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Technical Efficiency measurement
within the Ivorian Manufacturing Sector:
a Data Envelopment Analysis Approach

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Abstract

The African industrial structure is characterised by a strong firm-size heterogeneity with a co-existence of small if not micro-enterprises of the informal sector and large formal organisations operating with a modern technology. In this paper, we investigate the technical efficiency of Ivorian manufacturing firms in four sectors of economic activity: textile and garment, metal products, wood and furniture, food processing. The DEA production frontier is the non-parametric methodology to which we refer to.

Efficiency scores are calculated by following the *four-stage procedure* as presented by Fried, Schmidt and Yaisawarng (1999). In other words, the initial DEA scores are adjusted to take into account the impact of the external operating environment on the volume of the input use. Technical efficiency are then decomposed into three elements: the pure managerial effect, the impact of the production scale, but also a technological effect capturing the potential gain that could result from the adoption of the modern technology by small informal firms.

Key words: Technical efficiency, Côte d'Ivoire, non parametric frontier, manufacturing sector, formal-informal sectors

Résumé

La structure industrielle africaine est caractérisée par une importante hétérogénéité avec une coexistence de petites sinon de micro-entreprises du secteur informel et de grandes organisations opérant dans le secteur moderne. Dans cet article, nous étudions l'efficience technique des entreprises manufacturières ivoiriennes dans quatre secteurs d'activité: le textile et l'habillement, la métallurgie, le travail du bois et les activités agro-alimentaires. La frontière de production DEA est la méthodologie non paramétrique à laquelle nous nous référons.

Les scores d'efficience sont calculés en suivant la procédure en quatre étapes proposée par Fried, Schmidt et Yaisawarng (1999). En d'autres termes, les scores initiaux obtenus de l'utilisation de la technique DEA sont ajustés pour tenir compte de l'impact de l'environnent externe sur le volume de la consommation de facteurs de production. Les efficiences techniques sont alors décomposées en trois éléments: l'effet managérial pur, l'impact de l'échelle de production, mais également un effet technologique qui capte le gain potentiel pouvant résulter de l'adoption par les petites entreprises informelles de la technologie du secteur moderne.

Mots clé : Efficience technique, Côte d'Ivoire, frontière non paramétique, secteur manufacturier, secteurs formel-informel.

I. Introduction

In the standard neo-classical theory, the long run equilibrium refers to a situation where all firms supply homogenous products and quantities at the same market price (see Viner, 1932). We know that economic reality provides little evidence of this theoretical assumption. In developed countries, small firms have structurally maintained a significant share of the global manufacturing activity, but with a compensation between entering and dying enterprises that reflects a strong turn over effect. A similar asymmetric firm size distribution is also observed in developing countries. Here, however, not only do small or even micro-enterprises account for a significant proportion of aggregate employment and output, but some of them demonstrate a remarkable ability to survive a long time by producing below the minimum efficient scale of the sector (see Weiss 1991).

A current explanation for this structural coexistence of small and large firms has called attention on market, but also on government failures. When modern producers face public regulations while the activity is slowing down, there are some reasons to believe that large firms will remain within their possibility frontier, failing to reach the higher level of technical efficiency. Small and flexible informal enterprises will have more chance to be closer to their production frontier thanks to more limited adjustment delays. This economic and institutional context illustrates the *dual industrial structure* and sheds some light on the difficulty to stimulate an intermediate sector, the so-called *missing middle*. However, if small or microscopic firms may survive, sometimes over a long period, the external operating environment is not the sole factor to be mentioned. Specific managerial abilities have also to be considered.

In this paper, we investigate above issues by focusing on a sample of firms that are representative of the Ivorian manufacturing sector. Productive efficiency is the appealing concept to which we refer to. Empirical indicators are calculated by mathematical programming models derived from the Data Envelopment Analysis (DEA) technique. The data set comes from the Regional Program of Enterprise Development (RPED), a heavy survey that the World Bank conducted over six Sub

Saharan African manufacturing sectors (Burundi, Cameroon, Côte d'Ivoire, Kenya, Zambia, Zimbabwe) between 1995 and 1996.

Section II reviews the complex analytical relationship between firm size and economic efficiency. Section III presents the random sample that was drawn from four Ivorian manufacturing sectors: textile and garment; metal products; wood and furniture; food processing. Section IV describes the non-parametric frontier method. Two amendments to the classical DEA program are proposed. First, following the method used by Fried, Schmidt and Yaisawarng (1999), efficiency scores are adjusted for the average impact of short run exogenous variables which capture the external economic and institutional operating environment. Secondly, we propose a breakdown of efficiency scores in three elements: managerial, scale, and technological effects. The last effect allows to appraise the productive performance that the informal sector would reach by adopting the more efficient technology of the formal sector. Section V is devoted to comment the empirical results while section VI summarises this work and discusses avenues for further research.

