

# Multiple criteria and multiple periods performance analysis: the comparison of telecommunications sectors in the Maghreb countries

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**Abstract**— In four Maghreb countries (Algeria, Morocco, Mauritania and Tunisia), a considerable improvement of the situation of the telecommunication operators has been noticed during the nineties. The evolution in these countries was very different depending on their economic policies, their effort of reorganization of their telecommunication sector and their technological change. These differences will be exhibited and analysed by comparing the operators' performances over a decade (1992–2001). A first approach is based on the Malmquist DEA TFP index for measuring the total factors productivity change, decomposed into technical efficiency change and technological changes. Second, using the Promethee II method and the software ARGOS, a multiple criteria analysis is performed, taking into account a larger scope of analysis. A main issue is that the general performance ranking of sets of operators by country is almost the same according to the two methods, although the variables of inputs and output used for the index of Malmquist are different and narrower in the considered scope than the chosen families of criteria used in method Promethee and software ARGOS. Both methods of analysis provide however complementary useful detailed information, especially in discriminating the technological and management progresses for Malmquist and the two dimensions of performance for Promethee: that are the service to the community and the enterprises performances, often in conflict.

**Keywords**— *case study, multiple criteria decision aid, Promethee, Malmquist DEA TFP index, African telecommunications reforms, dynamic performance analysis.*

## 1. Introduction

Since the beginning of the eighties, the telecommunications sector knew two great evolutions: a fast evolution of technology on one part, and several policies implying regulatory reforms, the liberalization and the privatization on the other part. These evolutions differ according to countries and to their development levels. If the developed countries knew very early the waves of liberalization, privatization, and globalization of their economies, it is only at the end of this 20th century that the African public companies knew these phenomena, since they remained for a long time the kept hunting of the authorities. Some arguments were advanced to explain this tendency

and why these companies kept a level of financial profitability and/or productivity which is generally regarded as very low, if not poor [12, 14]. The economic opening by the liberalization for the services market and the deregulation of the communication infrastructures sharpened the appetite of the principal telecommunications operators of the zone OECD [9, 15] and privatization has become common across Africa [8]. And, even if there are still very strong disparities between the various countries of the zones North Africa and Middle East, a true explosion shocked the telecommunications sector during these last years. The number of private fixed lines knew or will know a clear increase (up to 67% between 1999 and 2007 according to IDATE). First operators on Internet made their appearance. The national markets were opened to the competition and the services of mobile telephony have been developed. Let us concentrate ourselves on Maghrebian telephony.

Karim Sabri was interested in the regulatory reforms in five countries: Algeria, Libya, Mauritania, Morocco and Tunisia [17]. Like other developing countries in Africa and elsewhere, the Maghreb countries have modified seriously their lawful frameworks for attracting foreign private investors and they have recently opened their telecom networks to the competition and the privatization: the state monopoly of the telecom is finished. All of them have reorganized, at the end of the nineties, their set of legal rules for facilitating the needed foreign investment and settled different control authorities, Libya still being penalized by its past behaviour, reproached by the international community. In the comparison of the four other countries, appeared several differences in terms of reforms and of key macroeconomic and sector's figures, these differences may be considerable in terms of macro economy and demography: the comparison of telecom performances must then lay upon ratios and productivities, rather independent of the sizes differences.

We shall focus this paper on two quantitative methods in view of comparing performances of the telecom Maghrebian sectors. The Sections 2 and 3 will present successively the Malmquist index and the multiple criteria ranking by the method Promethee II included in the software ARGOS. These latter two analysis highlight the evolution of the productivities and the service and enterprise performances of four countries sectors among the five quoted in the previous

paper: Algeria, Morocco, Mauritania, Tunisia, since it was impossible to obtain the corresponding figures for Libya.

## 2. A comparison of productivities of the telecom sectors based on the index of Malmquist

### 2.1. Methodology of the Malmquist index analysis

The index of Malmquist is often used to evaluate the performance of public utilities networks, using physical data which are more available than financial data [2–4]. The Malmquist quantity index is composed of ratios of distance functions. It measures the total factor productivity change (TFP) between two data points ( $K$  and  $K'$  in Fig. 1), each one representing a same firm (or a sector in our paper) by its 2 coordinates ( $X, Y$ ),  $X$  being an input (a set of inputs) and  $Y$  an output (a set of outputs) of a production of this firm, calculated at two different times  $t$  and  $t + 1$ . Between these two times, changes may have occurred in the used technology of production or (and) in the firm's management. The index is obtained by computing the ratio of the distances for each of these two data points relatively to a common technology (at a same period). This technology is obtained as the efficient frontier of production determined by the set of firms to be compared at a given time by means of non parametric programming techniques, well known in data envelopment analysis (DEA). One can read a complete description of this method in [2].

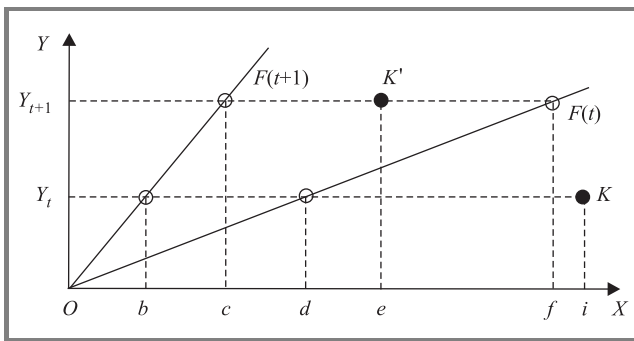


Fig. 1. The input based Malmquist index.

As presentation of this method, Fig. 1 [11] illustrates the input based Malmquist productivity index using constant returns to scale technology involving a single input and a single output. The technology at  $t$  is represented by  $F(t)$  and at  $t + 1$  by  $F(t + 1)$ , assuming that the firm produces at the points  $K$  and  $K'$  in periods  $t$  and  $t + 1$ , respectively. In each period, the firm is operating below the technology for that period, meaning that there is a technical inefficiency in both periods. We can therefore compare and measure the firm's progress in term of productivity from period  $t$  to period  $t + 1$ , and show that the improvement in productivity is due to the combination of the two factors: on one hand,

the positive shift of the frontier is considered as the result of technical progress, while on the other hand, an improvement in the technical efficiency could allow the firm in  $K'$  to be closer to or even to reach the frontier of the period  $t + 1$ . Since this frontier is determined by a set of country operators here, reaching it means only a relative efficiency. The input based productivity index ( $M_{it}$ ) for a firm  $i$ , in terms of the above distances along the  $x$ -axis (input axis) is given by

$$M_{it}(Y_{t+1}, X_{t+1}, Y_t, X_t) = \frac{Oe/Oc}{Oi/Od} \left[ \frac{Oc \ Ob}{Of \ Od} \right]^{\frac{1}{2}}, \quad (1)$$

where the first ratio  $\frac{Oe/Oc}{Oi/Od}$  measures the technical efficiency and the last ratio measures the technical change by means of a geometric mean of such changes.

