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**THE EFFECTS OF TRADE
LIBERALIZATION ON
PRODUCTIVE EFFICIENCY:
SOME EVIDENCE FROM THE
ELECTRICAL INDUSTRY IN
CAMEROON**

Ousmanou Njikam

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**The effects of trade liberalization
on productive efficiency: Some
evidence from the electrical
industry in Cameroon**

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List of abbreviations

	BD	Boarding duty
	c.i.f.	Cost insurance freight
11	CET	Common external tariff
	CGE	Computable general equilibrium
	CSNC	Cameroonian Shipper National Council
20	DEA	Data envelopment analysis
	ED	Exit duties
	EFD	Entry fiscal duty
22	EXD	Excise duty
	GPT	Generalized preferential tariff
	GTP	General trade programme
22	IMP	Industrial Master Plan
	IMTOT	Import turnover tax
	INTOT	Internal turnover tax
33	IPT	Internal production tax
	MLE	Maximum likelihood estimates
34	PCR	Phytosanitary control rights
	PSD	Proportional stamp duty
	PST	Proportional surcharge tax
	PT	Packaging tax
	QRs	Quantitative restrictions
	RTS	Returns to scale
	SFA	Stochastic frontier approach
12	STT	Standard time trend
	TC	Technical change
	TMM	Tax on the movement of meat
12	TOT	Turnover tax
	Translog	Transcendental logarithmic
	UDEAC	Union Douanière des Etats de l'Afrique Centrale
13	UNT	Unique tax
	UT	Unloading tax
	VA	Value added
13	VSIT	Veterinary and sanitary inspection tax
	WGR	Warehousing and guard rights
	UT	Unloading tax
	VSIT	Veterinary and sanitary inspection tax
	WGR	Warehousing and guard rights

Abstract

This study assesses the impact of trade liberalization in the Union Douanière des Etats de l'Afrique Centrale (UDEAC) on the productive efficiency of the electrical plants in Cameroon. A comparison of four-year balanced panel data on 29 firms before trade liberalization and five-year unbalanced panel data of 35 firms after trade liberalization shows that the reforms had the expected positive effects on firms' productive efficiency measures. Specifically, the average technical efficiency is 9.1% higher after trade liberalization than before trade liberalization. Post trade liberalization firm-specific technical efficiencies increase on average at the rate of 2.74%, while the pre trade liberalization firm-specific technical efficiencies increase on average at a mild rate of 0.59%. The positive impact of trade liberalization is also indicated in gains of about 4.74% in overall technical progress. These results were obtained by estimating a flexible stochastic production frontier, i.e., a transcendental logarithmic (translog) form, before and after trade liberalization.

1. Introduction

Like many sub-Saharan African (SSA) countries, Cameroon had initial optimism about the industrial sector's potential role in fostering development.¹ In this context, Cameroon pursued various industrial policies after 1960, when it gained its independence.

In the past decade, however, Cameroon's manufacturing sector has experienced a crisis of sorts, characterized by increase in imports, fall in production and decrease in exports. Between 1960 and 1970 imports of manufactured goods continuously increased whereas the objective of the government was to substitute them by local products.² During 1970–1980, manufacturing production fell by 14.04%. Exports of manufactured goods decreased from 8.9% of total exports in 1970/71, 6.9% in 1975/76, 5.6% in 1978/79 and 3.9% in 1979/80 to 1.7% in 1981/82 (World Bank, 1983). Between 1983 and 1992 the proportion of manufactured products in total exports fell from 4.4% to 1% (Karmiloff, 1988).

A number of factors have been advanced to explain the poor performance of Cameroon's manufacturing sector. It is now generally accepted that domestic policy errors have played a significant role. Among the many possible domestic policy mistakes, one of the most notable was the restricted trade policy regime—the design of an import substituting industrialization strategy—pursued since 1960. Also, productive inefficiency is widely regarded as the Achilles' heel of Cameroon manufacturing firms (Njikam, 1995, 1997).

The poor industrial performance, coupled with macroeconomic problems, ushered in the structural adjustment programme (SAP) pursued since 1988. The trade liberalization aspect of structural reforms affects firm performance by placing domestic producers in direct competition with their foreign rivals. The idea that trade reforms are important variables in determining firms' performance is now part of generally accepted wisdom and occupies a central position in the current debates on trade policy. Moreover, it is also now generally accepted that trade liberalization is a major contributor to enhanced productive abilities in many manufacturing sectors in developing countries.³

Unfortunately, there are very few firm-level case studies on the effects of trade liberalization on productive performance, with most of the studies to date relying on multi-country or cross-country data rather than firm-level data.⁴ Hence, policy formulation has been hampered by a lack of rigorous empirical studies at firm level. The economic policy question therefore is what has been the firms' response in terms of productive efficiency to trade reforms. That is, the principal issue we address is whether trade liberalization exerts its influence on productive efficiency by leading to an increase in

firm-level productive performance. In attempting to answer this question, the objective of the paper is to evaluate the effects of trade reform on productive efficiency (viewed in terms of input elasticity, returns to scale, technical change and technical efficiency measures) *before and after* liberalization periods in the Union Douanière des Etats de l'Afrique Centrale (UDEAC) zone, and to compare these firms' pre and post trade liberalization productive efficiency measures.

The paper is organized as follows: Section 2 provides the background to the issues of the study, i.e., the transmission mechanism of competition into efficiency. Section 3 describes the trade policy liberalization in Cameroon, and Section 4 describes the implementation of the trade liberalization in the electrical industry. Section 5 gives an overview (in terms of structure and performance) of the electrical industry before and after liberalization. The model specification is presented in Section 6, while Section 7 provides the data and empirical results analysis, and Section 8 gives the conclusion and policy implications of the findings.

2. Background to the study issue

For different reasons, development economists commonly argue that trade protection brings down the level of industrial sector efficiency. First, in markets characterized by entry barriers, the absence of foreign competition allows local firms to enjoy monopoly power and excess profits. The consequence is that domestic producers usually fail to produce at minimum cost (to achieve *allocative efficiency*) and/or to get maximum possible output from their input bundles (to achieve *technical efficiency*).⁵ Second, in markets characterized by Chamberlinean competition, trade protection usually attracts inefficiently small producers, causing increases in production costs.⁶

Indeed, the lack of competitive pressure generally induces costs to rise above the minimum level, owing to imperfect agency relationships within the firm. Also, resources are wasted through rent-seeking activities undertaken to procure advantages against actual or potential competitors. Last but not least, production capacity is often left idle because of the lack of concern for strict cost accounting.

The exposure to foreign competition has been considered to make an industry relatively free from such symptoms, because the competitive pressure forces firms to try to minimize their costs.⁷ The liberalization of trade is expected to have several advantages for an industry. First, upon exposure to foreign competition, firms' performance can be improved. In fact, the exposure to world competition typically increases the elasticity of demand that domestic producers face. *Ceteris paribus*, this causes firms to lose market power and forces them to move down their average cost curves.⁸ Second, greater exposure of domestic firms to foreign trade activities is viewed as a means not only of generating foreign exchange, but also of learning superior techniques of management and marketing, the infusion of modern technology and know-how through the cooperation of local firms with foreign counterparts. Thus, it is expected that an open trading regime will facilitate the flow of technical information.⁹ Also, openness, coupled with a liberal incentive structure, would inspire greater foreign investment inflow, and hence technology inflow into the economy. As pointed out by Oyejide (1997: 6–7):

... In the context of a more open trade regime, technology can be transferred through at least three distinct sources: as an integral part of foreign investment, through increased trade that embodies current technology and through export competition that induces firms to operate at the frontiers of technological development. Finally, under the liberalized environment, it is expected that foreign competition will reduce the market power that domestic producers may derive from scale economies, a rationed credit market or institutional constraints. Thus, reduction in protection should expand output among these producers and allow better exploitation of scale economies.

