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Microeconomic Adjustment During Structural Reforms: The Nicaraguan Manufacturing Sector, 1991-1995

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ABSTRACT

The main rationale for the implementation of structural reforms favoring free markets is that they, through increased competition, are likely to create incentives to improve the way firms operate i.e. firm efficiency. In this study we measure and analyze total factor productivity and technical efficiency in a large sample of Nicaraguan manufacturing firms. Our analysis indicates that whereas structural reforms may be necessary conditions for the development of developing economies, their expected positive effects on sources of growth such as total factor productivity and technical efficiency could be so slow that it may be necessary to develop sufficient conditions or policy instruments for spurring economic growth in the short run.

Key Words: Central America, Nicaragua, Productivity, Efficiency, Manufactures and Exports.

JEL Classification: D24, L6, O12, O4, O54

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INTRODUCTION

In 1990, when Violeta Barrios de Chamorro took office as the first democratically elected president of Nicaragua in forty years, the economy was suffering from hyperinflation, large fiscal and current account deficits, and decreasing rates of growth of real wages and GDP. In fact, the Nicaraguan economy had been shrinking: In 1989, the real per capita GDP was half of its 1970 level, while exports and manufacturing output amounted to approximately half of their 1977 levels. In this predicament, two immediate objectives of the new administration were to stabilize the economy, by reducing the fiscal, external and monetary disequilibria and to promote long-term growth, by implementing a series of market oriented structural reforms along the lines of the ”Washington Consensus”, see Williamson (1990), aiming, among other things, at increased efficiency and productivity of firms and privatized sectors.

The combination of the successful stabilization package of February 1991 and the availability of foreign aid to finance remaining budget deficits succeeded in reducing the inflation rate dramatically by 1992. The two major components of the structural reform program, the privatization of the 351 state enterprises and the liberalization of foreign trade, advanced swiftly. By the end of 1993, a great majority of the state enterprises were returned to their former owners, handed over to the workers, or sold off. By the same time, most non-tariff barriers were eliminated, and tariffs were lowered to the 5%-40% range. The effects of these policies on economic growth have not been apparent; the rate of GDP growth for 1990-1996 was only 2.2%. See Dijkstra (1996) for a complete description and critical appreciation of Nicaragua’s structural reforms.

A major argument in favor of structural reform is that privatization and trade liberalization increase competition and alter the structure of incentives facing individual firms in a way that improves their performance. Consequently, structural reforms are likely to affect the productive efficiency and productivity of individual production units and industries as well as entire sectors of an economy. There are numerous macroeconomic studies addressing different aspects of structural reform, while the significance of microeconomic adjustment has been a neglected area. For references to productivity measurement at the microeconomic level in developing countries, see e.g. Roberts and Tybout (1996) and Liu (1993). The scarcity of this kind of study is most certainly due to limited data availability.

The very object of this paper is, based on plant level data, to study the development of technical (productive) efficiency and total factor productivity during a period of structural reform in a developing country, Nicaragua. Methodologically, the study is based on a stochastic panel data approach estimating total factor productivity and the non-parametric Data Envelopment Analysis (DEA) method when estimating technical efficiency change. The data have mainly been constructed based on four Surveys of Manufacturing for the years 1991-1994 conducted by the Nicaraguan Statistical Institute (INEC) and the Central Bank of Nicaragua together with a relatively small complementary survey of exporting firms that we made in May 1996.

In the next section we present the major elements of the trade reform implemented during the Chamorro Administration and discuss the evolution of the manufacturing sector between 1991 and 1996. Section III outlines the data and methodology used to estimate total factor productivity and technical efficiency. In Section IV we present the main results of the analysis. Finally, concluding remarks are made in Section V.

I. TRADE REFORM AND MANUFACTURING PERFORMANCE

The industrialization of Nicaragua was closely linked to the establishment of the Central American Common Market (CACM) in 1960 (see Dijkstra, 1996). A free trade area was formed and protection was raised against other countries. This regional protectionist scheme created a stimulus for the establishment of new manufacturing firms that could serve not only the domestic, but also the regional market. Besides the more traditional industries such as food, beverages, textiles, and leather, industries producing chemicals and metal products were now established. The Nicaraguan economy experienced growth during the period that followed (1960-1978). The high rate of growth came to an abrupt halt during the 1980s, as the Sandinist revolution and the civil wars that engulfed Nicaragua and other members of the CACM disrupted production and trade. When the Chamorro Administration came into office in 1990, the civil war ended, and a process of structural reform was initiated. A period of slight economic recovery followed. The recovery of 1990-1996 is reminiscent of the 1960-1978 period, in that exports grew faster than production. In contrast, the manufacturing sector did not play the dynamic role that it played in the 1960s and 1970s[1].

Why was the growth of the manufacturing sector relatively slow during this period? A possible explanation might be that firms had a hard time adjusting to the new and more competitive environment brought about by the trade reform implemented by the Chamorro Administration. The main elements of this reform were (see World Bank (1994), Berlinski (1995, 1996) and Tello (1995, 1997): i) the replacement of most non-tariff barriers by tariffs; ii) the gradual reduction of tariffs over time[2]; and iii) the exemption of indirect taxes on intermediate and capital goods for exports (since 1992). In addition, non-traditional goods exported to non-Central American markets were subsidized, initially at 15% of the FOB value of goods exported and at 5% towards the end of the program. Finally, the Export Processing Zones Law implemented in 1992 practically exempted exporters in certain geographic regions (such as Las Mercedes) from taxes on exports. Together with the implementation of the trade reform, a crawling peg regime was instituted at the beginning of 1993 with the main objective of avoiding the appreciation of and the potential need for an abrupt devaluation of the Cordoba. In fact, the real exchange rate has remained quite stable since the stabilization plan of 1991 (see Aguilar, Stenman, and Aguilar 1995).

