GRUPO ESPAÑOL DE DECISIÓN MULTICRITERIO

Portfolio decision analysis (PDA) with M-MACBETH

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PDA case-study selection

Real-world applications of a multicriteria socio-technical approach for PDA using the M-MACBETH DSS in decision conferences

CASE-STUDY I

Model to select a R&D portfolio of robotic innovations for minimal invasive surgical interventions...
...under a limited budget

(Hummel, Oliveira et al. 2017)

CASE-STUDY II

Model to prioritize community care programmes...
... in view of allocating human resources...
... to assist the Head of the GHCC of Northern Lisbon

(Oliveira, Rodrigues et al. 2012)

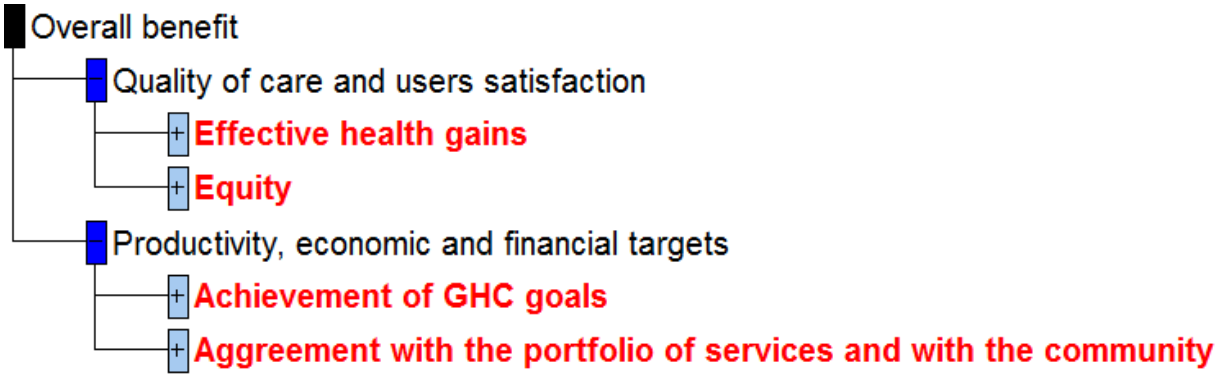
CASE-STUDY III

Model to prioritize health and competing non-health programmes...
...considering their value-for-effort...
... to assist the Head of the SEDSDH (Brazil)

(Bana e Costa, Lourenço et al. 2014)

Prioritizing Health Care Interventions: A Multicriteria Resource Allocation Model to Inform the Choice of Community Care Programmes

Several benefit (and risk) criteria:



‘Cost’ constraint:

Limited number of nursing hours

12 Programmes

P1 - Social integration income

P2 - Domiciliary visits: healthy lives

P3 - Physical exercise for the elderly

P4 - Prevention of domestic accidents for the elderly

P5 - Reproductive health and family planning

P6 - Group support for teenagers

P7 - Support to the child and youth vulnerable groups

P8 - Preparation for maternity/paternity

P9 - Preparation for post-delivery

P10 - Integrated long-term care

P11 - Health at home

P12 - Promoting family parenting for vulnerable families

Adapted from: Oliveira, M.D., et al (2011) In E. Tanfani and A. Testi (Eds) *Advanced Decision Making Methods applied to Health Care*. Springer

Prioritizing Health Care Interventions: A Multicriteria Resource Allocation Model to Inform the Choice of Community Care Programmes

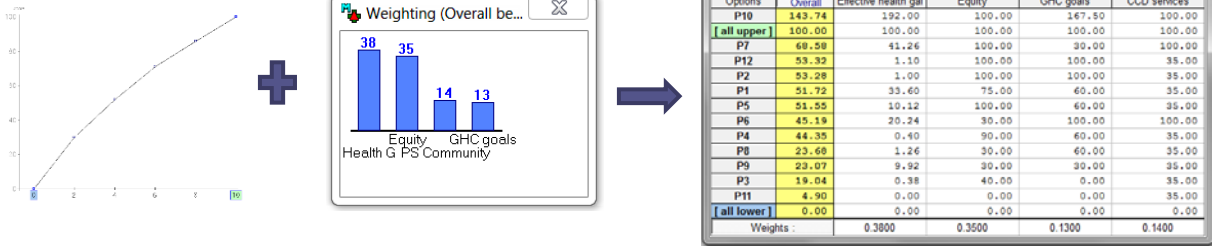
Several benefit (and risk) criteria:

- Overall benefit
  - Quality of care and users satisfaction
    - **Effective health gains**
    - **Equity**
  - Productivity, economic and financial targets
    - **Achievement of GHC goals**
    - **Aggreement with the portfolio of services and with the community**

Valuing programme benefits and risks on a common basis

$$v_j = v_j(x_{1j},\ldots,x_{nj}) = \sum_{i=1}^{n} k_i v_i(x_{ij})$$

Multicriteria additive value model



Options	Overall	Effective health gai	Equity	GHC goals	CCD services
P10	143.74	192.00	100.00	167.50	100.00
[all upper]	100.00	100.00	100.00	100.00	100.00
P7	69.58	41.26	100.00	30.00	100.00
P12	53.32	1.10	100.00	100.00	35.00
P2	53.28	1.00	100.00	100.00	35.00
P1	51.72	33.60	75.00	60.00	35.00
P5	51.55	10.12	100.00	60.00	35.00
P6	45.19	20.24	30.00	100.00	100.00
P4	44.35	0.40	90.00	60.00	35.00
P8	23.60	1.26	30.00	60.00	35.00
P9	23.07	9.92	30.00	30.00	35.00
P3	19.04	0.38	40.00	0.00	35.00
P11	4.90	0.00	0.00	0.00	35.00
[all lower]	0.00	0.00	0.00	0.00	0.00
Weights :		0.3800	0.3500	0.1300	0.1400

12 Programmes

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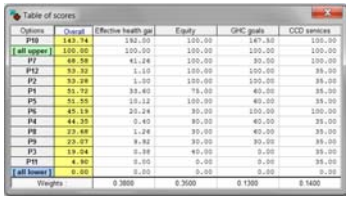

‘Cost’ constraint:
Limited number of nursing hours

Which PDA approach?