In sum, the essential elements of the liberalization package may be summarized as follows: gains are expected from greater trade and freer trade because of allocative improvements (shifting resources to where they can be most productive according to a country's comparative advantage), gains in x-efficiency (because freer trade means more competition, which promotes efficiency), and increased access to productive inputs and information (capital inflow raises the total capital stock and there are greater technological transfers, greater imports of capital goods and greater flow of ideas resulting from greater overall contact). Therefore, trade reform is important as a means of improving the efficiency with which resources are allocated and hence the wastefulness of domestic firms, and encouraging competition. Larger markets can serve as a more viable basis for exploiting economies of scale compared with small and isolated domestic markets. Taken together, these effects result ultimately in raising the level of productive efficiency. Central to these positive effects is, of course, effective trade liberalization.

3. Overview of Cameroon's trade regime

Since independence in 1960, Cameroon has followed mainly two types of trade regime: inward oriented (from 1960 to the eve of the liberalization period) and outward oriented (the liberalization period).

Cameroon's trade regime before liberalization

The inward-oriented trade regime followed before the liberalization period was enshrined in the import substitution policy. This policy used a range of instruments at the import, as well as the export of goods: high custom tariffs, quantitative restrictions (QRs), pure prohibition, etc. Some of these instruments are specific to Cameroon while others are common to UDEAC member states.

Imports were subjected to a common external tariff (CET) and selectively to incidental taxes. The common external tariff consisted of custom duty (CD), the entry fiscal duty (EFD), the import turnover tax (IMTOT) and the complementary tax (CT). The custom duty was ad valorem or specific and could be applied to all goods whatever the origin except in the case of preferential tariffs.¹⁰ The rate of the ad valorem custom duty varied from 5 to 20% according to the value of goods at the border, while the specific custom was established according to the nature, weight, dimension and volume of goods. The entry fiscal duty was ad valorem or specific and was applied to all goods, whatever the country of origin. Its rate was between 15 and 70% of the cost, insurance and freight (c.i.f.) value. The import turnover was equal to 10% of the c.i.f. value plus the custom duty and entry fiscal duty. The import turnover could be null for some first necessity goods, but sometimes reached 72% of the c.i.f. value for some luxury imports. Finally, the rate of the complementary tax varied between 5 and 40% of the c.i.f. value.

In addition to the taxes mentioned above, which were common to all UDEAC member states, Cameroon also applied specific taxes. The unloading tax (UT) was specific and varied according to port. The warehousing and guard rights (WGR) varied according to goods and the number of days spent in Cameroon. Its rate was between 5 and 1,500 CFA francs per day, ton, parcel, etc. The veterinary and sanitary inspection tax (VSIT) had rates that varied from 25 to 250 CFA francs per live animal, and from 1 to 30% of the c.i.f. value for fresh and frozen products. The phytosanitary control right (PCR) amounted to 5 CFA francs per ton. The main export duties were the boarding duty (BD), the municipal tax (MT), the tax on the movement of meats (TMM), the veterinary and sanitary inspection tax, and the packaging tax (PT).

The elements of internal indirect taxation were mainly the internal turnover tax (INTOT), the internal production tax (IPT) and the unique tax (UNT). The internal turnover tax was discriminately applied to both local production and imports. The internal production tax replaced the internal turnover tax, and all other custom duties on imported intermediate goods. Finally, the unique tax was applied to all industrial production for the UDEAC market. In its implementation, the unique tax replaced all the taxes applied to imported raw materials, all other indirect taxes and all other internal taxes.

For the non-tariff instruments, the Ministry of Trade and Industry annually published a document called General Trade Programme (GTP) that defined product categories and levy amounts. At the import level, four types of products were defined: a) "sensitive" products, imported under very restrictive conditions; b) "twinned" products, consisting of authorizing the import of a quantity of a specific goods in proportion to the local purchase of the same good; c) "government-controlled" products, subjected to obtaining an import authorization; and d) "freely imported" products. Finally, in order to attract foreign capital, the investment code consisted of four regimes, A, B, C and D.¹¹ In sum, the Cameroonian trade regime before liberalization was very restrictive and complex, thus the necessity for reforms.

Cameroon's trade regime after liberalization

In the late 1980s the policy debate on the merits of alternative trade regimes became confusing and increasingly ideological. At the centre of the controversies was the inability to clearly define what is meant exactly by trade liberalization. The literature on this subject has not always been successful in dealing with a precise definition of trade liberalization. Hence, the phenomenon of "liberalization episode" means different things to different analysts and its dating is problematic.

In general, trade liberalization can mean one of at least four things: a) a reduction in import barriers with no change in export incentive, i.e., it could refer to a reduction in import protection; b) a movement of relative prices towards neutrality via reduction in import barriers and/or an improvement in export incentive (an increase in support for the export sector); c) the replacement of more costly with less costly instruments of intervention (rationalization of protection), for example the replacement of quantitative restrictions (QRs) by tariffs; and (d) a compensating devaluation of the national currency. With time, however, the definition of liberalization has evolved into a sharper concept, becoming almost synonymous with free trade. Some authors have argued that trade liberalization should not aim at reducing the degree of anti-export bias and generating a neutral trade regime, but should rather strive to produce a liberal trade system where all trade distortions, including import tariffs and export subsidies, are completely eliminated.¹² In practice, policy reforms that embrace some combination of the definitions above are labelled liberalization. The determination of a liberalization episode therefore strongly depends on the adopted definition. In Krueger (1978), trade liberalization is defined as any policy that reduces the degree of anti-export bias. Also, for Papageorgiou et al. (1991), liberalization essentially means reducing anti-export bias. If successful, this policy

should clearly result in a growth of exports. A particularly important aspect of these definitions is that they do not require zero or even very low import tariffs. It is possible according to these definitions to have a liberalized economy with high tariffs. As Krueger (1978: 89) has stated:

Inspection of the definitions of bias and liberalization shows that there is no necessary reason, at least in theory, for a connection between the two. A regime could be liberalized and yet employ high tariffs in order to encourage import substitution. The regime would then be liberalized and highly biased.

Hence, for Edwards (1993), Ajakaiye and Soyibo (1995), and others, trade liberalization should aim at reducing or completely eliminating import tariffs and export subsidies. Once one has settled the different definitions of trade liberalization clearly, it becomes possible to identify the aggregate measures of distortions that have been used in order to identify the extent of liberalization episodes in a particular country.

In Cameroon, the trend towards liberalization began in the late 1980s. The SAP was put in place in July 1988, resulting in a wide range of economic reforms. More specifically, there is a relative relaxation of QRs on imports and exports. For example, in 1989/90 approximately 105 commodities did not require import licences, so they were removed from QRs. Also, there was a simplification of the process of obtaining import as well as export licences and authorizations, and the elimination of the twinning system.¹³ In 1990/91, there were 22 products classified in the free import category; this number increased continuously through 1991. By 1991/92, nearly all QRs had been removed. Price controls and sales in the domestic market had been removed. For example, the prices of sugar cane, palm oil and soap were liberalized. Exit duties (ED) on all commodities except coffee, cocoa and cotton were suspended. To allow firms more flexibility in responding to changing competition, reforming labour markets is vital. Thus, the domestic labour market was deregulated. Despite these efforts to reform the trade regime, this liberalization episode can be characterized as mostly institutional.

Only in 1992/93 did a substantial trade reform in a regional framework, i.e., within the Regional Fiscal Reform Programme in the UDEAC, take place.¹⁴ This reform aimed at reducing the tariff, rationalizing fiscal instruments, allowing easy and transparent administration of the fiscal system, increasing fiscal yield through improved revenue collection, and improving the efficiency and competitiveness of the manufacturing sector within each UDEAC member state. The achievement of these objectives requires a reduction not only in the number of fiscal instruments, but also in the levels of taxes and duties.

