series	Lags (p – 2)	Statistics
		τ
q^m	1	-10.21*
cr	5	-4.439*
rpc	11	-2.022**

* Significant until 1% probability level.

** Significant until 5% probability level.

The results of the cross correlation tests indicated that variations in the exported amount are related to contemporary variations in the international price of alcohol fuel and to variations in the domestic price (lagged by 4 months). In a similar way, they're related to contemporary variations of the relative price (the international price in R$ divided by the domestic price). In relation to the import series, there're not significant cross correlations.

4.1 Exports forecasting model

Although the cross correlation between the exported quantity and the real effective exchange rate or the per capita GDP didn't present any significant value, these variables were kept for the model estimation since that, combined with the other variables, they improved its predictive performance.

Once only the series of the per capita GDP was considered part of the first order in the model that assumes homogeneity to price variation, the performance of co-integration tests was not necessary. One assumption for the existence of co-integration is that, in the set of variables analyzed, at least two of its series were non-stationary – what doesn't occur in the model (12).

The different combinations tested for the specification of the ethanol exports prediction model had, without exception, high prediction errors. The criteria for the final model's choice were: Q test's significance level, adjusted coefficient of determination and regression sum of squares.

The results from model (12) estimation, including the autoregressive and moving average terms identified, are summarized on Table 6. The unique variable that presents a signal opposed to the one expected is the contemporary relative price (international/domestic) in R$ – $rel(0)$. Even though, this variable was kept in the model because it contributed with the prediction improvement. The estimated coefficients also indicate that the quantity exported of light vehicle fuels for America presents an income elasticity higher (in absolute value) than the unit. In other words, the Brazilian economy growth, with the increase in the per capita GDP, is implying on a more than proportional reduction in the fuel surpluses available to be exported. Historically, Brazilian fuel production has been guided, mainly, by the domestic consumption and, therefore, an improvement on the domestic population purchasing power tends to augment its demand – reducing the export's supplied quantity.

Table 3 – Results of the export function estimate as a Box-Jenkins model

Adjusted R^2 = 0.846	**Q = 14.805**	**Dependent variable = q^x**
Variable	**Coefficient**	***t* statistics**
Constant	25.470*	9.162
Trend	0.102**	2.599
rel (0)	-4.456*	-8.670
rel (1)	0.727	1.543
rpc (0)	-14.065	-1.311
rpc (1)	-11.930	-1.140
D_1	-1.660	-1.507
D_2	-1.754	-1.257
D_3	-0.060	-0.049
D_4	0.488	0.494
D_5	1.512	1.172
D_6	1.838	1.578
D_7	1.197	1.202
D_8	0.714	0.796
D_9	1.864***	1.788
D_{10}	0.845	0.810
D_{11}	0.798	0.775
P_2	-0.359	-0.250
P_3	1.261	0.616
N	-5.419*	-3.600
AR (1)	0.121	0.332
AR (2)	0.177	1.030
AR (4)	0.277**	2.030
MA (1)	0.099	0.248

* Significant until 1% probability level.

** Significant until 5% probability level.

*** Significant until 10% probability level.

Obs: [1] The number in brackets indicates the variable lag.

[2] The variables D_i are dummies that represent the different months during a year (December was considered the reference month).

[3] The variables P_2 and P_3 indicate, respectively, the periods from May 2004 to June 2006 and from July 2006 on.

[4] The variable N marks the months in which the exported quantity was null and, therefore, a restrictive price considered export was adopted in these periods.

4.2 Imports forecasting model

For the same reason of the last section, although the cross correlation between the imported quantity and the real effective exchange rate or the per capita GDP didn't present any significant value, these variables were kept. On the other hand, the expressive State intervention on the decision-making process of fuel imports is probably the responsible for the irrelevant influence of the price levels over the imports variations. That's why the relative price variable was taken out of the model.

Since the three variables in the model are integrated of the same order, I(1), augmented Engle & Granger tests (AEG) for co-integration were performed. The results presented on Table 4 aren't significant until the 10% probability level, which indicates that there aren't long term relations among the variables, i.e., that the variables aren't co-integrated.

