HAL
open science

Modelling decision making in an uncertain environment

Guy Bullen, Ouafae Bennis, Frédéric Kratz

To cite this version:

Guy Bullen, Ouafae Bennis, Frédéric Kratz. Modelling decision making in an uncertain environment. ICMCE 2010, Nov 2010, Chengdu, China. pp.467 - 474. hal-00658412

HAL Id: hal-00658412

https://hal.science/hal-00658412v1

Submitted on 10 Jan 2012

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Modelling decision making in an uncertain environment

RG BULLEN[1], O BENNIS[2], F KRATZ[3]

[1] British Telecom, Tour Ariane, 5 place de la Pyramide, BP 22, 92088 Paris La Defense Cedex, guy.bullen@bt.com

[2,3] Institut PRISME, Université d'Orléans, France

21 Rue Loigny La Bataille 28000 CHARTRES, ouafae.bennis@univ-orleans.fr, Frederic.kratz@ensi-bourges.fr

Abstract:

This article proposes a generative approach to decision making in a complex and uncertain environment, as an alternative to normative or descriptive approaches. A simple and intuitive graphical model provides management teams with a non-restrictive framework for thinking through their decisions.

The second half of the article proposes a mathematical model to estimate the multiple influences between decisions in a complex project, whether they are direct or indirect. This method is applied to a real situation, with simulations and results provided.

Keywords:

STCA, decision making, modelling decisions, generative approach, influences, decision networks

1 PROBLEM STATEMENT

1.1 Nature of the problem

Today, the uncertain and unpredictable nature of the economic environment is a major concern for business leaders, who grapple with questions like:

- How is it possible commit to a strategic decision when it is difficult or impossible to predict the environment in which my company will develop?
- What decision-making process should be used in an uncertain environment?

One way to think about this dilemma is to consider the environment as an affiliated network of actors and their decisions. This enables decision makers to summarize the essence of the problem with three key questions:

- How can we understand the workings of our own individual decisions?
- How can we foresee the impact of our decisions on other players?
- How can we take into account the influence that others' decisions may have on our decisions?

Bell et al. [1] have described three broad approaches to the problem of decision-making: normative, prescriptive descriptive.

1.2 Normative and prescriptive approaches

The normative approach defines an "ideal" decision, whilst the prescriptive approach defines "ideal decision practice". Though these approaches appeal to our logic, few companies use clearly specified strategic decisions-making processes' and even fewer implement them. Beyond the fact that managers (especially senior managers) do not like being locked into a prescriptive process that stifles their creativity, a singular process does not provide a response of requisite variety required for a complex and uncertain environment.

1.3 The descriptive approach

A descriptive approach to decision making analyses "real" decision to gain understanding. However, decision-making in business is often opaque and sometimes confusing. Moreover, the dynamic interactions between decisions complicates analysis. These decisions may form a network (with clustering or `small-world_ characteristics). The greater the number of decisions, the more complex the interactions, as illustrated in Figure 1.

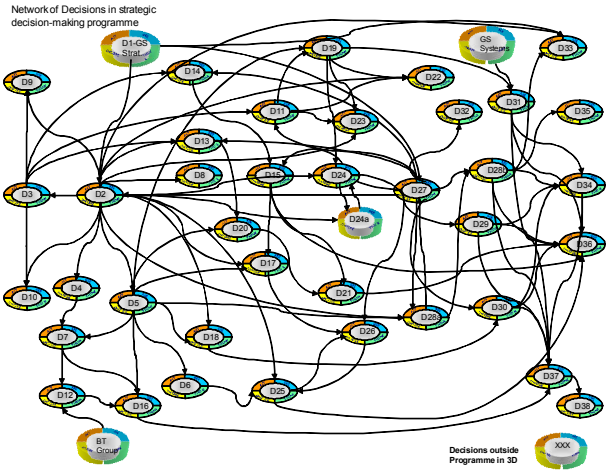

Figure 1. Example of a decision network

2 THE STCA MODEL

2.1 Proposal for a generative approach

A generative approach to the above problem provides a simple framework that allows a management team to reflect how it makes decisions, and to generate its own decision-making practice that matches its unique personality and specific context.

This approach is in line with the work of Mintzberg et al. [3], who demonstrated that there was a common, simple structure to so-called "unstructured" decisions, though without proposing a tool to assist decision-making practice.

