Resource Management Under Dynamic Complexity[1]

John Morecroft, London Business School

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Abstract

This paper examines resource management policies in dynamically complex systems as a basis for explaining differences in firm performance. A firm is viewed as an interlocking network of resources embedded in closed feedback loops. Resource management is represented in terms of operating policies, goals and feedback loops that control the build-up and retention of strategically important resources. A model is developed of a managerial world that involves a single tangible resource - staff. Even in this apparently simple world there is considerable dynamic complexity due to delays in building staff skills, misperceptions of productivity, and goal conflict. The analysis suggests that different firms handle dynamic complexity by adopting distinctive policies for resource management that reflect the dominant logic of influential policymakers[2]. Simulations show that differences in firm performance then arise from firm-specific patterns of resource accumulation determined by the dominant logic and resulting feedback structure.

The approach is applied to the well-known case of People Express airlines. People Express was a fascinating example of resource building that went wrong. The company grew from obscurity to industry prominence in a period of only five years against powerful rivals. But dramatic growth was followed by even more dramatic demise. The paper briefly outlines a dynamic analysis of the People Express resource system and management processes governing resource accumulation. The first step is to identify the tangible and intangible resources of the fledgling airline, such as planes and service reputation. The second step is to examine the dominant logic of the policies that control the time-evolution of these resources. A combination of partial and whole model simulations then unfolds the dynamic complexity of the resource system and reveals why the firm loses and destroys its competitive advantage. The paper concludes with comments on the contribution of feedback concepts and system dynamics to the resource and competence literature.

Introduction

The traditional resource-based literature seeks to explain superior firm performance and competitive advantage in terms of unique configurations of firm resources that rivals find difficult to imitate (Barney 1991, Foss et al 1995). Firms are viewed as complex bundles of resource endowments. However, a widely recognised limitation of the literature (Mosakowski and McKelvey 1997) is that there is no clear or agreed basis for *selecting* which of a firm's resources are in fact those that contribute most to performance. Part of the difficulty arises from the fact that "pure" resource-based thinking seeks idiosyncrasies solely from the list of static resource endowments. As Conner (1991:145) has observed "at some level, everything in the firm becomes a resource and hence resources lose explanatory power".

This paper proposes that competitive advantage and ultimately superior performance stem not only from the uniqueness and variety of the firm's current resources, but also from how they change over time as a result of management policies applied. This managerial view shifts attention from quasi-static comparison of resource endowments to dynamic analysis of resource accumulation and the dominant logic of policies and feedback processes that control them and drive their evolution over time. Such an approach allows for the discovery of firm idiosyncrasies in approaches to managing the dynamic complexity[3] of a resource *system* rather than in the detail complexity of an exhaustive resource list (thereby overcoming to some extent the implicit tautology in resource-based reasoning often cited by critics[4]).

Dynamic Resource Systems

Resource accumulation is a fundamental part of any dynamic resource system (Warren 1997). The idea of resource accumulation was first introduced into the strategy literature by Dierickx and Cool (1989) along with the bathtub metaphor shown in figure 1. Briefly they are saying that in order to understand competitive advantage one has to recognise the inertia of resource accumulation, or what they call asset stock accumulation. "While flows can be adjusted instantaneously, stocks cannot. It takes a consistent pattern of resource flows to accumulate a desired change in strategic asset stocks".

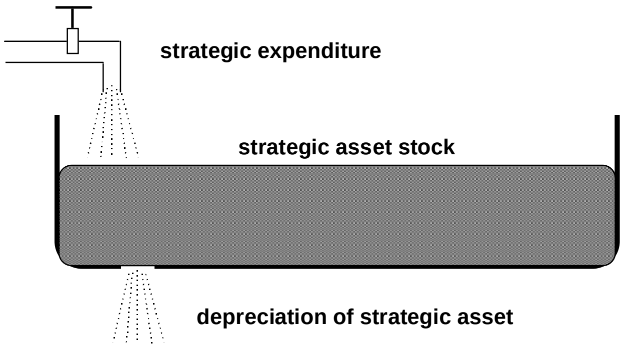

Figure 1: The Bathtub Metaphor, Visualising the Accumulation of Resources

Dierickx and Cool's ideas have been important in the strategy literature because they direct attention away from static endowments of resources toward the dynamics of resource accumulation. However, they have little to say about what determines a firm's pattern of resource flows or how one might gauge whether such a pattern is internally consistent or superior to rivals'. Dierickx and Cool thus explain why performance differences between firms exist, but not why these differences come into existence. Their thinking about flows is framed in terms of strategic expenditures and does not deal directly with the managerial policies and feedback processes that control resource flows by directing those expenditures.

More recently Heene, Sanchez et al (1996 and 1997) have proposed a systems view of the firm as the basis for developing a theory of competence-based management. Their approach characterises the firm as a system of tangible and intangible assets organised under a strategic logic for achieving the firm's goals. Building on Dierickx and Cool they recognise the importance of asset stocks and flows, but they also introduce management processes and strategic logic to control competence leveraging (applying existing assets and capabilities to market opportunities) and competence building (developing entirely new assets and capabilities in response to a changing environment). Their resulting conceptual model shows a hierarchy of system elements for managing firms' assets and capabilities, ranging from higher-order cognitive elements to lower-order operating elements. They use the conceptual model to explore promising new avenues of research in competence-based management including topics such as coordination, governance and managerial cognition.

System dynamics, a special branch of systems theory[5], can be used to study the coordination of dynamic resource systems through modelling and simulation. Figure 2 is an information feedback view of resource management using standard system dynamics notation (Forrester 1961 chapter 10, Morecroft 1994, Sterman 1989). The rectangles in the top half of the diagram represent resource accumulations (similar to the level of water in the bathtub in figure 1). The solid arrows in bold represent resource flows which either increase or decrease the level of a resource (like water flowing in or out of the bathtub). The taps represent the processes that regulate resource flows. The irregular cloud-like shapes represent the source or final destination of the resource flows. Typically the accumulation of a resource happens in (at least) two stages. The resource must first be acquired and then assimilated before it becomes fully productive. Figure 2 distinguishes these two stages in the stock and flow network. Corrective action controls the inflow of a new resource into resource in development. Assimilation controls the rate at which resource in development converts into fully productive resource. Attrition controls the rate at which fully productive resource leaves the organisation through obsolescence, retirement or turnover.

