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PRODUCTIVITY ASSESSMENT AND IMPROVEMENT MEASUREMENT OF DECISION MAKING UNITS - AN APPLICATION FOR RANKING CITIES IN ISRAEL

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Abstract: *In this paper we will demonstrate how productivity and improvement rate of urban organizational units (called also Decision Making Units - DMU's) may be assessed when measured along several time periods. The assessment and subsequent ranking of cities is achieved by means of the Data Envelopment Analysis (DEA) methodology to determine DMU's efficiency for each period, the Cross Efficiency ranking method to rank DMU's and the Malmquist Index approach which measures changes in productivity relative to a base period. The above combined methodology will be applied to a case study of 70 Israeli cities in years 2006, 2007 and 2008.*

Key words: *Data Envelopment Analysis (DEA); Malmquist Index; ranking methods*

1. Introduction

Banks, insurance companies, widespread food chains, police stations, etc., are organizations that have several branches and subunits (Decision Making Units - DMUs). Such organizations are often interested in assessing the productivity of their DMU's in two main aspects: 1) Relative efficiency of each DMU per every time period; 2) General improvement trends among DMU's. The importance of this assessment boils down to first know better relative productivity of each DMU as compared to other structural units, and in addition to be aware of improvement trends characteristic of every DMU. Profound knowledge of the above parameters enables decision makers in the regarded organizations to assess better specific performance of each division unit as well as their timely changes, thus contributing to a broader managerial view on every DMU within the organization. In our application we assume that cities are subunits of the organization, and therefore their relative productivities and their improvement trends should be estimated.

Relative efficiency of each DMU (productivity assessment) for every time period may be investigated by means of the DEA methodology (the so-called CCR or BCC models) which have been primarily suggested by Charnes, Cooper and Rhodes (CCR) in 1978 and subsequently developed and expanded by Banker, Charnes and Cooper (BCC) in 1984. The CCR model calculates the Technical and Scale Efficiency (TSE) while BCC determines Technical Efficiency (TE). In addition to that, productivity assessment may be facilitated by means of conventional ranking methods, like the Super Efficiency method (SE) developed by Anderson and Peterson (1993), the Cross Efficiency method (CE) introduced by Sexton et al. (1994), the bi-criteria method for efficient DMU ranking suggested by Hadad and Friedman (2004), as well as a combination of the AHP method (Analytical Hierarchic Process) and the DEA methodology described by Sinuany-Stern et al. (2000). A comprehensive review of contemporary ranking methods can be found in a study by Adler et al. (2002).

In recent years, a variety of scientific papers tackling the problem of productivity assessment by means of DEA and ranking methods, have been published and are available to the broad scientific community. Among others, one should mention Sueyoshi (1992) who measured the industrial performance of 35 Chinese cities by means of Data Envelopment Analysis, Doyle and Green (1994) who ranked 20 universities in the UK; Hadad, et al. (2009), to carry out comparative efficiency assessment and ranking of public defence authority in Israel; Malul, et al. (2009), measuring and ranking of economic, environmental and social efficiency of countries; Hadad, et al. (2007), measuring efficiency of restaurants; Hadad, et al. (2004), evaluating hotel advertisements efficiency using DEA; Hadad, et al. (2004), ranking fish farms.

Relative improvement trend for each DMU may be assessed when comparing productivities determined for every pair of consecutive time periods, or by means of Malmquist Index approach primarily suggested by Caves, et al. (1982) and subsequently developed by Fare, et al. (1985) and Fare, et al. (1994). This method investigates the improvement measure of each DMU during every pair of consecutive time periods. Should the amount of time periods exceed 2, the procedure boils down to determining improvement levels for consecutive time periods with subsequently calculating the mean geometrical product for all values obtained during the regarded complex time period (Coelli, (1996)). Practical implementation of the Malmquist Index approach have been demonstrated by Barros (2006) who investigated relative efficiency of 33 police stations in Lisbon during

2001-2002. In his research, Barros also estimates the total productivity change of the Lisbon Police Force.

In the present paper, we will demonstrate joint implementation of the DEA methodology, the Cross Efficiency ranking method and the Malmquist Index approach for productivity assessment of 70 Israeli cities between 2006-2008. The cities will be estimated every year separately upon a variety of parameters which we will regard as inputs or outputs. In addition, we will verify existence of positive correlation between the productivity ratios calculated by means of the Cross Efficiency method versus the Malmquist Index approach.

Our paper is organized in the following way. The next section introduces the presentation and formulation of DEA procedures, which will be employed in the analysis and the Super Efficiency. The third section presents the Malmquist Index approach. Part four illustrates how to evaluate city advertisements' efficiency using the models that have been described in sections two and three. Finally, the findings are presented along with conclusions and recommendations for future research.

2. Data Envelopment Analysis and Cross Efficiency

2.1. Data Envelopment Analysis

DEA is a procedure designed to measure the relative efficiency in situations when there are multiple inputs and multiple outputs and no obvious objective how to aggregate both inputs and outputs into a meaningful index of productive efficiency DEA was developed by Charnes Cooper and Rhodes (CCR) (1978). The method provides a mechanism for measuring the efficiency of each Decision-Making Unit (DMU).

The efficiency in CCR model is termed Technical and Scale Efficiency (TSE) and the relative efficiency of a DMU is defined as the ratio of its total weighted output to its total weighted input. The BCC model, named after Banker, Charnes and Cooper (1984) allow the production function to exhibit non-constant return to scale (Banker and Chang 1995)) whiles the CCR model imposes the additional assumption of constant returns to scale on the production function.

The formulation of CCR model for unit k is:

$$\text{Maximize } h_k = \sum_{r=1}^{s} U_r^k Y_{rk}$$

subject to

$$\sum_{r=1}^{s} U_r^k Y_{rj} - \sum_{i=1}^{m} V_i^k X_{ij} \le 0 \quad \text{for } j=1,2,..n, \qquad (1)$$

$$\sum_{i=1}^{m} V_i^k X_{ik} = 1,$$

$$U_r^k \ge \varepsilon > 0 \qquad r=1,2,..s,$$

$$V_i^k \ge \varepsilon > 0 \qquad i=1,2,...m.$$

where ε is defined as an infinitesimal constant (a non-Archimedean quantity).

2.2. The Cross Efficiency

The Cross Evaluation matrix was first developed by Sexton et al. (1994). This method calculated the efficiency score of each unit n times using the optimal weights evaluated by each run. The results of all the DEA cross efficiency are summarized in a matrix as given in (2)

$$h_{kj} = \frac{\sum_{r=1}^{s} U_r^k Y_{rj}}{\sum_{i=1}^{m} V_i^k X_{ij}}, \quad j = 1,2,...,n, \quad k = 1,2,...,n. \tag{2}$$

Thus h_{kj} represents the score given to unit j by the optimal weights of unit k. The elements in the diagonal h_{kk} represent the standard DEA scores h_k. The Cross Efficiency ranking method utilized the matrix h_{kj} for ranking the units one scale.

