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ECONOMIC IMPACT OF QUALITY CERTIFICATION OF INDUSTRIAL PRODUCTS ON THE BRAZILIAN DOMESTIC MARKET

Jaime M. Ticona (jmt@ituc.puc-rio.br) *and Mauricio N. Frota (*mfrota@metrologia.ctc.puc-rio.br)

Abstract: This work reviews the economics of standards, conformity assessment procedures and the trade of Brazilian industrial products. It also evaluates the associated economic impact resulted from their product certification based on international best practices. Four leading products were chosen: steel, bus coachwork, automotive tires and cement. The production time series of these products (made available by governmental agencies) were fitted by means of the multiple linear regression method. The method was successfully applied at a 5% level of significance (a probability value –p-value– lower than 0.05 guarantees the existence of non-zero polynomial coefficients).

The simulation investigated the combined economic impact of (i) the regionalization process that has led to the establishment of a common market in the South Cone (Mercosur); (ii) the exposure of the Brazilian market to international trade competition (the opening up of the Brazilian economy in the 1990's); (iii) product certification and (iv) the monetary inflation in Brazil, in the period. Each individual impact was documented. The product certification proved to be beneficial as 15.1% growth in production of cement, 12.4 % in steel, 11% in automotive tires and 13.3 % in bus coachwork were observed.

Keywords: Product certification, metrology, economic impact, Brazilian industrial products, multiple linear regression.

1. INTRODUCTION

In the 1990's, the macroeconomic reforms sponsored by Bretton Woods Institutions were implemented in Latin America. And a surge in the region's international trade favoured by an increase of global demand of their major products (fuels, metals and primary products) [1] made local policy makers believe that the systematic application of the new liberal agenda would bring about a new era of prosperity. But scant investments in basic infrastructure which would include an integrated network of MSTQ services (metrology, standards, technical regulations, accreditation and different forms of conformity assessment) arrested development.

Technologically speaking, Brazil was better equipped than most Latin American nations to face the challenges imposed by the IMF's structural adjustment programmes. Unlike the majority of its neighbours, the country implemented a sound MSTQ system, a shrewd strategy to build up a strong industrial base. Although difficult to measure, a correlation does exist between the two. In general, the more industrialized the nation the more robust is its MSTQ infrastructure.

Seen as an essential element to meet the tight requirements of a fast-growing world trade, an integrated MSTQ system has attracted the attention of local governments and the private sector. Furthermore, the voluntary nature of international standards –one of the MSTQ functions– which reduces transactions costs, fosters competitiveness and facilitates business through the trade goal "tested once accepted everywhere" may play a significant role in the region's economic growth.

With the onset of globalization, the world's economy has witnessed an increase in volume of cross-border transactions in goods and services. Markets have become global in scope and encompassed a greater range of goods and services. And financial markets around the world are now connected through instant computer link-up. No matter how enthusiastically welcome by some or strongly criticized by others, globalization is here to stay. According to a UN report [2] "…globalization has set in motion a process of deep changes with far-reaching consequences that is affecting everyone". New technologies have created an interdependent and interconnected world never seen before in human history.

The painful adjustments of the 1990's proclaimed by pro-market economic doctrines [3] and the inability of many Latin American governments to implement a sound and internationally recognized MSTQ system to support industrial development have yet to deliver the desirable economic and social results. Regrettably, income inequality has increased throughout the region.

To the economic volatility of global markets and the aggressiveness of global traders, Argentina, Brazil, Paraguay and Uruguay responded with regional integration mirrored in the European Community (EC). The Mercosur –a regional common market created in 1990– was meant to be a free trade zone to gain economic scale and enjoy comparative advantages (essentially the complementary character of the Brazil's and Argentina's economies) among its member states. Nonetheless, integration within Mercosur, does not seem to be delivering on its promises.

According to Averbug [4], due to protectionism (heavy agriculture subsidies, undesirable protectionism policies and asymmetry of national standards not yet harmonized through regional standards) exports from Mercosur to the EC increased by only 25 % while imports skyrocketed to 274 % between 1992 and 1996. Among other reasons, this certainly reflects vulnerability or lack of harmonization of their MSTQ system as products tested by exporters must be accepted by importers. Asymmetries in conformity assessment procedures usually lead to costly duplication of product testing and recertification.

A rebound in its economic activities has led South America's trade to recover vigorously in 2004. Real imports expanded nowhere else faster than in this region. However, a number of economies in Central America and

the Caribbean did not participate in this remarkable trade expansion. According to the 2005 WTO Report [5]. South American countries were among the most dynamic traders in 2004, period in which the region exhibited a 9 % growth in its foreign trade –the best performance since 2000. Real imports in South America grew by 18.5 per cent, which was twice as fast as that of the world trade. Argentina's imports recovered dramatically (by an increase of at least 50 %), while Brazil's and Chile's expanded by 20 %. In line with the prevailing post-war pattern, trade growth outstripped GDP growth in the region by a significant margin of 5 percentage points. If this pattern continues, trade will become an ever more crucial component of global economic activity.

