**Revisiting the Theory of Intra-Organizational Ecology and Organizational Change:
A System Dynamics Approach**

Abstract
I develop a System Dynamics simulation model to examine the conditions under which large firms adapt to sharp changes in the competitive landscape. This paper capitalizes on, and aims to extend the intra-organizational ecological theory of organizational adaptation, which reconciles the workings of selection and adaptation forces in the process of organizational change. The paper interprets the narrative theory from the feedback perspective, translates it into a system dynamics model, and simulates the model under different assumptions of firm characteristics. More specifically, I experimentally reproduce *in vitro* a firm's adaptation process to closely scrutinize how the morphology of firm's resource allocation mechanisms interacts with stocks of available resources to mould an unfolding adaptation path. The simulation experiments unveil the role of timing, path-dependence and self-reinforcing mechanisms in decision-making.

Key Words: System Dynamics – Organizational Change – Organizational Dynamics – IntraOrganizational Ecology Theory

Introduction

A fundamental issue in strategy concerns the mechanisms that underpin organizational change and the role managers play in governing a firm's adaptation behaviour. The intra-organizational ecology theory of organizational change (called the "IOE theory" in this paper), pioneered by Robert Burgelman (1991, 1994) and shared by some organizational theorists (e.g., Miner, 1994), presents a unique synthesis to adaptation *versus* selection debate on organizational change. The perspective views firms as ecologies of strategic initiatives, which fall both within and outside the scope of the firm's corporate strategy, and argues that organizational adaptation could be realized through a process of internal competition among these strategic initiatives. New initiatives, which fall outside the scope of the firm's current corporate strategy, may gradually acquire corporate resources. In the course of environmental changes, this process helps the firm to access new markets, and eventually challenge the validity of the firm's corporate strategy to pave the way for strategic renewal. Throughout the process of organizational change, the firm is both adaptive and inertial. Some features of the firm such as administrative systems, organizational culture, and most importantly, the concept of corporate strategy exhibit inertia and often resist against apparent needs for changes. But these inertial features could still function as an internal selection environment by relaying the pressures of external selection environment and guiding the emergence of adaptive behaviours within the firm. According to the IOE framework, corporate strategy emerges as an evolutionary, partially spontaneous, process; yet, top management of the firm plays an important role as a designer and operator of such an effective internal selection environment within an organization. The study presented in this paper examines the intra-organizational ecology theory of organizational change in details and aims to develop a deeper understanding of why established firms often fail when dealing with organizational change and how top management plays its role in guiding organizational adaptation. In doing so, this study takes a modelling and simulation approach following a logic of enquiry similar to Sastry's (1997). More specifically, according to a feedback perspective, the study interprets the IOE theory as a web of interrelated feedback loops and resource stocks, each of which captures a part of organizational dynamics involved in organizational change.

INTRA-ORGANIZATIONAL ECOLOGY THEORY OF ORGANIZATIONAL CHANGE

Although rooted in the tradition of strategic management research, the theoretical contributions of the IOE theory need to be understood in the context of the adaptation versus selection debate on organizational change, which has been, and still perhaps is, one of the central debates in the fields of organizational studies (Aldrich, 1979; Astley and Van de Ven, 1983; Bourgeois, 1984).

The Classic "Adaptation *versus* Selection" Debate

Despite the pray by practicing managers for continual adaptation and survival, the history demonstrates that it is quite difficult for the established firm to remain successful in the face of environmental changes brought by, for example, new technologies and deregulation. It is often the case that the firms which establish the leadership in the new environment are armed with a set of new resources and competencies and with a set of new management practices. This simple observation basically supports the emergence of an ecological perspective of organizational adaptation during the 1980s (e.g., Caroll, 1988; Hannan and Freeman, 1977, 1984, 1989). According to the perspective, the established firm exhibits strong structural inertia. During the process of earlier growth, a firm accumulates learning about the technologies, customers and the market of its core business so as to establish a presence in the market and achieve operational efficiency. Yet, it is this learning and resultant routines and capabilities that often hinder the established firm from experimenting new business ideas and searching for new operational and management solutions (Levitt and March, 1988; Levinthal and March, 1993). Core capabilities of the established firm become core rigidities (Leonard-Barton, 1992). In the presence of inertia, Darwinian evolutionary dynamics apply to the competition among firms. Organizational change takes place not in the form of voluntary adaptation by the established firm but in the form of change in the population of firms. One population of firms with a specific type of structural form dies out in the course of environmental changes, and is replaced by another population of firms with a new structural form which fits in better with new environments. The environment selects one population of firms over others. This ecological perspective is in sharp contrast to the traditional strategic perspective taken by business policy and management scholars, who believe in the discretion of management of a firm, particularly a large, resource-rich firm, in controlling the fate of his organization (e.g., Chandler, 1962; Andrews, 1971). They argue that managers are able to, and indeed do, achieve the re-alignment between their organization and environment over time by developing new purposes, and policies, by designing new organizational and administrative systems, and even by changing performance standards (Thompson, 1967; Child, 1972). It is particularly so when managers of the established firm are endowed with rich slack resources as demonstrated in the case of major American tobacco companies who strategically responded

to anti-smoking environment trends and diversified into new growing business areas (Miles and Cameron, 1982).

Intra-organizational Ecology Theory as a Synthesis

The IOE theory aims to present a fruitful integration of ecological and strategic perspectives by showing how a large established firm simultaneously deals with internal adaptive forces and external selection pressures when adapting to changes in its environment (Burgelman, 1991, 1994). In doing so, it capitalizes on the variation-selection-retention approach of the cultural evolutionary theory (Campbell, 1969; Weick, 1979). While the population ecologists take a population of firms as a unit of analysis, and focus mainly on ecology of populations, IOE theorists are interested in the analysis of an individual firm, and focus on ecology of strategic initiatives within an organization. *Variation* in strategic initiatives often comes from the bottom of the organization that is closer to market opportunities and where necessary knowledge and skills reside (Jensen and Meckling, 1992). These initiatives compete for limited organizational resources and the attention of top management within the organization. Some initiatives survive in the process of *internal selection* while others do not. *Retention* of a certain set of strategic initiatives leads to changes in corporate strategy, and strategic renewal of the firm. Based on this theoretical framework, the IOE theory explains organizational change as the dynamic interplay between two key strategic processes: induced strategic process and autonomous strategic process. The former process hosts strategic initiatives which fall within the scope of a firm's current corporate strategy and contributes to decrease the level of variation in terms of business areas the firm operates in. While the process is essential to build distinctive competence of the firm, it simultaneously contributes to develop organizational inertia by threatening the firm's capacity to experiment. The latter autonomous process consists of the strategic initiatives that fall outside the scope of corporate strategy and contributes to increase variation at the corporate level. When these strategic initiatives escape from the selective pressures of the internal selection environment within an organization, they may lead to the development of new competencies, and prepare for organizational change by challenging the existing corporate strategy. When environmental change makes obsolete or inadequate a firm's core capabilities and exerts selection pressures on the firm, these autonomous strategic initiatives, if survived the internal selection environment, can help the firm remain adaptive at the corporate-level (table 1).

Open questions in the IOE model

Burgelman's pioneering work is an in-depth clinical study within a single firm (i.e., Intel and its successful exit from DRAM business and entry into the memory business). While a grounded theory approach proves to be effective in understanding complex organizational phenomena (Glaser and Strauss, 1967; Burgelman, 1985), the development of a higher-order or a more general theory would require additional, equally carefully-conducted clinical studies in different organizational and environmental settings (Strauss and Corbin, 1994), or a large number of similar events in the same research site. Moreover, the IOE grounded theory is a verbal theory, and its construct and internal validity are equally limited. This leads to such questions as: Are there any missing variables in the theory? What are hidden assumptions, if any, behind the theory? More specifically, I addressed four questions in order to contribute to a further articulation of the IOE model.

First question deals with the role of so-called hidden variables. Burgelman refers to the fundamental role played by unabsorbed slack resources in the autonomous process [Burgelman, 1991: 248] and suggests that slack resources need to be associated to top managers' perceptions of opportunity costs related to permanence in a declining core business [Burgelman, 1983: 1356]. Yet, different roles may be played by initial level of stocks of slack resources, on the one hand, and the flow of slack resources that nurture corporate entrepreneurship, on the other, this latter depending on top managers' willingness to stimulate corporate entrepreneurship. I suggest that both initial stocks of available slack resources and flows of slack resources should be explicitly investigated in order to understand dynamics of corporate entrepreneurship and adaptation.

Second, to increase robustness and completeness of IOE theory, we need to disentangle different effects which led to the adaptation path observed at Intel. Burgelman suggests that a number of elements explain Intel's adaptation success: availability of unabsorbed slack resources [Burgelman, 1991: 248] and an official resource allocation mechanism oriented by a maximize-margin-per-wafer rule preventing escalation of commitment to core business [Burgelman, 1994: 49-50]. It is possible to further investigate what is the role independently played by each of these two elements?

Third, there is a key question concerning the generalisability of Burgelman's argument. To what contexts is such argument applicable or, in other words, what are its boundary conditions? As Burgelman suggests, Intel might just have been lucky [Burgelman, 1994: 49]. Bottom up adaptation might have just been the lucky result of the fact that "…fabs could, initially, be fairly easily converted from DRAM to EPROM or microprocessor production" [Burgelman, 1994: 43]. In addition, the growth of initiatives in the microprocessor

business may also be leveraged by distinctive competencies [Burgelman, 1994: 50], then, at what conditions can an autonomous initiative, completely disconnected by existing core competences, survive and emerge in the intra-organisational ecology?

