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Primary health care planning using DEA and location analysis

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Presentation Outline

- Background information
- Issues to consider
  - Equity
  - Quality of care
  - Efficiency
- Combined DEA-LA model
- Case study: Health Centres in the Peloponnese
- Conclusions

Background information

- Extensive reforms in the organization and delivery of health services
- Major reform in Greece in the 1980's
- Objective: increase equity
- Result: establishment of Health Centres (HCs)

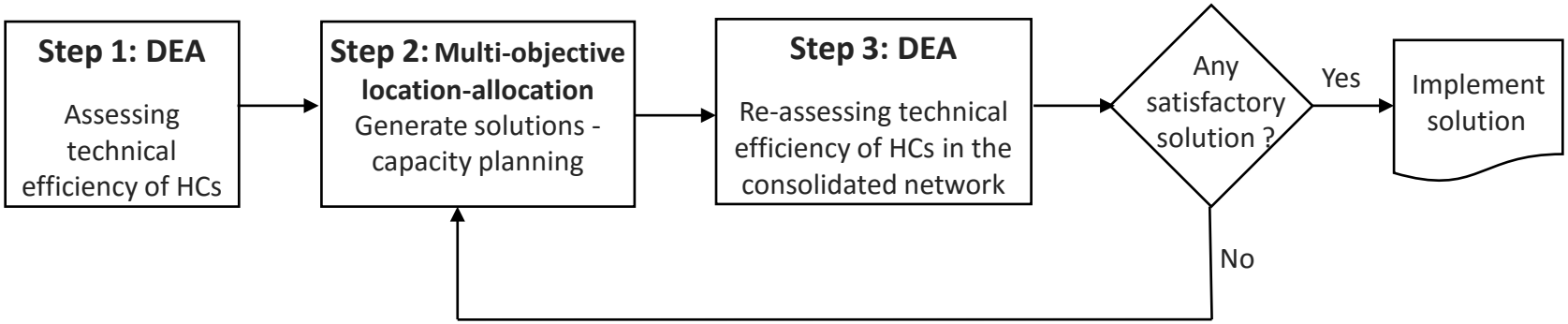
Background information/2

- Characteristics of HCs
  - First contact point with NHS
  - Actual performance has fallen short of expectations
  - Lack of managerial and financial autonomy
  - Large differences across regions
- Demographic changes
- Need to reform
  - Assign to HCs financial and administrative responsibilities
  - Introduce a fair system for resource allocation

Issues to Consider

- *Option demand*: a HC covers all of the population within its catchment area
- Performance of HCs is affected by their location
- The effect of location is alleviated by the range of services
- Objectives of the paper:
  - To evaluate the effectiveness of past location decisions
  - To identify the required services in HCs located within the region
  - To establish which HCs should be upgraded, which ones should provide basic vital services and which ones should close

Overview of the planning process



- DEA Inputs and Outputs:

Inputs	Outputs
I_1: Number of doctors	O_1: Medical exams
I_2: Number of nurses	O_2: Laboratory tests
I_3: Treatment population (non discretionary)	O_3: Transfers

The DEA model – Envelopment, input oriented

- Indices:
  - h: discretionary inputs
  - f: non discretionary inputs
  - r: outputs
  - k: HC under evaluation

$$\min \quad \theta$$

$$s.t. \quad \sum_j \lambda_j x_{hj} \le \theta x_{hk} \qquad for\ all\ h$$

$$\sum_j \lambda_j x_{fj} \le x_{fk} \qquad for\ all\ f$$

$$\sum_j \lambda_j y_{rj} \ge y_{rk} \qquad for\ all\ r$$

$$\lambda_j \ge 0 \quad for\ all\ j$$

$$\theta\ free$$

Combined DEA-LA model

- Notation:
  - I: set of population centres
  - J_1: set of HCs locations
  - J_2: set of hospital locations
  - $J=J_1 \cup J_2$
  - d_{ij}: distance between i and j
  - c_{min}: minimum HC capacity
  - d_{max} : maximum distance

  - $f_{ij}=1$, if $d_{ij}<d_{max}$
  - $f_{ij}=0$, otherwise

Combined DEA-LA model/2

$$\min \quad \sum_{i \in I} \sum_{j \in J} w_i d_{ij} x_{ij} + M \cdot \sum_{k \in J_1} D_k^-$$

$$\max \quad \frac{\sum_{k \in J_1} efficiency_k \cdot y_k}{\sum_{k \in J_1} y_k}$$

s.t.