The aim of this work is to assess by means of an econometric model the combined effect caused by (i) the presence of the Mercosur economic environment; (ii) the exposure of the Brazilian market to international trade competition; (iii) product certification and (iv) the inflation in Brazil in the period.

2. Basic MSTQ Infrastructure for Product Certification

In today's domestic and international trading environments, all countries need access to basic MSTQ services, to enhance quality and competitiveness, facilitating the entry of their products in strongly competitive markets.

As the technological basis of a streamlined regulatory framework, a well functioning MSTQ system is required to ensure uniformity, reliability and recognition of measurements performed by domestic laboratories and of testing and inspections conducted by conformity assessment bodies and regulators. An MSTQ system guarantees that products which comply with standards and technical specifications do meet quality expectations of consumers and are not detrimental to health and to the environment.

Figure 1 illustrates the fundamentals associated with product certification, a formal conformity assessment process underpinned by four essential major infrastructures which require international recognition and access to:

- measurement capability;
- documentary voluntary standards;
- to mandatory legislation applied to the regulated sectors (technical regulation) and
- a formal system of trust capable to assess the competence of the providers of conformity assessment services; i.e. to establish formal recognition that providers of these services are both technically competent and operate within the disciplines of international standards and best practices.

International recognition is then ensured through effective participation in international activities and/or access to complex systems of mutual recognition arrangements (MRAs) of international organizations dealing with metrology (BIPM), technical regulation (WTO, OIML), accreditation of laboratories (ILAC) and of certifying bodies (IAF) and international standards and quality management as defined by international standard bodies (ISO and IEC). Figure 1 depicts a typical example of certification used to attest the quality of products, facilitating their access to competitive markets. This figure also shows the underpinning services (metrology, standards, technical regulation and accreditation) required to ensure international recognition. Brazil has succeeded in implementing its integrated MSTQ basic industrial technology infrastructure

There are many other examples of economic benefits resulting from an adequate use of metrology and other MSTQ related functions which cannot be straightforwardly quantifiable. But there are also examples of risks created by the misuse of MSTQ functions and the penalties for not using them at all.

3. ASYMMETRY OF INFORMATION

In early studies, Akerlof [6], Spence [7] and Stiglitz [8] set up the governing principles of modern information economics. For their relevant individual contributions to this field they were awarded the Nobel prize for economics in 2001. Their remarkable work drastically modified the way economists perceived the functioning of the market and explained how information asymmetries affected the rationale of social and economic institutions. Since then, other researchers [9, 10, 11, 12] have used and extended their original ideas to confirm that information asymmetry does hinder market efficiency. In Stiglitz's own words [8] "lack of knowledge of products of good quality in a given market may lead to their exclusion by unfaith competition between producers; i.e. societal inefficiency to *asymmetric information flows"*.

Asymmetry of information naturally leads to:

- **adverse selection** – a term used in economics and insurance to refer to a market process in which bad results occur due to information asymmetries between buyers and sellers. As a result, "bad" products may be selected or uninformed customers may be deceived and
- **moral hazard** – opportunism characterized by an informed person who takes advantage of a less-informed one, through an *unobserved action* (example: employee shirks if not monitored by employer)

that, in turn, may induce to market failure or market exclusion of goods and services of higher quality.

Information asymmetries undoubtedly affect the efficient functioning of the markets, often leading to a supply of low quality products variety.

