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Phase 1. Establishing Your SMAU Decision System, Evaluating Current Corporate Performance, and Setting Requirements on New Decisions

(Consulting Fee $27k +$1k/attribute per decisionmaker; Your Involvement 24-34 hrs)

In this phase, a bespoke, decision-ready system is constructed. It is also applied to current attribute levels to establish the current Total Monetary Equivalent exceedance curve (see demo video), which will be used to construct some of the performance goals for prospective decisions (whose performances are evaluated in Phase II).

ANONYMOUS ATTRIBUTES, CATEGORIES, & DECISIONS: *With the exception of Earnings, all attributes, their categories, and (in Phase II) decisions, will be both named actually and named generically – Attribute 1, Attribute 2, Category 1, etc. - and only the latter shall be provided to the Consultant, who will always be unaware of the actual identities of the attributes. <u>This masking protects the confidentially of your Decisionmaking and Business Intelligence, prevents conflicts of interest on the part of the Consultant, and increases your confidence in the Consultant and freedom in the valuation process</u>. Consultant shall advise on or provide a utility for Client's computer that "stamps" the actual attribute names on the graphical results.*

1.a. Decision Team members & supporting staff Identify Attributes and their quantitative measures. Decision Impact Experts are Recruited and Interviewed to Establish Current Attribute Levels

($12k+$0.5K/attribute/decisionmaker, Participants' Time 6-10 hrs)
Consultant briefs Decision Team on MultiAttribute Utility Decisionmaking (MAU), Stochastic MAU, and the Monte Carlo method. In subsequent meetings Decision team individually and collectively identify Corporate Goal Categories/Subcategories and their Attributes, desirable - higher attribute levels preferred - and undesirable ones - lower levels preferred (Bond et al., 2008 recommend individual then group collaboration). Because several less significant attributes taken together may have considerable bearing on a decision, these should also be included provided that they each account for at least 1%-3% of the overall importance to the Organization.

Decision Team identifies individuals who are familiar with or expert regarding each attribute. These individuals can be expected to quantify at a fuzzy level - estimated mean value plus uncertainty - the impact of any decision upon the attribute assigned to them.   (Experts may also be external consultants). The most appropriate measure of each attribute will be determined. This metric should be reliably calculable with
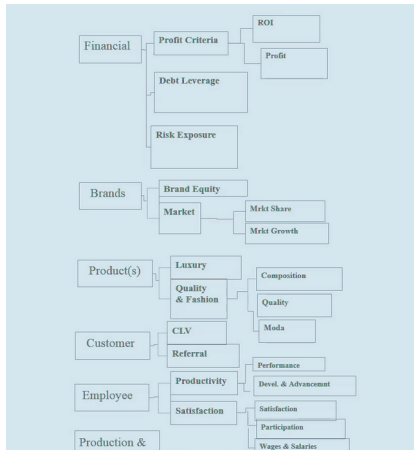
(Click pictures for larger view)

considerable certainty and be representative of the attribute.

The Experts are interviewed to establish quantitative values of current attribute levels.

Phase 1a Deliverables:

Client to Consultant:

1) List of <u>Attributes</u>, their possible ranges, and their Current Levels

2) Graphical Depiction of Goal Attributes, organized by Category/SubCategory

Consultant's Effort and Deliverables:

Consultant constructs all input databases to reflect Client's category & attribute configuration and the number of Decisionmakers, and adapts web interface components to this configuration. These interfaces apply a generalized SMAU engine to the Client's specific Decision topology. Consultant then validates the output using variations of assumed elicitation results and hypothetical decisions.

Client has unlimited access, for the duration of the project, to dedicated, secure web browser interfaces that run the SMAU system, computing the Meq curves for total utility and each attribute, and display elicited input information.
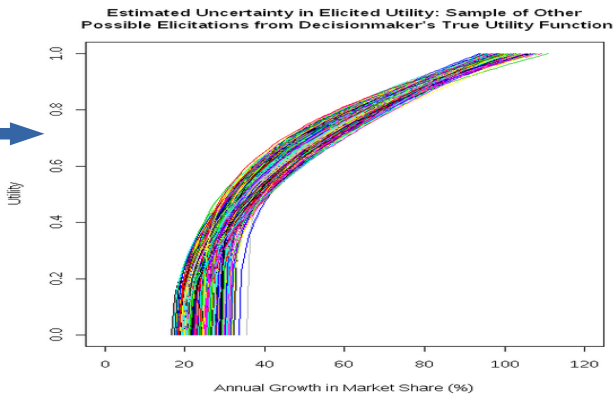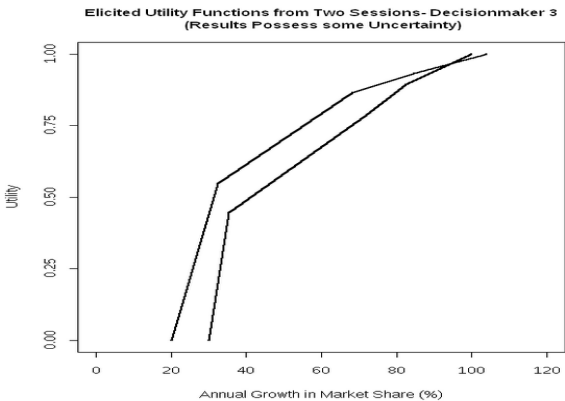
Client shall "test drive" the Decision System via the web interfaces, using current attribute levels and assumed DM elicitation results and performance goals (to be substituted by actual information in Phase 1.c and Phase 2). Using the system, Decision Team should begin to formulate corporate performance goals for Meq curves (see <u>demo</u>)

Phase 1.b Elicit each Decisionmaker's Utility Functions, Estimate their Uncertainties (Fuzziness), and elicit Probability Distributions on Category and Attributes Importance Weights

($12k + $0.5k/attribute/decisionmaker, Participants' Time 12 hrs ea.)

1) **Elicit each Decisionmaker's Attribute Utility Functions and Estimate the Functions' Probability Distributions:**

   Consultant works individually with Decision Team members to elicit their Utility Functions, then an empirical (probability) distribution on each function is created.

Elicited Utility Functions from Two Sessions- Decisionmaker 3
(Results Possess some Uncertainty)

Estimated Uncertainty in Elicited Utility: Sample of Other
Possible Elicitations from Decisionmaker's True Utility Function

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Phase 1.b (Cont'd)`
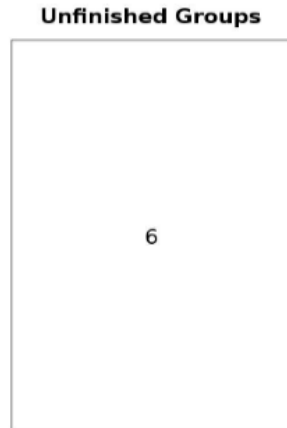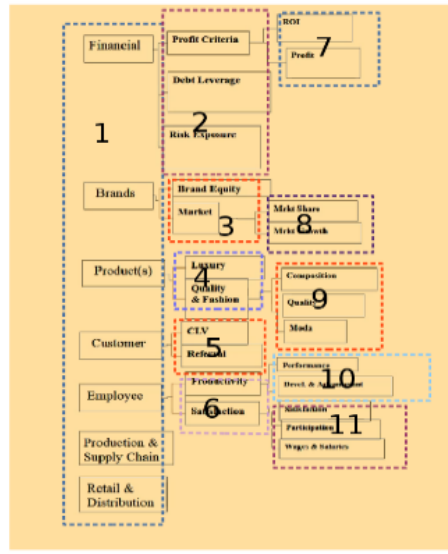
2) **Category and SubCategory Importance**

Weights, and Their Uncertainties, are Elicited from Each Decisionmaker

Decision Team members individually provide probability distributions on their Importance Weights on Categories and Subcategories, and on each Attribute's importance weight within it's subcategory.

Consultant verifies with each DM that elicited information is representative. Consultant constructs updated Input Databases and Decision System Output, reflecting each DM's elicited distributions on category/attribute weights and estimates of distributions of the DMs' attribute utility functions. See [example displays of inputs](#).

Your corporation's current performance is now the orange MEq curve in the [demo](#).

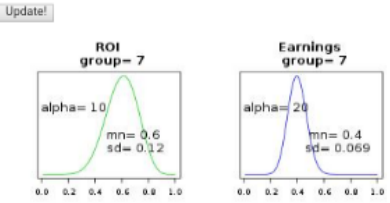### Elicit Distributions for Weights on Category Members

Phase 1.c **Display Current Performance (Meq Curve), and Set Performance Requirements for Future Decisions (***see [demo](#)***)**
($5k to $10k; DMs' Time 6-12 hrs ea.)

a) Consultant works with Decisionmakers to collectively define 1) probability performance requirements on MEq, Earnings, and other important attributes and 2) minimum curve levels (ie must lie to the right of these) on MEq. Other requirements and constraints on attributes will also be identified.

b) Consultant implements these constraints in Decision System, DM's review and either directly modify Constraint Frontiers or receive updated ones from Consultant.

c) Consultant and DM team together run System using hypothetical decision impact distributions and interpret results

The Stochastic MAU Decision System is now ready for New Decisions!

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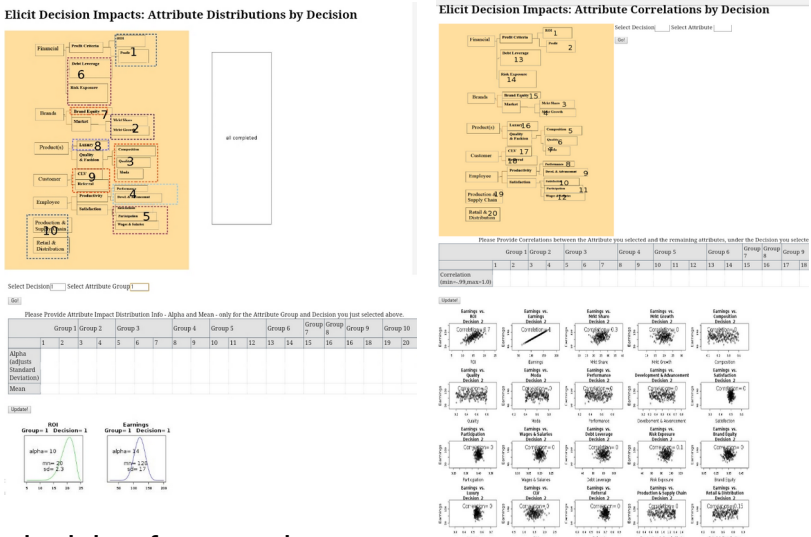### Consultant's Final Phase 1 Deliverable ($8k): Brief Report Document containing:

- a) Illustrated Decision Topology
- b) All Decisionmakers' Distributions on Attribute Weights
- c) Estimated attribute Utility Function distributions from each Decisionmaker's elicitation
- d) Consultant-constructed impact distributions for 2 hypothetical decisions
- e) MEq exceedance Curve for Current Attribute level and MEq and attribute-level Performance goals for future decisions
- f) MEq exceedance curves based on elicited weights, estimated utility functions, and hypothetical impact distributions
- g) A Formal Mathematical Description of SMAU System computations and generation of all random variables/functions

Phase 2. *Actual Decisionmaking*

> *(2.a Consulting Fee $25k + $0.4k per attribute-expert eg. $65k, for 5 experts on each of 20 attributes. 2.b Consulting Fee negotiated)*

2.a Best Decision: For Each Decision Under Consideration, Elicit Attribute Impact Distributions from Experts. Client Runs System and Obtains Decision Performance Results

a) Consultant elicits all <u>attributes' probability distributions, for each decision, from the experts</u> assigned to them and composites (weight-averages) these distributions to obtain a single distribution per attribute per decision (adjustable later). Time-discounting of attribute distribution levels may be applied for decisions whose benefits are lagged. Consultant also elicits correlations between attributes, by decision from each expert: composited correlations are then induced in the SMAU system via Latin Hypercube Sampling, and improve the realism of each decision's impacts, precluding impossible combinations from being included in the computation of the MEq exceedance curve.

b) Consultant constructs database comprising distributional and correlation information for each attribute under each decision, and initial expert-compositing weights for each attribute. This database, along with those from the Decisionmakers' elicitations, are the input for the System's <u>Monte Carlo Generation</u> of attribute levels, valuation weights, and utility functions, that are in turn used to compute, in each iteration, Total Utility, then Monetized Equivalent of Net Total Utility – MEq.