Some practical examples will illustrate the use and versatility of these symbols. Consider a resource such as staff. In this case corrective action means hiring. Assimilation corresponds to training and work experience, and attrition is the loss of staff through turnover or firing. The source and final destination of the staff flows is the external labour market. Fully productive resource corresponds to the number of experienced staff, while resource in development is the number of newly arrived or "rookie" staff.

In the case of capital equipment corrective action means ordering or investment. Assimilation corresponds to the arrival and commissioning of new equipment, and attrition is the withdrawal of equipment through obsolescence or sale. The source of capital equipment is the equipment supplier and the final destination of old and used equipment is the scrap heap or the second-hand market. Fully productive resource corresponds to the capacity of equipment currently in operation, while resource in development is equipment being built.

The large grey circular region of figure 2 shows the operating policy for resource management. Corrective action takes place whenever there is a gap between the apparent condition of the resource and the desired condition or goal sought by management. The apparent condition depends on management's perception of the available resource, which is usually some combination of fully productive resource and resource in development. For example the apparent condition of staff could be a simple measure of headcount (the sum of experienced staff and rookies) or else a more sophisticated measure that recognises the productivity differential between new recruits and more established members of staff. The desired condition may be an absolute or fixed target, but in practice is much more likely to be a function of the apparent condition of the resource in question as well as the condition of resources elsewhere in the firm.

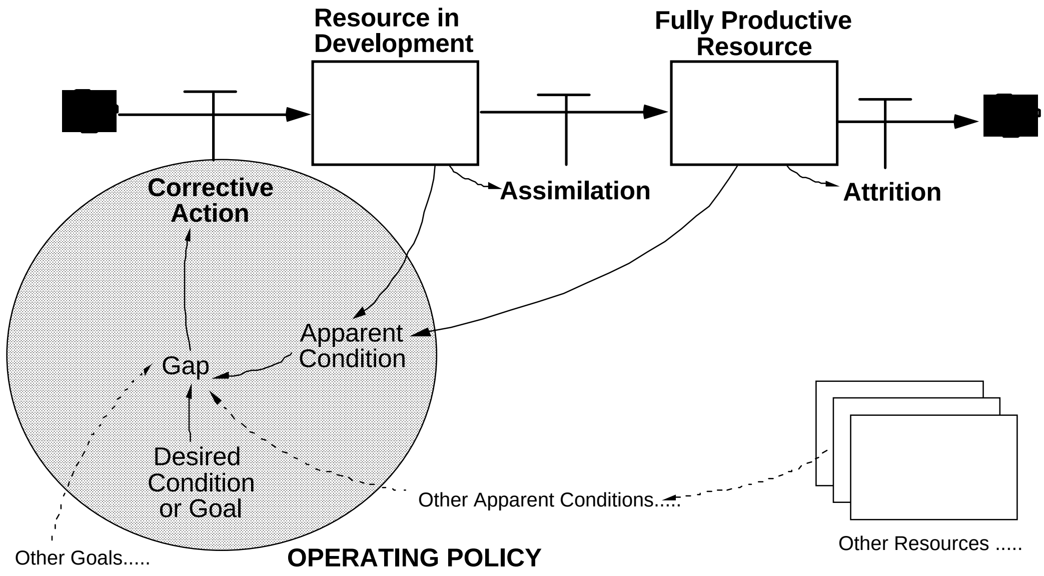

Figure 2: Operating Policy for Resource Management - Goals and Information Feedback

For example, an aggressive capital investment policy for a fast growing mobile phone producer might set an evolving goal for capacity which is 25 percent higher than current capacity. Such a policy continually stretches the organisation to expand regardless of other potential constraints to growth. On the other hand, a more cautious producer in the same industry may set an evolving goal for capacity that depends on the current (or projected) size of the sales force or on expected cash flow.

At the heart of a managed resource system is balancing feedback[6]. A *perceived* shortage of a given resource generates corrective action by management to eliminate the gap. New resource then flows into the organisation leading first to an increase in resource in development and subsequently to an increase in fully productive resource. Management monitors these changes in the resource stock to arrive at a new view on the apparent condition of the resource that forms the basis for further corrective action, thereby closing the balancing feedback loop.

The figure provides a basis for understanding the coordination of a dynamic resource system. A fundamental question is whether or not explicit strategic logic and management processes exist for active resource management within a firm. If so, we can expect the evolution of the resource to be purposive and goal directed. If not, then it is most likely that the resource accumulation is just drifting according to unmanaged pressures arising from the imbalances of resources elsewhere in the system. The components of the firm's operating policy hold useful clues about the likely degree of intent behind the evolution of a given resource. A prerequisite for active resource management is the existence of a clear and communicable goal. Without a goal there can be no corrective action. It is easy to imagine a target for staff arising from output objectives or an annual budget. But how do you formulate a target for an intangible resource such as employee motivation which lacks an agreed metric?

Another essential prerequisite for active resource management is the ability to accurately monitor the current condition of a given resource. Without precise knowledge of available resource it is impossible to take corrective action to adjust the resource toward the goal. This statement may seem obvious, but there are many practical situations where the apparent condition of a resource is difficult to gauge with confidence, even when the resource is countable. A classic case (which is developed below in more depth) is the apparent condition of skilled staff. Which is a more appropriate measure of staff resource - pure headcount, experienced staff or some combination? Different people have different views. The monitoring problem is especially difficult for intangibles. How do you measure employee motivation or quality as perceived by the customer? At best there are only indirect measures available which are subject to bias and distortion. For example, the current quality of a consumer durable rolling off a production line may be a poor guide to quality in the minds of consumers who collectively remember the history of quality over the product's normal lifetime.