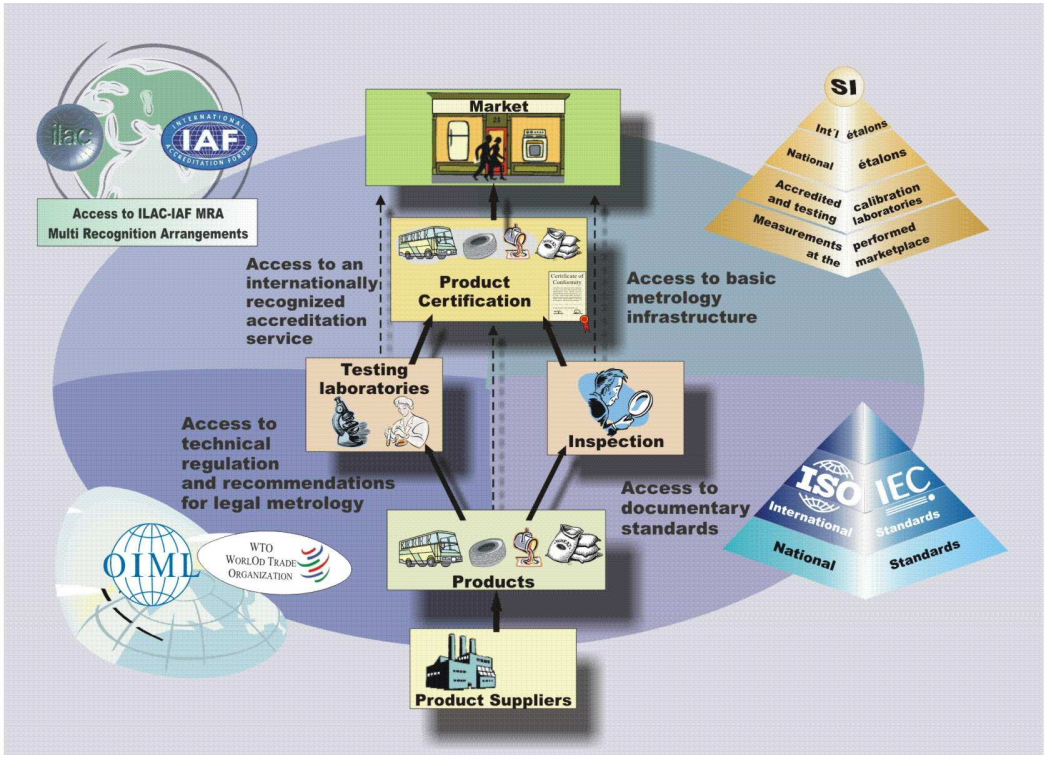


Fig. 1. Product certification: an internationally recognized process to ensure quality of products and to facilitate its access to competitive markets.

3.1 The economics of standards to international trade

As quoted in the 2005 WTO report *Exploring the links between trade, standards and the WTO* [5], "…we live in a world profoundly reliant on product standards. They affect our lives in ways we sometimes do not even notice, but they can have far-reaching implications for economic activity, including trade". In this respect, differences in regulation and national standards from country to country can act as no desirable barriers to trade, thus hindering commercial transactions. Because the responsibilities are usually spread and diffused under the control of different Ministries and regulatory agencies, the official asset of regulatory information is not always immediately available to domestic and international traders in a harmonized fashion. As a result, asymmetry in the perception sensed by the different parties affects the regulatory system. In this context, lack of harmonization of standards and drastic changes in trade legislations may be perceived as asymmetries in the regulatory information system. And, in this context, standardization, quality and product certifications, constitute effective strategies to reduce asymmetry of information between sellers and buyers.

Examples of how standards affect our world today abound in the literature. Safety technical regulations allow citizens to consume products with confidence that otherwise would be impossible if they were to make their own judgments about safety in everyday life at every turn. Rules of conduct and product standards in several areas of the industrial activity help consumers to avoid inefficiency, unpleasant surprises, and high transaction costs.

Safety, higher quality products, technological innovations, the expansion of commerce, social issues and the environment have boosted, in recent years, standardization activities. By the end of 2004, a consortium of European standards organizations (Perinorm) had recorded about 650,000 standards (national, regional and international) from 21 countries. Since its foundation in 1947, the International Organization for Standardization (ISO) has developed around 14,900 international standards. More recently, non-governmental organizations (NGOs) have also been involved in standard-setting, essentially related to the environment and corporate social responsibility [5].

Standards can also increase welfare of citizens by removing information asymmetries in markets. Information asymmetries that occur when producers have information about the characteristics of goods they produce which users do not possess. As end consumers or as firms, buyers may be at a significant disadvantage compared to sellers because the latter possess information about the good or service not available to the first. This asymmetry may significantly hamper the efficient functioning of markets. In the health sector, the economic cost from accidental injuries and deaths may be large. For instance, in 2003, in the United States alone, there were more than 12 million accidents related to inadequate products which led injured people to be treated in hospitals. The US Consumer Product Safety Commission estimates that the economic costs of these accidental deaths and injuries would be about USD 700 billion annually [5]. The potential gains resulting from adequate use of safety

standards and of conformity assessment procedures are unmistakably relevant.

3.2 Certification: an internationally recognized tool for reducing information asymmetry

Systematic applications of harmonized standards to international trade (asymmetry reduction) over the last decades have helped to bring down tariffs worldwide. When a product, a service or process has, or can be given, uniform certification, transactions are made much easier because economic agents know what they are buying and selling. As a result, expanding markets for goods and services provide new outlets for developing countries wishful to benefit from globalization. But access of developing countries products to developed countries markets is often hampered by differences in regulations as observed by Garcia et all. [13].

In the presence of information asymmetries, quality certification becomes essential to protect producers who want to be assured that the products they are selling comply with specified technical standards and (specially) consumers who want to be convinced of the quality of the products they are buying. As a result, certification enhances the efficient functioning of markets.