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Phase 2.a (Cont'd)

c) Client runs System (multiple times, for alternative sets of Decisionmaker compositing weights and of expert compositing weights, if desired). Client examines Exceedance Curves for MEq, Earnings, and all other attributes (or their monetized equivalents) selected for performance evaluation, and compares them with their performance requirements (see [demo]). Consultant assists Client in ranking admissible decisions in order of selection preference, considering MEq and attribute variation, stochastic dominance measures, and probablistic preferences and assurance metrics additional to those strictly required for admissibility. Also (fee negotiated) if decision-specific, formal inclusion of each decision's Implementation and Practical Aspects as attributes in the MEq computations is also possible provided that: 1) the DM's may state their valuations of these attributes' levels relative to their minimum level among all decisions eg. 1-1/2 to twice as preferred, etc., resulting in the equivalent of a utility function specific to these decision choices and 2) the DM's can assign importance weight distributions to these utility functions.

Consultant's Final Phase 2.a Deliverable: Brief Report Document containing:

a) Illustrated Decision Topology
b) All Decisionmakers' Distributions on Attribute Weights Distributions
c) Estimated attribute Utility Function distributions from each Decisionmaker's elicitation
d) Elicited Impact distributions, by expert, for each Decision
e) Total (net) MEq exceedance Curve and attribute MEq curves, by Prospective Decision, along with all performance Requirements on Total MEq and Attribute MEq values (see "demo.mp4" for a complete example)
f) Decision Choice recommendations in light of Client's ranking preferences stated in Phase 2.a
g) A Formal Mathematical Description of SMAU System computations and generation of all random variables/functions

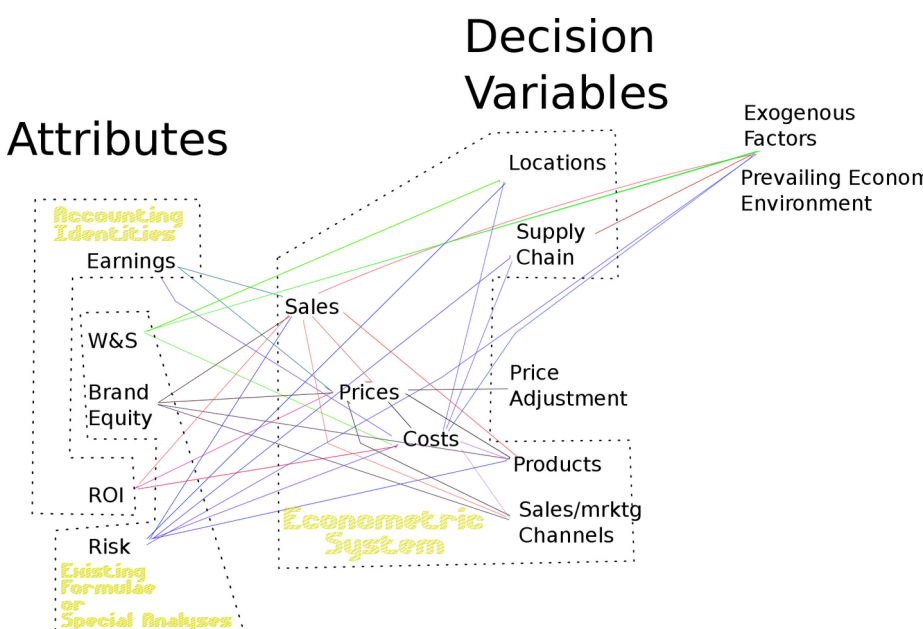## Phase 2.b or 2.b.alt *(either is optional and followed by 2.a)*

Using the Stochastic MAU System to Formulate a Decision

b) *Identification of the best combinations of all the attributes*
Consultant, using Decision System, conducts special analyses to identify combinations of attributes whose changes yield the greatest improvement in MEq exceedance curve. Client identifies, among these combinations, those which are signature results of specific decision types.
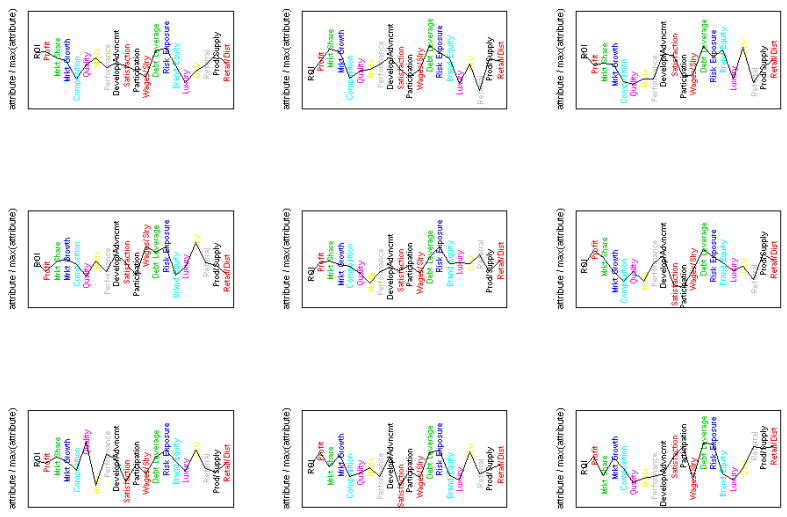
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Phase 2.b.alt   Computer-Assisted Decision Identification.   Monte Carlo Methods and a system similar to that depicted by the connecting lines are used. *(5 Attributes here, also additional Decision Variables may include choices of Financial Instruments, Investments, Earnings Distributions, Product Design Tweaks, etc., either as sole decisions or concurrently with changes in those shown).* All possible Attributes' levels are computed from

Decision Variables

Attributes

Exogenous Factors

Prevailing Economic Environment

Locations

Supply Chain

Price Adjustment

Products

Sales/mrktg Channels

Accounting Identities

Earnings

W&S

Brand Equity

ROI

Risk

Existing Formulæ or Special Analyses

Sales

Prices

Costs

Econometric System

Phase 2.b.alt (Cont'd)

all possible (and feasible) combinations of Decision Variables and probablistic values of Exogenous Factors. The prospective Decisions are then the Decision Variable combinations that closely induce the MEq-maximizing Attribute Combinations depicted in a1. *(Note: Decision Variable/Attribute System exists or is estimated by parties other than Consultant. Alternatively as an expanded workscope, Consultant can estimate Attribute Response Equations).*

b)   Client specifies prospective decisions, that satisfy all requirements on specific attributes, and in consideration of prospective decision types identified above. Consultant then conducts expert elicitation procedure identical to Phase 2.a

Thank you for your consideration! To get started, or for further information, you may reach us at 1.907.764.5428 or project@maut-decisions.com

Learn about *Optimized Marketing Strategies*,
          Estimation of Missing Data, and other Consulting Products at
          www.LinkedIn.com/in/pj-chamberlain-phd-b7a68bb1

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Sketch of Contract Terms and Conditions

MAUT Decisions, provider of SMAU consulting products and services, is also hereafter referred to as *Consultant*.
Client is the organization purchasing the consulting services, and also is the responsible individual(s) within that organization acting as technical contact for Consultant.

Value-Based Pricing

All pricing is value-based, typically under-priced relative to the probablistic added value of using SMAU and MEq. Therefore, if your organization recognizes only a cost-based pricing method (eg. as with many U.S. FAR contracts) a MAU or other decision algorithm is your only option, from another provider.

Contract Duration

Phases 1 and 2 are contracted separately. Unless otherwise negotiated, Contract Duration for Phase 1 is 90 days and Contract Duration for Phase 2 is 60 days.   A formal Purchase Order (PO) shall initiate each Phase, and payment, according to the terms below, shall be made for each Module (eg. Phase 1.a).

Client shall use due diligence in providing all information to Consultant and ensuring timely availability of appropriate staff for elicitations. In particular, Client shall provide Phase 1.a information to Consultant within 14 days of its initiation, and in Phase 1.b, Client's designees shall complete all elicitation participation within 30 days of the start of that module. For Phase 2.a, Client's designated experts shall complete elicitation participations within 30 days of start of that module.

Payment Terms

A Nonrefundable Payment of 50% of Module Price is required to initiate the work on each module, and payment of the remaining 50% is due, terms N/15, upon completion of that module's deliverables. No payments are due on subsequent modules until they are initiated.

Contract Duration Renegotiation

In the event of unforeseen circumstances, Client may renegotiate Contract duration, or cancel future modules in Contract. In such cases, Client shall immediately notify Consultant and pay remaining module obligation, even if Client is unable to complete or participate in remaining elicitations: if duration is renegotiated, this payment shall be credited to the same module after its future completion. Otherwise, if Contract is cancelled, current module payments remain forfeited to cover Consultant's costs and efforts,and no further obligation remains on the part of either party.

Disclaimer and Release of Liability

No Warranty on Consulting Services nor Guarantees on Decision Outcomes

While every reasonable effort has been and shall be made to assure theoretical and computational correctness of framework, web apps, databases, etc., MAUT Decisions provides no warranty on any aspect of services, method, databases, computations, or reports.   However, if during the Contract Period, Client finds specific errors, actual or apparent, Client shall notify Consultant of such, and allow Consultant time to investigate, and where applicable, provide updated results to Client.

Sketch of Contract Terms and Conditions (Cont'd)

Furthermore, SMAU, like any Decision Framework, is a decision selection algorithm – a posture - based on provided information and uncertain outcomes: therefore no guarantee is made by Consultant regarding the correctness of attribute outcomes or suitability of any decision recommendations, advice, failure to recommend, etc.

Legal Compliance and Release of Liability

It is the Client's responsibility to ensure Client's compliance with all applicable laws and regulations, regarding both its current and future prospective activities and decisions. Client shall comply with all such requirements, and Consultant shall act under the assumption that Client is in said compliance. Client holds harmless and releases Consultant from all liability, including that arising from contemplating, implementing, or operating under a selected decision.

Web Apps, Computational Engines, Databases

Ownership and Intellectual Property Rights

All Intellectual Property and computer implementations, included but not limited to current, corrected, or future modifications of SMAU mathematical Decision Framework, Monetized Equivalent of Net Total Utility Concept aka Meq, computational engines, and web interfaces, remain the property of MAUT Decisions, including versions reflecting improvements suggested by Client or others.

However, databases containing only Client-specific information (attribute topology, elicitation results, decision performance frontiers, etc.) are the property of the Client. All official versions, original and revised, of these databases shall be provided to Client during the Contract Period. After Contract completion, Consultant shall attempt to retain archives of all such information, but formal archival of these Client-owned databases remains the responsibility of the Client.

Access to Web Interface Apps

Our Web Interface Apps are Client-specific html pages and supporting scripts that facilitate access to generalized elicitation and computational engines that are executed on the Consultant's websites. During Contract Period, Client shall have free, unlimited access to various Web Interface Apps, commensurate with the completed and current work modules. Formal elicitations and production runs of SMAU system will be made by Consultant and scrutinized by same, but informal elicitations and SMAU runs may be made by client,for familiarization, insight, goal setting, and examining "what if" scenarios by selected tweaking.