Ranking of DMUs is thus based on the average cross efficiency score being calculated as

$$h_k = \frac{\sum_{j=1}^{n} h_{kj}}{n}.$$

3. The Malmquist Index Approach

To investigate improvement of productivity, Fare et al. (1994) have demonstrated that DEA methodology may be applied to assess Malmquist Total Factor Productivity (TFP) index numbers. As a matter of fact, Malmquist index is an approach enabling relative measurement of productivity changes between consecutive periods of time (e.g., a year). Those productivity changes may be broken down to structural elements depending on technical efficiency enhancement as well as technology changes and progress. The Malmquist DEA approach determines efficiency level in a certain year relatively to the previous one, thus enabling evaluation of productivity improvement between the two consecutive periods.

The Malmquist TFP index measures efficiency in each period t related to the base period s in terms of productivity improvement. Fare et al. (1994) specifies an output based Malmquist productivity change index:

$$m_0(y_s, x_s, y_t, x_t) = \left[\frac{d_0^s(y_t, x_t)}{d_0^s(y_s, x_s)} \times \frac{d_0^t(y_t, x_t)}{d_0^t(y_s, x_s)} \right]^{\frac{1}{2}} \tag{3}$$

where the notations $d_0^s(y_t, x_t)$, $d_0^t(y_t, x_t)$, $d_0^s(y_s, x_s)$, $d_0^t(y_s, x_s)$ are distance functions and x, y are the output and input vector.

An equivalent way of writing this would be

$$m_0(y_s, x_s, y_t, x_t) = \frac{d_0^t(y_t, x_t)}{d_0^s(y_s, x_s)} \left[\frac{d_0^s(y_t, x_t)}{d_0^s(y_t, x_t)} \times \frac{d_0^t(y_s, x_s)}{d_0^t(y_s, x_s)} \right]^{\frac{1}{2}}. \tag{4}$$

The above equation can be broken into two parts, namely the efficiency change component and the technical change component:

$$\text{Efficiency change} = \frac{d_0^t(y_t, x_t)}{d_0^s(y_s, x_s)} \tag{5}$$

and

$$\text{Technical change} = \left[\frac{d_0^s(y_t, x_t)}{d_0^s(y_t, x_t)} \times \frac{d_0^t(y_s, x_s)}{d_0^t(y_s, x_s)}\right]^{\frac{1}{2}}. \tag{6}$$

The Malmquist productivity change index may be determined as the result of solving 4 linear programming problems as listed below:

$$\begin{cases} d_0^s(y_t, x_t) = \min\theta \\ subject\ to \\ -y_{ot} + Y_s\lambda \geq 0 \\ \theta x_{0t} - X_s\lambda \geq 0 \\ \lambda \geq 0 \end{cases} \tag{7}$$

$$\begin{cases} d_0^s(y_s, x_s) = \min\theta \\ subject\ to \\ -y_{os} + Y_s\lambda \geq 0 \\ \theta x_{0s} - X_s\lambda \geq 0 \\ \lambda \geq 0 \end{cases} \tag{8}$$

$$\begin{cases} d_0^t(y_t, x_t) = \min\theta \\ subject\ to \\ -y_{os} + Y_s\lambda \geq 0 \\ \theta x_{0s} - X_s\lambda \geq 0 \\ \lambda \geq 0 \end{cases} \tag{9}$$

$$\begin{cases} d_0^t(y_t, x_t) = \min\theta \\ subject\ to \\ -y_{ot} + Y_t\lambda \geq 0 \\ \theta x_{0t} - X_t\lambda \geq 0 \\ \lambda \geq 0 \end{cases} \tag{10}$$

In (7-10), θ is a scalar, λ is a vector that representative the constants. The value of θ will be the efficiency score for the i-th DMU. It will satisfy θ less than or equal to 1, with a value of 1 indicating a point on the frontier and hence a technically efficient DMU. These four LPs must be solved for each DMU in the sample.

4. The Case Study on Israeli Cities

4.1. Determining DMUs

In order to proceed with the DEA procedure one has to determine first Decision Making Units (DMUs). In our research, we decided to determine DMUs as Israeli cities comprising a total of 10,000 inhabitants at least. The latter data has been adopted from the Central Bureau Statistics database published in 2006, 2007, 2008.

4.2. Selection of outputs and inputs

An important issue in employing DEA is the selection of inputs and outputs. In order to calculate the efficiency and the score of each city entering this study the following outputs and inputs have been implemented:

Inputs

X_1 - negative emigration percentage - the ratio between citizens that left the city to the total number of inhabitants (negative emigration ratio);

X_2 - percentage of unemployed citizens and obtaining minimal income insurance;

X_3 - percentage of deceased throughout the year;

X_4 - average number of schoolchildren in a classroom;

X_5 - average number of apartments per citizen;

X_6 - average spending by the local authority per citizen (in thousands NIS per citizen).

Outputs

Y_1 - positive immigration percentage - the ratio between citizens that joint the city to the total number of inhabitants (positive immigration ratio);

Y_2 - average monthly income per citizen (in thousands NIS per month);

Y_3 - percentage of successfully graduating from the city school system that complied with university entrance requirements;

Y_4 - average number of private vehicles per citizen;

Y_5 - average city income per citizen (including donations from the state).

We will demonstrate the regarded procedure for Year 2008. The data on 70 cities with 5 outputs and 6 inputs are given in Table 1:

Table 1. The numerical data for 2008

City	Year	X1	X2	X3	X4	X5	X6	Y1	Y2	Y3	Y4	Y5
Umm el-Faheim	2008	0.41%	16.21%	0.30%	30.25	0.28	4107.84	0.11%	3588.11	23.00%	0.1977	12924.81
OFAKIM	2008	3.77%	14.35%	0.55%	20.91	0.24	5863.73	0.09%	4182.77	37.60%	0.1604	17231.31
Or Yehuda	2008	3.53%	5.73%	0.49%	25.19	0.30	6250.42	0.11%	5706.27	43.60%	0.3121	20275.02
Or Akiva	2008	3.89%	8.03%	0.88%	21.25	0.31	6461.46	0.08%	4445.78	43.60%	0.2429	20919.81
Eilat	2008	10.99%	5.12%	0.32%	25.94	0.35	13736.39	0.10%	5334.78	51.80%	0.2974	39797.78
Ariel	2008	4.76%	3.51%	0.44%	27.52	0.28	6098.48	0.07%	5480.70	39.90%	0.2406	20728.72
Ashdod	2008	2.37%	8.54%	0.57%	26.61	0.29	5156.99	0.10%	5590.69	46.50%	0.1952	17595.95
Ashkelon	2008	2.84%	11.52%	0.69%	28.62	0.32	4692.72	0.10%	4989.72	49.40%	0.2343	16448.67
BakaJat	2008	0.76%	4.28%	0.34%	30.89	0.23	15958.20	0.08%	4275.78	41.00%	0.2457	55935.87
Beer-Sheva	2008	3.46%	10.95%	0.68%	26.22	0.37	5711.99	0.06%	5515.36	43.60%	0.2252	19125.60
Beit-Shean	2008	2.54%	9.35%	0.51%	20.99	0.28	9391.22	0.10%	4530.72	42.20%	0.2471	23928.66
Beit-Shemesh	2008	3.37%	4.07%	0.27%	24.07	0.22	3904.86	0.13%	5187.96	31.30%	0.1227	13059.96
Beitar-Illit	2008	2.49%	4.11%	0.10%	23.42	0.19	4100.62	0.19%	3345.32	25.30%	0.0523	10698.04
Bney-Brak	2008	3.74%	4.25%	0.46%	25.73	0.26	5249.03	0.08%	4613.07	36.00%	0.5272	17272.95
Bat-Yam	2008	4.73%	5.73%	0.99%	26.37	0.37	5314.27	0.09%	4755.76	42.50%	0.2486	17487.41
Givatayim	2008	6.40%	1.76%	0.92%	30.63	0.45	6798.70	0.11%	8775.23	66.30%	0.3988	21178.30
Dimona	2008	3.19%	15.87%	0.70%	24.51	0.33	5676.74	0.06%	5677.29	35.70%	0.1778	18799.31
Hod-Hasharon	2008	3.74%	1.42%	0.36%	28.36	0.31	6234.17	0.14%	9580.47	66.10%	0.3808	20975.07
Herzliya	2008	4.48%	1.90%	0.70%	27.34	0.39	8773.56	0.09%	8637.24	64.10%	0.4884	29958.56
Hadera	2008	3.06%	5.82%	0.75%	26.32	0.34	6128.19	0.10%	5492.21	44.60%	0.2937	19964.86
Holon	2008	3.67%	3.46%	0.72%	27.65	0.36	5580.70	0.09%	6013.82	53.10%	0.3474	18974.67
Haifa	2008	3.18%	7.38%	0.99%	25.49	0.42	8035.95	0.08%	7030.48	60.00%	0.3541	26247.90
Tiberias	2008	4.20%	12.19%	0.55%	24.13	0.35	8101.73	0.06%	4381.15	35.90%	0.2428	22693.33
Taibe	2008	0.34%	14.00%	0.38%	31.61	0.20	9559.56	0.13%	3898.18	30.90%	0.2393	26776.78
Tierra	2008	0.44%	3.60%	0.35%	28.73	0.25	3817.01	0.14%	3934.20	40.60%	0.2806	11242.56
Tirat-Carmel	2008	2.93%	10.66%	0.84%	22.98	0.33	7091.02	0.06%	4829.38	46.90%	0.2474	25790.75