II. The ambiguous relationship between productive Efficiency and firm size.

In the Marshallian microeconomic framework, the main function of the entrepreneur lies in the "business organisation". The technology being given by the market, the entrepreneur has to find the right allocation of the resources and the right scale of the production. The most talented will succeed in developing their business while the others will progressively excluded from the market. A positive correlation between entrepreneurial talents and the firm size is therefore expected, the heterogeneity of the industrial structure simply reflecting a temporary disequilibrium phenomenon. [1]

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[1] Lucas (1978) proposed the first major theory explaining the simultaneous existence of large an small firms in a given industry. Those managers who are endowed with a greater amount of competence are able to manage large enterprises

In the early development economics literature large organisations have effectively been considered as the driving force of the economic progress through the use of a modern technology while small enterprises have been seen as a temporary survival of archaic modes of production (see Fafchamps, 1994). Lewis (1954) contributed to the popularisation of these ideas, depicting small enterprises as a means to temporarily mitigate the social cost of large and unemployed people. Retrospectively, this hypothesis did not prove to be relevant as many small enterprises have demonstrated an ability to survive a long time for various reasons on which different bodies of literature have called attention.

Following the initial property rights theory or the more recent developments underlying the principal-agent approach, large modern organisations are particularly sensitive to the informational issue. They involve a wide range of delegations giving rise to adverse selection and moral hazard phenomena. The relationship between the owner and the manager has been the emblematic case of the agency theory. But the economic problematic still remains relevant for other contractual arrangements. To overcome any substantial deviation from the profit goal, penalties and rewards affecting the behaviour of rational agents have to be introduced within the contractual arrangement. Large organisations are very exposed to these transaction and agency costs. Due to the macroeconomic instability and unpredictable events, sophisticated arrangements are avoided. The structural weakness of the African judicial institution strengthens this propensity with few disputes finding a relevant resolution through legal proceedings. Direct bargaining is the favoured conflict resolution method within the informal sector while large operators give their preference to authority relation characterised by hierarchical relationships.

The interaction between the size of the firm and its economic efficiency has been an important issue for the transaction cost economics. Here, the authority relation through the internal governance structure is supposed to be a less costly and hazardous instrument for an efficient co-ordination than the negotiation and the writing of a network of optimal contracts. However the firm has to integrate that there are decreasing returns to the entrepreneurial function, the cost of organising additional

transactions rising with the size of the firm (see Coase, 1937). Williamson (1985) has extended this initial analysis by supporting the view that the governance is an efficient means against bounded rationality and opportunistic behaviours. But large firms will find themselves uneasy to set up the best hierarchical organisation in a context of high degrees of asset specificity and non-separable tasks.

With a large team of production, individual productivity cannot be assessed by measuring output. An incentive to free ride, or to shirk within the frontier of the firm, consequently exists which in turn requires more monitors, more bureaucratic costs to regulate inputs into work activity (see Alchian and Demsetz, 1972). The good shape of the hierarchical organisation is therefore a difficult challenge to take up. The maintained hypothesis of much of the organisation literature is the existence of economic gains that can only be achieved through large firm size, but above a certain size, the firm's activities become so complex that hierarchical management is no longer an efficient allocation mechanism (see Aoki, 1988).

The relationship between the size and the efficiency of the organisation is therefore a potential explanation for the strong heterogeneity of the industrial structure. Small enterprises have a limited workforce. The direct participation of the owner to the production means less agency costs and "free riding" phenomena. In these small organisations where the natural authority of the entrepreneur helps to promote loyalty, the emergence of efficient social conventions and behavioural norms might be easier. In accordance with the profit maximisation goal, internal pressure from the top as well as from the peers could be strong enough to ensure a high level of effort and lower X-inefficiency (cf. Schotter 1981, Leibenstein, 1989).

Beyond these theoretical arguments, attention has also been called upon factors proceeding from the external operating environment. In African manufacturing sectors, large firms have been created with a significant initial size. This suggests that size has not been the result of an endogenous process involving the emergence of efficient firms across the natural selection process. Big inward looking enterprises have been protected by public regulations from any entry within the modern sector and sheltered from the

international competition through high trade tariffs and quantitative barriers. This argument has been relevant for the Ivorian manufacturing sector where upward adjustments of the trade protection were recurrently operated, highlighting the principle of an endogenous protection and its perverse consequences for the organisational efficiency.

Small enterprises evolve in a more market friendly environment facing few public restrictions to adjust the labour input in accordance with the level of output and the profit goal. With regard to the capital input, as small Ivorian enterprises have a limited access to formal credit and moneylenders, investment has to be financed by personal savings or funds from friends and relatives. Difficulties in raising those funds and the willingness of borrowers to maintain trust and reputation are potential factors for a reduced waste of this financing.

If *small is beautiful*, thanks to lower supervision and tutoring as a result of a more limited workforce and fewer delegations, one has to keep in mind that being small entails some disadvantages too. When large private firms resort to delegations of powers, they are supposed to do it for the profit goal that results from human specialisation of tasks. In other words, bureaucratic costs and managerial slacks are only one side of the coin, economic efficiency being the final target when shaping the governance structure. Moreover, these organisational costs are not given once for all. They can be reduced through the redefinition of the hierarchical relation.