In this context, the common external tariff with four columns of the former regime is replaced by a common external tariff having two columns: the custom duty (CD) and the turnover tax (TOT) columns.¹⁵ At the import level the custom duty is defined according to four categories of products: necessity, equipment, intermediate and current consumption goods, with custom duty rates of 5, 10, 20 and 30% of the c.i.f. value, respectively. The turnover tax is applied to imports as well as to local production at three different rates: null rate or exempted products, reduced rate (5%), and normal rate (12.5%).¹⁶ Specifically

for imports, the turnover tax replaces the former import turnover tax and the complementary tax. For local products, the turnover tax replaces the former internal production tax, the unique tax, the internal turnover tax and the proportional stamp duty (PSD). In order to take into account the harmful effects of instituting the reform, an additional protection in the form of temporal surcharge is freely defined in each UDEAC member state, but the rate of this proportional surcharge tax (PST) should not exceed 30% of the c.i.f. value.¹⁷ Also, an excise duty (ED) of 25% of the c.i.f. value is applied to some current consumption goods, mainly imported luxury products or locally produced goods under foreign licence.

At the export level, the different taxes remain unchanged and their application is left to the discretion of each UDEAC member state. In Cameroon, service taxes such as the contribution to Cameroonian Shipper National Council (CSNC) and the Computer Charge (CC) are still applied at the rate of 0.3% and 1.5%, respectively. At the regional level, the unique tax applied to all inter-regional exchanges of products satisfying the rule of origin is replaced by a generalized preferential tariff (GPT), which is a proportion of the custom duty of the common external tariff applicable on the similar products that do not conform to this particular tax system.¹⁸

Having established the nature of trade reform against the time-frame, and since the Regional Fiscal Reform Programme in UDEAC aims at revamping the whole national economy through efficient resource allocation, improving the efficiency and the competitiveness of the manufacturing sector in each member state, we raise the fundamental question: Following these reforms, what level of productive performance can be expected in the Cameroonian manufacturing sector? The answer to this question necessitates an assessment of the impact of trade liberalization in the UDEAC zone on productive efficiency. But before doing that it is necessary to present a description of the analytical framework before and after liberalization.

4. Trade liberalization in the electrical industry

Import substitution and protection of infant industries were the foundation of industrial policy and development strategy in Cameroon until the end of the 1980s. Quantitative controls, reserved market shares and outright import bans were the dominant policy instruments. The so-called "law of similar domestic production" banned the importation of, or imposed prohibitive tariffs on any industrial product competing with domestic production.

The Cameroon electrical industry was characterized by government controls until 1988, when donor conditionalities on adjustment were imposed. Even during the implementation of SAP, the industry still adhered to a range of regulations. These controls reflected the relative importance of this industry in the economic context of Cameroon; the industry is critical to the supply of building materials to public works and the building sector, and to achieving the electrification programme launched by the government. However, the electrical tools industry suffered from severe illegal activities, including smuggling from neighbouring countries, especially Nigeria and to a lesser extent Chad. Hence, high tariff walls and/or very high protection are applied to this industry.

In this context, and in 1985/86, for example, the average tariff rate in the electrical industry was 65.25%, while the nominal rate of protection on electrical tools was 161.68%. The effective rate of protection, which takes into account not only the price of final products but also that of the inputs used in production, was nearly 355.88% (Industrial Master Plan – IMP, 1989), making the electrical industry one of the most closed sectors in Cameroon manufacturing. This wall of high protection sheltering the electrical industry from international competition implies that the gains to be made from trade liberalization are potentially large if they exist. The protective wall also probably had an impact on the performance and structure of the industry.

The trade liberalization process drastically reduced the barriers to trade. The average official tariff rate for the electrical sector dropped to 31.6%. Since liberalization the level of the nominal rate of protection is 22.2%, compared with the pre trade liberalization level of 161.7%. The effective rate of protection fell to 52.8% in 1992/93 and then to 20.6% in 1995/96 (IMP, 1989). It is worth noting that there was also a large decrease in the tariff dispersion.

5. Overview of the electrical industry

This section intends to provide a clear description, in terms of performance and structure, of the analytical framework before and after trade reform. In this respect, the common indicators of performance—, value added, gross output, labour productivity (value added per head, i.e., ratio of total value added to total labour) and export—are presented. The structure of the electrical industry is evaluated through an analysis of employment and total investment (Table 1).

Concerning the pre-liberalization period, the figures in Table 1 show that the electrical industry's value added and gross output each represented 12 to 14% of the total manufacturing value added and gross output. In terms of manufacturing total employment, the electrical industry's employment represented a share of 11–16%, while the electrical industry's share of total investment in the manufacturing sector stood around 7–15%. In terms of external market penetration, the electrical industry's exports represented a share of 11–14% of the total manufactured exports.

As for the post-liberalization period, the figures in Table 1 show the following. The weight of the electrical industry's value added and gross output in total manufacturing was less than that of the pre-liberalization period, with value added amounting to 5–12% while gross output was 10–12% of the total manufacturing. Relative to the pre-liberalization period, the post-liberalization electrical industry's employment declined to around 13% of total manufacturing employment. The post-liberalization investment in the electrical industry represented 5–13% of total manufacturing investment, while electrical exports represented respectable shares of 7–13% of the total manufactured exports.

In terms of evolution, the trends in the pre-liberalization exports and labour productivity are given in Figure 1. In this period export and labour productivity decreased on average at the rate of 16.52% and 2.05%, respectively. The export and labour productivity growth reached their peaks in 1989/90 and 1988/89, respectively, while the slowest export and labour productivity growth occurred, respectively, in 1988/89 and 1990/91.

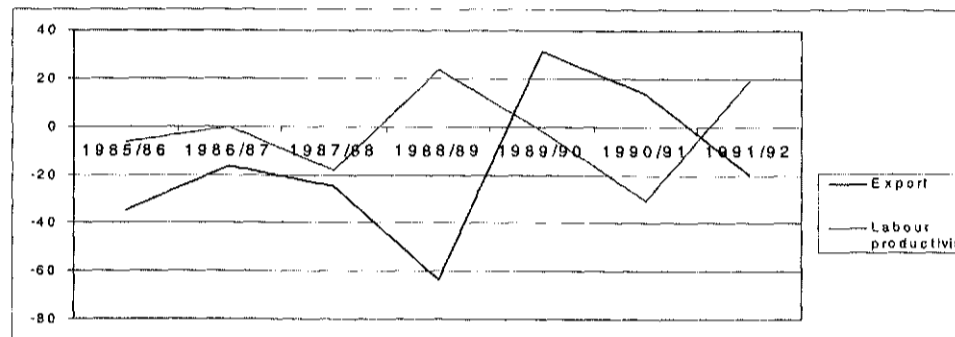
Table 1: Structure and performance of Cameroon's electrical industry before and after trade liberalization