Table 1 provides information on tariffs and growth rates by manufacturing industry between 1990 and 1996. The former are average tariffs of the items listed in the Central American System nomenclature, and the latter are average rates of change of the real value added. The table shows that a large proportion of the cuts in tariffs was implemented relatively early in the process: For some industries, the average tariffs as of December of 1991 were not very different from those of June 1996, while for industries, such as food, leather, and paper, tariffs were raised slightly after the first reductions. Table 1 also indicates that there is not a very clear correlation between tariff reductions and industry performance. Although some industries affected by large tariff cuts, such as the traditionally highly protected textiles and garments industries, displayed a poor performance in subsequent years, other industries that suffered large tariff cuts, such as beverages and non-metallic products, did relatively well.

Table 1: Tariffs and Growth Rates by Manufacturing Industry, 1990-1996

Sector	Average Tariffs Jan. 1990	Dec. 1991	Jun. 1996	Average Annual Growth Rates of Real Value Added 1990-91	1991-92	1992-94	1994-96	Share 1990-96
Food	51.2	16.1	23.7	-2.1	-4.2	3.7	2.7	38.9
Beverages	144.6	47.9	34.8	54.5	7.7	2.4	2.8	23.8
Tobacco	183.0	83.0	35.0	49.6	-15.7	-4.6	1.5	8.6
Textiles	58.9	18.3	16.6	-31.5	-25.6	-30.1	2.6	3.1
Garments	105.7	33.6	29.8	-52.0	-70.2	-30.4	1.6	0.3
Leather	45.5	18.6	20.4	22.7	8.6	-5.9	-2.6	0.2
Footwear	95.1	25.3	31.2	12.2	8.3	-3.3	1.7	0.9
Wood	55.8	21.0	17.3	1.0	-0.4	1.6	2.7	2.2
Furniture	113.0	36.3	25.9	43.6	-9.6	-10.2	0.2	0.5
Paper	24.7	11.1	13.7	29.5	-16.1	3.1	1.2	0.5
Printing	63.1	18.8	11.3	-14.5	-3.7	-1.2	2.1	1.8
Rubber	39.5	13.6	12.3	} -35.7	-2.2	-2.3	2.4	0.1
Plastics	72.0	18.4	13.8					
Chemicals	18.9	10.6	11.4	} -28.1	-36.1	3.7	3.2	3.5
Pharmaceuticals	38.7	13.1	9.0					
Petroleum	23.3	18.1	17.4	0.8	3.3	0.7	-3.7	5.1
Non-Metallic Prod.	65.9	19.5	16.7	24.9	9.1	-0.8	6.2	5.8
Basic Metals	18.4	11.9	11.1	} -23.3	-53.5	-17.6	-7.6	1.3
Other Metallic Prod.	41.1	12.9	12.4					
Eq. & Electr. Prod.	45.7	15.0	9.7	-61.1	-58.3	-5.9	1.2	0.6
Transportation	33.0	19.7	11.8	2.4	100.0	-8.5	2.1	0.2
Other	64.4	15.5	14.4	35.4	21.8	2.8	7.7	2.6
Total	43.2	15.2	15.3	6.4	-5.1	0.5	2.5	100.0

Source: Ministry of Economics and Economic Development (1996)

The trade reform is not the only factor affecting Nicaraguan manufacturing firms. Neither are changes in nominal tariffs a sufficient indicator of the degree of protection enjoyed by the manufacturing sector: The manufacturing sector is still highly protected and recent studies of effective protection by Berlinski (1995 and 1996) indicate that the average effective rate of the sector is close to 40%. Moreover, Tello (1997) finds that the export subsidies included in the trade reform package are concentrated to a small number of the exporting firms, implying that tariffs are only part of a larger picture. Furthermore, the inflow of foreign aid played a crucial part in support of the stabilization program. For the period 1990-1994, foreign aid amounted to approximately 30% of Nicaragua's GDP (see World Bank, 1994), which might have reduced the drastic impact of the stabilization program on aggregate demand.

As mentioned above, a general argument in favor of structural reforms, such as the one implemented in Nicaragua, is the expected improvement of economic performance at the firm and industry levels. In order to obtain a clearer picture of the consequences of the adjustment process, we focus on the individual firm or industry as the unit of analysis. In the next two sections we develop a quantitative analysis of firm/industry level productivity and efficiency change in the Nicaraguan manufacturing sector.

II. DATA AND METHODOLOGY

The data consist of four Annual Surveys of Manufacturing for the years 1991-1994 conducted by the Nicaraguan Statistical Institute (INEC) and the Central Bank of Nicaragua plus a small complementary survey for 1995 of exporting firms. The complementary survey was conducted within the NEPAI-USAID project. The INEC Annual Survey data were subjected to extensive consistency tests in order to correct a variety of errors. For instance, we eliminated dubious observations, such as firms with negative value added or incomplete answers to the survey questionnaire, we verified export data with customs data and corrected inconsistent export, production and value added observations on a case-by-case basis.

Table 2 presents the main characteristics of the data set. *Ne* denotes the number of firms in the surveys and *Ns* denotes the number of firms used for the computation of total factor productivity and technical efficiency. With the exception of 1992, when the data reporting of a large number of firms surveyed was incomplete, *Ns* is generally similar to *Ne*. A comparison of our sample to Nicaragua's national account statistics shows that the samples for 1991 and 1992 are highly representative in terms of value of production (Y), value added (VA), employment (L), and exports (X). The samples for 1993 and 1994 still represent around 40% of employment and 50% of value added, but are less representative in terms of exports (25%-30%). The 1995 sample is, however, too small to be considered representative.

As Table 2 shows, the data were divided into 4 size groups: large firms (50 or more workers), medium size firms (30 to 49 workers), small firms (10 to 29 workers), and micro firms (less than 10 workers). We define an export firm as a firm that exports part of its annual production at least once during the sample period. Based on this criterion, approximately 15% of the firms in the sample are export firms, and the majority (around 65%) are large firms. On average, the export firms exported between 7.5% and 27.3% of their production (XR), and consequently, their main market has been the domestic market.

