THE EFFECTS OF TARIFFS ON THE WHOLE MILK POWDER TRADE BETWEEN BRAZIL AND ARGENTINA: A GAME THEORETIC ANALYSIS*

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ABSTRACT In this paper we analyzed the effects of tariffs on the whole milk powder trade between Brazil and Argentina from 1990 to 2004. The methodology included estimation of whole milk powder demands for Brazil and Argentina as monopolists, members of Mercosul, and world exporters; and simulation of Cournot games considering the trade of this product under alternative tariff policies. The results show that although the tariff impositions create trade distortions, this kind of policy was important to protect Brazil against illegal practices of trade and to increase its competitiveness against traditional international competitors.

Key words: whole milk powder, trade, tariff, Mercosul

JEL Code: F13; F15

EFEITOS DE TARIFAS NO COMÉRCIO DE LEITE EM PÓ ENTRE O BRASIL E A ARGENTINA: UMA ANÁLISE COM TEORIA DOS JOGOS

RESUMO Neste artigo, analisaram-se os efeitos de tarifas no comércio de leite em pó entre o Brasil e a Argentina, no período de 1990 a 2004. A metodologia utilizada inclui a estimativa da demanda de leite em pó para o Brasil e a Argentina como

* Article received on November 7, 2006, and approved on August 19, 2008.

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monopolistas, como membros do Mercosul e como exportadores mundiais, e a simulação de jogos de Cournot, considerando o comércio deste produto sob diferentes políticas alternativas de tarifas. Os resultados obtidos mostram que, embora a imposição de tarifas tenha criado distorções no comércio de leite em pó, este tipo de política foi importante para proteger o Brasil contra práticas ilegais de comércio e aumentar sua competitividade frente a competidores internacionais tradicionais.

Palavras-chave: leite em pó, comércio internacional, tarifas, Mercosul

INTRODUCTION

Over the past decades, there has been a world tendency towards the development of economic blocks motivated by the process of economic openness to international trade and globalization. In 1988 Brazil and Argentina set in motion a process of integration for a common market by the end of 1994. In 1992 Paraguay and Uruguay were invited to join the Southern Common Market Treaty (Mercosul). A Custom Union was created under the Ouro Preto Protocol signed in December 1994. In that occasion, the intrablock tariffs were eliminated and a Common External Tariff (CET) was instituted.

In general, the trade liberalization affects the economic sectors differentially in each country. In the case of Brazil, while the manufactured sector expanded its intrablock exports after the implementation of Mercosul, some agricultural/food sectors did not respond to the new situation with the speed and depth required in order to provide economic expansion, as was the case with the dairy sector.

According to Lopes (1992), at the beginning of the integration process, the dairy sector was one of the most sensitive sectors in Brazil. This vulnerability was a consequence of the Brazilian government's intervention in this sector for over 40 years through the control of milk prices and imports. After the liberalization of the Brazilian milk market in 1991, the production expanded to non-traditional milk producing areas, and milk production increased substantially.

The Common External Tariff for dairy products became effective in Mercosul at the end of 1994. It was accorded that the powdered milk's CET would be gradually reduced from 32% in 1995 to 16% in 2001. However, from 1994 to 1998, the overvalued exchange rate stimulated the entrance of milk powder in Brazil. In 1995, whole milk powder (WMP) Brazilian imports reached the record level of 211 thousand tons, representing 105.5% of the national production. According to Sapya (2005), during the 1995-1999 period, about 72% of the Argentinean powdered milk exports was destined to Brazil.

The largest obstacle faced by Brazilian milk producers in the 1990s was the existence of illegal trade practices. Argentinean producers were import-ing subsidized milk from the European Union (EU) and reselling it to Brazil. In an attempt to avoid these imports at artificial prices, the Brazilian government implemented changes in the dairy products trade. Milk powder entered the "exception list" of the Mercosul's Common External Tariff. Brazil imposed an anti-dumping duty on milk powder imports from New Zealand, the EU and Uruguay. Argentina negotiated a minimum export price of US$ 1,900 per metric ton for powdered milk exports to Brazil and also agreed to maintain the same tariff lines in order to avoid imports from other countries entering through its territory and eventually reaching Brazil.

The main objective of this paper is to analyze the effects of tariffs on the whole milk powder trade between Brazil and Argentina under the perspective of the game theory during the 1990-2004 period. Specifically, we estimated whole milk powder demands for Brazil and Argentina — as monopolists, as members of Mercosul, and as world exports — and simulated sceneries considering the whole milk powder trade for Brazil and Argentina under alternative tariff policies.