Technical efficiency is synonymous with production efficiency. From a production point of view, a company may be considered technically efficient when, for a given set of production factors, it succeeds in maximizing its output, or put in another view, it minimizes the total resources deployed (production factors) to attain a given production level. The associated gains in technical efficiency and productivity are mainly the result of improvements in the firm's managerial practices. Technical progress is also a source of productivity enhancement that may come from:

- new investments in equipment,
- innovation in the sector (staff training, availability of highly qualified managers, new production techniques as the introduction of cellular into each telecom network, etc.).

Our practical study relies on the physical data of four Maghrebian telecommunications sectors (Algeria, Morocco, Mauritania and Tunisia) over a ten years period (1992 to 2001). This method will allow us to know the origins of the positive or negative evolutions of the total productivity of the operators with a splitting into and a change of efficiency and a technological change. The first component often reflects the improvement of management within each network and the last one comes from the innovation (new investments).

### 2.2. Presentation of the data and choice of the variables

Table 1 gathers all the data available for the analysis, concerning the telecommunications operators in the four Maghreb countries during the period 1992–2001.

As output, we chose the outgoing total traffic in minutes for meaning operators production. We could have chosen for example the sales turnover that reflects the sold production of the operators. But several problems remaining about the availability of reliable data and diversity of the countable standards in each country encouraged us to avoid this kind of output.

For inputs, we adopted two inputs, very often used in DEA, that are the factors of work represented by the full time

Table 1  
Inputs and output of the Malmquist DEA TFP index analysis

Sector of the country	Years	Outgoing total traffic [minutes]	Personnel (full time)	Principal lines
Algeria	1992	118 014 368	19 208	962 247
	1993	78 289 000	22 712	1 068 094
	1994	79 000 000	18 492	1 122 409
	1995	84 332 632	18 423	1 176 316
	1996	93 040 368	18 554	1 278 142
	1997	157 712 352	18 817	1 400 343
	1998	121 282 248	18 230	1 477 000
	1999	143 415 168	17 809	1 600 000
	2000	151 837 328	17 900	1 761 327
	2001	209 191 000	17 900	1 880 000
Morocco	1992	102 577 360	11 484	654 000
	1993	125 073 168	12 632	827 000
	1994	130 011 616	13 396	1 007 000
	1995	129 986 000	14 626	1 128 000
	1996	129 343 496	14 772	1 208 000
	1997	149 570 000	14 208	1 300 528
	1998	181 000 000	14 150	1 393 355
	1999	219 500 000	14 068	1 471 000
	2000	245 000 000	14 511	1 425 000
	2001	270 000 000	16 200	1 191 335
Mauritania	1992	4 357 334	400	6 750
	1993	4 277 511	410	7 499
	1994	4 503 822	456	8 426
	1995	4 127 943	451	9 249
	1996	4 889 159	443	10 204
	1997	5 475 163	456	13 045
	1998	6 300 266	454	15 030
	1999	8 078 267	480	16 525
	2000	9 029 041	720	18 969
	2001	9 800 000	600	25 199
Tunisia	1992	68 767 000	7 500	374 848
	1993	69 392 000	6 314	421 362
	1994	80 000 000	6 432	474 253
	1995	87 529 704	5 800	521 742
	1996	94 052 984	5 975	584 938
	1997	97 903 000	6 221	654 242
	1998	115 000 000	6 421	752 180
	1999	140 000 000	6 567	850 381
	2000	164 000 000	7 011	955 131
	2001	174 000 000	7 400	1 056 209
Sources: Algeria – Ministry for the Post and Telecommunication (MPT); Morocco – National Office of the Post and Telecommunications (NOPT); Mauritania – Office of the Post and Telecommunications (OPT); Tunisia – Tunisia Telecom.				

Table 2  
The mean productivity changes of the Maghrebian telecom of 1992 to 2001

Years	Malmquist index summary of annual means, converted in growths rates		
	Efficiency change [%]	Technological change [%]	Total factors productivity change [%]
1993/1992	-7.2	-2.2	-9.3
1994	-0.6	+5.6	+5.0
1995	-6.4	+4.9	-0.7
1996	-1.3	+5.7	+4.3
1997	+17.7	-1.6	+15.8
1998	-6.9	+10.0	+2.5
1999	+0.9	+17.5	+18.6
2000	+3.7	-1.9	+1.8
2001/2000	+12.3	-12.3	-1.5
<b>Mean</b>	<b>+1.2</b>	<b>+2.5</b>	<b>+3.7</b>

Note: all Malmquist index averages are geometric means.

Table 3  
The productivity changes of the Maghrebian telecom of 1992 to 2001 by countries

Sector of the country	Malmquist index summary of sector means converted in growths rates		
	Efficiency change [%]	Technological change [%]	Total factors productivity change [%]
Algeria	+0.5	+4.4	+4.9
Morocco	+2.2	+5.2	+7.6
Mauritania	0.0	-6.0	-6.0
Tunisia	+1.9	+7.1	+9.1
<b>Mean</b>	<b>+1.2</b>	<b>+2.5</b>	<b>+3.7</b>

Note: all Malmquist index averages are geometric means.

personnel and of physical capital represented by the number of principal lines [18]. Let us recall that a principal telephone line is defined as a line of telephone connecting the equipment of the subscriber to the commutated public network, and giving him a particular interface with the telephone communication network.

### 2.3. Presentation and analysis of the results

From Table 2 we conclude that the total growth annual rate is 3.7% over the period 1992–2001. The decomposition of this rate shows that this growth comes primarily from the column “Technological change” which reflects the innovation in the telecommunications sector, maybe by the introduction of new technologies. This change can also be due to the entry of mobile telephony. Technological progress takes part at a rate of 2.5% in the growth rate. The remaining 1.2% of growth comes from the column “Efficiency change” that determines the evolution of the management of the sector. It is difficult to interpret the evolutions year per year since meaningful tendencies can-

not be detected. We have converted the indices in growth rates<sup>1</sup>.

Table 3 indicates for each year, which are the networks that contributed more than others to the improvement of productivity. Thus we can confirm that Tunisia comes at the head of the ranking while contributing at a rate of 9.1% to the total growth rate, followed by Morocco that presents 7.6%, then Algeria in third position with a rate of 4.9% and in last position Mauritania comes in showing the only negative rate of -6%. We can notice for the first three operators that the rates of the “Technological change” column are higher than those of the “Efficiency change” column, which confirms the idea that the annual total growth rate results primarily from the technical progress that reflects the innovation in the telecommunications sector and the introduction of new technologies, and that to the detriment of the management change. Nevertheless for Mauritania, the negative total productivity change (-6%) is due completely to the technological effect.

<sup>1</sup>Let us recall that indexes are f.i. for the last line 1.012 and 1.025 producing by multiplication: 1.037, thus 3.7% of growth decomposed into 1.2% and 2.5%. Thus the last column can be sometimes obtained by an addition as an approximation.

According to these average productivities growths of Table 3, we can rank the countries telecom sectors as follows:

- 1. Tunisia (+9.1%),
- 2. Morocco (+7.6%),
- 3. Algeria (+4.9%),
- 4. Mauritania (-6%).

