Multi-Attribute Decision Making

Many decisions are based on other attributes than price. Choosing a car, for instance, although you might be looking in a particular price band. Comfort, performance, reliability, size, safety, style, image, equipment, handling, noise, running costs — these are some attributes of cars.

Example:

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Example: **helping a family to buy a car**

Steps: **(1) Clarify problem; (2) Identify objectives; (3) Measurement of effectiveness.**

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(1) *Clarify problem*	keep an older car? use public transport? constraints? —

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Steps: (1) Clarify problem; (2) Identify objectives; (3) Measurement of effectiveness.

(1) *Clarify problem*

keep an older car?
use public transport?
constraints? —
$
manual transmission / auto?
size?
power steering?
? 1. driving kids to school
? 2. reliable & safe commuting vehicle?
? 3. status symbol
? 4. help on family holidays

Example (cont.):

Attributes: Price, handling & performance, overall safety, overall comfort, brakes, visibility, manufacturer's reputation (AFR 17/11/04)

	(1) comfort 5A, or 1A + 5K	S_1
(2)	**(2) safe & reliable**	S_2
Identify	**(3) status**	S_3
objectives	**given the $ constraint**	

Example (cont.):

Attributes: Price, handling & performance, overall safety, overall comfort, brakes, visibility, manufacturer's reputation (AFR 17/11/04)

(2) *Identify objectives*	**(1) comfort 5A, or 1A + 5K**	S_1
	(2) safe & reliable	S_2
	(3) status	S_3
	given the $ constraint	

(3) *Measurement of effectiveness*	**(1) + (3) subjective—judgement**
	intuition
	experience
	(2) less subjective

Additive Valuation

1.

Additive Valuation

1. **Use scales for s_1, s_2, s_3**
   (1) (2) (3)

   For each of the three attributes (1), (2), and (3), score the cars on a scale from 0 to 1.

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   The three weightings w_1, w_2, w_3 should be normalised: $\sum w_i = 1$.

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3. From part (1), each car j has a score for attribute i:
   $\therefore x_{ij}$ is the score of car j in attribute i.

   $\therefore$ Each car's total score can be calculated: $\sum_i x_{ij} w_i \rightarrow$ score for car j

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4. **Choose the car with the highest total score, *or* iterate, until you feel happy with the scores, the weightings, and the final outcome.**

Multiattribute Problem

CBA a subset

e.g. which bank ?

quality of service	interest rates	location

Comparing specific	*outcomes*
	~~*projects*~~

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but – time consuming, costly
– continuous variables
$\rightarrow$ no information for *delegation*

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→

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- set minimum levels ("satisfy") of all attributes but one (the "target" attribute)
- choose the project/outcome/action with the highest level of the target

→ **iterative solution**

if min levels too | ***high*** / ***low***

So: ***useful, often used, attributes explicit***

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- **Examine the table on the next page, where countries' performances at the Atlanta Olympics are tabulated lexicographically.**

  This means there is no trade-off between numbers of Silver medals and numbers of Golds, so that Denmark (4 G, 1 S, 1 B) is ranked nineteenth, while Great Britain (1 G, 8 S, 5 B) is ranked thirty-sixth.

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- ➢ **Or we could rank by total number of medals, which means equal trade-offs between Gold and Silver and Bronze.**
- ➢ **Or we could weight the medals, say, Gold = 3, Silver = 2, Bronze = 1, which still allows a trade-off, but not an equal trade-off.**

Lexicographically Ranked by Gold, Silver, Bronze Medals (Atlanta)

