Accounting, empirical measurement and intellectual capital

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Abstract *The application of proper measurement to a company generating products, services, cash flow and reputation largely from intellectual capital (IC) assets is examined. The particular focus is to measure the organisation so that the contributions of intangibles to the business are measured in their own right. If the measurements are feasible in practice (they are), they will render the tangible as well as the intangible assets of a company to be managed explicitly. Then the contributions of the intangibles to cash flow become measurable, and thence on to estimates of business value, and shareholder value. Shows that the process view of an organisation deconstructs the "classical" structure of IC categories and formulations, and rearranges them in a form whose state and process variables are observable, measurable, and properly dimensioned for a multidimensional measuring space. Ends with a demonstration of the method applied to a hotel organisation that exemplifies many of the problems of measuring and optimising IC assets.*

The measurement process

Measurement is a way of acquiring knowledge about an object or organisation of interest: if the IC processes and value of an organisation are to be measured, it is necessary first to be quite clear what science-based measurement implies. Measurement theory provides the axioms that prescribe the conditions for a measurement to be unambiguous, proper and meaningful, while the protocols of empirical measurement guard against subjectivity and subterfuge. A measurement that satisfies the axiomatic and empirical requirements is said to be proper or canonical, anything else is quantified opinion at best, or a guesstimate. A representation of the Measurement Process is shown in Figure 1 to state its essentials. From left to right: the mapping definition, empirical primary measurement, and multidimensional measurement (with mathematical models representing the operational cauldron):

- *Mapping model.* All measurements are mappings from the properties or manifestations of an observable process to a symbol on an independent and admissible scale on the real line. A proper measurement complies with the axioms of measurement theory, i.e. represent the property or manifestation on an unambiguous scale that is not ad hoc: it must be agreeable, objective, testable and repeatable. The mapping must be meaningful and empirical. The validity conditions that guard proper

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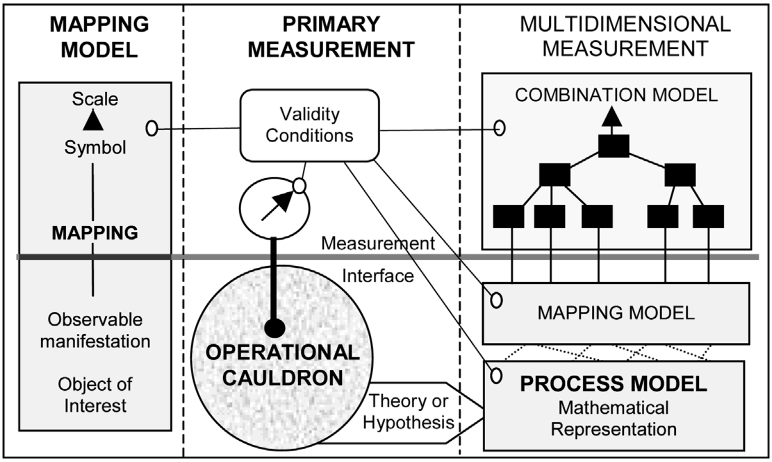


Figure 1.
The measurement process

measurement mapping are defined in detail in the literature (Krantz *et al.*, 1971; 1989; 1990; Roberts, 1979; Fenton and Pfleeger, 1997. Useful summaries are given by Finkelstein and Leaning, 1984; and Finkelstein, 1994a; 1994b).

- *Primary measurement* is an ordering one-to-one mapping, e.g. hotness into temperature, production activity into widgets/hour, morale into churn rate. Such mappings provide the basis of performance measurement. The measuring instruments have agreed and independent scales that are distinct and independent. The empirical conditions are satisfied if: the scales are agreed to an independent reference; the readings are repeatable by another observer under the same conditions; and the scales are not adjusted to give a result that an observer might prefer (wish fulfilment). The primary manifestations do not have to be physical or tangible: they can be counts (e.g. accounting), probabilistic, statistical, derived from proper mathematical models, or felt (e.g. attitude or psychophysical measurements conducted under rigorous and compliant conditions). Note that the measurement interface separates the real operational domain below with its cauldron, and the completely separate measurement domain above.
- *Multidimensional measurement* is a many-to-one mapping from a set of performance measurements (primary) to a secondary process whose single indicator reflects exactly the full meaning of the variations in the underlying primary measures. This two-stage process is called conjoint measurement: the validity requirements include all those for primary measurement plus special conditions for the validity of the combination process, in particular the completeness of the primary measure with respect to the inclusive meaning of the final output, and the logic of combination. Multidimensional measurement generates a need to define the necessary and sufficient (N&S) primary measurements that will

express exactly the full meaning of the measurement context. Using lists of likely and convenient measures is out of bounds.

It is clear that the many techniques referred to in the IC literature for "measuring" the contribution or value of IC assets are a form of multidimensional measurement, but it does not seem that, so far, much attention has been paid to their validity as proper measurement.