In the next section, we present the methodology used in this paper. This methodology includes the trade between two countries modeled as Cournot games, the formulation of these games as mixed complementarity problems, the specification of demand functions to be estimated by econometric methods, and the data and procedures used in this paper. The third section presents the results and discussion. Finally, in the fourth section, we present the concluding remarks.

1. METHODOLOGY

1.1 Cournot's duopolistic game

The imperfect competition theory has fundamentally changed the way economists think about international trade. The primary appeal of this theory lies in the fact that it helps to explain certain features of modern trading patterns, which do not conform with the neo-classical theory. On the other hand, the game theory has been widely used to analyze imperfect competition in the international trade. According to Carlton and Perloff (2000), the game theory analyzes the interaction among rational agents that are not capable to completely predict the results of their decisions.

In a game between two countries, each country can improve its trade terms with the use of tariffs. However, in its absence, the game cannot be in the Nash Equilibrium (NE), since each country improves its payoff with the imposition of tariffs. Therefore, the NE with positive tariffs tends to be inferior to the situation of free trade for both countries.

In a static Cournot model, countries have to choose their output levels at the same time and cannot make credible commitments, so no one can convince the other that it will produce a large output. In the absence of government intervention, these countries behave as Cournot duopolists. In this paper, we made the following assumptions: the countries produce identical products, so that the sum of their outputs equals the total output; the countries' inverse demand curve is linear; and these countries produce at a constant marginal cost.

Consider a Cournot game between two countries with a homogeneous product. They face the following inverse demand curve:

$$P(Q) = a - bQ,\ Q = q_1 + q_2 \tag{1}$$

where a and b are positive constants, q_1 is the output of Country 1 and q_2 the output of Country 2. Each country has a constant marginal cost of production, c.

Imagine that Country 1's government imposes a specific tariff, t, on Country 2's exports. Country 1's profit is:

$$\prod\nolimits_1 = Pq_1 - cq_1 = aq_1 - bq_1{}^2 - bq_1q_2 - cq_1 \tag{2}$$

where equation (2) is obtained by substituting for P using equation (1). Since there is no use of tariffs in Country 2, its profit is:

$$\prod\nolimits_2 = aq_1 - bq_2{}^2 - bq_2q_1 - cq_2 - tcq_2 \tag{3}$$

Country 1's Cournot best-response function is determined by differentiating $\prod_1$ (equation 2) with respect to q_1 and setting the result equal to zero. After rearranging terms, this condition is:

$$q_1 = (a - bq_2 - c)\ /2b \tag{4}$$

Similarly, Country 2's best-response function is:

$$q_2 = (a - bq_1 - c\,(1 + t))\ /2b \tag{5}$$

The Nash-in-quantities equilibrium is obtained by solving equations (4) and (5) simultaneously for q_2 and q_1 (the intersection of the two best-response functions):

$$q_1^* = (a - c(1 - t)) / 3b \tag{6}$$

$$q_2^* = (a - c(1 + 2t)) / 3b \tag{7}$$

The government in Country 1 sets t to maximize its welfare. In choosing t, Country 1 must take into account the countries' equilibrium response to t, which is given in equations (6) and (7). Thus, Country 1's problem is:

$$\underset{t}{Max} \prod\nolimits_1^* = aq_1^*(t) - bq_1^*(t)^2 - bq_1^*(t)q_2^*(t) - cq_1^*(t)$$

If we substitute q_1^* and q_2^* by their equations (6) and (7), we get:

$$\underset{t}{Max} \prod\nolimits_1^* = a[(a - c(1 - t))/3b] - b[(a - c(1 - t))/3b]^2 - b[(a - c(1 - t))/3b]$$

$$[(a - c(1 + 2t))/3b] - c[(a - c(1 - t))/3b] \tag{8}$$

Rearranging the terms, we have:

$$\underset{t}{Max} \prod\nolimits_1^* = (a - c + ct)^2 / 9b \tag{9}$$

When coming across the tariff imposition of Country 1, the profit maximization function of Country 2 is:

$$\underset{t}{Max} \prod\nolimits_2^* = aq_2^*(t) - bq_2^*(t)^2 - bq_2^*(t)\, q_1^*(t) - cq_2^*(t) - tcq_2^*(t)$$