City	Year	X1	X2	X3	X4	X5	X6	Y1	Y2	Y3	Y4	Y5
Tamra	2008	0.44%	21.37%	0.33%	29.18	0.23	5344.81	0.11%	3621.48	36.30%	0.2158	16442.14
Yavne	2008	3.66%	6.82%	0.42%	26.17	0.28	6130.53	0.07%	6679.61	51.70%	0.3398	22593.32
Yehud	2008	4.30%	2.25%	0.48%	28.56	0.32	10237.37	0.10%	8353.91	61.50%	0.3870	26502.27
Jerusalem	2008	2.35%	3.66%	0.44%	26.23	0.25	4900.07	0.06%	5699.61	31.60%	0.2057	15893.69
Kfar-Saba	2008	4.13%	1.95%	0.68%	28.27	0.31	6634.08	0.09%	7856.73	68.10%	0.4168	20607.02
Karmiel	2008	3.49%	6.95%	0.68%	27.16	0.34	4962.59	0.09%	5732.54	51.80%	0.2510	17681.90
Lod	2008	4.09%	9.07%	0.69%	25.79	0.30	4856.54	0.07%	5015.39	37.10%	0.4340	16640.97
Migdal-Haemeq	2008	3.37%	10.14%	0.66%	23.05	0.32	7704.21	0.06%	4805.62	37.80%	0.2241	23104.41
Modiin	2008	3.59%	1.23%	0.13%	29.86	0.28	6999.50	0.23%	9856.76	74.30%	0.2941	17710.30
Maale-Adummim	2008	3.36%	2.78%	0.23%	27.71	0.26	5552.77	0.19%	6398.11	59.40%	0.2623	18134.97
Ma'alot Tarshiha	2008	3.13%	9.39%	0.51%	25.94	0.30	5882.31	0.08%	5169.07	45.70%	0.2417	19837.36
Nahariya	2008	3.61%	8.01%	0.76%	27.31	0.36	5422.02	0.09%	6357.79	54.00%	0.2948	17830.30
Ness-Ziona	2008	2.98%	3.44%	0.56%	28.02	0.33	7315.87	0.25%	8289.72	55.80%	0.3527	24775.00
Nazareth	2008	1.96%	12.21%	0.37%	29.79	0.28	4128.86	0.04%	4355.33	42.90%	0.2844	13355.96
Nazareth-Illit	2008	3.45%	10.89%	0.98%	24.88	0.39	5265.44	0.07%	4782.66	50.00%	0.2413	18210.00
Nesher	2008	5.42%	6.20%	0.65%	27.01	0.42	7332.59	0.08%	6431.81	62.90%	0.3021	24611.84
Netivot	2008	4.30%	11.45%	0.34%	22.59	0.25	5861.29	0.09%	4054.92	33.00%	0.1681	18952.17
Netanya	2008	2.51%	7.29%	0.80%	26.80	0.35	5559.58	0.11%	5564.58	45.20%	0.2623	18538.35
Skhnen	2008	0.56%	18.27%	0.24%	31.15	0.24	5999.12	0.10%	3836.95	37.10%	0.2295	15653.16
Akko	2008	3.00%	17.49%	0.72%	25.99	0.33	6689.17	0.07%	4503.33	35.10%	0.2142	21268.37
Afula	2008	3.08%	8.84%	0.60%	24.36	0.36	7129.49	0.09%	4758.94	45.00%	0.2606	22146.03
Arad	2008	4.95%	9.87%	0.83%	23.61	0.37	5793.13	0.08%	5686.36	48.10%	0.2074	19617.81
Petah-Tikva	2008	2.98%	3.36%	0.68%	26.32	0.35	6035.23	0.15%	6473.14	52.80%	0.6057	20679.46
Zfat	2008	8.03%	13.13%	0.65%	23.04	0.34	6214.73	0.04%	4377.43	30.60%	0.1903	19933.67
Qalansuwa	2008	0.53%	12.99%	0.26%	32.89	0.18	3428.85	0.11%	3866.99	27.90%	0.1958	9909.31
Kiryat- Ono	2008	4.48%	1.78%	0.59%	29.81	0.38	6755.53	0.14%	9339.45	61.30%	0.3952	21758.02
kiryat-ata	2008	3.15%	8.42%	0.77%	26.02	0.36	6070.42	0.10%	5749.87	45.90%	0.2808	20550.04
Qiryat-Bialik	2008	5.06%	6.71%	0.98%	28.92	0.40	5310.60	0.09%	6339.89	49.10%	0.3205	18057.01
Qiryat-Gat	2008	3.27%	12.51%	0.70%	25.30	0.31	6117.45	0.07%	4283.38	46.00%	0.1921	21587.22
Qiryat-Yam	2008	4.99%	11.57%	1.09%	26.24	0.39	5526.85	0.06%	5020.33	38.00%	0.2246	18136.94
Kiriat-Motzkin	2008	4.88%	6.53%	0.83%	30.82	0.37	4963.27	0.09%	6567.83	53.80%	0.2832	17301.74
kiryat-malchy	2008	4.02%	16.59%	0.40%	23.68	0.28	9024.10	0.07%	4001.12	29.10%	0.2242	26195.74
kiryat-shmona	2008	3.79%	7.56%	0.56%	23.22	0.35	8378.68	0.07%	4843.79	43.40%	0.2830	24846.45
Rosh-Haayin	2008	3.25%	3.14%	0.35%	27.73	0.27	6932.40	0.11%	7142.81	50.70%	0.3206	22670.03
Rishon Lezion	2008	3.30%	3.95%	0.55%	28.48	0.31	4757.82	0.10%	7072.96	54.60%	0.3509	17637.87
Rahat	2008	0.49%	28.86%	0.27%	30.92	0.08	4028.05	0.17%	3584.18	24.70%	0.1333	12866.80
Rehovot	2008	3.90%	5.64%	0.63%	27.88	0.35	5655.50	0.10%	6996.33	50.20%	0.3036	19575.62
Ramla	2008	3.54%	7.09%	0.63%	25.46	0.27	5155.45	0.06%	4692.08	36.10%	0.2588	17390.87
Ramat-Gan	2008	5.47%	2.31%	0.89%	27.10	0.43	6174.25	0.10%	7621.22	65.60%	0.3820	22463.48
Ramat-Hasharon	2008	4.37%	1.20%	0.54%	27.56	0.36	9373.42	0.11%	10676.27	69.20%	0.4843	31185.27
Raanana	2008	4.59%	1.23%	0.45%	27.94	0.29	7383.13	0.08%	10102.80	70.00%	0.3767	27198.43
Sderot	2008	5.28%	10.38%	0.68%	21.52	0.32	7895.45	0.06%	4417.50	40.90%	0.2264	25164.65
Shefaram	2008	0.62%	17.28%	0.35%	31.09	0.24	4319.61	0.15%	4272.76	42.20%	0.2464	14148.12
Tel-Aviv	2008	5.45%	4.20%	0.93%	24.14	0.47	10503.32	0.10%	7780.98	58.40%	0.5925	35566.68
Umm el-Faheim	2007	0.52%	16.49%	0.27%	30.36	0.28	4232.17	0.07%	3503.46	30.10%	0.1942	9168.60
OFAKIM	2007	3.84%	14.81%	0.68%	21.18	0.25	5765.02	0.08%	4226.35	31.00%	0.1550	11569.14
Or Yehuda	2007	3.38%	6.33%	0.61%	25.14	0.31	6571.42	0.12%	5478.12	37.20%	0.3148	13865.64
Or Akiva	2007	3.81%	11.68%	0.64%	22.02	0.30	6749.95	0.08%	4194.08	41.80%	0.2368	13992.22