Table 2 also illustrates the data limitations. Most firms in the sample, have only reported information for one or two years. Naturally, this fact places restrictions on the possibilities of tracing the development of an individual firm over time. In view of the data limitations at hand, we have chosen to use a stochastic, panel data approach to estimate total factor productivity, and a deterministic, non-parametric approach (DEA) to estimate an intertemporal technical efficiency frontier for each industry for the period of observation (1990-1994). This is to ensure that we obtain results for as many production units as possible, and the utilization of both approaches also adds to the robustness of the results.

Table 2: Sample Features

	Number of Firms				Exports/				
	Total		Exporters		Product (%)	Share of Total (%) **			
	Ne	Ns	Ne	Ns	XR*	Y	VA	L	X
Total									
1991	236	235	71	71	7.45	123.52	116.81	73.74	49.00
1992	536	355	69	65	11.36	109.30	108.82	70.66	81.23
1993	420	419	43	43	14.67	41.74	50.44	40.60	24.94
1994	224	223	40	39	17.25	51.45	50.58	42.70	30.54
1995	7	7	7	7	27.25	3.08	2.89	2.86	2.15
Large Firms									
1991	97	96	48	48	7.67	91.18	91.33	89.28	93.88
1992	96	95	46	45	11.90	93.26	92.36	85.75	97.64
1993	54	54	30	30	14.67	83.18	81.20	72.86	84.29
1994	54	54	28	28	17.53	89.87	88.63	85.05	91.32
1995	5	5	5	5	20.56	91.58	87.56	95.64	69.09
Medium Firms									
1991	37	37	11	11	3.05	4.31	4.62	5.19	1.76
1992	43	42	14	15	4.36	3.77	4.21	6.75	1.45
1993	28	28	5	5	8.55	7.04	7.79	8.25	4.16
1994	19	19	5	5	18.40	6.40	7.27	5.43	6.82
1995	0	0	0	0	0.00	0.00	0.00	0.00	0.00
Small Firms									
1991	76	76	12	12	7.99	4.06	3.49	4.95	4.35
1992	62	61	5	4	3.75	2.11	2.49	4.53	0.70
1993	82	81	8	8	26.98	6.20	6.18	10.72	11.55
1994	47	46	6	5	9.47	2.70	3.08	6.01	1.48
1995	2	2	2	2	100.00	8.42	12.44	4.36	30.91
Micro Firms									
1991	26	26	0	0	0.00	0.46	0.56	0.58	0.00
1992	335	157	1	1	2.88	0.86	0.94	2.98	0.22
1993	256	256	0	0	0.00	2.25	2.23	8.18	0.00
1994	104	104	1	1	6.25	1.03	1.02	3.51	0.37
1995	0	0	0	0	0.00	0.00	0.00	0.00	0.00
By Number of Years									
5	2	2	2	2	19.70	2.00	1.90	6.10	3.20
4	36	36	20	20	3.20	14.10	14.60	14.90	3.80
3	120	114	36	35	21.00	37.30	35.80	35.60	64.50
2	205	203	40	40	7.60	40.60	42.30	30.70	25.60
1	313	313	17	17	5.90	6.00	5.50	12.70	2.90

Source: Annual Manufacturing Surveys 1991-1994 and NEPAI Survey of 1995. *Export ratio is computed for exporting firms only. * In the first five rows of the table the share is out of the total manufacturing universe.

A. THE PARAMETRIC APPROACH

We base our computations of total factor productivity (TFP) indices on the following translog production function:

$$\ln Y_{it} = a_i + \sum_{j=1}^{K} b_j \ln X_{jit} + \sum_{\substack{k=1 \\ k \le j}}^{K} \sum_{j=1}^{K} b_{kj} \ln X_{kit} \ln X_{jit} + \sum_{t=91}^{95} d_t D_t + e_{it}, \quad i = 1,\ldots, Ns, \qquad [1]$$

where Y_{it} is the real value of output (base 1994) of firm i in period t; X_{jit} is the real value of input j (base 1994) used by firm i in period t; and β_j, and β_{kj} are slope parameters of the production function. ε_{it} is a random error for firm i in period t which accounts for measurement errors in Y_{it} and factors uncontrolled by the firm (such as strikes or the weather) that affect their output level. In order to account for industry-wide shocks that affect all the firms in the sample in a given year, we include the terms $\delta_t D_t$, where the D_t`s are dummy variables that take a value of 1 for all the observations corresponding to year $t$ and the $\delta_t$`s are parameters to be estimated. Finally, α_i represents total factor productivity, our central parameter of interest.

The translog production function is flexible enough to allow for the testing of more restricted functional forms. For example, it becomes a Cobb-Douglas production function if we restrict the values of β_{kj} to be equal to zero.[3] Also, the existence of significant industry-wide shocks can be tested against the hypothesis of no shocks (δ_t=0). Since our sample is a panel, the total factor productivity parameter α_i can be estimated both as a fixed and as a random effect. We estimated both models, but found that the Hausman test strongly rejected the random effects specification.[4] Therefore, all the results reported are based on the fixed effects specification.

Following Baltagi (1995), using the socalled Within transformation that wipes out α_i, we estimate the parameters β_j , β_{kj} , and δ_t of Equation [1] for an unbalanced panel that includes all the firms with two or more observations. Then, we use the estimated parameters $\hat{b}_j$, $\hat{b}_{kj}$, and $\hat{q}_t$ to calculate the total factor productivity of each firm as

$$\hat{a}_i = \overline{\ln Y_i} - \sum_{j=1}^{K} \hat{b}_j \overline{\ln X_{ji}} - \sum_{\substack{k=1 \\ k \le j}}^{K} \sum_{j=1}^{K} \hat{b}_{kj} \overline{\ln X_{ki} \ln X_{ji}} - \sum_{t=91}^{95} \hat{q}_t \overline{D_t}, \qquad [2]$$

where $\overline{\ln Y_i}$, $\overline{\ln X_{ji}}$, $\overline{\ln X_{ki} \ln X_{ji}}$, and $\overline{D_t}$ are averages over time for each individual firm. We use this equation to estimate the total factor productivity of all the firms in the sample, including those with only one observation that were not used for the estimation of the production function. In all productivity index estimations, we have used three inputs: capital, labor, and intermediate products.[5] Due to space restrictions, Table A1 (see Appendix) shows regression results for the full sample only. Results for the subsamples of large and small firms are available from the authors upon request.