Based on abundant theoretical and empirical evidence Nicolau et. all. [14] suggested that a market reacts positively when certification is granted to a product or service. Their results strongly support the claim that quality and product certification employed by companies substantially reduces asymmetry in the information available to companies and consumers.

Asymmetry of information is a major source of problem which affects trade efficiency. In most areas of industrial technology, standards and certification are efficient tools to reduce it. From this perspective, globalization could be seen as a benign force for delivering economic prosperity.

In this context, standards and product certification provide key information to remedy distortions created by information asymmetries between buyers and sellers.

4. MODELING

To investigate the combined effect of technological and macroeconomic variables on the production of the four industrial goods, an econometric tool that uses a regression technique, was adopted. It models the effect introduced by product certification, the presence of the Mercosur economic environment, the exposure of these products to international competition (the opening up of the Brazilian market) and the inflation measured in the period. A confidence level of 95% probability that ensures, in all cases, a p-value of less than 0.01 (99%) confirmed the quality of the results generated by the method.

Several methods are available in the literature [15, 16] to model linear relationships between a dependent variable (usually called the predictand) and one or more independent variables (usually called the predictor). The multiple linear regression method (MLR), a variation of the classical least square technique (LS), minimizes the sum-of-squares of differences of observed and predicted values. And, in the process of fitting the model, statistics are compiled to validate the multiple linear regression.

An initial test had to be carried out to determine whether the relation between dependent and independent variables was linear. Otherwise, the MLR method could not be applied. Linearity between variables was verified by the EViews software (scatter-plot) which guaranteed the application of the method.

4.1 Governing equations

The governing equation (that relates the value of a predictand variable as a linear function of the predictor variables and an error term) may be written as follows:

$$Y_T = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + ... + \beta_K X_{iK} + u_i \quad (1)$$

Where:

Y_T is a time-dependent variable vector.

$X_{T,1:K}$ are values of the Kth term of the independent variable T (expressed in years), which assume values 1 or 0 (dummy variables).

β_0 is the regression constant

$\beta_{1:K}$ are a coefficient of kth independent variable

K is the total number of independent variables

u_T is a time-dependent error term vector.

$\hat{\beta}_{0:K}$ are estimated values

When applied to the four industrial products studied, equation (1) becomes:

$$Y_T = \beta_0 + \beta_1 X_1 ... + \beta_{K-1} X_{K-1} + \beta_K X_K + u \quad (2)$$

and the final regression equation, which fits the model, is given by the average production $\overline{Y}$ for the estimated period:

$$\overline{Y}_T = \hat{\beta}_0 + \hat{\beta}_1 \overline{X}_1 + ... + \hat{\beta}_K \overline{X}_K + u. \quad (3)$$

where:

$\overline{X}$ are the average of the predictors and

$\hat{\beta}_{1:K}$ are the linear regression coefficients.

4.2 Dummy variables and time series

To assess the economic impact of the combined effects (certification and macroeconomic variables) on the production of cement, steel, bus coachwork[1] and automotive tires, by means of the multiple linear regression method, three dummy variables were introduced in the model. These dummy variables characterize the periods that preceded and followed specific events:

- the introduction in Brazil of product certification for the four manufactured goods (August/ 1994, for cement; Jan/1997, for steel; Jan/1993, for bus coachwork and May/1996, for automotive tires);

[1] Also known as bus body or bus shell.

- the date (Jan/1995) when the Mercosur trade agreement came into effect;
- the date (Jan/1990) when the macroeconomic reforms begin to be implemented in the country (transition to a more competitive market economy);
- the effect of the monetary inflation in the period.

The production time series of the products investigated were made available by the Brazilian Institute of Economic and Planning (IPEA[2]). The following time intervals were used as input data:

- Cement: 1970-2004
- Steel: 1980-2004
- Automobile tires: 1975-2004
- Bus coachwork: 1980-2004 and

Due to its inherent nature, the causal variables under consideration are classified in two different categories. "Certification" is certainly a variable of technological nature introduced to infer quality while "the opening up of the market", "Mercosur" and "monetary inflation" are external variables of macro-economic nature.

"Certification" (CERT), "Mercosur" (MERC) and "the opening up of the Brazilian market" (APER) –not of numerical nature– were modelled as dummy variables and "production" (PROD) and "inflation" (INF) as time series.

The values 0 (zero) or 1 (one) were assigned to the dummy variables X_T according to their status (absence or presence, respectively).

When $X_t = 0$ and $X_t = 1$ are applied to equation (2) one obtains: $Y_{X_{T=0}} - Y_{X_{T=1}} = \beta_{1:K}$ (4)

where K=1, 2 and 3 stand for the variables CERT, APER and MERC.

The coefficients β_1, β_2 and β_3 for each one of the four products can then be obtained from equation (4) solved for each one of the dummy variables.