Exploring Dynamic Complexity in a Professional Service Organisation - Expansion of Staff with Training Delay and Hidden Coaching Load

In many service organisations such as hospitals, schools, and professional practices (lawyers, doctors, consultants, software developers) staff are the key strategic resource and the management of staff recruitment, retention and development is vital for high performance. Common features of such organisations include high staff costs (often more than 90% of total operating costs); the need for induction, coaching and prolonged on-the-job training; and the difficulty of objectively measuring productivity.

To explore dynamic complexity in such situations we examine an imaginary software organisation employing specialist software staff. A resource map of the system is shown in figure 3[7]. The stock and flow network shows two resource accumulations - experienced software staff and new software staff - together with flows for hiring, induction and turnover. The output of the organisation is measured as lines of code generated per week, and its success is judged in terms of its ability to meet an output target which is arbitrarily set at 6000 lines of code per week. If there is a shortfall in output then additional staff are hired. Normally it takes one month to recruit new staff, and a further three months before they become fully experienced. New staff are assumed to be half as productive as experienced staff. Moreover, they generate a hidden workload for experienced staff. Each new recruit requires on-the-job coaching which (on average) absorbs 50 percent of the time of an experienced member of staff.

Initially there are 50 experienced staff, on average they write 100 lines of good code per person per week, and initially there are no new staff. So the total initial output of the organisation is 5000 lines of code per week (50*100) - a shortfall of 1000 relative

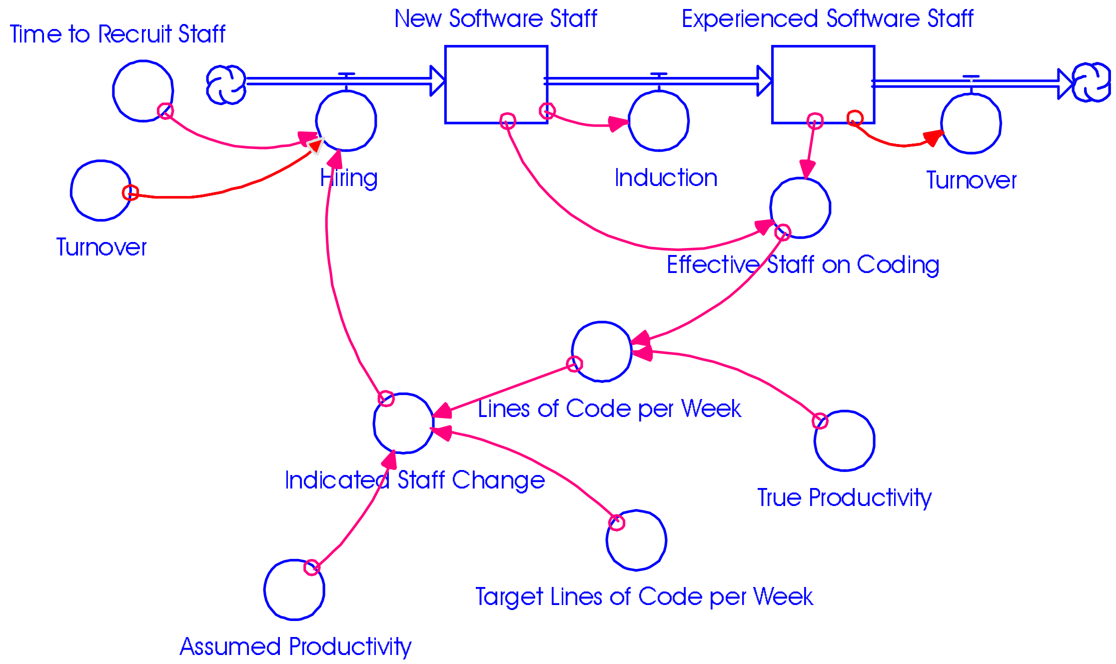

Figure 3: Resource System Map for Software Staff

to target. A simulation model of the resource system allows us to trace how the organisation adjusts output to meet the target through staff expansion. Dynamic complexity arises from the delay in training new staff, the relatively low productivity of new staff and the coaching workload for experienced staff. In this particular case, the coaching workload is set to exactly cancel the extra output of new staff. So the number of effective staff on coding is always equal to experienced software staff no matter how many recruits are in training[8]. Essentially new staff make no net contribution to output until they are fully experienced (after three months of coaching) and are therefore invisible in the hiring process, thereby making the process difficult to manage.

The top half of figure 4 shows simulated performance of the software organisation over a period of 12 months. Target output (line 1) is steady at 6000 lines of code per week. Actual output (line 2) starts below target at 5000 lines of code per week, falls briefly, then overexpands to about 6500 lines of code per week by month 7. After peaking, output gradually falls to just less than target by the end of the simulation. Performance is inversely proportional to the area between lines 1 and 2 (i.e. the cumulated difference between target and actual output), so there is room for improvement by accelerating the expansion of output and reducing the amount of overshoot.

Why is it difficult to achieve the output target? The answer lies in the behaviour of staff shown in the bottom half of figure 4. The initial gap in output leads to a rapid increase in new software staff (line 3) which grows from zero to a peak of around 30

