System Dynamics and Strategy:
Towards Compelling Behavioural Theories of Strategic Dynamics

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Abstract
There are increasing opportunities for work at the intersection of system dynamics and strategy
to make important contributions to mainstream strategy thinking and practice. Strategy scholars
are calling for and need theories (models) to explain the dynamics of strategy phenomena to
complement the large volume of work that has examined cross-sectional differences among firms
and industries. There is also a burgeoning behavioural movement in strategy to incorporate
realistic cognitive assumptions in managerial decision making in place of the optimizing
assumptions of perfect rationality. Scholars working at the intersection of system dynamics and
strategy are well positioned to build compelling behavioural theories of strategic dynamics that
penetrate the strategy mainstream. However, there are other competing ideas and methods and
there are significant challenges to overcome. This article lays out the promising opportunities
and, we hope, helps point the way for future research.

System Dynamics and the scholarly research field of Business Policy and Strategy (hereafter Strategy) both originated in the late 1950s. From very early on, these two fields have had overlapping areas of interest. The preface of *Industrial Dynamics* indicates that the goal of industrial dynamics is, "enterprise design to create more successful management policies and organizational structures. … [Industrial dynamics] integrates the separate functional areas of management," (1961). Similarly, the strategy field has long emphasized the interactions or interdependence among firms' policy choices across the whole enterprise. An early definition of strategy included, "the pattern of objectives, purposes or goals and major policies and plans for achieving these goals…" (Learned et al. 1965, p. 15).

Over time, the research topics explored in both strategy and system dynamics have become increasingly varied. Variety in strategy has emerged as ideas and methods from economics, sociology, and more recently psychology have been imported to explain the sources of heterogeneity among firms in profits and practices. A large range of different explanatory mechanisms has attracted attention, including: founding conditions; resources and capabilities; intellectual property and learning; industry structure; industry dynamics; social status and social networks; institutions; the globalization of trade and enterprise; conflict and rivalry with other firms; irreversible commitments; evolution of complementary firm practices; and designing fit between internal and external activities (for reviews of the expansive strategy field see, Rumelt, Schendel, and Teece 1995; Gavetti and Levinthal 2004; Pettigrew, Thomas, and Whittington 2006).

As a result of the increasing variety in both system dynamics and strategy, there has been far less cross-fertilization between these fields than might have been expected given the strong initial overlaps in the domain statements. Very little mainstream strategy work has been widely

recognized and appreciated in the system dynamics community. Similarly, although there has

been a stream of strategy-related system dynamics work over the last 50 years, only a small

fraction of that work has received widespread recognition from mainstream strategy scholars[1].

However, there are increasing opportunities for work at the intersection of system dynamics and

strategy to make important contributions to mainstream strategy thinking and practice going

forward. The 50th Anniversary of the field is a good time for us to reflect on these promising

opportunities. In doing so, we hope to help focus future research at the intersection of these

fields.

Two developments account for the increasing opportunities for work at the intersection of

system dynamics and strategy to make central contributions to mainstream strategy thinking.

Firstly, strategy scholars are calling for and need theories (models) to explain the dynamics of

strategy phenomena to complement the large volume of work that has examined cross-sectional

differences among firms and industries. Secondly, there is a burgeoning behavioural movement

in strategy to incorporate realistic cognitive assumptions in managerial decision making in place

of the optimizing assumptions of perfect rationality. Both of these developments play to the

strengths of research at the intersection of system dynamics and strategy.

Over the last several decades, strategy scholars focused much of their research on

explaining the sources of heterogeneity among firms in performance and practices and providing

suggestions to improve firm performance. Equilibrium concepts of optimal behaviour arising

from economics and sociology have served as the primary theoretical underpinnings of research

and teaching in strategy. While these core theories are now augmented by a host of additional

ideas (e.g., network location, social capital, transaction costs, and agency problems), even these

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[1] Given the scope of this paper, we do not attempt to provide any review of the strategy-related system dynamics work.

insights are derived as equilibrium outcomes of optimizing behaviour under some kind of

constraints (e.g., historic social linkages, asset specificity, and information asymmetry).

Statistical evaluation of cross-sectional data to identify these equilibrium effects abound.

Decades of cumulative strategy research along these lines has led to the development of theories

and models for understanding the performance implications of extant differences among

competing firms at a given point in time. However, relatively little is known about the origins of

these differences. The focus on cross-sectional comparisons crowded out numerous attempts to

bring longitudinal analyses to the forefront of the strategy agenda[2].

However, strategy researchers have become increasingly interested in understanding the

dynamic processes by which performance differences arise among competing firms. Research is

needed on the dynamic processes out of which such differences arise, persist, and disappear. A

growing number of strategy scholars are calling for research that begins to build compelling

dynamic theories (models) of strategy phenomena (Cockburn, Henderson, and Stern 2000;

Ghemawat and Cassiman 2007; Porter 1991). For example, existing strategy models do not have

adequate explanations for the dynamic process leading to firm-level competitive advantage or

how and why some firms gain advantage (Cockburn, Henderson, and Stern 2000). The editors of

a recent special issue in *Management Science* summarised the current state of research on

strategic dynamics concluding that, "the challenge of fully incorporating dynamics into how we

think about strategy is a major one, perhaps the biggest one that the field faces going forward"

(Ghemawat and Cassiman 2007).

At the same time, an increasing number of strategy scholars have started to question and

seek alternatives to the assumptions of rationality and optimizing behaviour attributed to

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[2] There has been a steady stream of research emphasizing the importance of dynamics in strategy over the last 50 years, but this work has always been on the periphery of the field. It is not within the scope of this paper to review this literature.

managers and firms in much of the existing strategy theory (Bromiley 2005; Denrell, Fang, and Winter 2003; Lovallo and Kahneman 2003). As behavioural economics and behavioural finance have ascended in their respective fields, the idea of behavioural strategy is becoming more legitimate for mainstream strategy scholars. In addition, as strategy researchers delve deeper into the micro foundations of decision making, there are increasing overlaps with psychologists. These overlaps have resulted in the recent importation of ideas and methods from psychology into strategy. As part of this overall movement, a growing stream of mainstream strategy research examines and/or adopts more realistic cognitive assumptions for managers and firms.

System dynamics is well positioned to make important contributions to building behavioural theories of strategic dynamics. Firms and industries are highly dynamic, complex systems managed by boundedly-rational actors. What better way to understand firms and firm performance than with a 'theory of structure' capturing enduring causal relationships and decision making processes that drive the dynamic behaviour of firms and industries over time? However, there are other competing ideas and methods and there are significant challenges to overcome in building compelling behavioural theories of firm and industry dynamics able to reach strategic management mainstream. We highlight a handful of the most important challenges below.

Challenges in Developing Compelling Behavioural Theories of Strategic Dynamics

There has been a great deal of research directed at building behavioural theories of firm and industry dynamics over the last 50 years (Cyert and March 1963; Nelson and Winter 1982), and yet these efforts have not blossomed in strategy. We will not review the extensive literature that has pushed these efforts forward, but instead highlight what we believe to be the major

hurdles standing in the way of the development and widespread acceptance of behavioural theories of strategic dynamics.