Multidimensional value measurement

The statement that intangible value is measurable often surprises because of the prevalent misconception that value appreciation is a subjective matter and not admissible to logical discussion, because – being emotional – it can neither be proved nor disproved (Ayer, 1936). Scientific measurement itself is not free of a normative element (van Brakel, 1984), and it has to manage uncertainty and error with statistical estimates (Frieden, 1998). An important result in axiology (value theory) is that value is measurable with respect to a well-defined context (Frondizi, 1971), and is separable into distinct intrinsic, instrumental and extrinsic domains. Axiology started as a philosophical initiative in Germany and Austria during the middle of the nineteenth century, at about the same time as the beginnings of measurement theory. The axioms of value preference are quite close to those of proper measurement (Rescher, 1969). Accounting methodology maps monetary variables into costs and revenues quite properly (Kranz *et al.*, 1971; Tippett, 1978; Willet, 1988).

Assuming that a proper context is defined for the measurement of a large-scale process (business, organisation, system), value measurement will be a conjoint process that combines all the primary value contributions from an underlying process into a final quantifier called "value". Thus, value measurement is a particular form of multidimensional measurement subject to the same validity requirements but with a particular accent on:

- The completeness and distinctness of the primary contributions with respect to the context: i.e. the primaries collectively provide the full meaning of the "value" defined by the context, and they do not overlap in meaning (no double-counting).
- The value streams must be scale-independent (not just distinct) so that a change in one value does not affect any other value reading.
- Commensurability of the value-measuring space, i.e. the various primary scales must be projected onto a value space that may have many dimensions but only one common value scale on each dimension. Commensurability is usually achieved by normalisation, i.e. if $\max p$ and $\min p$ define the feasible range of an operational variable, the equivalent value of p on a normalised scale is $n = (p - \min p) \div (\max p - \min p), 0 \leq n \leq 1$. This is an admissible transformation (e.g. centigrade into Fahrenheit), and means that the

scale of any kind of p can be transformed into an equivalent scale between 0 and 1 without any loss of information.

A set of primary value measures that satisfy these requirements is called necessary and sufficient (N&S).

The original definition of the value context is crucial, otherwise the ensuing measurements may be very skew of the real value of the process. The context statement lists the stakeholders involved, their agreed high level referent objectives, and the system of interest with its environment. The objectives ought to induce the intangible value domain for the context, i.e. the intrinsic, instrumental, and extrinsic sub-domains. For commensurability reasons the monetary domain (in $ units) is separated from the intangible domain.

The definition of the value context ends with the measurement requirement in which the N&S primary measures are stated with pedantic exactness (Figure 2). The primary measurement system must meet these requirements if the value measurement is to be valid. These validity conditions are well known and come originally from multiple objective decision analysis (Keeney and Raiffa, 1976; Saaty, 1980; Chankong and Haimes, 1983). Methods for deriving a set of N&S primary measures relative to a referent set of objectives are either heuristic (Harris and Sydenham, 1995) or logico-hierarchical (M'Pherson, 1999).

An operational value measuring system – the IVM™

An operational VMS provides the bottom-up measuring sequence from the primary measurements through the combining multidimensional criteria up to the supercriterion that delivers the single combined value indicator V at the top (Figure 2). Each criterion will have a hierarchical structure similar to that shown in the combination model (Figure 1), but now the black squares are combinatory operators or "nodes". The input performance vector is partitioned into separate

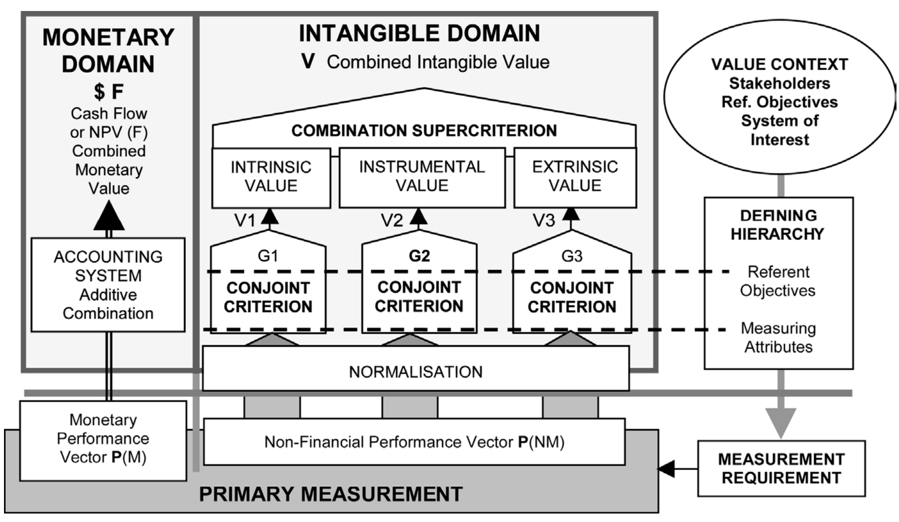


Figure 2.
Outline of the value measuring system

monetary and non-monetary subsets $\mathbf{P} = \{\mathbf{P}(M), \mathbf{P}(NM)\}$. The n non-monetary inputs generate an n-dimensional convex value-measuring space, all with scales in the range [0,1], and whose axes will be orthogonal if the independence and distinctness requirements are satisfied. Such a space is analysable.