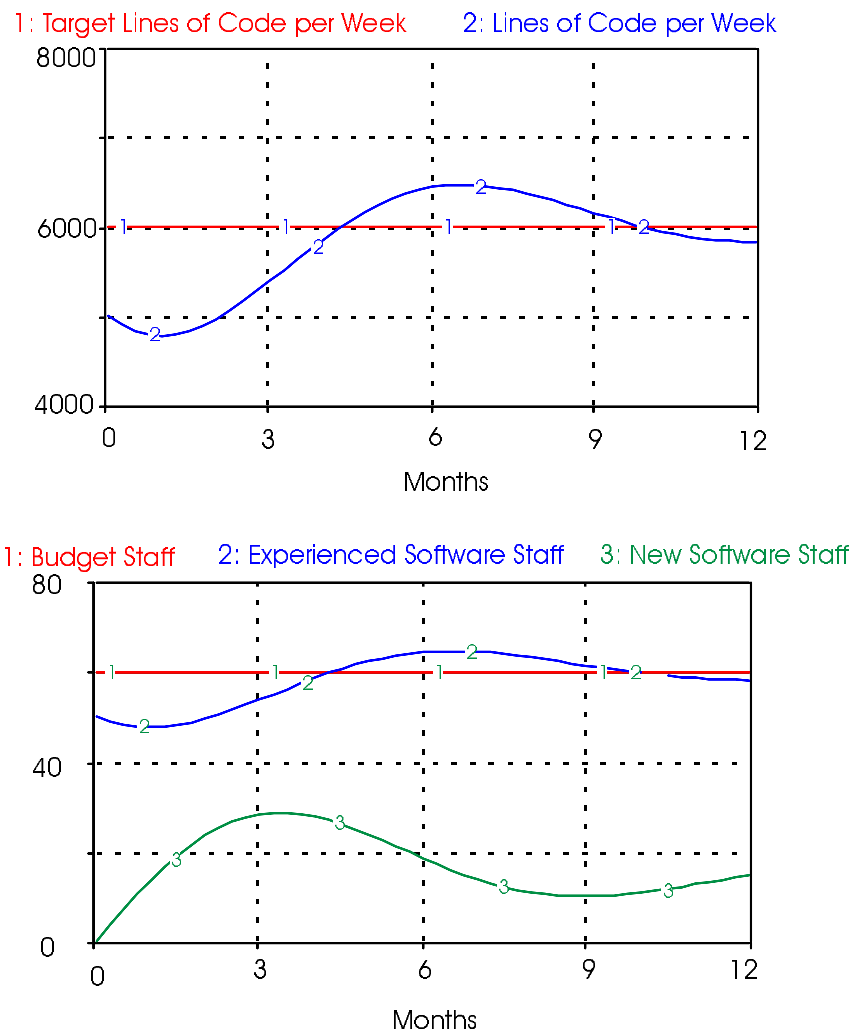

Figure 4: Time Charts of Output and Staff for Software Organisation

by month 3. As new staff complete their training then the number of experienced staff (line 2) begins to rise. By month 4 experienced staff equal budget staff (line 1) which represents the number of staff needed to meet target output at full productivity.

However, in month 4 there are still more than 20 new staff in training. As they complete their induction and become fully productive, the number of experienced staff continues to grow, leading to surplus staff and output above target. Gradually surplus staff are reduced through attrition.

Impact of Operating Policy on Performance - Time Compression Diseconomies

Imagine a competing software organisation that begins with the same endowment of staff resources as above: 50 experienced software staff and zero new staff. The competitor is also aiming for a target output of 6000 lines of code per week. In an effort to be more responsive, the competitor accelerates hiring by cutting the time to recruit new staff from 1 month to 2 weeks. How will this change of hiring policy affect performance?

The top half of figure 5 shows surprisingly that *performance worsens* in the sense that the gap between target and actual output becomes greater. By comparison with figure 4, actual lines of code (line 2) reaches the target (line 1) more quickly - which is a direct and beneficial consequence of accelerated hiring. However, the overshoot of output is much bigger than before. Output reaches a peak of almost 7000 lines of code per week in month 5 and then declines to equal the target once more in month 9. Thereafter there is a noticeable undershoot as output falls below the target.

The bottom half of figure 5 shows the staff dynamics that drive overshoot and undershoot in output. The more responsive hiring policy leads to a faster build-up of new software staff (line 3) which peak at almost 40 just before month 3. But these new recruits still take 3 months to train and continue to absorb the time and attention of more experienced colleagues. The excessive build-up of new staff eventually translates into a large increase of experienced staff (line 2) which reaches a peak in month 5 at a value much greater than the budget staff (line 1), leading to excess output. In this case a seemingly simple and well intentioned change in hiring policy causes a deterioration of performance, even though the new hiring policy seeks the same equilibrium staff resource as the original less responsive policy. The resource dynamics in figure 5 are an example of what Dierickx and Cool refer to as time compression diseconomies. Faster hiring fails to deliver better performance. Simply forcing more recruits into the system more quickly does not solve the basic problem of building experienced staff because time and effort are still required for on-the-job training.

Figure 5: Time Charts of Output and Staff for a Competing Software Organisation that Adopts a More Responsive Hiring Policy

Dominant Logic of Operating Policy

Competing firms with identical starting resources often adopt quite distinctive approaches to building and retaining strategic resources. These distinctive approaches reflect different operating policies that can be the basis of sustained differences in performance and gradual divergence of resource stocks over time. A common example is capital investment policy. Some firms invest only when there is a convincing financial case for doing so as indicated by criteria such as discounted cash flow or rate of return. Other firms take a more visionary approach, investing aggressively because the founders or leaders believe there is potential for (profitable) growth. Honda's investment in the post-war Japanese motorcycle industry is an example of visionary investment. During an early stage of industry growth the company approved capacity expansion equal to ten times total Japanese industry capacity! Honda's dominant logic for capital investment was rooted in the founder's confidence in the future of the motorcycle.

The term dominant logic is adapted from Prahalad and Bettis (1986) in their well-known paper on the link between corporate diversity and performance. Dominant logic describes a distinctive style of managing resources and investments in a multi-business enterprise, reflecting mindsets and attitudes of business leaders shaped by their experience of the firm and industry. Prahalad and Bettis apply the concept to corporate strategy. However, the same idea applies to individual businesses. Rival firms apply distinctive policies to control investment, resource accumulation and retention (Morecroft 1985).