We propose a tool that can help model both an individual decision, and also its interaction with a network of surrounding decisions.

This tool can enable the simulation of different scenarios of influence between decisions, and thereby improve decision-making practice.

2.2 Restatement of the problem

We can now reformulate the problem above, as posed by a management team:

- How can we understand individual decisions using a generic framework?
- How can we understand how our decisions may be influenced by other decisions taken elsewhere in our environment?
- How can we understand the impact of our decisions on other decisions in our environment?

2.3 The STCA Wheel

The STCA wheel is divided into four quadrants, with each quadrant representing key phases of a decision, along with key questions

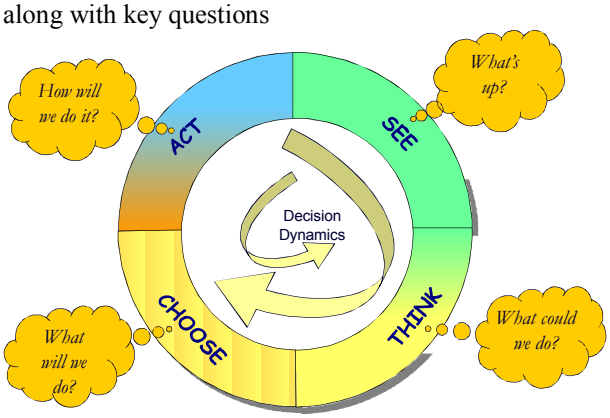

Figure 2. The STCA Wheel

- See. Something catches our attention and we ask `What˘s up?_
- Think. We think about the situation and ask `What can we do?_
- Choose. We take the decision, which answers the question: `What shall we do?_
- Act. We then move to action and ask `How will we do it?_

This radical simplification of the concept of decision making makes it cognitively simpler to take systemic view on the decisions around: those that influence the decision in question, and those influenced by it.

For purposes of analysis later on in this paper, we have split each phase into steps.

Table 1 Generic decision-making steps

See	Notice. The moment we realise that there is a situation we may need to react to
	Recognise. The moment we recognise the situation we are in, and that we do need to react to it.
Think	Design. The period when we think about how we will make the decision, and whom we will consult.
	Gather Data. The period when we define which data we need, and where to get it.
	Make Sense. Having gathered the data, we try to make sense of it.
	Evaluate Options. Having (at least partially) understood the data, we consider possible options.
Choose	Prepare Choice. Having thought through the options, we note down our conclusions so as to convince others.
	Simulate Consequences. We simulate the consequences of key options.
	Decide. The moment of choice.
Act	Communicate. When we communicate our decision to stakeholders.
	Plan. When we engage in detailed implementation planning.
	Implement. Actual implementation, without which any decision remains a dead letter. .

It is important to note that this is not a linear prescriptive process, but a description of generic steps to enable decision makers to identify where they are in their decision.

This enables a single framework to take into account a large number of different kinds of decisions. For example, the decision on where to build a reactor in a society aware of the dangers of nuclear energy will require careful planning before the `decide_ stage. On the other hand, a fire fighter may move directly from `See_ to `Act_ (and skip `Think_ and `Choose_). Using the STCA model can in both case help make sense of these decisions.

2.4 A complex system of decisions

Understanding the influences between different decisions equates to the analysis of complex systems, whose behaviour is often counter-intuitive.

In three case studies, Bullen [2] found the following:

- The earlier the influence of one decision came in the life of another decision, the greater its impact.
- The influence of one decision on another can accelerate, slow down, delay, or block it.
- One decision may change the result of another.
- Some decisions `give birth_ to other decisions. For example, the decision to marry will `engender_ decisions concerning the place, date and type of marriage.
- The influence of one decision on another can be direct, or indirect (i.e. through one or more intermediate decisions).

Each of these findings is easily understood. However, their combined implications are difficult or impossible to evaluate by a management team. This is where mathematical analysis can help.

3 PROPOSED MATHEMATICAL MODEL

The STCA wheel was originally developed to assist a management team in the practice of decision making in a complex environment. The pattern of interconnections in Figure 2 suggests that it is possible to exploit this model to evaluate some links and influences between different decisions.

These influences may be direct (simple connections) or indirect (through other intermediate decisions). Two

decisions may also have a reciprocal influence (direct or indirect) in a feedback loop, which can generate complex behaviour (e.g. D2 and D27 in Figure 1). These influences may accelerate, delay, or block the decisions in question.

