

The role of formal models in theory building: an application to strategy theory

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ABSTRACT

A problem of the management field is that concepts are often vague and this breeds fragmented theories, each concentrating on different aspects of an underlying issue. This paper proposes the development of formal models in management to clarify and integrate the issues of the field. It illustrates this approach with a model of competitive advantage.

INTRODUCTION

The foundation concepts of any field are important since they provide a shared basis to underpin research and allow results to be viewed cumulatively. Unfortunately this is hardly the case in organization theory. Zammuto and Connolly (1984) consider organisational science on the other hand to be severely fragmented, presenting a serious obstacle to scientific growth; they evidence the low level of interconnection of ideas found in organisational textbooks. Similarly, Pfeffer (1997) states that it has a low level of paradigm development and notes that consensus seems almost to be avoided, while some researchers have found little consensus even about what the most important research issues should be.

This paper starts from generally accepted concepts at the core of the notion of strategy and illustrates how a model of competitive advantage might be constructed around them. Some propositions found in strategy theories are considered in terms of a formal model. We show how strategy prescriptions can be evaluated by reference to formal models.

FORMAL MODELS

A model is a set of elements and a set of relations between them. In a formal model it is possible to deduce results (propositions) from the basic assumptions (elements and relations) of the model (Stegmuller 1976). Although the term model is widespread in organizational theory, many such 'models' are in practice no more than lists of factors. They lack the relations which would allow the deduction of propositions. Formal models provide both precision and deducible propositions. A sharp model lends itself to verification or disproof in a way that a set of fuzzy notions does not. Formal models which gain acceptance promote a standard set of factors thus assisting cross-case comparisons. In this way knowledge can be built by refining commonly held models.

An objection to the use of formal models in social systems is that the concepts involved do not lend themselves to precision or definite relationships. To model is to simplify reality, and it may be argued that oversimplification will result owing to the complexity and consequent contingent effects within social systems. Yet in specific areas formal models have been adopted e.g. in theories of financial risk behaviour (Brigham and Gapenski, 1997), organizational ecology, punctuated organizational change and in decision making.

STRATEGY

The concept of strategy in the literature remains unclear. Hart & Banbury (1994) note that the literature contains a bewildering array of schools of strategy, while Foss (1996) characterises research in strategy as too pluralistic and in need of integration. Shenhav et al (1994) in a study of published articles report that only 20% provided a theoretical definition of the concepts used. Strategy therefore provides a good example of a fragmented field of organizational research.

A proposition of the positioning school is that advantage is primarily a function of the firm's environment and is due to an industry effect and a positioning effect (Porter 1991). Competition arises from other firms with essentially similar resources entering the same market position.

A proposition of the resource based school (Barney 1991) is that competitive advantage comes primarily from resources owned by the firm. Different authors have proposed different concepts of inimitable, advantage sustaining resources, including distinctive competencies, underlying capabilities, core competencies, internal capabilities, and absorptive capacity. Grant (1991) notes that there is no single integrating framework.

The new institutionalism (Scott, 1995) provides the proposition that advantage accrues from the ways that the firm perceives its environment through the processes and structures which have acquired organizational or social validation.

The basic assumptions which do appear to be widely shared by theories of competitive advantage can be summed up as follows:

- Returns are a function of the fit between resources, position and the environment.
- The environment is uncertain and changing
- Competition means the erosion of returns to the firm.

Based on these assumptions we develop a formal model of competitive advantage in terms of the long term returns to a firm. The model is used to investigate examples of propositions found in the strategy literature. These propositions, such as that resources can produce sustainable strategic advantage, are often stated as though they necessarily follow from the assumptions and arguments employed. Without the benefit of formal models it is difficult to evaluate whether these claims are true. The model is used to investigate whether such propositions follow from the assumptions.