Dominant Logic of Hiring Policy in A Software Organisation

Hiring in figure 3 is dominated by the need to achieve an output target. When output falls below target, hiring corrects the gap. However, a completely different approach is possible if the organisation's hiring policies are constrained by a staff budget and financial control. Figure 6 shows the logic behind budgetary control of staff. Budget staff depends on both target lines of code per week and assumed productivity. The greater the target, the more staff authorised by the budget; whereas the higher productivity, the fewer staff authorised. But productivity is difficult to gauge, especially when the mix of new and experienced staff is changing over time. In reality assumed productivity is just an estimate most likely to be derived from surveys of experienced staff. In the model the estimate is set equal to the true productivity of experienced staff at 100 lines of code per person per week. Budget staff is compared with total staff to arrive at a variance in staff.

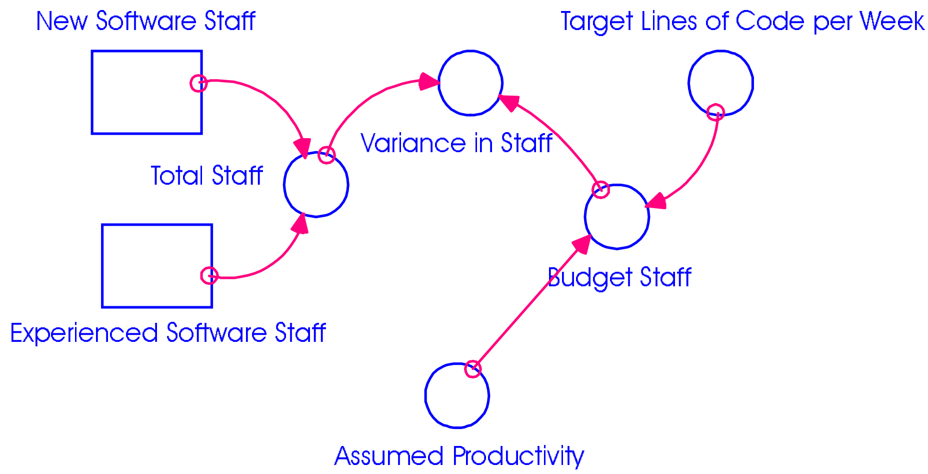

Figure 6: Hiring Policy Dominated by Budgeting and Variance in Staff

The resource system now contains two different measures of staff imbalance. The original measure in figure 3 is the indicated staff change which depends on the gap in output relative to target. The new measure is variance in staff. Either of these measures is a legitimate basis for hiring. The choice in practice reflects the underlying logic of the hiring policy. If budgetary logic dominates, then hiring responds to variance in staff. If not, hiring responds to output.

Figure 7 is a simulation of a software organisation where a budgetary logic determines hiring. The dynamics of the resource system are radically altered by comparison with figures 4 and 5. In the top half of the figure, output (line 2) settles at a value that is permanently lower than target (line 1). The organisation never achieves its output target.

The lower half of the figure shows why. Budget staff (line 1) imposes a rigid ceiling of 60 on the total number of staff that can be employed. In principle this ceiling should be adequate because 60 staff working at full productivity (100 lines of code per person per week) can generate 6000 lines of code per week - exactly equal to the output target. But the budget overestimates productivity by failing to take account of productivity dilution from new recruits. The result is that the organisation reaches its budget headcount of 60 staff, yet fewer than 50 are experienced. The rest are new staff who make no net contribution to output. Output therefore settles at a value lower than target. The organisation experiences goal conflict. The budgetary goal is met at the expense of the output target.

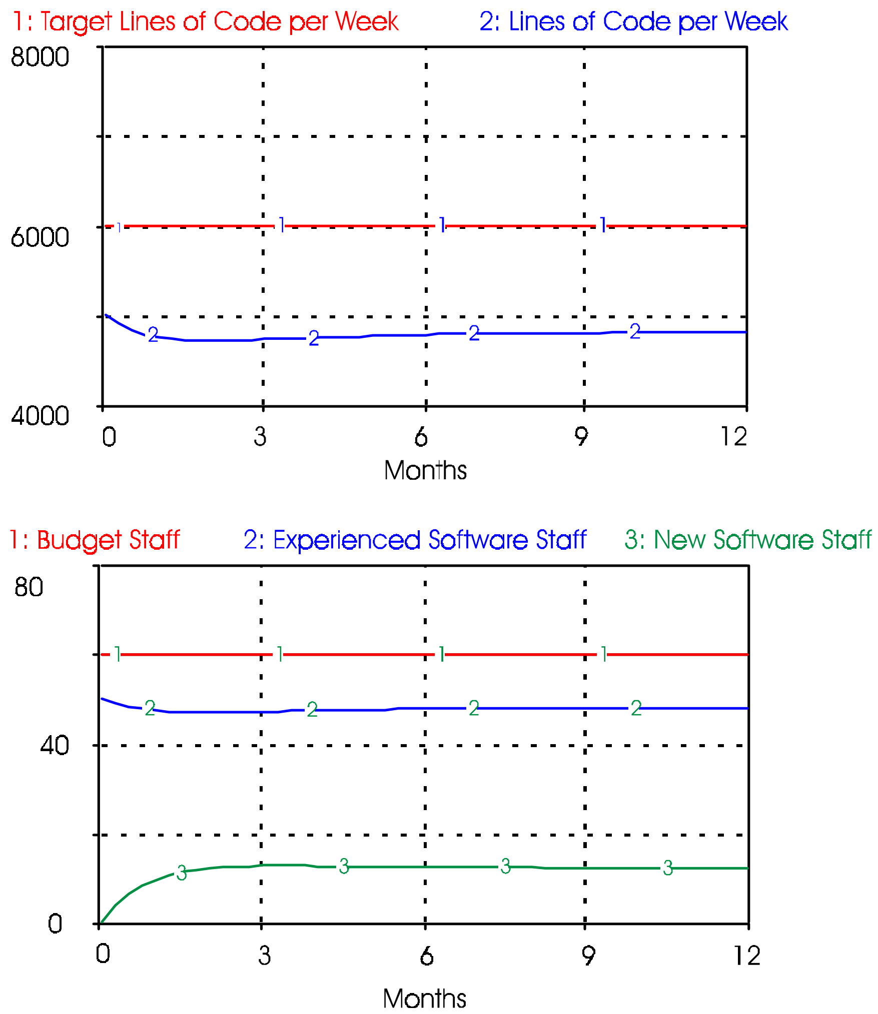

Figure 7: Time Charts of Output and Staff for a Software Organisation with a Dominant Budgetary Logic for Hiring