The IVM™ is a proprietary methodology embodying the above structure and complies with all the N&S conditions and validity requirements for a value measuring system. The special properties of the IVM's combinatory nodes ensure that the requirements are complied with within each node, between the nodes along each level, and between the levels of the whole structure. Additionally, the IVM's special node structure reduces the dimensionality of the value-measuring space significantly, for example a theoretical space with 20 distinct and orthogonal measuring attributes would have 2^{20} vertices, which is more than one million. This space could be serviced by as few as 15 IVM nodes with perhaps 52 vertices all told. This is a significant reduction, and accelerates the setting up of a rather complex analytical engine.

The IVM is essentially a multidimensional accounting system that grew out of the need for a rigorous method for measuring multidimensional cost-effectiveness of large scale systems (M'Pherson, 1981), since when it has been applied extensively, and extended to deal with the measurement and valuation of business intangibles (M'Pherson, 1999; brief summaries in 1996; 1997; also www.systemsvalue.co.uk).

The combination of intangible value streams

Value streams rarely combine with arithmetic addition although monetary value does within conventional accounting systems. This statement often comes as a surprise, accustomed as we all are to adding and subtracting money values. In fact the additive rule for value combination is the exception: conjoint measurement structures are akin to polynomials that have also to satisfy the combined value measurement requirement. For example, the IVM, in the final upper stages of its combinatory criteria, prescribes the use of a rule that is "goal" oriented. Mathematically it is a conventional Euclidean distance vector operating in a normalised space.

Consider the value-for-money combination for cost-effectiveness in the 2-D plane shown in Figure 3. E is the value (effectiveness) axis, and M is the money axis, where 1 = lowest cost. Formalise the 2-D plane as a normalised Euclidean space. The value of a coordinate $V(x,y)$ will be proportional to the normalised distance vector from (x,y) to (1,1):

- Clearly there is an increasing value gradient from the bottom left vertex $V(0,0)$ up to the top right vertex with max value $V(1,1)$. A solution at (1,1) means that max E has been obtained at min cost which is probably infeasible, but it represents the ideal.
- The circular arc through A indicates the location of all coordinates with the same value as A: it is an iso-value contour.

- A 3-D Euclidean space is created by introducing an orthogonal scale for combined value $V(E,C)$ orthogonal to the plane: it is normalised such that $V(0,0) = 0$, and $V(1,1) = 1$, (not shown in the figure).

Consider the cost-effectiveness or value-for-money of three alternative options A, B, C using an additive rule (the straight dotted line through A and B), and the vector distance rule (the radial arc though A). Remember, a coordinate nearer to the (1,1) vertex has more value. The preference orders over the three alternatives are:

- Additive rule: $V(C) > V(B)$, and $V(B) = V(A)$.
- Distance rule: $V(A) > V(C) > V(B)$.

The result using the additive rule is not a slight distortion of the correct ordering of A, B, C: the additive is wrong. No more need be said.

The distance rule is used by the IVM in the final upper stage of every measuring criterion: it is a true value metric. It tracks back to the method of the displaced ideal (Zeleny, 1973). The idealised iso-value contour in Figure 4 owes its origin to the preference trade-off analysis (e.g. Keeney and Raiffa (1976), MacCrimmon and Wehrung (1977)). It has been used in cost-effectiveness analysis for some time (M'Pherson, 1981).

The problem of IC measurement

Intellectual capital (IC) is often represented as an hierarchical structure like that in Figure 4 (Edvinsson and Malone, 1997; Roos *et al.*, 1997; Bontis, 1998; 1999; 2001; Bontis *et al.*, 1999). The figure has been divided between financial and intangible domains, which are also relabelled as (BV) and IC value (ICV) and leads to an equation MV = BV + IC (e.g. Edvinsson and Malone, 1997; Joia, 2000). However this equation is dubious because it implies that:

- all hierarchical elements in the two trees are distinct and independent;
- BV and ICV are commensurate;
- all value contributions are combined additively.

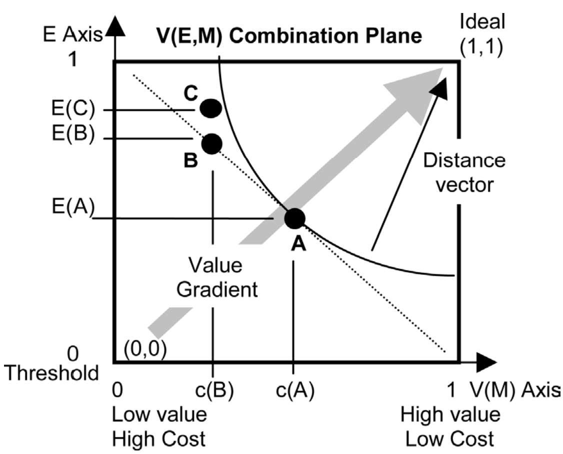


Figure 3.
Representation of the 2-D Euclidean space in which the value-for-money measurement is conducted (cost-effectiveness case). [Similar for cash flow, but now 1 = high cash flow, 0 = low.]