As Chandler (1962) has shown, the multidivisional organisation (M-form) has developed because of organisational problems created by diversifying within a functional/U-form structure. By this organisational innovation large firms succeeded to maintain the advantages of their size while reducing the accompanying costs by creating semi-autonomous divisions allowing less informational problems. In addition, as there is evidence that the labour turnover tends to be lower in large enterprises, some firm-specific skills can be acquired by individuals, allowing the creation of what some authors call "*core competence*". Then a collective learning of the organisation builds up,

making possible a high productivity resulting from the co-ordination of diverse production skills and the integration of a multiple streams of technologies.

Leibenstein (1989) discussion of intra-firm behaviour is useful in this respect. Management-worker relationships can be analysed in game theoretic terms with resulting co-operative and non-co-operative equilibria. The former is based on the development of trust, not on narrowly defined individual interest. This cooperation only emerges if the probability of mutual advantages is high enough for the stability of the reciprocity to be maintained on a long run basis. With few players and lower informational issues, small organisations might have an advantage. But the story can be turned around. The emergence of co-operation can be seen as easier if the same game is played repetitively an unknown number of times. To some extent, large firms are more likely to be in this situation. Their probability to survive over a long period being higher, it facilitates an efficient productive behaviour through human investments in new firm-specific skills.

No clear-cut conclusion appears at this stage about the relationship between size and productive efficiency. On the one hand, we do not neglect potential advantages of large formal firms, with their modern technology and their organisational *know how* but on the other hand, we do not ignore those of small informal ones through less diluted responsibilities and more operational flexibility. In his analysis of the reasons for policy interventions in favour of small manufacturing enterprises, Little (1987) suggests from surveys of small Indian and Colombian manufacturing enterprises, that small units use factor inputs more productively than their larger counterparts. In this context, a shift of resources in favour of smaller units would yield a net increase in output, as well as an increase in the demand for unskilled labour. Whatever the scope of this assertion from limited empirical observations, some authors will argue that when the incentive structure changes frequently and unpredictably, generally with the macroeconomic instability, plants created at different times and using different technologies may coexist indefinitely (Tybout,1996).

III. The sample of the Ivorian manufacturing firms.

Our data set comes from a survey of manufacturing firms conducted in six Sub Saharan African countries. The collection of these data has been implemented by several teams co-ordinated by the World Bank in the framework of the Regional Program on Enterprise Development (RPED). The main objective of these surveys was to enlarge the knowledge about the creation process of African manufacturing firms but also the problems that they encounter in their local development. Only four sectors of economic activity have been explored: Textile and garment, metal products, wood and furniture, food processing. The random sample of 230 firms was drawn from a population of 620 enterprises belonging to formal and informal sector, with a limited number of entities classified in the "half formal" category.

When the survey took place in 1995 and 1996, respectively, the whole Ivorian manufacturing sector had 10 000 enterprises and accounted for about 25% of the Gross Domestic Product. The survey involved two distinct stages. In 1995, the creation process of firms was investigated. In 1996, this phase was complemented by some light on the entry and exit movements within the manufacturing sector. Bankruptcy was the criterion retained to appraise the death of formal and half-formal registered firms. The loss of visibility on the organisation or its activity was considered for informal ones.

Table 1 summarises the main characteristics of Ivorian firms we are interested in. As suggested above the sample has been divided in two sub-samples reflecting the formal and informal status of enterprises. We know that these economic notions have enhanced considerable discussions, the main difficulty being to define exactly what is the "informal sector". Although some authors are sceptical on the operational value of this concept (see Little, 1987), few of them have rejected the importance of these activities over the development process. The informal sector, characterised by a labour intensive technology, operates in an institutional context where flexibility is generally seen as an element allowing a good productive efficiency. The former assertion is highlighted in table 1 while the latter is what we want to study in this paper.

Table 1: Main production characteristics of Ivorian firms, by institutional status.

Sample averages in 1995

	Formal	Informal	Total
1- Number of firms	129	57	186
2- Value added (Q) (a)	188 1860	12000	79 321
3- Capital stock (K)	542 370	1980	18 440
4- Workers (L) (b)	179.9	6.6	79.6
5- Human capital (H) (c)	5.20	5.13	5.16
6- Q/K	3.46	6.1	4.30

Nota bene. (a) Thousands of CFA francs ; (b) Number of workers, the number of hours being considered for the DEA calculations ; (c) number of school years, calculated from the representative agent of the firm.
Source: Authors' calculations from the Ivorian base, RPED, World Bank.

Table 2: Statistic distributions of firms according to their size, age and sector based activity.

(Sample: 230 firms)

	Sector of activity					Number of years (since the creation of the firm)				
	Food processing %	Textile and garment	Wood and furniture	Metal products	Rate of exit	[0, 5] %	] 5, 10]	]10, 20]	] 20, +[	Total
Micro	1 (2)	65 (61)	27 (42)	7 (18)	22	40 (66)	28 (46)	26 (32)	6 (12)	100
Small	22 (54)	34 (35)	23 (39)	21 (60)	18	15 (27)	28 (50)	41 (54)	17 (36)	100
Medium	37 (12)	11 (1)	19 (4)	33 (13)	16	19 (5)	11 (3)	35 (6)	35 (10)	100
Large	46 (32)	12 (3)	31 (15)	11 (9)	13	5 (2)	2 (1)	22 (8)	70 (42)	100
Total	17 (100)	43 (100)	25 (100)	15 (100)		24 (100)	24 (100)	32 (100)	20 (100)	100
Rate of exit %	19	18	12	18	18	12	16	25	17	