Imagine trying to explain the relative shortage of experienced staff shown in figure 7 in terms of static resource endowments. A typical explanation would seek imperfections in the labour market or else a deficient firm-level resource, difficult to replicate, but essential to attract and retain staff (an intangible such as reputation for software innovation). By contrast, a dynamic resource system view finds a reason for staff shortage in the policy controlling staff hiring. Critics might argue that the budgetary logic for hiring itself is flawed because it overestimates productivity. However, such bias can easily arise from the use of tangible static measures of productivity rather than more elusive dynamic measures of productivity that factor in the dilution effect of new staff.

To illustrate this point about productivity bias, figure 8 shows another simulation of a “flexible” budgetary logic in which assumed productivity is reduced by 20 percent from 100 lines of code per person per week to only 80. With a more generous staff budget it is possible to achieve the output target. In the top half of the figure actual output (line 2) approaches target with no tendency for overshoot. In this case budgetary discipline keeps tight control over new staff, preventing overhiring without compromising the output target. This discipline shows up in the lower half of figure 8. New software staff (line 3) grow quickly to a peak of 20 people in month 2. The budget then puts a

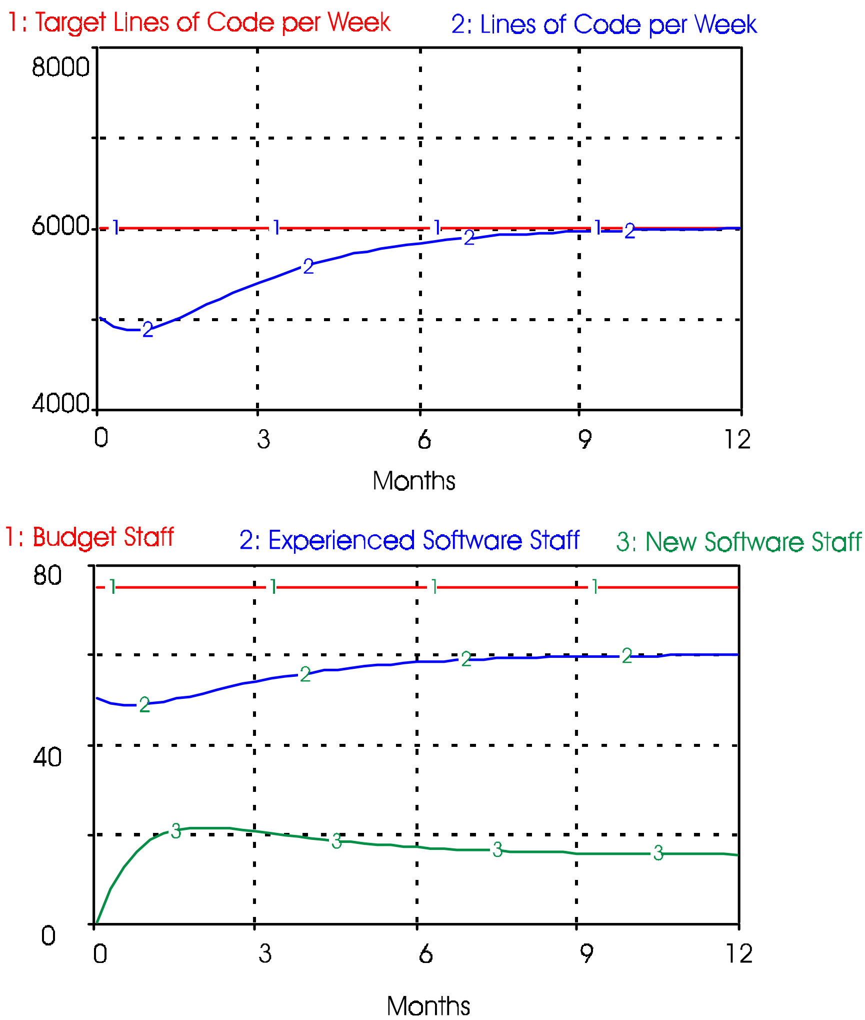

Figure 8: Time Charts of Output and Staff for a Software Organisation with Flexible Budgetary Logic for Hiring

limit on further expansion. After a training delay new staff become fully productive. Experienced staff (line 2) rise gradually to reach 60 people which is just sufficient to satisfy the output target. If such flexibility in hiring can be introduced, then it is possible for the firm to achieve the output target.

Clearly a flexible budgetary logic for controlling hiring is an improvement. It eliminates goal conflict and allows the organisation to achieve the output target within budget. However, such flexibility may be difficult to achieve in practice. It requires a deliberate underestimate of productivity relative to its measureable value for experienced employees -- contrary to the conservative spirit of much budgeting. Moreover, there is no guarantee that the adjustment to productivity would be just the right amount to satisfy the output target. Too small an adjustment would restrict output and too much would lead to excess output or idle staff.

Applying the Dynamic Resource System Framework to a Multi-Resource System: The People Express Case

The analysis of the simple software organisation suggests that reasons for superior performance can be found in the policies and feedback processes organisations use for managing key resources. Here we extend the approach to a multi-resource system - the well-known case of People Express airlines (Whitestone 1983 and Sterman 1989). People Express was a fascinating example of resource building. The company grew from obscurity to industry prominence in a period of only five years against powerful rivals. However, dramatic growth was followed by equally dramatic demise[9].