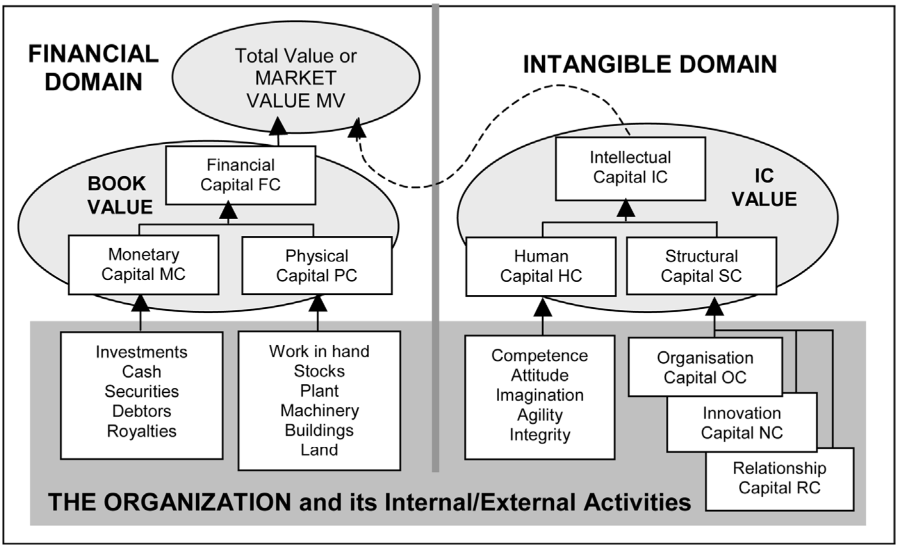


Figure 4.
Typical IC framework as given in the literature

These assumptions are acceptable within the financial domain, i.e. FC = MC + PC is the case as they are measured in $ terms. But within the intangible domain all three assumptions fail.

Distinctness and independence

In practice, physical, human, structural capital are interconnected: e.g. a working operational process generates cash flow (part of monetary capital) by a combination of elements of human capital, supported by structural and physical capital. The lower elements in the trees will make contributions to several of the higher elements, and vice versa. In measurement terms the components of IC are unlikely to be distinct and independent.

Commensurability

Financial capital will be expressed in $-units, but IC will be a composite of scales appropriate to HC and SC. The value of IC has to be expressed in a normalised value space. IC and FC are not immediately commensurate.

Combinatorial rules

$FC = $MC + $PC is properly additive, but the combination of the intangible elements of IC must conform to the requirements of conjoint measurement for a true estimate of ICV.

These difficulties arise because value measurement and IC structures view the organisation from two different viewpoints and use different "languages". IC brings insight into the nature and importance of the various forms of capital and directs management attention to the proper nurture of the all-important human and relational capital without which an organisation would die. But, IC structures so far are not useful for operational measurement purposes because measurement demands compliance with its rules and requirements.

Figure 5 brings the three languages of value together: value measurement, IC and financial. It shows that they are complimentary but the measurement language must dominate if the proper measurement of value is to take place. The upper part of the figure lists the three intangible value categories and indicates examples of measures that might be used under each category. The central part is a matrix that shows, in general terms, the interaction between the IC and value categories: the skewness of the two sets of categories is evident. The bottom row indicates how the financial domain also partitions into the three value categories.

Operational methods for calculating value are shown round the outside of the table. The $ costs of the IC elements (left) can be summed and combined with the $ revenues to produce $ cash flow (bottom). The estimation of business value is a function of cash flow, book value, and market valuation. Book value and market value are inherently subjective: they cannot be regarded as proper measurements, even though they are useful indicators. The combination of the measured achievements with respect to the three value categories is effected at the top to give the combined intangible value (as Figure 2). This is then combined with cash flow in a proper measuring space to indicate the inclusive value of both financial and intangible achievements in value space (as in