12 Programmes

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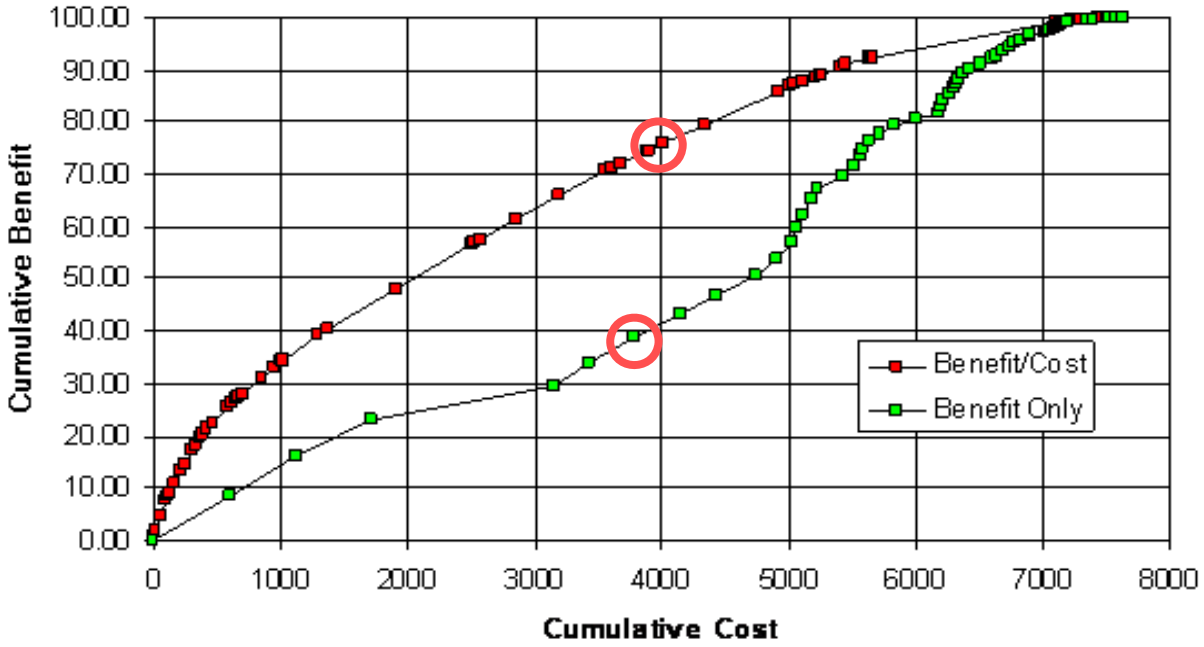
Adapted from: Oliveira, M.D., et al (2011) In E. Tanfani and A. Testi (Eds) *Advanced Decision Making Methods applied to Health Care*. Springer

Resource allocation managers' common critical mistake in prioritizing projects:

Projects prioritized by decreasing benefit, until the budget is exhausted



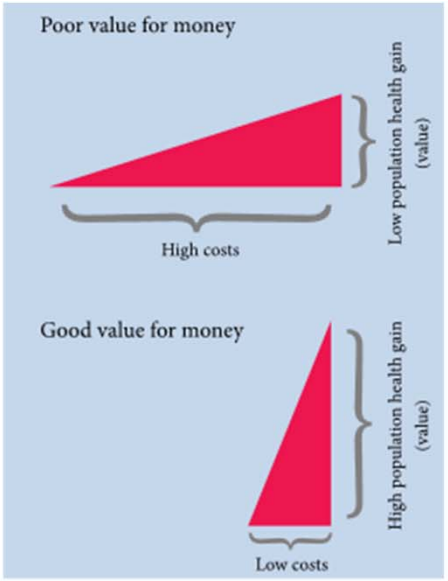
how do they do it in practice? Many different methods seem to be employed, but most are some variant of the following five steps: (1) List the projects (investments); (2) Determine the benefit that each project is expected to create; (3) Order the projects from most to least benefit; (4) Associate a forward cost for each project; (5) Go down the list, choosing projects until the budget is exceeded. In short, projects are prioritised on the basis of benefits only.

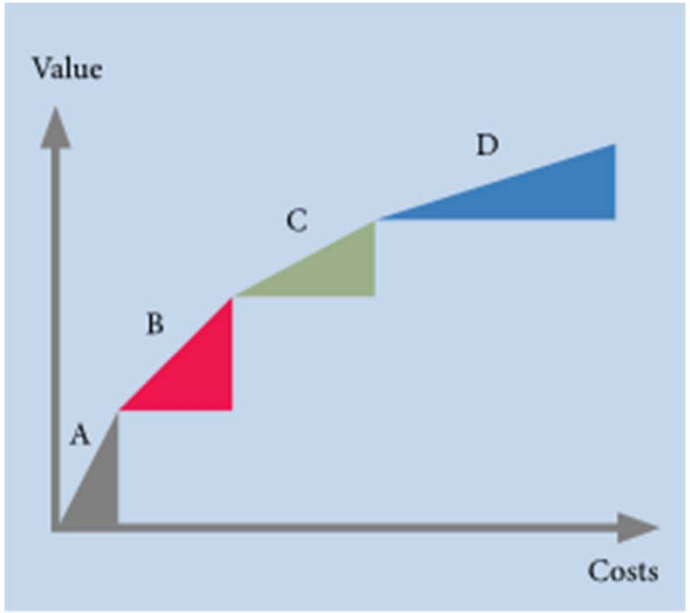
Phillips, L.D., Bana e Costa, C.A., 2007. Transparent prioritisation, budgeting and resource allocation with multi-criteria decision analysis and decision conferencing. *Annals of Operations Research*, 154(1), 51-68.

