# OPENNESS AND ECONOMIC EFFICIENCY: EVIDENCE FROM THE CHILEAN MANUFACTURING INDUSTRY

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## ABSTRACT

This paper highligts a long-standing debate on whether openess does help economic efficiency in the light of the data for Chilean manufacturing industry. To do so, we analyze the TFP growth during the period of the abrupt trade reform in the seventies. This data base provides evidence favoring the hypothesis that a shift towards a condition of *laissez faire* substandeally improves productivity in the economy. In actual fact, during the period 1975-1979, the annual rate of TFP growth in the manufacturing industry was 4.35 percent yearly on average. However, for the period 1980-1982 this growth was -0.67.

The sectors whose productivity increased at a greater speed, in the first years of the reform, were those associated with natural competitive advantages. Subsequently an increase in those industries which are more capital intensive was recorded. This contrasts whith some results which were obtained earlier and confirms others which are addressed in the paper.

## SINTESIS

Este artículo analiza una antigua controversia sobre si la apertura ayuda a la eficiencia económica a la luz de los datos para la industria manufacturera chilena. Para esto se analiza el crecimiento de la PTF durante el período de la abrupta reforma comercial de la década de los setentas. Esta base de datos proporciona evidencia que favorece la hipótesis de que un movimiento hacia una situación de *laissez faire* mejora sustancialmente la productividad de la economía. En efecto, durante el período 1975-1979, el crecimiento de la PTF de la industria alcanzó a 4,35 por ciento, promedio anual. Sin embargo, para el período 1980-1982 este crecimiento fue de -0,67.

Los sectores cuya productividad aumentó más rápidamente en los primeros años de la reforma, fueron los asociados con las ventajas comparativas naturales. Posteriormente, se vio reflejado un aumento en la productividad de aquellas industrias más capital intensivas. Esto contrasta con algunos resultados obtenidos previamente y confirma otros los cuales son discutidos en el artículo.

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## 1. INTRODUCTION

The discussion on the effects of trade orientation and growth is an old one. Ever since Adam Smith, economists have been arguing about the nature of gains and losses in openness or outward orientation. In the past few years there has been a renewed interest to find a theoretical and empirical relationship between international trade and growth. On the theoretical side, for example, it is well worth mentioning the works by Lucas (1988), Jones and Manuelli (1990), Grossman and Helpman (1991), and Young (1991) among others. They provide different arguments as to how international trade, under certain conditions, encourages growth and, under others, discourages it.

On the empirical side the amount of studies on trade and growth is immense. Edwards (1993) provides a survey of the literature on trade policy and economic growth in developing countries. He also makes explicit the distinction between outward orientation and openness. The first concept relates to the idea of how much of the total output is exported, while the second refers to the idea of lifting all barriers to trade. For example, an economy could be characterized as an outward oriented one if a substantial part of its GDP is exported. But this situation may be given by an export biased strategy rather than by indiscriminate openness, in the sense that there are few or no restrictions to international trade.

This paper pursues a more modest goal. Its primary interest is to relate growth in labor productivity and growth in total factor productivity (TFP) to economic policies by resorting to the case of Chile during the period of the deep trade reform (1974-1979). There is no doubt that the history of this country provides an interesting data set to study the effect of openness (outward orientation could be considered a consequence of this) on growth.

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Two concepts underlie TFP growth: changes in efficiency and technological progress. It will be argued that the measurement, which is obtained in this study, is basically due to an increase in efficiency rather than changes within the Chilean manufacturing industry.

The next section provides the relationship between these concepts and international trade from a theoretical point of view. Section 3 offers a data preview and illustrates the connection between the data and history. Section 4 shows the TFP calculations. Section 5 provides an interpretation of the results. The paper ends with a section of concluding remarks.

## 2. CONCEPTUAL FRAMEWORK

### 2.1. Definition

To study TFP it is necessary to know what is included in the measure of the production factors and what is not. For example, changes in the quality of capital and labor may not be included in the measurement of these factors and therefore an improvement in the quality of the production factor will be reflected in the "residual" or TFP. This becomes a major problem when dissagregated data is used to conduct empirical analyzes. Data is readily available on number of workers and capital stock at industry level for a particular country, but this data will not control for quality. Accordingly, if we use this data to calculate the contribution of each factor to the total output growth rate, the residual will reflect both technological changes and increases in the quality of labor and capital.

Let us write the production function in a traditional way:

$$Y = \phi(K,L,t) = R(t)F(K,L) \qquad (1)$$

where Y is total output, K is capital, L is labor and t represents time. The first function, $\phi$, is a general production function where total output depends on two production factors, K and L, and the technological stock is represented by t. The second equality is a special case of the former where a Hicks neutral technological change is assumed. This is the basic formulation presented by Solow (1957). But it is seen that R(t) can have a broader interpretation, as pointed out by Harberger (1990), as for example "cost reduction". In addition, assuming that F(.) exhibits constant returns to scale, R(t) will reflect not only technological changes, but also the existence of increasing returns. Therefore R could be also a function of Y, K or L (see section 2.2.2).

From equation (1), R(t) could be also called TFP, since we can rewrite (1) and define R(t) as:

$$\frac{Y}{F(K,L)} = R(t) \qquad (2)$$

The importance of R(t) is clear when the aim is to analyze the growth rate of total output, since in general the total output growth rate cannot be explained by the growth rate of total factors. The interest of the economist is to understand what underlies R(t) and which factors affect this important component of total output.

Let us write (1) in terms of growth rate. By differentiating and dividing both sides by Y we obtain the well known equation

$$\frac{\dot{Y}}{Y} = \frac{\dot{R}}{R} + \frac{F_K}{Y}\dot{K} + \frac{F_L}{Y}\dot{L} \qquad (3)$$

where the subscript stands for the partial derivative of the function with respect to that argument and the dot is the derivative with respect to time. By rearranging (3) we can express K and L also in term of growth rate.

$$\hat{Y} = \hat{R} + \theta_K\hat{K} + \theta_L\hat{L} \qquad (3')$$

where "^" represents the growth rate of the variable and $\theta_K = F_K K/Y$ and $\theta_L = F_L L/Y$ are the factor-output elasticity. Under the assumption of constant returns to scale and producer equilibrium conditions, $\theta_K$ and $\theta_L$ are the share of capital and labor on total output and therefore are added to one.

In equation (3') the variation in R can be calculated as residual after subtracting the growth rate of all factors weighted by their respective shares on total output from the growth rate of output. Changes in quality of labor and capital, increasing returns and technological changes are some of the variables that will be considered in the variation of R. The main concern is the role of international trade as an explanation of the variation in R, to be discussed in what remains of this section. The role of human capital was discussed in Fuentes (1993).

## 2.2. The role of international trade

### 2.2.1 Technological progress

Among developing countries most of the new technology is imported, at least initially. After growth is in place, they begin to invest more in research and development (R&D), thereby bringing about their own technological progress.

Edwards (1992), called the first process the "learning by looking" effect whereby a developing country basically absorbs technology imported from more developed economies. In Edwards' model the accumulation of knowledge depends on both the gap between domestic and world knowledge, and the capability of the country to absorb foreign technological progress. This capability, in turn, is positively related to the economic openness of the country. Edwards (1992) offers empirical support to his hypothesis in a cross-country study where, using different measures of trade distortions and openness, he finds that these variables have a measurable effect in explaining growth rate of per capita GDP. In this study, the goal is to test these ideas by resorting to more disaggregate data.

International trade plays an important role when countries bring about their own technological progress through R&D. Most of the time, developing economies are too small to become an interesting market for the domestic producer. Consequently, there are few incentives to bring about R&D requiring large markets because, most of the time, investment in R&D calls for production at larger scales. The world market provides this larger market. Concurrently, the world market, in that it is more competitive than the domestic market, provides additional incentives to invest in R&D.

### 2.2.2 Economies of scale

The importance of international trade is also related to economies of scale which can be of two types: national and international[1]. It is in the latter where the economic orientation plays an important role. Most of the time the degree of openness to trade allows a country to take advantage of these international economies of scale. Let us modify equation (1) to allow for economies of scale.

$$Y = A(t)B(Z)F(K,L) \tag{6}$$

where B(Z) is an increasing (decreasing) function if there are economies (diseconomies) of scale. Z can be thought of as the relevant level of output, that is to say, if there are national economies of scale, Z will be the domestic production alone; if the economies of scale are international, then the relevant Z will be the world levels of output. If there are inter-sectoral economies of scale, Z can be interpreted as a vector of different levels of output of different commodities. Assuming that $B(Z)=Y^{\alpha}$, we rewrite equation (6) in terms of growth rates.

$$\hat{Y} = \theta_K \hat{K} + \theta_L \hat{L} + \hat{A} + \alpha \hat{Y} \tag{7}$$

[1] For an excellent discussion of this topic, from the perspective of international trade, see Helpman (1984).