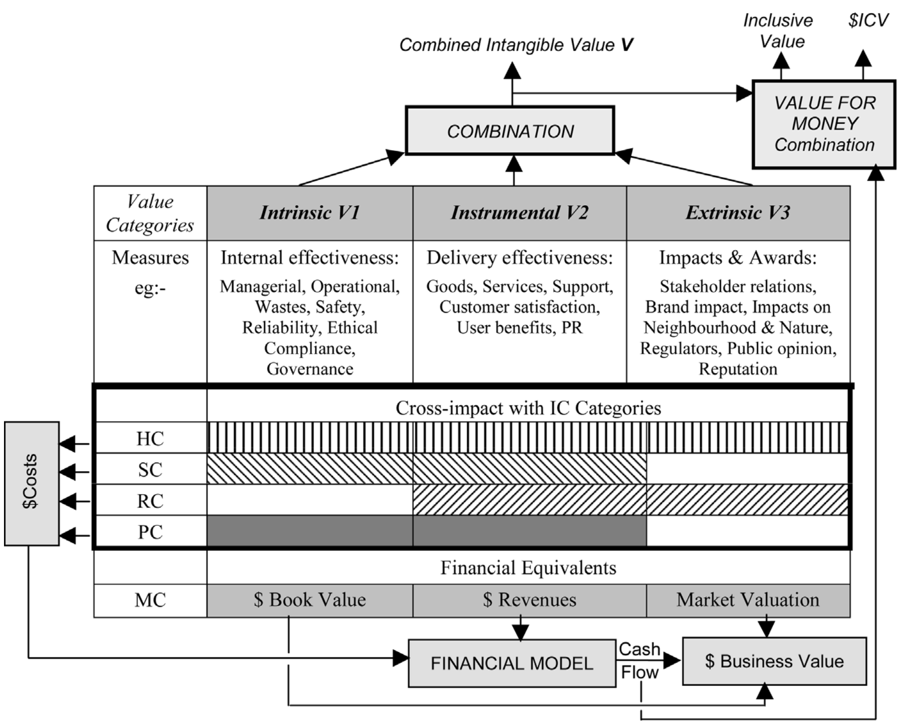


Figure 5.
Relationship of value, IC and monetary measurements

Figure 3). The IVM can project this result back onto the financial plane to indicate the $-component in cash flow that is contributed by the intangibles. All three approaches provide distinctive indications of value, but the three approaches must be confined to the measuring domains in which they provide proper results.

Demonstration of inclusive business value estimation

The demonstration shows how the elements of an inclusive business value model are constructed and combined to yield an auditable and useful tool. An example is provided by a private country hotel: the management's strategy is to develop it into a conferencing centre with integral sport and recreation facilities, optimising both financial and intangible value to the stakeholders (see Table I).

Structure of the model

The model for inclusive business evaluation (Figure 6) implements the concepts and structures for value measurement as indicated in Figures 2, 3, 5. It has three main components:

(1) *Harness*. Manages the simulation options and scenarios through projection time. Combines the financial and intangible value estimates for each time step, and displays the results for the strategic projection. A comprehensive database contains the operational and financial data that will be required to run each of the planned scenarios.

(2) *System builder*. Contains the business model. This takes the selected strategic options, and generates the N&S monetary and non-monetary performance measurements via a flexible architecture model.

(3) *Inclusive value measurement (IVM)*. Calculates the combined non-monetary (intangible) value on an objective basis, also from the viewpoint of each stakeholder (as Figure 2); and, separately, provides the final value-for-money combination (as Figure 3).

The system builder

The system builder provides a process model for a virtual business that can accommodate a wide range of options and events so that many scenarios can be explored on the same model basis. It is essentially a flexible matrix of algorithms that represents the business's changing value generating

Stakeholders	Options
Owners/Managers	Upgrade and extend hotel (baseline)
Customers	Add a swimming pool
Environmental and local interests	Add a 9- or 18-hole golf course
	Add a business centre
	Increase staff numbers
	Raise staff quality

Table I.
Example of inclusive business value estimation

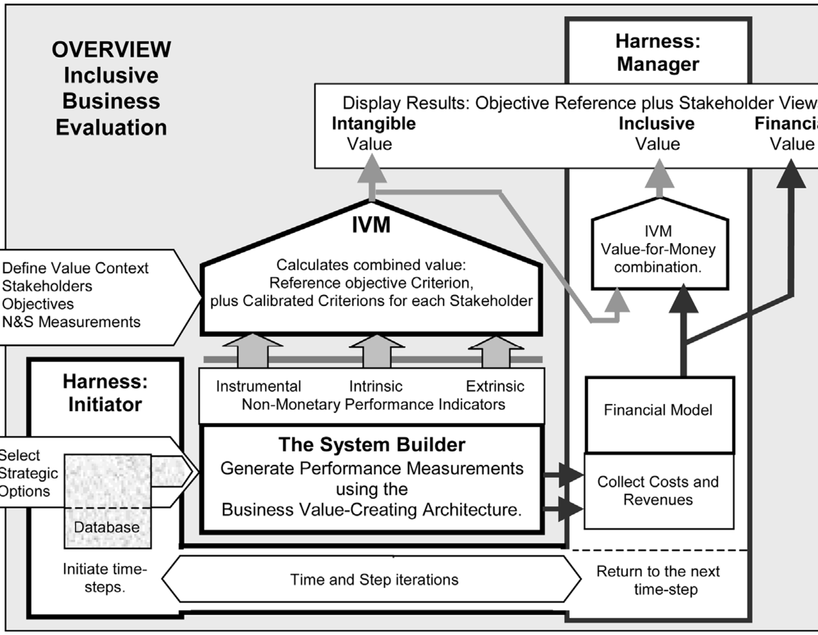


Figure 6.
Overview of the simulator

operational architecture during a time projection (Figure 7). The figure (for a simple illustration) shows a menu of six options at the left, and assumes a requirement of six performance measures for the IVM at the top. For a particular scenario the three shaded options are selected for insertion at the indicated times. Their impact on the performance measures is indicated by the shaded squares in the matrix: each column generates the resulting performance measure via algorithms that combine the options into process variables, and thence into outputs. The changes in the matrix architecture also generate corresponding changes in the costs and revenues (right).