Finally, as Burgelman suggests [Burgelman, 1994: 52], an interesting question is whether Intel would have done better if it had more quickly exited DRAMs. Burgelman suggests that an earlier divesture from DRAM would probably have resulted in a worse adaptation performance because "…time involved in dissolving the strategic context for DRAMs helped prevent strategic change that might have been too rapid" [Burgelman, 1994: 52] and, on the other hand, a too rapid push on autonomous initiatives might have "…a dissipating effect on the spawning organization's resources […]. In the IOE model, the same decision anticipated or postponed in time may yield very different results and top management may have a role in accelerating or holding back the strategic renewal process. The development of the IOE framework demands for introduction of ex ante predictions on effect of timing of events and decisions on emerging adaptation behaviour.

STRATEGIC RENEWAL IN THE IOE THEORY: A FEEDBACK INTERPRETATION

Self-referential behaviour in the induced process

According to the IOE theory, the rationale for large firms to maintain an induced strategic process is that "In this process, intentional strategy may serve the organization to leverage - do as much as possible with – its currently available learning, to fully exploit the opportunities associated with the current action domain." [Burgelman, 1991: 249]. On the other hand, when organizational adaptation is needed, induced process has, as likely outcomes, relative inertia and reluctance in changing strategy or, at best, relatively minor adjustments in it [Burgelman, 1991: 253]. In a feedback perspective, IOE model suggests that, within large organizations, conditions exist for emergence of positive feedbacks these latter producing some amount of path-dependency in strategic behaviour. Resource allocation mechanisms within the structural context, creates a resource allocation pattern that contributes to further accumulate resources in the areas of activities more closely connected to the firm's distinctive competencies. The mechanism guarantees that "…the system continues to operate consistent with its current strategy" [Burgelman, 1983b: 1350]. The mechanism is described by positive feedback P0 in figure 1. A firm accumulates asset in its core business, resources accumulated drive ex-post confirmation of espoused organizational strategy, which, in turn, direct resources allocation to the core business. The feedback mechanism P0 makes firms highly inertial and unreceptive to environmental selective pressures but, as Burgelman suggests [1991: 245], firms may decouple resource allocation pattern from "espoused organizational strategy" by adopting resource allocation mechanisms that incorporate profit-maximization criteria or, in general, financial criteria. In this way, firms align internal selection processes with external pressures and, eventually, positive performances accruing provide a time cushion for bringing organizational strategy in line with structural context [Burgelman, 1991: 245], presumably through an ex-post rationalization process. Yet, financial criteria, for example criteria that assign resources on the basis of return on assets, do not entirely solve the problem of potentials for self-referential behaviour. In positive feedback P1 (figure 1), the accumulation of distinctive competencies in large firm pushes to retroactively confirm organizational strategy. Given accumulated distinctive competencies, performances are likely to be high thereby legitimizing a resource allocation pattern that provides resources to profit-yielding activities. By assigning resources to the business, the basis is created to facilitate performance accrual to that business thereby reinforcing a resource allocation pattern in its favour. Positive feedback P1 creates pressures to defend current organizational strategy and to adversely select alternative strategies. In addition, until a fit exists between core business and its competitive environment, a second engine intervenes to strengthen the growth of core business and the reinforcement of organizational strategy. As described by P2, in figure 2, performances in core business augments corporate earnings and enlarges the amount of resources available which may be reallocated to the core business through the official resource allocation system. Thus, morphology of resource allocation mechanisms within large organizations might explain inertia in adaptation and results of strategic renewal processes. More precisely, resource allocation criteria coupled to organizational strategy are likely to prevent renewals; financially-oriented criteria are likely to facilitate adaptation by making the firm more responsive to external competitive pressures. Yet, financial criteria as well maintain an amount of inertia because is unlikely that a new strategic initiative, which cannot leverage the existing core competencies, may prove its attractiveness before it receives enough resources to start up the new venture.

FIGURE 1

FIGURE 2

Autonomous strategic process and Strategic renewal

Burgelman suggests that firms can circumvent the self-referential behaviour of the induced strategic process through the autonomous strategic process thereby paving the way for a firm's strategic renewal. In the autonomous strategic process, initiatives "…outside the current strategy" emerge and start to look for resources in order to survive. Such initiatives cannot be evaluated within the official resource allocation system, which typically "…selects initiatives that are consistent with an ex-ante vision" [Burgelman, 1991: 247]. According to this picture, middle managers search alternative avenues to obtain resources in order to demonstrate viability of autonomous initiatives and demonstrate to top managers their potential. In this phase, availability of unabsorbed slack resources plays a fundamental role [Burgelman, 1991: 248]. As indicated in figure 3, feedback 3 and P4, provide the engine that, within the autonomous process, sustains the take off of the strategic renewal process. Feedback 3 is fundamental in the renewal process. At the beginning of the process, the feedback is negative, we will call it N3 (figure 3): corporate earnings produce slack resources, these latter flow to sustain experiments and to build assets, yet, since return on assets is negative at the beginning of the simulation, the more assets is built the more losses accrue to the firm (this explains the minus sign connecting 'Asset in new business' and 'Performances in new business in figure 3), the more resources are dissipated and flow of funds to experiments relents. In figure 3, the plus sign connecting 'Return on asset in new business' and 'Performances in new business' means that, all other things being equals, an increase in return on asset generates an increase in performances. In figure 3, another feedback plays a key role. Feedback P4 represents the dynamics of learning and scale effects building. The more assets are accumulated, the more learning and economies of scale are built. As firm builds learning in the new business, profitability grows over the industry average and return on asset increases. As described in figure 3, in the mathematical model, an exogenous driver affects return on asset: the environmental scenario contributes to increase the average return on asset in the new business. Thus, as our modelled scenario unfolds, both feedback loop P4 and exogenous forces inflate return on assets. As a consequence, feedback 3 becomes positive and we will call it P3 in figure 4. Then, the more we invest in the business, the more assets are built and the more performances achieve the firm in the emerging business.

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     FIGURE 3
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     FIGURE 4
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A dilemma: pitfall of early moves or traps of late response

The feedback interpretation of strategic renewal helps to articulate why timing of decisions play a key role in successful adaptation. As described in figure 5, the strategic renewal process is very delicate under a dynamic point of view. If the flow of slack resources to experimentation is too strong, too early funding to non core initiatives corresponds, in a system with given resources, to deprive the core business from resources and to inhibit its chances to perform. Thus, feedback N3 prevents feedback P2 from earning money and from contributing to corporate earnings. If corporate earnings decrease because core business is weakened, flow of slack resources decreases and the new business will weakens as well. Of course, the strength of feedback P4 will be crucial in deciding how long feedback 3 will take to become an engine of the strategic renewal process rather than a brake. At the same time, as figure 5 suggests, there is a threat in holding back flow of slack resources to the new business. As flow of slack resources relents, feedback P4 slows down and the time needed for the profitability in the new business to take off increases. Thus, the moment in which the new business becomes self-sustaining is postponed.

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     FIGURE 5
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SIMULATING THE MODEL

The process of simulating the formal model unfolded in three stages.
First, to conduct our experiments, I selected an environmental scenario and plausible initial conditions in terms of organizational size. To select a plausible description for both environment and organisational size, I referred to the situation of INTEL as described by Burgelman [1991].

Second, to increase the confidence in the robustness of the simulation model, I run a number of behavioural tests [Forrester & Senge, 1980; Sterman, 2000]. In particular, I focused on equilibrium tests [Sastry, 1997]. Third, given the environment and organisational size, in terms of total firm's assets, I manipulated three elements that crystallize organizational morphology: (i) initial resource endowment (assets in core and new businesses and initial amount of unabsorbed slack resources); (ii) calibration of flow of slack resources conveyed to support experimentation in a new business and (iii) morphology of official resource allocation mechanism.

Initial settings

I selected those initial model conditions and settings that represent adaptation conditions and structural characteristics of a firm that, according to a number of stylized characteristics, resembles INTEL. I calibrated the model in order to simulate a competence-destroying environmental change [Tushman & Anderson, 1986]. The time period equals the time span of Burgelman's analysis of the Intel case. More specifically, I set a first phase of six months stability and a last phase of six month stability. The central two phases of core business decline and non core business surge was set as 9 years long (see figure 7). To design the scenario, I investigated a number of sources. For example, West's analysis of DRAM's price trends as reported in Ghemawat *et al.* [1999] describes a 10-years period of price decline, including a tail of 6-months period of stability.

FIGURE 7

Initial equilibrium test.

To increase the confidence in the model, I started with an equilibrium test simulation [Sastry, 1997] by assigning plausible initial conditions and testing the plausibility of emerging equilibrium behaviour. The equilibrium test represents a realistic description which is also coherent with Burgelman's account. In figure 8, I present the simulation run. As shown, the modelled firm does not move from its original trajectory. Core business produces enough resources to produce earnings, pay dividends and support experimentation in the new business.

FIGURE 8

Structure of the experiments

In the experiments, I selected five factors to represent organizational morphology: initial stock of assets in core and non core business, initial stock of available slack resources, flow of slack resources conveyed to support experimentation in a new business and, finally, morphology of official resource allocation mechanism. For each factor, I selected plausible calibrations as possible levels of the factors as described in tale 4. The analysis is articulated in two sets of experiments.

1° Set of Experiments. In a first set of experiments, I investigated how adaptation performances depend on relative sizes of stocks of assets, in core and new business, and availability of slack resources. Firms need slack resources to enact strategic renewal processes. Yet, I expect that the role of slack resources becomes increasingly important as the potential size of new business and, hence, experimentation effort increases. More importantly, I expect that relative size matter; that is, slack resources are fundamental when effort required in a new business is large compared to the size of core business. In addition, I am puzzled by the role of flow of slack resources conveyed to new business for experimentation. I expect that the size of the flow plays a key role in strategic renewal, independently on whether such a choice is planned or unintended. A large flow accelerates growth in the new business but rapidly subtracts resources to the organization. A small flow does not dissipate too early corporate resources but may be too feeble to support take off of new business. I run about 9000 simulation runs testing different combinations of parameters values as described in the first four columns of table 2.