A FORMAL MODEL OF COMPETITIVE ADVANTAGE

Competitive advantage is measured by long term returns. We model returns as resulting from the fit between the content of the strategy (resources and position) and the state of the environment at a given time. For simplicity, returns are evaluated at an infinite sequence of discrete time points (rather than continuously). At each time point the return depends on the strategy in place and the environment at that time. $s_t = \{ r_t, p_t \}$ is the strategy content at time t , described by the chosen resources (r) and positioning of the firm (p). r describes the firm and includes physical resources, intellectual property, routines. p describes the market conditions for the firm and includes market growth, customer characteristics, market share, level of competition. e_t is the state of the environment at time t , including economic conditions, level of competition, competitor actions, regulatory actions, etc.

r , p and e are modelled in terms of probability distributions. For simplicity, it is assumed that e_t depends only on the previous environment state e_{t-1} and strategy choice s_{t-1} .

The return due to the fit between strategy and environment is modelled by a function f depending only on s and e : $f(s, e)$. We make only minimal assumptions about the structure of f in accordance with the assumptions commonly shared by strategy theories described above.

If the environment becomes more uncertain or if the outcome of strategy implementation becomes more uncertain then this will make the returns more uncertain. This is modelled by making the variance of the return a monotonic function of both the variance of strategy and the variance of the environment:

$\text{var}(f)$ is monotonic increasing in $\text{var}(s)$ and in $\text{var}(e)$

Competition is modelled by the erosion of returns over time if the firm maintains a fixed strategy. This represents the assumption that competitors will eat into the firm's returns unless it takes active steps to prevent this. Hence if the firm sticks to the same strategy s over time, then denoting the n th use of the same strategy s by $f^{(n)}$

$Ef^{(n)}(s, e_t) < Ef(s, e_t)$

The efficiency of resource allocation is modelled by requiring f to be monotonic in the cost of s , i.e. if the firm becomes more efficient in resource usage then returns increase.

Following standard modelling practice, e.g. in the CAPM model (Brigham and Gapenski, 1997) the model discounts risky and future returns. The discount factor is a , $0 < a < 1$. The discount factor a depends upon the uncertainty of returns expected in each period. That is, a depends on the variance of the distribution of f , $a = g(\text{var}(f))$, and the function g is monotonic decreasing in $\text{var}(f)$. Since f is a function of s and e we write $a(s, e)$.

The total expected discounted return from following a series of strategy decisions s_1, s_2, \dots over an infinite time period where the environmental states are e_1, e_2, \dots is $\sum_{t=1}^{\infty} a^{t-1} Ef(s_t, e_t)$

where a^{t-1} refers to the multiple of the discount factors for periods 2 to t (the discount factor for period 1 is always 1) and where E denotes the expected (average) value of the distribution $f(s, e)$.

The notion of implementation costs for strategies is modelled by switching costs. A new strategy can be implemented at any time. But this involves changing resources and positions. Such changes have associated costs (managerial, information, resource) associated with them payable immediately.

$c(s_{t+1}, s_t)$ is the switching cost of changing to strategy s_{t+1} at $t+1$ from strategy s_t at t . If the strategy remains unchanged then there is no switching cost: $c = 0$ if $s_t = s_{t+1}$.

The strategic decision problem is then to maximise the total expected discounted value of the fit over time. The total expected value from t depends on the state at t : s_{t-1} and e_{t-1} . The maximised total expected discounted value (through choice of the optimal strategies $\{s_t\}$) over all future periods is denoted by $V(s_{t-1}, e_{t-1})$.

$V(s_{t-1}, e_{t-1}) = \text{Max} \{ \sum_{t=1}^{\infty} a^{t-1} E[f(s_t, e_t) - c(s_t, s_{t-1})] \}$ over $\{s_t\}$

DEDUCTIONS FROM THE MODEL

This model is one representation of competitive advantage based on common assumptions derived from the literature. The model developed here is intended as an illustration of the power of formal models to clarify issues in a well-trodden and much debated area. The model is used to examine whether common strategy prescriptions do in fact follow from the assumptions as embedded in the model.

1) Can we find a strategy for sustainable advantage?

Some strategy theories imply that resources or positions can be found which confer lasting competitive advantage. This means that a fixed (stable) strategy continues to be optimal. Can a stable strategy be optimal?

Consider a stable strategy $s_t = s^*$, for all t .