City	Year	X1	X2	X3	X4	X5	X6	Y1	Y2	Y3	Y4	Y5
Eilat	2007	10.49%	5.45%	0.38%	25.74	0.34	9775.43	0.11%	5150.50	49.30%	0.2864	22091.07
Ariel	2007	4.10%	3.66%	0.43%	26.77	0.27	6054.18	0.09%	5243.58	42.60%	0.2378	14106.72
Ashdod	2007	2.36%	9.72%	0.59%	26.48	0.29	4758.08	0.11%	5091.81	47.60%	0.1932	12479.80
Ashkelon	2007	2.55%	13.87%	0.74%	28.88	0.31	4781.68	0.10%	4780.43	46.80%	0.2312	11688.01
BakaJat	2007	0.55%	8.54%	0.35%	31.34	0.24	4643.00	0.13%	4365.51	41.50%	0.2409	8989.90
Beer-Sheva	2007	3.20%	12.08%	0.69%	26.41	0.37	5514.61	0.06%	5620.23	43.10%	0.2243	12955.26
Beit-Shean	2007	2.91%	10.29%	0.49%	21.24	0.28	9637.81	0.09%	4624.84	35.10%	0.2393	15766.02
Beit-Shemesh	2007	3.09%	4.96%	0.25%	24.27	0.23	4466.11	0.16%	4912.60	32.50%	0.1267	9050.65
Beitar-Illit	2007	2.50%	4.42%	0.08%	22.39	0.18	4823.16	0.20%	3197.23	32.50%	0.0533	6332.90
Bney-Brak	2007	3.74%	4.24%	0.48%	25.66	0.26	5173.50	0.08%	4514.19	32.50%	0.4731	11729.91
Bat-Yam	2007	4.59%	6.08%	1.04%	26.40	0.37	4958.59	0.08%	4586.62	43.60%	0.2466	11771.83
Givatayim	2007	6.10%	1.96%	1.05%	30.92	0.45	5998.44	0.12%	8259.25	66.60%	0.4071	13700.92
Dimona	2007	3.62%	17.95%	0.69%	24.59	0.33	5903.85	0.06%	5677.53	34.10%	0.1725	12518.99
Hod-Hasharon	2007	3.40%	1.69%	0.45%	28.69	0.31	5959.08	0.15%	8854.76	65.60%	0.3821	13155.74
Herzliya	2007	4.43%	1.99%	0.64%	27.40	0.39	7836.23	0.08%	8076.68	65.00%	0.5061	18810.79
Hadera	2007	3.08%	7.98%	0.69%	26.08	0.34	5741.28	0.09%	5301.80	45.60%	0.2895	13346.27
Holon	2007	3.67%	3.78%	0.75%	27.83	0.36	5003.69	0.09%	5678.08	48.80%	0.3517	12403.61
Haifa	2007	3.21%	7.98%	0.98%	25.75	0.42	7618.54	0.07%	6938.97	58.90%	0.3502	17267.25
Tiberias	2007	3.94%	12.62%	0.56%	24.46	0.35	6387.78	0.06%	4438.59	36.70%	0.2402	14632.41
Taibe	2007	0.40%	13.75%	0.34%	31.72	0.20	5383.81	0.12%	3938.88	32.50%	0.2290	4700.83
Tierra	2007	0.35%	4.15%	0.37%	28.66	0.25	4194.86	0.10%	4181.62	36.90%	0.2668	8477.00
Tirat-Carmel	2007	2.91%	11.68%	0.73%	22.31	0.33	7304.29	0.08%	4710.22	46.40%	0.2462	18785.79
Tamra	2007	0.50%	23.63%	0.23%	29.03	0.22	4873.81	0.12%	3621.66	42.90%	0.2131	9692.01
Yavne	2007	3.48%	7.40%	0.42%	26.78	0.27	6023.27	0.07%	6491.69	52.70%	0.3390	15322.93
Yehud	2007	4.00%	2.38%	0.49%	29.09	0.32	5833.91	0.08%	7496.08	58.10%	0.3859	13361.17
Jerusalem	2007	2.25%	4.27%	0.46%	26.18	0.26	5272.54	0.06%	5575.72	31.50%	0.2034	11294.58
Kfar-Saba	2007	3.69%	2.20%	0.59%	28.36	0.31	5645.17	0.10%	7502.91	65.40%	0.4124	13044.66
Karmiel	2007	3.82%	7.98%	0.69%	27.07	0.34	4790.15	0.08%	5664.58	49.20%	0.2502	11648.05
Lod	2007	4.08%	9.85%	0.65%	25.56	0.30	5331.43	0.06%	4720.34	38.40%	0.4202	12376.37
Migdal-Haemeq	2007	3.35%	11.08%	0.58%	22.64	0.32	5887.32	0.05%	4735.26	40.10%	0.2219	13558.24
Modiin	2007	3.35%	1.31%	0.09%	29.45	0.29	4988.70	0.28%	9280.00	76.70%	0.2987	11201.16
Maale-Adummim	2007	3.44%	2.59%	0.23%	27.49	0.26	5555.60	0.16%	6490.48	59.10%	0.2645	12036.37
Ma'alot Tarshiha	2007	2.90%	10.58%	0.55%	24.86	0.30	5747.82	0.09%	4989.13	45.80%	0.2367	12891.54
Nahariya	2007	3.86%	8.47%	0.88%	26.69	0.36	5404.66	0.10%	6190.95	53.00%	0.2937	11349.63
Ness-Ziona	2007	2.75%	4.36%	0.49%	27.55	0.32	7491.69	0.24%	7556.07	55.00%	0.3565	16905.03
Nazareth	2007	2.17%	18.49%	0.37%	29.67	0.28	3942.81	0.05%	4383.34	42.00%	0.2739	8725.22
Nazareth-Illit	2007	3.51%	13.06%	0.91%	26.05	0.39	5431.68	0.07%	4917.52	47.00%	0.2362	11834.19
Nesher	2007	4.41%	6.77%	0.68%	27.19	0.41	6286.14	0.09%	6251.48	60.70%	0.2994	14693.95
Netivot	2007	4.33%	12.97%	0.43%	22.56	0.26	5736.80	0.09%	3983.00	33.20%	0.1611	11997.82
Netanya	2007	2.61%	8.30%	0.80%	27.19	0.35	4993.63	0.10%	5241.44	43.90%	0.2584	12054.83
Skhnen	2007	0.51%	19.13%	0.28%	31.51	0.21	5662.27	0.11%	3753.30	37.10%	0.2223	10697.09
Akko	2007	2.88%	18.51%	0.78%	25.73	0.33	5346.91	0.07%	4531.23	37.10%	0.2102	12467.09
Afula	2007	3.12%	9.88%	0.65%	25.08	0.36	6248.25	0.09%	5077.78	46.70%	0.2579	12842.25
Arad	2007	5.30%	13.51%	0.75%	23.64	0.37	5901.65	0.06%	5531.71	50.20%	0.2084	12458.49
Petah-Tikva	2007	3.01%	3.25%	0.67%	26.49	0.35	5800.08	0.12%	6219.70	53.30%	0.5726	13728.57
Zfat	2007	5.51%	12.53%	0.62%	23.50	0.34	6438.91	0.07%	4427.93	32.80%	0.1839	13103.47
Qalansuwa	2007	0.48%	13.77%	0.25%	32.78	0.18	3460.11	0.15%	4093.00	27.80%	0.1903	6705.55
Kiryat- Ono	2007	4.28%	1.99%	0.67%	29.35	0.38	6819.38	0.13%	8539.01	63.20%	0.3971	14937.99