	Gold	*Silver*	*Bronze*	*Total*
United States	44	32	25	101
Russia	26	21	16	63
Germany	20	18	27	65
China	16	22	12	50
France	15	7	15	37
Italy	13	10	12	35
Australia	9	9	23	41
Cuba	9	8	8	25
Ukraine	9	2	12	23
South Korea	7	15	5	27
Poland	7	5	5	17
Hungary	7	4	10	21
Spain	5	6	6	17
Romania	4	7	9	20
Netherlands	4	5	10	19
Greece	4	4	0	8
Czech Republic	4	3	4	11
Switzerland	4	3	0	7
Denmark	4	1	1	6
Turkey	4	1	1	6
Canada	3	11	8	22
Bulgaria	3	7	5	15
Japan	3	6	5	14
Kazakhstan	3	4	4	11
Brazil	3	3	9	15
New Zealand	3	2	1	6
South Africa	3	1	1	5
Ireland	3	0	1	4
Sweden	2	4	2	8
Norway	2	2	3	7
Belgium	2	2	2	6
Nigeria	2	1	3	6
North Korea	2	1	2	5
Algeria	2	0	1	3
Ethiopia	2	0	1	3
Great Britain	1	8	5	15
Belarus	1	6	8	15
Kenya	1	4	3	8
Jamaica	1	3	2	6
Finland	1	2	1	4
Indonesia	1	1	2	4
Yugoslavia	1	1	2	4
Iran	1	1	1	3
Slovakia	1	1	1	3

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e.g. which building to choose, given the two main uses for the building of Athletics and Crafts?

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	Rank (ordinal)	
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A	4	4
B	1	2
C	3	5
D	2	1
E	5	3

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So we see that:

D,B *dominate* C,A,E
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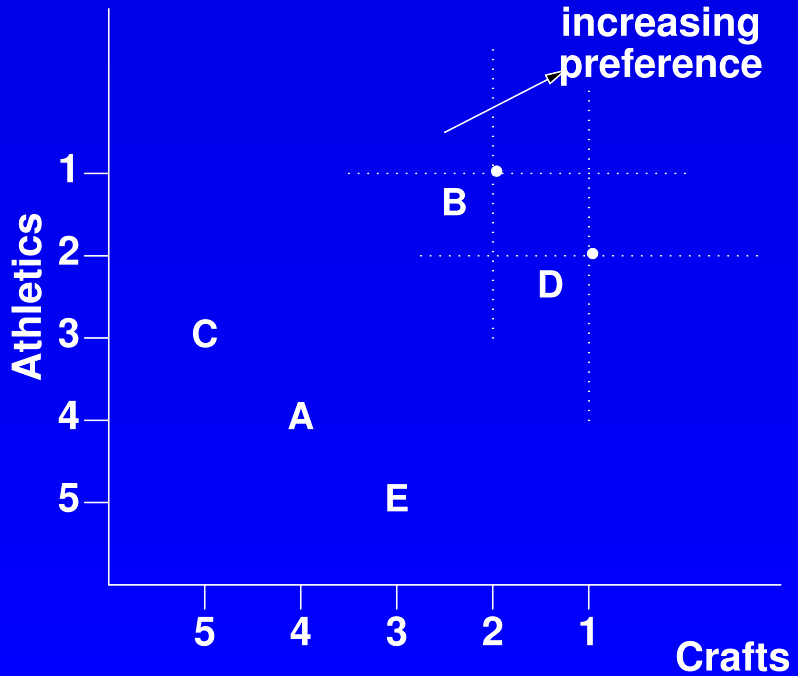

5. Even Swaps, or Pricing Out

[see the Hammond *HBR* reading in the Package.]

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e.g. which of five jobs to choose, given the five attributes of each job?

	Attributes / Characteristics				
Job	**Salary**	**Leisure Time**	**Working conditions**	**Co-workers**	**Where**
A	2	3	3	2	2
B	3	4	4	1	2
C	3	3	2	3	3
D	3	1	2	1	1
E	1	2	1	2	2

Freda has ranked the jobs in terms of each attribute.

$E \; \mathcal{P} \; A$
$E \; \mathcal{P} \; C$
$D \; \mathcal{P} \; B$

$\therefore$ **Freda's comparison is reduced to *D*, *E***

Even Swaps (cont.)

Spell out the measures of each attribute:

Job	Salary	Leisure Time	Working conditions	Co-workers	Location
D	$90k	8 days	W_D	C_D	L_D
E	$100k	5 days	W_E	C_E	L_E

Q:

Even Swaps (cont.)

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Q: How much of \$100K would Freda be prepared to give up to get 3 additional leisure days/year?

A:

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Q: How much of \$100K would Freda be prepared to give up to get 3 additional leisure days/year?