Before trade liberalization					
Variable	1988/89	1989/90	1990/91	1991/92	
Value added*	17,933.00	7,680.00	16,817.00	10,578.00	
Share in total manuf.	13.89%	11.62%	13.55%	12.38%	
Gross output*	49,398.00	23,800.00	47,066.00	36,711.00	
Share in total manuf.	13.82%	11.91%	13.96%	13.22%	
Employment*	9,660.00	3,350.00	7,476.00	6,770.00	
Share in total manuf.	16.32%	12.44%	15.40%	10.50%	
Export*	8,958.00	3,244.00	4,253.00	4,825.00	
Share in total manuf.	13.58%	11.52%	12.64%	13.17%	
Investment*	2,410.00	25,098.00	2,486.00	2,414.00	
Share in total manuf.	6.68%	15.78%	12.64%	8.05%	
Labour productivity	1.8564	2.2925	2.2495	1.5625	
After trade liberalization					
Variable	1992/93	1993/94	1994/95	1995/96	1996/97
Value added*	7,230.00	12,280.00	12,840.00	12,700.00	13,880.00
Share in total manuf.	5.54%	8.51%	12.43%	11.80%	14.43%
Gross output*	21,060.00	22,710.00	21,150.00	21,390.00	23,520.00
Share in total manuf.	11.81%	12.40%	11.22%	10.77%	11.03%
Employment*	3,890.00	4,190.00	4,580.00	4,710.00	4,720.00
Share in total manuf.	12.49%	12.54%	11.79%	12.89%	12.56%
Export*	3,864.00	4,791.00	4,947.00	8,696.00	6,483.00
Share in total manuf.	12.57%	9.78%	8.07%	11.74%	7.34%
Investment*	905.00	1,427.00	413.00	2,162.00	2,024.00
Share in total manuf.	5.09%	13.68%	10.52%	12.72%	12.08%
Labour productivity	1.8586	2.9308	2.8035	2.6964	2.9407

Note: *These quantities are in CFA millions and in constant prices. The deflators used are the Cameroonian manufacturing output price indexes for the value added and gross output, the export price indexes for the exports, and the investment price indexes for investment. Labour productivity is equal to the ratio of the value added to total employment.

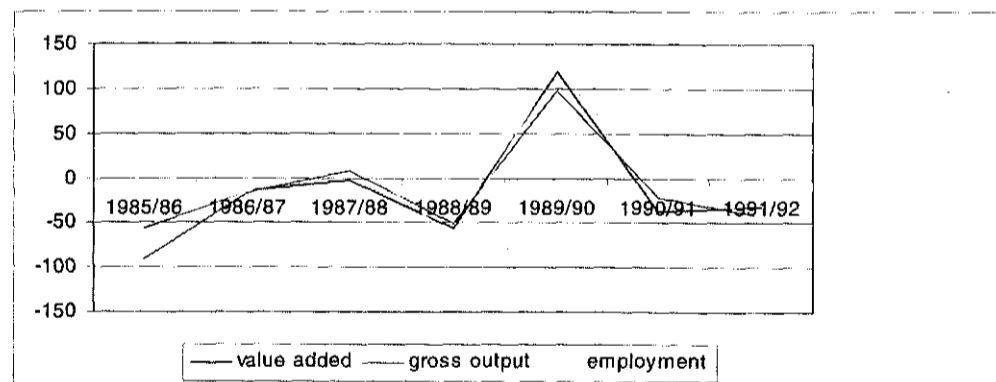
Source: Compiled by author from Industry Annual Survey Data.

Figure 1: Pre trade liberalization export and labour productivity growth in Cameroon'sal



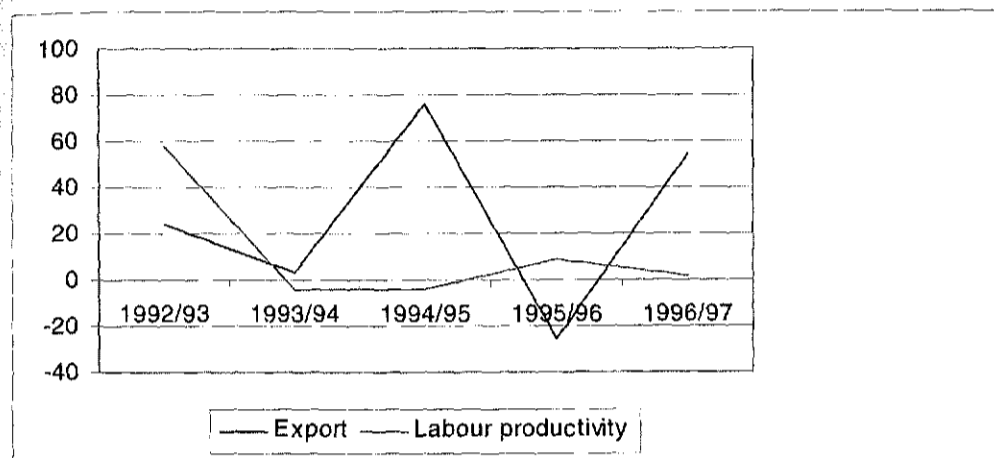
The electrical industry's economic performance before trade liberalization is further illustrated in Figure 2, which presents the growth of value added, gross output and employment. The pre-liberalization patterns of growth in the electrical industry's activity show that the value added, gross output and employment declined on average at the rates of 11.42%, 16.93%, and 6.25%, respectively. The highest losses in value added, gross output and employment occurred in 1988/89, 1985/86 and 1988/89, respectively, while the highest gains in value added, gross output and employment occurred, respectively, in 1989/90.

Figure 2: Pre trade liberalization patterns of growth in Cameroon's electrical industry



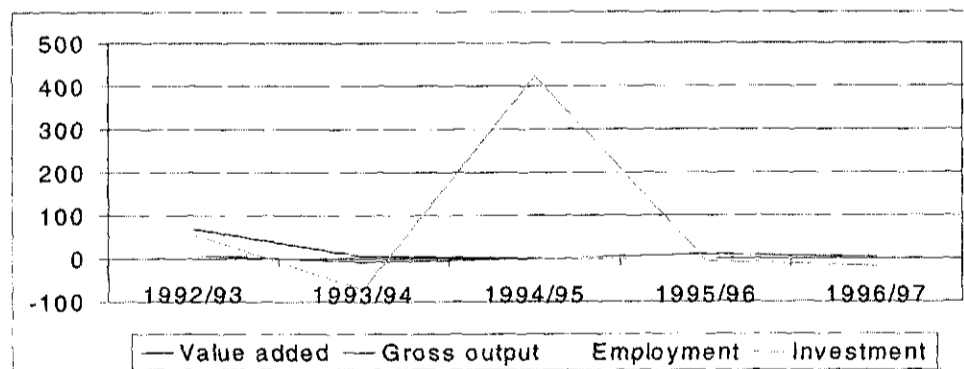
The patterns of export and labour productivity growth in the electrical industry over the post trade liberalization period are illustrated in Figure 3. Exports increased by 26.35% on average over the period, reaching a peak in 1994/95 and their lowest level in 1995/96. The patterns of labour productivity also show an average increase of about 12.02% during the post trade liberalization period. The biggest loss in labour productivity (-4.34%) was registered in 1993/94, while the highest gain (57.69%) occurred in 1992/93.

Figure 3: Post trade liberalization export and labour productivity growth in Cameroon's electrical industry



Other post-liberalization patterns of growth in electrical sector activity are illustrated in Figure 4. The trends show that the electrical industry experienced positive average growth rates of nearly 16.82% in value added, 3.14% in gross output, 11.39% in employment and 77.07% in investment. Given the trends in figures 3 and 4 we can maintain that the exposure of the electrical industry to foreign competition through the liberalization of commercial activities had a favourable impact on its exports—its ability to penetrate foreign markets, labour productivity, value added, gross output, investment and employment.

Figure 4: Post trade liberalization patterns of growth in Cameroon's electrical industry



In sum, the evidence since trade liberalization suggests that the response of labour, export productivity, value added, gross output, employment and investment to the improved environment has been positive. With that background on the effects of changes in trade regime on the structure and performance of the electrical industry, the remaining question is the effects of trade reforms on productive efficiency measures, i.e., on input elasticity, returns to scale, technical change and technical efficiency. This question will be answered in Section 7 on empirical results.

6. Model specification

Inevitably, analysts have had to recognize that in almost all least developed countries (LDCs), trade openness and the subsequent external competition may affect the growth of productivity. However, even though the liberalization paradigm has become dominant, major empirical investigations of the consequences of liberalization for economic performance are based at the macroeconomic level.¹⁹ Although the multi-country or cross-country investigations have unearthed significant information on trade practices and performance in a score of countries, none of these studies investigated empirically and in detail how trade liberalization specifically affects productive efficiency, and in particular manufacturing sectors.