City	Year	X1	X2	X3	X4	X5	X6	Y1	Y2	Y3	Y4	Y5
kiryat-ata	2007	3.07%	9.24%	0.75%	26.65	0.36	5536.75	0.10%	5572.76	46.70%	0.2775	13507.75
Qiryat-Bialik	2007	4.86%	7.61%	0.85%	29.52	0.40	5137.21	0.09%	6257.44	46.90%	0.3180	11811.60
Qiryat-Gat	2007	3.67%	13.80%	0.66%	25.18	0.31	6192.98	0.05%	4189.56	43.20%	0.1897	14900.79
Qiryat-Yam	2007	4.83%	12.47%	1.12%	26.91	0.39	5721.28	0.07%	5010.57	35.20%	0.2218	12345.43
Kiriat-Motzkin	2007	4.63%	7.14%	0.87%	30.98	0.37	4721.07	0.11%	6451.54	49.80%	0.2815	11689.02
kiryat-malchy	2007	4.34%	17.79%	0.61%	23.76	0.29	7686.50	0.07%	3920.29	29.90%	0.2186	15440.64
kiryat-shmona	2007	3.69%	8.20%	0.58%	24.08	0.35	7867.33	0.07%	4830.48	51.20%	0.2725	15627.54
Rosh-Haayin	2007	3.32%	3.45%	0.28%	27.07	0.27	6189.53	0.10%	6907.95	53.70%	0.3202	14317.89
Rishon Lezion	2007	3.23%	4.24%	0.55%	28.20	0.31	4800.22	0.10%	6620.68	55.60%	0.3494	12667.93
Rahat	2007	0.66%	29.91%	0.30%	30.84	0.08	3721.42	0.07%	3596.92	26.40%	0.1303	8398.82
Rehovot	2007	3.77%	6.61%	0.65%	27.94	0.35	6453.53	0.10%	6751.53	54.40%	0.3044	13353.42
Ramla	2007	3.78%	8.19%	0.67%	25.72	0.27	8669.89	0.06%	4459.08	33.50%	0.2541	14344.04
Ramat-Gan	2007	5.38%	2.62%	0.92%	26.75	0.44	6128.87	0.10%	7211.83	64.90%	0.3841	15008.28
Ramat-Hasharon	2007	4.20%	1.39%	0.52%	27.82	0.36	9199.04	0.10%	10041.18	71.10%	0.4964	21141.94
Raanana	2007	4.08%	1.42%	0.42%	27.92	0.30	7856.34	0.10%	9419.10	68.20%	0.3788	17121.83
Sderot	2007	4.59%	13.26%	0.64%	21.38	0.32	9007.15	0.08%	4264.63	36.60%	0.2197	19469.61
Shefaram	2007	0.74%	18.79%	0.34%	30.80	0.24	4376.51	0.15%	4372.88	36.70%	0.2429	9638.01
Tel-Aviv	2007	4.95%	4.66%	0.99%	24.25	0.47	9952.09	0.12%	7275.70	56.10%	0.5826	24263.23
Umm el-Faheim	2006	0.58%	16.96%	0.29%	29.60	0.26	4031.74	0.07%	3355.61	23.00%	0.1832	3973.11
OFAKIM	2006	3.97%	15.43%	0.55%	21.93	0.25	6140.57	0.09%	4021.56	25.30%	0.1502	5746.55
Or Yehuda	2006	3.91%	6.78%	0.62%	24.89	0.31	5717.50	0.12%	5557.37	37.20%	0.3075	5401.72
Or Akiva	2006	3.92%	13.33%	0.58%	22.99	0.30	7337.37	0.09%	4124.33	35.60%	0.2324	6592.19
Eilat	2006	11.45%	5.42%	0.32%	25.13	0.35	8831.58	0.10%	5170.14	46.80%	0.2827	9009.97
Ariel	2006	5.31%	4.08%	0.46%	27.02	0.27	5536.68	0.07%	5306.77	42.40%	0.2352	5278.97
Ashdod	2006	2.35%	10.73%	0.59%	26.41	0.29	4720.83	0.13%	5168.95	44.90%	0.1903	4535.28
Ashkelon	2006	3.10%	15.67%	0.71%	29.05	0.32	4345.39	0.09%	4645.88	48.10%	0.2276	4373.55
BakaJat	2006	0.71%	9.53%	0.26%	31.44	0.23	4919.84	0.11%	3900.28	36.50%	0.2287	4234.01
Beer-Sheva	2006	3.55%	15.19%	0.71%	25.73	0.37	5368.67	0.07%	5467.78	41.30%	0.2214	5229.46
Beit-Shean	2006	3.70%	11.19%	0.42%	21.38	0.28	7908.85	0.04%	4329.42	35.00%	0.2359	6270.90
Beit-Shemesh	2006	3.62%	5.43%	0.27%	24.48	0.24	4493.94	0.20%	5016.11	34.90%	0.1304	4245.61
Beitar-Illit	2006	3.37%	4.68%	0.09%	22.34	0.19	4761.60	0.17%	3256.01	4.50%	0.0544	4532.36
Bney-Brak	2006	4.41%	4.50%	0.48%	25.01	0.26	5198.57	0.08%	4552.57	7.80%	0.4267	4694.89
Bat-Yam	2006	5.68%	7.05%	0.96%	26.12	0.37	4571.60	0.07%	4638.47	43.20%	0.2424	4596.63
Givatayim	2006	7.01%	2.23%	1.01%	29.67	0.46	5702.59	0.11%	8269.47	67.00%	0.4086	5315.72
Dimona	2006	3.84%	20.47%	0.77%	24.83	0.33	5711.13	0.05%	5330.98	37.70%	0.1653	5294.57
Hod-Hasharon	2006	3.81%	1.79%	0.41%	28.86	0.32	6273.68	0.16%	8823.08	62.60%	0.3808	6029.56
Herzliya	2006	4.86%	2.19%	0.65%	27.51	0.39	7273.56	0.08%	7997.90	65.00%	0.4821	7535.40
Hadera	2006	3.53%	9.50%	0.75%	26.36	0.34	5375.72	0.09%	5162.32	40.90%	0.2830	5235.46
Holon	2006	4.38%	4.39%	0.72%	27.70	0.35	4967.89	0.08%	5718.21	47.50%	0.3571	5035.63
Haifa	2006	3.48%	8.53%	0.95%	25.96	0.41	7408.64	0.08%	6643.68	57.40%	0.3455	7508.53
Tiberias	2006	4.84%	13.74%	0.58%	23.28	0.35	7001.30	0.05%	4309.33	30.30%	0.2371	6715.83
Taibe	2006	0.64%	13.49%	0.26%	31.39	0.19	2906.52	0.08%	3550.05	28.10%	0.2192	2801.85
Tierra	2006	0.56%	4.50%	0.32%	28.10	0.25	4657.80	0.15%	3845.52	37.80%	0.2471	3653.06
Tirat-Carmel	2006	3.22%	12.39%	0.78%	23.18	0.33	6998.89	0.08%	4541.03	38.50%	0.2440	6937.71
Tamra	2006	0.53%	24.50%	0.36%	28.55	0.22	4644.45	0.10%	3427.45	38.70%	0.2023	4291.62
Yavne	2006	4.47%	8.01%	0.43%	27.68	0.27	6024.00	0.07%	6442.54	50.40%	0.3338	6110.68
Yehud	2006	4.69%	2.71%	0.56%	28.72	0.32	5899.54	0.09%	7613.75	57.50%	0.3860	5259.71
Jerusalem	2006	2.56%	4.49%	0.45%	25.86	0.26	4424.60	0.06%	5669.84	31.70%	0.2023	4321.84