Or, equivalently, after substitution of q_1^* and q_2^* by their equations (6) and (7):

$$\underset{t}{Max} \prod\nolimits_2^* = a[(a - c(1 + 2t))/3b] - b[(a - c(1 + 2t))/3b]^2 - b[(a - c(1 + 2t))/3b]$$

$$[(a - c(1 - t))/3b] - c[(a - c(1 + 2t))/3b] - tc[(a - c(1 + 2t))/3b] \tag{10}$$

which can be simplified to:

$$\underset{t}{Max} \prod\nolimits_2^* = (a - c - 2ct)^2/9b \tag{11}$$

We can observe that, in equations (9) and (11), the effect of the tariff is positive for Country 1 (which imposed the tariff) and negative for Country 2. The modeling of games between two countries presented previously can be extended in several directions. In this paper, we considered the inclusion of the variable income into the demand function of the players. This variable was considered exogenous in this new version of the model. As a result of that, the countries face a new inverse demand curve, that is:

$$P(Q) = a - bQ + dY, Q = q_1 + q_2 \text{ and } Y = y_1 + y_2 \quad (12)$$

where y_1 is Country 1's income, y_2 is Country 2's income, and d is the (positive) coefficient of the total income, Y. The other variables were previously presented. Under this assumption, the countries' profit is:

$$\prod_1 = (a - bq_1 - bq_2 + dy_1 + dy_2)\ q_1 - cq_1 \quad (13)$$

$$\prod_2 = (a - bq_2 - bq_1 + dy_1 + dy_2)\ q_2 - cq_2 - \mathrm{t}cq_2 \quad (14)$$

Including the variable income into equations (4), (5), (6), (7), (8), (9), (10) and (11), Countries 1 and 2 face their new maximization problems:

$$\underset{t}{Max} \prod_1{}^{*} = (a + dy_1 + dy_2 - c + ct)^2 / 9b \quad (15)$$

$$\underset{t}{Max} \prod_2{}^{*} = (a + dy_1 + dy_2 - c - 2ct)^2 / 9b \quad (16)$$

If a third player is considered, the same analysis can be used to derive the Nash-Cournot Equilibrium. In deriving Country 1's best-response function, we must consider the expected level of output presented by the other countries. All the countries decide the total output simultaneously. Thus, when three players play a Cournot game, the Nash Equilibrium presents different payoffs. See Gibbons (1992) and Carlton and Perloff (2000) for the modeling of a game with three or more players.

1.2 Mixed complementarity problem

In this paper, we formulated Cournot games as mixed complementarity problems to simplify the simulations with tariffs and their implementation in the GAMS software. A Mixed Complementarity Problem (MCP) consists of a system of linear or non-linear equations that are written as inequalities and are linked to bounded variables in complementarity slackness conditions. The main advantage of an MCP formulation lies in its flexibility and speed in solving economic models, which result from the fact that Kuhn-Tucker's first-order optimality conditions are used to set up the models. For details, see Rutherford (1995).

The formulation of a Cournot game as a Mixed Complementarity Problem assumes that the Nash-Cournot Equilibrium defines the market price and the level of production for each country, taking the first-order conditions into account for all countries (Ventosa et al. 2002).

Given the linear inverse demand of powdered milk defined by equation (12), and considering the possibility that both countries use the same tariff, the countries' profit functions are:

$$\prod_1 = aq_1 - bq_1^2 - bq_1q_2 + dy_1q_1 + dy_2q_1 - cq_1 - tcq_1 \tag{17}$$

$$\prod_2 = aq_2 - bq_2^2 - bq_2q_1 + dy_1q_2 + dy_2q_2 - cq_2 - tcq_2 \tag{18}$$

To solve the Cournot's duopolistic model as a MCP it is necessary to obtain the following Kuhn-Tucker conditions:

Marginal conditions:

$$\frac{\partial \Pi_1}{\partial q_1} = a - 2bq_1 - bq_2 + dy_1 + dy_2 - c_1\,(1 + t_1) \leq 0 \tag{19}$$

$$\frac{\partial \Pi_2}{\partial q_1} = a - 2bq_2 - bq_1 + dy_1 + dy_2 - c_2\,(1 + t_2) \leq 0 \tag{20}$$

Nonnegativity conditions:

$$q_1 \geq 0;\ q_2 \geq 0 \tag{21}$$

Slackness conditions:

$$q_1\,[a - 2bq_1 - bq_2 + dy_1 + dy_2 - c_1\,(1 + t_1)] = 0 \tag{22}$$

$$q_2\,[a - 2bq_2 - bq_1 + dy_1 + dy_2 - c_2\,(1 + t_2)] = 0 \tag{23}$$

Once the slackness conditions are obtained, it is necessary to transform these equations into the Mixed Complementarity Problem format. According to Flakowski (2004), it is important to notice that only positive defined variables can be made complementary to inequalities or equations. However, it is not necessary to match free variables to equations; it is only required to have the same number of equations as free variables. For details, see Ferris and Munson (2000). In this paper, the level of production for each player, the total production and the market price are defined as positive variables. Those variables are associated to the equations of each country's profit, the equation of total production and the equation of market demand, respectively.

