The efficiency analysis for Moldavian industry

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Abstract: In this paper we present a method for measuring the efficiency for any economical branch. We construct the econometric approach of production frontiers, using the DEA technique (Data envelopment analyses), based on the mathematical programming approach. We effectuate an analysis of some certain data concerning the efficiency or the inefficiency of the branches, using the Efficiency Measurement System Program (EMS).
Key words: efficiency measurement, production frontier, technical efficiency, allocative efficiency.

1 Introduction

The last decade of century marked major political changes for Moldova. Such events as the political independence of Republic in 1991, the introduction of national currency in 1993 led to great perturbations in economics, based on a new creative mentality. The first official document of consolidation of the new judicial, economical (including financial-bank) as well as the institutional instruments can be considered as the parliament Law adopted in 1990 "Concerning the Conception to adopt market economy in the Republic of Moldova". The economic of Republic in this period is characterized by the accomplishing of some great reforms, that also characterize the economic changes, which occur now. In some economical branches it can be noticed disappearances or dramatically jumps in the development, that identify achievements in reorganization and productivity reorientation.

2. Technique for efficiency measurement

The programming approach can be categorized according to the type of data available (cross-section or panel), and according to the type of variables available (quantities only, or quantities and prices). With quantities only, technical efficiency can be calculated, while with quantities and prices economic efficiency can be calculated and decomposed into its technical and allocative components, just as in the econometric approach.

The "data envelopment analysis" (DEA) [3] is a descriptive title for the mathematical programming approach to the measurement of efficiency relative to a production frontier. The frontier is calculated so that it envelops the data as tightly as possible, subject to various constraints (convexity, disposability, scale restriction) without imposing possibly misleading parametric structure on technology, choosing instead to let the data reveal the structure of technology. Since its setting up in 1978, with the study of Charnes, Cooper and Rhodes, the DEA methodology has been developed from a single linear programming model into a vast and still growing family of mathematical programming models. In what follows we shall describe the most simple, most restrictive DEA model assuming convexity of the set of feasible input-output combinations, strong disposability of inputs and outputs and constant returns to scale.

Suppose producers use input vector $\chi = \left(\chi_{1,\dots,}\chi_N\right) \in R_+^N$ to produce output vector $\gamma = \left(\gamma_1,\dots,\gamma_M\right) \in R_+^N$. We refer to affine displacements of the input and output vectors by means of $\overline{\chi_i} = \chi_i + \alpha$, $\alpha \geq 0$, and $\overline{\gamma_i} = \gamma_i + \beta$, $\beta \geq 0$, $i = 1,\dots I$, so as to eliminate zero or negative values that may exist in χ_i and γ_i. Thus $\overline{\chi_i} \in R_{++}^N, \overline{\gamma_i} \in R_{++}^M, i = 1,\dots,I.$ Further we consider $\chi_i = \overline{\chi_i}, \gamma_i = \overline{\gamma_i}, i = 1,\dots,I.$

Consider a set of I producers using vector $x \in R_{++}^N$ to produce output vector $y \in R_{++}^M$. Let x_0, y_0 be the input-output vector of the producer being evaluated and (x_i, y_i) the input-output vector of the i-th producer in the sample. The objective is to analyze the performance of comparing each producer to the best-observed practice in the sample. In order to do that, we search for a set nonnegative weights which, when applied to each of producer's inputs and outputs, minimizes the ratio of weighted input to weighted output for the producer under evaluation, subject to the normalizing constraint that no producer in the sample has a ratio less than unity as is developed in [4].

$$\min_{\varsigma,\nu} \frac{\varsigma^T x_0}{\mu^T y_0},$$

$$\frac{\varsigma^T x_i}{\mu^T y_i} \geq 1, \quad i = 1,\dots,0,\dots,I,$$

$$\mu, \varsigma \geq 0,$$

where: T means an operation of transposition.

The previous nonlinear ratio model is converted into a linear programming problem via the change of variables:

$$u = t\mu, \quad \nu = t\varsigma, \quad t = (\mu^T y_0)^{-1};$$

The dual linear programming "envelopment" of the last converted is the next:

$$\max_{0,\nu} 0,$$
$$X\lambda \le x_{0,} \qquad \lambda \ge 0.$$
$$0y_0 \le Y\lambda,$$

where: X is an N*I input matrix with columns $x_{i,}$, Y is an M*I output matrix with columns y_i and λ is an I*1 intensity vector. The problem is output oriented, which means that the performance of a producer is evaluated in terms of his ability to radial expand his output vector, and to subject to the constraints imposed by the best observed practice. We may now observe that optimal 0=1 is necessary but not sufficient for a producer to be technically efficient in the sense of Koopmans, since ($0y_0, x_0$) may contain slack in any of its (N+M-1) dimensions.

3. The Data Analysis.

We have chosen two inputs and two outputs. As inputs we decided to use Investments, **Employees,** and as outputs – the **Volume of Industrial Production and the Volume of Export.** (We would like to mention that in export tables we've included the intermediary export. As a result for some branches the volume of export is the biggest production volume).