An additional information about the 230 surveyed firms is given in Table 2. This information is presented in a way that aims at highlighting the relationships between size, age and the rate of exit. A rapid outlook suggests that microenterprises are particularly important in two sectors: textile and garment, to a lesser degree, wood and furniture. Few of them are found in metal products or food processing. The descriptive statistics confirm the intuition that size and age are positively correlated, small organisations are young ones while most of large firms have at least twenty years old. Furthermore, while 52% of the enterprises have more than ten years old, the last row of the table shows that 18% of them died between the two phases of the survey. The rate of failure is higher for micro (22%) and small enterprises (18%), but not negligible for medium ones which are for 70% within the age group of 10 years old and more.

IV. The formal procedure of the non-parametric measure of technical inefficiency.

A) The trade off between parametric and non-parametric frontier methods

The technical efficiency of Ivorian firms will be calculated using the Data Envelopment Analysis (DEA) approach. In comparison with the parametric technique, DEA does not require any hypothesis about the functional form relating inputs and outputs, and no specific assumption about the distribution of the error term. In a cross-section analysis with heterogeneous firms, this can be seen as an advantage, the risk of the econometric method being to confound the effects of misspecification of the functional form with efficiency (Lovell, 1993).

The programming approach is likely less subject to the aforementioned specification error, but it can't disentangle inefficiency from random noise. Therefore, any deviation from the deterministic frontier will be regarded as inefficiency, one consequence of which is a particular sensitivity to *outliers* (see Cornwell and Schmidt,1996). However, in contrast to parametric analysis where the single optimised regression equation is assumed to apply to each empirical observation, DEA allows to calculate the performance of each Decision-Making Unit with regard to a specific peer group reflecting the *best practice* for the observation (Seiford, 1996). An outlier with a

"very poor" performance does not influence the efficiency score of other units, as it does not contribute to the frontier, that is the convex hull of intersecting planes enveloping the data. If the outlier is a *peer,* its impact can be restrained with the convexity restriction limiting the benchmarking within a sub-sample of firms. With the variable returns to scale model (VRS DEA), a firm cannot be benchmarked against *peers* which are substantially larger or smaller than it.

B) The external environment and the four stage procedure.

In trying to explain the reasons of the heterogeneous structure of the manufacturing sector, implicitly the possibility for small firms to survive, attention has been called upon the complexity of the factors contributing to the productive performance. The potential impact of exogenous variables of the operating environment has been noticed, as well as the diversity of the economic elements contributing to this performance. To investigate the respective role of these factors, the *four-stage procedure* introduced and applied by Fried, Schmidt and Yaisawarng (1999) has been adopted.

First, the classical non-parametric DEA frontier is calculated to derive a distribution of efficiency scores. These scores refer to the radial measure of technical efficiency as defined by Farrell (1957). In the *second stage*, an econometric regression analysis is performed to correct the input use from effects outside the control of managers. To implement this exercise for an input oriented model, the sum of radial and non-radial input slack is econometrically regressed on a vector of variables reflecting the average impact of exogenous factors[2]. In the *third stage*, the regression parameters are used to reassess the virtual consumption of inputs that would be observed if all Ivorian firms had to evolve in the least favourable external conditions. In the last and *fourth stage*, adjusted primary inputs are used to re-run a DEA frontier with efficiency scores revealing a more appropriate measure of intrinsic managerial abilities.

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[2] Following a more strict definition than Farrell's, Koopmans (1951), defines technical inefficiency in terms of the radial reduction in inputs that is possible, but also in terms of input or output slacks. See Coelli et al (1998), or Fried et al (1999) for an illustration of the economic issue.

The first stage refers to the DEA mathematical programming model suggested by Banker, Charnes and Cooper (1984). This model makes it possible to control for an economic inefficiency coming from production under variable returns to scale (VRS). Firm performance can therefore be decomposed into "pure" and scale inefficiency. As African manufacturing firms operate in a context of imperfect competition with various financial and regulatory constraints, most of them do not exhaust scale economies.

The possibility to account for a sub-optimal scale (VRS) is easily obtained by the convexity constraint ($\lambda I = 1$), ensuring that an inefficient firm is only benchmarked against firms of a similar size. The input distance function being used, the production technology denotes the set of all input vectors (X), which can produce the output vectors (Q). The input distance function introduced by Shephard (1970) characterises the production technology by considering a minimal proportion contraction of the input vector given an output vector.

$$L(q) = \left\{ x : \mathbf{1}Q \geq q, \mathbf{1}X \leq x, \mathbf{1}I = 1, \mathbf{1} \in R_+^i \right\}$$

Given the piecewise linear input requirement set L(q), under variable returns to scale, the DEA model is derived from the following linear programming problem where θ is a scalar representing the proportional contraction of all inputs (j), holding input ratios and output level constant.