At the sector level the empirical evidence supporting the previous claims is ambiguous. Chen and Tang (1987), on Taiwan's electronics industry, compare the level of technical efficiency (as measured by distance from an estimated production frontier) in two groups of firms; one comprising firms that are constrained to export all their output, and one including firms that are allowed to service the protected domestic market. They find that the former group exhibits a higher level of technical efficiency than the latter.²⁰ But as Rodrick (1988b: 142) notes: "There is practically no direct evidence on the importance of scale economies in specific industrial sectors of developing countries". And Pack (1988: 353) observes: "To date there is no clear confirmation of the hypothesis that countries with an external orientation benefit from greater growth in productive efficiency in the component sectors of manufacturing". Bhagwati (1988: 55), in his study, concludes that although the arguments for success of the export promotion strategy based on economies of scale and x-efficiency are plausible, empirical support for them is not available.

Finally, Tybout et al. (1991: 243) analyse the changes in industrial sector performance that accompanied Chile's drastic trade liberalization of the 1970s. The results reveal little productivity improvement. However, the adverse macroeconomic conditions have masked the positive effects of trade reforms, and they conclude:

Industries undergoing relatively large reductions in protection experienced relatively large improvement in average technical efficiency levels, and relatively large reductions in cross-efficiency dispersion.

The lack of clear evidence of the impact of trade reforms on productive efficiency is not accidental. The lack of sufficient data for appropriate sectors at the appropriate times is an important shortcoming of the previous studies. Moreover, these studies don't evaluate

firms' productive efficiency measures, and cannot therefore compare pre- and post-liberalization levels of productive efficiency. As mentioned by Collier et al. (1997: 349–50):

There are three ways of evaluating the impact of liberalization on economic performance: 1) CGE modeling, it has the virtue of allowing systematic evaluation of alternative scenarios, 2) cross-section analysis, it involves comparing the experience of countries that have undergone liberalization with those that have not and 3) time-series analysis; depending upon the availability of data this is potentially the most fruitful; this is essentially a “before and after” methodology, that is it tracks the series concerned up to liberalization and after liberalization

The last approach is used in our analysis. In recent years the use of frontier models has become increasingly widespread for a variety of reasons. First, the notion of a frontier is consistent with the underlying economic theory of optimizing behaviour. Second, deviations from a frontier have a natural interpretation as a measure of the efficiency with which production units pursue their behavioural objectives.²¹ Since the pioneer work of Farrell (1957), there have been several approaches in frontier production estimation: deterministic as well as stochastic.²²

In the data envelopment analysis (DEA) no restrictive assumptions about technology have to be made, except about convexity. Although the main attraction of the DEA approach is its potential for handling multiple input/multiple output technologies, its main shortcoming is that the efficiency of a micro unit is measured relative to the efficiency of all micro units. The stochastic frontier approach (SFA), also called “composed error”, model of Aigner et al. (1977) and Meeusen and van den Broeck (1977) takes into account the possibility that a firm's performance may be affected by factors entirely outside its control (poor machine performance, bad weather, input supply breakdown, luck, etc.) as well as factors under its control (inefficiency).²³ Hence, the asymmetric component of the error term permits random variation of the frontier across firms, while a one-sided component captures the effects of inefficiency. There exist three categories of the SFA: The first is the regular panel data model with time-varying technical (in)efficiency.²⁴ The second is an extension of the first; it introduces some plant and production characteristics as variables, i.e., type of production process, fuel type, region, locations, etc.²⁵ The idea is to use these variables as controls instead of regular inputs. Finally, in the third category, technical (in)efficiency is explained by variables other than the regular inputs (see Reifschneider and Rodney, 1991). Given the purpose of our study, the first category is chosen.

To avoid strong a priori restrictions on the technology, a flexible functional form, i.e., translog, is adopted. As a form of benchmark model for technical change I apply the standard time trend (STT) model (Cotfas, 1997). If variables are in logarithmic form, the production technology of Cameroonian electrical plants can be represented by:

$$\ln y_{it} = \alpha_0 + \sum_{j=1}^6 \alpha_j \ln x_{jit} + \alpha_7 t + 1/2 \left(\sum_j \sum_k \beta_{jk} \ln x_{jit} \ln x_{kit} + \alpha_8 t^2 \right) + \sum_k \beta_{jk} \ln x_{jit} t - u + v \quad (1)$$

where y and x_j ($j = 1, \dots, n$) are the respective output and inputs measured in logarithms,

α and β are unknown parameters, t is the time trend representing the rate of technical change or shift in the production function over time, u is a firm-specific technical efficiency variable that follows a half-normal distribution, and v is a disturbance term that follows a full normal distribution.

Since the estimated coefficients of the translog production function¹²⁶ do not convey any economic interpretation, the elasticities of output with respect to inputs are calculated as follows:

$$\eta_j = \frac{\partial y}{\partial x_j} \cdot \frac{x_j}{y} = \frac{\partial \ln y}{\partial \ln x_j} = \alpha_j + \sum_k \beta_{jk} \ln x_{it} + \beta_{jt} t \quad (2)$$

with $j = L_1, L_2, L_3, K, M$ and E , where L_1 stands for foreigners and senior executives, L_2 for middle executive, L_3 for workers and unskilled workers, K for capital, M for materials, and E for energy. The input elasticities vary over time and across plants. Returns to scale (RTS), i.e., the elasticity of scale, is evaluated from the sum of the input elasticities as $RTS = \sum \eta_j$, where η_j is defined as in Equation 2. Technical change (TC) is specified as follows:

$$TC = \frac{\partial y}{\partial t} = \alpha_t + \alpha_{tt} t + \sum_j \beta_{jt} \ln x_{jt} \quad (3)$$

In Equation 3, TC consists of two parts: the pure TC component $\alpha_t + \alpha_{tt} t$, which is invariant across plants, and the non-neutral component $\sum_j \beta_{jt} \ln x_{jt}$, which varies across plants and over time.

Before attempting to estimate firm-specific technical efficiency, there are two alternative possibilities to consider. The first is that technical (in)efficiency changes over time, which means that $u_{1t} \neq u_{2t} \neq u_{3t} \dots \neq u_{nt}$. The second is that technical (in)efficiency does not change over time, which implies that $u_{1t} = u_{2t} = u_{3t} = \dots = u_{nt} = u_t$. This study assumes the first possibility. A flexible specification showing that technical efficiency is changing over time is defined as follows:²⁷

$$u_t = \theta_0 + \theta_1 t + \theta_2 t^2 \quad (4)$$

In order to take into account the assumption of time-variant, firm-specific (in)efficiencies, Equation 4 is estimated simultaneously with Equation 1. Individual firm-specific measures of technical efficiency are more important from a policy viewpoint. Also, such disaggregated measures facilitate straightforward comparison of firm-specific technical efficiencies over time, and across observations.²⁸ Measurements of technical efficiency for individual observations are derived from the conditional distribution of u_t given ε_{it} .²⁹ Hence a conditional measure of firm-specific technical efficiency is as follows:

$$E[\exp(u_i)|\varepsilon_i] = - \left[\sigma \frac{f\left(\frac{\varepsilon_i \lambda}{\sigma}\right)}{1 - F\left(\frac{\varepsilon_i \lambda}{\sigma}\right)} - \frac{\varepsilon_i \lambda}{\sigma} \right] \quad (5)$$

where $\sigma^2 = \sigma_u^2 \sigma_v^2 / T \sigma^2$, $\sigma^2 = \sigma_v^2 / T + \sigma_u^2$, $\lambda = \sigma_v^2 / T \sigma_u^2$ and $f(\cdot)$ and $F(\cdot)$ are density, and distribution functions of $N(0,1)$, respectively. From Equation 5, firm-specific technical efficiency, $\exp(u)$, can be readily calculated.