The expected return from the optimal strategy is

$$\text{Max} \{ \sum_{t=1} a^{t-1} E[f(s_t, e_t) - c(s_t, s_{t-1})] \} \text{ over } \{ s_t \}$$

This is greater than or equal to the return from any other strategy, in particular to the return from putting $s_t = s^*$ for all t :

$$\sum_{t=1} a^{t-1} E[f(s^*, e_t) - c(s^*, s^*)]$$

And from competitive erosion this is strictly greater than

$$\sum_{t=1} a^{t-1} E[f^{(t)}(s^*, e_t) - c(s^*, s^*)]$$

which is the expected return from using the stable strategy s^* .

So the proposition that a stable strategy can be found which gives lasting advantage is not consistent with the assumptions of the model.

2) The hare or the tortoise: does speedy strategy win?

Another proposition we consider is that speedier decisions give more advantage (Eisenhardt, 1989). A more reactive firm is able to make and implement decisions more quickly. In terms of the model this can be formalised as the ability to take decisions and change strategy more frequently. Does this ability increase competitive advantage by adding to the firm's returns?

Consider a new decision process which allows an extra decision to be made at some point ($t+dt$) between t and $t+1$. The value of the return from t to $t+1$ will now be split into two parts: return at t over a period of length dt plus return at $t+dt$ over the remaining period of length $1-dt$. Define $V_t(s_{t-1})$ as the optimal value from t onward if s_{t-1} was chosen at $t-1$, when an extra decision point is introduced at $t+dt$. Define $U_t(s_{t-1})$ as the optimal value from t onward if no change in strategy is made at $t+dt$.

$$\text{Define } U_{t+dt}(s_t, e_t) = (1-dt)E f(s_t, e_{t+dt}) + a(s_t)V_{t+1}(s_t, e_{t+dt})$$

$$\text{and } V_{t+dt}(s_t, e_t) = \text{Max}_s \{ (1-dt)E f(s, e_{t+dt}) - c(s, s_t) + a(s)V_{t+1}(s, e_{t+dt}) \}$$

i.e. the optimal value from $t+dt$ onward if strategy s_t (as before, the optimal choice at t if choices are allowed only at unit time intervals) which was chosen at t is kept (U) or allowed to change (V) at $t+dt$.

We consider the effect of a rapidly changing environment. The environment might change without affecting the choice of strategy. In this case there is no extra return from being able to react at intermediate decision points. However, the environment might change in a way which does affect choice of strategy. This means that:

$$V_{t+dt}(s_t, e_t) > U_{t+dt}(s_t, e_t) \text{ for some } dt, 0 < dt < 1.$$

$$\begin{aligned} \text{So } V_t(s_{t-1}, e_{t-1}) &= \text{Max}_s \{ dt E f(s, e_t) - c(s, s_{t-1}) + V_{t+dt}(s, e_t) \} > dt E f(s_t, e_t) - c(s_t, s_{t-1}) + \\ &U_{t+dt}(s_t, e_t) \\ &= U_t(s_{t-1}) \end{aligned}$$

So under conditions of rapid change the model shows that total return is increased by allowing an additional decision point, that is by rapid adaptation of strategy.

CONCLUSIONS

The introduction of formal models into management theory has several advantages. First it forces precision in the use of management concepts. Verbal concepts are often shrouded in ambiguity. In order to be incorporated in a formal model they must be stated in such a way that their relations to other elements of the model is clear.

Second, the web of interconnected assumptions which typically comprise management theories are mapped into one consistent framework by the model. The model illustrates how starting from a sparse set of generally agreed assumptions more complex propositions about strategic behaviour can be deduced from the model and how the claims of certain theories can be tested against the model.

Third, a formal model provides guidance in analysing complex situations. Without a formal model researchers are thrown back on their own selection of concepts and relationships and this leads to fragmentation of the field. Numerous contingent relationships may be separately investigated using different tools, without the possibility of integrating their results. A model allows research to concentrate on the important elements and relations in the data.

It is to be hoped that formal models will play a larger role in the future development of organizational theory.

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