$$\min_{\theta, \lambda} \theta^i$$

$$s \cdot t \quad \lambda Q \geq q^i$$
$$\lambda X \leq \theta x^i \qquad i = 1, ..., n \quad \text{(firms)}$$
$$\lambda I = 1 \qquad j = 1, ..., k \quad \text{(inputs)}$$
$$\lambda \in R_+^i$$

To adjust firm technical inefficiency for the excessive use of inputs resulting from factors outside the managerial control, tobit regressions have been retained to account for the unilateral distribution of the dependant variable that is, the sum of the radial and non radial input slack denoted (TIS_j^i). The radical input slack is calculated as

follows: $(1\text{-TEi})\,Xi$ [3]. It reflects the ability to maintain the output with a reduction of all inputs in the same proportion. This measure that underlies efficiency scores neglects the non radial input slack, indeed the possibility to maintain the output while contracting the volume of at least one input, the others being held constant (see appendix 1). The independent variables are the exogenous factors (Z_j^i) of the operating environment that may affect the input use (j) of firm (i). These factors are not the same across the three regressions we run separately (i.e., one for each input).

$$\begin{vmatrix} TIS_j^i = F_j\left(Z_j^i \cdot \beta_j \cdot U_j^i\right) \\ T\hat{I}S_j^i = F_j\left(Z_j^i \cdot \hat{\beta}_j\right) \end{vmatrix} \quad \text{With} \quad \begin{array}{l} j \;=\; 1,\,2,\,3 \quad \text{(inputs)} \\ n \;=\; 1\,..\,i\,..\,186 \quad \text{(firms)} \end{array}$$

$$X_{j\,adj}^i = X_j^i + \left[\max{}^i\left\{T\hat{I}S_j^i\right\} - T\hat{I}S_j^i\right]$$

As can be shown from the last expression, firms are placed in the least favourable environment observed within the empirical sample. This calculation does not modify the input use of the firm evolving in this environment. However, it affects the consumption of the others and means that the quantity of inputs they use would be larger if they had to operate in this environment while producing the same output. On the basis of these new virtual volumes of inputs, the DEA model can be recomputed so as to obtain a more appropriate assessment of managerial abilities in the fourth stage.

C) The measure of a technological efficiency differential.

To account for the heterogeneity of the surveyed firms, an additional hypothesis has been introduced into the measurement of efficiency scores and their component effects. Indeed, the decomposition of efficiency scores into scale and pure managerial inefficiency should be misleading if all organisations did not refer to the same frontier, or technology. *Prima facie* it can be reasonably considered that large modern firms resort to an efficient capital intensive technology while small micro-enterprises try to manage at best the macroeconomic uncertainty through a more labour intensive one. Accordingly a third element has to be incorporated, reflecting the technological distance

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[3] (TEi) is the Farrell's radial measure of efficiency. The formula of the text only means that the possible reduction equals the technical inefficiency times the volume of input.

between the two sub-samples. The breakdown of the sample has been decided by running various simple regressions. Efficiency scores were regressed on several alternative criteria including the firm size, the capital-labour ratio, and the technological dualism between formal and informal activities.[4] The last option proved to be the more relevant as evidenced by the adjusted coefficient of determination.[5] Figure 1 illustrates the problematic of the measurement we are interested in.

Figure 1 - Firm technical inefficiency and its components
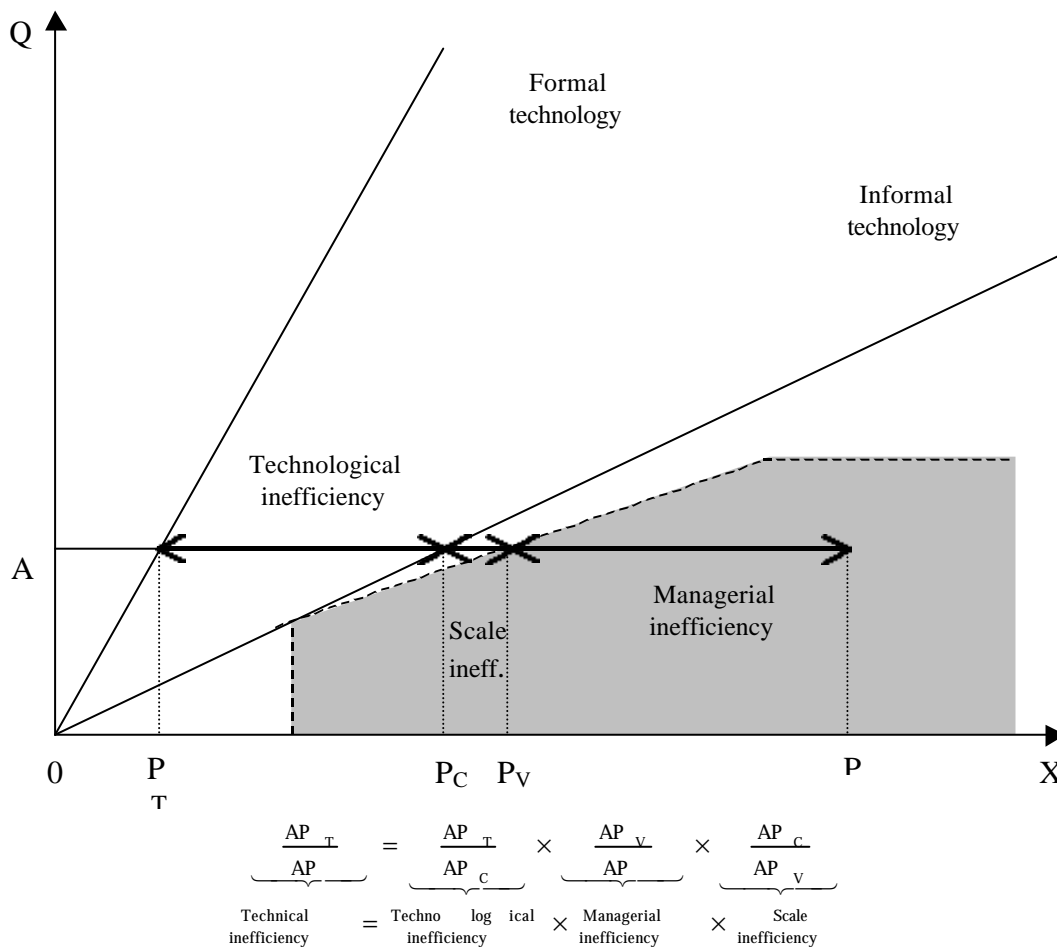
NB: Two sources of technical inefficiency are retained for formal firms, but three for informal ones. For a more convenient reading of the figure, let say that the P, PT,PV,PC on the abscissa (OX) refer to different levels of a input X for the production of output A.