City	Year	X1	X2	X3	X4	X5	X6	Y1	Y2	Y3	Y4	Y5
Kfar-Saba	2006	3.94%	2.41%	0.60%	28.72	0.31	5668.50	0.10%	7544.79	65.30%	0.4167	6345.94
Karmiel	2006	3.54%	8.72%	0.66%	27.13	0.33	5069.12	0.11%	5434.60	48.30%	0.2459	5260.46
Lod	2006	5.09%	10.83%	0.61%	25.16	0.30	5035.33	0.06%	4800.29	34.70%	0.4074	4427.78
Migdal-Haemeq	2006	3.40%	11.75%	0.64%	22.70	0.32	5876.33	0.07%	4505.44	36.50%	0.2216	5287.48
Modiin	2006	4.03%	1.33%	0.14%	30.21	0.30	5082.54	0.24%	9652.30	72.90%	0.3005	5016.07
Maale-Adummim	2006	3.53%	2.70%	0.31%	27.69	0.26	6173.08	0.22%	6565.38	55.70%	0.2652	6310.10
Ma'alot Tarshiha	2006	3.77%	11.21%	0.52%	25.30	0.30	6158.73	0.08%	4791.92	47.70%	0.2351	6012.77
Nahariya	2006	3.89%	9.04%	0.80%	27.70	0.36	5400.13	0.12%	6111.42	50.10%	0.2873	5429.66
Ness-Ziona	2006	3.35%	4.78%	0.50%	26.91	0.34	7458.10	0.21%	7484.89	55.20%	0.3497	7623.72
Nazareth	2006	1.78%	20.65%	0.34%	29.27	0.28	4140.83	0.07%	4198.90	40.00%	0.2626	3436.44
Nazareth-Illit	2006	3.73%	14.34%	0.93%	27.36	0.38	7506.09	0.08%	4621.52	51.00%	0.2303	7612.51
Nesher	2006	5.53%	7.30%	0.61%	26.68	0.41	6298.01	0.09%	6044.25	51.80%	0.2998	6909.04
Netivot	2006	4.21%	13.40%	0.40%	22.28	0.26	5400.69	0.11%	3759.65	26.30%	0.1582	5582.78
Netanya	2006	3.00%	9.15%	0.76%	27.18	0.35	4885.10	0.11%	5210.34	45.90%	0.2517	4812.54
Skhnen	2006	0.68%	19.65%	0.25%	31.02	0.21	4255.24	0.10%	3434.83	24.50%	0.2104	4294.47
Akko	2006	3.60%	19.09%	0.82%	25.02	0.32	5880.38	0.07%	4435.51	32.90%	0.2079	5215.99
Afula	2006	3.56%	11.49%	0.66%	24.96	0.36	5958.57	0.08%	4820.73	42.20%	0.2518	5931.07
Arad	2006	6.76%	22.37%	0.66%	23.24	0.36	5529.28	0.04%	5358.44	47.70%	0.2042	4854.75
Petah-Tikva	2006	3.41%	3.36%	0.71%	26.37	0.35	6125.10	0.11%	6206.13	53.00%	0.5408	5911.18
Zfat	2006	7.29%	13.38%	0.64%	23.32	0.35	6705.75	0.06%	4238.11	30.70%	0.1866	6778.28
Qalansuwa	2006	0.68%	13.76%	0.24%	31.90	0.19	3627.31	0.12%	3832.13	30.70%	0.1783	3448.67
Kiryat- Ono	2006	5.21%	2.21%	0.57%	29.28	0.38	6409.95	0.12%	8345.80	60.90%	0.3969	5982.21
kiryat-ata	2006	3.76%	9.79%	0.76%	26.21	0.36	5897.98	0.09%	5307.11	42.50%	0.2722	5691.01
Qiryat-Bialik	2006	5.60%	8.12%	0.87%	29.56	0.39	4860.59	0.08%	5926.38	50.10%	0.3141	4743.52
Qiryat-Gat	2006	4.04%	14.72%	0.66%	25.29	0.30	6221.10	0.05%	4254.37	43.30%	0.1839	5850.21
Qiryat-Yam	2006	5.40%	12.99%	1.04%	26.55	0.38	5169.58	0.07%	4782.72	40.60%	0.2194	4797.98
Kiriat-Motzkin	2006	5.47%	7.73%	0.87%	29.45	0.37	4507.54	0.08%	6109.22	50.50%	0.2846	4224.28
kiryat-malchy	2006	4.71%	18.84%	0.52%	23.61	0.29	7513.38	0.08%	3937.17	28.50%	0.2119	6970.30
kiryat-shmona	2006	4.25%	8.91%	0.52%	23.37	0.34	7824.78	0.08%	4613.46	42.30%	0.2677	7282.38
Rosh-Haayin	2006	3.95%	3.57%	0.34%	27.45	0.28	6158.39	0.09%	7009.25	48.10%	0.3143	6258.82
Rishon Lezion	2006	3.81%	4.70%	0.52%	28.34	0.31	4941.75	0.11%	6790.28	54.80%	0.3456	5211.72
Rahat	2006	0.78%	32.02%	0.35%	30.36	0.08	3369.27	0.09%	3621.49	16.30%	0.1230	3593.39
Rehovot	2006	3.96%	7.57%	0.73%	28.40	0.35	5818.41	0.12%	6736.51	52.30%	0.2984	5713.27
Ramla	2006	3.96%	9.31%	0.60%	26.60	0.27	5506.30	0.08%	4533.86	31.00%	0.2481	5131.61
Ramat-Gan	2006	6.22%	3.01%	0.87%	26.89	0.44	5935.48	0.10%	7191.15	63.20%	0.3875	5987.96
Ramat-Hasharon	2006	4.86%	1.42%	0.55%	27.69	0.36	7390.71	0.09%	9664.47	66.10%	0.5069	7373.36
Raanana	2006	4.72%	1.56%	0.47%	27.82	0.30	6437.40	0.09%	9269.74	68.40%	0.3848	6786.28
Sderot	2006	4.13%	15.51%	0.64%	21.61	0.32	7718.35	0.09%	4135.18	30.30%	0.2074	7083.78
Shefaram	2006	0.97%	19.29%	0.33%	30.99	0.24	5364.56	0.13%	4233.62	40.60%	0.2368	5057.73
Tel-Aviv	2006	5.52%	5.24%	0.97%	24.20	0.48	9785.80	0.12%	7208.46	55.70%	0.5957	9799.20