5. RESULTS AND DISCUSSION

Due to its industrial relevance and export potential to the Brazilian economy (evidenced by the data shown in Table I), cement, steel, automotive tires and bus coachwork, were the products selected to be studied.

Table I: Relevant data of the selected products

Production	World Ranking	Annual Brazilian Production	Export
Cement[3]	11º	34.5 (10^6 metric tons)	1.6%
Steel[1]	7º	32.9 (10^6 metric tons)	39.5%
Automotive Tires[4]	7º	52 (10^6 units)	32.8%
Bus coachwork[2]	2º	28,732 (units)	45.0%

Source: [1,3]United Nations "Statistical Bulletin" (2004), [2]ANFAVEA (www.ufavea.com.br, 2004) and [4]ANIP (www.**anip**.com.br/ 2004).

Based on these sensitive coefficients calculated by the multiple linear regression technique, equation (3) is rewritten in the form:

*PROD (Y) = C(1) + C(2)*CERT + C(3)*APER + C(4)*MERC + C(5)*(-INF) + C(6)*RESID01(-1)* (4)

applied to all products studied.

5.1 Multi linear regression: combined effect on production

The four blocks presented below summarizes information on product certification, the corresponding applicable standards, the MLR polynomial equation, and graphics EViews data output of actual and fitted time series (scattered in a monthly basis), for each of the four products). All relevant statistics generated by the multiple linear regression technique, which are displayed in standard format, the influence coefficients and the probability of model adequacy are also shown. Production under certification is indicated on the right side of the vertical dotted line shown in these figures.

Regression consistency tests carried out

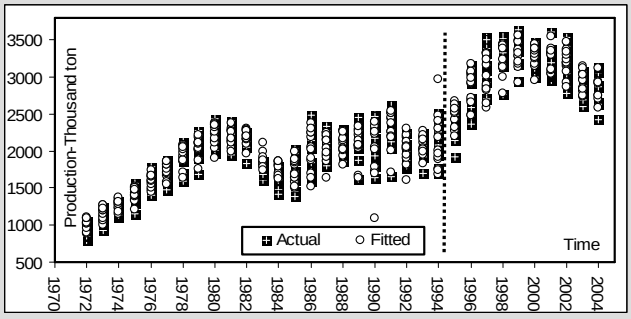
Autocorrelation – as shown in Tables II, III, IV and V, the Durbin-Watson coefficients lied in the interval [2, 2.2], thus discarding the existence of autocorrelation.

Normality – Jarque-Bera's coefficient, associated with the normal distribution, for cement was 0.51, Steel 0.63, bus coachwork (bus shells) 0.7, and automobile tires 0.82 and the probabilities associated with them were P-value = 0.77; P-Value = 0.74; P-value = 0.62; p-value = 0.57, respectively. And are within accepted limits.

Homoskedasticity – (the variance of the perturbed term is constant in each point of the sample) The White test guaranteed that the perturbed terms remained unchangeable as the ***p-value*** was always greater than the reference value (0.05).

Product: Cement
Type of certification: Voluntary (implemented in August/1994)
Applicable standard*: NBR 5736*

MLR Equation: ***PROD = 1689.206722 + 456.9674734*CERT + 181.8819619*APER + 711.9685557*MERC - 6.647507969*(-INF) + 0.7669036098*RESID01(-1) + 0.1826983139*RESID01(-24)***



Dependent Variable: Production of Cement
Method: Least Squares
Date: 05/12/05 Time: 12:18
Sample(adjusted): 1972:01 2004:08
Included observations: 392 after adjusting endpoints

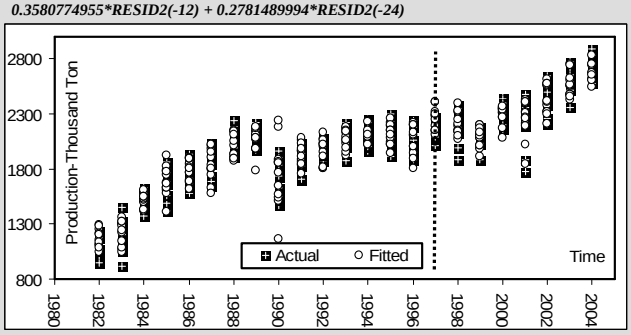
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1689.207	14.66832	115.1602	0.0000
CERT	456.9675	90.81483	5.031859	0.0000
APER	181.8820	32.15956	5.655611	0.0000
MERC	711.9686	85.80584	8.297437	0.0000
-INF	-6.647508	0.965980	-6.881622	0.0000
RESID01	0.766904	0.026387	29.06339	0.0000

R-squared	0.938258	Mean dependent var	2214.131
Adjusted R-squared	0.937296	S.D. dependent var	673.7915
S.E. of regression	168.7227	Akaike info criterion	13.11209
Sum squared resid	10959936	Schwarz criterion	13.18300
Log likelihood	-2562.969	F-statistic	975.1053
Durbin-Watson stat	2.105711	Prob(F-statistic)	0.000000

[2] IPEA – Instituto de Pesquisa Econômica Aplicada (Ministry of Planning, Budget and Management).