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[4] Through sector-based binary variables we have also tested, and statistically rejected, the possibility to have a different technology for each of the four sectors we are interested in.

[5] To implement these simple regressions, efficiency scores of the DEA model have been considered, calculated under the constant returns to scale hypothesis. Compared to the capital-labour ratio, this variable does not require the choice of any subjective threshold in the breakdown of the sample. But, of course, the restrictive hypothesis is that the category to which firms belong to is exogenously given.

We assume that formal firms have the appropriate technology, the upper frontier, while the informal ones refer to the lower frontier. Consequently, an informal enterprise operating with a combination (A,P) faces three sources of technical inefficiency that we express in a ratio form. The product of these ratios measures the input oriented technical inefficiency. As regards the failure to reach the frontier of the informal sector, we appraise the managerial inefficiency by AP_V/AP, and the scale inefficiency by AP_C/AP_V. The difference between the informal and formal constant returns to scale frontiers, AP_T/AP_C, captures the technological inefficiency, or the advantage that an informal firm would gain by adopting the more efficient technology of the modern sector[6].

V. Non parametric measures of efficiency scores: the empirical analysis.

A) *The variables of the production technology.*

To approximate the capital stock at constant market prices, we have referred to the perpetual-inventory method. As the organisations were not asked to report their balance sheet, and in fact informal ones do not have one, the capital stock has been constructed by combining data about the initial equipment and the value of registered investments over the 1984-1993 period. An other informational problem concerns the depreciation of the capital stock. Figures being unavailable neither by type of assets or in global terms, an annual depreciation of 4.5% has been hypothesised which represents a mean asset life of 22 years.

The labour input has been measured by category of workers as the number of hours multiplied by the relative weight of the category within the workforce of the firm. Compared to the number of employees, this calculation allows to account for temporary and permanent employees who are subject to vary across firms. In connection with this input, a third one has been taken into account to capture the specific impact of human

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[6] We assume that formal firms have only two potential sources of technical inefficiency : one resulting from the management, and one proceeding from the scale of production. In figure 1, the VRS-DEA model of formal firms is not represented. The illustrative example only refers to the case of an informal firm.

qualifications. Instead of distinguishing between skilled and unskilled workers, we have calculated a variable reflecting the specific human capital of the firm as follows. For each category of workers, the average number of school years has been considered for what the questionnaire calls the representative agent. A weighted average of these statistics proxies the human capital of the organisation.

B) The variables of the external operating environment.

To adjust input quantities for exogenous features of the external environment, the variables that affect the relative importance of transaction costs have been considered. Official regulation (REG) and corruption (COR) do not have the same impact among firms. The way they are subjectively perceived by managers reflects potential excess unit costs that could be more significant in large modern firms. A similar impact should be expected for firms where trade unions (UNION) are present and play an active role in internal negotiations upon the distribution of the potential surplus. To some extent, these organisations may be efficiency enhancing through the emergence of procedural arrangements encouraging efforts and loyalty. However, their behaviour also constraints the set of managerial decisions by restraining the speed of adjustment of the labour force to the trade liberalisation process as well as the cyclical swings of the domestic activity.

In addition to these institutional factors that seem to primarily affect the formal sector (FOR), we have tested the economic cost resulting from public restrictions in the geographical choice of investments (LOC), and the effect of the poor public infrastructure on productivity (INFRA). As recalled by a study conducted by Kerf and Smith (1996), no region in the World is in greater need of new investment in and more efficient operation of its infrastructure than Sub-Saharan Africa. Transportation costs and inadequate provision in electricity or telecommunication services may handicap small enterprises, in spite of their flexible technology, but also, and perhaps even more, large firms for which poor services increase economic uncertainty. In the survey we refer to, Ivorian managers were asked to value the severity of the productive problem

arising from infrastructure. Their answer has been retained as a proxy for the problem they face.