Table 2. Score and Malmquist productivity change index

City	Cross Efficiency					Malmquist productivity		
	2008	2007	2006	Mean	Rank	2006-2007	2007-2008	Mean
Umm el-Faheim	0.7547	0.7442	0.7667	0.755	54	0.777	0.561	0.660
OFAKIM	0.7228	0.7201	0.7491	0.731	63	0.723	0.570	0.642

City	Cross Efficiency					Malmquist productivity		
	2008	2007	2006	Mean	Rank	2006-2007	2007-2008	Mean
Or Yehuda	0.8159	0.7957	0.7897	0.800	31	0.738	0.615	0.674
Or Akiva	0.7936	0.7644	0.7603	0.773	47	0.742	0.587	0.660
Eilat	0.7003	0.8116	0.793	0.768	49	0.631	0.546	0.587
Ariel	0.7957	0.8402	0.7509	0.796	35	0.724	0.528	0.618
Ashdod	0.8472	0.9064	0.7849	0.846	17	0.852	0.534	0.675
Ashkelon	0.8466	0.8264	0.7591	0.811	27	0.803	0.584	0.685
BakaJat	0.8778	0.7549	0.7564	0.796	33	0.406	0.644	0.511
Beer-Sheva	0.7977	0.8083	0.7616	0.789	39	0.752	0.548	0.642
Beit-Shean	0.6782	0.6852	0.717	0.693	68	0.696	0.504	0.592
Beit-Shemesh	0.8029	0.7389	0.7532	0.765	50	0.781	0.710	0.745
Beitar-Illit	0.6603	0.542	0.7139	0.639	69	1.018	0.669	0.826
Bney-Brak	0.8154	0.8219	0.7441	0.794	36	0.824	0.668	0.742
Bat-Yam	0.769	0.7696	0.7162	0.752	55	0.794	0.580	0.679
Givatayim	0.8018	0.811	0.7614	0.791	37	0.921	0.681	0.792
Dimona	0.781	0.7421	0.7246	0.749	56	0.701	0.572	0.633
Hod-Hasharon	0.9233	0.8963	0.8867	0.902	8	0.849	0.644	0.740
Herzliya	0.8883	0.9334	0.913	0.912	5	0.833	0.615	0.716
Hadera	0.8083	0.8322	0.7795	0.807	29	0.775	0.555	0.656
Holon	0.8495	0.8551	0.8034	0.836	20	0.833	0.611	0.713
Haifa	0.8436	0.8637	0.8707	0.859	16	0.828	0.613	0.712
Tiberias	0.6754	0.7921	0.7588	0.742	60	0.785	0.515	0.636
Taibe	0.7184	0.4331	0.7628	0.638	70	0.552	0.844	0.682
Tierra	0.8151	0.7819	0.73	0.776	45	0.944	0.608	0.758
Tirat-Carmel	0.8799	0.9465	0.8279	0.885	11	0.781	0.475	0.609
Tamra	0.782	0.7622	0.7889	0.778	44	0.869	0.573	0.705
Yavne	0.915	0.9477	0.8557	0.906	6	0.784	0.592	0.681
Yehud	0.7135	0.8669	0.792	0.791	38	0.847	0.642	0.738
Jerusalem	0.7832	0.7935	0.7899	0.789	40	0.779	0.606	0.687
Kfar-Saba	0.8421	0.893	0.9577	0.898	10	0.914	0.679	0.788
Karmiel	0.8669	0.8245	0.8146	0.835	21	0.802	0.581	0.682
Lod	0.8172	0.811	0.7231	0.784	41	0.778	0.629	0.699
Migdal-Haemeq	0.7331	0.8169	0.7389	0.763	52	0.792	0.526	0.646
Modiin	0.7887	0.9351	0.9014	0.875	13	1.063	0.556	0.769
Maale-Adummim	0.8798	0.851	0.9015	0.877	12	0.815	0.667	0.737
Ma'alot Tarshiha	0.823	0.8187	0.8017	0.814	25	0.755	0.598	0.672
Nahariya	0.829	0.7635	0.8065	0.800	32	0.815	0.653	0.730
Ness-Ziona	0.9108	0.9168	0.9268	0.918	3	0.843	0.603	0.713
Nazareth	0.7881	0.7453	0.6936	0.742	59	0.852	0.650	0.744
Nazareth-Illit	0.829	0.7452	0.8145	0.796	34	0.739	0.647	0.692
Nesher	0.8327	0.8329	0.8452	0.837	19	0.832	0.616	0.716
Netivot	0.7583	0.734	0.7855	0.759	53	0.668	0.570	0.617
Netanya	0.8271	0.833	0.7818	0.814	26	0.787	0.554	0.661
Skhnen	0.686	0.7354	0.808	0.743	58	0.794	0.573	0.675
Akko	0.7486	0.7878	0.7028	0.746	57	0.750	0.487	0.604