Perhaps the most fundamental, albeit painfully mundane, challenge apparent in previous work is access to data and appropriate methods for manipulating data. Only recently have systematic longitudinal databases become widely available and these generally provide only a narrow selection of numerical and mostly financial records. As these databases have improved, so have statistical methods for analyzing them. Access to such data increasingly provides opportunities to test the generalizability of dynamic hypotheses and rule out alternative explanations. Much of the best research going forward will require richer use of evidence in the form of longitudinal data and increased data analysis and interpretation skills for researchers.

A second challenge is that firm and industry dynamics are subject to strong influences at multiple organisational levels (e.g., individuals, groups, and organisational subunits) and supra-organisational levels (e.g., competitors, political bodies, and social norms). The academic response to the multiplicity of influences on organisations has largely been a fragmentation of research streams among levels. Historically, much of the research at the intersection of system dynamics and strategy has focused on the intra-firm organizational level. A smaller amount of work at this intersection has focused on the industry-level (e.g. commodity cycle dynamics) typically with an implicit assumption of homogeneity among firms in the industry. Research integrating multiple levels of analysis may be required to build compelling behavioural theories of strategic dynamics. In particular, a great deal of strategy research focuses on performance differences among competing firms, and therefore scholars working at the intersection of strategy and system dynamics will need to engage in more careful theorizing about competitive

interactions. Richer multi-firm models may be required to adequately explore performance differences among rivals.

Addressing the multiple-level problem sets the stage for a third basic challenge: How do we keep theories simple enough that we can evaluate them, communicate them widely, and rely on them to have not only explanatory power but predictive validity in new settings? While Simon (1962) offers us the hope of a 'nearly decomposable' world, the difficulty of understanding and testing theories grows exponentially with the complexity of the interacting factors considered. Specialization in response to growing research volume and sophistication places a premium on our ability to communicate complex ideas clearly and simply.

Ironically, perhaps the greatest challenge we face is in understanding and representing human behaviour and decision making within organizations. In circa 1960, Herbert Simon was very optimistic about how rapidly we would develop our understanding of human cognition.

> "Within the very near future- much less than 25 years- we shall have the technical capability of substituting machines for any and all human functions in organizations. Within the same period, we shall have acquired an extensive and empirically tested theory of human cognitive processes and their interaction with human emotions, attitudes and values." (Simon 1960, pg 22)

Almost 50 years later, we are a long way from an extensive and empirically tested theory of human cognitive processes to underpin compelling behavioural theories of strategic dynamics. Researchers have tended to split along polarizing assumptions about human decision making and behaviour with one side progressing by selectively placing limits on assumptions about optimal organizational behaviour while the other introduces assumptions about behaviour based on direct observation largely unrestrained by theory. Attempts to meld the two have rarely met with approval from both sides at once (see Gibbons 1999; and the response by Granovetter 1999). The result has been weaker theory on both sides and limited acceptance of research findings.

How do we understand and model decision making of individuals within organizations in a way that captures both their creative and teleological nature while recognizing their biases and the forces that divert attention from organizational goals? Until we do so systematically and richly, our research will progress less quickly, meet with understandably narrower acceptance, and the organizations we model will show very little of the heterogeneity and fundamental discovery that occurs in organizations.

In this paper we discuss several ongoing streams of research at the intersection of system dynamics and strategy that are addressing these challenges. Although research is clearly needed on many fronts, we believe these research streams have the potential to make important contributions to building more compelling behavioural theories of strategic dynamics.

The paper is organized as follows. The next section discusses an example of strategy-related system dynamics work that is widely known in the system dynamics and strategy communities- the rise and fall of People Express. We use this example to highlight the connections between familiar ideas in system dynamics such as stock accumulation and boundedly-rational actors and the language of contemporary strategy. More importantly, we use the People Express example to demonstrate both the promise and challenges of developing behavioural theories of dynamic strategy phenomena and discuss some of the requirements necessary to build a strong behavioural dynamic perspective. In the subsequent section, we summarize some specific research areas with high potential for contributing to building stronger behavioural theories of firm and industry dynamics. We do not claim to cover the exhaustive set of relevant research at the intersection of system dynamics and strategy. Instead, our choice of research areas to summarize is pragmatic. They represent specific, concrete examples of ongoing research threads at this intersection. We conclude by pointing the way for future

research capable of building compelling behavioural theories of strategic dynamics.

An Example Application at the Intersection of System Dynamics and Strategy

There are numerous example applications of work at the intersection of system dynamics and strategy. One of the most vivid example applications is provided by the People Express case (Holland and Beer 1990; Whitestone 1983). The People Express microworld (Sterman 1988) and the feedback structure underpinning the story of the rise and fall of People Express (Senge 1990) is well established and widely known in the system dynamics community. In addition, the combination of the case and management flight simulator have been widely used in business schools around the world to introduce 'students' of management to the scope, ambition and intellectual challenge of the strategy field. It is one of the few examples of work at the intersection of strategy and system dynamics that is well known in both fields, though it is known primarily as a pedagogical example and has never been published in a scholarly journal. In real life People Express grew from obscurity to industry prominence in a period of only five years against powerful rivals. Dramatic growth was followed by equally dramatic demise.

A feedback theory of the demise of People Express

In The Fifth Discipline, Senge (1990) outlines a feedback theory of what happened at People Express that builds on the growth and underinvestment archetype (chapter 8, pages 130-135). At the heart of the feedback theory is underinvestment in service capacity as shown in Figure 1. Service capacity, in terms of experienced staff, failed to keep pace with the growth of flights and passengers and so, ultimately, the service reputation of the business was destroyed. At first glance this argument seems compelling. But it fails to explain why, in real life, a company could have made such a fundamental strategic error without realizing it.

INSERT FIGURE 1 HERE

A fundamental proposition (and partial explanation) is that underinvestment in staff was very difficult for managers at People Express to discern at the time the company's spectacular growth was taking place. According to Senge, investment in service capacity was driven by a 'perceived need to improve service quality'. This criterion for investment sounds plausible yet it led to an organization that was chronically short of staff. But why? Senge hints at two reasons (each informed by feedback systems thinking and the chosen archetype): 1. experienced staff (controlled by a balancing loop) did not keep pace with the growth of the fleet (controlled by a powerful reinforcing loop); and 2. implicitly this imbalance was masked by tremendous growth in headcount which did not fully translate into corresponding growth in service capacity. Nevertheless one is left wondering why the company persisted in its aggressive fleet expansion and why in its hiring policy the company did not appreciate that headcount and service capacity are fundamentally different.

Connecting to Ideas from the Strategy literature that help to interpret the People Express Case

To examine these anomalies we turn to two sets of ideas from the strategy literature. The first is the resource based view (RBV) of the firm which explains differences in firms' performance and competitive position in terms of endowments of critical productive assets or resources (Barney 1991; Foss, Knudsen, and Montgomery 1995). In particular we draw on a dynamic view of resource accumulation developed by Dierickx and Cool (1989) which makes the same distinction between stocks and flows (or levels and rates) as found in system dynamics, and which has been extensively developed in Warren (2002). The second idea is the notion of dominant logic which provides a cognitive/behavioural explanation for different managerial styles of resource management (Prahalad and Bettis 1986). Senior managers' dominant logic is

their belief system or overall logic for firm success. Dominant logic captures some of the information filtering and misperceptions of feedback in decision-making implied by bounded rationality and the 'Baker' criterion (Sterman 2000, chapter 13).