7. Data and empirical results

This paper uses two sets of panel data (in the sense that the same firms are observed from different periods) to evaluate the impact of the UDEAC trade reform on the productive efficiency of Cameroonian electrical plants. The first set of panel data (pre-liberalization panel data) covers the period before trade liberalization (1988/89–1991/92), while the second panel data (post-liberalization panel data) cover the period immediately after trade liberalization (1992/93–1996/97). The data hence enable us to assess whether the trade policies pursued since 1993 have been firmly grounded in the empirical reality. In this context, we test two hypotheses, that firms' productive efficiency measures (input elasticities, returns to scale, technical change and technical efficiency) change across firms and over time, and that trade liberalization improves firms' productive efficiency. Since the analysis is based on firms producing the same products, the homogeneity assumption for production conditions is valid.

Data sources and definition

The data came from the Fiscal and Statistical Declarations forms of firms available at the Department of Statistics and National Accounts. The data are defined as follows: output is the observed production of electrical tools per year, measured in volume, while the deflator used is the industrial price index.

Labour is the total amount of permanent workers per year, grouped into three categories according to the level of skill (L_1 is the total amount of foreigners and senior executives per year, L_2 is the total amount of middle executives per year, and L_3 is the total amount of workers and unskilled workers per year).

The capital variable is obtained from the balance sheet of the different plants and covers machinery and equipment. Following Ahluwalia (1991) and Harrison (1994), the gross capital stock estimates at constant prices for this study are derived using the perpetual inventory method. This requires data on a) the gross capital stock for a benchmark year and b) the gross investment for all the years. Fortunately, data on gross investment at current price are available for each year and for each firm. Thus, the real capital stock in period t is defined as follows: $K_{it} = (1 - d)K_{it-1} + I_t$. As a benchmark we used 1985/86 capital stock for each firm and then added real investment while accounting for depreciation. Real investment and real capital stock are computed by deflating capital stock and investment at current prices by the wholesale price index for machinery and

machine tools.

Raw material is not proportional to output, and is therefore included in the analysis; it is measured in volume and the deflator used is the price index of raw materials in the industrial sector.

The total value in CFA francs of energy used per year is in constant prices (using the price index of energy as deflator); it is an aggregate of the plant level consumption of fuel, water and electricity. The summary statistics of data before and after trade reforms are given in Appendix Table A1.

Empirical results

The application of the translog functional form to the production structure of the electrical industry was tested using the likelihood ratio test. The negative of twice the logarithm of the likelihood ratio has approximately χ^2 distribution with degrees of freedom equal to the number of restrictions. In the "before trade reform" period, the statistic works out to be 13.9583, whereas after trade liberalization period it is 18.9192, both of which are well above the critical values of 12.879 at the 1% level. Therefore, the pre- and post-liberalization data are well supported by the translog functional form.

The pre- and post-liberalization maximum likelihood estimates (MLE) of Equation 1 are given in Appendix Table A2. The variance ratio (γ) estimates before and after trade liberalization are, respectively, 0.5779 and 0.7275 and are significant at the 1% level. This implies that before and after trade liberalization firm-level technical efficiency, rather than random factors such as bad weather, luck, machine breakdown, etc., is responsible for 57.8% and 72.8%, respectively, of the difference between the firms' potential and actual outputs.

The maximum likelihood estimates (MLE) in Appendix Table A2 do not convey any direct economic interpretation. In this context, the output elasticities with respect to foreigners and senior executives, middle executives, workers and unskilled workers, capital, and material and energy inputs are derived from these estimates using Equation 2. The calculated elasticity measures before and after trade reform periods are presented in Table 2.

Table 2: Production elasticities in Cameroon's electrical industry before and after trade liberalization

Inputs	Before trade liberalization Elasticity	After trade liberalization Elasticity
Foreigners/Senior executives	-0.2010	0.1805
Middle executives	0.0845	0.8915
Workers/Unskilled workers	0.1516	0.5255
Capital	-0.3652	0.4477
Materials	0.8957	0.1187
Energy	0.0417	0.0149
Returns to scale (RTS)	0.6073	2.1788

The differences between the pre- and post-liberalization elasticities in Table 2 are probably due to the changing environment characterized by more constraints in terms of competition and more care about the cost of inputs. Before trade liberalization in the UDEAC zone the output elasticities with respect to foreigners and senior executives, and capital inputs have negative signs. This implies that over the pre-liberalization period, it was impossible to increase the level of output by increasing the application of these inputs. If, for example, foreigners and senior executives were increased by 10%, *ceteris paribus*, output could be decreased by about 2.01%. Also, the output response resulting from an increase in capital seems to be in accord with that of foreigners and senior executives; i.e., if, for example, the capital stock were increased by 10% holding constant all the other factors of production, output could be decreased by about 3.66%. However, the output elasticities with respect to middle executives, workers and unskilled workers, materials, and energy inputs have positive signs. This means that before the trade reforms it was possible to increase output by increasing the application of these inputs. For example, if materials were increased by 10%, holding all the other inputs constant, output could be increased by nearly 8.96%. Since these input elasticities vary over both time and plants, returns to scale (RTS), i.e., the elasticity of scale, are calculated to be 0.6073, which means that decreasing returns to scale prevailed in the Cameroon electrical industry before trade liberalization.

After trade liberalization and in terms of sign, the output elasticities with respect to all inputs are positive. Therefore, it is possible to increase output by increasing the application of these inputs. For example, if workers and unskilled workers, and capital, are increased by 10%, holding all the other inputs constant, output can be increased by about 5.26% and 4.48%, respectively. The returns to scale (RTS) are far above 1, suggesting that the Cameroon electrical industry has been using a technology with fairly large increasing returns to scale. Thus, after trade liberalization the average Cameroon electrical plant is of suboptimal size.

The overall rate of technical change (TC) is obtained as the logarithmic derivative of the production function with respect to time (see Equation 3). Over the pre-liberalization period the overall rate of TC is -53.45%. This overall TC is decomposed into effects due

to pure TC ($\alpha_t + \alpha_{tt}$) and effects due to non-neutral TC ($\sum_j \beta_{jt} \ln x_{jt}$). This decomposition reveals for the standard time trend (STT) model a pure component (-47.06%) neutralized by a correspondingly non-neutral component (-15.95%). After trade liberalization, the overall rate of TC is +25.12%. According to its effect on relative input utilization, the overall rate of TC is further decomposed into effect on the pure TC, and effects owing to non-neutral TC. Decomposition into pure and non-neutral components reveals a pure component (-4.74%) neutralized by a corresponding very low non-neutral component (-0.0714%). Over time both components are fairly changeable. All these results are summarized in Table 3.

Table 3: Variation in overall technical change and its components in Cameroon's electrical industry before and after trade liberalization

	Before trade liberalization	After trade liberalization
Overall TC	-47.06%	-4.74%
Pure TC ($\alpha_t + \alpha_{it} * t$)	-47.06%	-4.74%
Non-neutral TC ($\sum \beta_{jt} \ln x_{jt}$)	-15.95%	-0.0714%

One of the most important questions for the present study is whether it is possible to increase the output without having to increase the levels of any input, i.e., by improving the application of technology, and moving closer to the frontier. In this context, the estimated firm-specific technical efficiency measures for individual observations before and after trade liberalization are presented in Table 4.