The first step in a dynamic resource system analysis is to classify resources into tangible-intangible and managed-unmanaged. For People Express the relevant information is in the case and it is a matter of (modelling) judgement 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 managed and unmanaged resources is quite subtle, but it is vital because it is often unmanaged resources (usually invisible at the operating level, and often intangible) that are the undoing of a strategy for resource accumulation.

Recall figure 2 which provides clues of what to look for in making the managed-unmanaged classification. For a typical managed resource there is usually a clear desired condition or goal. The apparent condition of the resource is often measurable. As a result the gap that drives corrective action is objective and beyond dispute, and the managerial feedback and control process is purposive and goal-directed. However, in many cases key intangible resources are not well-managed, or not managed at all. The desired condition or goal may itself not be clear or appropriate, and the resource in development may be difficult to discern because it is not fully productive. In the case of People Express, unmanaged resources include potential passengers, newly-hired staff, service reputation and staff motivation[10].

A rough classification of resources leads to the second step of analysing dominant logic. This phase of analysis is demanding but also interesting because it 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 decisions could be governed by funding constraints, market share goals, return criteria, demand forecasts, or staffing constraints. The dominant logic at People Express however appears (between the lines of the case and video on the firm, Whitestone 1983) to be 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 that works to increase the resource stock of planes.

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 filtered (with input from 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 through time allocated to interviewing.

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 programmes to eliminate any gaps relative to goal. Other companies don't really actively manage the size of the customer base at all, 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 to 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). Low-low prices (as little as one-third normal) were newsworthy and a topic of conversation among the flying public. The more who heard the news, the more there were to pass it along. Pricing policy was designed to exploit reinforcing feedback among potential passengers.

The resulting tangible resource system contains three reinforcing feedback loops, each a compelling engine of growth, but operating independently of one another to produce uncoordinated expansion of planes, staff and passengers. Partial model simulations reveal the power of these growth engines to drive the kind of spectacular growth actually achieved by the People Express[11].

Intangible Resources and Baffling Growth Dynamics

The third step of the 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 managed. 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. For example, how do you get inside the minds of customers to measure service reputation, or into the emotions of staff to discern motivation?). So reputation and motivation are allowed to just evolve from operating conditions. Motivation responds to a range of dynamic factors such as company growth rate and profitability and in turn influences 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.

Since the three tangible engines of growth are out of step (and it would only be a coincidence if they were exactly coordinated, because the underlying policies governing resource accumulation are so different), 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 rest of the organisation of latent growth stresses; and (2). the powerful dominant logics of policies governing tangibles are insensitive to such weak signals. This seeming paralysis in the face of impending doom is symptomatic of management loss of coordination under conditions of dynamic complexity.

As figure 9 shows, service reputation declines steadily for the first six years in an 8-year simulation of People's growth strategy (the apparent recovery in the last two years results from an unintended abundance of staff as disillusioned passengers switch to competing airlines).

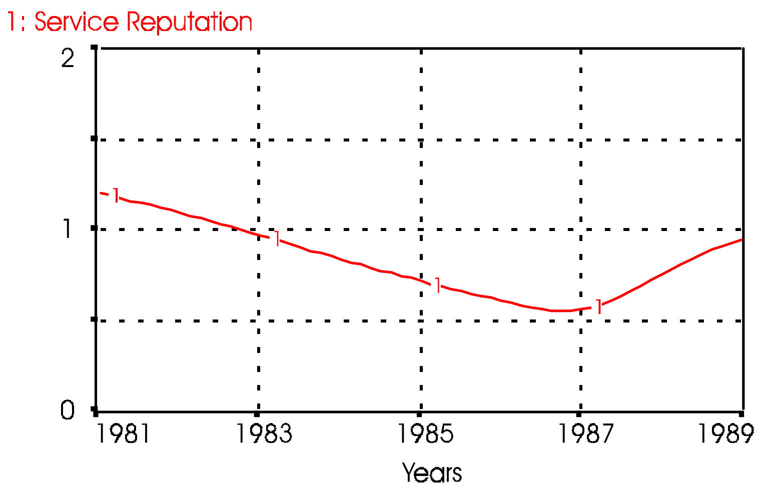

Figure 9: Time Behaviour Chart of Service Reputation at People Express

In figure 10 staff motivation (though invisible and beyond direct management) remains both steady and high for the first six years, contributing to 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 become demoralised.

Planes fly half-empty. The company begins a downward spiral 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.

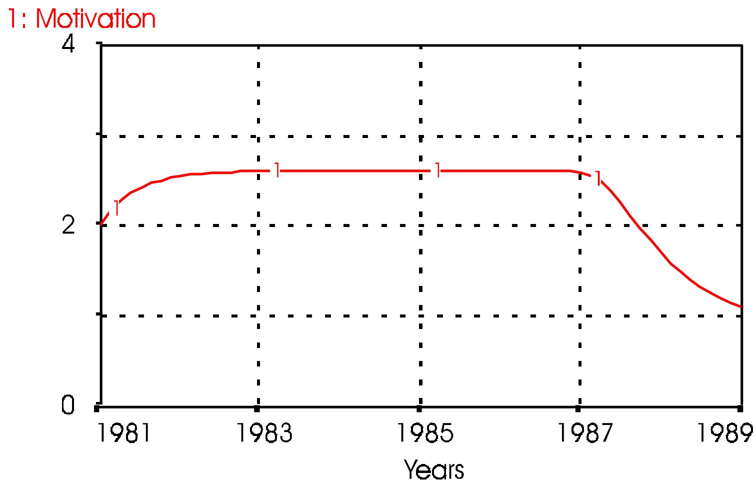

Figure 10: Time Behaviour Chart of Staff Motivation at People Express

Implications of a Dynamic Resource System View of the Firm

A dynamic resource system view of firm performance leads to insights into the rise and fall of People Express airline. At the heart of this view is a synthesis of two powerful and influential sets of ideas from the strategy field: (1). processes of *resource accumulation* as a way of understanding firms' distinctive resource endowments and enduring differences in firms' strategy and performance; and 2. dominant logic or strategic logic as a way of understanding firm-specific approaches to resource management and their effects on firm performance.