Under some conditions a simple alternative prioritization approach applies:

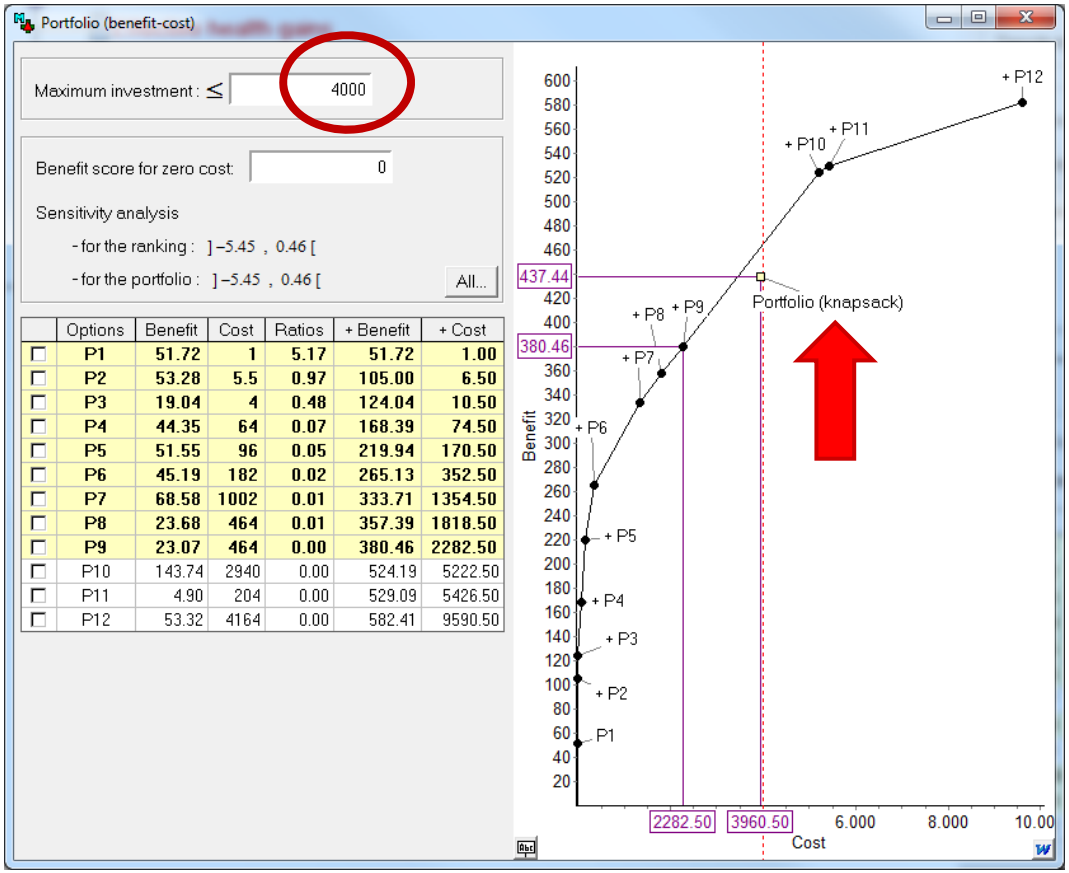
Projects prioritized by decreasing benefit/cost ratio, until the budget is exhausted

Programmes	Overall Benefit	Nursing hours required	Benefit/ Cost ratio	Cum. Overall Benefit	Cum. Overall Cost
P1 - Social integration income	51.7	1	51.7	51.7	1
P2 - Domiciliary visits: healthy lives	53.3	5.5	9.69	105	6.5
P3 - Physical exercise for the elderly	19.0	4	4.76	124	10.5
P4 - Prevention of domestic accidents for the elderly	44.4	64	0.69	168.4	74.5
P5 - Reproductive health and family planning	51.6	96	0.54	220	170.5
P6 - Group support for teenagers	45.2	182	0.25	265.2	352.5
P7 - Support to the child and youth vulnerable groups	68.6	1002	0.068	333.8	1354.5
P8 - Preparation for maternity/paternity	23.7	464	0.051	357.5	1818.5
P9 - Preparation for post-delivery	23.1	464	0.050	380.6	2282.5
P10 - Integrated long-term care	143.7	2940	0.049	524.3	5222.5
P11 - Health at home	4.9	204	0.024	529.2	5426.5
P12 - Promoting family parenting for vulnerable families	53.3	4164	0.013	582.5	9590.5
TOTAL	**582.5**	**9589.5**	-	-	-





(The Health Foundation 2012)