TABLE 2

2° Set of Experiments. In the second set of experiments, I added to the picture the role played by a firms' official resource allocation mechanism. Thus, I repeated the previous simulations, assuming different features of a firm's official resource allocation mechanisms. In particular, I varied the weight that decoupled, profitability maximizing, criteria have on a firm's official resource allocation mechanism. I assumed that the weight ranges from 100% to 0 (last column of table 2). A weight of 100% entails that, within the organization, official funds are allocated only comparing profitability of different businesses with no regard to official organizational strategy. On the other hand, when the weight equals zero, official funds are allocated on the base of official organizational strategy.

Synthesis of results

Simulation experiments help us to pull out a number of conclusions.
First, as expected, there is key connection between the relative size of core and new businesses, on the one hand, and initial stock of slack resources, on the other. As initial proportion of assets invested in non core business increases relatively to asset invested in core business, adaptation requires a larger amount of initial unabsorbed slack resources to sustain the initially unprofitable strategic initiative. For example, if we set initial assets in core business equal to 85 and assets in non core business equal to 15, the modelled firms adapts successfully independently of either initial stock or flow of slack resources available. Table 3 shows an adaptation patterns which is the same independently from initial stock of slack resources, this latter ranging from 0 to 100. On the contrary, if we set initial assets in core business equal to 80 and assets in non core business equal to 20, the modelled firm adapts only if a very large, not necessarily plausible, amount of slack resources exists (table 4 shows adaptation pattern given an initial stock of resources equal to 100 or 90). As we assign initial stock of slack resources equal to 80, or below, the firm cannot adapt (table 4).

TABLE 3
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TABLE 4

Second, for a wide range of initial setting of the model, given a plausible initial stock of slack resources, successful adaptation strongly depends on both calibration of slack resource flow and morphology of official resource allocation mechanisms. If we select, for example, one of such initial conditions (initial assets in core business equal to 83, initial size of assets for experimentation in non core business equal to 17 and initial stock of available slack resources equal to 25% of total assets), firm's adaptation depends strongly on the size of the flow of slack resources and on the weight that profit-maximization has on resource allocation pattern (table 5).

TABLE 5

History-Dependence in Dynamics of Strategic Renewal

In the following, we explain results reported in table 4 by investigating in detail the causal structure of strategic renewal. We present four selected simulation runs to explore in depth the role of slack resources and resource allocation mechanism in adaptation behaviour.

Selected Simulation Run 1. Feedback Dynamics in Successful Adaptation. In figure 8, I consider the dynamics of earnings in core and non core business in a simulation run where initial assets in core and non core businesses are, respectively, 83 and 17 millions $, initial stock of slack resources is 25 millions $, weight of financial criteria in official resource allocation pattern is 100% and flow of slack resources is 30%. Core business grows exponentially in the first 6 months. Around month 6, exogenous jolts start displaying their effects and return on investments in new business increases. Despite decrease in industry returns on assets, earnings in core business grow due to the working of positive feedback P2: large asset base drives earnings and earnings generate funds available for further allocation. Such a mechanism is still strong enough to counterbalance the effect of decreasing industry average returns. The firm due to large stock of accumulated assets enjoys profitability greater than the industry average.
In the new business, earnings decrease at a decreasing rate. The shape of the curve is explained by feedback N3 in figure 3. The return on asset in the business is negative, therefore, investment in non core

business lead to an increase in losses. The more the firm invests the more losses accrue; corporate earnings and slack resources suffer the losses and the flow of resources to experimentation decreases thereby decreasing investments in non core business and, as a consequence, holding back losses.

Around time 35, return on investments in new business becomes positive and feedback 3 becomes positive supporting experimentation and growth in the new business (the emerging feedback structure is the one represented in figure 4). Earnings in the core business are collapsing, forced by the exogenous scenario; the rate at which core earnings fall depends on the strength of feedback P2. Core business is deteriorating and the new business is still weak to support corporate earnings. If core business deteriorates too rapidly, it will not be able to produce slack resources to successfully support the development of new business. If new business grows too slowly, it will dissipate resources for too a long time for the organization to survive. Yet, to grow and become robust the new business needs more funding, funds conveyed for experimentation are not enough, the firm needs to recognize the call for a radical shift in the official resource allocation pattern. Here is where feedback P5 and P6 come into the picture. Around month 48, profitability in new business become greater then profitability in core business and financial criteria, which in this simulation experiment driving resource allocation, rapidly shift resources from core to new business, thereby reinforcing the growth of the new business that becomes the main source of corporate earnings. The core business expires gradually as investments are cut and existing assets are eroded away by obsolescence and depreciation (figure 8).

Figure 9 explains in details the role of key feedback processes to explain behaviour of earnings in new business. Curve 1 capture the behaviour of earnings as in the successful adaptation previously presented, curve 2 represents the behaviour of earnings if feedback loop P4 was paused and curve 3 captures behaviour of earnings if feedback loop P5 was clogged-up. If we pause feedback P4 (curve 2), the losses in new business will be deeper and will last more, and we will not observe the exponential growth in earnings that characterizes the behaviour, between 12 and time 48, of earnings in curve 1. If we, then, block loop P5, which leverages growth from time 48 to the end of the simulation, we observe that earnings will have similar behaviour as in curve 1 until time 48 (remember that P4 is now functioning) but will collapse beyond. This happens because P5, which should trigger reallocation of resources within the organization, does not work properly.

FIGURE 8

FIGURE 9

Selected Simulation Run 2. Early Entrepreneurship, Resource Dissipation and Failure. Figure 10 describes the dynamics of earnings in non core business when it is assumed that a large flow of slack resources is conveyed to support experimentation. In the presented simulation run, initial assets in core and non core businesses are, respectively, 83 and 17 millions $, initial stock of slack resources is 25 millions $, weight of financial criteria in official resource allocation pattern is 100% and flow of slack resources is 80%. That is, we assume that large part of available slack resource is made immediately available for experimentation in the early history of the strategic renewal process. As described in the figure, a large flow of resources is invested in experimentation generating a higher amount of the losses in the early history of the strategic renewal process. In feedback terms, large amount of funds at this stage of the renewal process produces more losses, through feedback N3, than produces increases in profitability through feedback P4 and the dissipation of resources hinders feedback P4. Thus, core business weakens and cannot produce enough corporate earnings to further support the development f the new business.

FIGURE 10

Selected Simulation Run 3. Weak Entrepreneurship, Feeble Engines of Growth and Failure. In figure 11, we present dynamics of earnings in non-core business in a simulation run where initial assets in core and non core businesses are, respectively, 83 and 17 millions $, initial stock of slack resources is 25 millions $, weight of financial criteria in official resource allocation pattern is 100% and flow of slack resources is 1%. That is, I depict a parsimonious use of slack resources. Unabsorbed slack resources exist but the firm is cautious and tightly controls flow of spending for experiments. Result obtained is a failure in adaptation. The focal organization is able to control losses in the early development of strategic renewal process and to avoid dissipation of corporate resources (see difference between curves 1 and 2 in the early stage of the simulation run reported in figure 11). Yet, the lack of investments in the autonomous process undermines feedback P4, which weakens and exerts only a feeble action on N3. Thus, when N3 becomes the self-

reinforcing mechanism P3, it is powerless and the growth is slow (notice the difference between curves 1 and 2 around time 48 of the simulation run reported in figure 11). The retard in feedback P3 and P4 delays the emergence of performances in the new business and, thus, hinders the shifting of the firm's official resource allocation mechanism in favour of the new business thereby blocking feedbacks P5 and P6. As explained in figure 12, routine resource allocation pattern begins to reallocate funds to the new business too late, when corporate earnings and, hence, available resources are dissipated.

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FIGURE 11
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FIGURE 12
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Selected Simulation Run 4. Coupled Resource Allocation Mechanisms and Failure. In the simulation experiment, we assumed that only 60% of official corporate earnings are distributed following the decoupled profitability maximization criteria and the remaining 40% is coupled to organizational strategy and is allocated to core business. Figure 13 compare resource allocation pattern in selected simulation 1 and 4. The graph shows that, when resource allocation mechanism is coupled to historical official strategy (curve 2) the reallocation process is weak and only a portion of available funds shift to the new business. In a feedback view, loop P5, which ought to redirect resources, is delayed. As described in figure 13, only after month 60 loop P5 begins to assign majority of resources to the new business. Yet, as described in figure 14, after month 60 corporate earnings are declining because core business absorbs, rather than creating, resources. Thus, the official resource allocation mechanism conveys a declining amount of resources. Table 5 presents a set of results where we varied the proportion of corporate earnings reallocated through coupled and decoupled criteria along with the proportion of slack resources flowing to support experimentation in a new business.

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FIGURE 13
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FIGURE 14
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DISCUSSION

Building on our formalization of Burgelman's verbal theory, simulation experiments suggest that Intel adaptation behaviour is a particular case within a larger framework. In addition, the experiments illuminate on the role played by time and path-dependence. In particular, in Intel adaptation process, seem to have played a fundamental role availability of slack resources and margin maximization criteria at work in the structural context, in presence of clear signals arising from the firm's external environment.