Corporate Confidentiality: Client Nondiscloses Actual Attribute and Decision Identities

To protect the confidentialy of Client's Decisionmaking and Business Intelligence and to prevent conflicts of interest on the part of the Consultant, with the exception of the attribute Earnings (used in calculating Monetary Equivalent) **all Attribute, Category, and Decision names shall be generically relabeled for Consultant: Client shall make every reasonable effort to ensure that Consultant will at no time have knowledge of their actual names or functions.** Pursuant to maintaining this confidentiality, Consultant shall conduct all elicitation sessions remotely, providing guidance in the use of elicitation Web Apps to client's designees via telephone.
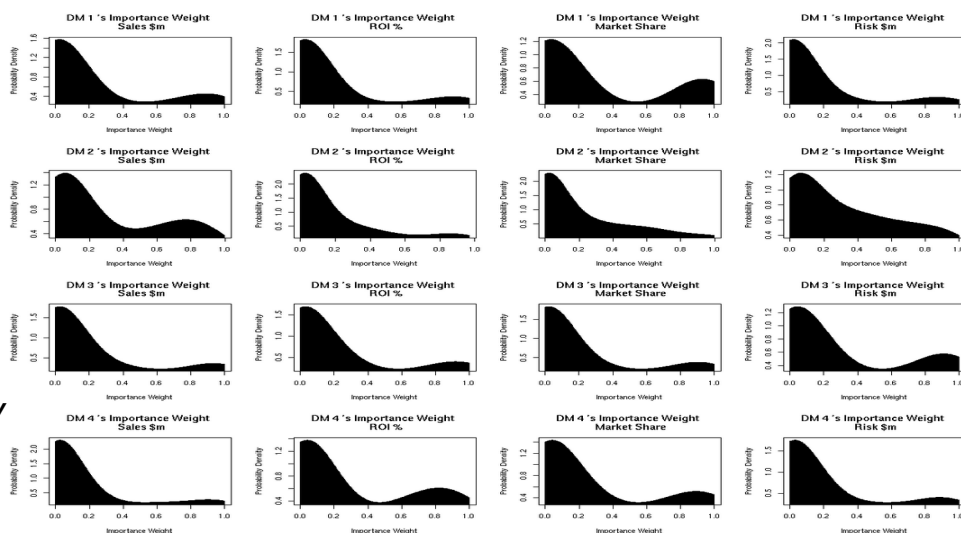
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## Example Displays in Decision System

1) **Probability distributions on inputs:**

on weights of attributes, on weights of subcategories and categories.

(Also Exceedance Probabilities on attributes - not shown here - with any requirement frontiers)b

Estimated Uncertainty in Elicited Utility: Sample of Other Possible Elicitations from Decisionmaker's True Utility Function
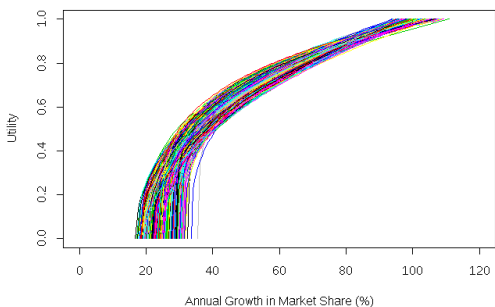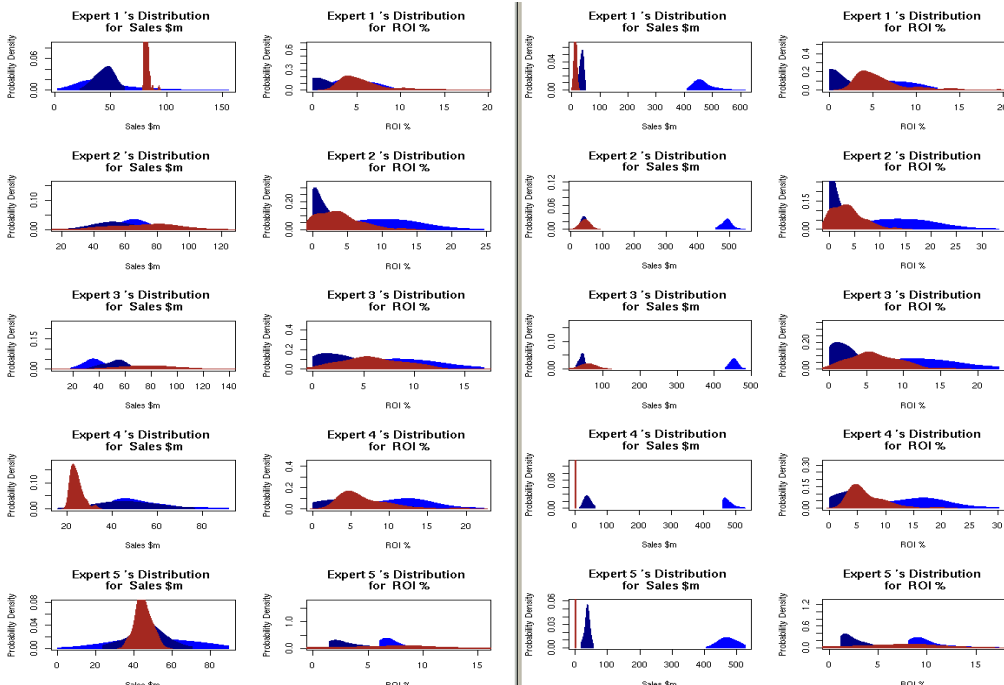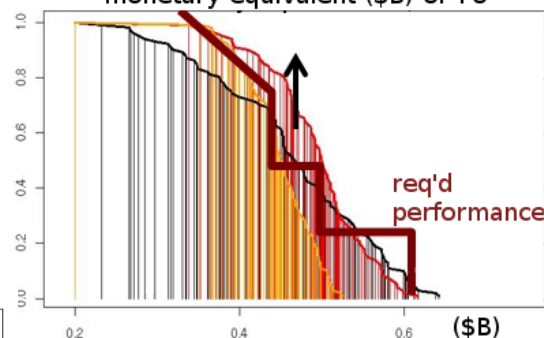
and possible attribute utility functions, by DM

(back to DM elicitation)

2) **Graphical Postprocessor & Decision Selection Tool**

Tabulation of Decisionmaker-composited TU and MEq, and display of its exceedance probabilities (and cumulative probabilities).

See demo for more complete example of performance requirements.
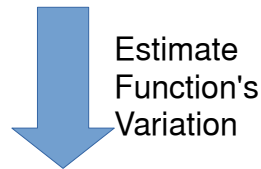
Also a graphical display of Decision Impacts, by expert and decision (here [tiny example] 4 attributes, 5 experts per attribute, 3 decisions)
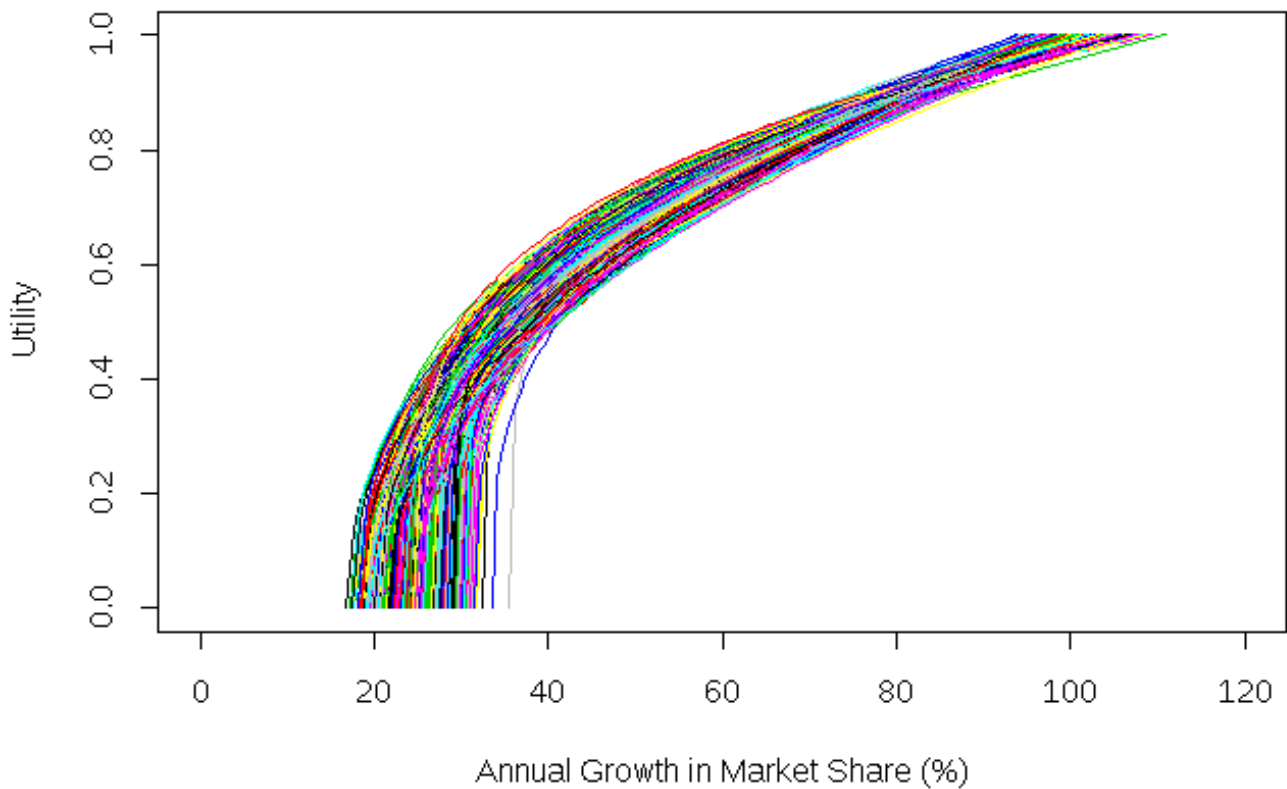
(back to decision impact elicitation)

Elicited Utility Functions from Two Sessions- Decisionmaker 3 (Results Possess some Uncertainty)

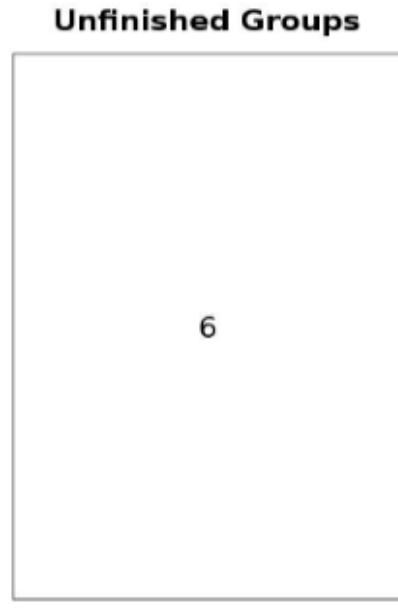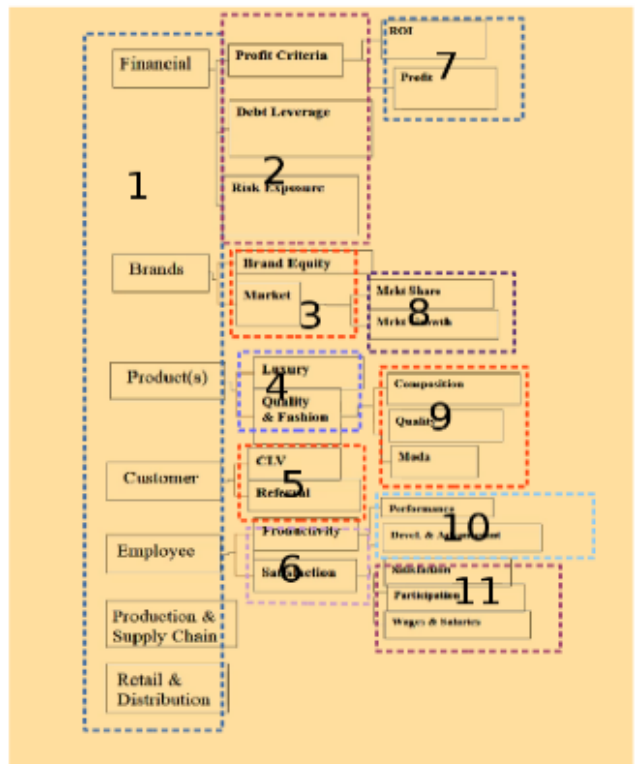Annual Growth in Market Share (%)