Table 4 – Co-integration tests results.

Model	Q test	AEG
q^m = *constant* + rpc + cr	0,34	-3,17
rpc = *constant* + q^m + cr	0,14	-1,50
cr = *constant* + q^m + rpc	0,42	-2,88

The integration and co-integration tests results indicated that the transfer function model for the fuel import should be estimated with its variables on their first differences, but without the addition of an error correction term. Table 5 summarizes the results of the model with the best performance, according to the previously mentioned criteria. The variable cr was expressed only contemporarily; the variable rpc was considered both contemporarily and with a three-month lag. The coefficients were significant until the 10% probability level, though only $rpc(0)$ presents the expected signal. Even though, the other variables were kept, once they improve the prediction adjustment.

Table 5 – Results of the import function estimate as a Box-Jenkins model

Adjusted R^2 = 0.820	Q = 11.013	Dependent variable = q^m
Variable	**Coefficient**	***t* statistics**
Constant	13.253	1.053
Trend	0.101*	3.097
rpc (0)	0.269***	1.920
rpc (3)	-0.294**	-2.332
cr (0)	0.811*	3.109
D_1	-15.645	-0.657
D_2	4.734	0.218
D_3	-35.122*	-3.280
D_4	-21.361	-1.007
D_5	-47.271**	-2.244
D_6	-27.734**	-2.118

D_7	-13.094	-0.664
D_8	-7.934	-0.373
D_9	1.619	0.150
D_{10}	-21.217	-1.131
D_{11}	-39.983***	-1.840
AR (1)	-0.824*	-5.872
AR (2)	-0.548*	-3.663
AR (4)	-0.386**	-2.416
AR (5)	-0.613*	-3.139
AR (6)	-0.446*	-3.310
SAR (12)	-0.482*	-3.872

* Significant until 1% probability level.

** Significant until 5% probability level.

*** Significant until 10% probability level.

Obs: [1] The number in brackets indicates the variable lag.

[2] The variables D_i are dummies that represent the different months during a year (December was considered the reference month).

4.3 Verification of the models' performance

To verify the performance of the estimated models, one-step forward outside-the-sample predictions were carried out for the variables q^x and q^m. Through Figures 7 and 8 it's possible to compare the observed and the predicted values. As the series exhibits an irregular behavior with huge oscillations, the results were considered satisfactory.

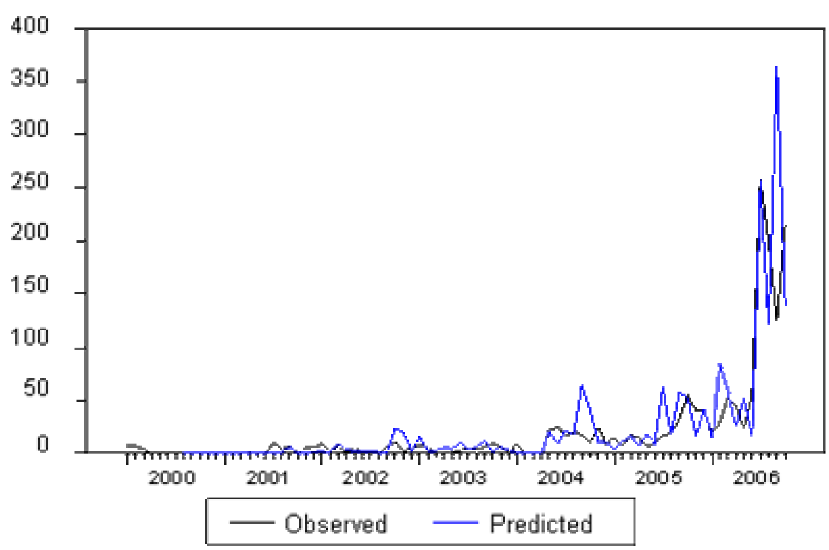

Figure 7 – One-step-forward outside-the-sample predictions and observed values for the series q^x – FOB value (in US$ million) – Jan/2000 to Oct/06.