Hidden variables in the IOE model: The role of slack resources in strategic renewal

As suggested by Burgelman's [1991: 248], the reported simulation experiments confirm that availability of slack resources is a necessary condition for a successful strategic renewal. Slack resources provide ground for the take off of autonomous strategic initiatives, which do not receive resources through the official resource allocation mechanism. Yet, the experiments corroborate Chakravarthy's hypothesis that internal resources for adaptation, in particular slack resources, should not be measured in absolute terms but in terms of "their relative abundance" (1982: 37) for an industry. In particular, simulations advise that:

H1: *if the size of initial needed assets for experimentation in new business is small enough in comparison with the size of core business, chances of successful strategic renewal are high independently of available slack resources and morphology of resource allocation mechanisms*

H2: *if the size of initial needed assets for experimentation in new business is large enough in comparison with the size of core business, chances of successful strategic renewal are small independently of plausible available slack resources and morphology of resource allocation mechanisms*

On the other hand, simulation experiments encourage further speculation on the role of slack resources since

H3: *For a wide rage of plausible proportions between initial needed assets for experimentation in new business and size of core business, successful strategic renewal depends on both the available stock of slack resources and the calibration of slack flow to experimentation.*

Organisational Morphology: Sufficient and Necessary Conditions in Successful Strategic Renewals

In addition to the stock of available slack resources, success of strategic renewal depends on the morphology of a firm's structural context. In particular, the simulations explore crucial role played by financial resource allocation criteria and calibration of flow of slack resources that is conveyed to support experimentation. Computer simulations suggest that:

H4: *For a wide range of plausible proportions between initial needed assets for experimentation in a new business and the size of a core business, given a plausible initial stock of available slack resources, chances of successful strategic renewal depends on morphology of resource allocation mechanisms.*

Confirming the role that Burgelman assigns to financial criteria, computer simulation suggests that:

H 5: the working of internal allocation mechanisms oriented by financial criteria, which decouple allocation criteria from organizational strategy, is a necessary condition for successful strategic reorientation.

Yet, the experiments suggest that an appropriate resource allocation mechanism is a necessary but not sufficient condition for successful strategic renewal. Firms may adopt financial allocation criteria and still failing strategic renewal due to inappropriate calibration of the slack which flows to support experimentation.

H 6: given a financial allocation mechanism, firms may fail strategic renewal if slack resource flow is inadequately calibrated, independently of the stock of unabsorbed slack resources in the organization.

In particular, the new business needs slack resources to build up a critical mass of asset when the autonomous initiative has not proved its viability and cannot receive resources from the official resource allocation mechanism. If the flow of slack resources is weak, the asset stock may result insufficient to build up upon when the new business will be ready to receive resources from the official resource allocation mechanism. On the other hand, the flow of slack resources needs not to be too strong at the beginning. Indeed, in the early history of strategy renewal process, moving too many slack resources to the new business, while the new business is resource-dissipating, might result in huge losses that weaken corporate resources and the core business, this latter, in the early phase of the strategic renewal, is a resource-generating business.

Feedback view of strategic renewal: Top Managers Visible Hand

In the experiments, I focused on the relationships between a new business, which emerged as the target for a firms' strategic renewal, and the firms' historical core business. Simulation experiments suggest that the two businesses interplay within a complex feedback structure. Top managers may facilitate a firm's metamorphosis in the strategic renewal process if they are able to interpret pressures emerging from the interaction among several feedback mechanisms and appropriately intervene along the time path of a strategic renewal process. Figure 15 describes how interwoven feedback mechanisms interact in a successful path of strategic renewal.

Inertia and momentum in organizational strategy. In a first stage, when the core business is still vigorous, even in the presence of external signal of decline, positive feedback P1 and P2 reinforce the core business. Loop P2 is the engine which trigger positive loop P4. Slack resources contribute to make available funds for experimentation in the new business thereby supporting learning and scale effects. These latter, in turn, contribute to increase the new business' capability to generate performances. At this stage, a crucial effort is to guarantee a sustained learning rate in the new business in order to accelerate loop 4.

H 7: in a successful strategic renewal, a first stage exists in which top managers sustain momentum in official organizational strategy by enforcing financial resource allocation criteria that stimulate internal competition among strategic initiatives and exclude autonomous initiatives from the official resources.

Harmonising rate of change in core and new businesses. Based in the simulation experiments and interpretation of feedback dynamics, I tried to capture problems arising during the strategic determination process when new initiatives cannot be evaluated but, on the other hand, begin to attract large flows of slack resources. In a feedback approach, the simulation experiments focus on feedback 3 and 4. Feedback loop 3

represents a double-faceted process (figure 3). In the first part of the simulation loop is negative (N3) and dissipates corporate resources, in the second part of the simulation loop 3 becomes positive (P3) thereby creating a further engine for a successful strategic renewal process. At this stage, it is key both to maintain a robust core business to cover losses generated in the new business and accelerate both learning processes and scale economies in the new business. Through feedback lenses, the key point is to use loops P2 and P4 to nurture loop 3 facilitating a quick shift from N3 to P3. If a firm forces too much negative feedback N3, the core business is weakened and will not be able sustain experimentation in the longer term. The consequence is the weakening of feedback loop P2 and P4, which will not provide enough strength to facilitate the evolution of N3 in P3 (see figure 16). On the other hand, a firm may restrain too much resources flowing to experimentation. In this case, the new business will suffer the competition of the old business in the official resource mechanism and will not gain enough momentum to take off; positive feedback loop P4 will be relented because lack of resources prevent accrual of both scale and learning economies, and negative feedback loop N3 does not receive enough push to became the positive feedback loop P3 (see figure 17). These considerations suggest the following hypotheses:

H 8: in a successful strategic renewal, to safely reach the second turning point, top managers control and calibrate the flow of slack resources conveyed to the new business has to be adjusted in order to harmonise the rate at which the new business growth with the rate at which the core business is eroding.

Reversal of official allocation path. In the third turning point, the new business starts to generate performances and can be considered for funding in the official resource allocation mechanism. In this phase, timing is crucial: delays in the working of P5 may create two problems, First, the new business fails because does not receive resources to growth. Second, delays in P5 lead to investments in a core business that is weak and absorbs, rather than generates, resources. This is a typical pattern of failure in strategic renewal that emerges when resource allocation mechanism is coupled with organizational strategy. In this case, when the new business is mature to be adopted as the new core business, a firm's official resource allocation mechanism shelters the old core business from competition and does not reallocate funds to the new business. In this case, a firm is constrained by 'lethargy' generated by its prior history of success [Tushman & Anderson, 1986: 461] and 'competency traps' [Levitt & March, 1988: 322-323] hinder P5. This latter feedback loop is not reacting to the emerging change in business relative profitability and P6 is delayed (see figure 18). On the other hand, if loop P5 is enacted too early, redirection of official resource allocation pattern in favour of the new business takes place when this latter is too weak. As a consequence, loops P2 may be weakened when it is still the major engine of growth. In this respect, the ability of top managers lies in the timing of their intervention for ex post recognition of potentials of autonomous initiatives These considerations suggest the following hypotheses:

H 9: in a successful strategic renewal, to safely reach the third turning point, top managers ought to structure and preserve structural context in which resource are allocated on the base of strict financial criteria, that stimulates tough competition on official resources between a new and the old core business.

Momentum and irreversibility in strategic renewal. In the fourth stage, a firm's choice for the new business is irreversible; the old core business is abandoned and the new one built up rapidly. In our simulation, positive feedback loop P6 is the engine that allows the new business to survive and to build a sustainable competitive position. The description of the last step in the strategic renewal process captures Amburgey, Kelly and Barnett's suggestion that 'once inertial forces inhibiting change are overcome, the change process exhibits momentum on its own' [1993: 70]. Top managers may dedicate their attention on the adjustment organizational strategy in order to emphasize external rather than internal competition.

H 10: in a successful strategic renewal, when the fourth turning point is reached, top managers manipulate organizational strategy in order to shift focus from internal to on external competition.

CONCLUSIONS AND CONTRIBUTIONS

The simulation experiments articulated the causal-effect structure underpinning Burgelman's IOE model and enhanced its robustness and the consistency. In addition, simulation experiments provided the environment to analyse strategic renewal process as a sequence of turning points thereby exploring how the pace, or the history, of the process affects its outcome. In this way the IOE model was enriched by further exploring how top managers may influence strategic renewal by differently intervening as the path of change unfolds.

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Table 1 – Textual Analysis of IOE Theory:
The Ecology of Strategic Initiatives

| Role of Top Mgmt	(Designing Structural Context)	(Managing Strategic Context)
Retention	Retention of initiatives leading to the reinforcement of structural context	Accommodation of initiatives through retro-active justification of new corporate strategy
Selection	Initiatives selected through structural context	Initiatives escaping selective pressures of structural context and challenging the concept of corporate strategy
Variation	Initiatives induced by structural context	Initiatives fall outside the scope of corporate strategy
	Induced Strategic Process in a core business	**Autonomous Strategic Process in a new business**