Estimate Function's Variation

Estimated Uncertainty in Elicited Utility: Sample of Other Possible Elicitations from Decisionmaker's True Utility Function

Annual Growth in Market Share (%)

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Elicit Distributions for Weights on Category Members

Unfinished Groups

6
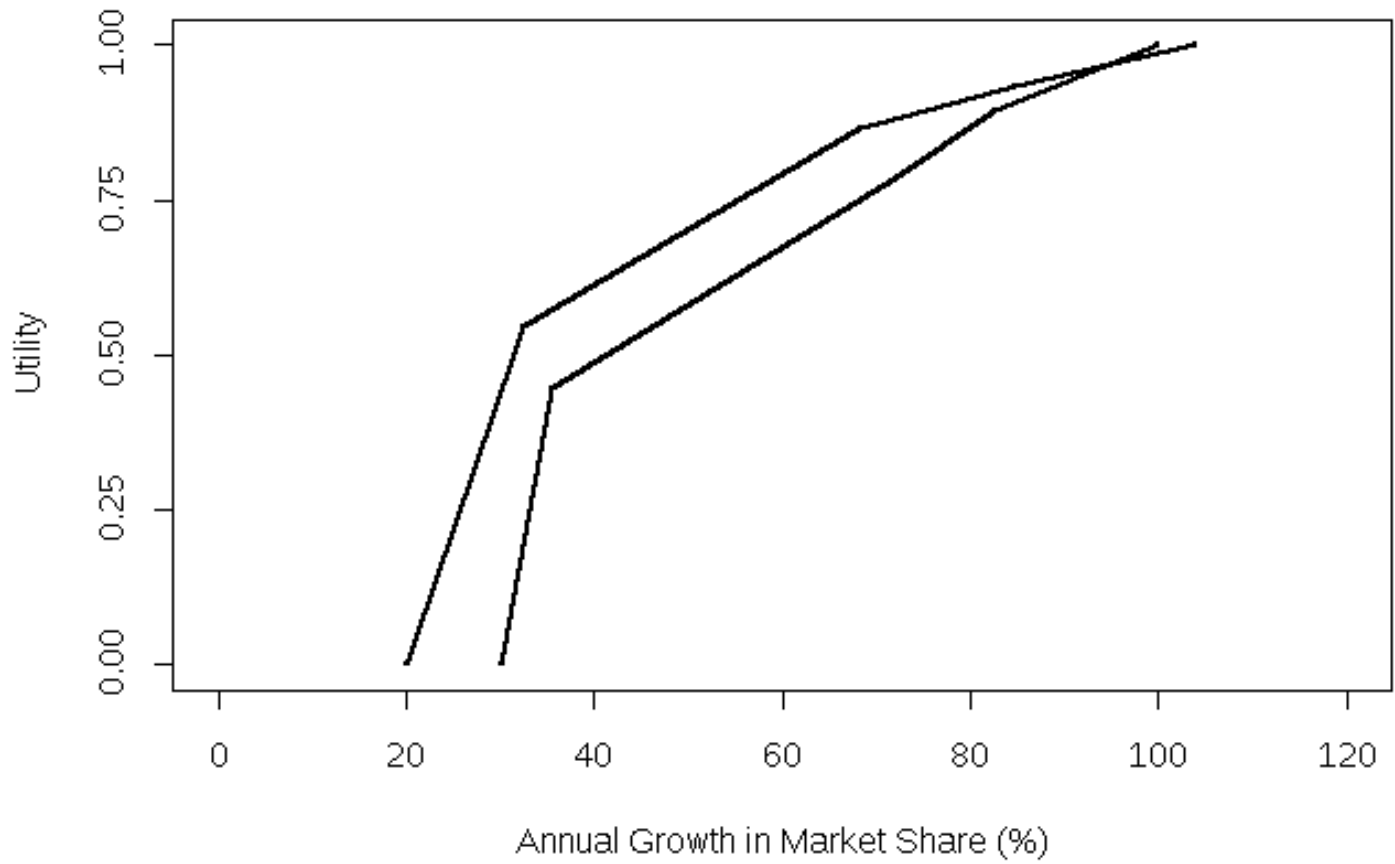
Select Category Group [_____]

Go!

Please Provide Alpha and Mean (sum of Means in a Group must equal 1.0) on the Member Weights only for the Category Group you just selected above.

	Group 1							Group 2			Group 3		Group 4		Group 5		Group 6		Group 7	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	16	18	19	20
Alpha (adjusts Standard Deviation)																				
Mean (sum of Means must equal 1.0)																				

	Group 8		Group 9		Group 10		Group 11		
	21	22	23	24	25	26	27	28	29	30
Alpha										
Mean										

Update!

ROI group− 7

alpha= 1.0
mn= 0.6
sd= 0.12

Earnings group− 7

alpha= 2.0
mn= 0.4
sd= 0.069
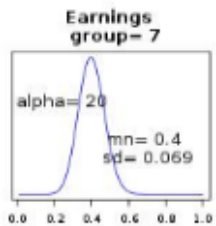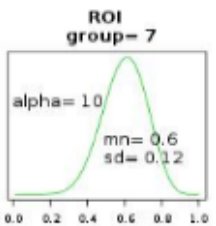
Distributions of Top-Level Weights for Attributes (all weights factored in - "W tilde in demo.mp4")

This provides a transitivity check on relative overall importances of attributes when each attribute is at its best level. (In each Monte Carlo realization, these compound weights sum to 1.0)
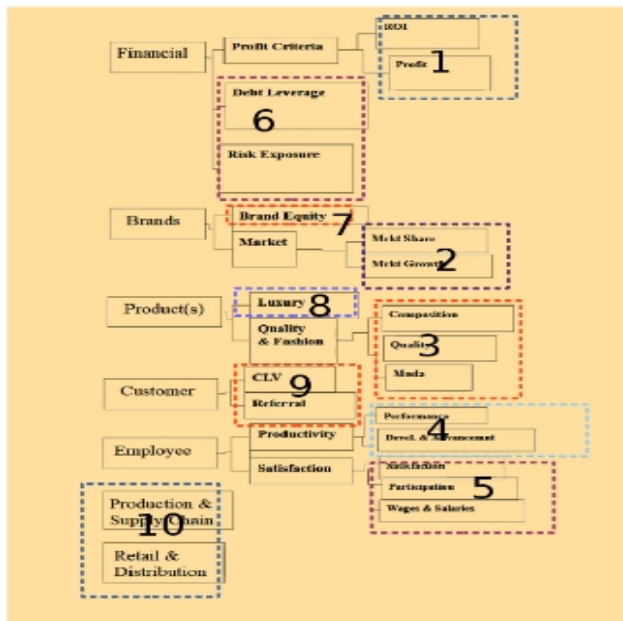
Use only after completing all groups' weights above!
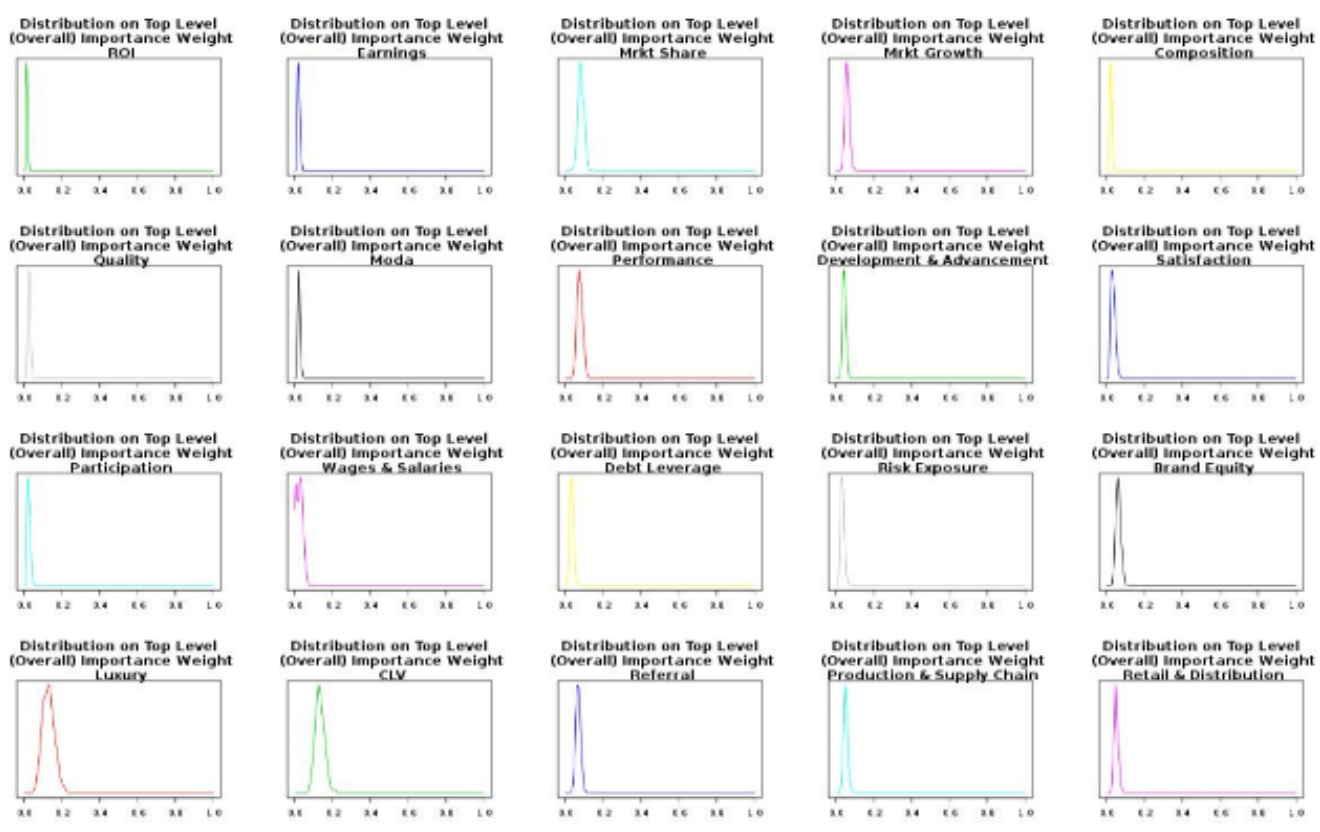
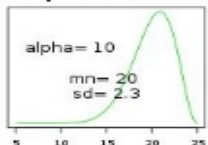## Elicit Decision Impacts: Attribute Distributions by Decision

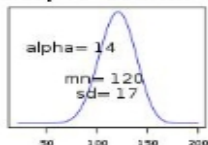Select Decision [1]   Select Attribute Group [1]

[Go!]

Please Provide Attribute Impact Distribution Info - Alpha and Mean - only for the Attribute Group and Decision you just selected above.

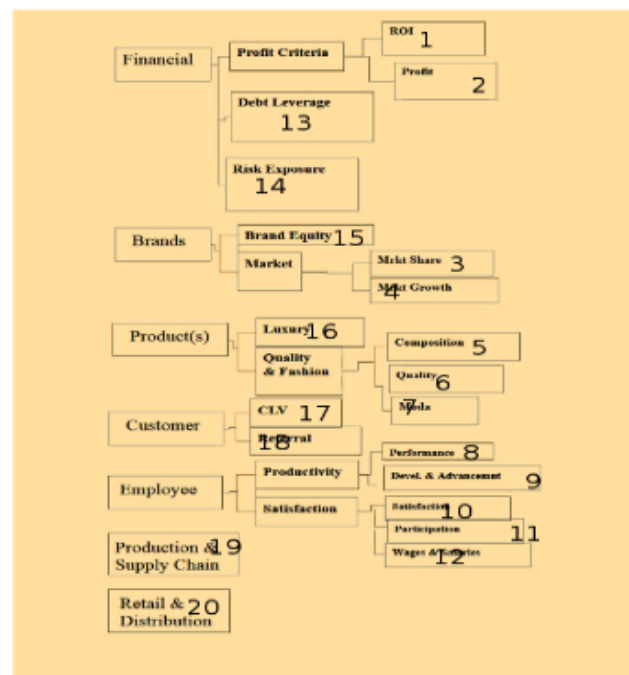|	Group 1		Group 2		Group 3			Group 4		Group 5			Group 6		Group 7	Group 8	Group 9		Group 10	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	16	18	19	20
Alpha (adjusts Standard Deviation)																				
Mean																				

[Update!]