We describe below a way of making these influences explicit, using the STCA framework.

3.1 Influence of a decision i on a decision j:

3.1.1 Direct influence of i on j:

The STCA wheel consists of twelve steps, the last of which is implementation. One can note:

- I_d (ij): direct influence of decision i on decision j.
- S_i the stage in decision i from which decision i influences decision j
- S_j the stage in decision j where this influence begins.
- Oscill(i) the number of oscillations created by going backwards on the wheel
- Jumps(i): number of stages skipped on the wheel
- Time(i) = [13 - (S_i - Oscill(i) + Jumps(i))], the duration of decision i after it has begun to influence decision j. During this period, decision j is accelerated or decelerated, depending on the role played by decision i.
- duration(j) = [13 - (S_j - Oscill (j) + Jumps (j))], the duration of the decision j after the beginning of the influence of i.

Direct influence is expressed by:

I_d (ij) = duration (i) * duration (j) * Cij (1)

Where Cij is a coefficient for each pair of decisions (i,j), determined according to a priori knowledge of their interaction.

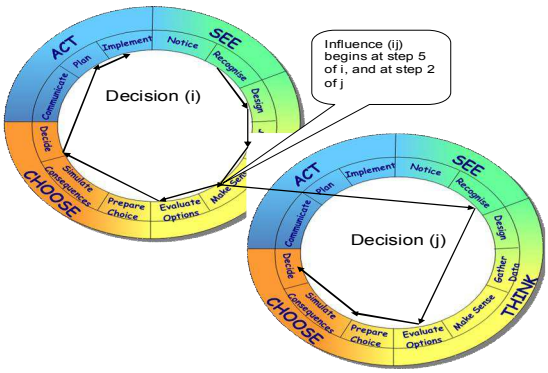

Figure 3 Influence of decision i on the decision d

Notes:

1) The earlier the influence, the greater it is.

2) From the start of the influence of i on j, the more oscillations in j, the more this influence will last, and the greater the influence. Conversely, the more jumps, the less influence will last, and the smaller the influence. The duration of influence is therefore a function of the number of steps, rather than the number of stages through which those steps have passed through. This corresponds to the use of the model as a framework to learn about the process of decision making, and not as prescriptive process involving "boxes" mandatory.

3.1.2 Indirect influence of i on j:

By observing the pattern of interconnection of Figure 2, above, we note that through a decision through k, the influence of i extends to all decisions influenced by k j: D_i influences D_k which, in turn influences D_j.

We note this influence as I_{ind} (ij) using the formula:

$$I_{ind}(ij) = \left[\prod_{\substack{k=1 \grave{a} N \\ k \neq i \\ k \neq j}} I_d(ik) * I_d(kj) \right]^{\frac{1}{N-1}} \quad (2)$$

N is the total number of decisions involved in the project.

The influence of i on j is the product of these two (or more) influences (equations (1) and (2)), direct and indirect; $I(ij) = \left[I_d(ij) * I_{ind}(ij) \right]^{\frac{1}{2}}$ (3)

This kind of influence can extend to more steps: D_i influences D_k which influences D_l which in turn influences D_j which influencesŭ

3.1.3 Overall impact on a decision j:

A decision i can be influenced by several decisions. Ij is the total influence of all other decisions on decision j

Ij is calculated by: $$I_j = \left[\prod_{\substack{i=1 \grave{a} N \\ i \neq j}} I_{ij} \right]^{\frac{1}{N-1}} \quad (4)$$

represents the product of all direct and indirect influences on the decision d.

3.2 Role of the influence I_j on the evolution of a decision j.

This influence can take many forms:

3.2.1 Influence throughout the STCA wheel

Depending on the degree of influence, the decision j is either:

1) accelerated or slowed down (if I_j> 1 or I_j <1), I_j determines the average speed of the decision on the wheel. It directly impacts the duration T_j.

2) exits the wheel ($_jI$>> 1). The decision j is then executed.

3) blocked (if I_j <<1).

Note: 2) or 3) are borderline cases of 1).

3.3 Dynamics of a decision:

On the STCA wheel, the twelve stages are numbered from 1 to 12. To exit the wheel, a decision goes across the a 12 stages.