When the growth rate of TFP is estimated as the residual, in the presence of economies of scale (diseconomies of scale), the growth rate of the output level also accounts for part of this residual. If the parameters are corrected for this economies of scale effect then we have:

$$\hat{Y} = \frac{1}{1-\alpha}(\theta_K \hat{K} + \theta_L \hat{L}) + \frac{1}{1-\alpha}\hat{A} \qquad (8)$$

If economies of scale occur at the industry level rather than at the firm level, then a significant increase in an industry's output should be accompanied by a significant increase in the number of firms operating in that industry. If the economies of scale are internal to the firms, a monopoly or, at least, an increase in firm size within that industry should be expected, but not in the total number of firms. Note that a monopoly is not a necessary condition at the level of aggregation, to be discussed in the empirical part.

## 3. DATA PREVIEW

In this section, the structure of the manufacturing industry in Chile, for the period under study will be analyzed. For a description of the data set and the variable constructions, see Appendix 1.

The data comes from a survey conducted by the Chilean National Statistics Institute (INE), which covers firms with more than 50 employees. Tables 1 to 3 show the names and a description (in terms of value added distribution, capital and labor allocation across industries) of the 24 industries considered in this paper. The next subsections will relate this description of the manufacturing industry structure to the history of economic policies applied in the country.

### 3.1. Data and history

One of the most interesting and controversial periods of the Chilean economy was the one which followed the trade reform carried out during the first years of the military government. The military took over Allende's government in September 1973. Among the main trade restrictions prevailing at the end of 1973, there were a highly dispersed (0% to 750%) ad valorem tariff structure averaging 105 percent and having a mode of 90 percent[2], and 10 different exchange rates. Many non-tariff restrictions had been lifted by 1976.

[2] For a more detailed description see Alonso (1990).

The first tariff reduction occurred the last day of 1973 when the maximum tariff was lowered to 220 percent and the average to 94 percent. Since there were so many restrictions, the impact which this measure had was minimal, as many of them were no longer binding. By mid-1976 the maximum tariff reached 65 percent, the average nominal tariff was 33 percent and the mode was 30 percent. In addition, by then all quantitative restrictions had been lifted. By June 1979 the trade reform ended with a nominal tariff of 10 percent for all items, except automobiles[3].

Although the trade reform was one of the most impressive reforms conducted by the military government, there were several others implemented over that period which are worth mentioning here[4]. Given the high inflation at the beginning of the period, primarily due to macroeconomic disequilibrium, the economic authority decided to cut the fiscal deficit rapidly from 30.5 percent of GDP to 2.6 percent of GDP in 1975. This reduction was accompanied by a high real exchange rate using a crawling peg system, which lasted until the beginning of 1978; price liberalization of many products; financial liberalization (meaning free interest rate); and external financial liberalization, by gradually eliminating restrictions on the ability of commercial banks to borrow from abroad.

Given all the trade reforms mentioned above, it is hard to believe that the results obtained in studying the manufacturing industry are due exclusively to trade liberalization. Yet, given the magnitude of these reforms, it is still possible to attribute many of the results to the effect of those policies[5].

The trade reform was expected to be beneficial in several aspects. On the one hand, the economy would improve resource allocation by redistributing resources toward sectors where Chile had comparative advantages and, on the other hand, increase the efficiency of the different sectors. This trade reform introduced a shift in relative prices that favored sectors such as agriculture, forestry and fishing, but disfavored the manufacturing sector in which the relative price decreased. In addition, there were shifts in relative prices within the manufacturing sector. These will be discussed below. The effect of these changes reduced the participation of the manufacturing sector in the GDP from 29.5 percent in 1974 to 21.7 percent in 1979.

Another important economic policy was followed from June 1979 until 1982. The economic authority decide to adopt a fixed exchange rate system. This policy, combined with the external financial liberalization, was translated into a continuous fall of the real exchange rate, which jeopardized the import substitution sector and was also detrimental to the development of the export

[3] See Appendix 2 for a table with the effective rate of protection for each sector considered in this study.
[4] For a deeper discussion and description of this period in Chile, see Edwards and Edwards (1987).
[5] See Corbo and Sánchez (1992) for a discussion of the effects of all these policies on individual firms.

sector. This policy, accompanied by a terms of trade deterioration and a financial liberalization, led the country to a balance of payment crisis. Over this period the import substituion sector faced, basically, a second "trade liberalization". As Corbo and Sánchez (1992) have pointed out firms did not have too much room left for increases in productivity to face this second shock.

**TABLE 1**

**VALUE ADDED DISTRIBUTION ACROSS SECTORS**

| Code | Industry Name | 1970 | 1974 | 1978 | 1982 |
|---|---|---|---|---|---|
| 311 | Food Products | 10.58 | 11.66 | 20.04 | 17.74 |
| 313 | Beverage | 3.49 | 3.37 | 4.44 | 6.00 |
| 314 | Tobacco | 2.84 | 3.01 | 4.05 | 5.47 |
| 321 | Textile | 7.56 | 5.73 | 5.85 | 3.21 |
| 322-324 | Clothing and Footwear | 3.67 | 2.68 | 3.42 | 3.34 |
| 323 | Leather Products | 0.66 | 0.75 | 0.68 | 0.45 |
| 331 | Woods Products c.f. | 1.22 | 1.37 | 2.76 | 2.59 |
| 332 | Furniture e.m. | 0.40 | 0.27 | 0.46 | 0.55 |
| 341 | Paper Products | 2.60 | 3.10 | 5.20 | 4.93 |
| 342 | Printing | 2.19 | 1.49 | 3.27 | 3.66 |
| 351 | Industrial Chemicals | 1.10 | 3.25 | 2.59 | 1.62 |
| 352 | Other Chemical Products | 3.81 | 4.39 | 6.46 | 8.05 |
| 353 | Petroleum and Coal Products | 2.12 | 3.61 | 4.40 | 6.46 |
| 355 | Rubber Products | 1.93 | 1.31 | 1.44 | 0.92 |
| 356 | Plastic Products | 1.08 | 0.81 | 0.89 | 1.06 |
| 361 | Pottery | 0.42 | 0.48 | 0.69 | 0.12 |
| 362 | Glass | 0.69 | 0.60 | 0.85 | 0.50 |
| 369 | Non-metallic Products | 2.05 | 1.31 | 2.28 | 2.47 |
| 371 | Iron and Steel | 5.24 | 8.38 | 4.66 | 4.41 |
| 372 | Non-ferrous Metal | 31.26 | 27.98 | 10.62 | 19.28 |
| 381 | Metal Products | 3.83 | 3.85 | 4.10 | 3.26 |
| 382 | Machinery | 2.54 | 2.21 | 2.89 | 1.54 |
| 383 | Electrical Machinery | 3.53 | 3.58 | 2.29 | 1.14 |
| 384 | Transport Equipment | 5.19 | 4.80 | 5.66 | 1.25 |

The allocative effect is shown in Tables 1 to 3. The data for 1970 stands for the "normal" or benchmark year since it corresponds to the beginning of Allende's government. The Table also shows 1974 –when the trade reform started– 1978, and 1982.

In 1970 the labor force in the manufacturing industry was mainly concentrated in food products and textiles (Table 3). However, Table 1 shows that the most important industries, in decreasing order, were Non-ferrous Metal, Food

Products, and Textiles. While considering the figure for physical capital, Iron and Steel also has a large share of the total capital stock in the manufacturing sector. This ranking does not vary very much over the period 1970-1974. Perhaps the most notorious change is the increase in the participation of Iron and Steel and the decrease of the Textile sector in terms of value added. The trade liberalization implemented over the 1974-1978 period clearly favored those sectors related to natural resources in which Chile had comparative advantages. These sectors were Food Products (related to seafood and agriculture), Wood Products, Furniture, Paper Products and, Printing. It has been pointed out earlier that one of the effects of the trade reform was the shifts in relative prices which favored the agriculture, forestry and fishing sectors. They all supply the inputs to the manufacturing sectors. Iron and steel and Non-ferrous Metal (Table 1) were the sectors which were affected negatively by the reforms. However, as shown in Tables 2 and 3, capital and labor allocation to these sectors did not change in a significant magnitude.

TABLE 2

CAPITAL ALLOCATION ACROSS SECTORS

| Code | Industry Name | 1970 | 1974 | 1978 | 1982 |
|---|---|---|---|---|---|
| 311 | Food Products | 14.02 | 11.16 | 11.98 | 16.92 |
| 313 | Beverages | 2.60 | 2.28 | 2.39 | 4.00 |
| 314 | Tobacco | 1.58 | 1.04 | 0.91 | 1.00 |
| 321 | Textiles | 14.68 | 10.53 | 9.07 | 7.38 |
| 322-324 | Clothing and Footwear | 3.31 | 2.22 | 2.14 | 2.10 |
| 323 | Leather Products | 0.55 | 0.45 | 0.39 | 0.37 |
| 331 | Woods Products c.f. | 1.03 | 0.96 | 1.30 | 1.86 |
| 332 | Furniture e.m. | 0.17 | 0.67 | 0.52 | 0.56 |
| 341 | Paper Products | 8.03 | 5.97 | 5.17 | 8.99 |
| 342 | Printing | 2.27 | 2.23 | 2.42 | 3.24 |
| 351 | Industrial Chemicals | 3.04 | 2.55 | 3.19 | 2.71 |
| 352 | Other Chemical Products | 1.56 | 1.70 | 1.99 | 2.56 |
| 353 | Petroleum and Coal Products | 3.63 | 3.98 | 2.17 | 1.97 |
| 355 | Rubber Products | 1.02 | 0.88 | 0.76 | 0.73 |
| 356 | Plastic Products | 0.90 | 0.68 | 0.63 | 0.98 |
| 361 | Pottery | 0.68 | 0.60 | 0.61 | 0.43 |
| 362 | Glass | 1.87 | 1.51 | 1.30 | 1.25 |
| 369 | Non-metallic Products | 6.89 | 4.77 | 3.78 | 3.91 |
| 371 | Iron and Steel | 15.54 | 14.03 | 18.07 | 13.00 |
| 372 | Non-ferrous Metal | 8.56 | 21.11 | 21.55 | 16.90 |
| 381 | Metal Products | 2.79 | 2.33 | 2.08 | 2.40 |
| 382 | Machinery | 1.08 | 3.90 | 3.49 | 3.04 |
| 383 | Electrical Machinery | 1.71 | 1.57 | 1.71 | 1.63 |
| 384 | Transport Equipment | 2.49 | 2.89 | 2.37 | 2.07 |