Table 4: Summary statistics of firm-specific technical efficiency (%) in Cameroon's electrical industry before and after trade liberalization

Period	Mean	Standard deviation	Coefficient of variation	Minimum	Maximum	No. Obs.
Before trade liberalization	74.06	11.76	0.1588	26.27	92.87	116
After trade liberalization	83.12	6.82	0.0821	61.04	93.24	172

From Table 4 the pre and post trade liberalization average technical efficiencies of 74.06% and 83.12% imply that nearly 25.94% and 16.88% of technical potentialities of the electrical industry were not achieved before or after trade liberalization. The post-liberalization coefficient of variation is less than that of the pre-liberalization period, meaning that after trade liberalization the levels of firm-specific technical efficiencies were less dispersed than the pre-liberalization levels. In terms of growth, the pre-liberalization firm-specific technical efficiencies increased on average at a mild rate of 0.59%, while post trade liberalization they increased on average at the remarkable rate of 4.72%.

By applying a parametric test, we tested the hypothesis that the pre- and post-liberalization average technical efficiencies of the electrical industry were equal. If we assumed that the null hypothesis was true, and since the samples are rather large, the difference of average technical efficiency of both periods follows a normal distribution,

$$N(0; \sqrt{\sigma_1^2/n_1 + \sigma_2^2/n_2}),$$

where σ_1 and σ_2 are the standard deviations of the random variable "technical efficiency" before and after the trade liberalization period, respectively. The estimations gave $S_1 = 11.76$ and $S_2 = 6.82$. Hence, the standard deviation of the difference between both average technical efficiencies is 1.2094. Since in our study the difference between the average technical efficiencies before and after trade liberalization is 9.06%, the

absolute value of the t statistic given by $|t| = |ate_1 - ate_2| / \sqrt{\sigma_1^2/n_1 + \sigma_2^2/n_2}$ is 7.4913.

At the 1% level this value is higher than the critical value of 2.576. Thus we have reason to reject the null hypothesis of equal pre- and post-liberalization levels of the average technical efficiency. In other words, the post-liberalization level of the average technical efficiency was significantly higher than that of the pre-liberalization.

Using a non-parametric test, on the other hand, we investigated a much stronger hypothesis that not only the average technical efficiency, but also the distribution of firms according to their scores of technical efficiency, is identical before and after trade liberalization. Thus, on the basis of the test of difference between two distributions, the difference in the frequency distributions of firm-specific technical efficiencies before and after trade liberalization is significant. In fact, if $F_B(x)$ and $F_A(x)$ stand for the empirical cumulative frequency distributions of individual technical efficiencies before and after trade liberalization, respectively, the statistic $D = |F_B(x) - F_A(x)|$ is equal to 1.4415. This value is higher than the critical value of 0.984 on the Kolmogorov-Smirnov λ 2-distribution table³⁰ at the 5% level of significance. Therefore, the non-parametric test led to the rejection of the null hypothesis. This result means that in the Cameroon electrical industry, post-liberalization firm-specific technical efficiencies were significantly higher than the pre-trade liberalization levels. Therefore, the trade liberalization moved the producers from inefficient positions towards potential technical efficiency gains.

8. Conclusion and policy implications

This paper provides micro evidence on the relationship between trade reform and the productive efficiency of the electrical industry in Cameroon. By estimating two stochastic frontier production functions, one before the trade liberalization period, and the other after the trade liberalization period the study derived “before and after” trade reform measures of productive efficiency (input elasticities, returns to scale, technical change and technical efficiency). The comparison of the before and after trade liberalization measures of productive performance such as technical progress and technical efficiency indicates that trade liberalization had a positive effect on the firms’ performance. Indeed, the study found gains of about +9.1% in average technical efficiency and 147% gains in overall technical progress following trade liberalization. The differences in firm-specific technical efficiencies over both periods were statistically significant. Before trade liberalization the firm-specific technical efficiencies increased on average at the rate of 0.59%, while after trade liberalization they increased on average at the rate of 4.72%. We therefore agree with many authors that trade liberalization positively affects firms’ productive performance.

These conclusions are consistent with our expectations, but it is important to emphasize the policy implications of the results. Our efficiency frontier study using firm-level data clearly found strong evidence of a positive effect of trade policy liberalization on productive efficiency. Hence, the sustainability of efficiency gains in the electrical industry will very much depend on further institutional and policy reforms at the trade front. More specifically, trade liberalization should be credibly implemented. Generally, the supply response is influenced by the perception that the reforms will last; expectations of failure and reversal become self-fulfilling prophecies.

Further extensions of this research are desirable. The attention has been focused on the electrical industry, and this constitutes a limit since it gives a partial view of the effects of trade reforms on productive efficiency. A study carried out at the level of the whole Cameroonian manufacturing sector will give more insights on the expected positive benefits of trade reforms, and could serve as an important tool to support trade policy reforms in the UDEAC zone. Also, while the different measures of productive efficiency are very useful for industrial policy, the firm-specific technical efficiencies are aggregate measures, and so they are incapable of identifying (in)efficiency of individual input. As pointed out by Kopp (1981: 491):

In a sense, these measures threaten the contribution of each factor to productive efficiency equally and thereby mask any differences in efficiency that might be attributed to particular factor inputs. For example, the parsimonious use of fuel and excessive use of capital can yield the same technical efficiency as the reverse pattern of factor use.

In this context, it becomes necessary to evaluate each input's efficiency score.

Notes

1. This initial attraction of manufacturing lay in a combination of perceived favourable characteristics: a chance to realize high (labour) productivity, and its continued growth via the systematic application of science, a perception that the international price of industrial goods would secularly increase relative to that of primary products, and the externalities generated in the form of skill accumulation and technology acquisition that would follow to other sectors as a result of labour mobility. See Pack (1988) for more developments.
2. According to Samen (1990), Cameroon was the second most open economy of the CFA Zone in terms of imports during the 1960 decade.
3. Some researchers have argued that Southeast Asian countries owe their economic success partly to the outward orientation of the manufacturing industries, while the inward-oriented strategy is partly responsible for the poor performance of the manufacturing sector in Africa. See Edwards (1993) and Shafaeddin (1995), among others.
4. To this end Pack (1988: 372) writes: "... Moreover, the firm-level data collected for estimation of production frontier are quite reliable and confirm the pattern established at more aggregated levels".
5. For a compact review of literature linking trade and technical efficiency in least developed countries (LDCs), see Rodrick (1988a), among others.
6. For more details see Robert and Tybout (1990).
7. Lower cost at any given output level likely results in higher efficiency. It also makes the rules of the game much less ad hoc, allowing less room for rent-seeking activities.
8. These salutary effects of trade exposure are widely held to apply. See Tybout and Westbrook (1995), among others, for more developments.
9. It is likely that trade liberalization, combined with explicit efforts to improve technological capacity could result in a competitive industrial sector. Indeed, such

a view is the basis for structural adjustment loans by the World Bank and other international aid agencies.

10. For example, goods coming from one UDEAC member state were duty-free, but were subjected to a flat complementary tax.
11. For a compact description and advantages of each regime, see Samen (1990), among others.
12. See, among others, Edwards (1993), Greenaway (1993), Greenaway and Sapsford (1994), and Shafaeddin (1995).
13. The system of twinning imported and local products consisted of authorizing the importation of a quantity of a specific product in a proportion equal to the local purchase of the same product.
14. These measures of trade reform were implemented gradually. But at the beginning of the budgetary year 1993/94, all the reform measures were totally implemented.
15. The "custom duty" column merges with the former regime columns of "custom duty" and "entry fiscal duty", while the turnover tax merges with internal turnover tax.
16. However, the 1994/95 Cameroon financial law fixes the levels of the turnover tax at 5% (reduced rate) and 15% (normal rate). When communal additional centimes are applied to local production but not to custom operations, 10% majoration of the basic rate brings these rates to 5.5% and 17.5% for the reduced and normal rates, respectively.
17. However, this measure of fiscal reform remains unapplied until now.
18. According to the text of the Regional Fiscal Reform Programme in UDEAC, and in order to allow free movement of products subjected to this tax, this proportion was supposed to stand at 10% in 1997 and 0% in 1998.
19. In this context, modern empirical works on trade policy and growth can be classified into two broad distinct categories: (a) large-scale multi-country studies that have investigated in detail the experience of a group of countries with trade policy reform, and (b) econometric studies that have investigated, on broad cross-country data, the relationship between the pace of exports expansion and aggregate economic growth. By analysing the impact of trade policy, and/or openness on economic growth using either of the two methods, the majority of authors have concluded that more open or liberal regimes achieve higher rates of economic

growth. In this connection see, among others, Dollar (1992), Greenaway (1993, 1994), Greenaway and Sapsford (1994), and Sachs and Warner (1995).