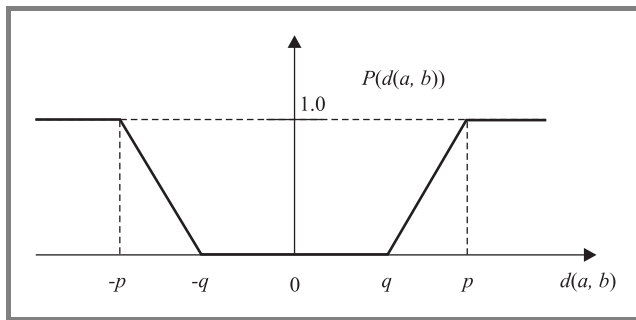
### 3. Multi-criterion analysis by Promethee of the telecommunications performances of the Maghrebian operators

#### 3.1. Data and ratios presentation

The data concerning the telecommunications operators in the four Maghrebian countries during the period 1992–2001 are gathered in Table 4 hereafter while on Table 5, we computed ratios being free of the rates of money changes and inflation.

#### 3.2. Recalling the Promethee II method

Multiple criteria methods are well known in the literature [6, 16, 19]. One of the best known method is the second release of Promethee II by Brans *et al.* [1]. The Promethee II method is an outranking multiple criteria device that provides a preorder of items by making pair wise comparisons of these items (telecom sectors in our case), first for each criterion, and then for all criteria. The final ranking is obtained according to the decreasing order of the preference flows of the items. Among the six kinds proposed by the method, we used only one kind of criterion: the pseudo-criterion with a linear preference between the two thresholds (Fig. 2).



**Fig. 2.** The linear pseudo-criterion used in Promethee:  $P(d) = 0$  if  $|d| \leq q$ , there is indifference;  $P(d) = 1$  if  $|d| > p$ , there is a strong preference;  $P(d) = (|d| - q)/(p - q)$  else, there is a weak preference.

Let  $a$  and  $b$  stand for two items and let  $d(a,b)$  be the difference of their evaluations on a criterion  $c$ . We assume that a positive  $d(a,b)$  corresponds to a preference for  $a$  over  $b$ . The preference function  $P(d(a,b))$  is assumed to take the value 1 as soon as the preference is strong (= clearly stated), i.e., when  $|d| > p$ , the preference threshold, and is assumed to take the value 0 when an indifference between  $a$  and  $b$  is decided, since their evaluation difference does not reach the threshold  $q$ . Between these two

decisions, a weak preference is expressed and  $P$  linearly increases with  $d$ .

Thus, this criterion states that  $a$  is surely preferred to  $b$  when  $P(d(a,b)) = 1$ . For the sake of simplicity, let us write  $P_c(a,b) \equiv P_c(d(a,b))$ : the preference function for the criterion  $c$ .

The method defines then a multi-criteria preference index as the weighted average of the preference functions  $P_c$  for all criteria. In our application, we considered that the three criteria of each point of view had the same weights<sup>2</sup>. The index  $Phi(a,b)$  is computed by the next equation:

$$Phi(a,b) = (P_1(a,b) + P_2(a,b) + P_3(a,b))/3. \quad (2)$$

This index is called the (multi-criteria) preference flow of  $a$  over  $b$ . We are more confident that  $a$  is preferred to  $b$  according to all criteria of the considered family, when the flow value is closer to 1. Of course,  $a$  is surely preferred to  $b$ , when the unanimity of criteria is in favour of  $a$ , and  $Phi(a,b) = 1$  then. At this stage, Promethee proposes to build a graph on the set  $K$  of considered items: its nodes are all of the compared items:  $a, b, c, \dots$  of  $K$ ; the arcs joining two items are valued by  $Phi(a,b)$  and  $Phi(b,a)$  for a pair  $(a,b)$ . Then, the method computes two flows for an item  $a$ :

$$Phi^+(a) = \sum_{b \in K} Phi(a,b) : \text{the leaving flow;}$$

$$Phi^-(a) = \sum_{b \in K} Phi(b,a) : \text{the entering flow.} \quad (3)$$

One may interpret the leaving flow as a multi-criteria force of preference of  $a$  on the other items in  $K$ , and the entering flow as a multi-criteria preference weakness of  $a$ .

In Promethee II, a balance of flows is completed, delivering  $a$  net preference flow for each item  $a$  on all of the others items and for all criteria of the family:

$$Phi(a) = Phi^+(a) - Phi^-(a) : \text{the net flow in favour of } a. \quad (4)$$

Usually, by ranking the net flows in a decreasing order, we obtain the preference ranking of the items, the positive flows being associated to the dominating items and the negative ones to the dominated ones. An important point is that we did not divide the flows by  $(n - 1)$ ,  $n$  being the number of items in Eq. (3), like in the classical method, in order to point out the maximum number of possible dominances.

#### 3.3. Methodology of the multi-criterion analysis at three levels

In order of analyzing by a multi-criterion method the performances of the telecommunication sectors in the four

<sup>2</sup>In a decision aid context, there is a subtle aid to supply to the deciders for the choice of weights attributed to the criteria (for instance, the software visual decision and, in some respect, ARGOS present a special aid for this allocation of weights). In a context of multiple criteria analysis where no stakeholders are considered, the choice of weighting must be neutral if no socio-economic consideration indicates a special weighting. This is the reason why we have adopted everywhere the same weights of criteria, families and dimensions of performance.



Table 4  
Multi-criterion data representing the networks of 4 countries of Maghreb