**TABLE 3**

**LABOR ALLOCATION ACROSS SECTORS**

| Code | Industry Name | 1970 | 1974 | 1978 | 1982 |
|---|---|---|---|---|---|
| 311 | Food Products | 13.57 | 15.18 | 19.01 | 21.51 |
| 313 | Beverages | 3.11 | 3.55 | 3.99 | 4.80 |
| 314 | Tobacco | 0.52 | 0.61 | 0.37 | 0.51 |
| 321 | Textiles | 15.03 | 14.43 | 12.50 | 8.64 |
| 322-324 | Clothing and Footwear | 7.55 | 6.84 | 7.17 | 8.18 |
| 323 | Leather Products | 1.11 | 0.96 | 1.08 | 1.06 |
| 331 | Woods Products c.f. | 4.35 | 5.18 | 5.91 | 5.00 |
| 332 | Furniture e.m. | 1.08 | 0.98 | 0.85 | 1.41 |
| 341 | Paper Products | 2.25 | 2.88 | 3.65 | 3.30 |
| 342 | Printing | 3.12 | 3.05 | 3.54 | 4.59 |
| 351 | Industrial Chemicals | 1.55 | 2.77 | 2.32 | 0.99 |
| 352 | Other Chemical Products | 4.03 | 4.03 | 4.93 | 6.63 |
| 353 | Petroleum and Coal Products | 0.97 | 1.06 | 1.03 | 1.16 |
| 355 | Rubber Products | 1.74 | 1.91 | 1.71 | 1.47 |
| 356 | Plastic Products | 1.37 | 1.36 | 1.60 | 2.11 |
| 361 | Pottery | 0.77 | 0.99 | 0.97 | 0.48 |
| 362 | Glass | 1.57 | 1.49 | 1.35 | 0.63 |
| 369 | Non-metallic Products | 4.62 | 2.54 | 2.36 | 2.31 |
| 371 | Iron and Steel | 4.41 | 4.86 | 4.48 | 4.21 |
| 372 | Non-ferrous Metal | 2.74 | 3.07 | 2.91 | 5.17 |
| 381 | Metal Products | 7.32 | 6.46 | 5.72 | 7.19 |
| 382 | Machinery | 5.16 | 5.63 | 4.59 | 4.27 |
| 383 | Electrical Machinery | 3.75 | 4.16 | 2.90 | 1.96 |
| 384 | Transport Equipment | 8.31 | 6.02 | 5.05 | 2.38 |

Therefore, it can be stated that the first effect of the trade reform on the manufacturing industry structure was that, with hardly any changes in resource reallocation, the value added of those sectors in which Chile has comparative advantages, increased as a percentage of the total. Given that the allocation of resources did not change very much, it should have been expected that these changes would be accompanied by productivity increases in the expanded sectors and deep productivity falls in the contracted sectors.

This necessarily brief description of the industrial structure in Chile can not ignore some of the studies that have investigated the sources of these changes. For example, Vergara (1980) and Gatica and Pollack (1986) studied the sources of the manufacturing industry's structural changes over this period. In essence, they decomposed the changes in production into three effects: internal demand effect, export effect and import substitution effect and concluded that the most important one was the internal demand effect. The export effect was important

only for Food and Wood Products. They attribute this effect to the concurrent impact of trade liberalization and several of the other structural changes in the economy which were addressed earlier.

An important fact, not mentioned by them, is the business cycle characterized by two deep recessions (1975 and 1982) and a very large increase in national income in 1980. The results show that the predominant effect on the productive structure was internal demand. It should be obvious that these results are strongly influenced by the choice of the years. But, the examination of export figures will show that except for the Non-ferrous Metal industry, all other industries increased the real value of their exports between 1974-1979[6]. Some of them (such as Textiles) increased their exports by as much as 10 times. As a magnitude, the export effect was small compared to the internal demand effect, but it should not be considered unimportant.

## 4. TFP ESTIMATIONS AND INTERPRETATION OF THE RESULTS

This section discusses the methodology to estimate the relevant parameters to calculate the TFP growth rate for the period under analysis. Next, it shows the TFP growth rate estimations for different sub-periods and derives some possible hypotheses to explain the findings.

### 4.1. Estimation of the relevant coefficients

In order to compute the variations of TFP there is the need to calculate the capital output elasticities that in the case of the Cobb-Douglas production function are the same as the share of factor cost on total cost.

Under the assumption of constant returns to scale and Hicks-neutral technological progress for each industry we can compute

$$(\hat{Y}_{it} - \hat{L}_{it}) = \theta_{Ki}(\hat{K}_{it} - \hat{L}_{it}) + T\hat{F}P_{it} \qquad (11)$$

where the left hand side is the growth rate of labor productivity and the right hand side is the sum of the growth rate of capital-labor ratio and TFP. Note that (11) is the same as (3') where $\theta \equiv \theta_{Ki} = (1-\theta_{Li})$ and subscript i indicates industry i. This is the traditional decomposition of labor productivity into capital deepening and a residual.

[6] As stated, in June 1979 the authority fixed the exchange rate at 39 pesos/dollar, and thereafter the economy experienced a deep drop in the real exchange rate. Accordingly, 1979 is used for proposes of comparison. The figures mentioned are to be found in Gatica and Pollack (1986).

As already pointed out the capital shares and changes in TFP will be computed without taking into account the changes in quality in the measurement of factors.

There are two methods to compute capital shares: an econometric method and direct calculations from wage data. In this section the econometric method is used. The discussion on possible changes in the results using the second method is postponed to section 5[7].

The specification chosen was the trans-log type of production function. A general form of this type of production function, with variable returns to scale, can be written as

$$\log(Y/L)_{it} = \alpha_i + \beta_{1i}\log(K/L)_{it} + \beta_{2i}[\log(K/L)_{it}]^2 + \gamma_i \log(L_{it}) + \mu_{it} \qquad (12)$$

where $\gamma$ captures the economies of scale. Depending on whether $\gamma$ is positive or negative there are then increasing or decreasing returns to scale[8].

Using (12), the capital-output elasticity is calculated as $\eta_{iK} = \beta_{i1} + 2\beta_{i2}\log(K/L)_{it}$ and the labor-output elasticity is $\eta_{iL} = \gamma + 1 - (\beta_{i1} + 2\beta_{i2})$. The industries were grouped in high, medium and low capital intensive. For each group there was a set of $\beta$'s estimated.

Let us define total factor productivity in this context. With constant returns to scale the factor share coincides with the elasticities. But under conditions of variable returns to scale it is necessary to redefine capital share as

$$\theta_K = \frac{\eta_K}{\eta_K + \eta_L} \qquad (13)$$

and labor share as

$$\theta_L = \frac{\eta_L}{\eta_K + \eta_L} \qquad (14)$$

[7] The limitations of the asumption of constant returns to scale, which is made when using wage data, was pointed out by Hall (1988).

[8] This formulation comes from the general form:

$$\log(Y) = \alpha + \phi_K \log(K) + \phi_L \log(L) + \phi_2[\log(K/L)]^2$$

Adding and subtracting $\phi_L \log(L)$ in the right hand side and subtracting log(L) from both sides of this equation, equation 12 in the text is obtained.

If the production function is homogeneous of degree $\nu$, then the factor shares are equivalent to the real return to the factor, times the amount of the factor used, divided by $\nu$ times the output, i.e., $\theta_K = F_K K/\nu y$.

TFP now can be calculated as

$$TFP = \frac{Y}{K^{\theta_K} L^{\theta_L}} \tag{15}$$

The change in TFP will be calculated as shown in section II using variations in labor productivity and capital-labor ratio variation.

Note that under this formulation TFP captures two effects: a) economies of scale, and b) technological progress and improvement in factor quality.

## 4.2. TFP estimations

Table 4 shows the capital shares estimations from the production function estimation and from the wage data provided by the survey. The next step was to calculate the variation in TFP using the $\theta$'s estimated in that table.