The IVM

The criterion hierarchy used in the simulation is outlined in Figure 8: extending down from the combined value of the hotel to its stakeholders to a level where the attributes become measurable.

The impact of IC categories with the measuring attributes is shown at the bottom.

Sensitivity analysis

A sensitivity analysis of the criterion provides an important output: it indicates the significance of each attribute as a value generator, and provides decision-makers with early indications of which business process variables are critical. For this example the sensitivities for each criterion are shown in Figure 9. The attributes are grouped into three categories: instrumental,

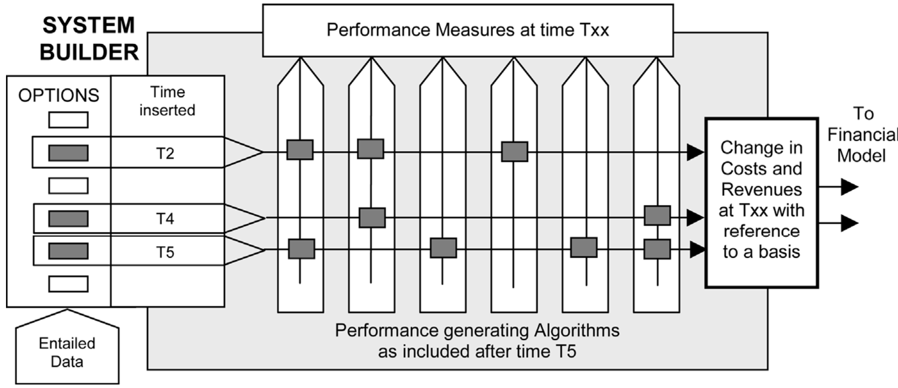
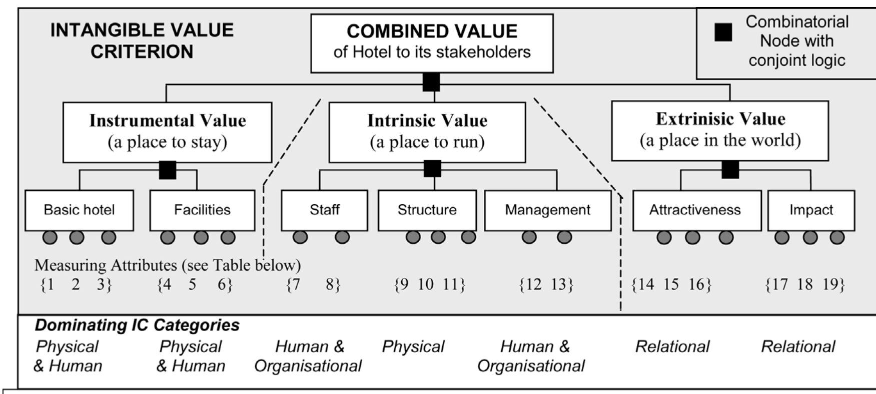


Figure 7.
The system builder



Measuring Attributes / Performance Indicators					
1	Room Comfort	7	General Staff - Competence & Adequacy	14	Location, Usability & Access
2	Common Area Amenity	8	Specialist Staff - Competence & Adequacy	15	Ambience & Formality
3	Restaurant Quality	9	Sports Org. & Maintenance	16	Listings & Booking
4	Conference Facilities	10	Hotel Structure & Maintenance	17	Welcome
5	Sports Facilities	11	IT & Electronic systems & services	18	Neighbourhood Impact
6	Golf Course	12	Training & Renewal	19	Use of local services
		13	Business processes		

Figure 8.
Outline of the value hierarchy and criterion

intrinsic, extrinsic. The length of each bar shows the sensitivity to each measuring attribute:

- *Reference*. All referent objectives and all performance indicators are given equal weight, except for a small increase for those relating to staff and managerial quality in the intrinsic category. Justification: a hotel business depends critically on the quality of its staff.
- *Owner/Manager*. Weights represent a hardheaded managerial viewpoint focussed on quality and ease of management, rather than on extreme customer satisfaction or environmental interests.
- *Customers*. Accentuate the amenities and facilities of the hotel.

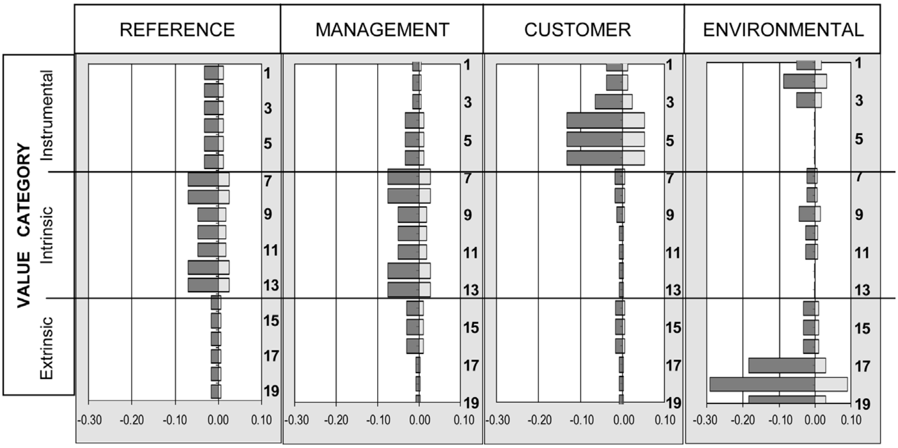


Figure 9.
Criterion sensitivities

- *Environmentally sensitive customers*. Want comforts but are anxious about environmental impact.