Networks of the country	Years	Outgoing total traffic [minutes] (1)	Personnel (full time) (2)	Principal lines (3)	Teledensity* (4)	Income [USD] (5)	Investment [USD] (6)	Population (*1000) (7)
Algeria	1992	118 014 368	19 208	962 247	36.627	245 192 307	173 397 435	26 271
	1993	78 289 000	22 712	1 068 094	39.715	287 066 381	148 479 657	26 894
	1994	79 000 000	18 492	1 122 409	40.820	250 114 090	108 528 237	27 496
	1995	84 332 632	18 423	1 176 316	4.921	224 464 960	77 465 379	28 060
	1996	93 040 368	18 554	1 278 142	44.743	227 506 849	128 493 150	28 566
	1997	157 712 352	18 817	1 400 343	48.213	224 345 867	98 631 086	29 045
	1998	121 282 248	18 230	1 477 000	50.056	287 248 893	146 305 754	29 507
	1999	143 415 168	17 809	1 600 000	53.422	290 821 691	114 465 975	29 950
	2000	151 837 328	17 900	1 761 327	57.965	305 607 228	105 465 311	30 386
	2001	209 191 000	17 900	1 880 000	60.968	361 642 061	96 464 646	30 836
Morocco	1992	102 577 360	11 484	654 000	25.600	563 700 234	257 611 241	25 547
	1993	125 073 168	12 632	827 000	31.724	500 537 634	193 655 913	26 069
	1994	130 011 616	13 396	1 007 000	38.621	550 108 695	269 130 434	26 074
	1995	129 986 000	14 626	1 128 000	42.373	659 367 681	312 412 177	26 621
	1996	129 343 496	14 772	1 208 000	44.461	695 183 486	197 591 743	27 170
	1997	149 570 000	14 208	1 300 528	47.261	683 001 049	180 797 481	27 518
	1998	181 000 000	14 150	1 393 355	50.316	773 541 666	131 666 666	27 692
	1999	219 500 000	14 068	1 471 000	52.786	867 857 142	237 346 938	27 867
	2000	245 000 000	14 511	1 425 000	49.643	1 128 880 526	221 072 436	28 705
	2001	270 000 000	16 200	1 191 335	40.841	1 415 929 203	229 209 687	29 170
Mauritania	1992	4 357 334	400	6 750	3.262	25 830 173	1 401 815	2 069
	1993	4 277 511	410	7 499	3.531	20 428 772	3 294 429	2 124
	1994	4 503 822	456	8 426	3.865	24 081 566	9 443 275	2 180
	1995	4 127 943	451	9 249	4.135	24 936 425	12 391 153	2 237
	1996	4 889 159	443	10 204	4.444	27 444 978	17 431 861	2 296
	1997	5 475 163	456	13 045	5.535	29 720 118	12 683 569	2 357
	1998	6 300 266	454	15 030	6.213	28 278 862	5 565 577	2 419
	1999	8 078 267	480	16 525	6.655	2 880 974	4 095 269	2 483
	2000	9 029 041	720	18 969	7.445	25 230 202	4 830 423	2 548
	2001	9 800 000	600	25 199	9.640	26 905 588	4 462 846	2 614
Tunisia	1992	68 767 000	7 500	374 848	44.329	200 000 000	126 136 363	8 456
	1993	69 392 000	6 314	421 362	48.679	194 000 000	129 000 000	8 656
	1994	80 000 000	6 432	474 253	53.978	218 811 881	121 782 178	8 786
	1995	87 529 704	5 800	521 742	58.217	262 105 263	134 736 842	8 962
	1996	94 052 984	5 975	584 938	63.984	296 907 216	198 969 072	9 142
	1997	97 903 000	6 221	654 242	70.821	326 126 126	138 738 738	9 238
	1998	115 000 000	6 421	752 180	80.576	350 877 192	156 140 350	9 335
	1999	140 000 000	6 567	850 381	89.892	378 151 260	104 201 680	9 460
	2000	164 000 000	7 011	955 131	99.638	400 729 927	159 124 087	9 586
	2001	174 000 000	7 400	1 056 209	108.887	475 694 444	212 500 000	9 700

\* This column is expressed in:  $\div$ 1000 inhabitants.

Sources: Algeria – Ministry for the Post and Telecommunication (MPT); Morocco – National Office of the Post and Telecommunications (NOPT); Mauritania – Office of the Post and Telecommunications (OPT); Tunisia – Tunisia Telecom.

Table 5  
Ventilation of the criteria according to the families and dimensions, the thresholds

Dimensions, families, criteria	Threshold $q$	Threshold $p$	Criterion direction
<b>Technical-economic evaluation</b>			
Economic family of criteria:			
– traffic part for 1000 inhabitants = (1)/(7)	500	5000	Max
– traffic(*1000 min)/sector income = 1000*(1)/(5)	10	100	Max
– investment part for 1000 inhabitants = (6)/(7)	500	5000	Max
Lines family of criteria:			
– teledensity = (4)	5	50	Max
– number of lines/number of personals = (3)/(2)	2	20	Max
– number of lines/sector investment = (3)/(6)	1	100	Max
<b>Sector performance evaluation</b>			
Traffic family of criteria:			
– traffic/number of lines = (1)/(3)	20	200	Max
– traffic/number of personals = (1)/(2)	100	1000	Max
– traffic/investment = (1)/(6)	0.25	1	Max
Income family of criteria:			
– sector income/number of lines = (5)/(3)	200	2000	Max
– sector income/number of personals = (5)/(2)	1000	5000	Max
– sector income/sector investment = (5)/(6)	2	8	Max

Maghreb countries, we took as a starting point the work [7]. Authors based their analysis on two dimensions of performance of the public companies: namely the effectiveness of the public service and the efficiency of those in terms of using resources. These authors constituted a hierarchy at 3 levels of the selected criteria. Here we have initially incorporated 3 basic criteria to constitute a coherent family and that for 4 families, which are then gathered into two dimensions of analysis. Table 5 presents this hierarchy and the preference and the indifference thresholds of the adopted twelve pseudo-criteria. According to the first dimension described as technical-economic, we aim at collecting the performance of the sector from the points of view of the user in technical terms and of the economic health of the sector: they will be the two families: economic and lines. This first dimension is a general performance function measuring the importance of the (public) service given to the user and to the country by the telecom sector. The second dimension evaluates the physical and financial enterprise performances of the set of companies of the telecom sectors; this is done by countries and they are entitled under the names of family: traffic and income. We adopted only one type: the linear pseudo-criterion (with two thresholds of decision), since this type fits well less reliable data than usual and avoids a strong preference for a small variance. The first threshold ( $q$ ) is the limit between a decision of indifference between two actions and a decision of weak preference.

For the calculation of multi-criterion preference flows of all sectors, we used software ARGOS [5], which has the advantage of being able to treat directly two levels of hi-

erarchy of criteria. Recall however that the multi-criterion flows are not reduced in an interval  $[0,1]$  in this software, as it was in the original Promethee method.

Table 5 synthesizes the criteria and the families with their thresholds. The second column indicates the thresholds  $q$  which mark the end of an indifference between two operators due to the weakness of the differences in evaluation between these two operators on a same criterion; a third column indicates the thresholds  $p$  and a last column shows the preferable direction (max or min) for each criterion.

### 3.4. Interpretation of the results of the multiperiod and multi-criterion rankings

According to Table 5, we got three levels of analysis of the performances of the telecom sectors in Maghreb for every year 1992 to 2001. At the upper level, we obtained Table 6 that is the aggregation of preference flows of Table 7, that are the four applications of Promethee II to the data of Table 4 for each family of criteria, taking into account the ventilation and the thresholds of Table 5. Each cell of Table 7 contains a multi-criterion net preference flow (multiplied by ten for more readability) indicating how much the corresponding country sector dominates the other ones in this family, if it is positive. A negative flow indicates how much the sector is dominated by the others in its family. For instance in 1992, the Mauritanian sector dominates the 3 other sectors in traffic and income (the flow is then  $+30/10 = +3$ ). All other figures results of flows additions, vertically or horizontally. The horizontal total additions

Table 6  
Promethee II preference flows of general performance dimensions by sub-periods for telecom  
in four Maghreb countries

Years	Algeria		Morocco		Mauritania		Tunisia		Balances
	Enterprise performances	Service	Enterprise performances	Service	Enterprise performances	Service	Enterprise performances	Service	
1992	-32	12	-5	-1	60	-39	-22	27	0
1993	-27	-6	-2	6	30	-38	-2	39	0
Before change	-59	6	-7	5	90	-77	-24	66	0
1994	-27	-6	-3	7	30	-38	1	36	0
1995	-24	-3	-9	3	28	-37	5	37	0
1996	-30	-1	-10	-5	32	-32	7	39	0
1997	-20	4	-14	-1	28	-40	5	38	0
During change	-101	-6	-36	4	118	-147	18	150	0
1998	-30	2	-3	-3	32	-40	2	40	0
1999	-31	-1	-5	2	32	-41	5	39	0
2000	-19	1	7	-6	9	-36	3	41	0
2001	-22	7	9	-11	15	-35	-2	39	0
After change	-102	9	8	-18	88	-152	8	159	0
Total	-262	9	-35	-9	296	-376	2	375	0

Source: calculation of Karim Sabri from ARGOS results.