The first step in a dynamic resource-based study is to classify resources into tangible or intangible (Warren 2002) and those that are overtly managed or unmanaged. For People Express the relevant information is in the case and it is a matter of modelling judgment which of the many listed resources to include. Obvious tangibles are planes, staff and passengers. Intangibles include service reputation and staff morale. The classification into overtly managed and unmanaged resources is quite subtle yet vital because it is often drifting and unmonitored resources (invisible at the operating level, and usually intangible) that are the undoing of an otherwise successful strategy of resource accumulation. Figure 2 provides some clues of what to look for in making this managed-unmanaged classification. For a typical managed resource there is usually a clear desired condition or goal. The apparent condition of the resource is readily measurable. As a result the gap that drives corrective action is objective and the managerial feedback control process is purposive and goal-directed. A simple and familiar example would be a production policy that manages factory inventory to a strict goal. If all resources in a firm were managed with such ideal clarity (and if all underlying goals were not only clear but also internally consistent) then an effective resource strategy should emerge. However, in many cases key resources are inadequately managed, or not managed at all. There are many small hints and clues to isolating unmanaged resources in practical situations. Often the resources are intangible or soft, so that it is difficult to discern the apparent resource condition. The desired condition or goal may itself not be clear or appropriate. The resource in

development may be invisible. In the case of People Express unmanaged resources include

potential passengers, service reputation and staff motivation.

A rough classification of resources leads next to a study of dominant logic. This phase of

modelling work (spanning conceptual aspects of formulation) reveals the managerial rationale

for the firm's continuing resource accumulation strategy. Let's start with the tangible resources at

People Express. What is the dominant logic of fleet expansion? Such strategic investment could

be governed by funding, market share goals, return criteria, demand forecasts, or staffing

constraints. The dominant logic at People Express however appears to be (reading between the

lines of the case and video) CEO Don Burr's ambitious personal growth target, stemming from

his vision of industry revolution embodied in the precepts of the company. Clearly such logic is

both powerful and persistent. The imposition of Burr's dominant logic leads to reinforcing

feedback in the resource stock of planes; growth is desirable.

The dominant logic of staff expansion is quite different. From the case one gathers the

impression of a Human Resource VP insistent on high-quality recruits, carefully selected by the

top management team and trained on the job. The imposition of this dominant logic leads to

reinforcing feedback in which the resource stock of experienced staff is the principal determinant

of hiring.

The dominant logic of passenger growth is also noteworthy at People Express.

Customers are a vital resource stock for all companies. Some companies explicitly manage

customers by setting sales targets, tracking customers in huge databases, and implementing

marketing programs to eliminate any gaps relative to goal. Other companies do not actively

manage the customer base, but instead allow it to evolve from advertising, word-of-mouth and

churn. People Express seems to have adopted an ambitious but essentially unmanaged approach

to growth of customers. Deep price discounts coupled with targeted advertising unleashed a powerful word-of mouth effect that caused a very rapid build-up of potential passengers (those fliers willing to try People Express should the opportunity arise). The imposition of this dominant logic embodies reinforcing feedback characteristic of word-of-mouth.

The resulting tangible resource system contains three reinforcing feedback loops, each a compelling engine of growth, but each operating independently to produce autonomous expansion of planes, staff and passengers. Partial model simulations reveal the power of these growth engines to underpin the kind of spectacular growth achieved by People Express in reality.

The third step of a dynamic resource-based analysis looks to the behaviour of the intangibles (service reputation and motivation) to explain the demise of People Express and more importantly the invisibility of the company's mounting resource problems. From the case it appears that neither service reputation nor staff motivation is overtly managed. This observation is no surprise when one considers that almost all the requirements for active resource management (in Figure 2) are absent. Operating goals are not clearly defined and the apparent condition of the resource stocks is unknown. It is difficult to read the mind of the customer and measure service reputation, or register the emotions of staff to discern motivation. So reputation and motivation just evolve from operating conditions. Motivation responds to a range of dynamic factors such as company growth rate, share price and profitability which in turn influence staff productivity. Reputation responds with a time lag to the balance of flying passengers and service capacity, while service capacity itself is a complex dynamic mix of the number and blend of experienced and newly-hired staff as well as staff productivity.

When the three positive feedback loops driving growth in the firm's tangible resources are out of step (and it would only be an accident if they were exactly coordinated, since their

dominant logic is so different), then problems begin to accumulate in the intangibles. No management action is taken to fix these problems because: 1. the unmanaged intangibles provide only weak signals to the rest of the organization of latent growth stresses; and 2. the powerful dominant logic governing tangibles is insensitive to such weak signals. In fact, the case and video suggest that Don Burr's overall dominant logic for firm success was that any employee motivation or customer service reputation problems were best remedied through further growth.

INSERT FIGURE 2 HERE

A simulation of People Express' growth strategy reveals the mounting strategic problem. As Figure 3 shows, service reputation declines steadily for six years between 1980 and 1986 when the airline was growing rapidly. The apparent recovery of reputation in the last two years results from an unintended abundance of staff as disillusioned passengers switch to competing airlines. Motivation, though invisible and beyond direct management, remains both steady and high for the first six years, underpinning People's competitive cost advantage. But as the customer base saturates and then collapses, the excitement and profit-lure of a fast-growth enterprise evaporates. Employees are demoralized. Planes fly half-empty. The company dies with a configuration of resources both tangible and intangible that is markedly inferior to its major competitors. There is no commercially viable route of recovery from this resource trap.

INSERT FIGURE 3 HERE

The Promise and Challenges Raised by the People Express Example

We have sketched a dynamic resource-based view of the rise and fall of People Express combining system dynamics and two influential sets of ideas from the strategy field: 1. resource accumulation as a way of understanding firms' resource endowments and enduring differences in

firms' strategy and performance; and 2. dominant logic guiding firm-specific decision-making as a way of understanding resource management and firm performance. System dynamics is a natural way to unite these ideas. Stocks and flows portray resource accumulation, while information feedback and policies embody dominant logic and decision-making processes. The stock/flow and policy framework provides a versatile means of visualizing firms' resource systems and formal strategic simulation models enable us to reliably analyse the dynamic consequences arising from the underlying resource management policies.

However, there is still some way to go in bridging the gap between this dynamic resource-based view and the mainstream RBV strategy literature. RBV strategy work typically focuses on endowments of critical productive assets or resources to explain superior equilibrium performance relative to rivals and has adopted a static optimizing view of resource development (Barney 1991). This classic or 'high-church' RBV builds on microeconomics with its characterisation of objectively rational economic man and efficient equilibria (Levinthal 1995). In contrast, system dynamics builds on information feedback theory and behavioural decision making with its characterisation of boundedly-rational administrative man and inefficient disequilibria. Connecting strategy-related system dynamics work to the mainstream strategy literature is a big step forward, but there are several additional challenges and hurdles remaining before work at the intersection of system dynamics and strategy penetrates the strategy mainstream.

A number of these challenges for building compelling behavioural theories of strategic dynamics are raised by the People Express example. One important challenge is associated with the data and evidence needed to support the model assumptions. For example, what quantitative and qualitative longitudinal data is available for Employee Morale, Service Reputation, and the

Impact of Service Reputation on Bookings? We must take care to present the evidence supporting our model assumptions so that other scholars can judge for themselves the soundness of the assumptions. Data is also crucially needed to support and justify policy and decision making assumptions in the model. This brings us to the second challenge raised by the People Express example regarding the theoretical and empirical foundations necessary for building compelling behavioural models of strategy phenomena.