A: \$25K $\rightarrow E'$

D	90k	8	W_D	C_D	L_D
E′	75k	8	W_E	C_E	L_E

from above W_E (1st) > W_D (2nd)

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Q: How much of \$90k would Freda be prepared to give up to get W_E?

A:

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from above W_E (1st) > W_D (2nd)

Q: How much of \$90k would Freda be prepared to give up to get W_E?

A: \$10k $\rightarrow$ D′ "*pricing out*"

Even Swaps (cont.)

D'	\$80k	8	W_E	C_D	L_D
E'	\$75k	8	W_E	C_E	L_E
D'	\$80k	8	W_E	C_D	L_D
E''	\$70k	8	W_E	C_D	L_E
D''	\$72.5k	8	W_E	C_D	L_E
E''	\$70k	8	W_E	C_D	L_E

i.e. all attributes "priced out" by Freda, whose choice is job *D*

$$D' \, \mathcal{I} \, D'' \text{ -- ?}$$
$$E' \, \mathcal{I} \, B'' \text{ -- ?}$$
$$D \, \mathcal{I} \, D' \text{ -- ?}$$
$$E \, \mathcal{I} \, B' \text{ -- ?}$$
$$E'' \, \mathcal{I} \, D''$$
$$\therefore \quad E \, \mathcal{I} \, D$$

$$D \, \mathcal{I} \, D'' \, \mathcal{P} \, E'' \, \mathcal{I} \, E \Rightarrow D \, \mathcal{P} \, E$$

6. Additive Value Models

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three attributes:

Net Present Value	***PV***	⊕	**the more, the better**
Time to Completion	***T***	⊖	**the less, the better**
Impact	***I***	⊕	

	A	B	C
NPV	$20m	$15m	$25m
T	8y	5y	12y
I	200k	300k	100K

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○ ***Independence*** ○

If the trade-off between {*PV* & *T*} is independent of the level of *I*

& if the trade off between {*T*, *I*} is independent of the level of *PV*

***then* {*PV* & *I*} are independent of *T*.**

i.e. *Preference Independence* of *PV*, *T*, *I*

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$$V(\text{project } j) = \sum_{i}^{attributes} w_i[v_{ij}(x_{ij})]$$

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- where w_i are attribute weights, $\sum w_i = 1$
  Project $j \rightarrow$ score V_j & can compare projects : V_j to obtain ranking

e.g.	w_i	A j=1	v_{i1}	B j=2	v_{i2}	C j=3	v_{i3}
NPV	0.9	\$20m	0.5	\$15m	0	\$25m	1
T	0.06	8y	0.6	5y	1	12y	0 (−ve)
I	0.04	200k	0.8	300k	1	100k	0

e.g. x_{23} = level of attribute T in Project 3 = 12.

$\sum w_i = 1, \; w_i \geq 0$ attribute weights

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project A: $V_A = 0.9 \times 0.5 + 0.06 \times 0.6 + 0.04 \times 0.8 = 0.518$

$V_B = 0.9 \times 0 + 0.06 + 0.04 = 0.1$

< >

	Alternatives				
	Job A	Job B	Job C	Job D	Job E
Objectives					
Weekly salary	**$2000**	**$2400**	**$1800**	**$1900**	**$2200**
Flexibility	**mod**	**low**	**high**	**mod**	**none**
Business skills	**computer**	**people man.**	**operations**	**org.**	**time man.**
Development		**computer**	**computer**		**multitasking**
Annual leave	**14**	**12**	**10**	**15**	**12**
Benefits	**health, dental retirement**	**health, dental**	**health retirement**	**health**	**health, dental**
Employment	**great**	**good**	**good**	**great**	**boring**
Location	**Syd**	**Melb**	**Syd**	**Bris**	**Perth**

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5. Don't double count.

Only individuals matter

+

All individuals matter equally
(or: a $ is a $, no matter whose)

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7. the Winner's Curse when choosing one of several:
   the estimates of future costs and benefits are not unbiassed in the most attractive project (highest benefits – costs): possibility of negative NPV.

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3. ***with growth options:***
   or follow-on investments, with distant and uncertain payoffs. Often, learning more about future options is most valuable.

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Answer: **the principles of risk-neutral valuation with the Black-Scholes option pricing techniques.**