ROI
Group=1   Decision=1
alpha= 10
mn= 20
sd= 2.3

Earnings
Group=1   Decision=1
alpha= 14
mn= 120
sd= 17

Elicit Decision Impacts: Attribute Correlations by Decision

Select Decision [   ] Select Attribute [   ]

Go!

Please Provide Correlations between the Attribute you selected and the remaining attributes, under the Decision you selecte

	Group 1	Group 2		Group 3			Group 4		Group 5			Group 6		Group 7	Group 8	Group 9	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Correlation (min=-.99,max=1.0)																		

Update!
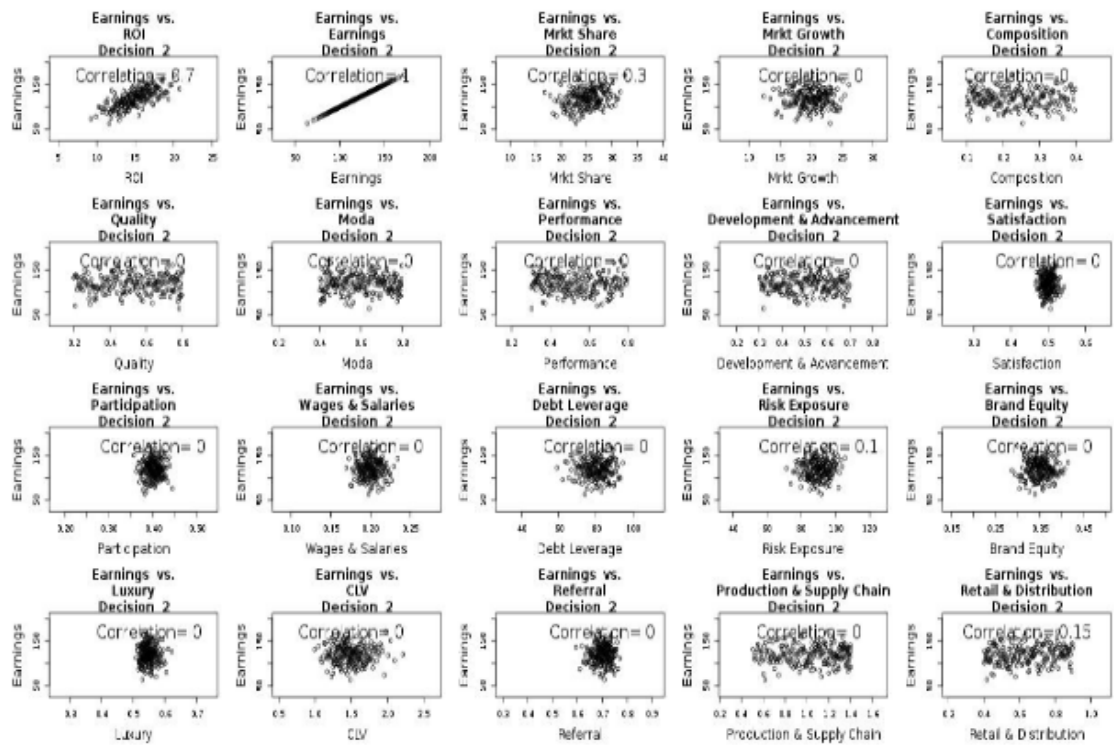
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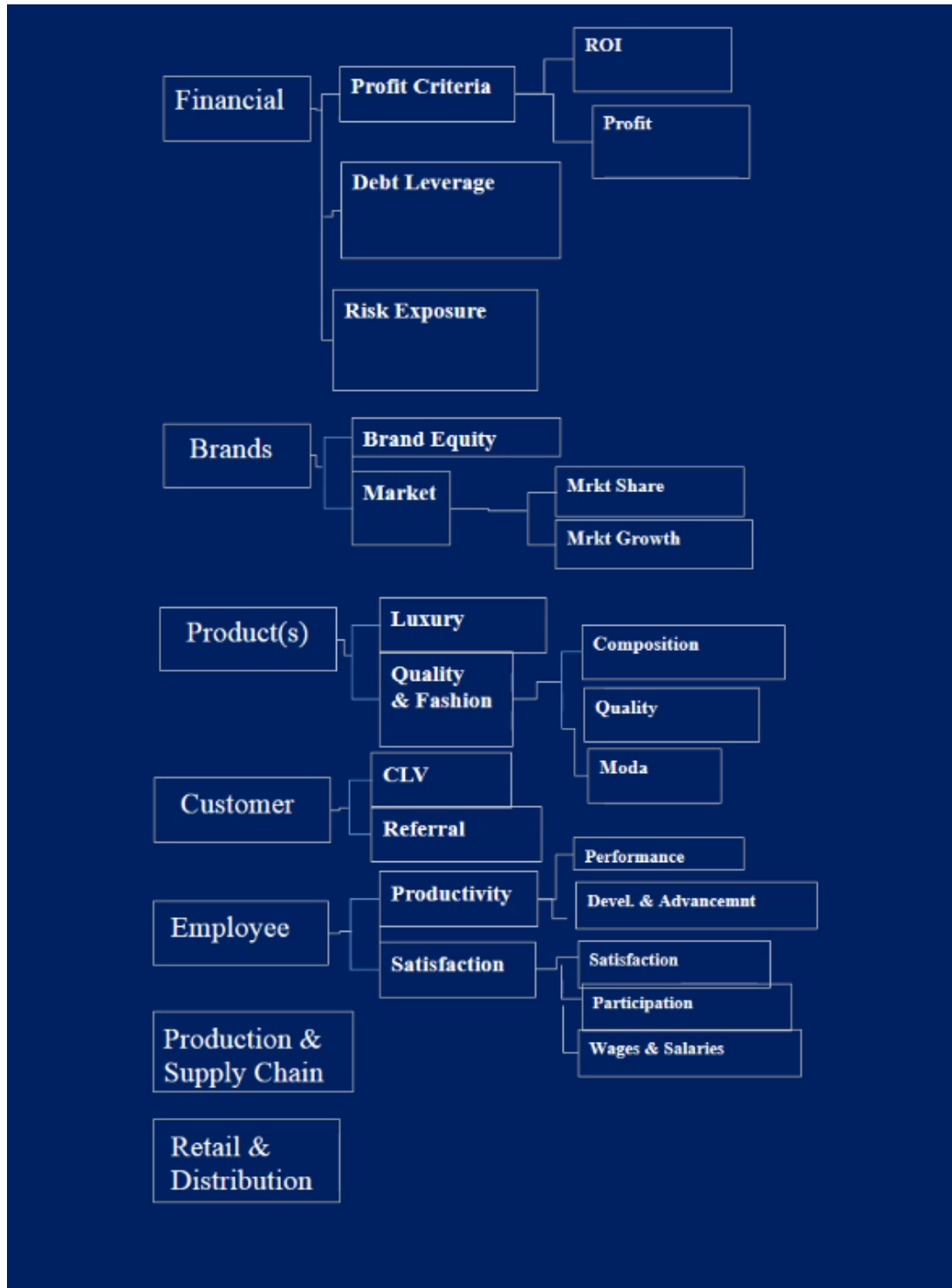
An Abstracted Example

- *Attributes* - ie. having *utility functions* - are the rightmost leaves on each branch eg. *Quality*, *Profit*.
- *Subcategories* without leaves are also attributes eg. *Luxury*, *CLV* but their weights are elicited as subcategory weights, at a higher level than the attributes beneath adjacent subcategory members
- Even at the top Category level, members without branches are also attributes eg. *Retail & Distiribution* (abstractly depicted here with no subcategories) .
- (20 attributes in total, over all levels)   *(back)*
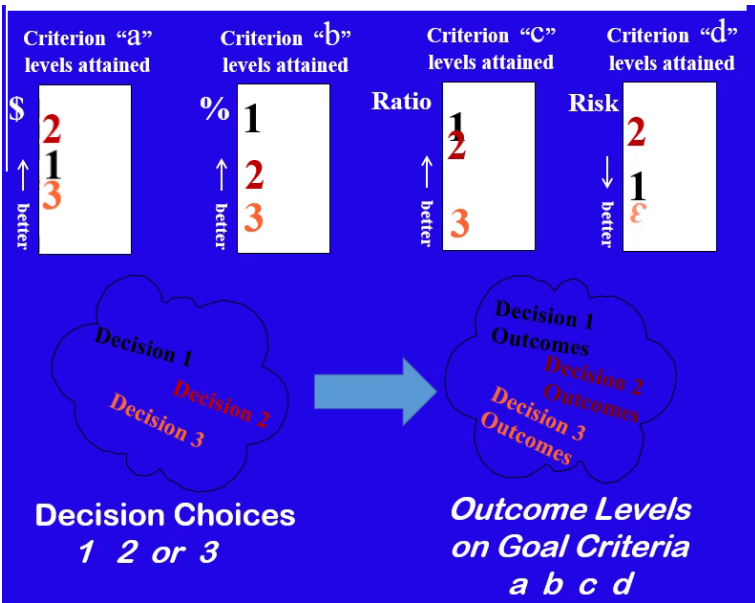
Now it's your turn!   What's important in your organization?

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MAU (MultiAttribute Utility) and Stochastic MAU

from:

Criterion "a" levels attained — $ — 2 1 3 — ↑ better

Criterion "b" levels attained — % — 1 2 3 — ↑ better

Criterion "C" levels attained — Ratio — 1 2 3 — ↑ better

Criterion "d" levels attained — Risk — 2 1 ε — ↓ better

Decision 1
Decision 2
Decision 3

→

Decision 1 Outcomes
Decision 2 Outcomes
Decision 3 Outcomes

Decision Choices
1 2 or 3

Outcome Levels
on Goal Criteria
a b c d

Introducing . . . the

attribute *Utility Function!*

Decisionmaker Assigns Values To possible Attribute Levels...
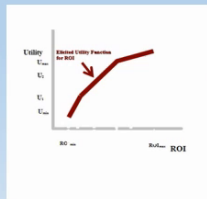 eg. On a Scale of 1-100

Attribute Level: $,%,ratio,category,etc.

What Is It?
It's the decisionmaker's valuation of different attribute levels.

How is it obtained?