Before going into the results, it is necessary to highlight a correction that was necessary to make in TFP and labor productivity growth rate figures, because of important changes in relative prices over the period, mainly due to the decrease of ERP from a wide range to a level consistent with no quantitative restrictions and a 10 percent tariff for all items (except automobiles)[9]. In 1974, the manufacturing sectors had different effective rates of protection as shown in Table A2.1 (Appendix 2). The rate for each sector and the dispersion across sectors were decreasing (as shown in that table) over time. The importance of these changes, for the calculations, is that the value added from all sectors was expressed in real terms by the deflator for GDP in manufactures. Therefore, a sector that was above the average protection will experience a larger reduction in relative prices with respect to the average deflator for the manufacturing sector as a whole and, consequently, would tend to have a smaller growth rate of TFP even though there was no decrease in efficiency. Thus, this relative price change effect tends to go in the opposite direction to the efficiency improvement effect. Hence, the change biases the results of highly protected industry toward lower TFP growth rate than the true rate. The opposite is also true for industries with

[9] Harberger (1990) does not agree with this approach. He pointed out that those relative price changes are part of the residual or the "cost reduction", and show a resource reallocation.

lower than average protection. The correction method, based on ERP changes, is shown in Appendix 2. The implicit assumption is that, over that period, the major relative price changes for these industries were mainly due to changes in ERP. Table 5 shows the annual growth rate of labor productivity over the periods 1975-1978 and 1979-1982[10]. The figures on labor productivity were also corrected for relative price changes.

**TABLE 4**

**CAPITAL SHARES ESTIMATED, 1974-1983**

| Code | Industry Name | VRS Production Function | Growth Accounting Data |
|---|---|---|---|
| | High Capital Intensive | | |
| 353 | Petroleum and Coal Products | 0.21 | 0.94 |
| 372 | Non-ferrous Metal | 0.13 | 0.94 |
| 371 | Iron and Steel | 0.17 | 0.78 |
| 341 | Paper Products | 0.22 | 0.85 |
| 369 | Non-metallic Products | 0.24 | 0.78 |
| 314 | Tobacco | 0.22 | 0.96 |
| 362 | Glass | 0.27 | 0.74 |
| 351 | Industrial Chemicals | 0.24 | 0.83 |
| | Intermediate Capital Intensive | | |
| 311 | Food Products | 0.20 | 0.82 |
| 321 | Textiles | 0.20 | 0.71 |
| 361 | Pottery | 0.20 | 0.69 |
| 342 | Printing | 0.20 | 0.75 |
| 313 | Beverages | 0.20 | 0.85 |
| 356 | Plastic Products | 0.23 | 0.74 |
| 355 | Rubber Products | 0.22 | 0.74 |
| 384 | Transport Equipment | 0.21 | 0.79 |
| | Low Capital Intensive | | |
| 323 | Leather Products | 0.23 | 0.78 |
| 383 | Electrical Machinery | 0.21 | 0.72 |
| 381 | Metal Products | 0.24 | 0.73 |
| 352 | Other Chemical Products | 0.23 | 0.80 |
| 322-324 | Clothing and Footwear | 0.25 | 0.75 |
| 382 | Machinery | 0.20 | 0.54 |
| 331 | Woods Products c.f. | 0.26 | 0.77 |
| 332 | Furniture e.m. | 0.22 | 0.75 |

[10] Plastic Products (356) and Transport Equipment (384) were excluded from this table. The reason is that there is no measure available of the effective protection in the case of those sectors.

TABLE 5

LABOR PRODUCTIVITY AND TFP VARIATIONS

| Code | Industry Name | % variations in Y/L (1975- 1978) | % variations in TFP (1975- 1978) | % variations in Y/L (1979-1982) | % variations in TFP (1979-1982) |
|---|---|---|---|---|---|
| | High Capital Intensive | | | | |
| 353 | Petroleum and Coal Products | 12.46 | 14.53 | 16.45 | 14.68 |
| 372 | Non-ferrous Metal | -23.34 | -23.98 | 10.89 | 11.78 |
| 371 | Iron and Steel | -14.80 | -17.31 | 10.40 | 9.36 |
| 341 | Paper Products | 8.41 | 9.88 | 11.05 | 3.45 |
| 369 | Non-metallic Products | 14.45 | 14.60 | 12.75 | 8.92 |
| 314 | Tobacco | 19.47 | 16.26 | 8.30 | 6.54 |
| 362 | Glass | 9.61 | 8.94 | 16.58 | 6.62 |
| 351 | Industrial Chemicals | -7.21 | -11.54 | 20.47 | 12.65 |
| | Intermediate Capital Intensive | | | | |
| 311 | Food Products | 8.77 | 8.85 | 3.09 | -1.07 |
| 321 | Textiles | 7.51 | 6.80 | 5.06 | 1.25 |
| 361 | Pottery | 7.88 | 6.89 | -16.25 | -21.31 |
| 342 | Printing | 15.64 | 15.25 | 6.33 | 3.31 |
| 313 | Beverages | 6.71 | 6.34 | 13.20 | 8.37 |
| 355 | Rubber Products | -5.81 | -6.47 | 2.76 | -1.04 |
| | Low Capital Intensive | | | | |
| 323 | Leather Products | -4.01 | -3.29 | 0.05 | -3.06 |
| 383 | Electrical Machinery | -6.97 | -10.72 | 1.92 | -2.73 |
| 381 | Metal Products | 2.78 | 1.86 | -1.01 | -3.87 |
| 352 | Other Chemical Products | -1.20 | -1.79 | 7.35 | 4.37 |
| 322-324 | Clothing and Footwear | 9.58 | 9.22 | 6.85 | 4.33 |
| 382 | Machinery | 7.62 | 6.30 | -4.28 | -6.75 |
| 331 | Woods Products c.f. | 15.47 | 13.10 | 11.90 | 4.06 |
| 332 | Furniture e.m. | 14.83 | 14.65 | -0.05 | -0.59 |

## 5. INTERPRETATION OF THE RESULTS

This section focuses on the growth rate of TFP over the trade reform period so as to analyze the expected increase in efficiency. What should be expected is that those sectors with a high effective rate of protection (ERP) would tend to have more gains in efficiency since they are undergoing a significative change in their market conditions. However, for the second subperiod the most relevant part was the real overvaluation of the domestic currency

During the severest part of the reform (1975-1978) only 7 industries had a negative growth rate in labor productivity and 7 out of 22 had a negative TFP growth rate. The weighted average of labor and TFP annual growth rate, over that period, was 2.89 percent and 2.24 percent respectively. If we take the period 1975-1979, labor productivity grew by 4.35 percent per year and TFP grew by 4.39 percent per year in the same period.

The results for the second period shown in the second graph may be biased by the effects of the deep recession in 1982[11] and by the effect of the real overvaluation of the peso with respect to the U.S. dollar due to a fixed exchange rate which prevailed from June 1979 to 1982. However, the manufacturing industry as represented by these 22 sectors, experienced a 3.9 percent TFP annual growth rate. But, if the year 1979 is left out, the rate of 1980-1982 would be -0.67 percent. This is consistent with the hypothesis put forth by Corbo and Sánchez (1992) which states that after 1979 firms could not gain more in productivity, due to the effort made during the period 1975-1979.

The good performance, in terms of TFP increase, over the first sub-period for industries such as Tobacco (314), Non-metallic Products (369), Printing (342), Wood Products (331) and Furniture (332) should be contrasted with the poor performance experienced by the Basic Metal Industries (371 and 372) and Industrial Chemicals (351). It seems that these industries needed more time to adjust their structure to the new environment, given that their performance in the second sub-period (1979-1982) was quite good[12]. As discussed above, natural comparative advantages in those sectors related to agriculture, forestry and fishing plus changes in relative prices in favor of those sectors steered resource allocation and productivity over the first sub-period under consideration. However, among the capital intensive industries, those exhibiting positive TFP growth rate have experienced a very high annual growth rate, which is generally true for almost all the industries with a positive rate over that period (save for Metal Products with a rate equal to 1.86%).

Another point worth noticing, in the period 1979-1982, is the good performance of the more capital intensive industries, relative to the rest of the sectors. Remember that TFP will reflect a cost reduction, and that these sectors needing to import capital goods experience a very important cost reduction, clearly shown in the TFP increase. The average growth rate for this group was 9.71 percent over this period, i.e., almost 6 percentage points above the average

[11] The effects of this recession were a 14.1 percent decrease in GDP and a 21 percent decrease in the Chilean manufacturing sector.

[12] Edwards and Edwards (1987) quoted a survey conducted by the Chilean Manufacturers Association (SOFOFA), which shows that more than 75 percent of the firms in Non-metallic industries (361, 362 and 369) and Basic Metals (371 and 372), and more than 60 percent of total firms in Textiles (321) and Clothing and Footwear (322) were rigorously affected by the external competition due to the trade reform.

of the whole manufacturing sector. As expected, those sectors with a very fast growth in the first sub-period slow down in the second. Also the results in this second period are strongly affected by an overvaluated exchange rate and the deep 1982 recession.

At this point, the high correlation between labor productivity growth rate and TFP growth rate should be mentioned. This period was characterized by low capital formation and therefore low capital deepening. Therefore, the increase in labor productivity reflects an increase in efficiency.