System dynamics policy formulations incorporate a number of crucial assumptions regarding the information cues managers use in making decisions, the functional form of the relationships between those cues, and specific parameter weights for each cue. For the People Express case, how do we know managers in the firm were not actually following alternative policies to guide decision making? More broadly, what theory guides our assumptions about how firms make decisions under uncertainty in imperfect markets? How do the decision making processes of individuals – such as People Express's CEO Don Burr – scale-up, relate to and differ from organizational-level decision making? In short, there is some way to go in developing and testing theory to identify the systematic features of decision making that will provide clear guidance about the assumptions that will replace perfect rationality in mainstream strategy models.

Another challenge is related to the role of competitors' strategies and policies in driving performance outcomes. The policies and decisions of rivals may be a crucial part of the feedback structure of behavioural models of firm and industry dynamics. The combined decisions of all competitors in the market shape the context or environment firms must operate in and therefore necessarily impact performance distributions and outcomes. In the People Express case study, there is a detailed discussion about the competitive moves by incumbent airlines in

response to People Express's success in the market (Holland and Beer 1990). Specific examples include introduction of yield management systems for pricing, launching point-to-point subsidiary airlines to compete on People Express's routes at discount fares, and negative marketing campaigns aimed at discrediting People Express. How important were these competitive responses to the decline of People Express versus the internal policy coordination issues discussed above? What impact did different competitors have on People Express's performance and how many different 'types' of competitors should be captured in the behavioural model? These are questions about the boundaries and appropriate level of aggregation for behavioural models of strategic dynamics. Also, what data and evidence are available to support the assumptions about competitors' behavioural policies? All of the challenges mentioned above regarding behavioural decision policies for the focal firm also apply for competitors. Finally, strategy scholars are very interested in the distribution of performance outcomes across all competitors in the market. Can behavioural theories of firm and industry dynamics contribute to understanding heterogeneity among competing firms?

A final challenge identified using the People Express example deals with the generalizability of the internal policy coordination problems of growth and underinvestment. How many firms fall into the growth and underinvestment trap? Does this problem afflict only small and medium-sized enterprises or do large multibusiness and multinational firms also fall prey to growth and underinvestment internal policy coordination problems? Does this problem occur with equal frequency across different modes of firm growth such as internal/organic growth, mergers and acquisitions, and joint ventures? Much more data and evidence are needed to establish just how widespread this 'generic structure' or 'archetype' really is. Also, what

normative prescriptions would emerge from a behavioural theory of firm and industry dynamics to avoid the growth and underinvestment trap?

In the next section we explore several ongoing areas of research at the intersection of strategy and system dynamics that have the potential to make important contributions towards addressing these challenges. Although research is clearly needed on many fronts, we believe these research areas have the potential to make important contributions to the ambitious objective of building more compelling behavioural theories of strategic dynamics[3].

Towards Stronger Behavioural Theories of Strategic Dynamics

In order to understand heterogeneity in business strategies, strategy researchers have become increasingly interested in industry and firm dynamics and behavioural decision making processes. To be compelling, underlying differences in behavioural decision rules must be conceptually clear, measurable, and the theories about them falsifiable. To be tied to strategy outcomes, these behavioural decision making rules must be embedded in models that show how they produce observable aggregate dynamic behaviours and a distribution of firm outcomes.

Representing managers and firms as rational, optimizing agents is very powerful because it specifies the set of assumptions for constructing economic, sociological, and strategy theories. These parsimonious theories provide the foundations for countless empirical studies that have been accumulating for decades. A compelling behavioural theory of strategic dynamics will necessarily relax many of these constraints. At the same time, such a theory must also provide

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[3] Our aim is not to provide an overall review of the wealth of strategy-related system dynamics work over the last five decades. Instead, we focus on a handful of current lines of research that go some way towards addressing the challenges just discussed and that we believe have high potential for contributing to developing compelling behavioural theories of strategic dynamics going forward.

clear guidance about the assumptions that will replace optimising behaviour and equilibrium, and ideally constrain these assumptions to a finite set.

Efforts on numerous fronts are required to build a compelling behavioural theory of strategic dynamics. In the following sections we discuss four specific research areas where concrete progress is being made. These contemporary research areas include: 1) experimental work investigating cognition, mental models, and decision making processes in dynamic decision environments; 2) empirical studies of organizational policies and routines; 3) examining the impact of competition (i.e. the combined policies and decisions of competing firms in the market) on firm heterogeneity; and 4) research on the internal policy coordination problems of growth and underinvestment in multibusiness firms. We will discuss each of these areas starting with the research at the micro-level of cognition and mental models, working up to the organizational-level, and finally to the level of research on multibusiness firms.

Cognition, Decision Making & Mental Models in Dynamic Decision Environments

Insights about micro-level decision making acquired through experimental work are necessary to help build a stronger foundation for understanding macro level policies and decision making processes at the organizational level. Research in this area builds on extensive findings from previous experimental studies on systematic decision biases (Camerer and Lovallo 1999; Kahneman and Lovallo 1993; Kahneman and Tversky 2000; Kahneman and Tversky 1979; Smith, Suchanek, and Williams 1988; Tversky and Kahneman 1974), misperceptions of feedback in dynamic decision environments (Diehl and Sterman 1995; Moxnes 1998; Paich and Sterman 1993; Sengupta and Abdel-Hamid 1993; Sterman 1989, 1989, 1987; Langley and

Morecroft 2004), and organisational routines (Cohen 1991). Results from previous dynamic decision making research indicate that individuals suffer from systematic misperceptions of feedback that are (at least partly) responsible for poor decision making and performance outcomes in complex decision environments. These studies suggest that dysfunctional macro-organizational behaviour (e.g. poor or puzzling firm performance) can be caused by systematic misperceptions of feedback at the micro-individual level. Two examples of recent work contributing to our understanding in this area include experimental studies focusing on measuring and improving mental models and decision making. These examples are discussed below.

Building on the research in dynamic decision making, recent experimental work at the intersection of system dynamics and strategy examines mental models, decision making and performance in complex decision environments (Gary and Wood 2007; Gary, Dosi, and Lovallo *Forthcoming*). The findings indicate that there is significant variance in the mental models decision makers develop about the causal relationships in a complex managerial simulation, and that mental model accuracy is a significant predictor of performance (Gary and Wood 2007). These results provide empirical evidence that different management strategies can originate from different mental models and that such differences can drive performance differences.

Overall, the results also show that estimated information weights for participants' decision rules ensured poor performance. The analysis indicated decision rules form quickly, with little subsequent improvement. This suggests participants prematurely automate their decision rules; a result that is consistent with the research findings that novices typically automate action and decision rules prematurely in novel, complex problem solving domains (Ericsson, Krampe, and Tesch-Romer 1993). The results also demonstrate that providing

information about the causal feedback structure of the simulation task significantly increases mental model accuracy (Gary and Wood 2007). However, the beneficial effects of providing such causal structure information leave enormous scope for continued improvement relative to potential.

A related line of research examines the reasoning process guiding decision making in dynamic decision tasks. The potential to transfer insights from commonly recurring generic structures has long been a topic of much discussion in system dynamics (Senge 1990; Paich 1985; Forrester 1992). Recently, strategy scholars have started exploring the closely related issue of analogical reasoning. Emerging strategy research indicates that managers often use analogical reasoning to make strategic choices, but are typically not aware they are reasoning by analogy and are undisciplined in the application of analogies (Gavetti and Rivkin 2005). Unfortunately, prior research in cognitive psychology and dynamic decision making suggests that people typically have great difficulty in transferring knowledge from one problem to another, even when the structures underlying the target and the source problems are very similar (Gick and Holyoak 1983; Markman and Gentner 1993; Bakken, Gould, and Kim 1992).