To facilitate the interpretation of the results, we then normalize the obtained estimate by calculating the following total factor productivity index

$$TFP_i = 100.\exp[\hat{a}_i - \max_i\{\hat{a}_i\}], \qquad i = 1, \ldots, Ns \qquad [3]$$

The index represents the total factor productivity of firm i as a percentage of the total factor productivity of the most efficient firm. Consequently, TFP_i equals 100 for the most efficient firm of the sample.

An underlying assumption in the above calculations of TFP indices is that the firms in the sample share the same basic technology. This assumption can be questioned on two grounds. Firstly, large and small firms may use different technologies—even within the same manufacturing industry. Secondly, technology is likely to differ across manufacturing industries. In order to address these issues, and to test the robustness of our results, we have computed various sets of TFP estimates (see Tables 4 and 5). For the computation of the first two sets, TFP1 and TFP2, we used the full sample of 902 observations corresponding to 355 different firms, thus assuming a single technology for the entire manufacturing sector. We then assumed that technology differs between large and small firms: From a subsample of 504 observations of the 137 firms that, on average, employed 30 or more employees per year, we calculated

TFPL1 and TFPL2. Correspondingly, TFPS1 and TFPS2 were estimated based on a subsample of 398 observations of the 218 small firms that, on average, employed less than 30 employees per year. We estimated TFP1, TFPL1 and TFPS1 including time dummies in the production function, and TFP2, TFPL2 and TFPS2 without time dummies. Finally, we assumed that technology differs across industries and obtained industry-specific TFP estimates for 20 manufacturing industries[6] (due to space limitations, these estimates are not presented in this article; they are however, available from the authors upon request; it should also be noted that all technical efficiency estimates presented in Table 6 are based on the assumption that technology differs between industries). TFPb combines the industry-specific indices into a single index for the manufacturing sector. Thus, each TFPb estimate represents the total factor productivity of a firm as a percentage of the total factor productivity of the most efficient firm of the industry in question; see Table 5.

Given the short time dimension of our panel and the fact that for 77% of the firms there are only one or two observations, we are limited in our possibilities to explore the TFP development of individual firms over time. For a small sample consisting of the 37 firms that have reported information for each year between 1991 and 1994 we have calculated the following measure of TFP change:

$$\Delta TFP_i = \frac{TFP_i^2 - TFP_i^1}{TFP_i}, \qquad i = 1,\ldots,37 \qquad [4]$$

where

$$TFP_i^p = 100.\exp[\hat{a}_i^p - \max_i\{\hat{a}_i\}], \qquad i = 1,\ldots,37, \quad p = 1,2$$

and

$$\hat{a}_i^p = \overline{\ln Y_i}^p - \sum_{j=1}^{K} \hat{b}_j \overline{\ln X_{ji}}^p - \sum_{\substack{k=1 \\ k\le j}}^{K} \sum_{j=1}^{K} \hat{b}_{kj} \overline{\ln X_{ki} \ln X_{ji}}^p - \sum_{t\in p} \hat{q}_t \overline{D_t}^p, \qquad p = 1,2$$

where $\overline{\ln Y_i}^p$, $\overline{\ln X_{ji}}^p$, $\overline{\ln X_{ki} \ln X_{ji}}^p$, and $\overline{D_t}^p$ are individual firm averages over the period *p*. *p*=1 includes 1991 and 1992, and *p*=2 includes 1993 and 1994. As above, we estimate measures of TFP change corresponding to different estimates of $\hat{b}_j$, $\hat{b}_{kj}$, and $\hat{q}_t$.[7] The results are presented in Table 5.

B. THE DATA ENVELOPMENT ANALYSIS (DEA) APPROACH

In view of the data limitations, we supplement the results of the stochastic panel data approach with non-parametric estimations of technical efficiency change. By applying the DEA method, we are able to obtain results for all the included firms for all years of observation.

The central feature of this method is that there is no need to make any assumptions regarding the functional form of the underlying production function. In DEA, a convex hull is constructed instead of an explicit frontier production function This hull constitutes the production possibility set and is solely based on the actual observations of the different production units of a specific sector or industry. The hull is defined by areas made up by the most efficient units, while the less efficient units are inside the hull. The distance from an observation to the hull constitutes the measure of the unit's technical efficiency; see Figure 1. The efficiency of a production unit is thus measured relative to the efficiency of all the other production units, subject to the restriction that all units are on or below the frontier.

Farrell (1957) provided a methodology by which technical efficiency could be measured against an efficiency frontier, assuming constant returns to scale. The DEA method is closely related to Farrell's original approach and should be regarded as an extention of that approach. It was further developed and reformulated by e.g. Banker, Charnes and Cooper (1984), Deprins, Simar and Tulkens (1984) and by Färe, Grosskopf and Lovell (1985). The method became best known through the works of Charnes, Cooper and Rhodes (1978) who formulated the estimation of efficiency as a Linear Programming (LP-) problem; efficiency is calculated separately and directly for each production unit in turn, while at the same time the location of the corresponding linear facets is determined.