Table 7  
Promethee II preference flows of performance by families of criteria by sub-periods for telecom  
in four Maghreb countries

Years	Algeria					Morocco					Mauritania					Tunisia					Balances
	Traffic	Income	Economic	Lines	Total	Traffic	Income	Economic	Lines	Total	Traffic	Income	Economic	Lines	Total	Traffic	Income	Economic	Lines	Total	
1992	-14	-18	7	5	-20	-3	-2	-6	5	-6	30	30	-23	-16	21	-12	-10	21	6	5	0
1993	-12	-15	-6	0	-33	-1	-1	-1	7	4	6	24	-21	-17	-8	6	-8	28	11	37	0
Before change	-26	-33	1	5	-53	-4	-3	-7	12	-2	36	54	-44	-33	13	-6	-18	49	17	42	0
1994	-15	-12	-7	1	-33	-3	0	0	7	4	10	20	-20	-18	-8	8	-7	26	10	37	0
1995	-10	-14	-4	1	-27	-6	-3	-2	5	-6	8	20	-18	-19	-9	8	-3	24	13	42	0
1996	-15	-15	-1	0	-31	-6	-4	-9	4	-15	12	20	-13	-19	0	9	-2	24	15	46	0
1997	-5	-15	4	0	-16	-9	-5	-6	5	-15	9	19	-20	-20	-12	5	0	23	15	43	0
During change	-45	-56	-8	2	-107	-24	-12	-17	21	-32	39	79	-71	-76	-29	30	-12	97	53	168	0
1998	-15	-15	4	-2	-28	-3	0	-8	5	-6	14	18	-20	-20	-8	5	-3	23	17	42	0
1999	-17	-14	0	-1	-32	-10	5	-1	3	-3	20	12	-21	-20	-9	8	-3	21	18	44	0
2000	-6	-13	-1	2	-18	-4	11	-5	-1	1	8	1	-16	-20	-27	2	1	22	19	44	0
2001	-9	-13	1	6	-15	-5	14	-5	-6	-2	15	0	-16	-19	-20	-2	0	20	19	37	0
After change	-47	-55	4	5	-93	-22	30	-19	1	-10	57	31	-73	-79	-64	13	-5	86	73	167	0
Total	-118	-144	-3	12	-253	-50	15	-43	34	-44	132	164	-188	-188	-80	37	-35	232	143	377	0

Source: calculation of Karim Sabri from ARGOS results.



give zero, since the flows of dominating sectors are exactly compensated by those of the dominated ones.

Let us interpret some figures of Tables 6 and 7. For instance we shall compare the first line representing the year 1992 and the last line of the year 2001. In these lines, we observe first the traffic performance, remembering that the traffic family will synthesize 3 criteria that are the ratios where the importance of traffic is reported respectively to the number of lines, to the number of personals and to the investment. These 3 ratios can be considered as 3 measures of productivity in terms of traffic produced by the available resources of each sector in lines, manpower and capital variation. In 1992, we observe that Mauritania has a positive flow of 30 while Morocco, Tunisia and Algeria have the three negative flows -3, -12 and -14 respectively. For understanding well these figures, we must remember that we proceed to a multiple criteria comparison of *relative* performances of the 4 sectors and that the sum of these four figures is zero (at the rounding close) – the balance of flows by family and by line should be zero. By obtaining a high positive preference flow of 30, we see that the telecom sector of Mauritania in 1992 is dominating the other 3 sectors of Morocco, Tunisia and Algeria in terms of its capacity to produce good ratios traffic/resources. The Algerian and Tunisian sectors have relatively weak ratios.

Nine years later in 2001, the situation of this family is quasi similar except for 2 observations: if the dominance of the Mauritanian sector (a flow of 15) on the 3 others still exists, its importance has been divided by 2, while the Tunisian sector is now second in the ranking for this family. Let us consider for these two lines 1992 and 2001, the relative performances in terms of production of income with these same resources, i.e., the family of income.

In 1992, the situation of the four compared sectors is nearly the same for this ratio income/resources: Mauritania has the same dominance (30) and the ranking is identical; this is not a surprise since a higher traffic for given resources should generally produce a higher income. However, it must be observed that the Moroccan sector has reached the Mauritanian sector performances in 2000 with a flow of +11 in 2000 and +14 in 2001. This disparity of performance of the Moroccan sector in terms of traffic and income could be explained by an increasing of the price paid by minute in this sector since 2000. This tendency of a better relative financial performance of the Moroccan sector is perceptible during all the sub-period 1998–2001 that follows the phenomena of privatization of this sector.

If we aggregate the flows of the 2 families for obtaining the flows of the general enterprise performance showed in Table 6, we are not surprised that the Mauritania's sector is still considered more dominating in 1992 with a mark of 60. Since the traffic and the income ratios reported to the same resources are normally highly correlated, it seems that there is some kind of double counting in these aggregated flows in this dimension of enterprise performances. This potential double counting tends to disappear when a dif-

ferential of prices marks the compared sectors like in the years 2000 and 2001.

Until now, we can summarize our analysis by observing that the Mauritanian sector has higher ratios of traffic and income than the 3 other sectors but that this relative better performance is no more true with respect to the Moroccan sector that becomes the best or equivalent in terms of income and not in terms of traffic at the end of the period 1992–2001. The last observation that the Moroccan sector has relatively progressed in terms of income but not in traffic ratios may leave us with the supposition that the privatization was not so favourable to the consumer who will pay a relatively higher unit price.

So it is useful to observe the other general objective of a telecom sector: **its capacity to supply some public service**, measured here by the production of lines by 1000 inhabitants and by used resources in terms of manpower and investment for the family lines, and measured for the family economic by the traffic and the investment of the sector reported to the number of 1000 inhabitants or to the sector income. As the theory announced it, there may exist some conflict between the two general objectives of the enterprise performance and of the public service, although the relative excellence of a sector would be to be very good in the two dimensions. Clearly this kind of relative excellence is not reached by any Maghrebian telecom sector. Indeed, we observe on Tables 6 and 7, that the Mauritanian sector, that is the best in terms of enterprise performances, is also the worst in terms of service to the consumers and to the economy, and that for all the period 1992–2001. This result is no more astonishing if we recall that the Mauritanian telecom sector is still little developed.

From a very general point of view, by looking at the total of flows for the whole period at the bottom of Table 6, we read the following figures for the service: Tunisia 375, Algeria 8, Morocco -10 and a very low score of -374 for Mauritania!