However, research on the acquisition of expertise indicates that experts in a particular problem domain are able to recognize and combine deep structural information common to analogous problems and apply insights and solutions across classes of problems. Developing rich mental models of the feedback structure for commonly recurring management problems could facilitate disciplined analogical reasoning and may help senior managers overcome misperceptions of feedback and other decision biases that undermine decision making (Gary, Dosi, and Lovallo *Forthcoming*). A number of high-level, simplified causal models of common management problems and challenges already exist. This includes launching a new product

(Paich and Sterman 1993; Nord 1963; Bass 1969), project management (Abdel-Hamid 1989; Cooper 1980; Rodrigues and Williams 1998; Roberts 1978; Ford and Sterman 1998), inventory management in supply chains (Machuca and Pozo Barajas 1997; Sterman 1984), managing commodity production cycles (Meadows 1970), and others.

These two examples of experimental research on mental models and decision making demonstrate how work in the laboratory help map out the micro foundations of strategic decision making. To build compelling behavioural theories of strategic dynamics further research is needed to document the systematic shortcomings of mental models. Research is also needed to identify the range of decision rules people adopt and investigate why decision makers incorporate some information cues into their decision rules and exclude others. There are also opportunities for further research examining the formation and premature automation of decision rules. To address the normative objectives of strategy and system dynamics, research is also needed to refine and test the efficacy of a range of different interventions targeted at improving mental models and decision making in dynamically complex environments.

Empirical Studies of Organisational Decision Policies & Routines

Another research front that is needed to build compelling behavioural theories of strategic dynamics includes gathering empirical data from the field on organisational decision policies and routines. This includes rigorous, in-depth case studies, primary data collected through questionnaires, and making use of existing secondary databases. This data from the field is needed to cross validate and complement the systematic features of decision making identified

through experimental work in the lab. This section discusses recent research making advances in gathering empirical field data on organisational decision making using bootstrapping.

Bootstrapping involves estimating decision rules from datasets capturing past decisions and the information available to managers at the time. There is a long tradition of estimating decision rules (Bowman 1963; Dawes 1979; Dawes and Corrigan 1974; Huber 1975) with prominent use both outside of the system dynamics community (Camerer 1981) to try to improve decision making directly and within system dynamics trying to understand decision making (Sterman 1989; Sterman 1988).

Most of the bootstrapping research within the system dynamics community involves estimating decision rules from experimental data or a very limited number of cases (Hall 1976). Bootstrapping, however, has promise for highlighting the generality of case-based modelling efforts. For example, recent research examines how much variance in the performance of magazines can be explained using Hall's (1967) model (Rockart and Mitchell 2007). The process has involved extensive work to assemble longitudinal data on a sample panel of magazines. The panel data is being used to estimate decision rules at the various magazines that can then be inserted back into the model. Ultimately, the goal is to see whether or not changes in model behaviour due to different decision rules closely mimic differences in the performance of the actual magazines. In the system dynamics literature this involves performing the vastly underutilized 'family member test' (Forrester and Senge 1980). More importantly, tests of this kind build a natural bridge to compelling accounts of the generality of our findings particularly to others in the strategy field who do little modelling of theories but extensive empirical testing.

Examining the Impact of Competitors' Strategies & Policies on Firm Heterogeneity

Another research front that is needed to build compelling behavioural theories of strategic dynamics includes examining the impact of competitors' strategies and policies on firm heterogeneity. Research within the system dynamics tradition has typically focused on behaviour largely generated within the organization (Forrester 1961; Hall 1976; Oliva and Sterman 2001; Sterman, Reppenning, and Kofman 1997) or by groups of largely homogenous firms who create cycles or industry overshoot and collapse (Meadows 1970). Practitioner work has broadened this focus to evaluate competition among dissimilar firms and the behaviour of entire ecosystems of organizations, institutions, and individual actors (Barabba et al. 2002).

Overall, there has been far too little effort to identify and document general insights into settings where heterogeneous actors compete with one another. For those who define strategy as understanding heterogeneity among populations of firms, conflict, irreversible commitments, or positioning within industries, the flow of these latter kinds of studies will determine whether system dynamics is recognized in the academic community as contributing to strategy. More importantly, these kinds of studies are an underexploited way for system dynamics to contribute in meaningful ways to an understanding of strategy. Some ways to move forward are offered next in the form of examples of recent research at the intersection of system dynamics and strategy.

In a recent paper, a multi-firm model was developed to explore heterogeneity in performance and practices among competing firms (Rockart 2007). Reinforcing feedback effects for social learning were found to underpin stable differences among competing firms' capabilities. The results suggest the typical normative advice regarding learning curves–to set prices low and get big fast–does not apply to quality driven social learning processes. Unlike quantity-driven learning, social learning implies that firms cannot develop or maintain capability

advantages through aggressive pricing and must carefully restrict market share. The contrast between the implications of quantity and quality-driven reinforcing feedback processes highlights the importance of considering context when analyzing reinforcing feedback processes. These results emerged from comparisons between firms and required a multi-firm model.

Another related line of recent research adopts a resource mapping approach to understand the different mental models of managers in competing firms and the evolving competitive position of rival firms (Kunc and Morecroft 2005). Resource mapping is essentially a qualitative approach for extracting managers' conceptual representation of the firm and likely performance consequences using a resource-based view and concepts from system dynamics. This work recognizes that managers in rival firms may have quite different views of the resources needed to compete successfully in an industry. Each manager has a blueprint in his or her mind of the system of asset stocks that drives performance and dynamic behaviour of the firm over time. Traditionally the study of top management mental models and their effects on strategic decision-making have been carried out through cognitive maps (for a review see Eden and Spender 1998; Hodgkinson, Maule, and Bown 2004; Huff 1990), and the resource mapping approach builds on this tradition.

As a practical illustration, a resource mapping study was conducted using publicly available information about the strategy of rival radio broadcasting firms, interpreted by an experienced modeller. The data included Chief Executive Officer's (CEO) comments from annual statements, for 1998-2000, of two leading firms in the UK commercial radio broadcasting industry: GWR plc and Scottish Radio Holdings plc. The study focused on identifying the list of resources that CEOs (top management) mentioned in describing their strategy and then sketching the likely network of resources these leaders had in mind. Scottish Radio Holdings plc (hereafter

SRH) sees the radio business as part of a multimedia strategy (see resources inside the red circle presented in Figure 4). Therefore, SRH owned radio stations and also newspapers, and oriented both media to the interests and general informational requirements of Scottish communities. On the other hand, GWR plc viewed commercial radio broadcasting as its core competence. GWR plc management leveraged the 'Classic fM' brand to classic music listeners located not only in UK but also around the world (arrow 3 in Figure 4).

INSERT FIGURE 4 HERE

The resulting resource maps provide an overview of the interrelated resource building activities believed by GWR and SRH management teams to underpin their competitive strategy as synthesized from annual reports. This line of research complements measurements of mental models in lab studies and empirical work examining organisational decision policies and routines.