Graph 1 shows the relationship between the annual growth rate of TFP and the initial ERP, for the period 1975-1978. An upward sloping relation between these two variables should be expected, i.e., the most protected sector should have the largest gain in efficiency in order to survive. The initial ERP is highly correlated with the change in ERP, as shown in Table A2.1, since at the end of the period ERP was almost the same for all industries, when the nominal tariffs were set at the 10 percent level. The graph shows a weak evidence of a slightly upward relationship between these two variables. However, a regression of TFP on ERP yields a coefficient of 0.07 with a t-statistic of 1.31[13]. Graph 2 shows the same relation for the period 1978-1982. It is possible to observe a more equal level of protection across industries and also how the more capital intensive industries tend to lead the group of manufacturing industries. A graph showing the relationship between TFP growth and changes in ERP will not give more information since all industries have, basically, the same ERP at the end of the period.

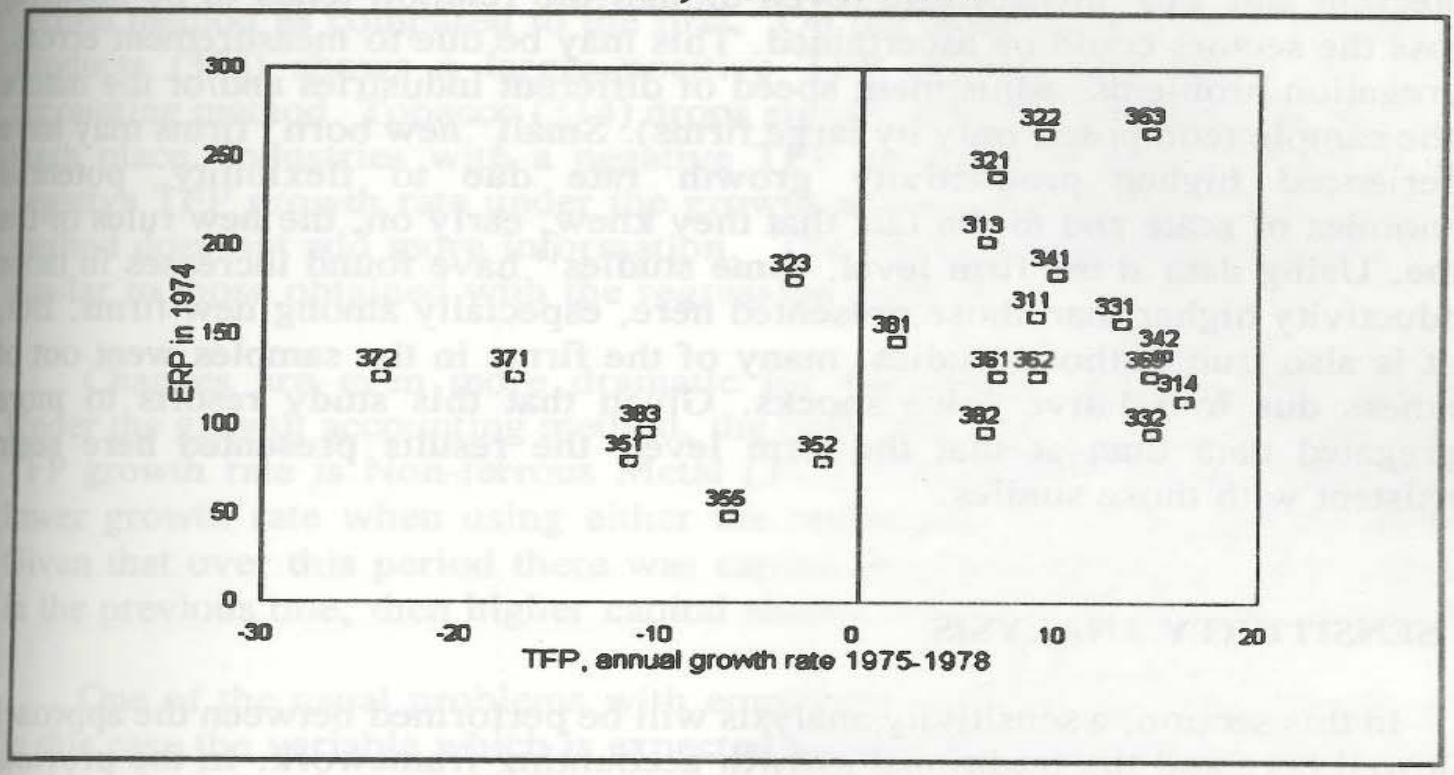
Another way to see how the gains in efficiency were important for the manufacturing sector is to study the change in market orientation. One-third of total exports in 1980 were accounted for by the manufacturing industry compared with 7.17 percent in 1973 and 11.56 percent in 1970. The sector with the highest increase in participation was Wood from 0.33 percent to 6.26 percent of total exports, in that period. Also Food and Basic Metallic industries increased their participation approximately eight-fold. Note that in 1973, Wood was the only sector for which external markets were important. This is another evidence that gains in productivity and the structural change in the manufacturing sector were mainly driven by the country's comparative advantages.

In conclusion, trade liberalization seems to be beneficial for the manufacturing industry as a whole and, in terms of gains in efficiency and productivity, particularly better for some industries than for others. This is not true for the period 1980-1982, when policy inconsistencies such as the real appreciation of the exchange rate, mentioned earlier, took place in Chile.

[13] Similar results have been found for the East Asian countries. See Urata (1994) for a summary.