- Using an app, the DM rates the relative values at min and max.
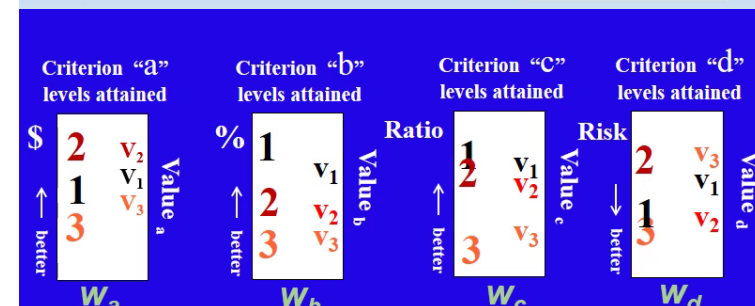- An elicitation procedure helps them trace out values at intermediate points

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Multi-Criteria Complexities:

- **No decision scores best in all criteria**
  - ⇒ *Need a single measure compositing all criteria*

- **Decisionmaker(s) criteria scales may be nonlinear:** *twice as much could be 4 times better*
  - ⇒*Need decisionmakers' value scales for each Criterion*

- **The criteria usually aren't equally important**
  - ⇒*Need decisionmaker's importance weights on the Criteria*

Multi-Criteria Decisionmaking (MCDM): Simplifying with Attribute Utilities

- **Problem:** Decisionmaker(s) criteria scales may be nonlinear: *twice as much could be 4 times better*
  - ⇒*Solution: Individual Utilities express decisionmakers' value scales, for each Criterion/Attribute*

- **Problem:** The criteria usually aren't equally important
  - ⇒*Solution: Decisionmaker's importance weights across Criteria are elicited. The attribute utilities are multiplied by their weights, placing them on the same basis.*

  After elicitation, the weights are rescaled to sum to 1....
  In our example $w_a + w_b + w_c + w_d = 1$

- **Problem:** No decision scores best in all criteria

- ⇒ *Solution: The Weighted Attribute Utilities are added: this composite metric, accurately represents the value and importance of each criterion.*

(back)

Criterion "a" levels attained — $ — 2 1 3 — v_2 v_1 v_3 — Value a — ↑ better — w_a

Criterion "b" levels attained — % — 1 2 3 — v_1 v_2 v_3 — Value b — ↑ better — w_b

Criterion "C" levels attained — Ratio — 1 2 3 — v_1 v_2 v_3 — Value c — ↑ better — w_c

Criterion "d" levels attained — Risk — 2 1 ε — v_3 v_1 v_2 — Value d — ↓ better — w_d

MAUT Decisions *Stochastic MAU Products*
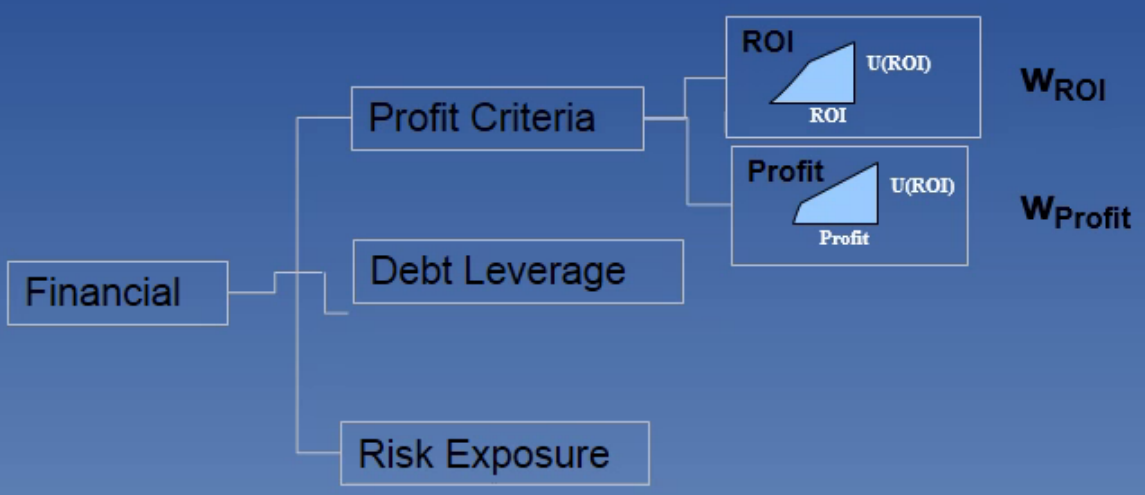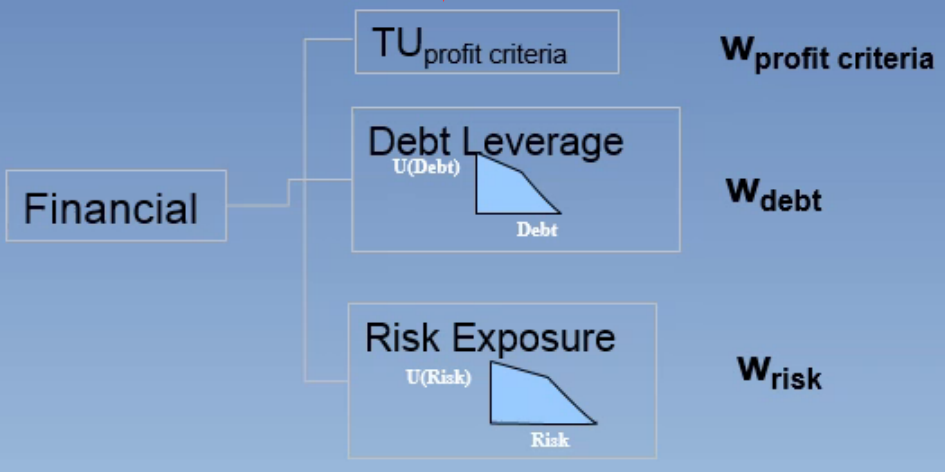

$$TU_{\text{profit criteria}} = w_{ROI} U_{ROI} + w_{Profit} U_{Profit}$$

$$TU_{Financial} = w_{Debt} U_{Debt} + w_{Risk} U_{Risk} + w_{ProfitCriteria} TU_{ProfitCriteria}$$

$$= w_{Debt} U_{Debt} + w_{Risk} U_{Risk} + w_{ProfitCriteria}\{w_{ROI} U_{ROI} + w_{Profit} U_{profit}\}$$

→ Category Utilities are weighted sums of lower Utilities
→ Attributes in Subcategories are weighted twice or more

(back)

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$w_{financial}$ X $\boxed{TU_{Financial}}$

+

w_{brands} X $\boxed{TU_{Brands}}$

+

$w_{products}$ X $\boxed{TU_{Products}}$

+

$w_{customer}$ X $\boxed{TU_{Customer}}$

+

w_{employ} X $\boxed{TU_{Employee}}$

+

$w_{prod\ \&\ sc}$ X $\boxed{TU_{Production\ \&\ SC}}$

+

$w_{retail\ \&\ dist}$ X $\boxed{TU_{Retail\ \&\ Dist}}$

= **TU**

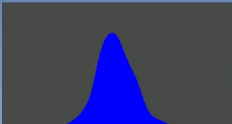Uncertainties in DMs' weights & utilities, and Experts' attribute distributions are obtained as before
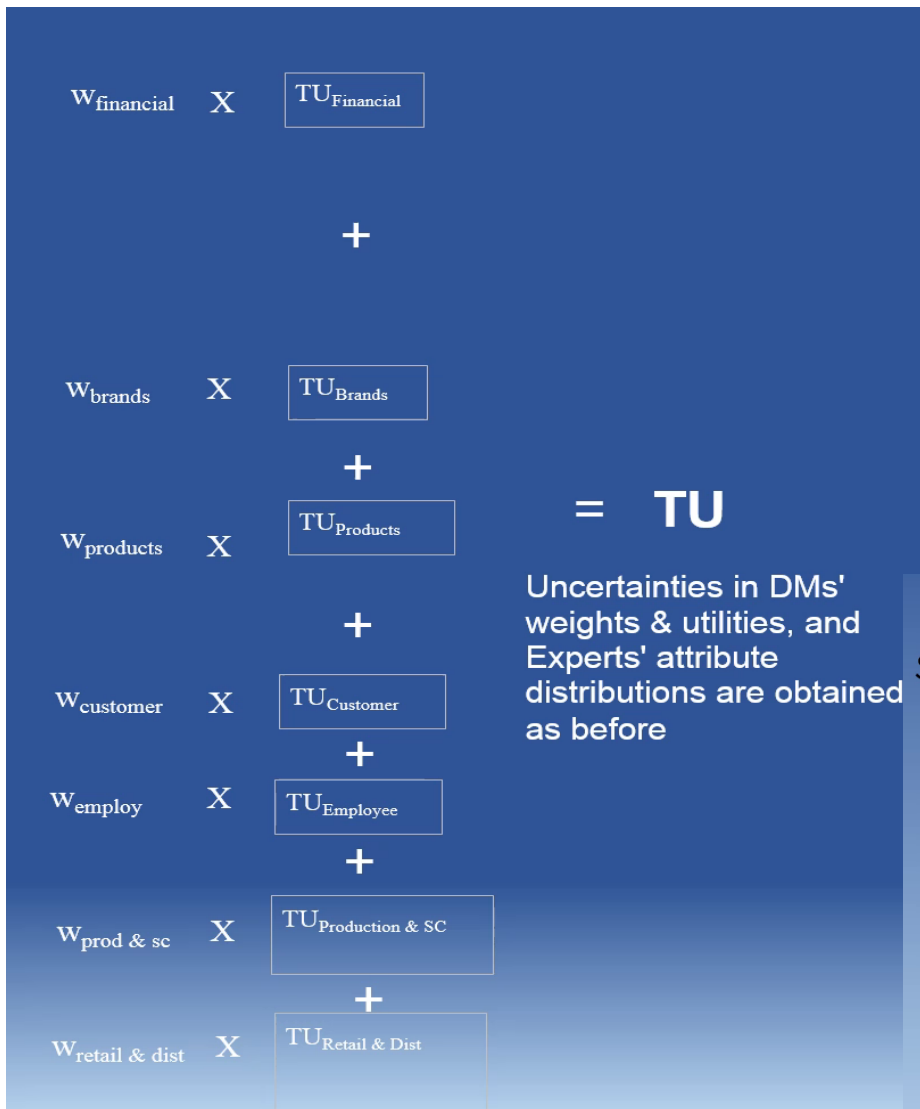
That's how TU is computed….

Now introducing *Stochastic MAU*, where weights, utility functions, & decision impacts on attributes possess uncertainty
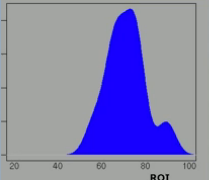
- each attribute could have *several possible outcomes*

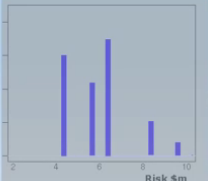… so the attributes really have **probability distributions**

and, these distributions change with *each* decision

many attribute distributions will have infinitely many possibilities…
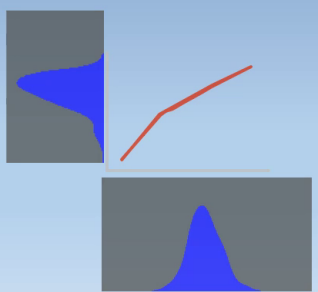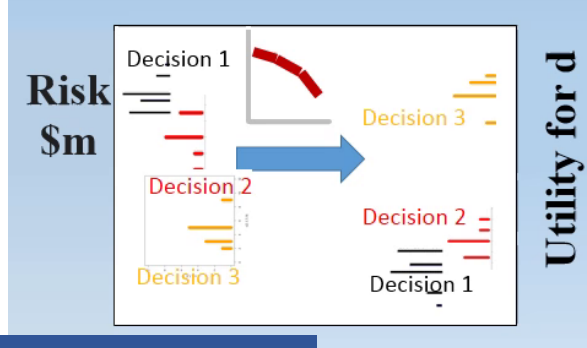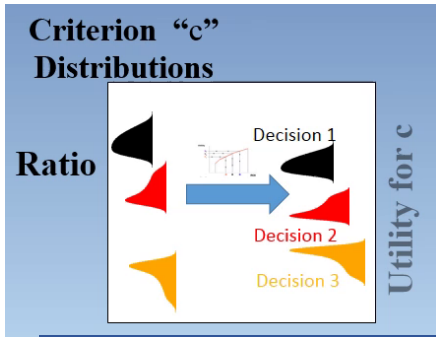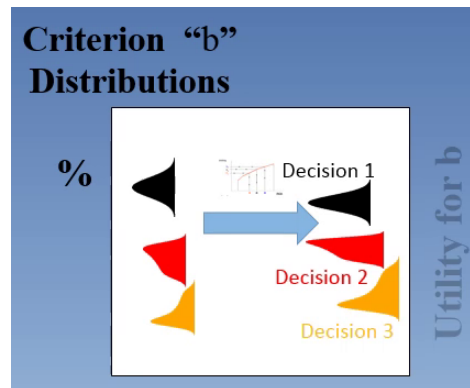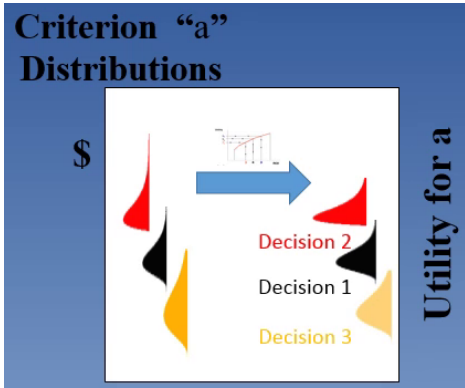
… but some will have just a few possibilities

(back)

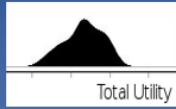utility = f(attribute)

… so how does the attribute uncertainty affect its Utility Value?