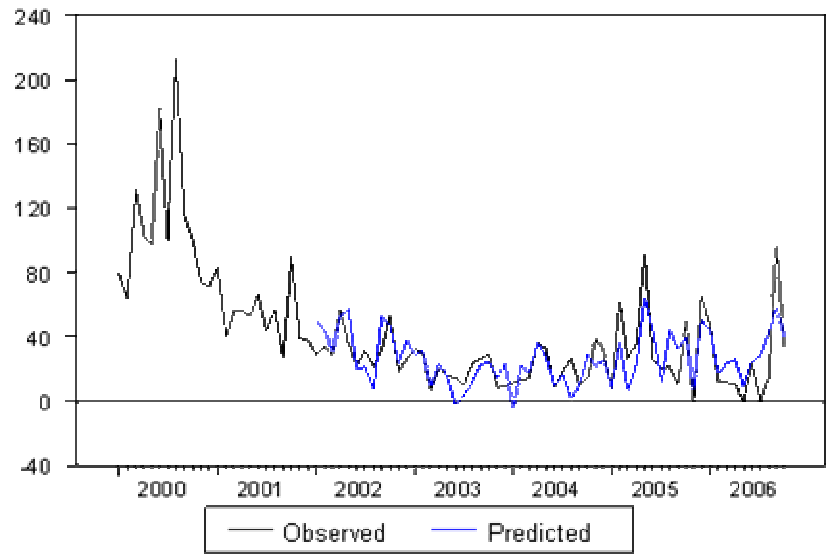

Figure 8 – One-step-forward outside-the-sample predictions and observed values for the series q^m – FOB value (in US$ million) – Jan/2000 to Oct/06.

Through Figure 9 it's possible to evaluate the joint models' performance to calculate the GLI, considering the years from 2002 to 2006. The solid line shows the evolution of the intra-industry trade index (calculated using the observed data), while the dotted line represents the evolution of the predicted index (calculated with the forecasting from the models adjusted for the imports and the exports). Although the predicted index had overestimated the intra-industry trade on the light vehicle fuels sector, it presented a behavior similar to the observed one and its predictions were well-adjusted throughout the analyzed period on average. In 2002, for example, observed index was 0,254 and the predicted index was 0,281.

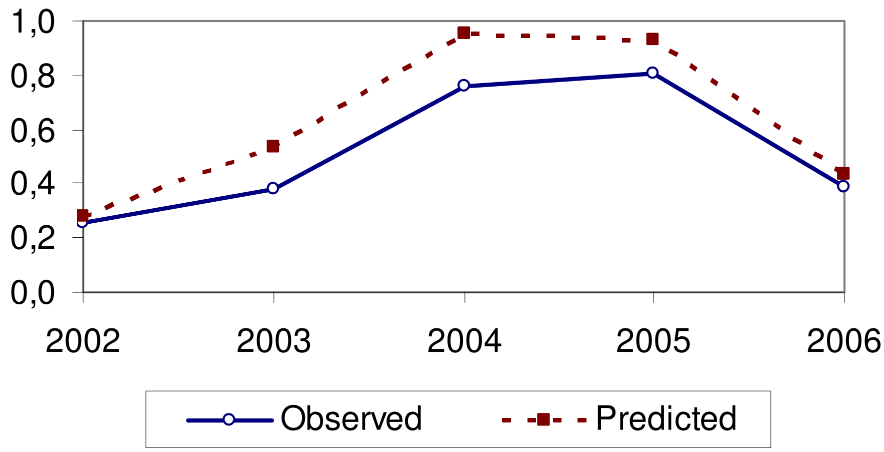

Figure 9 – Evolution of the Grubel & Lloyd observed and predicted index – from 2002 to 2006.