Consider the variables:

- T_j : the total length = j, expressed in days,
- $P_j(0)$, the entry box j in the wheel STCA,
- Vit_moy: the average speed of progression of j = $12/T_j$
- Ns, Nosc, respectively the number of jumps and oscillations of j, expressed in numbers of squares crossed during a jump or repositioned during a swing.

For t belonging to the interval T_j, we define the variable $P_j(t)$, the position of decision j at time t. The progression of decision j may be modeled by the expression:

$$P_j(t) = P_j(0) + Vit_moy + Ns - Nosce \quad (5)$$

t is in days and the position of the decision on the wheel STCA is defined by the integer part of $[P_j(t)+1]$.

4 SIMULATIONS RESULTS

Table 2 shows the results of calculating the influence on the speed of some decisions into one of three projects Bullen [2].

Decision	Total influence	Days with total influence	Nb days if no influence
36	3.77	30.00	113.23
37	2.43	20.00	48.53
34	1.93	30.00	57.78
25	1.89	91.00	171.83
26	1.48	39.00	57.84
17	1.46	48.00	69.98
2	1.27	20.00	25.46
3	0.98	10.00	9.77

Network convergence on certain decisions

Almost all major decisions converge on decisions D34, D36 and D37. D34 was the decision to close the project, D36 defined the financials, D37 defined the implementation plan of future activities. These are the decisions to which all other decisions lead. By placing these decisions as the most influenced, the mathematical model confirms this hypothesis and validates the model.

Mutual influence between decisions

D25 (validation of the cost of wholesale calls between France and Turkey) and D26 (validation of proposed commercial launch of a calling card in these two countries) have a strong mutual influence. Without low-cost calls, the business case (D26) would not have been not accepted. At the same time, D25 was accelerated by the need for the D26 to have low-cost calls. One needs the other, and they accelerate each other.

Diffuse slowing influence

It is important to note that D2 (slowed down by D27) in turn gives birth to D3, and that this slowing influence of is reflected, indirectly, on D3. This phenomenon was observed consistently in the modelling.

Modelling these decisions has helped us to understand that D27 had a widespread influence that slowed the whole network of decisions, including those which it did not influence directly.

Figure 6 gives a simple, directly usable example. With no accelerating influence, the D25 would be only half complete in the 11 days it actually took when accelerated.

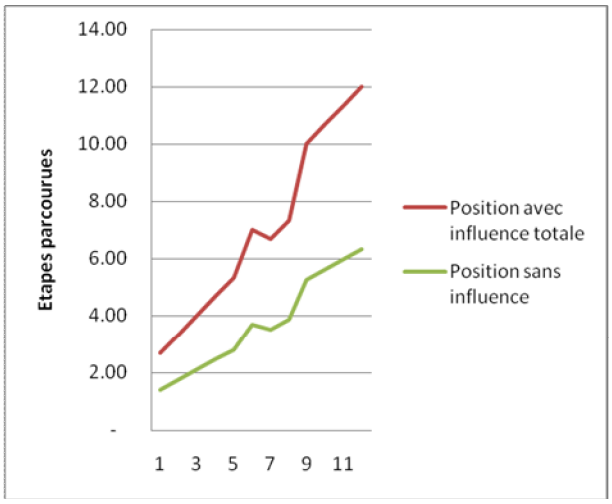

Figure 6 Diagram of difference between a decision with and without influence

5 CONCLUSIONS

The generative approach and the STCA model presented in this paper have helped to give an overall picture of the multiple influences between the different decisions in a real project. It is a powerful communication tool that enables business leaders to better understand the interplay between decisions in a complex and uncertain environment.

The mathematical model proposed has:

- allowed us to identify the most influenced decisions, D34, D36, D37;
- shown, through indirect influence, a link between decisions, which a priori were not correlated (influence on D3 and D27 through D2 and others);
- opened the possibility of quantifying the qualitative results of the STCA model, making it directly useable by business leaders.

REFERENCES

[1] Bell, DE., Raiffa, H., Tversky, A., Eds, 1998. Decision making: Descriptive, normative and prescriptive interactions. Introduction. Cambridge University Press.

[2] Bullen, R.G. Decision Making in a Complex and Uncertain Environment. Thèse doc, février 2009.

[3] Mintzberg, H., Raisinghani, D., Theoret, A., 1976. The Structure of `Unstructured_ Decision Processes, Administrative Science Quarterly Vol 21, No. 2, 246-275.