Product: Steel
Type of certification: mandatory (implemented in Jan/1997)
***Applicable standard**: NBR 7480/96*

MLR Equation: ***PROD = 1500.553894 + 279.0194385*CERT - 7.536612234*(-INF) + 348.2859789*APER + 207.9067159*MERC + 0.8368947359*RESID1(-1) + 0.3580774955*RESID2(-12) + 0.2781489994*RESID2(-24)***



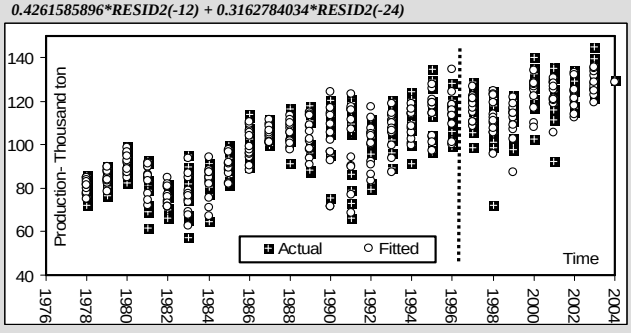
Dependent Variable: Production of Steel
Method: Least Squares
Date: 05/19/05 Time: 15:34
Sample(adjusted): 1982:02 2004:09
Included observations: 272 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1500.554	14.69403	102.1200	0.0000
APER	348.2860	19.40876	17.94478	0.0000
MERC	207.9067	30.76982	6.756840	0.0000
CERT	279.0194	25.28757	11.03386	0.0000
-INF	-7.536612	0.643365	-11.71437	0.0000
RESID1	0.836895	0.026623	31.43537	0.0000

R-squared	0.921864	Mean dependent var	1998.716
Adjusted R-squared	0.919792	S.D. dependent var	388.0484
S.E. of regression	109.8993	Akaike info criterion	12.26598
Sum squared resid	3188556.	Schwarz criterion	12.37203
Log likelihood	-1660.173	F-statistic	444.9588
Durbin-Watson stat	2.079732	Prob(F-statistic)	0.000000

Product: Automotive tires
Type of certification: mandatory ((implemented in May/1996)
***Applicable standard**: INMETRO (Resolution, of Dec. 27,96)*

MLR Equation: ***PROD = 85.36367744 + 13.27356515*CERT + 14.09353007*APER + 7.23907449*MERC - 0.304128258*(-INF) + 0.717058231*RESID1(-1) + 0.4261585896*RESID2(-12) + 0.3162784034*RESID2(-24)***



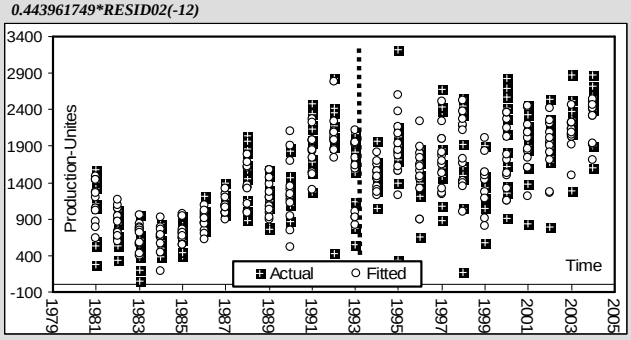
Dependent Variable: Production of Tires
Method: Least Squares
Date: 01/25/05 Time: 17:46
Sample(adjusted): 1978:01 2004:01
Included observations: 313 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	85.36368	0.811451	105.1989	0.0000
CERT	13.27357	2.176935	6.097363	0.0000
APER	14.09353	1.330753	10.59064	0.0000
MERC	7.239074	2.484511	2.913682	0.0038
-INF	-0.304128	0.042522	-7.152243	0.0000
RESID1	0.717058	0.033277	21.54817	0.0000

R-squared	0.831870	Mean dependent var	102.8824
Adjusted R-squared	0.828011	S.D. dependent var	18.65956
S.E. of regression	7.738411	Akaike info criterion	6.955497
Sum squared resid	18264.32	Schwarz criterion	7.051246
Log likelihood	-1080.535	F-statistic	215.5813
Durbin-Watson stat	2.091419	Prob(F-statistic)	0.000000

Product: Coachwork bus
Type of certification: mandatory (implemented in Jan/1993)
***Applicable standard**: Government Resolution INMETRO nº 109 and subsequently updated in 1992 no. 19 and 49*