Some variables have also been included to appraise the difficulty of firms in getting loans from commercial banks. Small and microenterprises are generally said to be handicapped by the risk aversion of formal banks and the high transaction costs resulting from the negotiation and the supervision of small scale loans. This effect has been tested through a variable that combines information about managers who asked for a formal loan but failed to get it, and those who did not solicit any commercial bank, as a negative answer looked certain (LOAN). These financial difficulties tend to raise the age of the capital stock (AGE) of small enterprises. As regard technical efficiency, one has to mention that there may be a positive counterpart to capital market imperfections. As own savings, funds from relatives or costly informal credit are the main alternative sources to formal financing, small enterprises are probably less likely to waste this productive capital than larger ones.

C) Efficiency scores and their decomposition: the empirical analysis.

Efficiency scores have been calculated under the conventional DEA (VRS) method and after correction of the input use for economic and institutional conditions outside the organisational control of the manager. In each case, the overall distribution of scores is proposed with two breakdowns. The former helps to appreciate the difference between average technical efficiencies of the formal and informal sectors. The latter sheds some light on the respective contribution of the three effects discussed above: managerial, scale and technological effects. Under each distribution, the standard deviation is given in parentheses while in the last column, on the right hand side, the non parametric Wilcoxon test has been implemented to test the presence of statistical differences between bilateral distributions at the conventional levels of confidence.

Before commenting the efficiency scores, corrected or not for the impact of the external effects, we have to come back to the variables that influence the tobit

regressions of table 3. Most of them display the expected sign with statistically significant coefficients. In other words, the economic and institutional environment partly determine the managerial performance of organisations. Especially for the labour input, the hypothesis that the external conditions enhances a severe constraint for modern firms is evidenced by the positive correlation of three variables: the presence of a trade union in the firm (UNION), the role of regulations (REG) and corruption (COR). As regards the other inputs, the conclusion is not so clear although larger organisations suffer a greater sensibility to the quality of the infrastructure (INFRA). For technical capital as well as human capital, the positive correlation of FORM does not reject the hypothesis of an excess use of inputs by the "modern" activities. Under the hypothesis that this variable is exogenous (see infra), it sums up a potential loss of technical efficiency that highlights why an important part of small and medium-size enterprises try to evade these costs by remaining informal.

Due to the cross-sectional dimension of the sample, the omission of relevant variables is likely, illustrating one of the limits of the above econometric results. For example, we have been unable to test the implications of the fiscal system. Some authors assert that taxes are predominantly focused on small businesses, others qualify this assertion and notice that the collector fails to reach micro-enterprises, although the weight of taxes on small modern enterprises can be significant. In Fortin *et al* (1997) this fiscal aspect is one way of defining the informal sector. Informal enterprises are those that are unregistered to avoid state regulations, but also corporate income taxes and social security contributions, registration fees or income taxes on informal wage income. But the reason why some firms comply with the legal requirements of registration while other do not is itself a debatable issue. For McPherson and Liedholm

Table 3: **Primary input adjustment for the external operating environment.**

(tobit regressions)

	Labour	Technical capital	Human capital
UNION	155.241 (4.475)***		
REG	21.259 (1.380)		
COR	87.592 (1.805)*	1044236 (1.875)*	
LOAN		608377.5 (1.478)	
LOC		-2444300 (-1.666)*	5.219 (1.731)*
INFRA		2340521 (2.223)**	
FOR		674142.5 (1.717)*	2.337 (2.156)**
AGE		10892.71 (2.677)***	
Food processing *(specific intercept)*			-2.518 (-2.136)**
INTERCEPT	-61.811 (-2.198)**	-1068595 (-2.964)***	-0.141 (-0.156)
Log likelihood	-1075.85	-2741.83	-371.57

NB   The dependent variables are total radial plus non radial slacks. The student t-test is given under the coefficient with the following level of confidence 99% (***), 95% (**) and 90% (*).

(1996), the lack of information rather than the willingness to avoid the visibility to agents of the Administration would be the prevailing explanation. The way we answer the questions is not of minor importance. In one case the classification of firms proves to be endogenous while in the second, the categorization (i.e. formal versus informal) remains an exogenous variable.

The parameter estimates of the three tobit equations have been used to re-compute the DEA program with adjusted primary inputs, so as to place all the sample firms in the least favourable set of external conditions. A high heterogeneity prevails within the sample and sub-samples of efficiency scores (see table 4). The correction for the external environment does not deeply modify this result although in this case, the average performance of the formal sector increases somewhat and reveals a lower standard deviation. The decomposition of technical efficiency scores is interesting in several respects. First, it is shown that the managerial efficiency is higher with the informal sector, the difference being narrower when adjusted primary inputs are considered. Therefore, arguments underlying the transaction cost economics and the theory of agency relationships are not rejected. Secondly, and to some extent surprisingly, if small organisations prove to be better than large ones in reducing X-inefficiency, they are not more efficient in choosing the scale of production while the labour intensive technology would help to do it as investment decisions are less subject to indivisibility effects. This result suggests that when starting a business, small entrepreneurs face fixed or sunk costs that prevent them to reach the cost minimisation gaol. The relative importance of this cost is especially significant, as micro-enterprises are young and exposed to a higher rate of exit. The procedural rationality underlying the decision-making has its own part of responsibility. Because of their limited knowledge and power of calculation, small operators fail to determine the right dimension of their initial investment.