Another line of recent research explores how firms and industries co-evolve in embedded feedback processes (Levinthal and Myatt 1994). In an experimental study Kunc and Morecroft (2007) used the well-known Fish Banks gaming simulator as a practical example of rivalry among firms in the same industry. While the 'tragedy of the commons' depletion of fishing stocks is a typical result of the game, the findings showed that some fisheries perform much better than others and that some teams achieve sustained positive performance over the lifetime of the fishery while others fail dramatically. Each team's performance results were a function of not only their own decisions but also other teams' decisions. The authors observed that different decision making styles across teams and also differences in the type of decision rule selected combined to generate a wide range of performance outcomes. For example, a highly aggressive team was successful in fisheries where most other teams sold their fleets, but was very

unsuccessful when other teams followed the same strategy. The results demonstrate that the effectiveness of any given strategy depends on the strategies adopted by competitors in the market, and it is therefore important to model the heterogeneity of rival firms. This message is reinforced by the results of recent research on the efficacy of different strategies in the context of new product launch in a duopolistic market (Sterman et al. 2007).

Future research at the intersection of system dynamics and strategy will need to include richer theorizing about competitive interactions. Multi-firm models may be required to address many of the issue central to mainstream strategy.

Internal Policy Coordination Problems of Growth and Underinvestment in Multibusiness Firms

The final high potential research area to be discussed takes a step to further generalize the growth and underinvestment trap highlighted in system dynamics models of market growth as influenced by capital investment and the rise and fall of People Express (Forrester 1968; Sterman 1988). Recent research investigates the performance consequences of implementing different corporate growth and diversification strategies (Gary 2005, 2006, 2002). This work builds on and is connected strongly with an enormous body of strategy research on corporate diversification (Bettis 1981; Markides 1995; Rumelt 1982). Behavioural models of the process of implementing a diversification move were constructed through a combination of rigorous case studies and by integrating different strands of existing diversification theory.

In a recent paper, Gary (2005) begins the analysis from the perspective of a single business firm focused entirely on its core business. The Single Business Focus strategy established a benchmark for the value created by remaining a specialist, focused firm. The next

step in the analysis was to explore the implications of diversifying beyond this core business into a related business. The Ideal Related Diversification strategy represented a related diversification move where the firm extracts all of the potential synergy benefits of sharing resources across the core and new businesses without any implementation costs. This established an unattainable standard for an idyllic related diversification.

The No Investment strategy shown in Figure 5, represents a diversification move into a new business exploiting the same potential synergy benefits of the Ideal Related Diversification strategy. Total work demand, shown in the top of Figure 5, increases as the new business grows. Organization slack – shown in the top of Figure 5 – steadily declines as total work demands rise and ultimately exceed the capacity of shared resources. Negative values of slack indicate the firm has a shared resource shortfall compared with the level required for the normal, efficient operations of the firm; shared resources are considerably overstretched.

It takes time for overstretching shared resources to have an impact on performance. Poor decisions or work quality throughout the firm- resulting from overextended managers, scientists, sales staff, engineers, and other factors of production- may take several quarters to impact overall financial performance. The impact of overstretching shared resources on costs, shown in the bottom part of Figure 5, indicates that overstretching costs start rising around the fourth year and continue rising gradually over the rest of the simulation. By the end of the simulation, overstretching burdens the firm with an additional 10% over the ordinary operating costs.

After appearing to create value for the first several years, by the end of the time horizon the related diversification move destroys value compared to the Single Business Focus and Ideal Related Diversification benchmarks. The No Investment strategy demonstrates how a firm can destroy value through poor implementation in a related diversification move even when there are

significant potential synergy benefits. These results are also consistent with the growth and underinvestment trap identified in previous research for single firm business growth. This suggests that the growth and underinvestment trap generalizes to multibusiness firms and sheds light on why corporate diversification efforts fail so often. This result is also supported by the data from two in-depth case studies.

INSERT FIGURE 5 HERE

This work demonstrates that a behavioural theory of diversification can help explain the equivocal empirical results in a central research area of strategy. A current working paper extends and provides an empirical test of this work by combining a grounded process field study and formal simulation modelling to identify how and why specific managerial decision rules were responsible for poor performance outcomes in a related product line acquisition for a firm in the medical devices and equipment industry (Gary 2006). Further research is needed to ground the behavioural assumptions and generalize the decision rules embedded in the model that lead to growth and underinvestment in diversifying firms. This research could involve collecting the necessary longitudinal data for a sample of diversified firms that enable estimation of managerial routines and decision rules through bootstrapping as discussed previsouly. There is also scope for research using lab experiments to see if individual decision makers adopt similar decision rules for implementing diversification strategies. Multi-method approaches help push our knowledge forward when examining complex strategy phenomenon.

Conclusions and Directions for Future Research

There is a tremendous opportunity for research at the intersection of system dynamics and strategy to make progress towards building compelling behavioural theories of strategic

dynamics. The mainstream strategy community is eager for scholarship of this kind, particularly when it can tell us not only why one firm succeeded or failed, but point to how prevalent specific behaviours are and which issues explain most of the variance in firm performance. However, there are a number of challenges and hurdles to overcome if strategy-related system dynamics work is to penetrate the strategy mainstream.

Four of the most important challenges include: 1) collecting and analysing longitudinal data (both quantitative and qualitative) to support and justify crucial model assumptions; 2) integrating multiple organisational and supra-organisational levels of analysis into our models, particularly multi-firm models examining competitive interactions; 3) expanding and further developing an empirically tested theory of human cognition to underpin behavioural assumptions in our models; and 4) identifying the domain limits of applicability for our models as we seek general theories of behaviour instead of special-case theories. This last challenge supports a prior call from Jay Forrester on the utility of models:

> "A model is a theory of the system that the model represents. … If the model is a good representation of an actual situation, then it becomes a theory of how that part of the real world operates. The primary utility of a theory lies in its generality and transferability." (Forrester 1983, pg 6)

These are not the only challenges. Others include keeping our theories (models) simple enough to communicate them widely, connecting our work strongly to the existing strategy literature, and all of the other challenges of selling system dynamics to other social scientists (Repenning 2003). We believe the research areas discussed in the previous section are making a start at addressing some of these challenges and have high potential to make significant contributions to building compelling behavioural theories of strategic dynamics. These are only a handful of current examples; there are many more.

There is also a lot to learn from existing work in strategy and other related disciplines.

Figure 6 illustrates the position of some prominent and/or rising strategy theories and modelling

approaches mapped onto the landscape defined by the type of decision making assumptions on

one axis (behavioural through to perfectly rational) and the primary form of analysis (static

cross-sectional through to dynamic longitudinal). As shown in Figure 6, we have a close kinship

to the evolutionary economics stream of research characterized by the state-space modelling

approaches of Nelson and Winter (1982), the behavioural theory of the firm organizational level

research and state-space models of Cyert, Feigenbaum, and March (1959), the NK model

introduced in to management research by Levinthal (1997) and many others. We also have much

to learn from the methods, advances, and history of disciplines that have traditionally not been

receptive to the methods and perspectives of system dynamics.[4]

INSERT FIGURE 6 HERE

Future work at the intersection of system dynamics and strategy has the opportunity to

make big contributions to mainstream strategy. To capitalise on this opportunity, future research

should make richer use of evidence (data) in supporting model assumptions and testing internal

and external validity, help develop an extensive and empirically tested theory of managerial

decision making to build a stronger foundation for understanding macro level business policies

and strategy, incorporate more careful theorising about competitive interactions to explore

central strategy issues about heterogeneity among rival firms, and seek to extend existing

behavioural models to general theories of strategic dynamics. Research addressing these

challenges has the potential to build compelling behavioural theories of strategic dynamics that

will penetrate the strategy mainstream. We also very much encourage scholars working at this

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[4] See Akerlof (2007) for a history of the internal debate within the field of macroeconomics that shows great similarities to the modern debate between behavioural and optimizing approaches to modelling.

intersection to continue to develop and build new behavioural theories for areas of strategic

dynamics where we cannot transfer existing models. It may well take another 50 years to fully

realise the potential opportunities discussed in this paper, but we hope progress will be made

much faster. Much has already been accomplished, but much remains to be done.