… The answer: the attribute's utility has a probability distribution too

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Criterion "a" Distributions

$

Decision 2
Decision 1
Decision 3

Utility for a

Criterion "b" Distributions

%

Decision 1
Decision 2
Decision 3

Utility for b

Criterion "c" Distributions

Ratio

Decision 1
Decision 2
Decision 3

Utility for c

Risk $m

Decision 1
Decision 2
Decision 3
Decision 3
Decision 2
Decision 1

Utility for d

Total Utility's Comprehensive Uncertainty:
Incorporating
*All Sources of Variation*

Total Utility

So far, we've only looked at Uncertain Effects of
decisions on the *goal attributes* and their *utilities* ...

(top) (back to Phase 2.a)
Monte Carlo method

Distributions for TU/MEq are computed using **Monte Carlo Simulation** where a dataset is created having thousands or even millions of replications of inputs that are randomly generated from their distributions – here utility functions, and weights on attributes, categories, and subcategories. In the same or another database, attribute levels are generated from their expert and decision-specific distributions, and the random utility functions are evaluated at those attribute levels - one record per realization of inputs. TU & MEq are then computed for each record and the resulting set of values approximates their probability distributions

Here are 3 other sources of uncertainty
that cause variation in total utility:

Decisionmaker's uncertainty about their attribute utility functions

Utility Fuzziness (Uncertainty Decisionmaker 1, Market Share)
Utility
Market Share
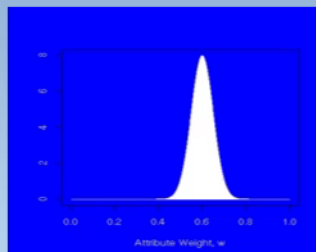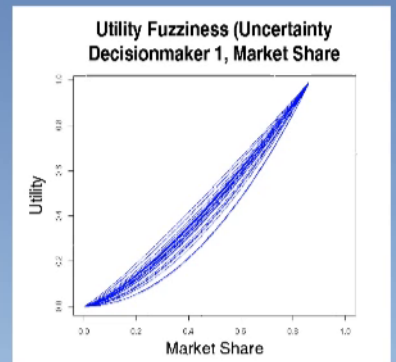
Decisionmaker's attribute weight uncertainty

Attribute Weight, w

Utility = $w_a \times$ + $w_b \times$ + $w_c \times$ + $w_d \times$

. Applicability of the Additive form of Utility Model
(not addressed in this video)

Total Utility's Uncertainty…
Stochastic MCDM output

Total Utility's
*Probability
Distributions…*
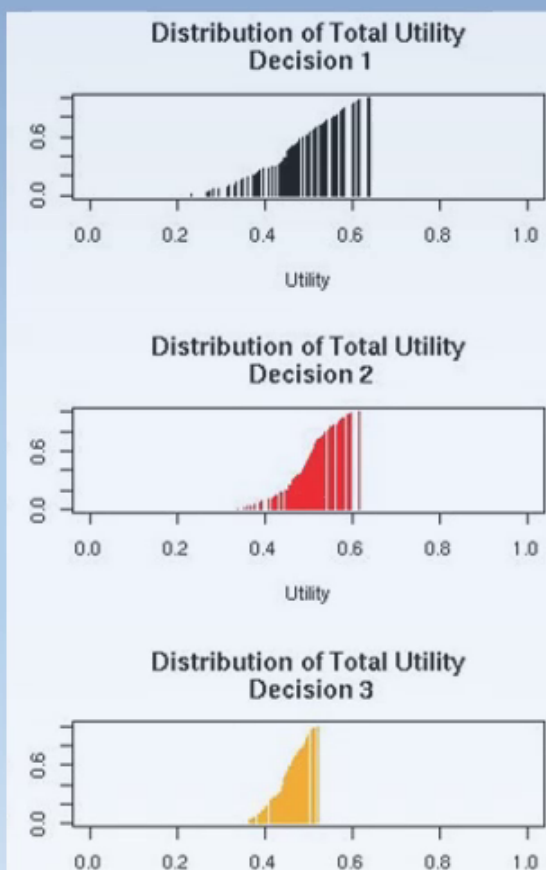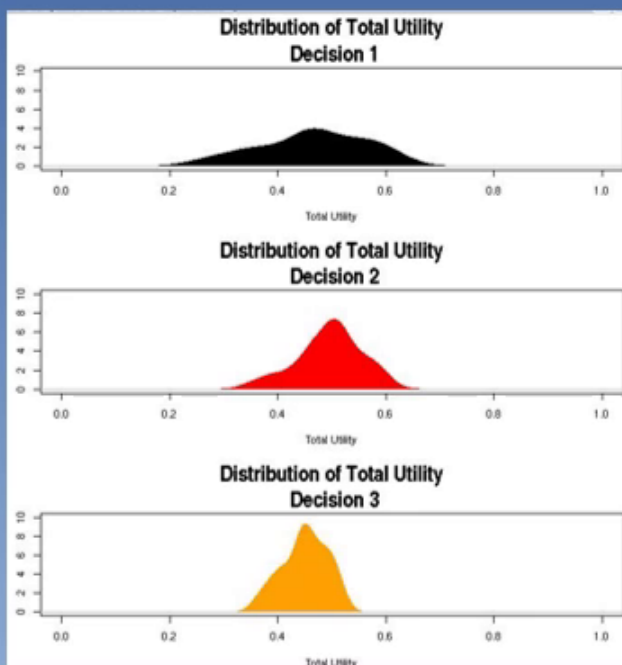
and its
Cumulative
Probabilities
*(we'll use these
in our example)*

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Here are some possible metrics to use for decision selection:

. **highest Average or Median**

. highest Average subject to **Variation not exceeding some limit**

... and more sophisticated (and realistic) metrics:

. *Probablistic* **best of worst case** outcomes
eg. decision with highest 2nd percentile

. *Probabilistic* **best of best case** outcomes
eg. decision with highest 98th percentile

. highest **stochastic dominance** measure
eg. decision with all percentiles strictly highest

→ highest **exceedance probabilities** at selected target levels:
"at least as high as these levels with _, _,..., and _ probabilities"
ie. having the best ***Exceedance Probability frontier***

Exceedance Probabilities, by Decision
monetary equivalent ($B)

req'd performance

($B)
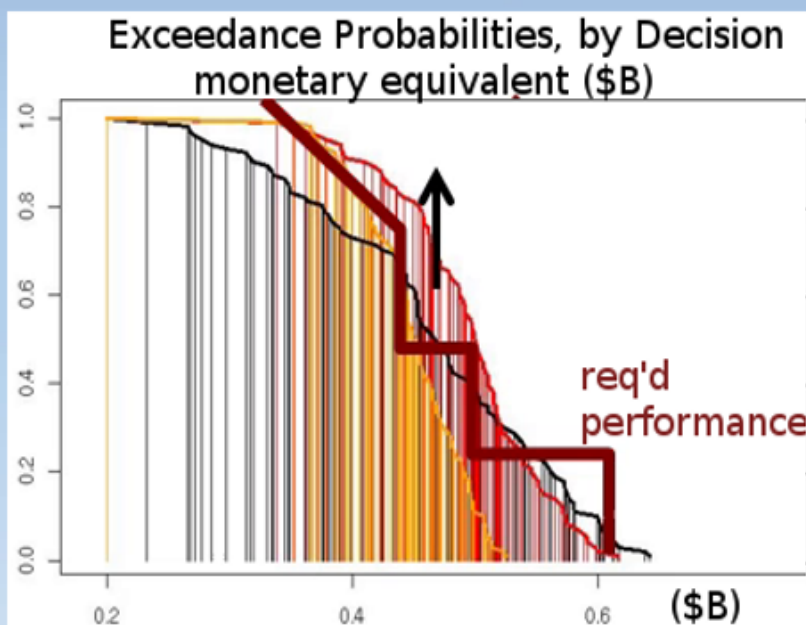
(top)

Stochastic Joint Decisionmaking…
A Numerical Example

4 Decisionmakers/Influential Stakeholders
(weighted sum of the individual DM's Total Utilities)

3 Competing Decisions impacting the Goal Attributes
Sales, ROI, Market Share, and Risk

5 Decision Impact Experts per goal to evaluate its
uncertainties for each decision

From every DM are elicited…
each Goal Attribute's
Utility Function and its
Fuzziness (uncertainty) :
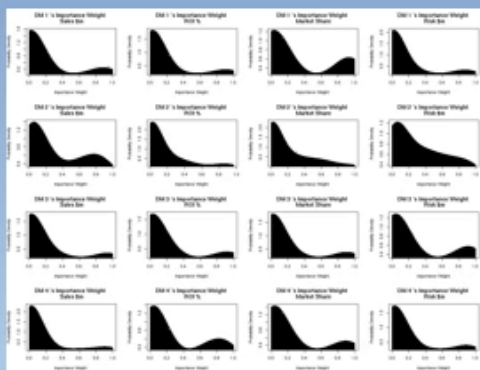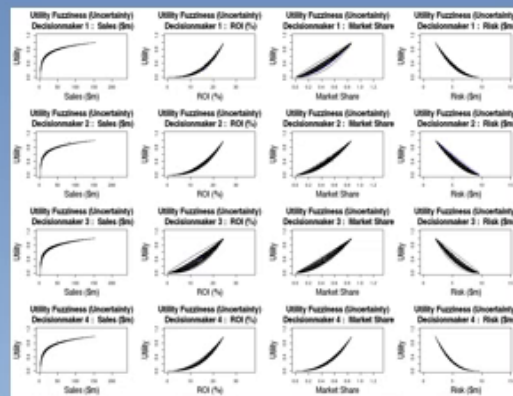
and each Attribute's
Importance Weight
and its *Fuzziness*

Each Expert's
Decision Impact Fuzziness
on every Attribute,
for each Decision

(top)

MAUT Decisions *Stochastic MAU Products*
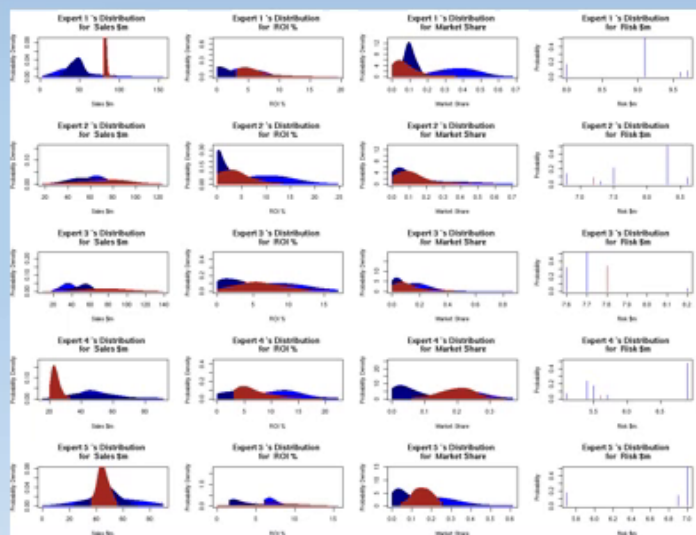
Here are the Results!
Using Weights (0.5, 0.25, 0.15, 0.1) on the four DMs' Total Utilities

the *Cumulative Probabilities (by decision)*

and the *Exceedance Probabilities*

(top)