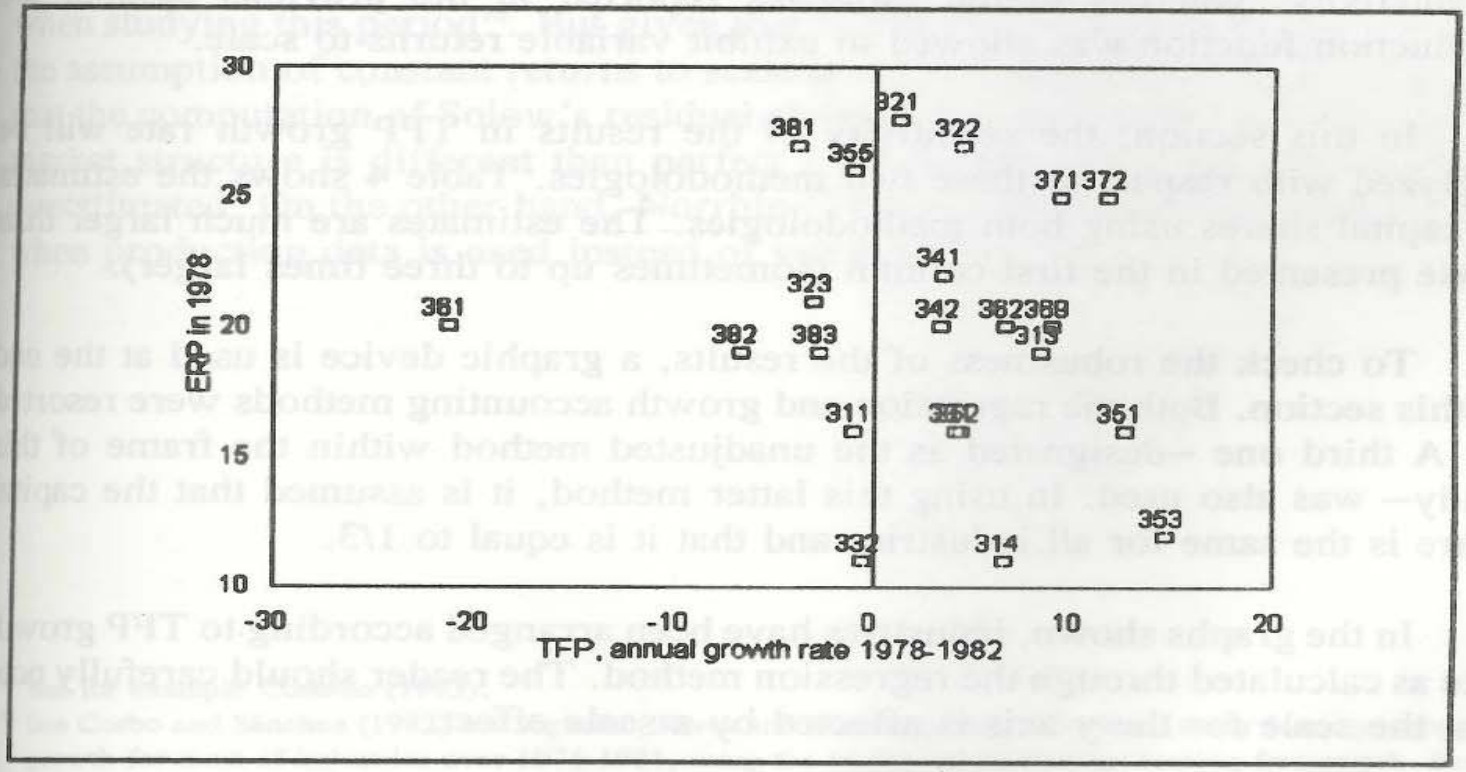
## GRAFICO 1

## CHILE, ERP AND TFP

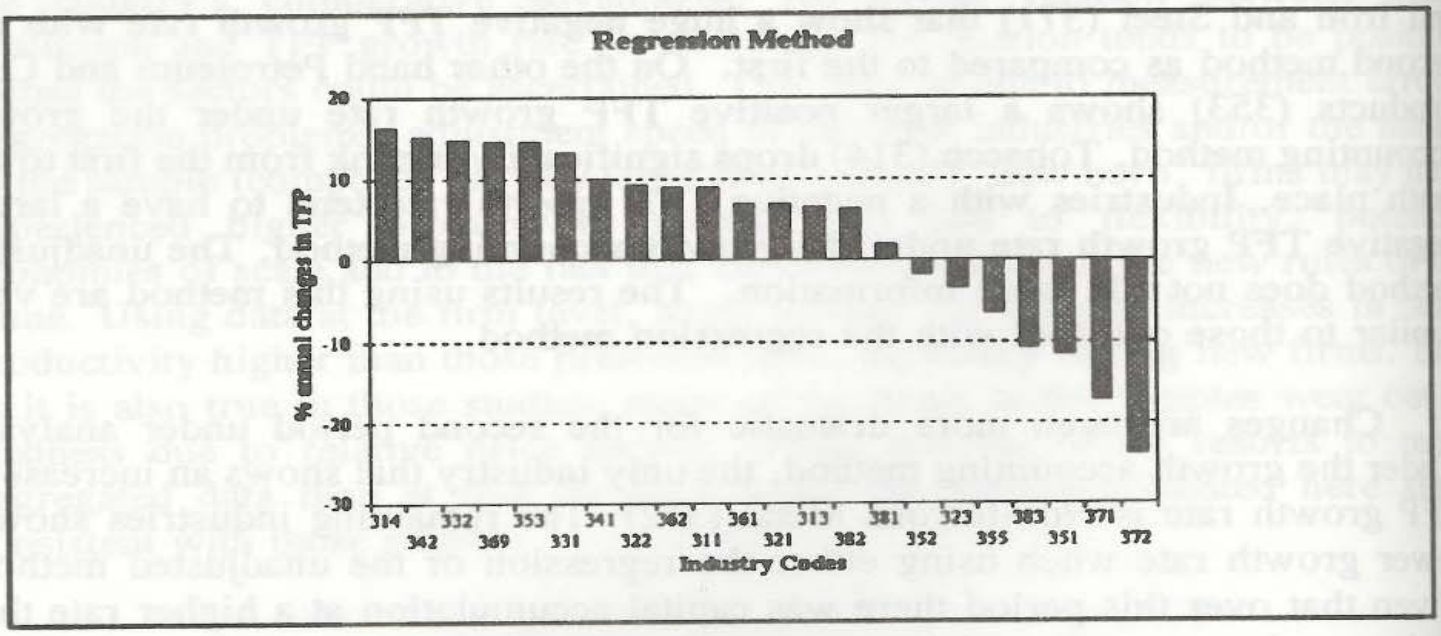


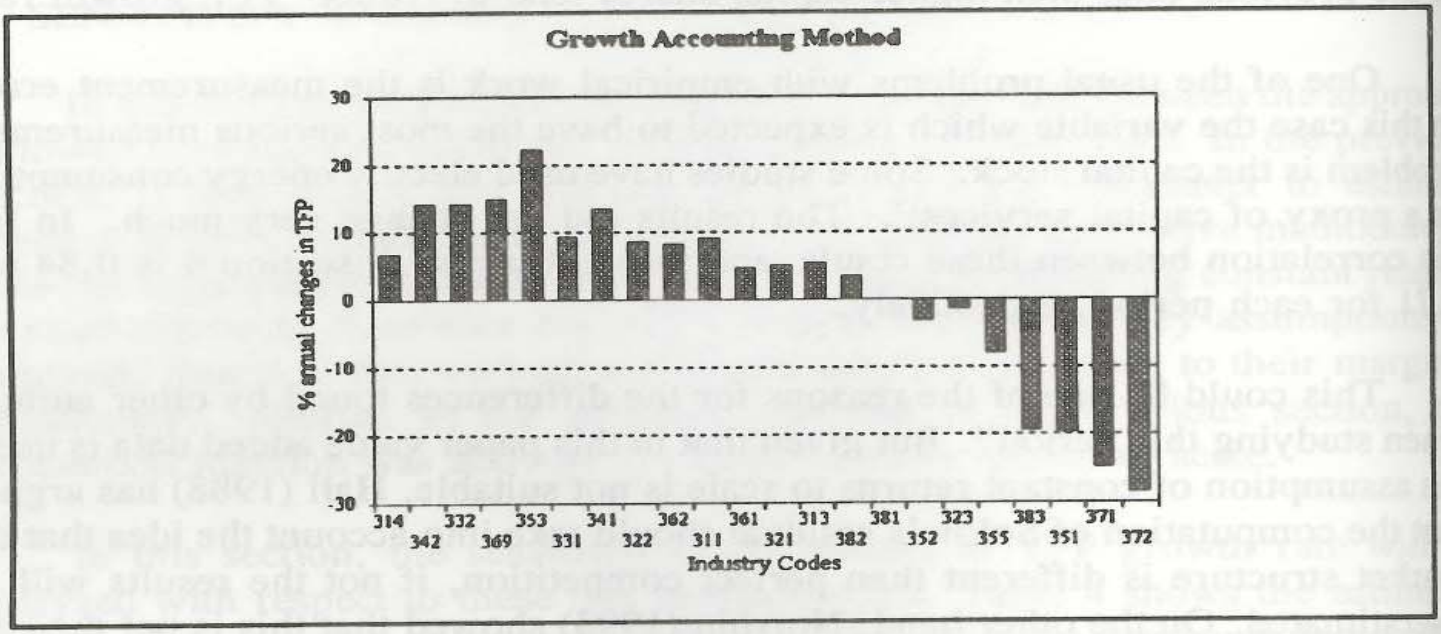

## GRAFICO 2

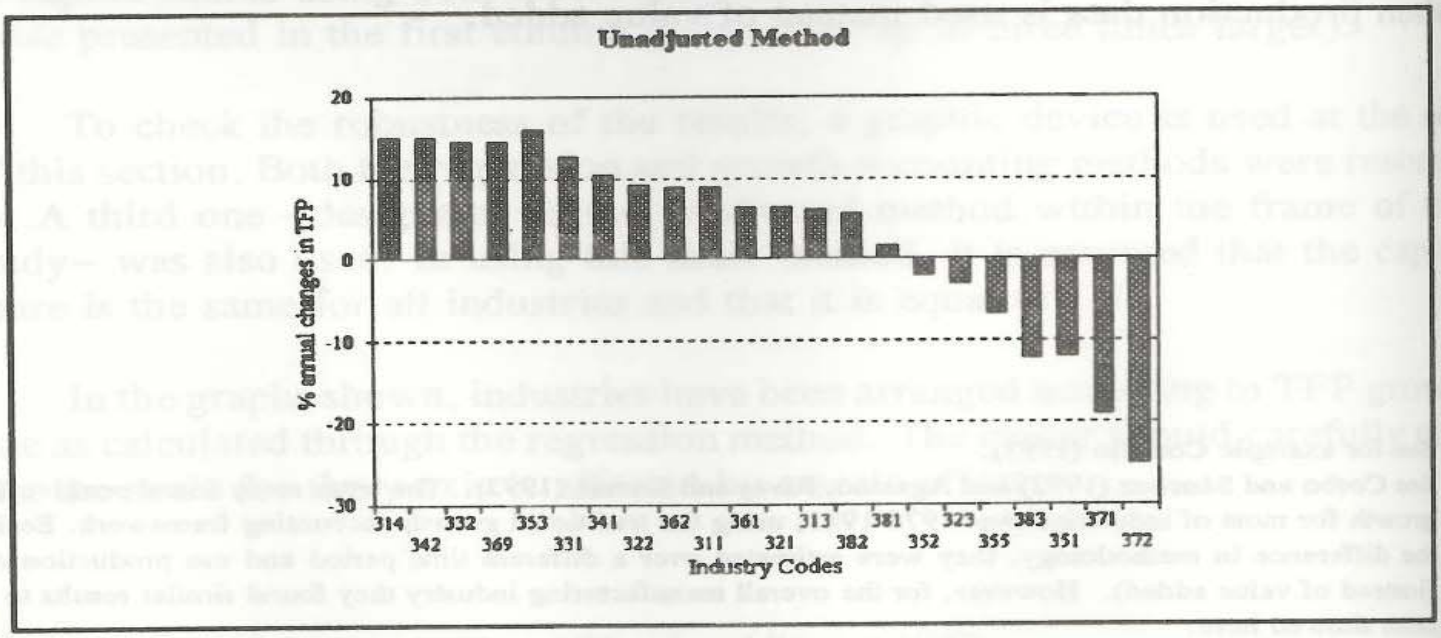
## CHILE, ERP AND TFP



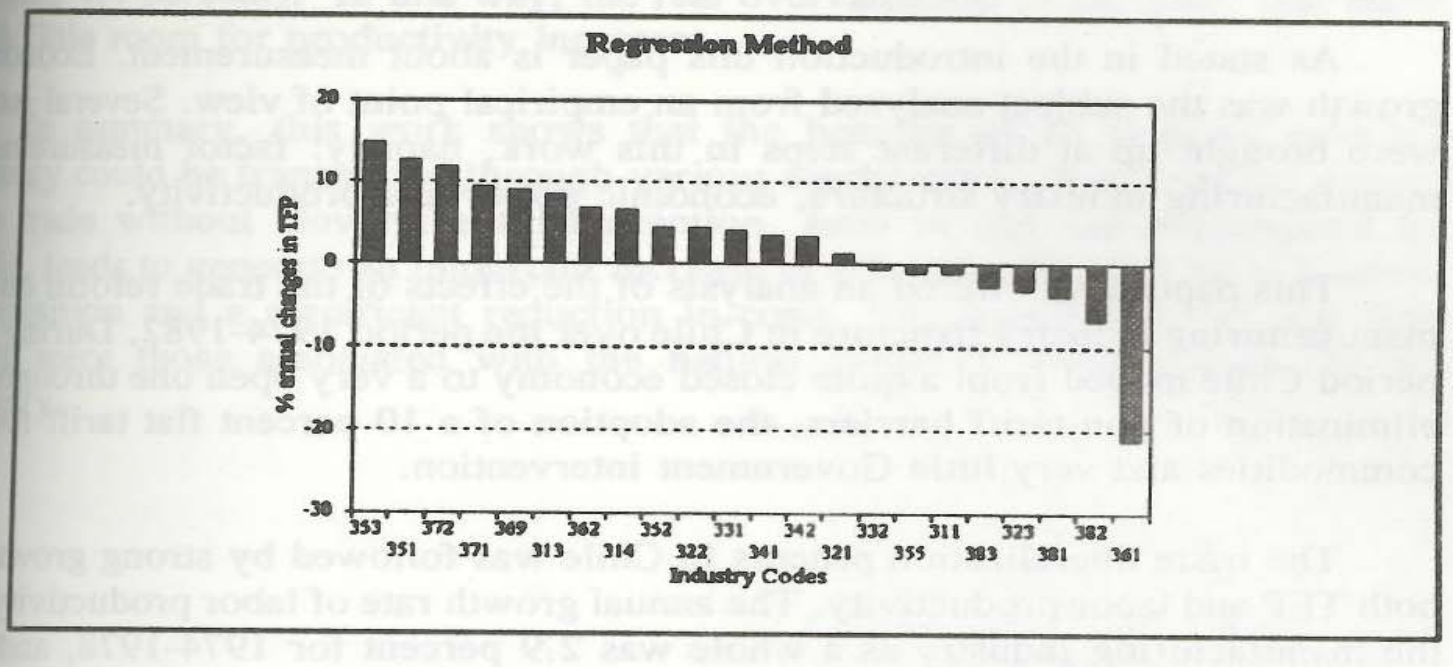
# CHILE, TFP 1975-1978

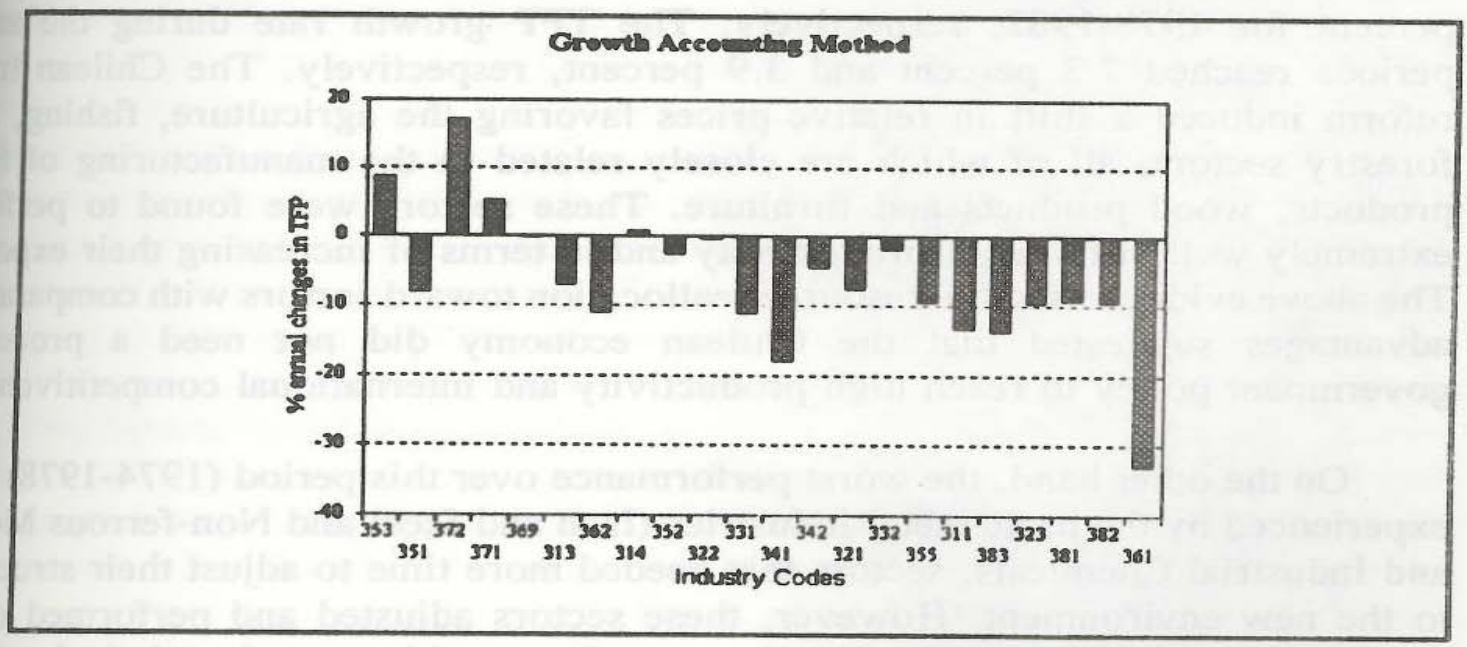


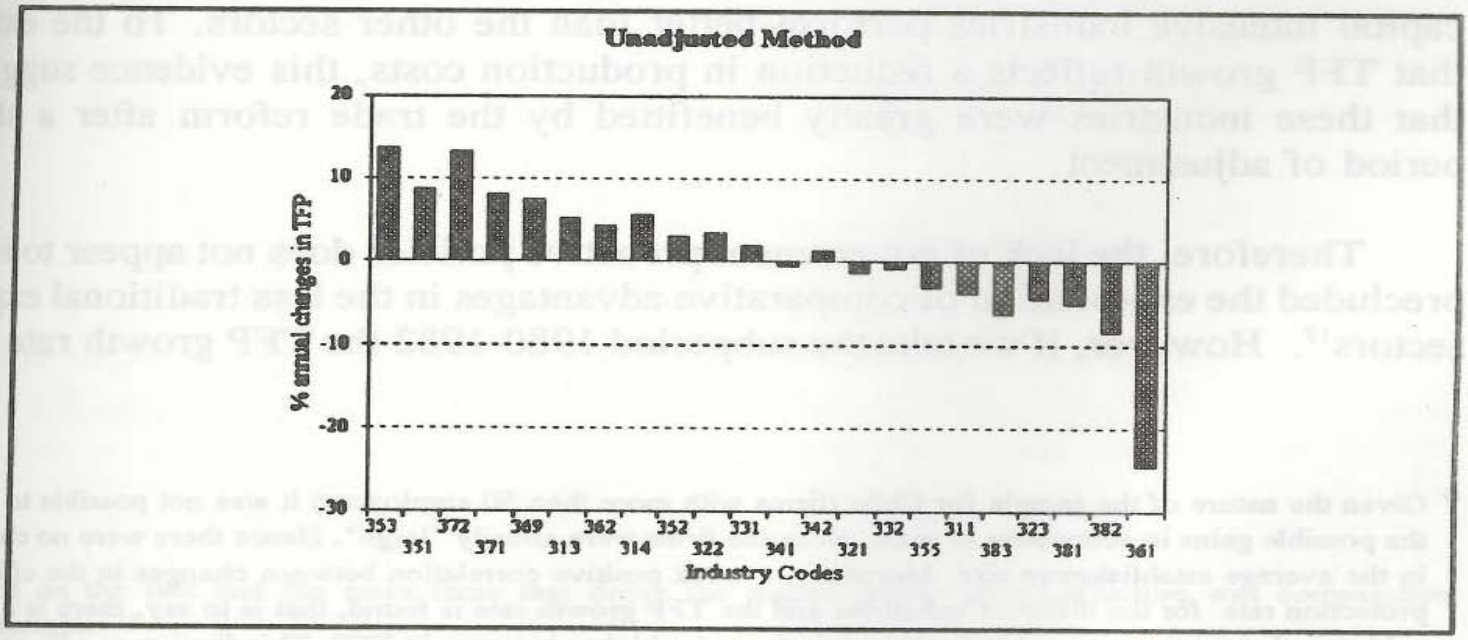



# CHILE, TFP 1978-1982



## 7. CONCLUDING REMARKS

As stated in the introduction this paper is about measurement. Economic growth was the subject analyzed from an empirical point of view. Several issues were brought up at different steps in this work, namely: factor measurement, manufacturing industry structure, economic policy and productivity.

This paper first offered an analysis of the effects of the trade reform on the manufacturing industry structure in Chile over the period 1974-1982. During this period Chile moved from a quite closed economy to a very open one through the elimination of non-tariff barriers, the adoption of a 10 percent flat tariff for all commodities and very little Government intervention.