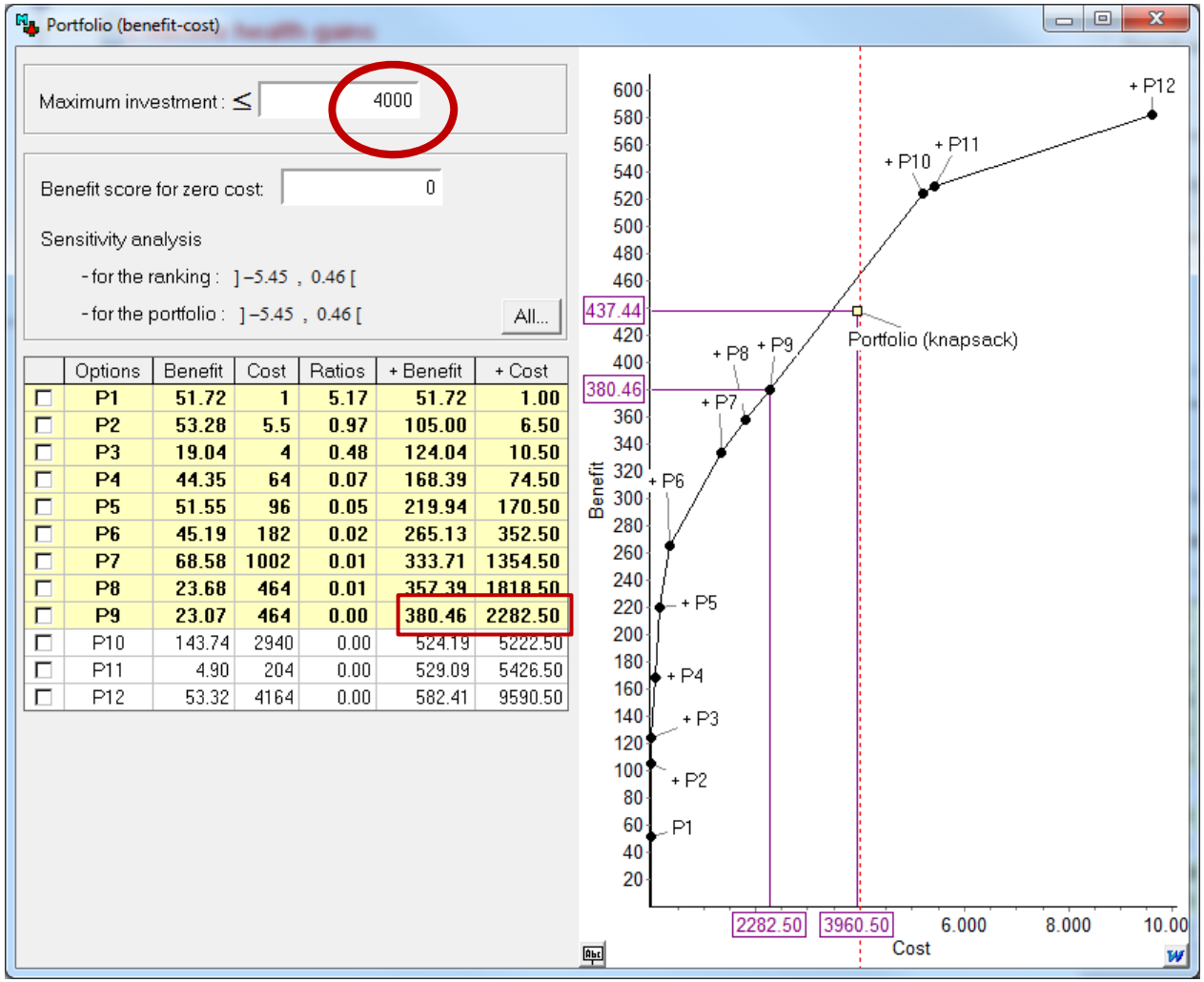


Alternatively, the portfolio selected by the optimization approach is the optimal solution of the following binary integer programming problem (known as the "0–1 knapsack problem" [47]):

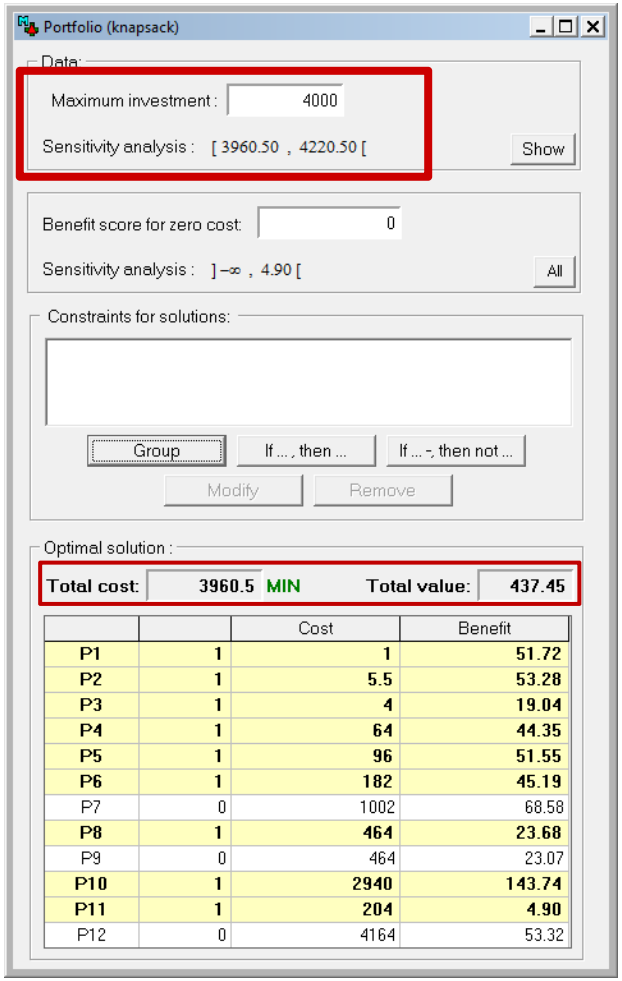
$$\begin{aligned} \text{maximize} \quad & \sum_{j=1}^{m} v_j x_j, \\ \text{subject to :} \quad & \sum_{j=1}^{m} c_j x_j \leq B, \\ & x_j \in \{0, 1\}, j = 1, \ldots, m, \end{aligned} \tag{8}$$

Lourenço, J.C., Morton, A., Bana e Costa, C.A., 2012. PROBE—A multicriteria decision support system for portfolio robustness evaluation. *Decision Support Systems*, 54(1), 534-550.

PDA: Ratio prioritization or knapsack optimization…?
M-MACETH answer: Both!