4.4 Intra-industry trade index forecasting in different scenarios for the income growth

The GLI prediction through the estimated exported and imported quantity transfer functions requires the explanatory variables added in the models (per capita income, exchange rate and price levels) to be projected. Figures 10 and 11 show the behavior of these series, according to the models used to filter the series before the performance of the cross correlation tests. The domestic price, international price and exchange rate index projections – presented on Figure 10 – were used to estimate the GLI under three different scenarios for the per capita income variation: equivalent (i) to an average reduction of 2%, (ii) to the maintenance of the current pattern and (iii) to an average increase of 2% - as illustrated on Figure 11. The higher and lower scenarios were determined with the multiplication and the division of the median one by the series' seasonal regularity index, calculated through the centered moving geometric mean[3].

[3] For further details, see Hoffmann (2006).

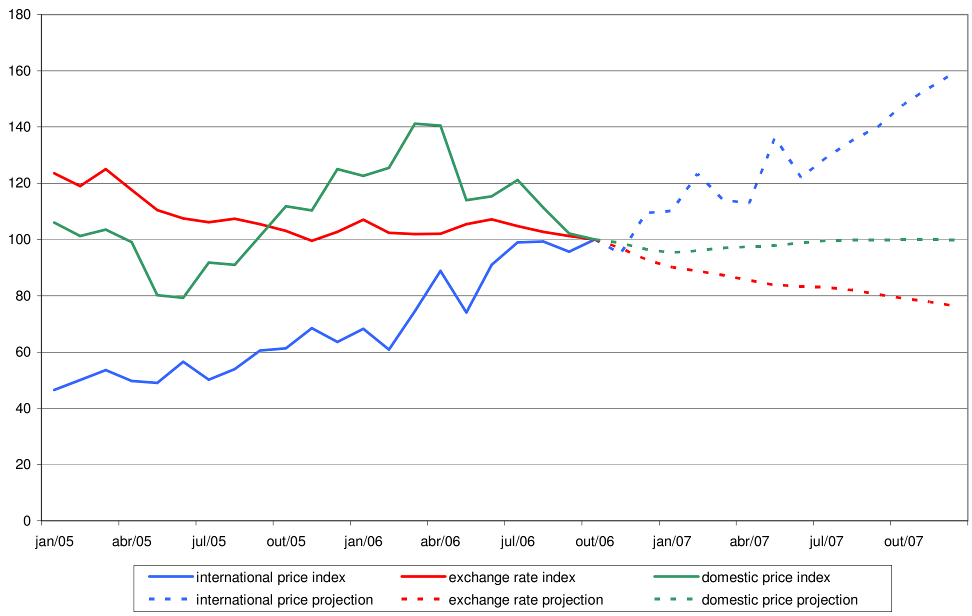

Figure 10 – Evolution and projection of the exchange rate, domestic price and international price indexes (from January 2005 to December 2007)