The problem facing the managers is to build up a profitable hotel while keeping both business and "green" customers happy.

Input-output screen for a strategic run

A great many possible sets of results could illustrate the simulation. In this example, one result is shown from the search for an optimum harmonisation between financial optimisation, IC asset optimisation and stakeholder satisfaction.

Figure 10 is a copy of the harness input/output screen for a set of options indicated by the "1s" in the top matrix:

(1) *Financial results (relative to a baseline of hotel upgrade only), (below right chart)*:

- Free cash flow recovering to £1m at year three, but levels off and begins to fall.
- Increased NPV (from £4.31m to £5.32m).

(2) *Perceived value (output from criterion) (left chart)*:

- The reference and manager sensitivities correspond closely. Value nearly doubles, then levels and falls slowly (a slight degradation factor is built in to represent a reduction of new customer interest after the initial "splash").
- Business customers are not interested in a rural hotel: value rises significantly when leisure and sport facilities are added.
- The environmentalists like the rural hotel, but value drops due to the high environmental impact.

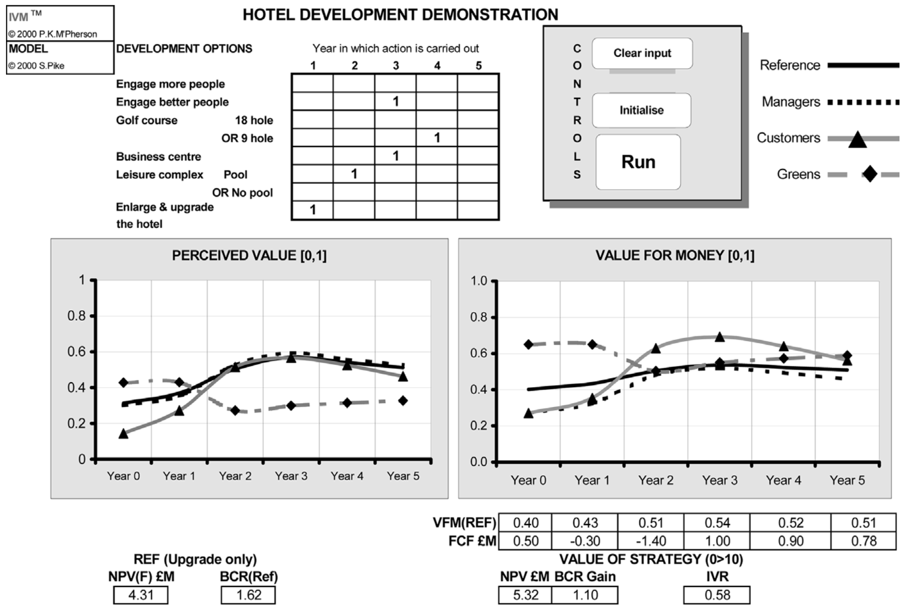


Figure 10.
Input/output screen

(3) *Value for money (right chart).*
- Intangible value ratio (IVR) = 0.58, i.e. 58 per cent of the cash flow comes from the intangible assets.
- The NPV value of the intangibles = 0.58 – 5.32m = $ 3.09m.

The crux: does the combination of quality offered to customers balance the prices charged?:

- Managers' satisfaction matches the objective reference as the strategy begins to be realised.
- Business customers like the added value now offered. The challenge is to keep that market.
- The distaste of the environmentalists for a leisure hotel is overcome by the value added from the civilised comforts inside the hotel.

This is a promising strategy: the value for money for all stakeholder groups converges to a similar high(ish) level.

Conclusion

The demonstration clearly shows that the extra information about stakeholder attitudes and IC values adds considerably to the one-dimension of financial analyses:

- Financial figures may give a measure of the returns that the stakeholders (especially shareholders) may receive during the simulated lifetime, but little else.

- Through-life variations in the levels and relative contribution of the intangible elements makes the most telling commentary on the likely ability of the hotel's management to maintain the advantage they seek over the longer term.
- The ability to measure the value contributions from the business process enables the management of IC assets to be manipulated to enhance both financial and inclusive value.
- The methodology demonstrated is compliant with proper measurement: the IC categories become measurable.
- The results from the reference criterion provide an objective measuring yardstick, so that the perspectives of the human stakeholders can be compared and negotiated towards a final harmonious optimum.

References

Ayer, A.J. (1936), *Language, Truth and Logic*, Dover Publications XX, (1950).

Bontis, N. (1998), "Intellectual capital: an exploratory study that develops measures and models", *Management Decision*, Vol. 36 No. 2, pp. 63-76.