1.3 Econometric model

Before solving the Mixed Complementarity Problem, it is necessary to estimate the market demands for whole milk powder (WMP). First, we estimated individual market demands for Brazil and Argentina. After that, we estimated a market demand to simulate a game between both countries. Finally, we estimated a market demand to simulate a game between Brazil, Argentina and a third player, the Rest of the World.

Specifically, those market demands were defined as:

(a) Whole Milk Powder (WMP) demand for Brazil:

$$QB = \beta_{11} - \beta_{21}\, PB + \beta_{31}\, RB + u_1 \tag{24}$$

(b) WMP demand for Argentina:

$$QA = \beta_{12} - \beta_{22}\, PA + \beta_{32}\, RA + u_2 \tag{25}$$

(c) WMP combined demand for Brazil and Argentina:

$$QAB = \beta_{13} - \beta_{23}\, PAB + \beta_{33}\, RA + \beta_{43}\, RB + u_3 \tag{26}$$

(d) WMP demand for Brazil, Argentina and the Rest of the World:

$$QM = \beta_{14} - \beta_{24}\, PI + \beta_{34}\, RM + u_4 \tag{27}$$

where QB = demanded quantity of WMP in Brazil, 1990-2004 (expressed in thousand tons); QA = demanded quantity of WMP in Argentina, 1990-2004 (thousand tons); QAB = demanded quantity of WMP in Brazil and Argentina, 1990-2004 (thousand tons); QM = demanded quantity of WMP in Brazil, Argentina, Australia and New Zealand, 1990-2004 (thousand tons);

PA = WMP domestic price in Argentina, 1990-2004 (US$/ton); *PB* = WMP domestic price in Brazil, 1990-2004 (US$/ton); *PAB* = WMP average price in Brazil and Argentina, 1990-2004 (US$/ton); *PI* = Oceania international WMP price (FOB), 1990-2004 (US$/ton); *RA* = Argentina's real gross domestic product (GDP), 1990-2004 (million pesos); *RB* = Brazil's real gross domestic product, 1990-2004 (million reals); *RM* = world's gross domestic product real variation, 1990-2004 (annual percent change); β_{ij} ($i = 1, 2, 3, 4$; $j = 1, 2, 3, 4$) are the parameters to be estimated, and the error terms are represented by μ_i ($i = 1, 2, 3, 4$).

According to economic theory, we assumed that the parameters associated with prices are negative and those associated with income are positive. We assumed also that the error terms present mean zero and variance is constant.

1.4 Data and procedures

The demand equations for whole milk powder considering annual data covering the 1990-2004 period were estimated using the E-views econometric software. The time series data of WMP production and exports for Brazil, Argentina, New Zealand, and Australia were collected from the United States Department of Agriculture (USDA) through the Foreign Agricultural Service (FAS). In this paper, we considered demanded quantity as the produced amount once the WMP stocks for Brazil and Argentina are held at insignificant levels. The time series data on WMP prices (US$/ton) for Brazil and Argentina were collected from the *Secretaria de Comércio Exterior* (SECEX) and the *Secretaría de Agricultura, Pesca y Alimentación de la República Argentina* (SAPyA), respectively. The time series of international WMP prices were obtained from the USDA. The Argentinean real GDP (used as proxy of the income) was taken from the *Instituto Nacional de Estadística y Censos* (INDEC). The Brazilian real GDP and the world's gross domestic product real variation were taken from the *Instituto de Pesquisa Econômica Aplicada* (IPEADATA).

The marginal costs of WMP production were taken from the dairy report of the International Farm Comparison Network (IFCN). In this paper, we assumed constant marginal cost. The WMP import tariffs for Brazil, Argentina, Australia and New Zealand were taken from the United Nations Conference on Trade and Development (UNCTAD). The parameters used for the numeric resolution of the games as mixed complementarity problems were the ones implemented by the GAMS software (General Algebraic Modelling System) using the PATH solver. The codes for implementation of Cournot's duopolistic game in GAMS can be found in the Appendix (figure 1a).

In this paper, we considered the main changes in the whole milk powder trade between Brazil and Argentina from 1990 to 2004 as a reference to define the different scenarios. In the first two scenarios, we proposed to measure the effects of an autarchy on the WMP production for Brazil and Argentina in each domestic market. The third scenario simulated games between both countries on WMP production, starting with free trade all the way to the highest level of protection through prohibitive tariffs. Finally, the last scenario intended to simulate a three player game, considering Brazil, Argentina and the Rest of the World (New Zealand and Australia) as world exporters of whole milk powder.