	Options	Benefit	Cost	Ratios	+ Benefit	+ Cost
☐	**P1**	**51.72**	**1**	**5.17**	**51.72**	**1.00**
☐	**P2**	**53.28**	**5.5**	**0.97**	**105.00**	**6.50**
☐	**P3**	**19.04**	**4**	**0.48**	**124.04**	**10.50**
☐	**P4**	**44.35**	**64**	**0.07**	**168.39**	**74.50**
☐	**P5**	**51.55**	**96**	**0.05**	**219.94**	**170.50**
☐	**P6**	**45.19**	**182**	**0.02**	**265.13**	**352.50**
☐	**P7**	**68.58**	**1002**	**0.01**	**333.71**	**1354.50**
☐	**P8**	**23.68**	**464**	**0.01**	**357.39**	**1818.50**
☐	**P9**	**23.07**	**464**	**0.00**	**380.46**	**2282.50**
☐	P10	143.74	2940	0.00	524.19	5222.50
☐	P11	4.90	204	0.00	529.09	5426.50
☐	P12	53.32	4164	0.00	582.41	9590.50

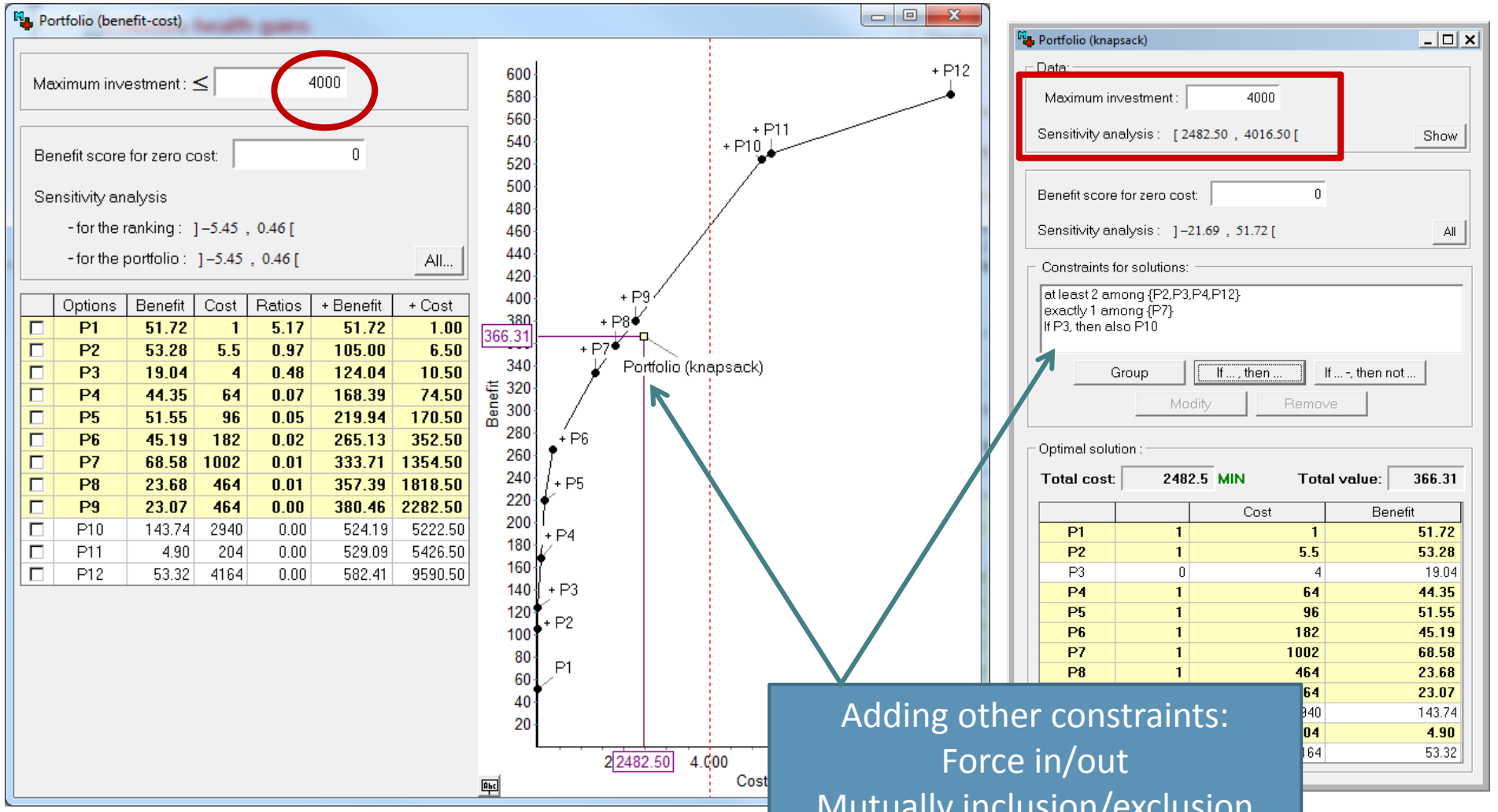


		Cost	Benefit
P1	**1**	**1**	**51.72**
P2	**1**	**5.5**	**53.28**
P3	**1**	**4**	**19.04**
P4	**1**	**64**	**44.35**
P5	**1**	**96**	**51.55**
P6	**1**	**182**	**45.19**
P7	0	1002	68.58
P8	**1**	**464**	**23.68**
P9	0	464	23.07
P10	**1**	**2940**	**143.74**
P11	**1**	**204**	**4.90**
P12	0	4164	53.32

Justification for new software: Existing commercial DSS for multicriteria resource allocation do not combine interactively benefit /cost prioritization and optimization and, therefore, do not allow an on-the-spot discussion of the advantages of both approaches