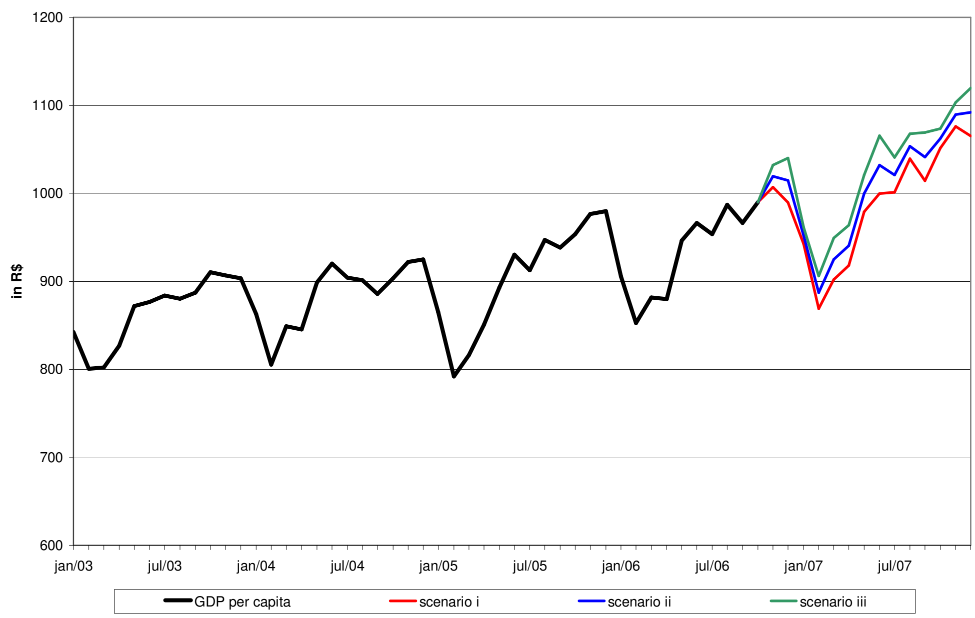

Figure 11 – Evolution of the per capita income proxy and its projection in the different considered scenarios (from January 2003 to December 2007)

With these values and using the models 12 and 14, the monthly exported and imported quantities of light vehicle fuels were predicted. On Figures 12 and

13, the results in the three scenarios are presented annually (format used for the calculation and for the forecasting of the intra-industry trade index).

According to what was exposed in Section 1, the fuels import in Brazil passed through an intense State intervention and, therefore, the economic variables present a lower explanatory power over the quantity imported. Figure 12 emphasizes the characteristics of this fuel market, since the predicted quantity of light vehicle fuels import is almost perfectly inelastic to per capita income variations.

On the other hand, the exported quantity prediction shows a sensibly different behavior in the three scenarios (see Figure 13): in (ii) and (iii) the exports present a growth trend, with the estimate values for the scenario that assumes a 2% increase in the per capita income remaining always below the one that considers the current pattern maintenance (respecting the hypothesis beneath the theoretical model used for the export function estimation); in (i), there's a reversion in the exports trend growth – an unexpected fact if the domestic income were considered inversely proportional to the export supply, but perfectly acceptable from the economic viewpoint.

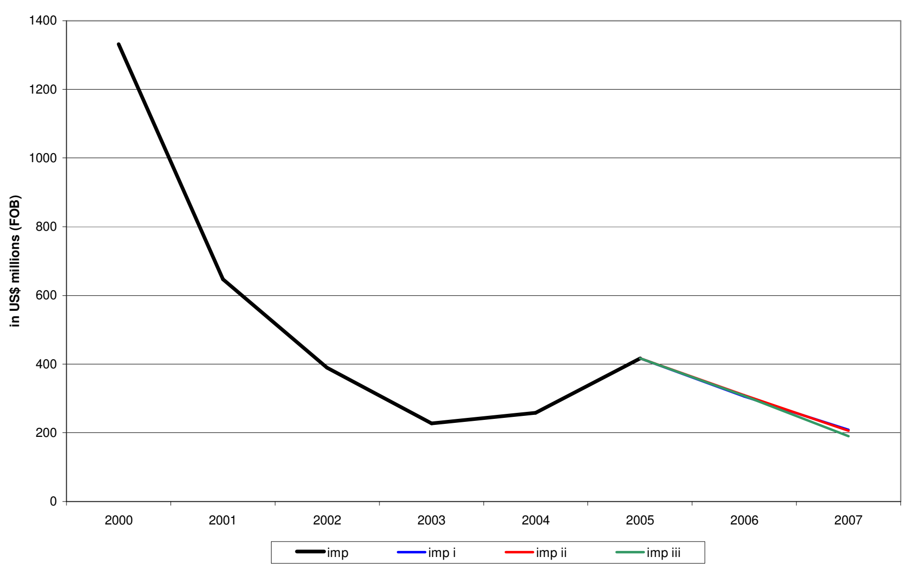

Figure 12 – Evolution of the light vehicle fuels imported quantity (imp) and its prediction in the different scenarios considered (from 2000 to 2007)

From the export guided domestic surpluses' point of view, the domestic income variations might present some duality: on the consumption side, an increase in the income available for the consumption would increase the domestic demand, reducing the supply surplus and, then, the exported quantity; on the product side, the income growth might be related to a production increase that, dissociated from an increase in the domestic demand, would augment the supply surplus and, consequently, the exports. Thus, the domestic income will be inversely proportional to the exported quantity if its effect over the consumption is higher than its effect over the production; otherwise, the domestic income will be directly proportional to the exports.