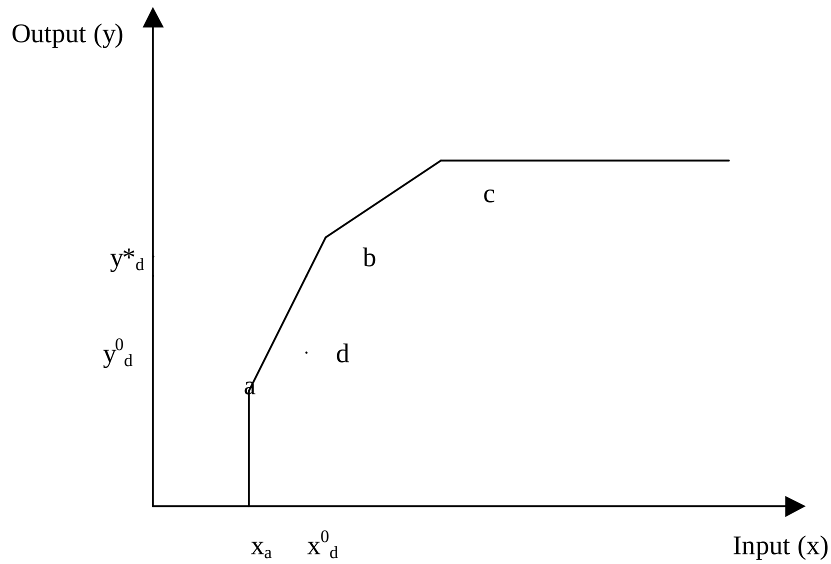

Figure 1. The Output Increasing Efficiency Measure

As illustrated by the figure, the output increasing efficiency measure, usually denoted by E_2, measures observed output relative to the potential frontier output. The points a, b, c, and d represent different production units. The output increasing efficiency measure is derived from the reference technology $x_a$abc and the horizontal line to the right of c. The units a, b and c are fully efficient frontier units with $E_2=1$. Unit d, on the other hand, is not efficient with E_2 as measured by $y_d^0 / y_d^* < 1$, where y_d^0 denotes the observed amount of output and y_d^* denotes the maximum potential amount of output for unit d. x_d^0 denotes the observed input use. In this study, we do not place any restrictions on the scale properties of the underlying production technology.

This study applies Farrell type ray measures as generalized into input saving and output increasing efficiency measures by Førsund and Hjalmarsson (1974, 1979 and 1987). For a more detailed presentation of different Farrell type efficiency measures and their application to Data Envelopment Analysis, see e.g. Hjalmarsson and Veiderpass (1992). Furthermore, data considerations i.e. the number of missing observations together with the short time period of study, make a socalled intertemporal frontier approach suitable in this case (see Tulkens and Vanden Eeckaut (1991)). Assuming the reference production set to be invariant over time, output increasing efficiency estimation is thus made in reference to all the data for all years of observation. It should be noted that in the DEA estimations we assume that technology differs between industries. Consequently, we estimate one (intertemporal) efficiency frontier for each industry of the manufacturing sector.

A Linear Programming-problem must be solved for the different production units to obtain the output increasing efficiency measure under variable returns to scale. For example, for unit d with output y_d and input x_d, the LP-problem (where λ_d is a vector containing the non-negative weights, λ_{dj}, which determine the reference point) is

$$Max_{l_d} \{1/E_{2d}\} \quad [5]$$

subject to the following restrictions:

(5a) $$(1/E_{2d})\,y_{rd} \le \sum_j^N l_{dj}\,y_{rj}, \quad r = 1,\ldots,m$$

(5b) $$x_{id} \ge \sum_j^N l_{dj}\,x_{ij}, \quad i = 1,\ldots,n$$

(5c) $$\sum_j^N l_{dj} = 1$$

(5d) $$l_{dj} \ge 0, \quad j = 1,\ldots,N$$

where, m is the number of outputs, n is the number of inputs and N the number of units. Restriction (5a) implies that the efficiency adjusted volume of output produced by unit d must be less than or equal to the output produced by the reference (frontier) unit while restriction (5b) implies that the volume of input used by unit d must at least amount to the input volume used by the reference unit. Restriction (5c) is the condition for variable returns to scale. If this restriction is omitted, constant returns to scale is implied.

Summary measures of efficiency for an entire sector or industry may be constructed in various ways. In analogy with Farrell, this study applies an output increasing structural efficiency measure (S_0), based on the E_2-values of each firm, calculated as the output weighted average efficiency for the entire industry in question. In the estimations we use a two input, one output model specification. The inputs are labor (average number of workers employed) and capital (book value, in thousands of 1994 cordobas), while output is the gross value of production (in thousands of 1994 cordobas). The results are presented in Table 6. Due to space restrictions, we only estimate structural efficiency for 25 of the industries of the Nicaraguan manufacturing sector. These are the 25 industries with the highest number of production units (total number of observations is 972 out of 1211). For complete efficiency estimates of all individual units as well as of industries between 1990 and 1994, see Veiderpass (1997).

III. PRODUCTIVITY AND EFFICIENCY OF NICARAGUAN MANUFACTURING FIRMS, 1991-1995

Like most developing countries, Nicaragua has a history of subsidizing and protecting the export sector and the large producers. This, in combination with small domestic as well as export markets, would indicate that substantial efficiency gains may be made from increased domestic demand and the exposure to competitive international markets. The Nicaraguan process of structural reform was initiated in 1990, and the full adjustment of firms to changed conditions is a lengthy process. In this study, our aim is to provide an overwiev of the situation during the inital period of adjustment as regards productivity and efficiency change.

Due to the short time dimension of our data, the analyses focus on cross-section comparisons of total factor productivity across different types of firms. When studying the development over time, we calculate results on productivity change for a small sample of 37 firms where data were observed for each year between 1991 and 1994. In addition, we apply intertemporal best practice frontiers when studying the technical efficiency change over the period.

Table 3 presents average total factor productivity by firm size. The table also includes average values of labor productivity (PL, defined as value added per worker), capital-labor ratios (KL and SKL, where the first represents machinery and equipment per worker and the second total assets or social capital per worker), the 4-firms concentration ratio (CR, as calculated by Tello (1995)), number of workers employed (L), nominal tariff (NT), export share of total gross product (XR) and the number of firms in the sample (Ns). The table indicates that total factor productivity increases with firm size; see TFP1 and TFP2. The TFPL measures indicate that large firms have higher productivity values than medium sized firms, and the TFPS measures show higher values for small firmes as compared to micro-sized firms. Isgut (1996) found indications of a similar relation when studying productivity levels and firm size in Colombia. The measure of labor productivity points in the same direction. The table also shows that larger firms tend to be more capital intensive, belong to concentrated manufacturing industries, and have higher export ratios (XR). There does not seem to be any correlation between firm size and average nominal tariffs.