Demand is satisfied (1)

Assignment to HCs (2)

Assignment to hospitals (3)

Minimum capacity constraint (4)

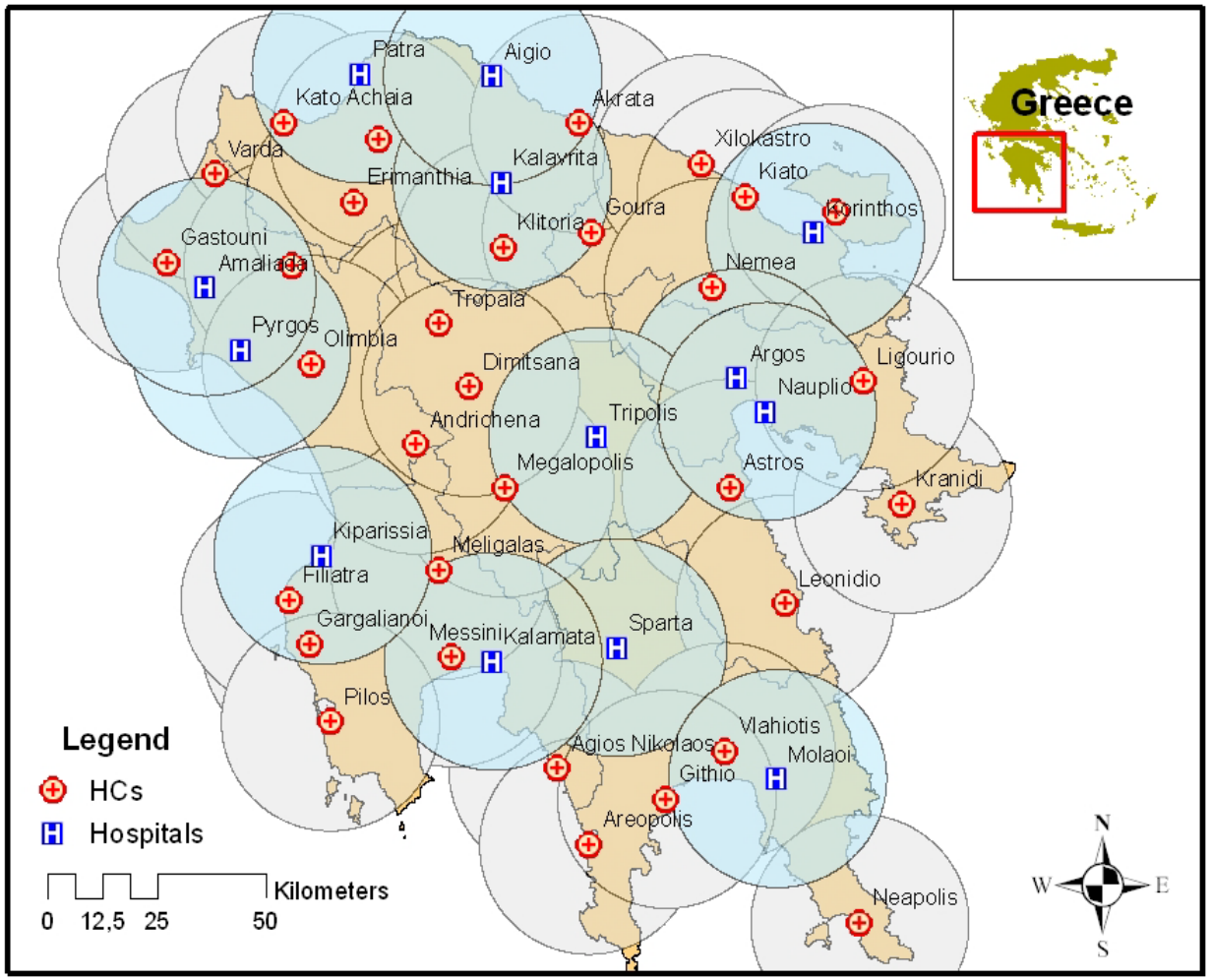
(5)

Closest assignment constraints (6)

$$D_k^- \geq 0, \quad k \in J_1 \qquad (7)$$

$$x_{ij} \in \{0,1\}, \quad i \in I, j \in J \qquad y_k \in \{0,1\}, \quad k \in J_1$$

The case study area



Current situation

- 13 hospitals
- 32 primary health centers
- 1340 population centers
- 3 options for the provision of HCs services