MLR Equation: ***PROD = 898.5417859 - 332.9432012*CERT + 858.2414414*APER + 418.7980387*MERC - 5.939085625*(-INF) + 0.6376881205*RESID01(-1) + 0.443961749*RESID02(-12)***



Dependent Variable: Bus Shell
Method: Least Squares
Date: 05/12/05 Time: 12:15
Sample(adjusted): 1981:02 2004:10
Included observations: 285 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	898.5418	41.21898	21.79922	0.0000
CERT	332.9432	92.79201	3.588059	0.0004
APER	858.2414	71.08214	12.07394	0.0000
MERC	418.7980	87.51952	4.785196	0.0000
-INF	-5.939086	1.910054	-3.109381	0.0021
RESID01	0.637688	0.041391	15.40636	0.0000

R-squared	0.740341	Mean dependent var	1463.049
Adjusted R-squared	0.734736	S.D. dependent var	648.1074
S.E. of regression	333.7996	Akaike info criterion	14.48321
Sum squared resid	30975355	Schwarz criterion	14.57292
Log likelihood	-2056.858	F-statistic	132.1056
Durbin-Watson stat	2.014266	Prob(F-statistic)	0.000000

5.2 Impact on production

As can be observed, certification promoted an increase in production. From the results obtained by the linear regression, it is even possible to build indicators of quality and productivity inspired in international references. In this context, certification plays a key role in the standardization of production, forcing industry to comply with common protocols.

Summary of the overall multi linear regression data (presented in the four blocks above) are shown in Table 6.

The $\beta_{1:K}$'s sensitive coefficients reveal the impact of each variable on production of the four manufactured goods.

As an overall result, the impact of these variables on the industrial production (the dependent variable also modelled as time series) confirmed the evidence (95% probability) of the existence of a causality effect between this production and the variables studied.

5.3 Economic impact

Tables 7, 8 and 9 quantify the economic impact of each dummy variable (certification, the opening up of the Brazilian market and the presence of Mercosur, respectively) for the four manufactured goods. The following highlights a few remarkable examples of the economic impact (based on market prices) induced by each one of the four variables on the manufactured goods. Each of the calculated sensitive polynomial coefficients reflects the correspondent surplus in production which can then be translated in economic impact.

Table 6: Summary of multi linear regression data

$$Y = \hat{\beta}_0 + \hat{\beta}_1 \text{CERT} + \hat{\beta}_2 \text{APER} + \hat{\beta}_3 \text{MERC} + \hat{\beta}_4 (\text{-INF}) + \text{RESID}$$

Product	Y	$\hat{\beta}_0$	$\hat{\beta}_1$ CERT	$\hat{\beta}_2$ APER	$\hat{\beta}_3$ MERC	$\hat{\beta}_4$ INF	RESID
Cement	3034.3	1689.2	457.0	181.9	712.0	-6.6	0.95
%	(100%)	(55.7%)	(15.1%)	(6%)	(23.5%)	(-0.2%)	(0.03%)
Steel	2329.7	1500.6	279.0	348.3	207.9	-7.5	1.47
%	(100%)	(64.4%)	(12%)	(14.9%)	(8.9%)	(-0.3%)	(0.06%)
Automotive Tires	121.1	85.4	13.3	14.1	7.2	-0.3	1.46
%	(100%)	(70.5%)	(11%)	(11.6%)	(6%)	(-0.3%)	(1.20%)
Bus coachwork	2503.7	898.5	332.9	858.2	418.8	-5.9	1.08
%	(100%)	(35.9%)	(13.3%)	(34.3%)	(16.7%)	(-0.2%)	(0.04%)

Note: With the exception of bus coachwork expressed in manufactured units, the production (Y) of the

- **Induced by Certification –** In the Table 7, Cement is the product which most benefited from certification (15.1%). Since certification was implemented, it is estimated that the accumulated impact is of the order of USD 11.6 billion. As expected, certification unquestionably impacts on production. By its very nature, certification –a technological control variable– does affect production in a rather uniform fashion (between 11 and 15% on all products).
- **Induced by the opening up of the Brazilian market** – Similar to the previous analysis, bus coachwork was the product most affected by the variable "the opening up of the Brazilian Market" (34.3%), representing, in a 16-year period, USD 11.1 billion, shown in Table 8. This corresponds to an economic impact of USD 813 millions in the 2005 production.
- **Induced by Mercosur —** In the Table 9, cement was also the product most affected by the Mercosur trade agreement (23.5%), representing, in a 10-year period, USD 17.6 billion, which, based on international prices, corresponded to an impact of about USD 176 millions in 2005. But affected automotive tires by a mere 6%.
- **Induced by the monetary Inflation** — It's well known that inflation is detrimental to economic activity. The negative values of $\hat{\beta}_4$ INF obtained in this work (Table 6) unequivocally confirmed the harmful effect of inflation..