Source: Burgelman (1983a; 1983b; 1991)
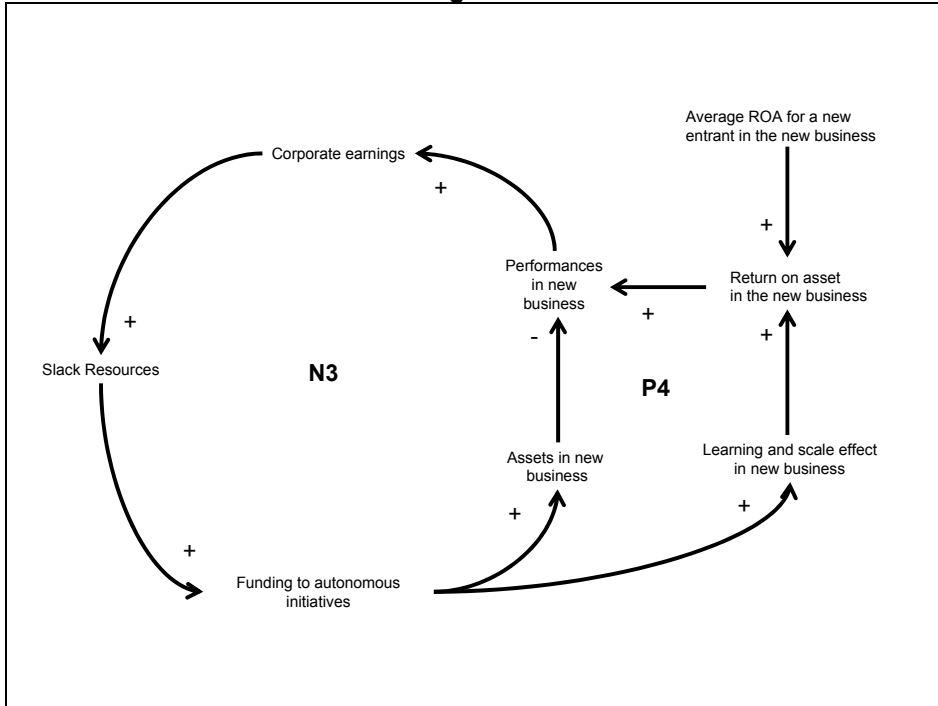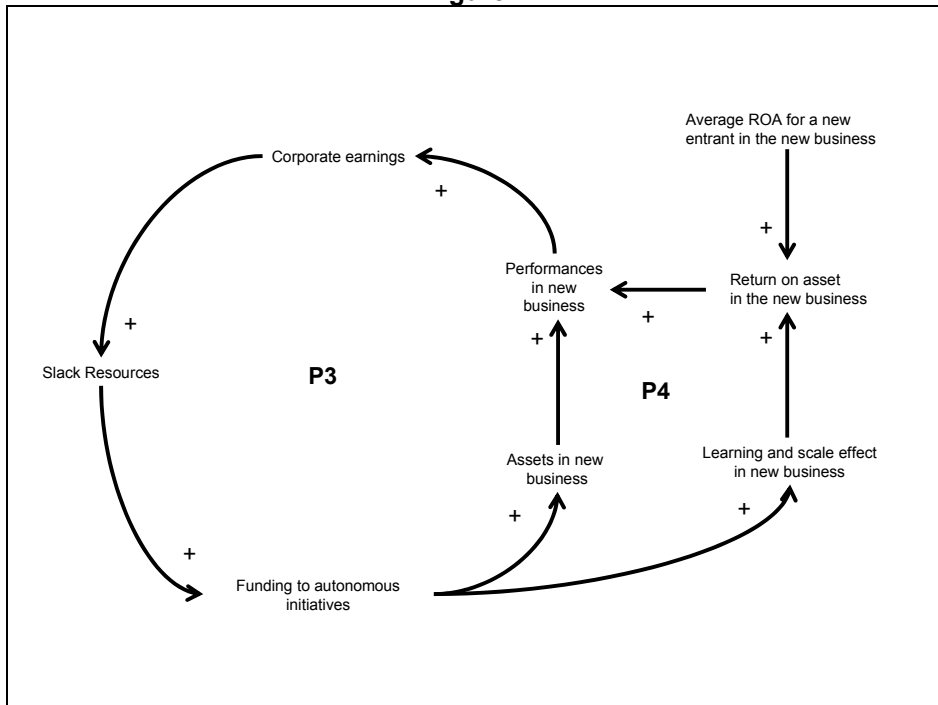
Figure 1
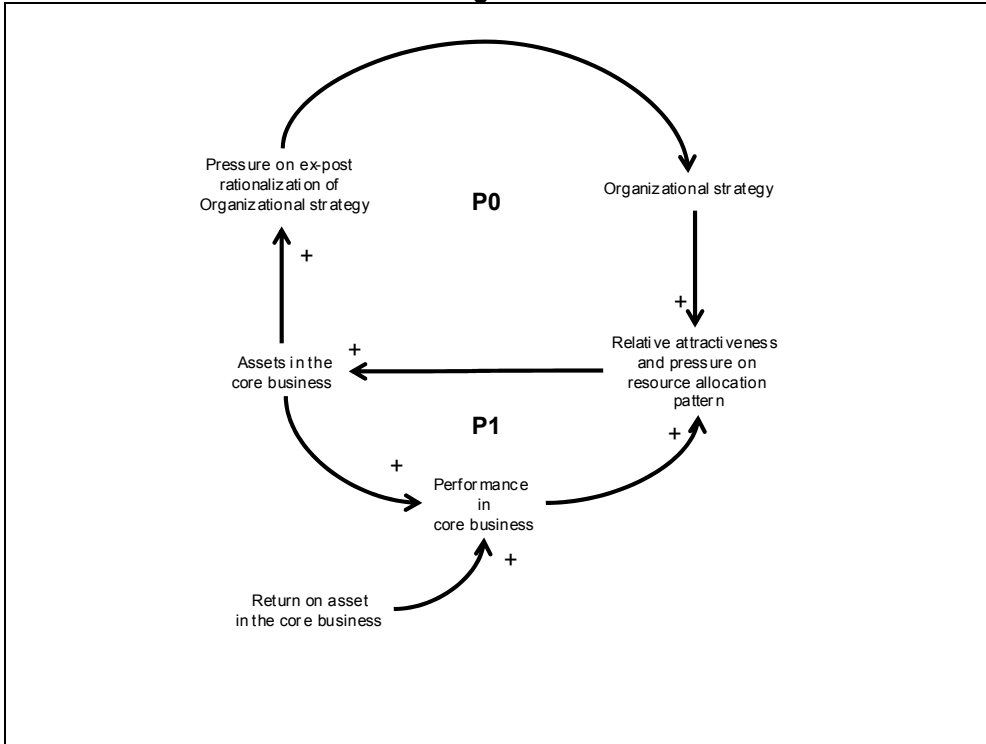
Figure 2
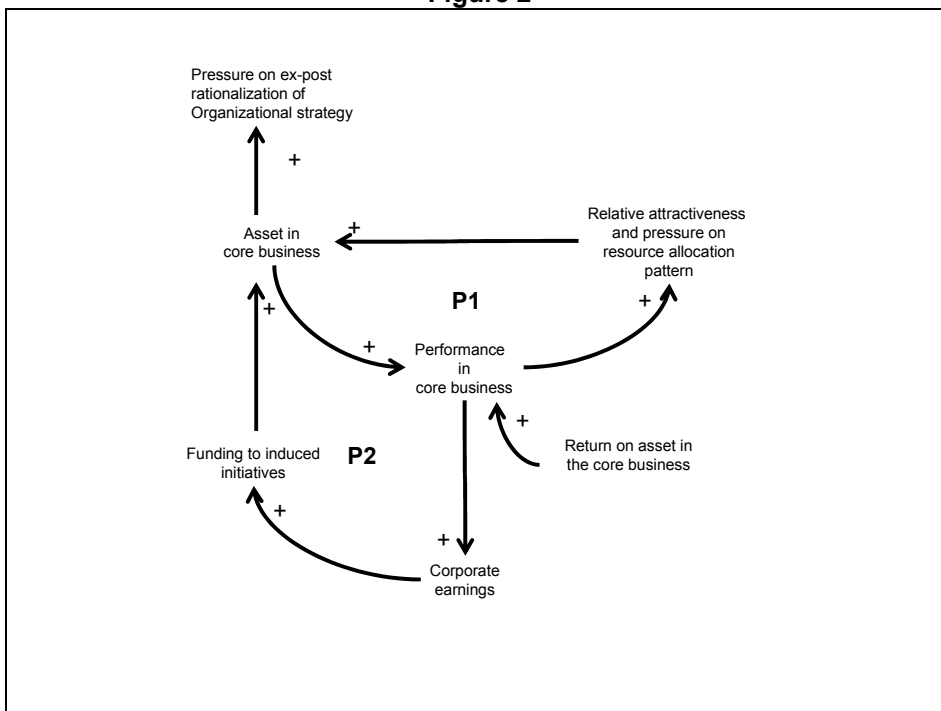
Figure 3