DEA results

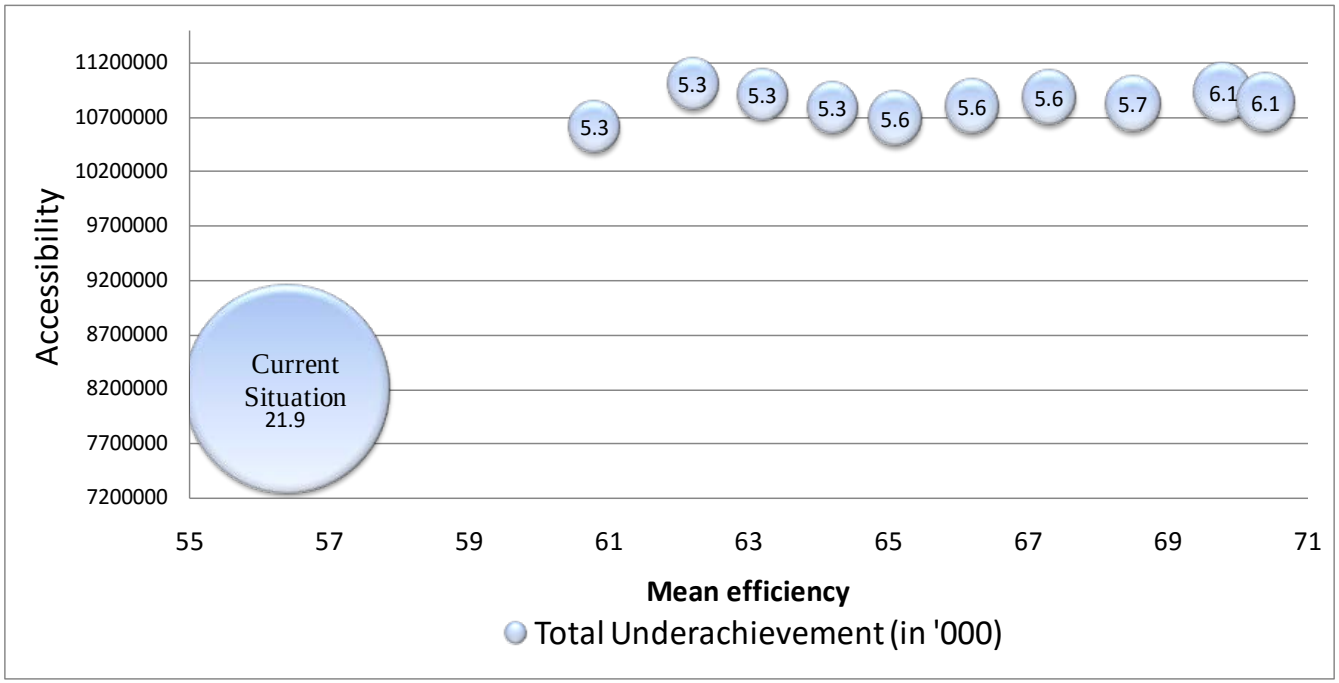
No	HC	Efficiency	No	HC	Efficiency
1	Xylokastro	0.61	17	Gargaliani	0.99
2	Ag. Nicolaos	0.26	18	Guthio	1
3	Meligala	0.27	19	Filiatra	0.61
4	Messini	0.26	20	Gkoura	0.18
5	Pilos	0.27	21	Nemea	0.24
6	Kiato	1	22	Neapoli	1
7	Kranidi	0.90	23	Akrata	0.32
8	Loutraki	1	24	Aandrichena	0.32
9	Ligourio	0.31	25	Olimbia	0.10
10	Areopoli	1	26	Varda	0.83
11	Astros	0.79	27	Gastouni	0.34
12	Vlahioti	0.50	28	Erimanthia	0.49
13	Dimitsana	0.65	29	Kato Achaia	0.37
14	Leonidio	0.86	30	Kleitoria	1
15	Megalopoli	0.82	31	Chalandritsa	0.78
16	Tropaia	1	32	Simopoulo	0.68

Pareto-efficient location–allocation configurations

Solution No	Total No of HCs	Accessibility '000 man.km	Total underachievement	Consolidation mean efficiency
0*	32	8,191	21,940	56,4
1	19	10,607	5,258	60,8
2	18	11,000	5,258	62,2
3	19	10,905	5,258	63,2
4	19	10,781	5,643	64,2
5	20	10,685	5,644	65,1
6	19	10,794	6,106	66,2
7	19	10,876	6,106	67,3
8	20	10,816	7,955	68,5
9	19	10,925	8,417	69,8
10	20	10,830	8,417	70,4

* Current situation

Pareto-efficient location–allocation configurations/2



- Remarks:
  - evident underutilization of resources
  - optimal number of HCs ranges from 18 to 20