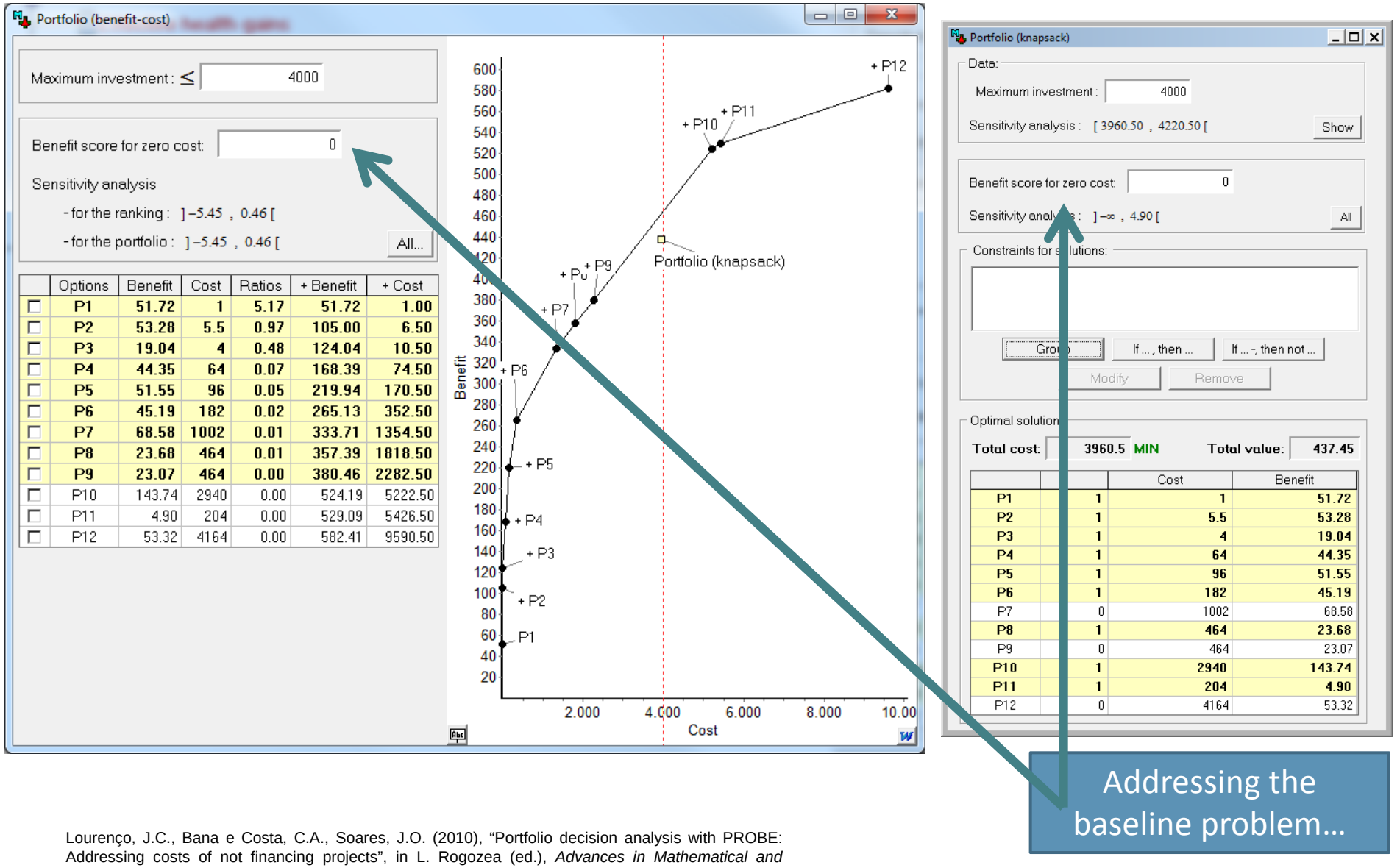
Lourenço, J.C., Bana e Costa, C.A., Morton, A. 2008. Software packages for multi-criteria resource allocation, Proceedings of the IEMC-Europe 2008, IEEE, Estoril, Portugal, pp. 93-98.

Additional features: Adding other constraints



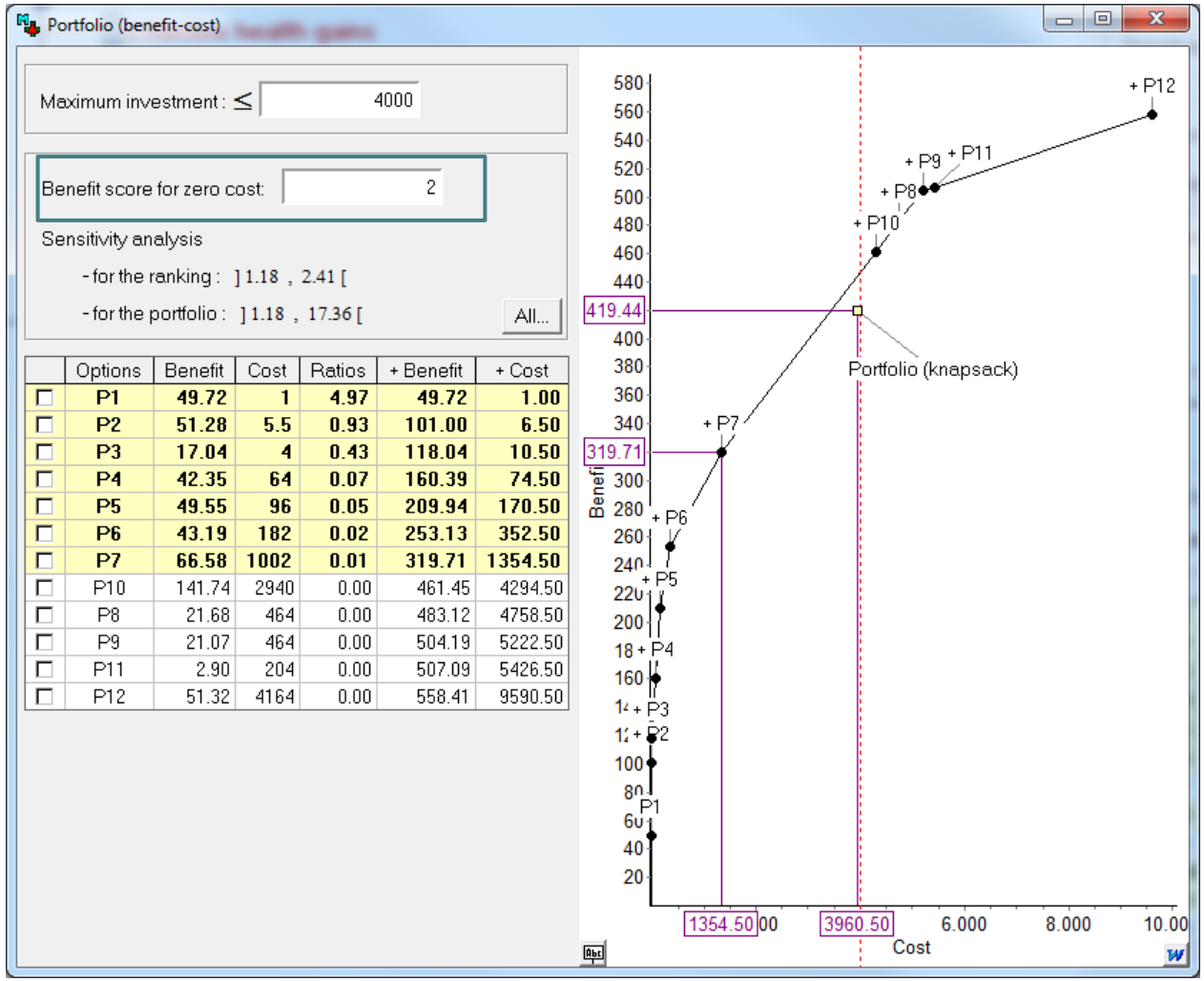
Adding other constraints:
Force in/out
Mutually inclusion/exclusion
Dependency between projects
Group constrains
...