This clearly means that the Tunisian telecom sector produced the relatively best service in Maghreb and the Mauritanian one the relatively worst. For the other dimension of enterprise performances, it is also clear that the Mauritanian sector was the best with a score of 297 and the Algerian one was the worst with a mark of -261.

The general rankings according to each of these 2 dimensions and together are thus:

- **Enterprise performances:**

- |                      |                    |
|----------------------|--------------------|
| 1. Mauritania (296), | 3. Morocco (-35),  |
| 2. Tunisia (2),      | 4. Algeria (-262); |

- **Service technical-economic:**

- |                   |                       |
|-------------------|-----------------------|
| 1. Tunisia (375), | 3. Morocco (-9),      |
| 2. Algeria (9),   | 4. Mauritania (-376); |

- **Together:**

- |                   |                      |
|-------------------|----------------------|
| 1. Tunisia (377), | 3. Mauritania (-80), |
| 2. Morocco (-44), | 4. Algeria (-253).   |

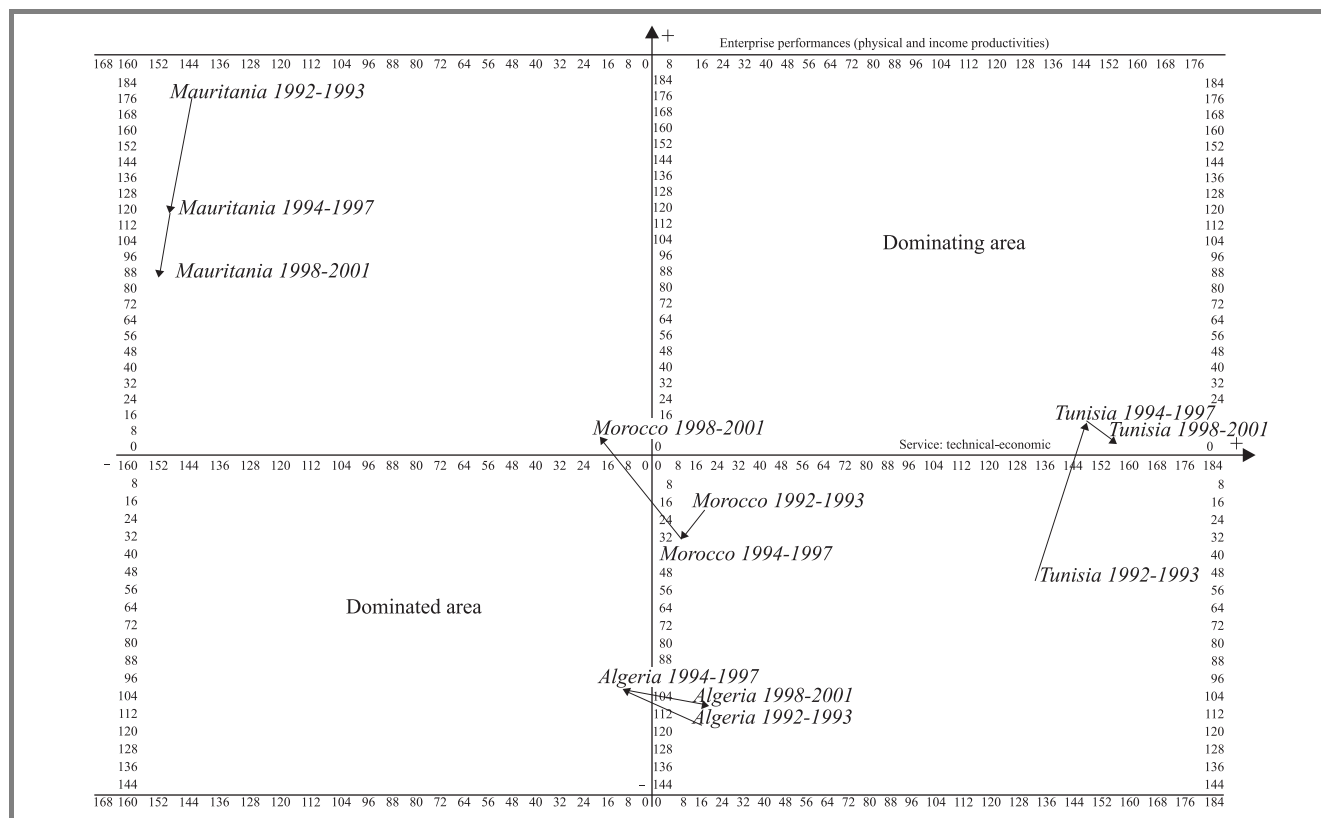


Fig. 3. Relative positions and moves of the telecom sectors in terms of performances versus service (1992–2001).

Finally, let us observe that the Tunisian telecom sector is the sole sector having a positive preference flow for the two dimensions for all the period (3;375): it is not so far from a relative excellence<sup>3</sup> in Maghreb.

### 3.5. Interpretation of the results by sub-periods

The main changes of laws and regulation for the Maghrebian telecom sectors took place during the sub-period 1994–1997. Therefore, we want to compare the changes of relative positions of the telecom in the four countries between the three sub-periods: before the change (1992–1993), during the change (1994–1997) and after the change (1998–2001). Thus, we shall use the corresponding lines in Tables 6 and 7 that have been visualized under the form of moves in the three figures (Figs. 3–5). First, let us remark that in Tables 6 and 7 and in Figs. 3–5, the figures of the sub-period totals before change have been doubled for a possible comparison with the other sub-periods totals that aggregate the flows of 4 years rather than 2 years. Also, in Fig. 3, the relative flows per period for the four telecom sectors have been mapped into the two dimensions (enterprise and service performances), in Fig. 4, the map-

<sup>3</sup>It must be underlined again that all performances are only expressed in **relative terms** issued from the comparison and that no assessment of absolute value is attempted in this method.

ping is done for the two components of service: economics and lines and the mapping of the two other components of enterprise performance: traffic and income productivities is sketched in Fig. 5.

By looking at Fig. 3, the following general moves between periods can be observed:

1. Tunisia’s sector, that had the best position in terms of service but a dominated position in terms of enterprise performance before the change, seems to benefit of the change in improving a bit its enterprise performances by passing in a dominating position (positive flows) during and after the change periods.
2. Mauritania’s sector, that had the best position in terms of enterprise performance but a dominated and the lowest position in terms of service before the change, seems to deteriorate relatively its enterprise performances, however keeping its leader’s position (positive flows) during and after the change periods.
3. Morocco’s and Algeria’s sectors are and remain in median positions with respect to the service, while Algeria’s sector remains in the lowest position in terms of enterprise performances all through the changes.
4. We can summarize the ranks evolutions in Table 8.