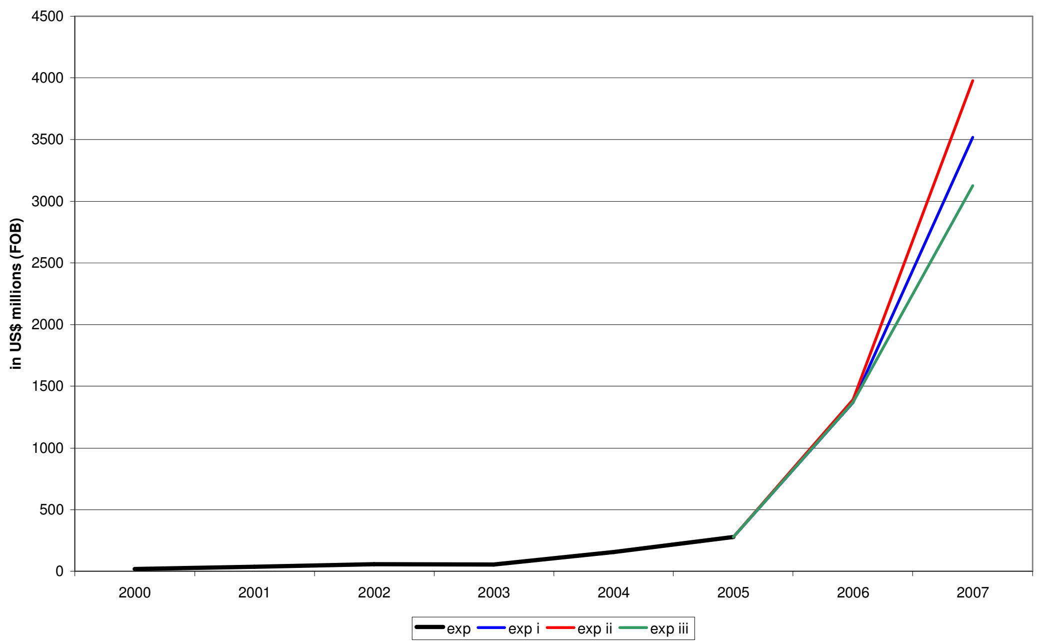

Figure 13 – Evolution of the light vehicle fuels exported quantity (exp) and its prediction in the different scenarios considered (from 2000 to 2007)

The results of GLI estimation in the three different scenarios converge to the same statement (see Figure 14): from 2000 to 2003, the lower values observed for the intra-industry trade index indicate the existence of specialization in the international trade on light vehicle fuels between Brazil and the other American countries; in 2004 and 2005, when the index reached values higher than 50%, the intra-industry trade was more important than the inter-industry trade in this market and, therefore, diversification could be diagnosed;

however, for the years 2006 and 2007, the predictions indicate new specialization in the international trade of light vehicle fuels among the analyzed countries.

It's worthy to say that, in the first years, Brazil was specialized on light vehicle fuels imports, while the last year's forecasts pointed at a specialization on their export. So, a transitory increase in the intra-industry trade can be seen as a consequence of the paradigm change in this trade flow.