MAUT Decisions   *Stochastic MAU Products*

Two Cases:
1) Baseline – experts' attribute distributions as depicted earlier (top picture)
2) Sales and Market Share distributions made best for Decision 1 (bottom picture)

Highest Percentiles

Cumulative Probabilities for Total Utility (by Decision)
All Decisionmakers/Shareholders Combined

Decision 1
Decision 2
Decision 3

Case 1:
Decision 3 is uniformly highest in all Percentiles

2 Percentiles: select "Best of Worst"
98 Percentiles: select "Best of Best"

Utility = f(Sales, ROI, Market Share, Risk)

Cumulative Probabilities for Total Utility (by Decision)
All Decisionmakers/Shareholders Combined

Decision 1
Decision 2
Decision 3

Case 2: *Decision 3 is highest up to 90th Percentile and Decision 1 has highest 91-100 percentiles*

2 Percentiles: select "Best of Worst"
98 Percentiles: select "Best of Best"

Utility = f(Sales, ROI, Market Share, Risk)

and the *Exceedance Probabilities*

Exceedance Probabilities for Total Utility (by Decision)
All Decisionmakers/Shareholders Combined

Case 1: *Decision 3 has highest Exceedance Probabilities & alone meets Req'd Exceedances*

Decision 1
Decision 2
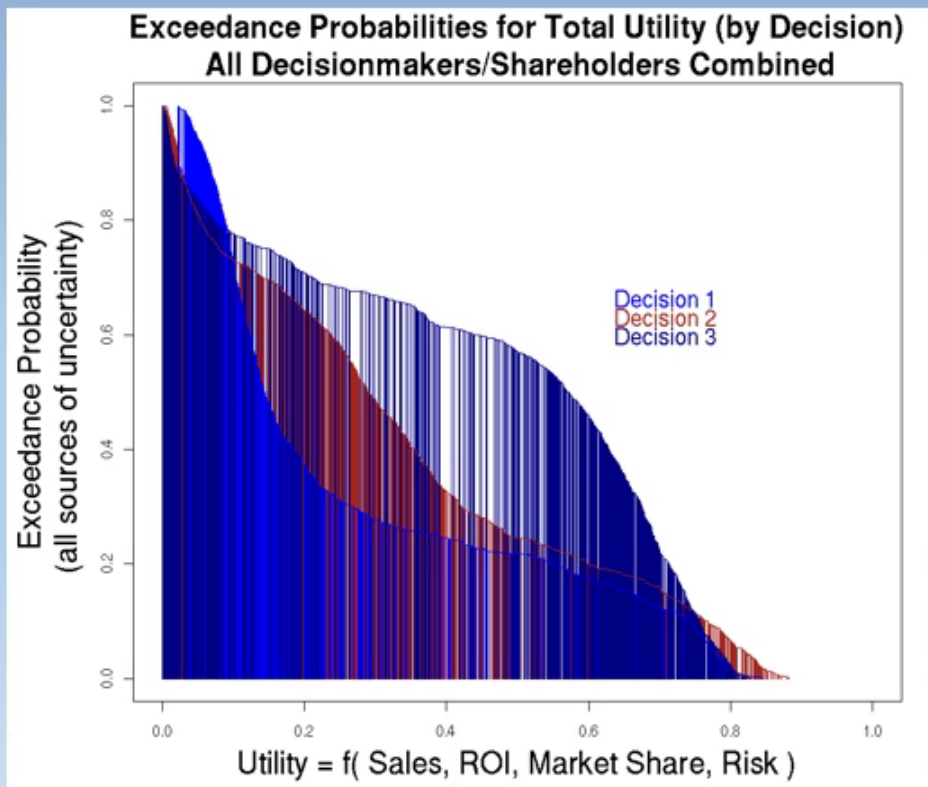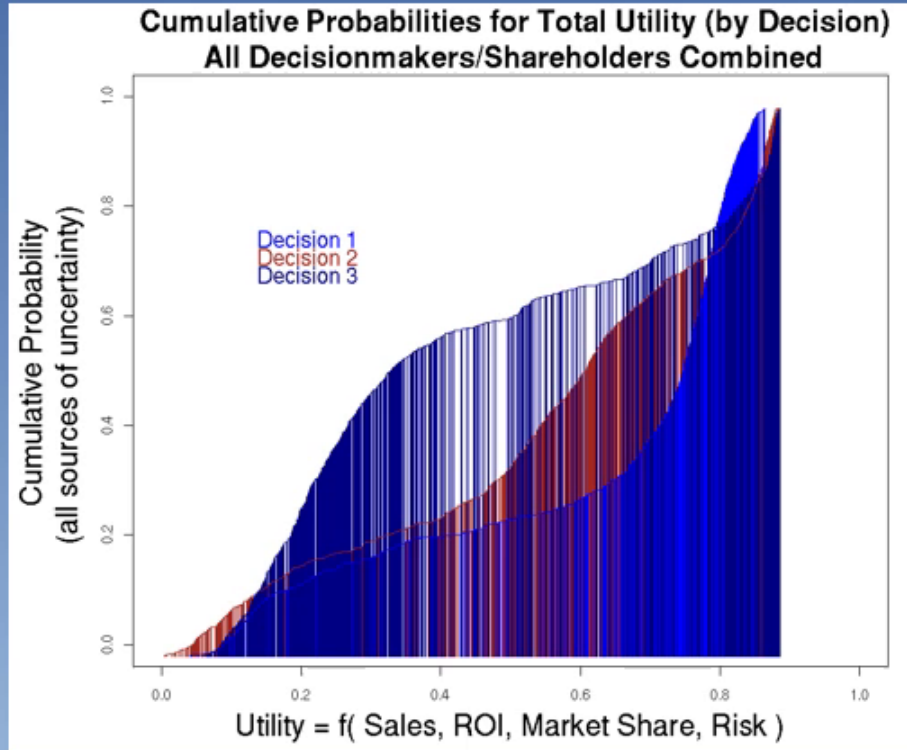Decision 3
Req'd Probabilities

TU must exceed:
0.1 with prob .8
0.3 with prob .4
0.6 with prob .05

Utility = f(Sales, ROI, Market Share, Risk)

Exceedance Probabilities for Total Utility (by Decision)
All Decisionmakers/Shareholders Combined

Case 2: *Decision 3 has mostly highest Exceedance Probabilities (up to 0.10), but only Decision 1 meets Req'd Exceedances ⇒ Decision 1 is Best*

Decision 1
Decision 2
Decision 3
Req'd Probabilities

TU must exceed:
0.1 with prob .8
0.3 with prob .4
0.6 with prob .05

Utility = f(Sales, ROI, Market Share, Risk)

(top)

Reanalyze with Other Decision Values

Stockholder & Stakeholder Segments

Criteria & Emphasis: long-term profitability, short term profits, global citizenship, employee considerations, ethically sustainable supply chain,

Political & Regulatory Views

Criteria & Emphasis: proactive compliance, liaisonship, supply chain & product ethics, etc.

Industry Opinion

Criteria & Emphasis: profitability, market share, sales, marketing channel coverage, trade marketing, etc.

Stock Market Viewpoint

Short term profitability, financial indicators, market share, etc.

Public Opinion

prestige, sales, ad content, environmental sustainability, supply chain ethics, globilization, localization

Use Their Goal Weight Distributions & Possibly Other Goal Criteria...

Did the best decision change?

Composite all the DMs' Decision Values with theirs.

The results?

Many Uses of the MultiCriteria System

Your Values, Defined.   Essential Corporate Goal Variables are Identified for Multiple Categories & Subcategories

1) Explicit Identification of Decisionmaker & Stakeholder Goals

2) Relative Importances of Goals also determined

This System Used Forwards ⇒ The *Value* to Decisionmakers & Stakeholders of...

Decision Choices: The Framework for supporting Corporate-Wide Decisions, under all *Uncertainty Sources*

Budget Changes: Tightening Impacts or Budget's Improvements

Corporate Intelligence, Quality Control, etc.   The Value of...
Additional Information, Quality Improvement,
Reducing Variation in Supply Chain/Production, etc.

Product Design Changes: Can Expand System to Include Design & Technical Features: *the value of Product Design tweaks*

Using it *Backwards* ⇐   Identify Organizational Activities that have the Most Impact....

Decision Development: A Guidance Tool for Conceiving
Multilevel Corporate Decisions

"Majoring on the Majors"... A Guiding Basis for Where to Focus for selected Audits, Performance Evaluations, etc.

Benefits from the MultiCriteria System

1° Benefits

Definition and Organization. All Important Goal Criteria, and their Relative Importances, are Identified by key players in the Corporation. Of tremendous value,

Decionmakers have claimed that this benefit alone justifies the MCDM effort!

Quantitative, Probablistic Goals as basis for Decisionmaking

Decision Choice based on all Decisionmakers' Values:
Composite Decisionmaking

(previous slide)   *The Engine* to:
1) Assess the value of virtually any Corporate Change
2) Achieve the best impact in: New Decisions Development or where to focus Corporate Activities

2° Benefits

Best Decision's Stability: Can assess if it changes under different Climates - Consumer, Economic, Political, etc.

Extra-Corporate Values Representable: Can Composite with DM's Criteria & Valuations:
Stockholders, Gov't, Industry Viewpoint, Public Opinion, Stock Market

(top)

MAUT Decisions   *Stochastic MAU Products*

Why MAU?   Multiattribute Utility Decisionmaking allows you to make decisions the way you naturally do, valuing a decision(s) impact on goals and intuitively weighting each goal by it's overall importance, but it does so over many important attributes, formally valuing each in terms of a common "apples and apples" basis – utility - then importance-weights their contributions to the totaled utility. Also, using a utility function extended to accommodate extreme levels, total utility may be converted back to an attribute value such as dollars/Euros where the contributions of all attributes are now valued on this basis. - eg. a "dollar-equivalent" of total utility. Finally the MAU system may be used in reverse, where decisions, expansion, or budget changes are developed by examining actions that affect the most important (highest weighted) attributes and categories.

What Decisions have been made using MAU?

MAU is being applied in areas from supply through end use, in nearly every sector in industry, well as government and academics.   To learn about decision applications in your vertical and industry, search (without quotes) "MAUT applications in *your industry*" along with additional relevant keywords.

Why Stochastic MAU?

Stochastic (antonym to *Deterministic*) here means that a complete probability distribution on the final computed value - Total Utility - is assessed, for each Decision. This probability distribution reflects the effects of uncertainties in each of the variables that underly this computation – fuzziness in decisionmakers' importance weights, in the elicited utility functions, in the impacts of the decision on each attribute, in other influential variables, and even any uncertainty on the importance weighting of each Decisionmaker's Total Utility. The analysis of this overall probability distribution is usually called an *Uncertainty Analysis*, and often involves looking at its various percentiles as well as simple measure of variation.

But why stochastic MAU? Comparing Decisions by their perceived average impacts is both incorrect - the average values are nonlinear and don't equal the result from using average weights with average attribute utilities – and misleading: even if ordinary MAU calculations represented the average, two decisions may have the same average but be such that one is "boom or bust" and the other has a more certain outcome, or the guaranteed minimum performance of one decision may make it more attractive even though its mean is somewhat lower. Stochastic MAU also allows you to evaluate decisions based on the probablistic performance – eg. comparing each decision's 75th percentile in utility (25% *exceedance probability* - being at least a high as this level), 90th percentile, etc.

References:

Bond, S.D., K.A. Carlson, R.L. Keeney. 2008. Generating Objectives: Can Decision Makers Articulate What They Want? Management Science 54(1) 56-70.

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Decision Signature Analysis: Examining Attribute Level Combinations with Highest (rightmost) MEq Exceedance Curves