2. RESULTS AND DISCUSSION

Before estimating the equations of the whole milk powder market demands, we tested the time series for unit roots. Dickey-Fuller's unit root test indicated that the time series used to estimate the Brazilian market demand (equation 24), the combined demand for Brazil and Argentina (equation 26), and the combined demand for Brazil, Argentina and the Rest of the World (equation 27) are stationary at the 5% level. However, by the Dick-Fuller test, the *QA* time series (Argentinean market demand) is stationary only at the 15% level. Unlikewise, the Phillips-Perron's unit root test indicated that this time series (*QA*) is stationary at the 5% level. Based on these results, we considered all time series used in this paper stationary.

2.1 Scenarios 1 and 2: Brazil and Argentina as monopolists

In this scenario, we assumed that the Brazilian milk powder producers do not face foreign competitors in the domestic market. First, we estimated the Brazilian whole milk powder market demand. The estimated results are found in table 1a. The variables Intercept, WMP market price and Brazilian income are statistically significant at the 5% level. In the estimated model,

Table 1a: Estimation Results for WMP market demand in Brazil

Dependent Variable: QB				
Sample: 1990-2004				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
Intercept	267.4043	44.8179	5.9664	0.0000*
PB	–0.0689	0.0277	–2.4833	0.0288**
RB	0.1444	0.0139	10.3425	0.0000*
R^2	**0.8999**		**F-statistic**	**53.9549**
Adjusted R^2	0.8832		Prob (F-statistic)	0.0000
Durbin-Watson stat	1.5632			

the R^2 value indicates that the variables used in the model explain 89.99% of the total variation in WMP demand.

The negative value of the price coefficient indicates that a US$ 1 increase per WMP ton reduces the demanded quantity in 68.9 tons. The demand price elasticity price of –0.5217 indicates that the 10% increase in the WMP price reduces its demanded quantity in 5.22%. Martins (1992) obtained milk demand price-elasticities between –0.1 and –0.6. According to Gomes (2002), the low milk demand price-elasticity in Brazil, around –0.5, combined with the growing supply price elasticity helps to explain the great oscillations on the milk price received by the Brazilian milk producers.

Assuming the monopolist maximizes profit, the profit maximizing output level is found by setting marginal cost equal to marginal revenue. At this point, Brazil output level reached 214.84 thousand tons. From 1990 to 2004, Brazil consumed an average of 323.77 thousand tons of milk powder per year. The WMP consumption increased from 185 thousand tons in 1991 to 428 thousand tons in 2004 (USDA 2005). Under the same assumptions, the optimal market price is equal to US$ 3,398.47. Over the period from 1990 to 2004, the average price was US$ 1,861/ton. The lowest price in the Brazilian market, US$ 1,390/ton, in 1991, is 37% inferior to the highest price found in 2000, US$ 2,210. These results show that if there was a monopoly in the Brazilian WMP market, there would be a consumer's surplus reduction due to an increase in the product price and a decrease in the quantity supplied.

Table 2a: Estimation Results for WMP market demand in Argentina

Dependent Variable: QA
Sample: 1990-2004

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Intercept	206.4428	63.4123	3.2555	0.0099*
PA	–0.0605	0.0322	–1.8754	0.0935***
RA	0.3724	0.2762	1.3478	0.2106 ns
R^2	**0.8608**		**F-statistic**	**18.5529**
Adjusted R^2	0.8144		Prob (F-statistic)	0.0003
Durbin-Watson stat	1.5526			

Afterward, Argentina was considered a monopolist in its domestic market. The coefficients of the Argentinean WMP market demand are presented in table 2a. The variables Intercept and domestic market price (RA) are statistically significant at a 1% and 10% level, respectively. The R^2 value indicates that 81.44% of the variation in the demanded quantity of Argentinean whole milk powder is explained by the predetermined variables of the model. The negative value of the market price (PA) indicates that a US$ 1 increase per WMP ton reduces the demanded quantity in 60.5 tons. In terms of the demand price-elasticity, the value of –0.7319 denotes that a 10% increase in the market price reduces the WMP demanded quantity in 7.32%.