Table 3: Total Factor Productivity and Other Indicators by Firm Size: 1991:1995

	Firm Size:				
Indicators	Large	Medium	Small	Micro	Total
TFP1	11.53	5.76	4.19	2.50	4.88
TFP2	11.09	5.62	4.10	2.56	4.79
TFPL1	10.78	4.91	n.a.	n.a.	8.93
TFPL2	9.97	4.59	n.a.	n.a.	8.27
TFPS1	n.a.	n.a.	12.95	8.53	9.85
TFPS2	n.a.	n.a.	12.75	8.78	9.97
L	229	38	17	4	53
PL	101.46	51.77	46.67	20.90	44.47
KL	33.68	27.73	18.79	22.20	28.46
SKL	43.63	35.00	33.94	11.19	24.35
XR	10.84	7.29	8.44	n.a.	10.49
CR	61.43	51.04	43.25	36.22	43.34
NT	25.7	18.89	24.52	31.86	27.97
Ns	126	57	146	336	665

Table 4 presents results according to the degree of export orientation of the firms. It should be noted that the great majority of export firms export less than 20% of their output. Although export firms in general seem to have higher average productivity than non export firms, irrespective of productivity measure, the table shows that the most productive firms are not found in the category with the highest export ratio. The total productivity measures (TFP1 and TFP2) as well as the measures for large and medium sized firms (TFPL1 and TFPL2) and small and micro sized firms (TFPS1 and TFPS2) show that for all firm sizes, the most productive firms are those that export beween 60 and 80 percent of their output. Another common feature of these firms is also that they are relatively labor intensive as compared to the more export oriented firms.[8]

Table 4: Total Factor Productivity and Other Indicators by Export Orientation: 1991-1995

	Type of Export Firms					Export	Nonexport
Indicators	XR>80%	60%<XR<80%	40%<XR<60%	20%<XR<40%	0%<XR<20%	Firms	Firms
TFP1	9.42	13.04	10.06	7.41	12.25	11.43	3.56
TFP2	9.23	12.85	9.76	7.11	11.78	11.03	3.54
TFPL1	10.21	13.11	8.94	7.08	12.40	11.58	6.11
TFPL2	9.43	12.37	8.25	6.40	11.52	10.74	5.65
TFPS1	12.11	21.70	18.56	16.63	10.22	13.97	9.71
TFPS2	12.26	20.89	20.09	16.12	9.35	13.61	9.84
L	106	108	667	185	177	190	25
PL	68.79	98.50	37.71	64.15	135.84	115.31	30.43
KL	34.55	29.71	24.29	34.89	44.99	41.32	20.58
SKL	43.44	33.23	30.45	49.63	57.11	52.24	48.87
XR	86.24	71.27	44.81	29.44	1.98	13.82	0.00
CR	42.45	63.35	60.23	52.43	61.44	40.06	59.08
NT	22.02	16.58	23.35	23.53	27.50	25.65	28.43
Ns	8	8	5	13	76	110	555

As opposed to Tables 3 and 4, where average productivity levels are presented, Table 5 illustrates the productivity change over the four-year period. Table 5 summarizes the characteristics of a sub-sample of 37 firms observed each year between 1991 and 1994 (it should be noted that the table presents median firm characteristics). To classify the firms we computed the average of the five measures of TFP change calculated. Firms with negative values were classified as having negative productivity growth (12 firms), firms for which this measure was between 0% and 20% were classified as having moderate productivity growth (12 firms), while firms with an average productivity change of 20% or more were classified as having high productivity growth (13 firms). Four characteristics of the firms deserve to be mentioned. First, the firms with high productivity growth do, on average, have a lower level of productivity than the other firms. This means that these firms are catching up with the most productive firms, reducing the dispersion of productivity levels across firms. Second, the firms in the high productivity growth group are smaller than the firms in the two other groups. Third, there does not seem to be any systematic association between changes in labor demand and productivity growth.[9] Fourth, there does not seem to be an association between productivity growth and export growth. Only five of the 13 firms belonging to the high productivity growth group are exporters, three of which increased their exports while the exports of two firms were reduced. The other groups are also equally divided between firms with increased and reduced export quantities.

Given the short time span of the data, these measures of productivity change should be interpreted with care. They may not be used to predict long term trends in productivity growth. It should also be kept in mind that the number of observed firms is small, and caution should therefore be exercised in extrapolating the above observations to the entire manufacturing sector. Nevertheless, the results are informative with regard to the immediate adjustment of a small, but representative group of firms.

A final question with regard to productivity change, is whether some industries appear to have done consistently better or worse than others. The answer is yes. The five firms in the sample belonging to printing and non-metallic products are all in the high productivity growth group. The two firms belonging to footwear, beverages and tobacco are in the low productivity growth group. However, firms belonging to other industries, such as plastics and sugar, are represented in each of the different productivity growth groups. This observation suggests that the initial effect of the structural reform may be cutting across manufacturing industry sectors, independently of comparative advantage considerations. Although trade reform may be expected to have a stronger effect on the industries that afforded the largest reductions in tariffs, as is certainly the case of footwear, beverages and tobacco, the more competitive environment may be affecting firms independently of industry.