Figure 4

Figure 5
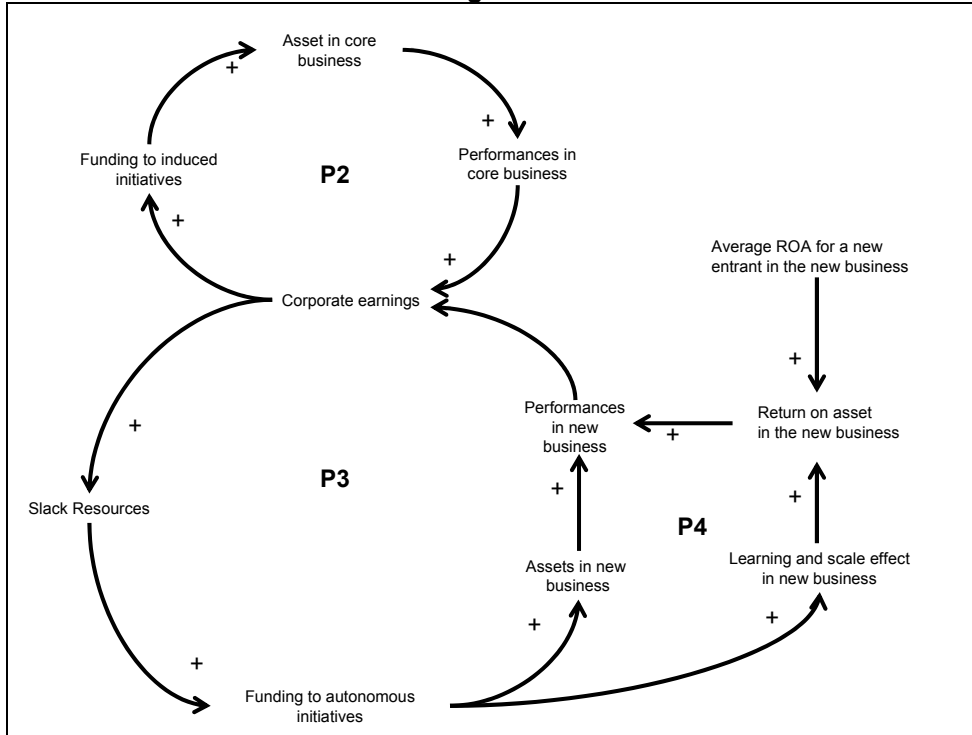
Figure 6
Equilibrium run
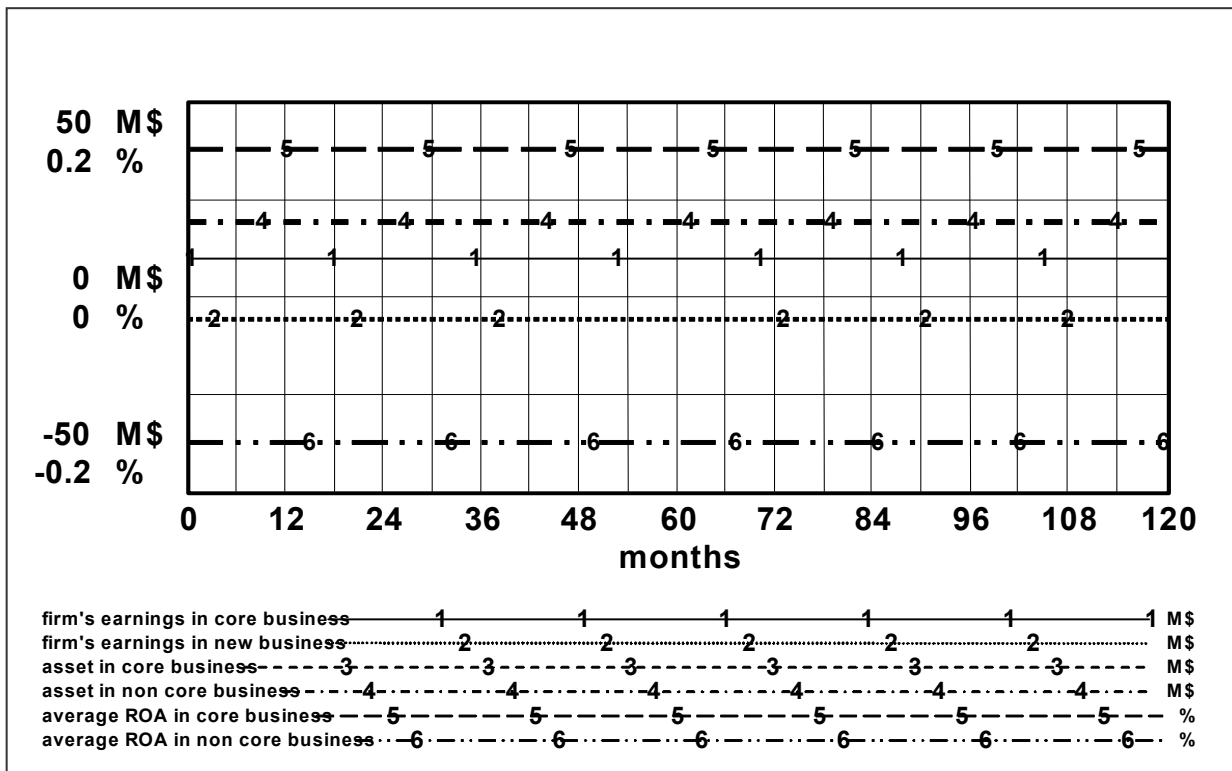
Figure 7
Environmental Scenario
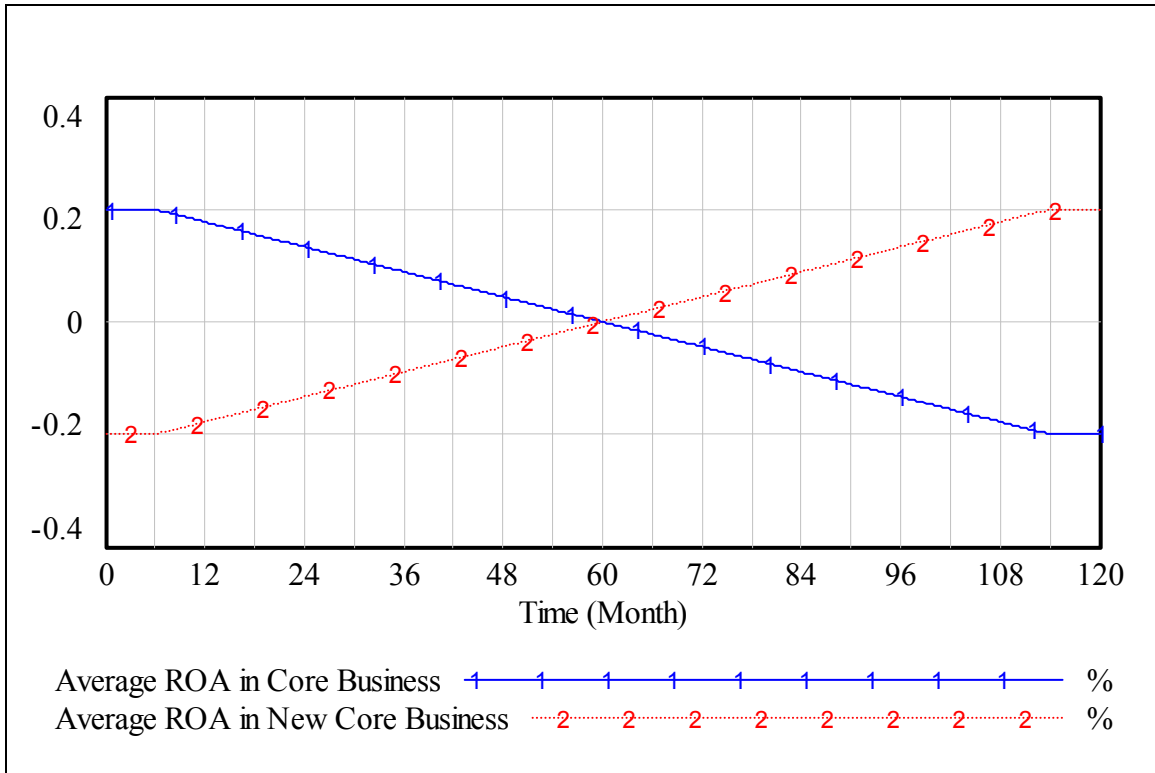
Table 2
Simulation experiments

	Initial stock in core business (C_0)	Initial stock in non core business (NC_0)	Initial stock of slack resources (SR_0)	Flow of slack resources (α_{Rf})	Weight of profit-maximization on resource allocation (*a*)
Values assigned in different calibrations of parameters	90	90	10	0.01	0.01
	80	80	20	0.1	0.1
	70	70	30	0.2	0.2
	60	60	40	0.3	0.3
	50	50	50	0.4	0.4
	40	40	60	0.5	0.5
	30	30	70	0.6	0.6
	20	20	80	0.7	0.7
	10	10	90	0.8	0.8
			100	0.9	0.9
				1	1

Table 3 – Adaptation patterns
Initial assets in core business = 85
Size on assets for experimentation in new business = 15

Flow of slack resources (α_{Rf}) (% of initial stock)	Initial stock of available slack resources (*SR*) (MI $)										
	0	10	20	30	40	50	60	70	80	90	100
0.01	1	1	1	1	1	1	1	1	1	1	1
0.1	1	1	1	1	1	1	1	1	1	1	1
0.2	1	1	1	1	1	1	1	1	1	1	1
0.3	1	1	1	1	1	1	1	1	1	1	1
0.4	1	1	1	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1	1	1	1
0.6	1	1	1	1	1	1	1	1	1	1	1
0.7	1	1	1	1	1	1	1	1	1	1	1
0.8	1	1	1	1	1	1	1	1	1	1	1
0.9	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1

Survival is indicated with 1; Failure is indicated with 0. Initial stock of assets in core business=85 MI $ and initial stock of assets in new business= 15 MI $.

Table 4 – Adaptation patterns
Initial assets in core business = 80
Size on assets for experimentation in new business = 20

| Flow of slack resources (α_{Rf}) (% of initial stock)	Initial stock of available slack resources (*SR*) (MI $)										
	0	10	20	30	40	50	60	70	80	90	100
0.01	0	0	0	0	0	0	0	0	0	0	0
0.1	0	0	0	0	0	0	0	0	0	1	1
0.2	0	0	0	0	0	0	0	0	0	1	1
0.3	0	0	0	0	0	0	0	0	0	1	1
0.4	0	0	0	0	0	0	0	0	0	1	1
0.5	0	0	0	0	0	0	0	0	0	1	1
0.6	0	0	0	0	0	0	0	0	0	1	1
0.7	0	0	0	0	0	0	0	0	0	1	1
0.8	0	0	0	0	0	0	0	0	0	1	1
0.9	0	0	0	0	0	0	0	0	0	1	1
1	0	0	0	0	0	0	0	0	0	1	1

Survival is indicated with 1; Failure is indicated with 0. Initial stock of assets in core business=80 MI $ and initial stock of assets in new business= 20 MI $.