City	Cross Efficiency					Malmquist productivity		
	2008	2007	2006	Mean	Rank	2006-2007	2007-2008	Mean
Afula	0.7735	0.7568	0.7951	0.775	46	0.770	0.622	0.692
Arad	0.8106	0.7346	0.6671	0.737	62	0.783	0.624	0.699
Petah-Tikva	0.9157	0.9086	0.8788	0.901	9	0.846	0.653	0.743
Zfat	0.7006	0.6958	0.7388	0.712	66	0.659	0.571	0.613
Qalansuwa	0.7304	0.7151	0.7688	0.738	61	0.949	0.667	0.796
Kiryat- Ono	0.8552	0.8515	0.8136	0.840	18	0.823	0.645	0.728
kiryat-ata	0.8318	0.8541	0.7754	0.820	23	0.785	0.528	0.644
Qiryat-Bialik	0.8093	0.769	0.7334	0.771	48	0.786	0.637	0.707
Qiryat-Gat	0.834	0.828	0.7431	0.802	30	0.707	0.527	0.610
Qiryat-Yam	0.7454	0.7074	0.6776	0.710	67	0.672	0.565	0.616
Kiriat-Motzkin	0.8299	0.8101	0.7097	0.783	42	0.848	0.608	0.718
kiryat-malchy	0.6894	0.7275	0.7591	0.725	65	0.630	0.533	0.580
kiryat-Shmona	0.7394	0.7617	0.7934	0.765	51	0.809	0.630	0.714
Rosh-Haayin	0.8454	0.9006	0.8781	0.875	14	0.792	0.601	0.690
Rishon Lezion	0.9341	0.9419	0.8739	0.917	4	0.847	0.611	0.720
Rahat	0.7923	0.8102	0.8267	0.810	28	0.674	0.662	0.668
Rehovot	0.8574	0.7841	0.812	0.818	24	0.741	0.652	0.695
Ramla	0.7926	0.6538	0.7399	0.729	64	0.672	0.546	0.606
Ramat-Gan	0.9114	0.8701	0.8126	0.865	15	0.822	0.649	0.730
Ramat-Hasharon	0.9001	0.9564	0.9233	0.927	2	0.779	0.601	0.684
Raanana	0.9631	0.9093	0.9432	0.939	1	0.791	0.612	0.695
Sderot	0.7598	0.8104	0.7684	0.780	43	0.786	0.469	0.607
Shefaram	0.8488	0.8041	0.8143	0.822	22	0.793	0.639	0.712
Tel-Aviv	0.8686	0.9401	0.9029	0.904	7	0.820	0.616	0.711
Mean	0.808	0.805	0.793	0.802		0.778	0.598	0.682

- Note that all Malmquist index averages are geometric means.
- The results of Malmquist index from DEAP version 2.1

Table 3. 10 top ranked Israeli cities

City	Cross Efficiency					Malmquist productivity		
	2008	2007	2006	Mean	Rank	2006-2007	2007-2008	Mean*
Raanana	0.9631	0.9093	0.9432	0.939	1	0.791	0.612	0.695
Ramat-Hasharon	0.9001	0.9564	0.9233	0.927	2	0.779	0.601	0.684
Ness-Ziona	0.9108	0.9168	0.9268	0.918	3	0.843	0.603	0.713
Rishon Lezion	0.9341	0.9419	0.8739	0.917	4	0.847	0.611	0.720
Herzliya	0.8883	0.9334	0.913	0.912	5	0.833	0.615	0.716
Yavne	0.915	0.9477	0.8557	0.906	6	0.784	0.592	0.681
Tel-Aviv	0.8686	0.9401	0.9029	0.904	7	0.82	0.616	0.711
Hod-Hasharon	0.9233	0.8963	0.8867	0.902	8	0.849	0.644	0.740
Petah-Tikva	0.9157	0.9086	0.8788	0.901	9	0.846	0.653	0.743

City	Cross Efficiency					Malmquist productivity		
	2008	2007	2006	Mean	Rank	2006-2007	2007-2008	Mean*
Kfar-Saba	0.8421	0.893	0.9577	0.898	10	0.914	0.679	0.788

- Note that according to the Cross Efficiency method results Raanana, Ramat-Hasharon and Ness-Ziona turned out to be ranked first. The common feature of these cities is their geographical position in the centre of the country and along the sea coast line.

Table 4. 10 bottom ranked Israeli cities

City	Cross Efficiency					Malmquist productivity		
	2008	2007	2006	Mean	Rank	2006-2007	2007-2008	Mean*
Qalansuwa	0.7304	0.7151	0.7688	0.738	61	0.949	0.667	0.796
Arad	0.8106	0.7346	0.6671	0.737	62	0.783	0.624	0.699
Ofakim	0.7228	0.7201	0.7491	0.731	63	0.723	0.57	0.642
Ramla	0.7926	0.6538	0.7399	0.729	64	0.672	0.546	0.606
Kiryat-Mal'achy	0.6894	0.7275	0.7591	0.725	65	0.63	0.533	0.580
Zfat	0.7006	0.6958	0.7388	0.712	66	0.659	0.571	0.613
Qiryat-Yam	0.7454	0.7074	0.6776	0.71	67	0.672	0.565	0.616
Beit-Shean	0.6782	0.6852	0.717	0.693	68	0.696	0.504	0.592
Beitar-Illit	0.6603	0.542	0.7139	0.639	69	1.018	0.669	0.826
Taibe	0.7184	0.4331	0.7628	0.638	70	0.552	0.844	0.682

- Note that bottom ranked cities listed in Table 4 belong generally to the northern and southern outskirts of the country.

5. Conclusions and Future Research

In this paper we intended to demonstrate an important application area of the DEA methodology enabling relative effectively assessment of DMUs in conjunction with the CE method to carry out fully ranking for the same, all this compared with the Malmquist productivity index capable of evaluating relative improvement of each DMU per every pair of consecutive time periods. These methods have been applied to evaluating 70 Israeli cities within years 2006, 2007 and 2008. The results obtained which have been reported in the present study may lead to the following conclusions:

- No correlation whatsoever has been identified between the ranking position of the city and its relative improvement through years. As a matter of fact, the majority of cities investigated in our research show actually worsening rather than improvement, no matter whether being ranked at the top of the list or close to the bottom.
- Ranking positions obtained as well as improvement rates refer of cause to the set of input / output criteria chosen for the research. A different choice of input / output criteria might cause other results, accordingly.

- There is no consistency within the ranking obtained on the basis of existing ranking methods. The substance of the ranking method is important for obtaining specific ranking results whatsoever.
- No correlation whatsoever has been identified between the size of the city (number of inhabitants) and its ranking / relative improvement through years. In other words, one cannot claim those features to be size dependent.

Ranking and improvement as reflected in our research relate to a broad spectrum of instances such as: education, health care, the local authority's municipal spending, etc. We suggest further research to be undertaken to estimate ranking of cities according to each criterion separately, while calculating relative weights for every criterion chosen. Then, efficiency score and ranking position for every participating city might be re-calculated with reference to the established weights. In addition, further investigation has to be undertaken as to specific reasons for cities' productivity worsening as detected in the framework of the current research.

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