Table 5: Median Firm Characteristics by Change in Total Factor Productivity

	Negative Productivity Growth	Moderate Productivity Growth	High Productivity Growth
? TFP1	-18.97	9.82	32.64
? TFP2	-18.73	9.75	33.01
? TFPLS1	-21.50	12.34	36.86
? TFPLS2	-25.39	7.36	38.95
? TFPb	-14.28	-1.09	35.57
TFP1	6.29	7.30	5.48
TFP2	6.09	6.91	5.33
TFPLS1	10.76	8.17	6.28
TFPLS2	9.73	7.34	5.71
TFPb	39.74	27.34	10.31
Ns	12	12	13
L	65.38	66.69	41.25
? L/L	-2.77	-4.93	-2.28
Y	8215.48	12635.53	3563.16
? Y/Y	-18.33	7.52	33.13
X	0.00	13.36	0.00
? X/X	0.00	0.00	0.00

To further enhance our knowledge of the changes in performance of the different industries of the manufacturing sector over the four-year period, Table 6 illustrates the observed development of technical efficiency. The estimations are based on the assumption that technology differs between industries, and that consequently, individual estimates are industry specific, i.e the actual values of each industry relate to an intertemporal (four-year) best practice (efficiency) frontier for the industry in question.

As mentioned above, this study focuses on output increasing efficiency, and structural output increasing efficiency measures indicate the output increasing potential for an entire industry. For example, as seen in Table 6, in 1991 Industry 1541, on average, produced 80 percent of the output that would have been possible to produce with the same amount and combination of inputs had the production been fully efficient. We also see that the industry is moving away from the efficiency frontier, i.e efficiency is declining and in 1994 S_0 has fallen to 49 percent.

Table 6: Efficiency Change 1991-1994

ISIC	S_0:1991	S_0:1992	S_0:1993	S_0:1994
0140	0.19	0.34	0.20	0.22
1422	0.54	0.54	0.66	0.53
1512	*	0.50	0.57	0.79
1520	0.76	0.88	0.57	0.62
1531	0.64	0.50	0.17	0.67
1533	0.91	0.87	0.96	0.96
1541	0.80	0.64	0.56	0.49
1542	0.80	0.82	*	*
1549	0.72	0.71	0.59	*
1810	0.29	0.44	0.31	*
1911	0.96	0.44	0.72	0.51
1912	0.51	0.49	0.75	0.79
1920	0.66	0.50	0.64	*
2010	0.86	0.63	0.31	No observations
2109	0.86	0.87	0.87	*
2219	0.45	0.49	0.53	No observations
2421	0.59	0.35	0.36	0.63
2423	0.91	0.68	0.57	*
2424	0.76	0.61	0.71	0.77
2520	0.92	0.64	0.55	0.57
2695	0.81	0.43	0.55	0.56
2811	0.87	0.57	0.37	0.80
2893	0.88	0.78	0.54	*
2899	0.86	0.59	0.40	*
3610	0.67	0.51	0.22	0.20

*Only one or two production units observed. Industry definition: ISIC Rev.3, 4-digit level.

According to Table 6, industry efficiency generally declined or remained virtually unchanged between 1991 and 1994. Only in three industries (ISIC 1512: Processing and preserving of fish and fish products, 1912: Manufacture of luggage, handbags and the like, saddlery and harness, and 2219: Other publishing) do we find clear evidence of increased efficiency over the period. As was the case when studying productivity change, in every industry there are both ”winners” and ”losers” among the individual producers as regards efficiency change.

Although we did not find any indications of links between productivity growth and export, an interesting question is whether there is any significant difference between the efficiency change of export oriented industries as opposed to non-export industries. Of the three industries with increasing efficiency, a majority of the firms in Industry 1512 export their product, while only one export firm is found in 1912 and none in 2219. Veiderpass (1997) also found that while for some firms the individual efficiency of the export firms appeared to be higher than the efficiency of the non-export firms, the situation was quite the opposite in other industries. There is, however, not sufficient information available to allow any testing to reach a definite conclusion. The same also applies to the issue of potential correlation with firm size.

CONCLUSION

The Nicaraguan manufacturing sector played a dynamic role during the 1960s and 1970s, growing at a higher rate than both overall GDP and exports (see Endnote 1). However, its performance during the initial phase of the structural reforms implemented by the Chamorro administration was lackluster. The main rationale for the implementation of structural reforms favoring free markets is that they, through increased competition, will create incentives to improve firm performance. The full adjustment of firms to changed conditions is, however, a lengthy process and it is too early to write an epitaph, either for the structural reforms or for the manufacturing sector.

The study of the performance of individual firms and industries in periods of structural reform has been a neglected area. Data restrictions are most certainly the cause of the scarcity of this kind of study. This study is an attempt to fill part of that vacuum by measuring total factor productivity and technical efficiency change of individual firms as well as of individual industries of the manufacturing sector, using the most complete microeconomic data set available on Nicaragua. Although data limitations naturally were present, it was nevertheless possible to obtain sufficient information to provide a stable basis for estimations of productivity as well as of efficiency change.

The cross-section analyses suggest that large firms and export firms in general are among the most productive firms of the Nicaraguan manufacturing sector. Although export firms in general seem to have high average productivity, the most productive firms are not found among the firms with the highest export ratio.

When studying the productivity change over time, we find indications of catching up. Firms characterized by high productivity growth usually have relatively low initial productivity. On average, the productivity growth of the firms with high initial productivity levels, i.e. large firms, is generally slower than the growth of firms with lower initial productivity. Thus, the firms with relatively high growth rates are the small firms. Although we identified a few manufacturing industries that may be considered net winners or net losers with regard to productivity growth, the general picture is that within each manufacturing industry there are both winners and losers.

The fact that all industries include winners and losers is also reflected in the study of technical efficiency change. Another fact that is obvious is that the adjustment process is slow. During the four years of study, we find that structural efficiency increased substantially in only three industries. In the rest of the industries efficiency either declined or remained more or less unchanged.

In developed economies, efficiency gains are often acheived by substituting capital for labor. There are several reasons why this is not an appropriate first step in a developing economy like Nicaragua. Using more of the relatively cheaper production factor, labor, is often the most rational choice for a firm. As indicated in this study, the relatively labor intensive firms that export between 60 and 80 percent of their output are the most productive export firms (Table 4). Furthermore, we do not find any indications of a positive relationship between reduced labor demand and productivity growth (Table 5). In addition, capital growth must take place at a rate that is consistent with the rate of growth of human capital.