Table 5 – Adaptation patterns
Initial assets in core business = 83
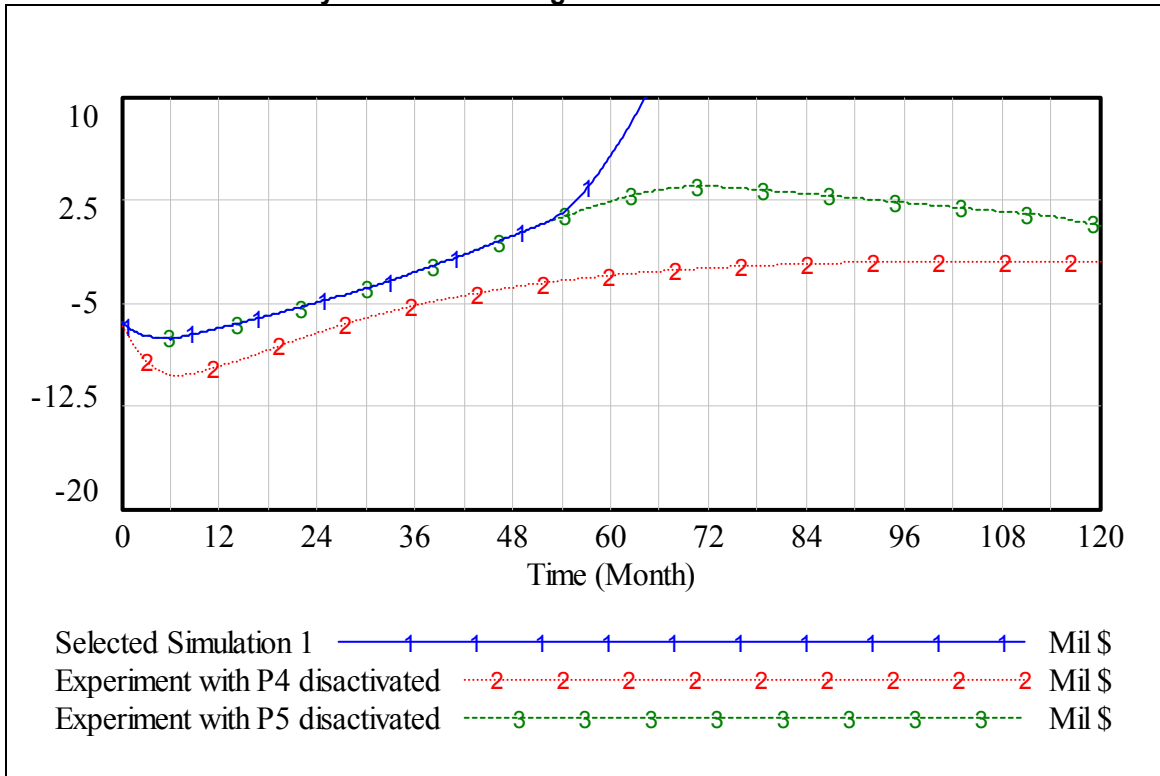**Size on assets for experimentation in new business = 17**

	Weight of financial criteria (% of funds assigned using profitability maximization)										
	0	10	20	30	40	50	60	70	80	90	100
Flow of slack resources (α_{Rf}) (% of initial stock)											
0.01	0	0	0	0	0	0	0	0	0	0	0
0.1	0	0	0	0	**1**	**1**	**1**	**1**	**1**	**1**	**1**
0.2	0	0	0	0	0	0	**1**	**1**	**1**	**1**	**1**
0.3	0	0	0	0	0	0	0	**1**	**1**	**1**	**1**
0.4	0	0	0	0	0	0	0	0	**1**	**1**	**1**
0.5	0	0	0	0	0	0	0	0	0	**1**	**1**
0.6	0	0	0	0	0	0	0	0	0	0	**1**
0.7	0	0	0	0	0	0	0	0	0	0	0
0.8	0	0	0	0	0	0	0	0	0	0	0
0.9	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0

Survival is indicated with 1; Failure is indicated with 0. Initial stock of slack resources =25.
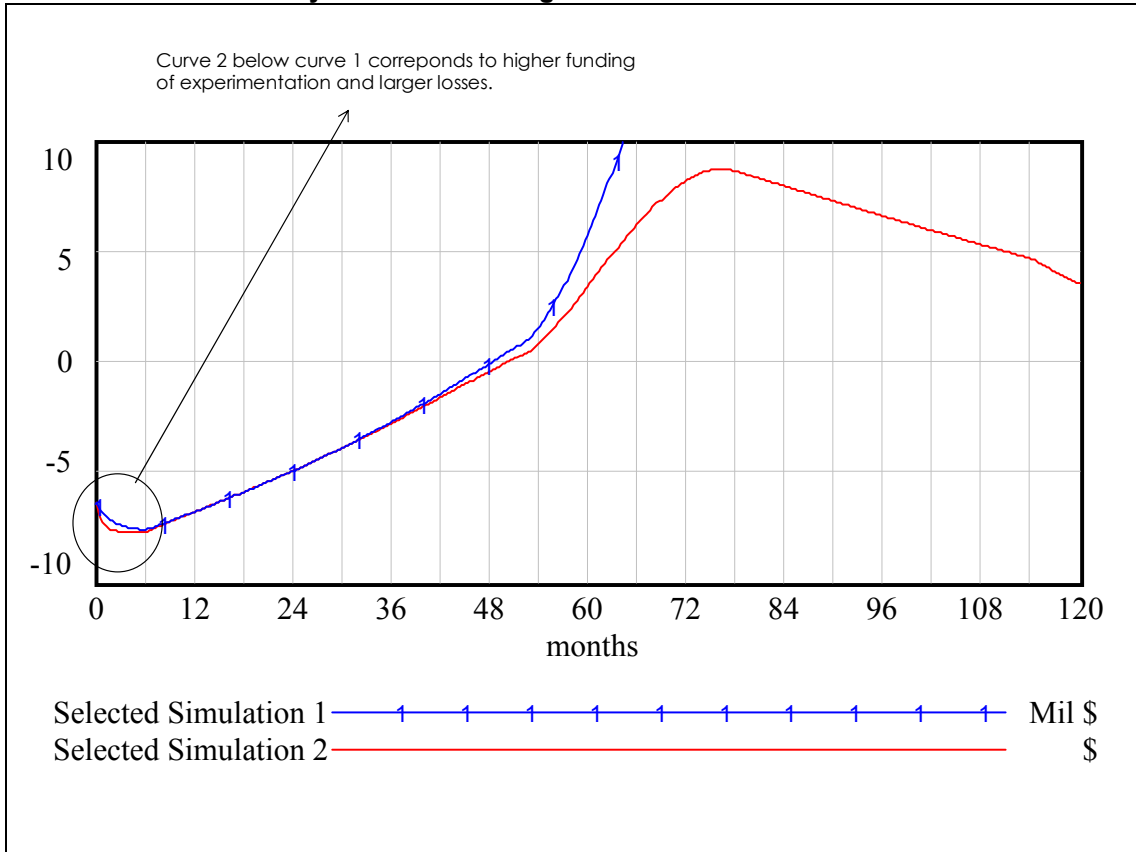Initial stock of assets in core business=83 Ml $ and initial stock of assets in new business= 17 Ml $.