21. See Hjalmarsson and Forsund (1993), Kumbhakar and Hjalmarsson (1995), and Hjalmarsson and Odeck (1996), among others, for more developments.
22. See, for surveys, Forsund et al. (1980), Bauer (1990), Lovell (1993), Greene (1993), and Hjalmarsson et al. (1996), among others.
23. One of the main attractions of the SFA model is the possibility it offers for a richer specification, particularly in the case of panel data. It also allows for, among other things, a formal statistical testing of hypotheses and the construction of confidence intervals.
24. See Battese and Coelli (1992) and Hjalmarsson et al. (1996) among others.
25. Hjalmarsson et al. (1996).
26. This production function will be estimated by the maximum likelihood method using Coelli (1994), 4.1 Frontier Software.
27. See, among others, Battese and Coelli (1988, 1992), Cornwell et al. (1990), Bauer (1990), Defourny et al. (1992), and Greene (1993).
28. See Pitt and Lee (1981), Bagi and Huang (1983), Huang and Bagi (1984), and Battese and Coelli (1988, 1992), among others.
29. See Jondrow et al. (1982), Huang and Bagi (1984), Kalirajan and Shand (1989), Cornwell et al. (1990), and Battese and Coelli (1992), among others.
30. For explanation of the test, see Huang and Bagi (1984), among others.

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Appendix

Table A1: Summary statistics of Cameroon's electrical plants before and after trade liberalization

Variables	Mean	Std. Dev.	Min.	Max.
Before trade liberalization, 1988/89–1991/92'				
Output	667.81	678.99	41.30	3896.00
Foreigners and senior executives	10.00	12.00	1.00	56.000
Middle executive	8.00	10.00	1.00	53.000
Workers and unskilled workers	149.00	514.00	4.00	5163.00
Capital	808.55	908.55	18.60	4338.00
Intermediate consumption	492.01	675.21	12.60	3878.00
Energy	23.58	25.63	1.90	111.20
Number of years observed (T)	2.500	1.12	1.00	4.00
After trade liberalization, 1992/93–1996/97''				
Output	450.16	644.49	10.2	3480.00
Foreigners and senior executives	8.00	11.00	1.00	53.00
Middle executive	8.00	9.00	1.00	47.00
Workers and unskilled workers	55.00	84.00	3.00	411.00
Capital	554.44	746.42	3.50	4691.00
Intermediate consumption	335.85	480.81	3.00	3158.00
Energy	15.40	21.35	1.00	117.10
Number of years observed (T)	3.03	1.42	1.00	5.00

As summary statistics in Table A1 indicate, the "before and after" trade reform samples display substantial variance in all the variables. Before the trade liberalization, the mean statistics show that the average firms produces a volume of 668 electrical products, and consists of relatively large firms that average 10 foreigners and engineers, 8 middle executives, and 149 workers and unskilled workers. Also the average firm consumes a volume of 492 intermediate inputs, and an average quantity of energy of 24. Moreover the average plant uses a quantity of capital of about 809. After the trade liberalization, the mean statistics show that the average firms now produces a volume of 450 electrical products and consists of relatively small firms that average 8 foreigners and engineers, 8 middle executives, and 55 workers and unskilled workers. Also, the average firm consumes a quantity of 336 intermediate inputs, an average amount of energy of 15 and an average quantity of capital of about 554.

Tables A2: MLE of the translog production function in Cameroon's electrical industry before and after trade liberalization

Variables	Parameters	Before trade liberalization		After trade liberalization	
		Coef.	T-value	Coef.	T-value
Constant	α_0	1.7161	2.393	5.0616	4.7600
$\ln L_1$	α_1	-0.2010	2.627	-0.3851	2.4671
$\ln L_2$	α_2	0.0845	3.242	0.4214	3.9961
$\ln L_3$	α_3	0.1516	3.0052	-0.0154	2.0171
$\ln K$	α_4	-0.3652	1.9181	0.0733	3.1688
$\ln M$	α_5	0.8957	2.353	-0.6864	2.9271
$\ln E$	α_6	0.4171	2.203	0.3669	2.4833
t	α_t	-0.4800	1.778	-0.0441	2.2331
$(\ln L_1)^2$	β_{11}	-0.1279	1.462	0.0262	1.1777
$(\ln L_2)^2$	β_{22}	0.0948	1.126	0.1710	1.7499
$(\ln L_3)^2$	β_{33}	-0.0035	2.158	-0.1839	1.9366
$(\ln K)^2$	β_{44}	0.0918	1.313	-0.0377	3.5911
$(\ln M)^2$	β_{55}	0.0612	1.111	0.0605	1.5266
$(\ln E)^2$	β_{66}	0.0288	2.221	0.1753	2.6788
t^2	α_{tt}	0.0677	2.589	-0.0026	2.0881
$\ln L_1 * \ln L_2$	β_{12}	-0.1154	4.9501	0.2511	1.2444
$\ln L_1 * \ln L_3$	β_{13}	0.0384	2.5941	0.1128	0.7772
$\ln L_1 * \ln K$	β_{14}	0.0643	2.4951	-0.0846	0.6707
$\ln L_1 * \ln M$	β_{15}	-0.0206	0.1882	0.0708	0.4874
$\ln L_1 * \ln E$	β_{16}	0.1717	1.0044	-0.1334	1.5161
$\ln L_1 * t$	β_{1t}	-0.0232	0.2959	-0.0079	0.1077
$\ln L_2 * \ln L_3$	β_{23}	0.0621	0.9222	-0.2086	1.0999
$\ln L_2 * \ln K$	β_{24}	-0.0103	2.0941	-0.1477	1.5522

Tables A2 Cont:

Variables	Parameters	Before trade liberalization		After trade liberalization	
		Coef.	T-value	Coef.	T-value
$\ln L_2 * \ln M$	β_{25}	-0.0285	2.3061	0.1393	1.3588
$\ln L_2 * \ln E$	β_{26}	-0.0574	1.3631	-0.2409	1.0211
$\ln L_2 * t$	β_{2t}	-0.0094	4.1313	-0.6473	1.0199
$\ln L_3 * \ln K$	β_{34}	-0.0174	2.2062	0.1461	0.0822
$\ln L_3 * \ln M$	β_{35}	-0.0195	2.2161	0.2179	1.4188
$\ln L_3 * \ln E$	β_{36}	-0.0129	1.1244	0.0924	2.3177
$\ln L_3 * t$	β_{3t}	-0.0154	2.3000	0.0647	3.9788
$\ln K * \ln M$	β_{45}	-0.0954	2.8233	0.0849	2.6411
$\ln K * \ln E$	β_{46}	-0.0992	1.6046	0.1127	2.6898
$\ln K * t$	β_{4t}	0.0215	2.217	0.0149	3.3188
$\ln M * \ln E$	β_{56}	-0.1021	0.9041	-0.3078	1.5922
$\ln M * t$	β_{5t}	0.0283	2.3277	-0.0467	0.9554
$\ln E * t$	β_{6t}	-0.0126	2.1777	0.0109	2.0933
Variance ratio $\gamma = \sigma_u^2 / \sigma^2$		0.5779	3.7781	0.7275	4.4444
Total variance σ^2		0.5611	8.5554	0.8321	9.0045
Log-likelihood function		-108.514	/	-111.6861	/

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