Table 7: Economic impact induced by product certification

Product	Period under consideration (after certification was implemented)	Cumulative Production	Percentage of Impact	Production surplus (due to certification)	International Market Average Price (11/2005) (USD)	Overall Economic Impact for the whole period (Billion USD)
Cement[4]	from Aug/94 to Aug/04	365.7 10^6 ton	15.1%	55.2 10^6 ton	212/ton	11.6
Steel[2]	from Jan/97 to Sept/04	214 10^6 ton	12%	25.7 10^6 ton	395/ ton	10.2
Automotive Tires[3]	from May/95 to Jan/04	1.1 10^6 ton	11%	121 10^3 ton	1.297/ton	0.16
Bus coachwork[1]	from Jan/93 to Oct/04	319,491 u	13.3%	42492.3 u	81.069/u	3.4

Source:[4,2,3] Bovespa entrée in 12/2005, [1]Revista Automotive business 11/2005 (for table 7 to 9)

Table 8: Economic impact induced by the opening up of the Brazilian market

Product	Period under consideration (after exposure to international competition)	Cumulative Production	Percentage of Impact	Production surplus	International Market Average Price (11/2005) (USD)	Overall Economic Impact for the whole period (Billion USD)
Cement[4]	from Jan/90 to Dec/04	481.3 10^6 ton	6%	28.9 10^6 ton	212/ton	6.1
Steel[2]	from Jan/90 to Dec/04	382.2 10^6 ton	14.9%	56.9 10^6 ton	395/ ton	22.5
A. Tires[3]	from Jan/90 to Dec/04	1.9 10^6 ton	11.6%	0.22 10^6 ton	1,297/ton	0.28
Bus coachwork[1]	from Jan/90 to Dec/04)	400,954 u	34.3%	137,527 u	81,069/u	11.1

Table 9: Economic impact induced by the presence of MERCOSUR

Product	Period under consideration (in the presence of Mercosur)	Cumulative Production	Percent of Impact	Production surplus	International Market Average Price (11/2005) (USD)	Overall Economic Impact for the whole period (Billon USD)
Cement[4]	from Jan/95 to Dec/04	353.9 10^6 ton	23.5%	83.2 10^6 ton	212/ton	17.6
Steel[2]	from Jan/95 to Dec/04	264.3 10^6 ton	8.9%	23.5 10^6 ton	395/ ton	9.3
A. Tires[3]	from Jan/95 to Dec/04	1.3 10^6 ton	6%	0.08 10^6 ton	1,297/ton	0.1
Bus coachwork[1]	from Jan/95 to Dec/04	271,219 u	16.7%	45,294 u	81,069/u	3.7

Table 10 summarizes the economic impact at a glance.

Table 10 summarizes the economic impact induced by the dummy variables, based on international prices practiced in 2005

Product	Average Market price (oct/2005) USD	Cumulative Production in 2005	% Economic Impact of the including causality variables 2005		
			Certification	Open market	Mercosur
Cement	212/ton	36,533'430 ton	15.1% USD 1.169.508.161	6.0% USD 464.705.230	23.5% USD 1.820.095.483
Steel	395/ton	31,650'400 ton	12.0% USD 1.500.228.960	14.9% USD 1.862.784.292	8.9% USD 1.112.669.812
Automotive Tires	1,297/ton	145,000 ton	11.0% USD 20.701.417	11.6% USD 21.830.585	6.0% USD 11.291.682
Bus coachwork	81,069/unity	35,244 u	13.3% USD 380.007.046	34.3% USD 980.018.172	16.7% USD 477.151.705

6. CONCLUSIONS

Public awareness of the role played by national standards and by conformity assessment infrastructure to promote trade has increased with the advent of globalization. An ever growing need to quantify the importance of product certification in the world trade has led academics to build up mathematical models to assess its economic impact. The econometric model used here proved to be a simple and effective analytical tool to account for the combined effect of technological and macroeconomic variables on four selected manufactured goods. The model also confirmed the feasibility to express (i) the effects induced by the variables "product certification", "the opening up of the market" and presence of a "regional trade agreement (Mercosur)" as dummy variables and (ii) the effect of the monetary inflation by a time series. The results strongly suggested the existence of a cause-effect mechanism. With the exception of inflation, whose deleterious effect is well documented in the literature, all other variables induced an increase in production. Unlike the macroeconomic variables, certification impacts on production in a rather uniform manner. This is may be accounted for by its technological nature. A product certified is, in general, exempt of macroeconomic fluctuations. In terms of financial gain, the economic impact is quite substantial. Based on international prices practiced in 2005 (taken as reference year), the economic impact induced by the certification of the Brazilian steel (12%) represented USD 1.5 billion (0.2% of the Brazilian GDP), an evidence that certification adds economic value to a product. The overall combined impact on steel totals USD 4.5 billions.

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