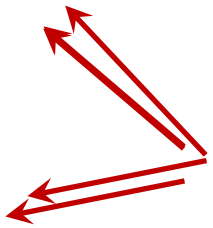
Pareto-efficient location–allocation configurations/3

no.	HC	initial capacity	HCs Capacities in optimal solutions									
			1	2	3	4	5	6	7	8	9	10
1	**Xylokastro**	16886	16981	16981	16981	16981	16672	16981	×	17587	17343	17409
2	Ag. Nicolaos	-4192	×	×	×	×	×	×	×	×	×	×
3	Meligala	13821	×	×	×	×	×	×	×	×	×	×
4	Messini	24153	26420	26420	26420	26420	26412	26181	26181	26420	26175	26175
5	Pilos	-943	10302	10302	10302	10302	-943	-943	10302	-943	-943	-943
6	Kiato	34001	34001	34001	34001	34001	34245	34001	37767	34001	34245	34245
7	Kranidi	15875	15875	15875	15875	15875	15875	15875	15875	15875	15875	15875
8	Loutraki	28783	28783	28783	28783	28783	28783	28783	28783	28783	28783	28783
9	Ligourio	-600	-600	-600	-600	-600	-600	-600	-600	-600	-600	-600
10	Areopoli	-5289	-4143	-4143	-4143	-4914	-4914	-4914	-4914	-4914	-4914	-4914
11	Astros	-1372	-1372	-1372	-1372	-1372	-1372	-1372	-1372	-1372	-1372	-1372
12	Vlahioti	12782	×	×	×	×	×	×	×	×	×	×
13	Dimitsana	-5855	×	×	×	×	×	×	×	×	×	×
14	Leonidio	-819	-765	-765	-765	-765	-765	-765	-765	-765	-765	-765
15	**Megalopoli**	12108	×	×	12120	×	12120	×	12120	12120	×	12213
16	**Tropaia**	-2905	-1236	-1198	-1199	-1236	-1237	-1207	-1245	-1602	-1593	8360
17	Gargaliani	17756	×	×	×	×	×	21545	21545	×	21578	21578
18	Guthio	11379	×	×	×	12362	12362	12362	12362	12362	12362	12362
19	Filiatra	18163	20625	20625	20625	20625	20633	×	×	20625	×	×
20	Gkoura	-5918	×	×	×	×	×	×	×	×	×	×
21	Nemea	12920	13153	13153	13153	13153	13219	13153	13219	13185	13185	13119
22	Neapoli	-442	-442	-442	-442	-442	-442	-442	-442	-442	-442	-442
23	Akrata	-266	10086	10086	10086	10086	10093	10086	10208	×	×	×
24	Andrichena	-3655	-1957	-1995	-1995	-1957	-1957	-1969	-1931	-1987	-1977	-1931
25	Olimbia	24333	×	×	×	×	×	×	×	×	×	×
26	Varda	17421	18945	19661	19661	19661	19763	19661	19661	19661	19763	19763
27	Gastouni	31248	31248	×	×	×	×	×	×	×	×	×
28	Erimanthia	-3839	×	×	×	×	×	×	×	×	×	×
29	Kato Achaia	23653	×	×	×	×	×	×	×	×	×	×
30	Kleitoria	-4723	×	×	×	×	×	×	-4227	-4227	-4227	-4227
31	Chalandritsa	-3062	10490	10490	10490	10490	10490	10490	10490	10490	10490	10490
32	**Simopoulo**	10048	×	×	×	×	×	×	×	×	×	×
	Total	**32**	**19**	**18**	**19**	**19**	**20**	**19**	**19**	**20**	**19**	

"×": HC closure,
shaded cells: upgraded services,

"-": underachievement from treatment population of 10,000

(Bold): HCs with different configuration



Importance of spatial constraint on population

Some remarks

- Increase of Mean Efficiency by 3d objective
- Steady operational patterns
- Hospitals offer stability
- Importance of constraint on treatment population

Re-assessment of efficiencies

- DEA inputs and outputs are replaced by expected ones
  - Treatment population is estimated by the solution of the DEA-LA model
  - Doctors and nurses are determined by the level of services offered
  - Outputs are estimated according to the outputs of neighboring HCs that are closed
- New average DEA efficiency increases by 18%
- These results are used as future targets

Conclusions

- Combination of DEA with resource allocation models
- Model can be extended to include additional objectives
- More complicated restrictions may be considered
- Interesting to consider a dynamic version of the problem
- Create scenarios concerning changes in population over time, migration, etc