We have performed two kinds of analyses, a static analysis and a dynamic analysis on a data set for 17 economical branches of Moldova in the 1993-1998 period [7], [8]. To compare the industrial branches among them we have transformed the data of Investments, Volume of Industrial Production and Volume of Export in dollars, then we have converted the data according to 1993 price.

We convert the data using the formula developed in [4], that is the next:

$$\sum_i q_i p_i^b = \frac{\sum q_i p_i^t}{(1+\frac{\text{int}^{b+1}}{100})...(1+\frac{\text{int}^t}{100})}$$

.

Here:

q_i - denotes the investments, industrial productions and export, respectively and expressed in physical units, corresponding to year t,

p_i^b - denotes the price of the reference year,

p_i^t - denotes the price of year t,

int^t -denotes the level of inflation in the year t, relatively to the year (t-1),

int^{b+1} - denotes the level of inflation in the year (b+1), relatively to the year b (reference year).

The data concerning the value rate of exchange and the yearly inflation level have been collected from the yearly Reports of the National Bank of Moldova and are used at estimation of inputs and outputs.

Investments represent expenditures for construction, installations and assembly works, for equipment and transport means of acquisition and other expenditures for the creation of the new fixed assets, for the developing, modernizing, and rebuilding the existing ones.

The distribution of investments among branches of industry has been performed taking into account their destination within economic and social-cultural units according to the classification of the national economy branches.

Indices of the investment dynamics have been calculated on comparable price bases.

Industrial production represents the value sum of delivered finite works (services) with industrial character, semi-manufactured products stock and unfinished productions.

Export represents one of the most important characteristics of a country, which shows us clearly its economic development. Export represents our commercial relationships with the foreign countries, where to sell a part of goods.

The **Employees** indicator measures the average number of employees in different industrial branches (the minimum unit being one thousand people).

4. Technical efficiency analysis

The distance functions are equivalent to Farrell's measure of technical efficiency [4]. It follows that the distance function completely describes technology, and simultaneously provides a very useful measure of deviations from frontier performance of technical efficiency. The choice between weak and strong disposability is important for explaining the origin of inefficiency.

This input (output) distance functions are reciprocals of the Debreu-Farrell input (output)-oriented measures of technical efficiency.

Let $x^t = (x_1^t,...,x_N^t) \in R_+^N$ and $y^t = (y_1^t,...,y_M^t) \in R_+^M$ denote respectively an input vector and an output vector in period t, t =1,…,T, where T means the time during the practical estimations.

* a backward-looking approach which evaluates the performances of the data from periods t and t+1 relative to technology (production possibilities) from period t:

$$M_0^t(x^t, y^t, x^{t+1}, y^{t+1}) = \frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)},$$

* a forward-looking approach which evaluates the performances of the data from periods t and t+1 relative to technology (production possibilities) from period t+1:

$$M_0^{t+1}(x^t, y^t, x^{t+1}, y^{t+1}) = \frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^t, y^t)}.$$

The economic interpretation is that it measures the relative change in either input-conserving or output-expanding efficiency between two periods with reference to the same frontier technology.

4.1 Forward input-oriented analysis.

We performed the registered data of the selected branches according to the input and output structure and calculated the efficiency scores using the DEA technique on the input-oriented analysis. They are annexed in Appendex1. Improvement in productivity occur whenever $M_i(y^{t+1}, x^{t+1}, x^t, y^t) < 1$.We selected the branches more or less near to be efficient.

Scores of Branches that have been efficient at least for two years. Table1.

Branches	1993	1994	1995	1996	1997	1998
Bakery prod.	1125,23	580,24	559,3	440,41	266,08	349,02
Wood furnit.	1156,39	4585,99	1226,67	16,42	8,34	10,48
Tobacco	79,8	170,31	93,64	321,06	284,28	236,71
Soap, det., cosm	184,36	75,45	239,78	158,91	109,82	29,49
Mach., equipm.	17,68	42,24	42,63	68,09	528,92	349,49
Pharm., chemical	104,68	168,87	95,79	106,29	118,22	125,5
Records, TV	110,19	160,75	167,72	341,13	170,64	256,11

Analyzing the efficiency scores from Appendix 1 and Table 1 we can conclude:

1. there were two efficient branches in the Republic during the period 1993 to 1998: *Production of bakery products and the Technical industry (equipment to record and reproduce of TV); the* : *Production of bakery products* has undergone a fall in its efficiency during 1994-1997; *the technical industry* has always been growing efficiently except 1997;
2. *the Pharmaceutics preparations, medical and chemical substances* have been efficient every year, except 1995;
3. there era seven branches, with a negative efficiency during 1993-1998; three branches were efficient just one year;
4. a dramatic decline in *Production of wood, products including furniture* during 1995-1998 has been registered;
5. a considerable growth in the branch of *Machines and equipment's production* has been registered in 1997.