System dynamics is a natural discipline to unite these ideas. Stocks and flows portray resource accumulation, while information feedback and policies embody dominant logic. The stock/flow and policy framework provides a versatile approach to visualising firms' resource systems and formulating algebraic equations. Simulation of the resulting algebraic model is a reliable way to infer how the dynamics of strategic resource accumulation arise from underlying resource management policies and feedback structures[12].

The framework shares vocabulary and concepts now well-established in the competence-based management literature. Firms are viewed as dynamic resource systems. Resources can be classified into tangible-intangible and managed-unmanaged. Patterns of resource accumulation (both effective and ineffective) result from firms' dominant policy logic for managing resources. Strategies (like People Express) where failure follows dramatic success can be explained in terms of flawed dominant logic for managing resource accumulations. These flaws stem from operating goals and information feedback that are inadvertently at odds with overall strategy, as well as unintended accumulations of invisible or unmanaged resources that interact with managed resources in unexpected (and usually detrimental) ways.

Competence and resource views are to be found at the heart of areas such as competitive strategy, diversification, corporate portfolio management (joint ventures and acquisitions), and international strategy (geographical diversification). Until now, most firm-related system dynamics has (like People Express) focused on single businesses. A dynamic resource system view opens the door to the intriguing and dynamically complex worlds of the multi-firm industry and the multi-business firm with the possibility of model-based theories to explain the dynamics of competition, diversification, transformation and internationalisation.

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[1] An earlier version of this paper was presented at the Fourth International Conference on Competence-Based Management. Norwegian School of Management, Oslo, June 18-20, 1998 in a panel session on 'Resource Dynamics, Competence and Firm Performance'.

[2] The term "dominant logic" used in this paper corresponds to the term "strategic logic" in the Sanchez and Heene (1996) model of the firm as an open system, and the term "policy" corresponds to "management processes" in the Sanchez and Heene model. For further discussion of parallels in terminology see chapter 1 of this volume.

[3] Senge (1990) suggests that dynamic complexity is present in business or social systems whenever cause and effect are subtle or where the effects over time of interventions are not obvious. For example, when an action has dramatically different effects in the short run and the long run, or when the local consequences of an action differ from consequences elsewhere in the system, then there is dynamic complexity.

[4] See for example Heene and Sanchez (1997), pp 26-28, for a discussion of the apparent circularity in resource-based arguments about successful firms and their sources of competitive advantage.

[5] Strictly speaking system dynamics belongs within a tradition of feedback thought often called servomechanisms. By contrast, general systems theory, as developed by von Bertalanffy and others, belongs within a second and distinct tradition of feedback thought called cybernetics. The distinctions and ancestry of these two traditions are described with scholarly precision in chapter 3 of Richardson's (1991) book *Feedback Thought in Social Science and Systems Theory.*

[6] Simple balancing feedback devices have fascinated engineers, social scientists and philosophers since they were first invented. They seem to embody purpose and primitive intelligence because they relentlessly strive to achieve their desired condition or goal regardless of changing conditions in their immediate environment. Consider for example automatic speed control in a car. The desired condition or goal is the set-speed - let's say 70 miles per hour for motorway driving. The speed controller monitors the current speed of the car. If current speed is below desired then the speed controller initiates corrective action by depressing the accelerator pedal, leading to a burst of acceleration which causes speed to rise. Anyone who has driven a car with automatic speed control has experienced the uncanny intelligence of balancing feedback as the accelerator pedal moves up and down depending on the road terrain. The car begins to climb a steep hill and the accelerator pedal automatically moves down, just as you the driver would move the pedal in the same circumstances.

[7] The resource map and subsequent simulations of the imaginary software organisation are created with the graphical modelling package 'ithink' developed by High Performance Systems (1997). The design philosophy of the modelling package builds on a graphical user interface that supports both expert and less skilled practitioners of the modelling process. The user interface uses standard system dynamics icons for stocks, flows, converters and connectors to represent resources and feedback loops in business and social systems. Within each stock, flow and converter symbol is a repository for

storing equation logic and documenting assumptions. More details of the design philosophy behind ithink are provided in Peterson (1994).

[8] Effective Staff on Coding is made up of new staff and experienced staff. New staff are half as productive as experienced staff and absorb half an expert in hidden training. So the formula is:
Effective Staff on Coding = (Experienced Staff - .5 * New Staff) + .5 * New Staff = Experienced Staff

[9] The analysis of People Express in this paper is a brief synopsis of a fully developed dynamic resource system analysis used in the London Business School course 'Dynamics of Strategy'. For details readers are referred to Morecroft 1999 which is an educational document comprising software and slidepack, designed around the People Express case.

[10] The classification of firm resources into managed and unmanaged reflects the notions of *lower order* and *higher order* control loops in the Sanchez and Heene (1996) systems model. Lower order loops represent managers' bottom-up adaptation of system elements for which hard, quantified data are available. Higher order loops represent managers' efforts at top down adaptation which requires "significant processing of ambiguous qualitative data ….. to discover plausible interpretations about the states of the firm's higher system elements".

[11] The partial model simulations of People Express show exponential growth of planes, staff and passengers over a five-year period, but all at different annual growth rates. These simulations are not shown in the paper, but are included in the educational document (Morecroft 1999) that accompanies the People Express case in the 'Dynamics of Strategy' course.

[12] More information on system dynamics modelling, including conceptualisation, mapping, equation formulation and simulation analysis is available in Sterman's comprehensive textbook "Business Dynamics: Systems Thinking and Modeling for a Complex World" (Sterman 2000). The book also includes a host of practical examples taken from business and public policy; a thorough guide to contemporary and historical literature in system dynamics; and a description of the most widely used software tools including ithink, Powersim and Vensim. The application of the approach to business policy, competitive strategy and management education is described in Coyle and Morecroft (editors, 1999), Larsen and Lomi (editors, 1999) and Warren (2000).