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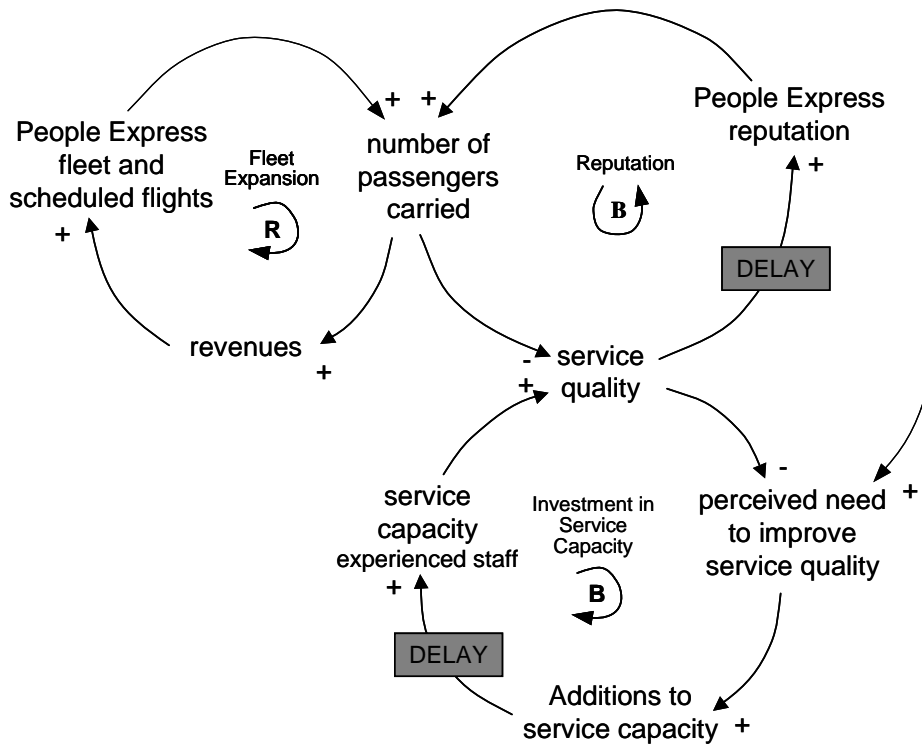
Adapted from Senge *The Fifth Discipline*, Chapter 8

Figure 1: Feedback Loops in Senge's Theory of the Rise and Fall of People Express Airlines
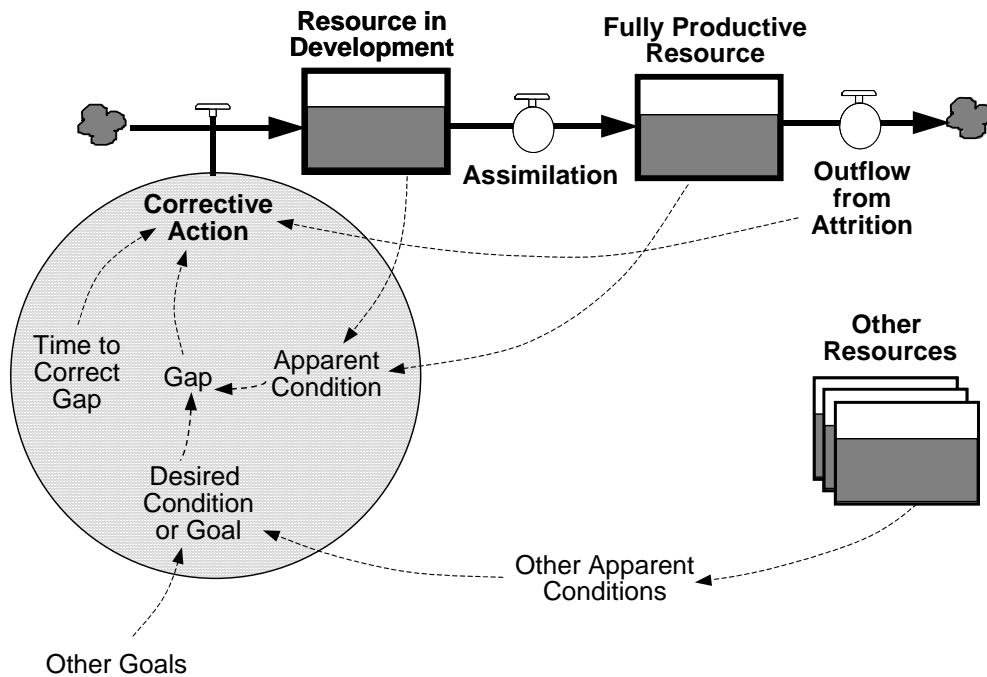