If the expected positive effects of structural reforms on essential sources of growth, such as total factor productivity and technical efficiency, are slow, it may be necessary to develop complementary microeconomic policy instruments to create sufficient conditions for spurring economic growth in the short run. Borner, Brunetti and Weder (1995) point to the importance of institutional reforms aimed at a better enforcement of property rights. Other examples of microeconomic policies are the facilitation of investment in human capital, the development of different kinds of crucial service markets, the main purpose of which being to provide information, and the enhancement of firm level efficiency and productivity by establishing markets that generally do not exist in developing countries, such as markets for marketing, financial and organizational services. For a more detailed discussion on the topic of short run policy instruments to enhance economic sources of growth, see Tello and Tyler (1997).

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APPENDIX

Estimation of Translog Production Functions. Full Sample and Subsamples by Size of Firm

Variable	All Firms		Large Firms		Small Firms	
	Without Temporal Dummies					
	Coefficient	t-statistic	Coefficient	t-Statistic	Coefficient	t-Statistic
ln L	0.170	0.84	-1.094	-1.43	-0.062	-0.17
ln K	0.304	4.45 ***	1.078	5.30 ***	-0.007	-0.06
ln M	1.074	9.71 ***	0.303	0.90	1.021	6.45 ***
ln L * ln L	0.038	1.67 *	0.143	2.41 **	0.055	1.16
ln K * ln K	0.009	2.68 ***	0.009	1.42	0.014	3.33 ***
ln M * ln M	0.018	2.76 ***	0.030	2.96 ***	0.017	2.01 **
ln L * ln K	0.017	1.38	-0.081	-2.55 **	0.027	1.14
ln L * ln M	-0.055	-2.79 ***	-0.019	-0.53	-0.061	-2.11 **
ln K * ln M	-0.054	-5.96 ***	-0.044	-2.65 ***	-0.037	-3.34 ***
R^2	0.51		0.31		0.69	
R^2	0.51		0.30		0.68	
F	104.4 ***		19.6 ***		120.1 ***	
	With Temporal Dummies					
	Coefficient	t-Statistic	Coefficient	t-Statistic	Coefficient	t-Statistic
ln L	0.163	0.80	-1.190	-1.55	0.044	0.12
ln K	0.311	4.31 ***	1.158	5.60 ***	-0.079	-0.67
ln M	1.115	10.05 ***	0.373	1.10	1.029	6.54 ***
Ln L * ln L	0.042	1.84 *	0.158	2.65 ***	0.039	0.84
Ln K * ln K	0.010	2.78 ***	0.009	1.39	0.015	3.58 ***
Ln M * ln M	0.017	2.71 ***	0.029	2.88 ***	0.017	1.97 **
Ln L * ln K	0.016	1.30	-0.089	-2.79 ***	0.037	1.55
Ln L * ln M	-0.059	-2.98 ***	-0.025	-0.68	-0.060	-2.08 **
Ln K * ln M	-0.054	-6.01 ***	-0.044	-2.67 ***	-0.038	-3.41 ***
D92	-0.095	-2.54 **	-0.061	-1.17	-0.175	-3.01 ***
D93	-0.026	-0.66	0.056	0.88	-0.136	-2.39 **
D94	-0.072	-1.65 *	0.017	0.25	-0.213	-3.52 ***
D95	0.161	1.01	0.301	1.53	0.546	1.35
R^2	0.52		0.32		0.70	
R^2	0.51		0.30		0.69	
F	73.7 ***		14.2 ***		86.5 ***	

* Significant at 10%; ** significant at 5%; *** significant at 1%.

NOTES

[1] Average Annual Growth Rates according to the Central Bank of Nicaragua:

	1960-78	1979-89	1990-96
GDP Net of Exports	4.9	-0.2	-2.2
Manufacturing	8.4	-1.3	1.2
Exports	7.8	-3.2	10.7
GDP	5.6	-0.9	2.2

[2] However, a change in the tariff reduction schedule implemented in 1994 raised the nominal tariffs slightly in some sectors. From 1990 to mid-1994 there were four import duty rates: the DAI (external common tariff), the ITF (fiscal tariff), the IBS (surcharge on luxury goods) and the IEC (specific consumption surcharge). From mid-1994 the last two rates were replaced by the ATP (temporal protection rate) with the main objective of protecting the socalled "fiscal industries" (beverages and tobacco).

[3] An example of a more flexible production function is the trending frontier model proposed by Koop, Osiewalski, and Steel (1995), in which the parameters of the translog production function have linear or quadratic time trends. We decided not to implement such a model because of the short time dimension of our panel.

[4] It is not surprising that the random effects model was rejected. There are reasonable theoretical grounds to believe that total factor productivity is not independent of the observed production inputs. See e.g. Isgut (1996) for further discussion (and an application to Colombia).

[5] We deflated all the nominal variables by the CPI (1994=100). Specification tests rejected the significance of a fourth factor, energy, that we used in our regression analysis. We used two alternative definitions of capital(machinery and equipment and total assets of the firm), but the results were virtually identical irrespective of definition. Additional tests (not reported here) rejected restricting the translog production function to a Cobb-Douglas function.

[6] Due to degrees of freedom limitations, we did not include time dummies in this case.

[7] The notation used for the measures of TFP change corresponds to that used for the TFP indices. For example, ΔTFP1 is the measure of change in TFP1. The only difference is that we combine the measures of TFP change for small and large firms into two single measures: ΔTFPLS1 and ΔTFPLS2. If the firm is large, these measures represent the change in productivity with respect to TFPL1 and TFPL2; if it is small they represent changes in TFPS1 and TFPS2.

[8] An additional break-down of the results is by concentration ratio. We have found that firms that belong to concentrated industries are not necessarily the most productive. In particular, the TFP indices for small firms have roughly the same average values, independent of the degree of concentration.

[9] 7 out of 13 firms reduced their labor in the "high productivity growth" group, 7 out of 12 in the "moderate productivity growth" group and 6 out of 12 in the "negative productivity growth" group.