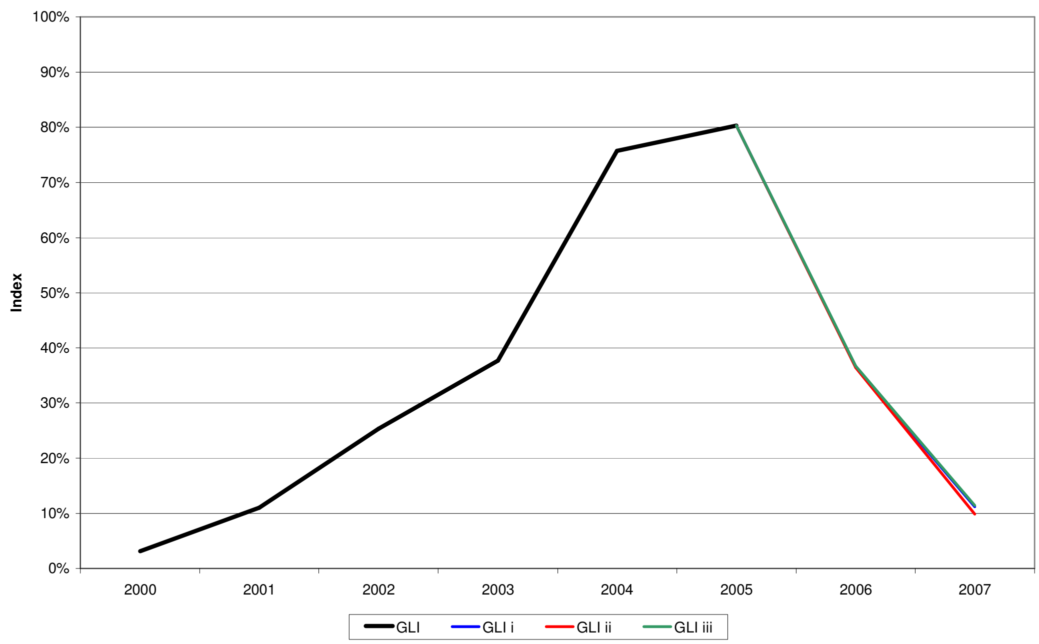

Figure 13 – Evolution of the Grubel and Lloyd Index and its prediction in the different scenarios considered (from 2000 to 2007)

5 CONCLUSIONS

This article analyzed the trade on light vehicle fuels between Brazil and the other American countries. Preliminarily, transfer function models were adjusted for the alcohol and gasoline exports and imports prediction, using monthly series of the imported and exported value, the per capita income, the effective exchange and the domestic and international prices for the period ranging from January 2000 to October 2006.

These models were used for the Grubel and Lloyd Index of intra-industry trade calculation and, through the construction of scenarios for the per capita income, for an impact simulation on different economic conjunctures over such trade flow.

Overall, the models presented a good performance for the prediction of both imported and exported quantities, as well as of the Grubel and Lloyd Index.

Certainly, with the improvement on the fuel alcohol international trade in the years to come, the model's forecasting power will also be improved – mainly due to the recent change on Brazilian exports path, dating from July 2006, which clearly interferes in the one-step-forward outside-the-sample predictions.

The intra-industry trade index for the light vehicle fuels market highlighted that this type of trade was very important along a transitory period between the ones characterized by specialization on imports (until 2003) and on exports (predicted to happen from 2006 on). This statement can be seen as evidence that, generally, a sudden increase in the intra-industry relative share precedes a paradigm change on the international trade specialization. Nevertheless, further investigation on this theme is needed to confirm a strong hypothesis like that.

BIBLIOGRAFIC REFERENCES

BANCO CENTRAL DO BRASIL – BCB.

Site: http://www4.bcb.gov.br/pec/series/port/ (21 Nov. 06).

BARROS, G.S. de C.; BACCHI, M.R.P. & BURNQUIST, H.L.. *Estimação de equações de oferta de exportação de produtos agropecuários para o Brasil (1992/2000)*. Rio de Janeiro: IPEA, mar. 2002. 53 p. (Texto para Discussão n. 865).

BLANCHARD, O. *Macroeconomia: teoria e política econômica*. Tradução [da 2.ed original] de Maria José Cyhlar Monteiro. – Rio de Janeiro: Campus, 2001.

BOX, G. E. P.; JENKINS, G. M. *Time series analysis: forecasting and control*. San Francisco: Holder-Day, 1976. 182p.