In this scenario, where Argentina is considered an autarchy, the point where marginal revenue equals marginal cost and maximizes the profits is equal to 160.97 thousand tons of WMP. The whole milk powder consumption in Argentina increased from 83 thousand tons in 1990 to its highest value of 243 thousand tons during 1997-1998. Under monopoly, the WMP market price practiced by Argentina is US$ 3,284/ton. This value is significantly superior to the highest price of US$ 2,540/ton in 1993, and the lowest price of US$ 1,440, found during the Argentinean economic crisis of 2002. From 1990 to 2004, the average consumption of WMP in Argentina was equivalent to 165.13 thousand tons per year, while the domestic price presented the average value of US$ 1,997.67/ton. As observed before for Brazil, the autarchy in the Argentinean market reduces the output level and increases the domestic price.

2.2 Scenario 3: Cournot duopolistic game between Brazil and Argentina

The first simulation of this scenario assumed the absence of WMP import tariffs between Brazil and Argentina. These countries, while members of Mercosul, established a Common External Tariff for non-member countries. We formulated a Cournot game assuming Brazil and Argentina as duopolists. The estimation results of equation (26) are presented in table 3a. The variables Argentinean income (RA) and market price (PAB) are statistically significant at a 10% level. The variables Intercept and Brazilian income (RB) are statistically significant at the 1% level. The high R^2 value indicates that the model accounts efficiently for the behavior of the dependent variable. The negative coefficient of market price (PAB) points out that a US$ 1 increase per WMP ton reduces the demanded quantity by 196.2 tons. The demand price-elasticity indicates that a 10% increase in the WMP price reduces the amount in 9.13%, ceteris paribus.

The Brazilian income coefficient (0.6807), higher than the Argentinean income coefficient (0.4897), indicates that an increase in consumer's income in the first country has a larger effect in the total demanded quantity. In fact, Brazilian's economic stabilization plan reduced the inflation and provided a real increase in income. As a result, it contributed significantly to an increase in the consumption of dairy products by people of lower income, as a consequence of their high price elasticity.

The results of the first simulation using GAMS were obtained considering the estimated coefficients of equation (26). The market price established in this game is equal to US$ 1,983.22 per WMP ton. Argentina and Brazil produced 226.76 and 236.14 thousand tons, respectively.

Table 3a: Estimation results for WMP market demand between Argentina and Brazil

Dependent Variable: QAB

Sample: 1990-2004

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Intercept	892.1364	122.0190	7.3114	0.0000*
PAB	–0.1962	0.0665	–2.9504	0.0765***
RA	0.4897	0.2639	1.8556	0.0906***
RB	0.6807	0.0462	14.7336	0.0000*
R^2	**0.9745**		**F-statistic**	**140.2697**
Adjusted R^2	0.9676		Prob(F-statistic)	0.0000
Durbin-Watson stat	1.9277			

During the first stage of the Real Plan (1994-1998) the WMP production in Brazil increased 42.86%, reaching 240 thousand tons of whole milk powder in 1998 (USDA 2005). However, the high level of WMP domestic consumption and the overvalued exchange rate stimulated the increase of the WMP Brazilian imports over this period.

In spite of presenting favorable conditions of development, the great transformations in the Argentinean dairy sector did not occur until the end of the 1980's because of an inappropriate economic environment. The stabilization plan, combined with the implementation of Mercosul, promoted an expressive increase in Argentinean WMP production and exports. Over the period from 1990 to 2004, Argentina's WMP production increased 254.84%, reaching the record level of 244 thousand tons in 1999 (USDA 2005).

In 2001, WMP was included in Brazil's Common External Tariff exception list. After that, a 27% tax is charged in addition to the import tariff of 18.5% to all markets, including Mercosul members. The new game between Argentina and Brazil was simulated considering the WMP import tariff changes adopted by Brazil. In this second simulation, the imposition of tariffs in the WMP trade flow between Brazil and Argentina was considered. The new market price was US$ 2,077.86/ton, 4.86% higher than the first simulation. Under these conditions, Brazil produced 254.72 thousand tons of WMP. According to USDA (2005), Brazil WMP output level was equivalent to 256 thousand tons in 2000.

After the inclusion of the whole milk powder in the exception list of the Common External Tariff, Argentina reduced its production in 13.9%, to 229.61 thousand tons. Brazil's currency devaluation in January 1999 and the continuous growth of the Brazilian WMP production led Argentinean WMP to become less competitive. In fact, according to Spaya (2005), the Argentinean whole milk powder production fell from 244 thousand tons in 1999 to 208 thousand tons in 2000, representing a 14.75% decrease.