The trade liberalization process in Chile was followed by strong growth in both TFP and labor productivity. The annual growth rate of labor productivity for the manufacturing industry as a whole was 2.9 percent for 1974-1978, and 4.4 percent for 1978-1982, respectively. The TFP growth rate during the same periods reached 7.3 percent and 3.9 percent, respectively. The Chilean trade reform induced a shift in relative prices favoring the agriculture, fishing, and forestry sectors, all of which are closely related to the manufacturing of food products, wood products and furniture. These sectors were found to perform extremely well in terms of productivity and in terms of increasing their exports. The above evidence and the resource reallocation toward sectors with comparative advantages suggested that the Chilean economy did not need a proactive government policy to reach high productivity and international competitiveness.

On the other hand, the worst performance over this period (1974-1978) was experienced by the basic metal industries (Iron and Steel and Non-ferrous Metal) and Industrial Chemicals, sectors that needed more time to adjust their structure to the new environment. However, these sectors adjusted and performed quite well in the sub-period 1978-1982. In general, over this second period, the more capital intensive industries perform better than the other sectors. To the extent that TFP growth reflects a reduction in production costs, this evidence suggests that these industries were greatly benefitted by the trade reform after a short period of adjustment.

Therefore, the lack of government proactive policies does not appear to have precluded the exploitation of comparative advantages in the less traditional export sectors[17]. However, if we take the subperiod 1980-1982 the TFP growth rate was

[17] Given the nature of the sample for Chile (firms with more than 50 employees) it was not possible to study the possible gains in economies of scale, since the firms were already "large". Hence there were no changes in the average establishment size. Moreover, a weak positive correlation between changes in the effective protection rate for the different industries and the TFP growth rate is found, that is to say, there is a weak evidence that more protected industries experienced a higher increase in TFP. This finding can be justified

poor. All the gains took place between 1975 and 1979 (the TFP anual growth rate reached 4.4 percent). In this way, the real overvaluation of the peso, was faced with little room for productivity increases.

In summary, this work shows that the benefits of an outward oriented strategy could be transmitted through various mechanisms. A movement toward free trade without Government intervention, such as the one experienced by Chile, tends to generate an important increase in efficiency through more internal competition and a significant reduction in costs. The leading sectors at a first stage were those associated with the natural comparative advantages of the country.

based on the fact that the main force that drove the manufacturing sector structure was comparative advantages.

# APPENDIX 1

## Data construction

Industries at the three digit level of the ISIC classification were used. The codes and the names are shown in table 1. It is worth noting that industry 353 (Petroleum Refineries) includes 354 (Misc. Products of Petroleum and Coal). For some years in the 60's, some of the industries were aggregated (e.g. 356,385 and 390; 361, 362 and 369). To disaggregate them, in order to arrive at what is shown in Table 1, the first year of complete disaggregate data was taken and using the proportions from that year, then they were extrapolated back to the 60's.

The data for value added, workers and gross capital formation was obtained from the U.N. Industrial Statistical Yearbook. The figures were in nominal terms and in order to transform them into real terms the deflator of manufacturing industries and the deflator of total investment, published in "National Account Statistics: Analysis of Main Aggregates" by U.N., were used.

The major problem was the estimation of capital stock for each sector. There were two methods to be considered. The first one, and more straight-forward, is to accumulate the investment figures for a certain amount of periods, i. e., under the assumption of linear depreciation as, for instance, if the initial capital stock lasts 10 years at the end of that period the value of that capital will be zero. The capital stock at the beginning of period 11 will only be the accumulation of the real investment adjusted for depreciation. The main problem with this method is that the data set used starts in 1963 and therefore it was impossible to calculate the capital stock at the beginning of the period under analysis. Assuming that the capital stock lasts 15 years it would be only possible to calculate the capital stock for 1978. For this reason this method was disregarded.

The second method to be considered was the one explained by Harberger (1976). The key assumption to be made is that the capital-output ratio is relatively constant for short periods of time. That is to say:

$$\frac{d(K/Y)}{dt} = \frac{\dot{K}Y - K\dot{Y}}{Y^2} = 0 \qquad \text{(A1.1)}$$

where as usual the dot stands for a derivative with respect to time. Note that the change in capital stock correspond to the net investment and denoting the gross investment by I we can substitute in (A1.1):

$$K = \frac{(I - \delta K)Y}{\dot{Y}} \qquad \text{(A1.2)}$$

Solving for K in the above equation we obtained:

$$K = \frac{I}{(\hat{Y}+\delta)} \qquad \text{(A1.3)}$$

where as usual "^" denotes percentage variation. The intuition of (A1.3) is provided by Harberger. The new investment is used to replace depreciation and to increase the capital stock. Using (A1.3) the capital stock for period 0 was calculated. For the following years the net investment[18] was added to obtain the capital stock for subsequent periods.

The depreciation rate was assumed to be equal to 6.5 percent and the growth rate of output (and the capital growth rate) was estimated taking the average rate over two years[19].

For the period 1963-1967 the following industries were added in only one industry in the data set from the U.N.: Industrial Chemical and other Chemicals Products (351, 352), Petroleum Refineries and Miscellaneous Products of Petroleum and Coal (353, 354), Pottery, Glass Product and other Non-metallic Mineral Products (361, 362, 369) and Professional Photographic Goods, other Manufacturing Products and Plastic Products (385, 290, 356). In order to obtain the disaggregation shown in table 1 it was necessary to take the proportion of each industry in the total for 1968 (which was the first year with full disaggregation) to extrapolate back until 1963.

The figures for labor were taken from the table labeled number of persons engaged. This measure includes employees, working owners, active business partners and unpaid family workers.

[18] The net investment was calculated as gross investment minus the depreciation of the capital stock of the previous period and minus one half of the depreciation rate applied to the new investment.

[19] Sector 353 (Petroleum Refineries) shows a negative output growth rate of 22 percent which makes the initial capital stock to be negative. In order to avoid this negative sign, an initial investment level according to the regression $I = \alpha + \beta t$ with $t=0,1,2,\ldots$ is calculated, where $\alpha$ represents the initial level of investment. As expected, this was negative generating a positive initial capital stock. The same regression was also run for the other sectors without important changes.

# APPENDIX 2

## Relative price corrections

This appendix shows the methodology used to correct the figures for labor productivity and TFP in the case of Chile. As shown in Table A2.1 there were high disparities in effective rate of protection (ERP) across sectors at the beginning of the trade reform (1974). These disparities decrease abruptly over the period 1974-1979. On June 1979 tariffs were set at 10 percent for all goods except automobiles.

In this study, value added data deflated by the implicit deflator of GDP in manufactures is used. The intuition of the problem is that when a sector shows a drastic reduction in its ERP with respect to the average of manufacturing sector, then labor productivity and TFP will decrease without any change in efficiency.

The real value added used in this paper, Y, can be written as:

$$Y_j = \frac{p_j q_j - \sum_i a_i \pi_i z_i}{P} \qquad \text{(A2.1)}$$

where $p_j$, $q_j$ are price and quantities of gross output in sector j, $a_i$, $\pi_i$, $z_i$ are the input coefficient, price and quantity of intermediate inputs respectively. P is the price index of the manufacturing industry as whole. Given that all prices are domestic prices, the following must hold:

$$\begin{aligned} p_j &= p_j^* (1+t_j) \\ \pi_i &= \pi_i^* (1+t_i) \\ P &= P^* (1+t) \end{aligned} \qquad \text{(A2.2)}$$

where the star stands for the international price in the national currency[20]

Working with equation (A2.1) we can rewrite it as:

$$Y_j = \frac{p_j}{P}\left(q_j - \sum_i a_i \frac{\pi_i}{p_j} z_i\right) \qquad \text{(A2.3)}$$

[20] For simplification, it was assumed that there is a single exchange rate. However, it has been recognized in the text that there were multiple exchange rates in the country at the time analyzed and that they were rapidly substituted by a system of three different exchange rates.

Taking natural log and differentiating equation (A2.3), to express everything in percentage changes, we have:

$$\hat{Y}_j = \hat{Q}_j + \hat{p}_j - \hat{P} = \hat{Q}_j + P_j^* + (1\hat{+}t_j) - \hat{P}^* - (1\hat{+}t) \qquad \text{(A2.4)}$$

The change in value added computed in the paper is equal to the change in the "true" real quantity plus the changes in an error term.

TFP growth rate was defined as:

$$\hat{TFP} = (\hat{Y} - \hat{L}) - \theta_K(\hat{K} - \hat{L}) \qquad \text{(A2.5)}$$

Plugging expression (A2.4) in (A2.5) in order to obtain the "true" change in labor productivity, we get (A2.6).

$$\hat{TFP} = (\hat{Q} - \hat{L}) - \theta_K(\hat{K} - \hat{L}) + (p_j^* - \hat{P}^*) + [(1\hat{+}t_j) - (1\hat{+}t)] \qquad \text{(A2.6)}$$

Using the data from table A2.1 it was possible to construct an aggregate index of (1+t), and in the table we have ($1+t_j$). Given the magnitude of the changes in tariffs, only the last term, in square brackets, in (A2.6) will be considered. Subtracting this term from the figures obtained for TFP growth rate we obtain a corrected TFP growth rate[21].

[21] The same was done with the labor productivity figures reported in Table 3.10.

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