Additional features: Addressing the baseline problem

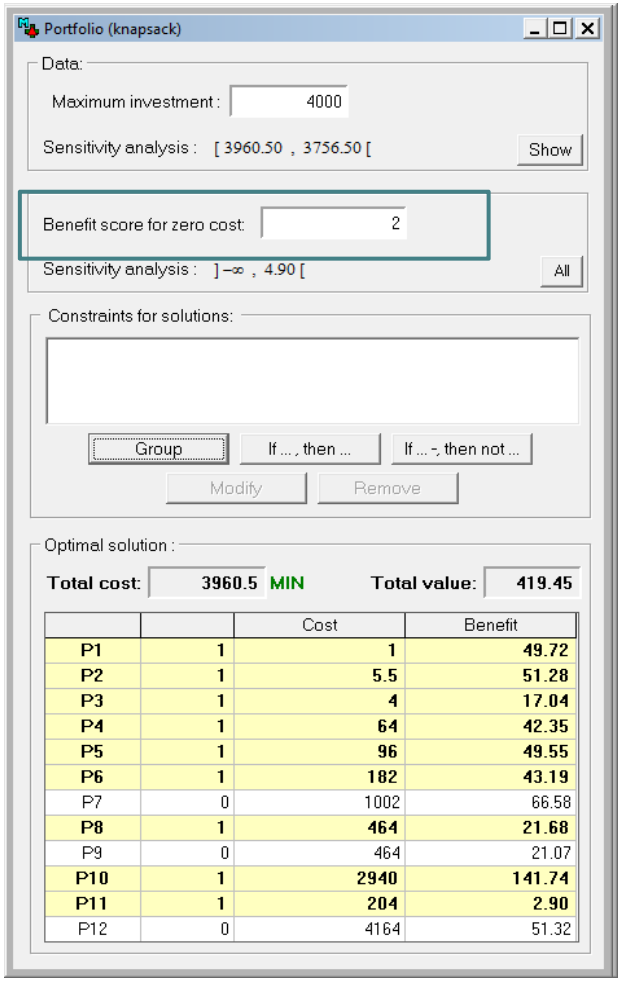


Lourenço, J.C., Bana e Costa, C.A., Soares, J.O. (2010), "Portfolio decision analysis with PROBE: Addressing costs of not financing projects", in L. Rogozea (ed.), *Advances in Mathematical and Computational Methods - 12th WSEAS International Conference on Mathematical and Computational Methods in Science and Engineering (MACMESE '10)*, University of Algarve, Faro, Portugal, November 3-5, 2010, WSEAS Press, pp. 340-344 (ISBN 978-960-474-243-1).

Addressing the baseline problem…



R. T. Clemen and J. E. Smith, On the choice of baselines in multiattribute portfolio analysis: A cautionary note, *Decision Analysis*, Vol. 6, No.4, 2009, pp. 256–262.