Finally, and this is a key element in the explanation of the average technical efficiency difference between sub samples, on balance, being in the formal sector means the use of a more efficient technology. The question then arises to know whether

Table 4:   Descriptive statistics of technical efficiency scores, adjusted or not for the external operating environment.

Exogenous factors	Technical efficiency components	Formal (129)	Informal (57)	Total (186)	Wilcoxon test (formal versus informal)
Not adjusted for external environment	Total	0,43 (0,30)	0,26 (0,18)	0,38 (0,26)	*** F>I
	Technological	1	0,55	0,84	
	Managerial	0,62 (0,37)	0,82 (0,49)	0,68 (0,40)	*** I>F
	scale	0,70 (0,38)	0,60 (0,35)	0,67 (0,38)	** F>I
Adjusted for external environment	Total	0,53 (0,18)	0,25 (0,16)	0,44 (0,12)	*** F>I
	Technological	1	0,55	0,86	
	Managerial	0,71 (0,34)	0,78 (0,51)	0,73 (0,41)	** I>F
	scale	0,75 (0,31)	0,59 (0,28)	0,70 (0,44)	** F>I

Note: Standard deviation is given in parenthesis. The Wilcoxon test is a non-parametric rank test that we use to compare the formal and informal distributions. The difference of the distributors is tested at the 99% (***), 95% (**) and 90% (*) level of confidence.

such a technology could be adopted and properly managed by Ivorian micro-entrepreneurs. Indeed, the industrial skill of a firm consists of a practical knowledge

and know how, a set of relevant habits, acquired and routinised over time. Therefore, trying to become fully efficient is an uncertain process as changing capital and retraining labour means significant costs before the process earns its full return. As Stiglitz (1989) remarked, a major difference between the more and less developed countries arises from learning by doing and limits on the ability to transfer what learning occurs across boundaries. Such a transfer is not locally easier between formal and informal organisations in accordance with the *missing middle* analysis. The productive interest of a modern technology is therefore hypothetical, especially if the objective of small enterprises remains to satisfy some niches, some specific segments of the domestic demand.

VI. Conclusion

We have investigated the technical efficiency of Ivorian firms by considering a random sample that has been drawn from four sectors of manufactured activities. To implement this exercise, the conventional Data Envelopment Analysis (DEA) method has been adopted with efficiency scores derived from a non-parametric linear programming framework. Following the *four-stage procedure*, we have also calculated a performance adjusted for the influence of external variables on the use of primary inputs. Whatever the DEA model we refer to, small and informal enterprises have demonstrated a higher managerial performance. This empirical result is in accordance with the views that relations between managers and the labour force are weakened with an increasing hierarchical structure that tends to reduce effort levels. But this is only one side of the coin as large modern firms benefit a more efficient technology that proves to be a crucial element in the explanation of the overall technical efficiency.

Although these results are interesting in themselves, they still remain exploratory in nature. More work is needed to strengthen the empirical conclusions. One important factor limiting our study comes from restrictive assumptions about the calculation of efficiency scores and their components. The empirical hypothesis that all formal firms have the good technology while informal ones do not and would gain economic efficiency in choosing it is restrictive. The reality is certainly more complex and the hypothesis would deserve to be revisited. It is reasonable to consider that small

businessmen do not have the managerial "know how" required by such a radical change. And we do not forget that a capital intensive technology means more rigidities when the production capacity has to be adjusted downward. In other words, a labour intensive technology allows small informal firms to benefit from the flexibility of their environment. But will these advantages go on in a trade liberalisation context?

We would expect that the more competition in an industry appears to be impeded, the greater the chance for inefficient firms to survive. Some impediments are likely to occur, coming from entry or exit barriers. The trade liberalisation process makes the local markets more *contestable*. Lower quantitative barriers mean a credible threat against the survival of large and inefficient firms. But a more flexible labour market is also a chance for large efficient ones to improve the management of this resource. Thus, the deregulation might enhance dramatic changes in the Ivorian industrial structure. Vis-à-vis large and modern local firms, small informal enterprises might loose a significant part of their comparative advantage arising from their managerial flexibility and ability to satisfy narrow segments of the demand through small scale production techniques (see Sherer 1973 and Pryor 1972). These organisations will prove to be very exposed to changes in economic policy measures and programs for an improvement of the infrastructural endowment implying a higher level of market contestability and a lower natural trade protection. In short, in Côte d'Ivoire as anywhere else in Sub-Saharan Africa, a more market friendly environment could contribute to enlarge the role of competitive organisations combining the right technology and the good management of scarce resources in the right production scale. The operating environment will be a more selective one with an uncertainty outcome for the evolution of the industrial structure. According to the so-called Darwinian principle of the *survival of the fittest*, economic selection should eliminate weaker organisations, small or large ones, those which prove to be unprofitable.

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