CAMPOS, M.F.S.S.; HIDALGO, A. *Abertura, comércio intra-indústria e desigualdade de rendimentos na indústria de transformação brasileira*. Banco do Nordeste: 2005. Site:http://www.bnb.gov.br/content/aplicacao/eventos/forumbnb2005/docs/abertura_comercio_intra-industria_e_desigualdade.pdf (15 Jan. 07).

CENTRO DE ESTUDOS AVANÇADOS EM ECONOMIA APLICADA DA UNIVERSIDADE DE SÃO PAULO – CEPEA-ESALQ/USP.. Site: http://www.cepea.esalq.usp.br/ (20 Nov. 06).

DICKEY, D. A.; FULLER, W. A. Distribution of the estimative for auto-regressive time series with a unit root. *Journal of the American Statistical Association*, n.74, 1979.

DICKEY, D. A.; FULLER, W. A. Likelihood ratio statistics for auto-regressive time series with a unit root. *Econometrica*, v. 94, n. 4, 1981.

ENDERS, W. *Applied Econometric Time Series*. New York: John Wiley & Sons, 1995.

ENGLE, R.F.; GRANGER, C.W.J. Cointegration and error correction: representation, estimation and testing. *Econometrica*, Chicago, v. 55, n. 2, p. 251-76, 1987.

FULLER, W. A. *Introduction to statistical time series*. New York: John Wiler, 1976.

FUNDAÇÃO GETÚLIO VARGAS – FGV.

Site: http://www.fgv.br (21 Nov. 06).

GUJARATI, D.N. *Econometria Básica*. Tradução [da 3.ed original] de Ernesto Yoshida. – São Paulo: Makron Books, 2000. 846p.

HIDALGO, A.B. O intercâmbio comercial brasileiro intra-indústria: Uma análise entre indústrias e entre países. *Revista Brasileira de Economia*, 47(2): 243-264. Rio de Janeiro: 1993.

HOFFMANN, R. *Estatística para economistas*. São Paulo: Pioneira Thomson Learning, 2006.

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA – IBGE. Site: http://www.ibge.gov.br (21 Nov. 06).

INSTITUTO DE PESQUISA ECONÔMICA APLICADA – IPEA. Site: http://www.ipea.gov.br. (21 Nov. 06).

KENEN, P.B. *Economia Internacional – Teoria e Política*. Tradução [da 3.ed original] de Silvia Düssel Schiros. – Rio de Janeiro: Campus, 1998. 648p.

KRUGMAN, P.R.; OBSTFELD, M. *Economia Internacional – Teoria e Política*. Tradução [da 5.ed original] de Celina Laranjeira. – São Paulo: Makron Books, 2001. 797p.

MARJOTTA-MAISTRO, M.C. Ajustes nos mercados de álcool e gasolina no processo de desregulamentação. Piracicaba, 2002. 180p. Tese (Doutorado) – Escola Superior de Agricultura "Luiz de Queiroz", Universidade de São Paulo.

MORAES, M. de. Prêmio de exportação da soja brasileira. Piracicaba, 2002. 90p. Dissertação (Mestrado) – Escola Superior de Agricultura "Luiz de Queiroz", Universidade de São Paulo.

RUFFIN, J. R. *The Nature and Significance of Intra-Industry Trade*. Federal Reserve Bank of Dallas: 1993. Site:http://www.dallasfed.org/research/efr/1999/efr9904a.pdf (12 Oct. 06).

SISTEMA DE ANÁLISE DAS INFORMAÇÕES DE COMÉRCIO EXTERIOR VIA INTERNET – ALICEWEB. Site: http://aliceweb.desenvolvimento.gov.br (20 Nov. 06).

UNITED STATES BUREAU OF LABOR STATISTICS.

Site: http://data.bls.gov/cgi-bin/surveymost?cu (21 Nov. 06).

VANDAELE, W.. *Applied Time Series and Box-Jenkins Models*. Orlando: Academic Press Inc., 1983.