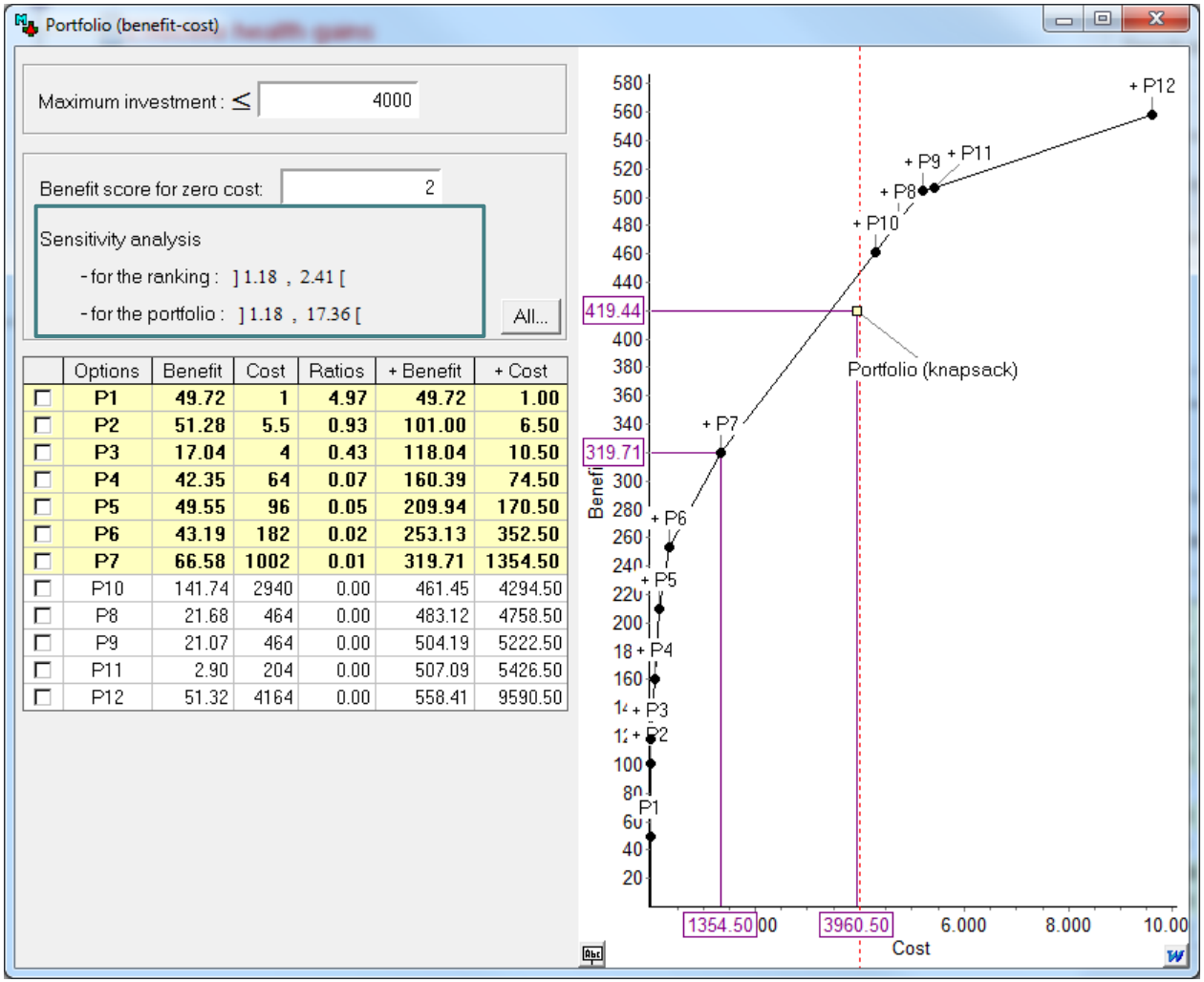


Mathematically, it is easy to reformulate the optimization problem (1) to allow nonzero values for not doing a project. If we let v_i° represent the value of not doing project i, the optimization problem can be rewritten as

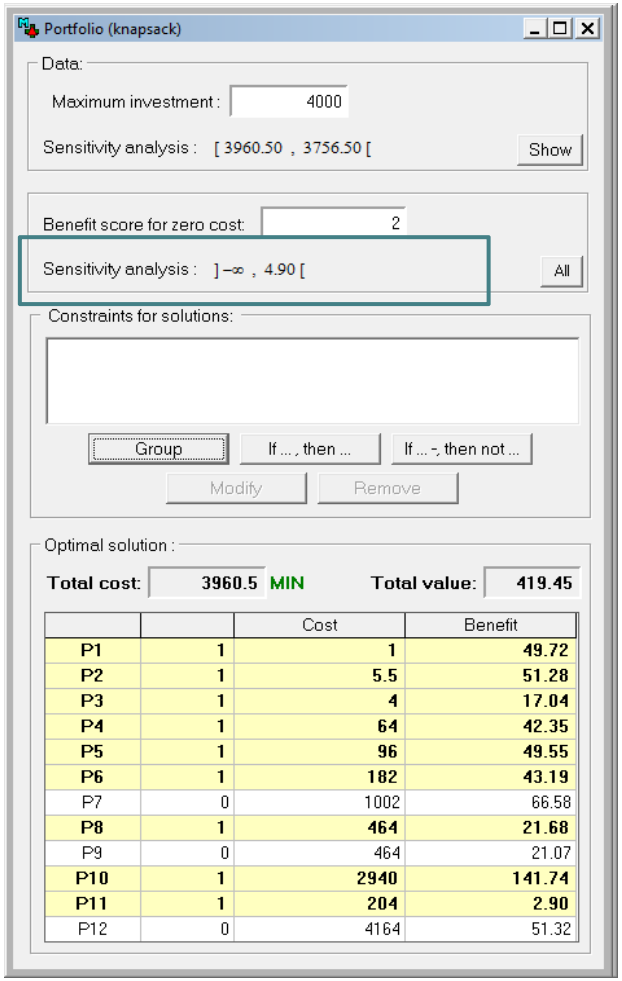
$$\max_{x_i \in \{0,1\}} \sum_i x_i v_i + (1 - x_i) v_i^\circ$$

$$\text{subject to } \sum x_i d_i \leq 2{,}500.$$

Addressing the baseline problem…



	Options	Benefit	Cost	Ratios	+ Benefit	+ Cost
☐	**P1**	**49.72**	**1**	**4.97**	**49.72**	**1.00**
☐	**P2**	**51.28**	**5.5**	**0.93**	**101.00**	**6.50**
☐	**P3**	**17.04**	**4**	**0.43**	**118.04**	**10.50**
☐	**P4**	**42.35**	**64**	**0.07**	**160.39**	**74.50**
☐	**P5**	**49.55**	**96**	**0.05**	**209.94**	**170.50**
☐	**P6**	**43.19**	**182**	**0.02**	**253.13**	**352.50**
☐	**P7**	**66.58**	**1002**	**0.01**	**319.71**	**1354.50**
☐	P10	141.74	2940	0.00	461.45	4294.50
☐	P8	21.68	464	0.00	483.12	4758.50
☐	P9	21.07	464	0.00	504.19	5222.50
☐	P11	2.90	204	0.00	507.09	5426.50
☐	P12	51.32	4164	0.00	558.41	9590.50



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P7	0	1002	66.58
P8	**1**	**464**	**21.68**
P9	0	464	21.07
P10	**1**	**2940**	**141.74**
P11	**1**	**204**	**2.90**
P12	0	4164	51.32

Liesiö J, Punkka A. Baseline value specification and sensitivity analysis in multiattribute project portfolio selection. European Journal of Operational Research. 2014; 237(3): 946-56.