The third simulation of this scenario tried to quantify the effects of a potential decision by Argentina to retaliate its main trade partner by applying the same tariff level adopted by Brazil. Considering Argentina's retaliation, the new WMP market price is US$ 2,196.63/ton, the highest value of this scenario. Brazil reduces its production to 208.31 thousand tons, the smallest output level considering the other game payoffs. After retaliating

Brazil, Argentina's production is 252.84 thousand tons. Even equalizing the import tariff level, Argentina does not overcome its first game's output level in which the use of tariffs did not exist for either country. However, without cooperation it may be difficult for the two countries to realize the superior free trade outcome. In a non-cooperative game, if both countries begin with free trade, each country has an individual incentive to deviate and implement tariffs.

In the final simulation of this scenario, we considered what would be prohibitive WMP tariff for both countries. When the Brazilian WMP import tariff increased to 327% there was no incentive to the international trade. In other words, this was the first tariff level at which the second player did not produce any amount. When the Argentinean WMP import tariff reached 232%, Brazil was not motivated to produce whole milk powder. In fact, according to Gibson et al. (2001), in some countries the import tariffs on dairy products reach prohibitive tariff levels. Japan, for instance, has an average import tariff for dairy products equivalent to 322%.

As it can be observed, the adoption of tariff practices in the whole milk powder trade by Brazil and Argentina reduces the total amount of production for both countries. As the market price behaves inversely to the total output level, the price goes up as the tariff level increases. The final outcome, after retaliation occurs, is very likely to cause reductions in the welfare of both countries. This occurs because each trade policy results in a decline of the consumer's surplus of both countries.

2.3 Scenario 4: three player Cournot game (Brazil, Argentina and the Rest of the World)

The simulation of the fourth scenario illustrates a three player Cournot game considering tariff imposition and free trade. In this game, Brazil and Argentina are considered as world WMP exporters inserted together in the international trade against a third player formed by New Zealand and Australia. According to Sapya (2005), New Zealand and Australia were the main WMP exporters in 2003, representing a share of 37% and 14% of the world's total net WMP exports, respectively. The estimated parameters of the demand equation are presented in table 4a.

The variables Intercept and Trend are statistically significant at a 5% level. World's income is not statistically significant. The R^2 value for equa-

Table 4a: Estimation Results for WMP market demand between Argentina, Brazil and the Rest of the World

Dependent Variable: QM

Sample: 1990-2004

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Intercept	1529.992	294.1752	5.2001	0.0003*
PI	–0.313798	0.140538	–2.2328	0.0473**
RM	28.19297	78.42446	0.3595	0.7260 ns
@trend	**128.0171**	**23.86531**	**5.2384**	**0.0003***
R^2	0.8816		F-statistic	27.2906
Adjusted R^2	0.8492		Prob (F-statistic)	0.0000
Durbin-Watson stat	1.6309			

tion (27) indicates that the three independent variables explain 88.16% of the variation in the world's demanded quantity of WMP. The demand price-elasticity value of 0.5785 indicates that a 10% increase in the market price reduces the WMP demanded quantity in 5.78% .

Considering the estimated coefficients, two Cournot games were simulated among the three players. The first game was simulated considering the current WMP tariff levels adopted by the countries. According to Unctad (2005), the whole milk powder import tariffs for Brazil, Argentina and the Rest of the World (Australia and New Zealand) correspond to 27%, 16% and 5%, respectively. Under these conditions, Argentina, Brazil and the Rest of the World produced 208.38, 387.79 and 423.77 thousand tons of whole milk powder, respectively.

Although Argentina produced and exported record levels of whole milk powder during the 1990's, it stagnated in the subsequent years. The economic recession that began in 2000 and the following economic crisis in 2002 hit the Argentinean dairy sector very hard. However, the strong devaluation of 2002 and very firm world prices in the past years are driving a strong recovery of that sector in Argentina. According to Saypa (2005), Argentina produced approximately 204 thousand tons of WMP in 2002, 2.15% above the estimated amount for this player.

In Brazil, in spite of the vertiginous growth of milk production in the 1990's, the output level was still insufficient to supply the domestic consumption. After 2001, Brazilian exports of whole milk powder began to obtain prominence positions. The dairy sector registered its first trade surplus in 2004, as the value of dairy exports surpassed that of imports. The increase of import tariffs, the exchange rate depreciation, the prohibition of imported powdered milk in the federal government's social programs and the increase in fitosanitary measures support higher Brazilian WMP production. In the first game of this scenario, Brazilian's production achieved a similar value to the observed amount of 390 thousand tons in 2003, as indicated in USDA (2005).