Bontis, N. (1999), "Managing organizational knowledge by diagnosing intellectual capital: Framing and advancing the state of the field", *International Journal of Technology Management*, Vol. 18 Nos. 5-8, pp. 433-62.

Bontis, N. (2001), "Assessing knowledge assets: A review of the models used to measure intellectual capital", *International Journal of Management Reviews*, Vol. 3 No. 1, pp. 41-60.

Bontis, N., Dragonetti, N.C., Jacobsen, K. and Roos, G. (1999), "The knowledge toolbox: a review of the tools available to measure and manage intangible resources", *European Management Journal*, Vol. 17 No. 4, pp. 391-402.

Chankong, V. and Haimes, Y.Y. (1983), *Multiple Objective Decision Making: Theory and Methodology*, North-Holland, New York, NY.

Edvinsson, L. and Malone, M.S. (1997), *Intellectual Capital*, Piatkus, London.

Fenton, N.E. and Pfleeger, S.L. (1997), *Software Metrics: A Rigorous and Practical Approach*, PWS Publishing, Boston, MA.

Finkelstein, L. (1994a), "Measurement and instrumentation science – An analytical review", *Measurement*, No. 14, pp. 3-14.

Finkelstein, L. (1994b), "Intelligent and knowledge based instrumentation – An examination of basic concepts", *Measurement*, No. 14, pp. 23-29.

Finkelstein, L. and Leaning, M.S. (1984), "A review of the fundamental concepts of measurement", *Measurement*, Vol. 2 No. 10, pp. 25-34.

Frieden, B.R. (1998), *Physics from Fisher Information*, Cambridge University Press, Cambridge.

Frondizi, (1971), *What is Value?*, Open Court, La Salle, IL.

Harris, D.D. and Sydenham, P.H. (1995), "PRO-MINDS: Development of a software tool to support the measurement system designer", *Measurement*, No. 15, pp. 1-14.

Joia, L.A. (2000), "Measuring intangible corporate assets: Linking business strategy with intellectual capital", *Journal of Intellectual Capital*, Vol. 1 No. 1, pp. 68-84.

Keeney, R.L. and Raiffa, H. (1976), *Decisions with Multiple Objectives: Preferences and Tradeoffs*, Wiley, New York, NY.

Krantz, D.H., Luce, R.D., Suppes, P. and Tversky, A. (1971), *Foundations of Measurement*, Vol. 1, Academic Press, New York, NY.

Krantz, D.H., Luce, R.D., Suppes, P. and Tversky, A. (1989), *Foundations of Measurement*, Vol. 2, Academic Press, New York, NY.

Krantz, D.H., Luce, R.D., Suppes, P. and Tversky, A. (1990), *Foundations of Measurement*, Vol. 3, Academic Press, New York, NY.

M'Pherson, P.K. (1981), "A framework for systems engineering design", *The Radio and Electronic Engineer*, Vol. 5 No. 12, pp. 59 – 93.

M'Pherson, P.K. (1996), "Business value modelling"; and "The inclusive value of information", Proceedings of the 48th Conference and Congress of the International Federation for Information and Documentation, Graz, Austria.

M'Pherson, P.K. (1999), *The Measurement of Value: Multidimensional Accounting*, Systems and Value Consultancy, Berkhamsted.

M'Pherson, P.K., Rowley, I. and Stupples, D. (1997), "The integration, harmonisation and evaluation of complex systems", *Joint ESA/INCOSE Conference on Systems Engineering*, Noordwijck, pp. 4a.5.1-5.27.

MacCrimmon, K.R. and Wehrung, D.A. (1977), "Trade-off analysis: the indifference and the preferred proportions approaches' in Bell, D.E., Keeney, R.L. and Raiffa, H. (Eds), *Conflicting Objectives in Decisions*, Wiley, Chichester.

Rescher, N. (1969), *Introduction to Value Theory*, Prentice-Hall, Englewood Cliffs, NJ.

Roberts, F.S. (1979), *Measurement Theory with Applications to Decisionmaking, Utility, and the Social Sciences*, Vol. 7 of Encyclopedia of Mathematics and its Applications, Addison-Wesley, Reading, MA.

Roos, J., Roos, G., Dragonetti, N.C. and Edvinsson, L. (1997), *Intellectual Capital*. Macmillan, Basingstoke.

Saaty, T.L. (1980), *The Analytic Hierarchy Process*, McGraw-Hill, New York, NY.

Tippett, M. (1978), "The axioms of accounting measurement", *Accounting and Business Research*, Autumn, pp. 266-78.

van Brakel, J. (1984), "Norms and facts in measurement", *Measurement*, Vol. 2 No. 1, pp. 45-51.

Willet, R.J. (1988), "An axiomatic theory of accounting" Part 1 and 2, *Accounting and Business Research*, Vol. 19 No. 73, Spring, pp. 155-71; Autumn, pp. 79-91.

Zeleny, M. (1973), "Compromise programming" in Cochrane, J.L. and Zeleny, M. (Eds), *Multiple Criteria Decision Making*, University of South Carolina, Columbia, SC, pp. 373-91.