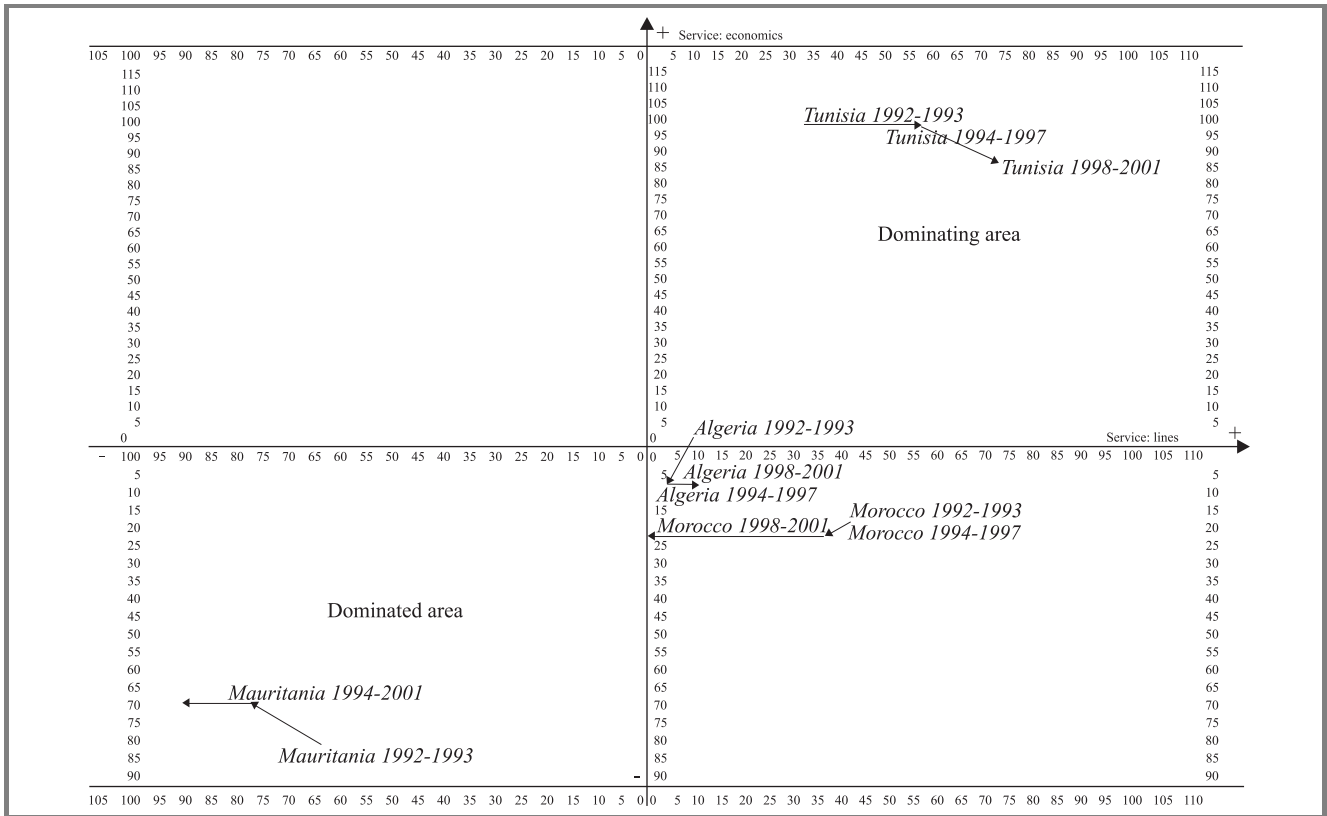


Fig. 4. Relative positions and moves in service performances in terms of economy and lines (1992–2001).

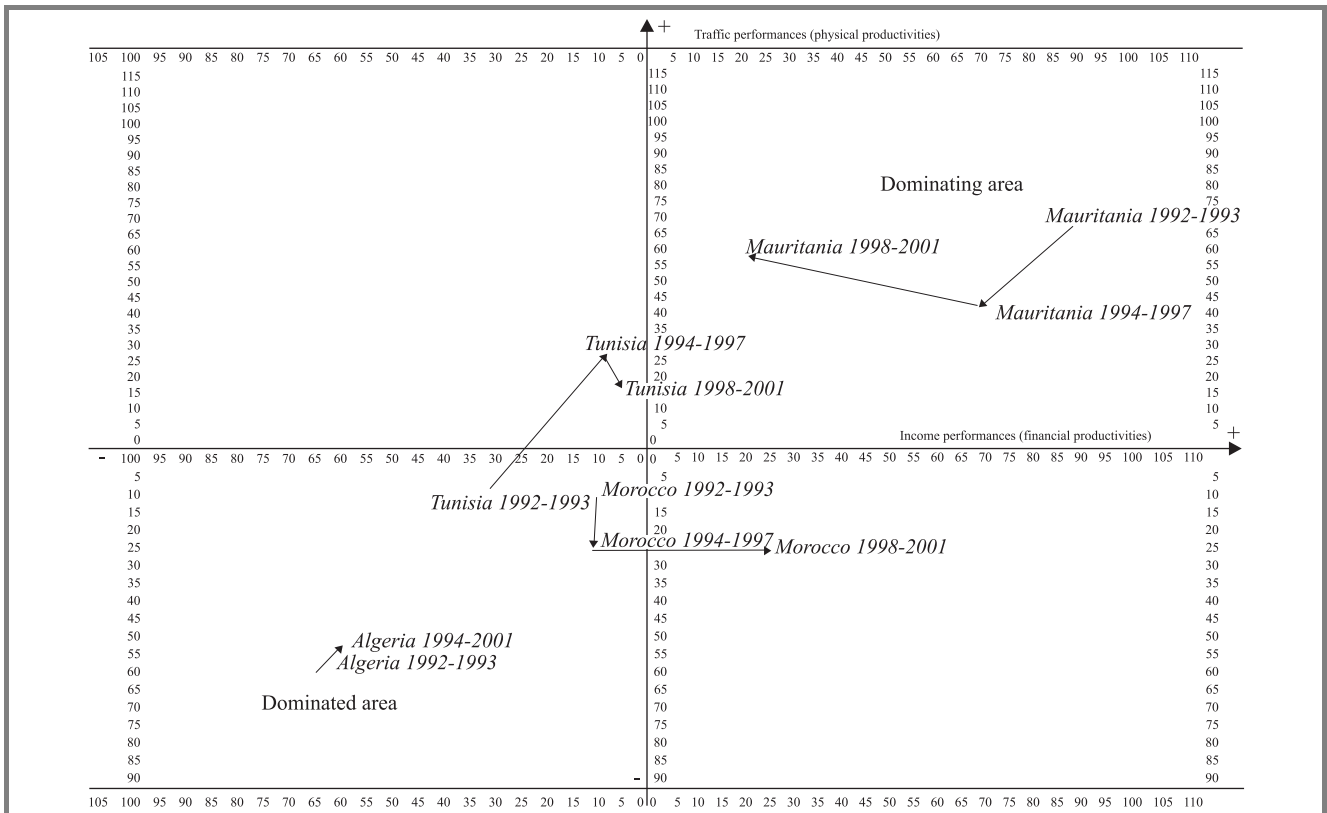


Fig. 5. Relative positions and moves in enterprise performances in terms of traffic and income (1992–2001).