4.2 Forward output-oriented analysis.

According to the registered economical data for the chosen branches we performed the output –oriented efficiency analysis using the same selected inputs and outputs. The obtained efficiency scores are annexed in Appendix 2. A value larger than 1 for $M_0(y^{t+1}, x^{t+1}, y^t, x^t)$ indicates positive productivity growth from period t observation to the period t+1 technology, while a value less than 1 indicates a productivity decline.We selected the branches more or less near to be efficient.

Scores of branches that have been efficient least for two years. Table2

Branches	93	94	95	96	97	98
Bakery prod.	8,89	17,23	17,88	22,71	37,58	28,65
Wood, furnit	8,65	2,18	8,15	609,04	1199,4	954,17
Tobacco	125,31	58,72	106,8	31,15	35,18	42,24
Soap,det.,cosm	54,24	132,54	43,33	62,93	91,05	339,11
Mach.,equipm.	556,66	236,75	234,55	146,87	18,91	28,61
Pharm.,chemical	95,53	59,22	104,4	94,08	84,59	79,68
Records, TV	90,76	62,21	59,66	29,31	58,6	39,05

Analyzing the scores of efficiency from the Appendix 2. and the Table 2 we can conclude:

1. there are two economical branches efficient (the same as the previous analysis) during the entire period 1993-1998;
2. there are seven branches with no efficiency (as in the input oriented analysis) during 1993-1998; three branches were efficient just one year. We detect the same declines and growths for all economical branches (as the input oriented analysis), consequently the same positive or negative frontier shifts.

5. Conclusions

Studying the results of a forward-looking approach we can notice that the both analyses , input and output oriented, concerne:

a) the same economic branches while surveying the efficiency and inefficiency (through the scores of efficiency);
b) the same periods of growth and decline in economical efficiency ;
c) the same dramatic drop in the economic development for the same branches (Wood Production).

Practical results confirm again the theoretical results on maintaining the relations of equiproportionality between inputs and outputs in economic efficiency studies [5], [6].

In conclusion we can affirm, that the DEA technique is efficient concerning the study of the efficiency of any economic branch or sector. The DEA models permit to compare the actual efficiency of every branch witch the optimal efficiency and show the dependence between the observed values of inputs and outputs. We believe that such analysis is very useful for the evaluation of the actual economic situation, and makes a real appreciation of the development or stagnation factors.

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Appendix 1.

Scores of Branches for input oriented analysis (%).

Branches	1993Y	1994Y	1995Y	1996Y	1997Y	1998Y
Bakery prod	1125	580,2	559,4	440,4	266,1	As 30
Wood, furnit	1156	4586	1227	16,42	8,34	10,48
Paper, art.	128,5	66,96	62,59	72,08	58,31	47,84
Rub.plast.ar	30,15	57,41	193,4	60,49	55,8	53,29
Leather,trun	17,8	25,84	19,99	29,38	32,3	13,22
Food, drinks	53,96	87,54	58,86	77,38	66,65	42,09
Tobacco	79,8	170,3	93,64	321,1	284,3	236,7
Textile	46,68	73,59	45,92	56,23	94,39	134,8
Clothes, fur.	16,77	23,49	14,74	21,56	23,45	13,59
Soap,det,co	184,4	75,45	230,8	158,9	109,8	29,49
Mineral prod	61,05	46,3	27,34	25,26	36,72	63,99
Cement, lim	8,66	6,54	3,94	9,14	10,36	8,29
Mach.,equip	17,68	42,24	42,63	68,09	528,8	349,5
Foot-wear	18,03	7,89	3,79	4,14	8,33	6,94
Pharm.,cher	104,7	168,9	95,79	106,3	118,2	125,5
Records,TV	110,2	160,8	167,6	341,1	170,6	256,1
Ind.Wines	61,06	46,13	48,84	48,46	66,2	92

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Appendix 2.
Scores of Branches for output oriented analysis (%)

Branches	1993Y	1994	1995Y	1996Y	1997	1998Y
Bakery prod.	8,89	17,2	17,9	22,7	37,6	28,7
Wood, furnit	8,65	2,18	8,15	609	1199	954
Paper, art.	77,84	149	160	139	171	209
Rub.plast.art.	331,6	174	51,7	165	179	188
Leather,trunk	561,9	387	500	340	310	756
Food, drinks	185,3	114	170	129	150	238
Tobacco	125,3	58,7	107	31,2	35,2	42,2
Textile	214,2	136	218	178	106	74,2
Clothes, fur.	596,4	426	678	464	426	736
Soap,det,cos	54,24	133	43,3	62,9	91,1	339
Mineral prod.	163,8	216	366	396	272	156
Cement, lime	1155	1528	2537	1095	965	1206
Mach.,equipr	565,7	237	235	147	18,9	28,6
Foot-wear	554,5	1267	2635	2417	1200	1440
Pharm.,chem	95,53	59,2	104	94,1	84,6	79,7
Records,TV	90,76	62,2	59,7	29,3	58,6	39,1
Ind.Wines	163,8	217	205	206	151	109