Figure 2: Operating Policy for Resource Management
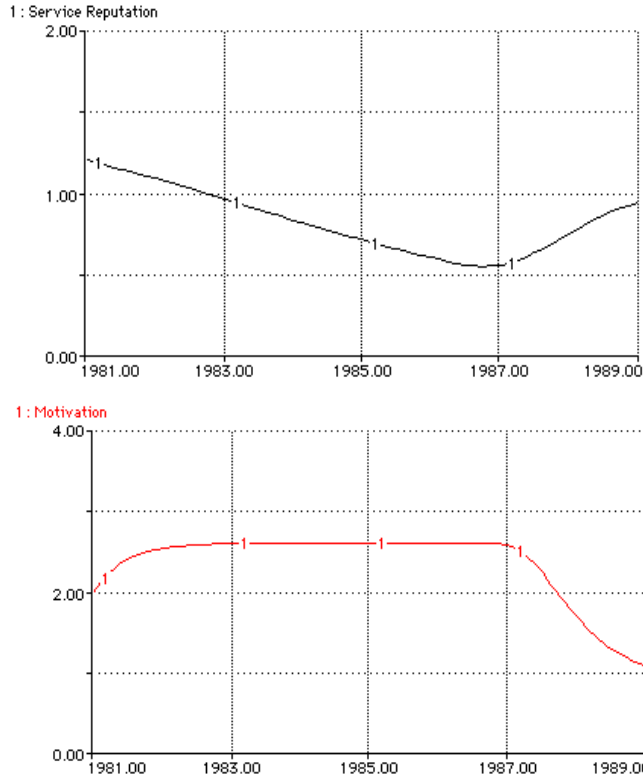
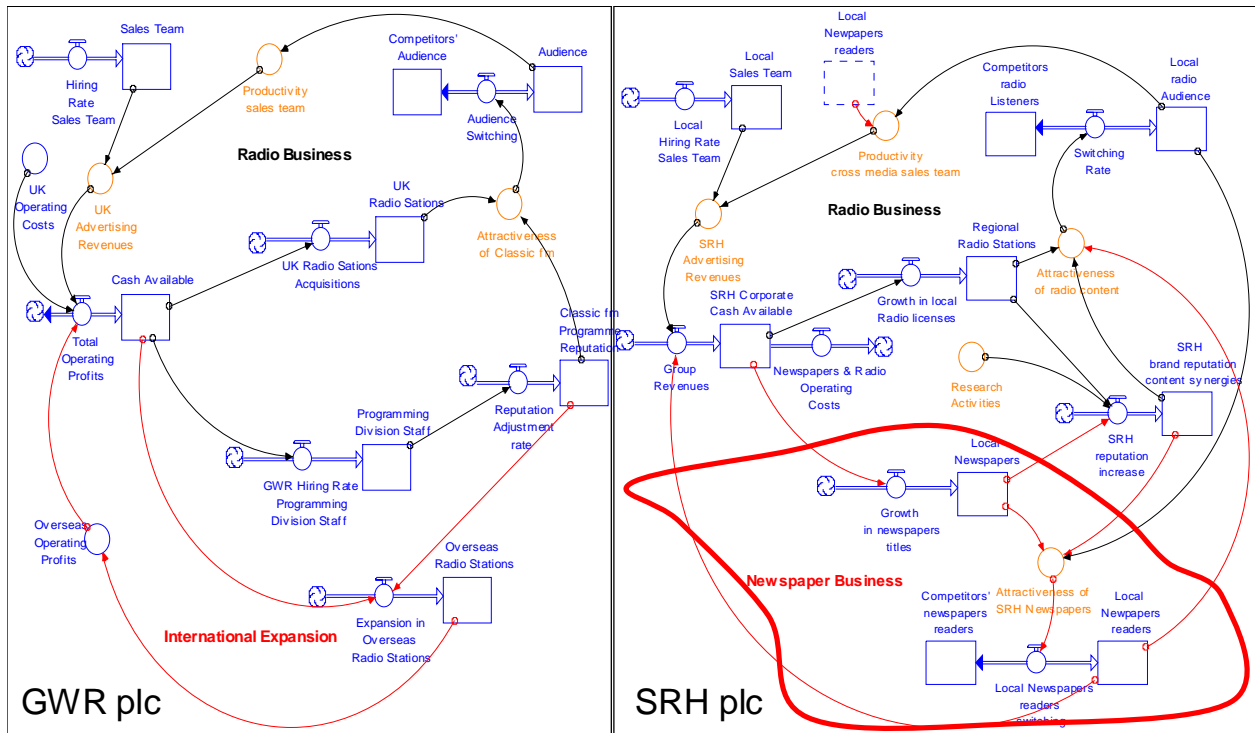Figure 3: Time Charts of Intangible Resources: Service Reputation and Staff Motivation

Figure 4: Comparative Resource Maps between Two Close Competitors in the UK Radio Broadcasting Industry
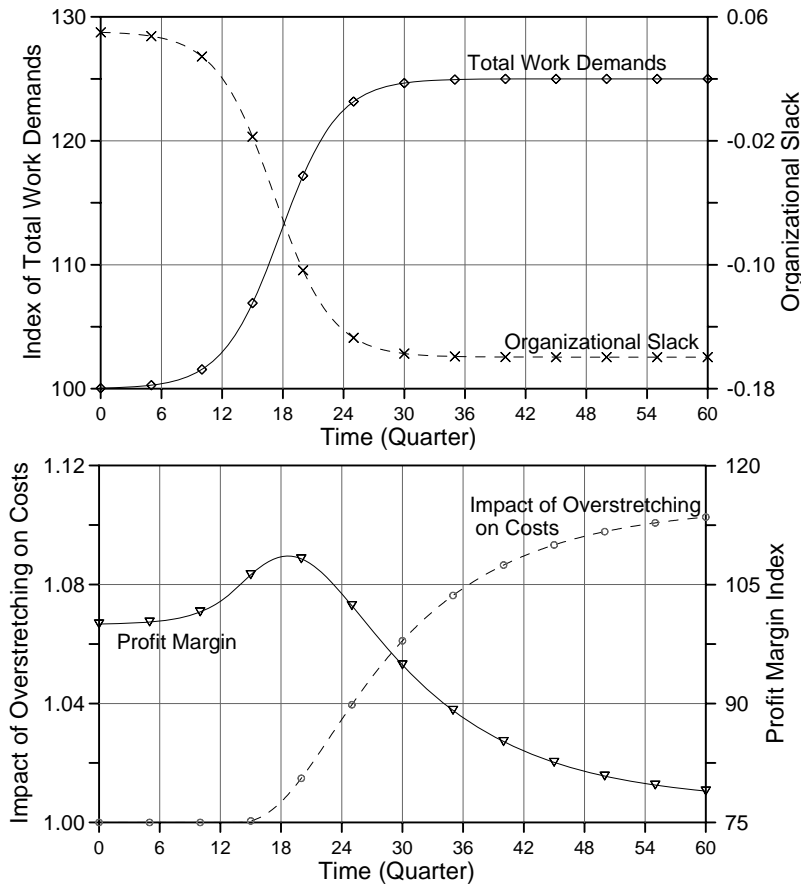
Figure 5 Evolution of Work Demands, Organization Slack, Overstretching Costs (expressed as a multiplier of total operating costs), and Profit Margin for the No Investment Strategy
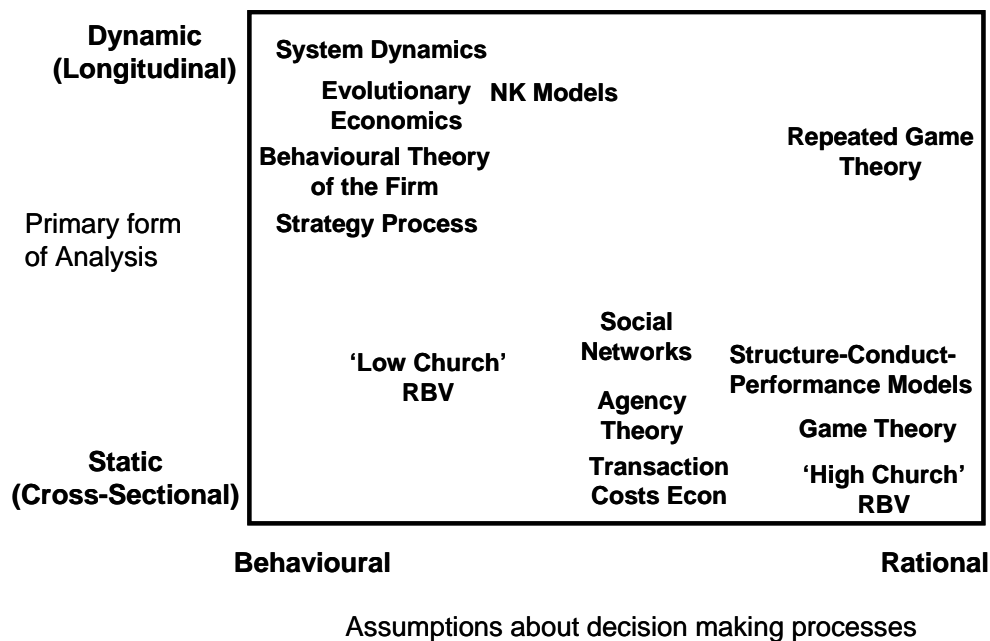

Figure 6 Map of Prominent and/or rising strategy theories and modelling approaches