Table 8  
The telecom sectors' ranks for each sub-period and by dimension; the general ranking of the countries sectors for 1992–2001

Sub-periods	Sector of the country							
	Algeria		Morocco		Mauritania		Tunisia	
	Performance	Service	Performance	Service	Performance	Service	Performance	Service
1st sub-period 1992–1993	4	2	2	2	1	4	3	1
2nd sub-period 1994–1997	4	<b>3</b>	<b>3</b>	2	1	4	<b>2</b>	1
3rd sub-period 1998–2001	4	<b>2</b>	3	<b>3</b>	1	4	2	1
1992–2001 ranks	4	2	3	3	1	4	2	1
General ranking	4		2		3		1	
Note: the changes of ranks from one sub-period to another are in bold characters.								

The consideration of the small and few changes of ranks from one sub-period to another reveals the weak influence of the technological and lawful changes on the relative positions of the telecom operators in Maghreb. Although its relative backward in terms of service, the Mauritanian telecom sector remains in the same positions: 1st on the enterprise performance and last (4th) on the service, all through the sub-periods. Except for Tunisia, the changes of ranks are not significant. *We could say that the Tunisian telecom sector benefited more than the others of the changes in laws and techniques, during the sub-period 1994–1997.*

Looking now at the level of families, we consider Figs. 4 and 5.

In Fig. 4, the service supplied by the sectors is decomposed into the physical service of production of lines and the influence to economy.

The issues are as follows:

1. The Tunisian sector maintains its high positive flows all through the period with an improvement of the productivity on lines and a small decrease of the economic flows.
2. The Mauritanian sector is nearly stationary with a small increase of economic flows counterbalanced by the small decrease of the productivity on lines.
3. In the middle remain positioned Algeria's and Morocco's sectors that change a little.
4. There is a significant relative decrease of the productivity on Moroccan lines and a less important decrease in both components of service for the Algerian sector.

On Fig. 5, the enterprise performances achieved by the sectors are decomposed into the physical traffic and financial income reported on the used resources. The issues are as follows:

1. Here, the relative moves are greater, except for the Algerian sector, that improves a little both performances.
2. Like for the falling move in economic service, the Mauritanian sector movement is characterized by a considerable fall of flows in the income ratio and a small decrease of the traffic ratio followed by an increase. This differential of behaviours is explained by a fall of the unit prices of Mauritanian telecommunications with the respect to other Maghrebian prices, and by the increase of Moroccan unit prices.
3. Both Tunisian performances are marked by a considerable relative improvement during the change period, followed by a small decrease of the sole productivity on lines.
4. After a short fall in both components of performance enterprise, the Moroccan sector makes a bound of income performance in 1998–2001 while the physical performance remains stationary. Combining this observation with the point 2, it appears clear that a differential of unit prices between Morocco and Mauritania is the probable cause of such compensatory moves of relative financial performance of both sectors.
5. The Algerian sector sees its physical more than its financial enterprise performance progresses slightly.

Summarizing the issues about sub-periods moves, observed in Figs. 4 and 5, and Tables 6, 7 and 8, we could dare the following conclusions:

1. In terms of enterprise performances, there is some centripetal tendency to a convergence of performances of the telecom sectors in Maghreb.
2. But in terms of service to the community, the divergence is rather observed for the two extremes: Tunisian and Mauritanian sectors, the Tunisian telecom increasing its advance in lines production and the Mauritanian telecom being distanced.

#### 4. Synthesis and conclusion

According to the productivities analysis, the Malmquist index revealed a general growth of the Maghrebian telecom productivities, reaching only 3.7% on a decade 1992–2001, decomposed in 2.5% due to the technological change and 1.2% in a better management. These growths are very unequal for the four compared countries, attaining 9.1% for Tunisia, 7.6% for Morocco, 4.9% for Algeria while Mauritania had a negative growth of 6%. Now in all these countries, we observed very small changes due to the management change and this result may indicate that the regulatory reforms and privatisation has not yet produced their expected effects of improvement of the management.

We enlarged the scope of analysis in the Promethee II multiple criteria comparisons of the four countries, taking into account the two general objectives of a utility enterprise: the performances of the enterprises in the sector, on one hand, and the service given to the community, on the other hand. According to these two classical dimensions, we observed, without a great surprise, that the leader in enterprise performances: Mauritania's sector becomes the last ranked in service. This is some confirmation of the theoretical hypothesis that it is difficult to be the best or even good in both dimensions, which are often in conflict. However, the Tunisian sector is close to the relative excellence, by being largely the best in service and the second in enterprise performances. More details were obtained in decomposing these two general objectives, each one into two families of criteria.

For the first dimension: the enterprise performances, the productivities of the resources were declined in terms of traffic and of income of the telecom sectors. Of course, these two kinds of ratios are mainly different by the unit price of the traffic: when the countries tariffs are constant or have the same moves, both ratios produce the same moves. So, the Mauritanian sector practiced a strong unit prices decrease from 1995 to 2001 while a small unit prices rise was observed in Morocco since 1998. These corresponding "bad" income performance move for Mauritania and "good" income performance move for Morocco were indeed a benefit for the Mauritanian consumers and a loss for the Moroccan ones, since both traffics increased in the same periods. For the second dimension: the relative service

progress in lines productivity was observed for the service leader, i.e., the Tunisian sector of telecom.

In terms of evolution of the relative positions of the different sectors, we tried to observe the impact of regulatory and competition changes on these countries relative positions: the main conclusion for these moves through the three sub-periods of analysis is that only small changes of ranks were observed revealing the weak influence of the technological and lawful changes on the relative positions of the telecom operators in Maghreb. This latter conclusion, in turn, can be explained by two hypotheses: either the differences in technical and legal evolutions are too weak or these differences have not yet produced all their effects.

A last comparison was potentially possible between the results issued from the Malmquist DEA TFP index analysis and the Promethee method. From a general point of view, the rankings of the countries telecom sectors were similar. According to the Malmquist index, the best progress was observed in Tunisia, then for Morocco, Algeria being the third and Mauritania being the last with a regression while in terms of management progress, Morocco is a bit before Tunisia, both before Algeria and Mauritania. By adding the preference flows of the two dimensions service and enterprise performance, we obtained the ranking: the Tunisian sector remains the leader, then comes the Moroccan sector followed by the Mauritanian sector, far before the Algerian one. The only difference of general ranking between both methods bears on the last position of Mauritania's or Algeria's sectors. Now, on the field, we can consider that these two countries as nearly incomparable in terms of populations, political regimes, and telecom sectors. Anyway the two methods of analysis are indeed different in scope and used data and they give complementary information. While the Malmquist index analysis can separate the effects of technological and management changes, the 3-levels multiple criteria method can score the preference flows via two levels of aggregation and highlights the two dimensions of service and enterprise performance, useful to fully evaluate a utility sector like the telecom.

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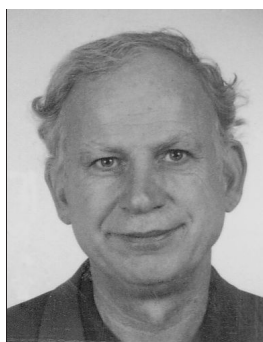
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