The estimated production of player Rest of the World was 22% inferior to the average volume produced by Australia and New Zealand from 1990 to 2004, about 543 thousand tons of whole milk powder (USDA 2005). This difference can be attributed to the fact that Australia and New Zealand, besides having higher production costs than Brazil and Argentina, are traditional exporters of powdered milk. Therefore, they have consolidated market positions for their powdered milk through preferential trade agreements (PTAs) and international sale contracts. Since we did not consider these issues in the simulations, the model did not capture such effects.

The international price of WMP in the first game of this scenario was US$ 2,044.77/ton. The American dollar depreciation relative to the Euro, the New Zealand and the Australian dollar can be considered as a decisive factor in the increase of WMP prices. According to OCDE (2005), the international WMP price increased from US$ 1,340 in 2001 to US$ 2,108.65 in 2004.

In the second simulation of this scenario, we intended to quantify the impact if free trade was assumed among the three countries. In other words, what would happen if the three players eliminated import tariffs? Under these conditions, Brazil reduced its output level by 31 thousand tons. It is noticed that the compensatory measures against Argentina and New Zealand and the inclusion of WMP in the "exception list" of the Common External Tariff of Mercosul allowed Brazil to improve its terms of trade.

Once we assumed free trade, Argentina and the Rest of the World increased their output level. The Argentinean powdered milk presents the smallest production cost of the three players, so the elimination of tariffs improved its terms of trade. Under these conditions, Argentina obtained an increase of 30.76%, producing 271.88 thousand tons, its highest value considering all scenarios. Player Rest of the World presented a positive but smaller impact facing trade liberalization, increasing its output level in

5 thousand tons and reaffirming New Zealand's position as the world's largest WMP net exporter.

When a country like Brazil sets trade policies to improve its terms of trade, there is a subsequent reduction in world efficiency. The elimination of tariffs provided an increase of consumer's surplus through the combination of lower prices and larger output level. The total amount produced by the three players increased 4% after trade liberalization, while the market price of US$ 1,914.42/ton is 6.35% inferior to the game with tariffs.

3. CONCLUSIONS

Since the implementation of Mercosul, the calendar of negotiations among member countries has been intensely focused on dealing with trade conflicts. Over the last years, whole milk powder has created trade divergences between Brazil and Argentina. In this paper, we analyzed the effects of tariffs on whole milk powder trade flow between Brazil and Argentina from 1990 to 2004. We formulated tariff games among countries as Mixed Complementarity Problems and developed their implementation in GAMS.

When there were no tariff impositions between Argentina and Brazil, the first country reached a higher output level. Then, after the Brazilian government implemented WMP import tariffs over Argentina, Brazil got a better payoff due to changes in its terms of trade. As expected in the hypothesis of retaliation, Argentina would produce more than Brazil and the market price would be higher.

In the three player game with current WMP tariff levels, Brazil got its highest output of all scenarios. Once free trade was considered, players Argentina and the Rest of the World increased their output level while Brazil reduced its production.

Besides possibly representing a loss in terms of society's welfare, indeed WMP import tariffs have been important to protect Brazil's dairy sector from illegal practices of international trade. Therefore, it can be interesting for Brazil to maintain import tariffs as an opportunity to improve its terms of trade, to increase its competitiveness against traditional international competitors and to consolidate its recent position as a dairy exporter.

APPENDIX

Figure 1a: Codes for Cournot duopolist game with tariffs as a MCP in GAMS

Scalars

a	intercept /4151.996996/
b	inclination/4.664788/
$c1$	marginal cost country 1 /624/
$c2$	marginal cost country 2 /780/
$t1$	import tariff to country 1 /0.455/
$t2$	import tariff to country 2 /0/
d	income coefficient /7.132913/

Positive Variables

$q1$	output level country 1
q^2	output level country 1
qt	total output
p	demand function
yt	total income
$y1$	income country 1
$y2$	income country 2

Equations

profit1	profit condition country 1
profit2	profit condition country 2
price	demand condition
output	output condition
income	total income condition
income1	income condition country 1
income2	income condition country 2
profit1..	$2*b*q1 + b*q2 - d*y1 - d*y2 = g = a - c1*(1 + t1);$
priofit2..	$b*q1 + 2*b*q2 - d*y1 - d*y2 = g = a - c2*(1 + t2);$
price..	$p = g = a - b*q1 - b*q2 + d*y1 + d*y2;$
output..	$q1 + q2 = g = qt;$
income..	$y1 + y2 = g = yt;$
income1..	$y1 = g = 0;$
income2..	$y2 = g = 0;$

Cournot model

	profit1.$q1$
	profit2.$q2$
	price.p
	output.qt
	income.yt
	income1.$y1$
	income2.$y2$/;

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