Figure 8
Dynamics of Earnings and Industry Profitability
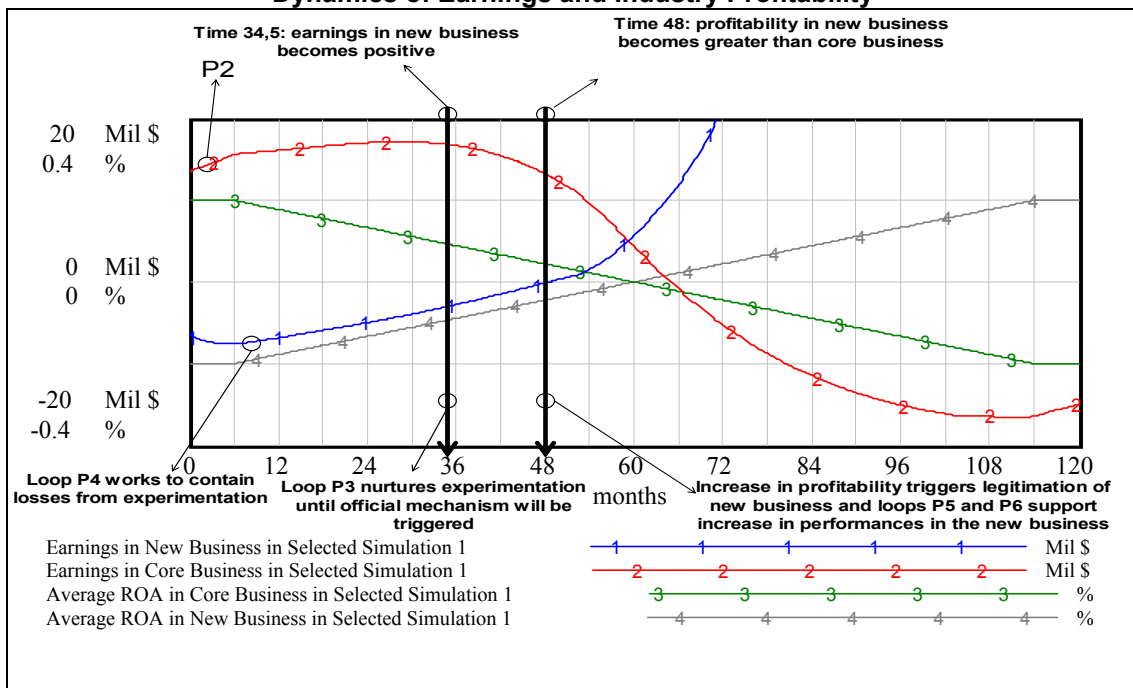
Figure 9
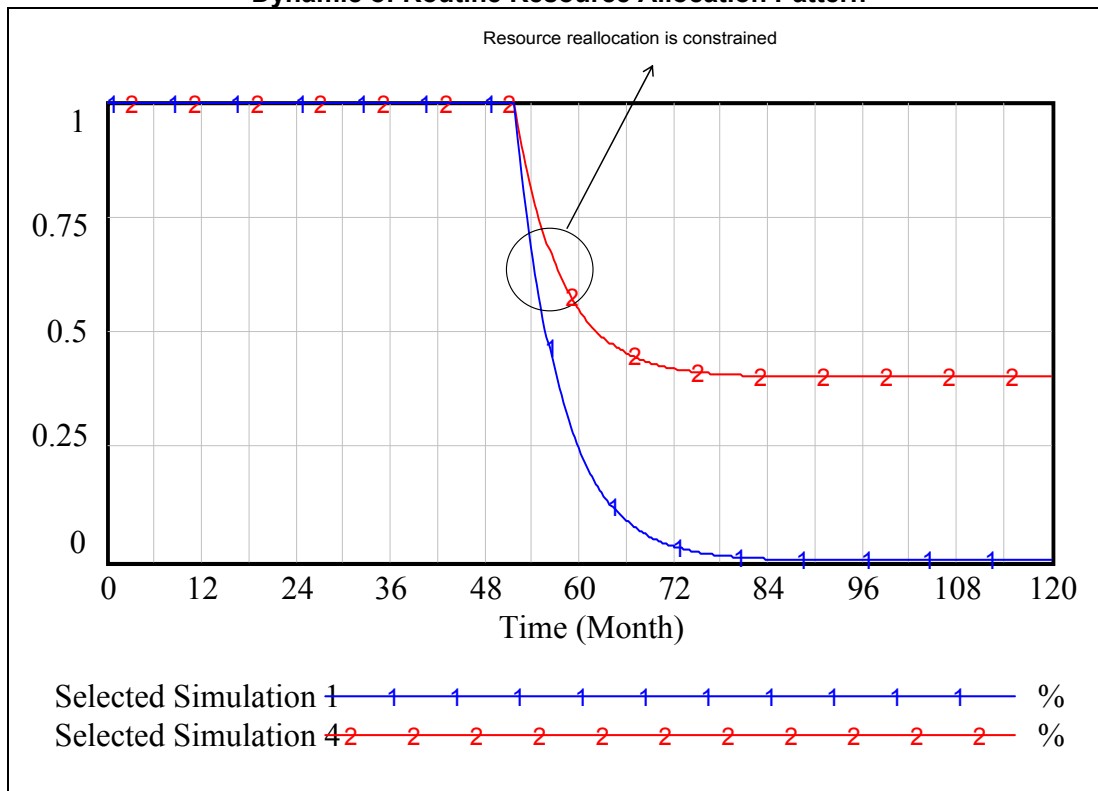**Dynamics of Earnings in Non-Core Business**

Figure 10
Dynamics of Earnings in Non-Core Business

Figure 11
Dynamics of Earnings in Non-Core Business

Smaller losses in the early history

Less strength of fedback P3 and P4

Selected Simulation 1 ——1——1——1——1——1——1——1——1——1——1—— Mil $
Selected Simulation 3 —2——2——2——2——2——2——2——2——2——2——2— Mil $

Figure 12
Dynamic of Routine Resource Allocation Pattern

When resource allocation pattern shifts, corporate earnings are dissipating.

Delay in shifting resource allocation pattern

Resource Allocation Pattern in Selected Simulation 1 —1——1——1——1——1—— %
Resource Allocation Pattern in Selected Simulation 3 ———————————————
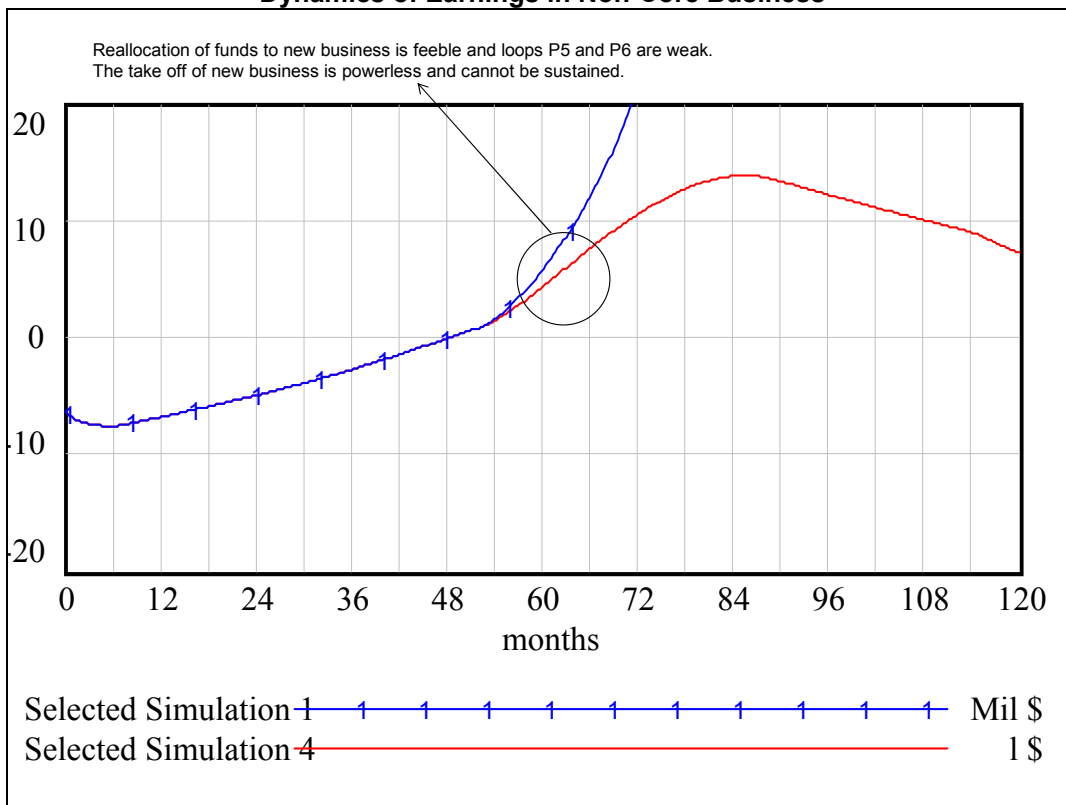Corporate Earnings in Selected Selected Simulation 3 —3——3——3——3—— Mil $
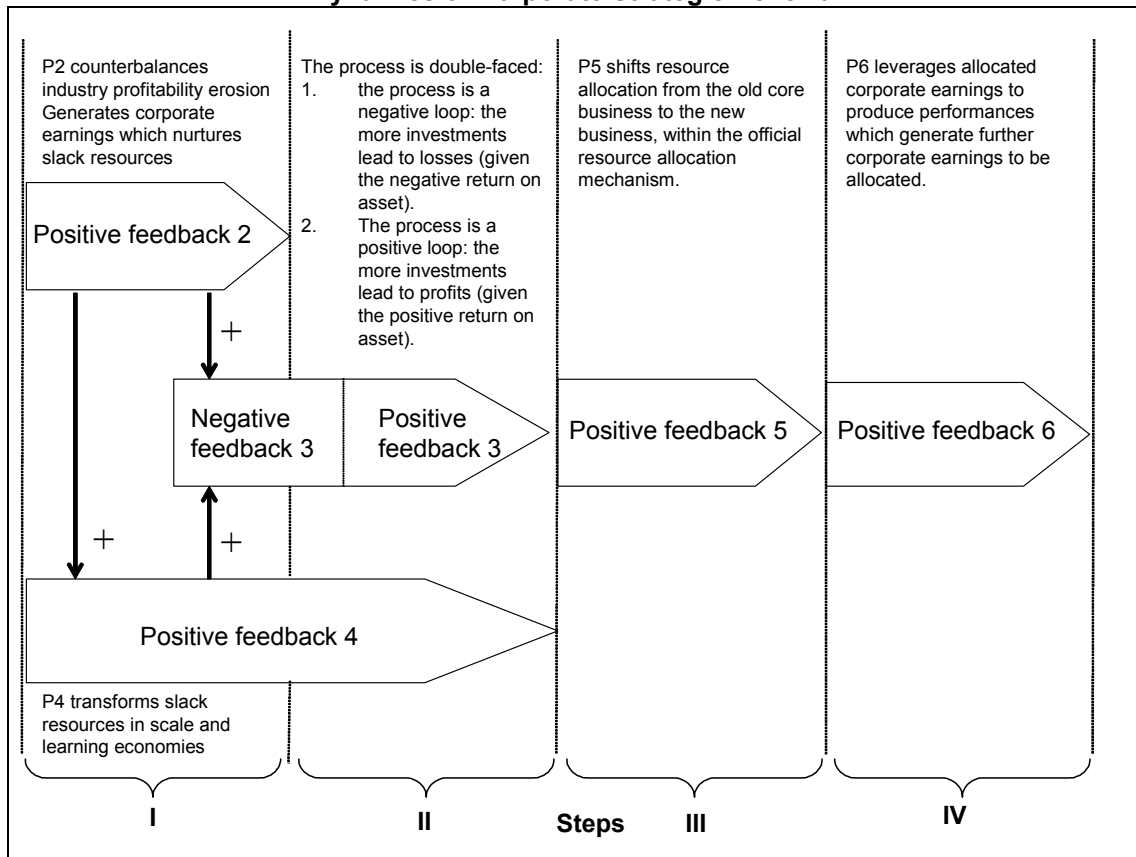
Figure 13
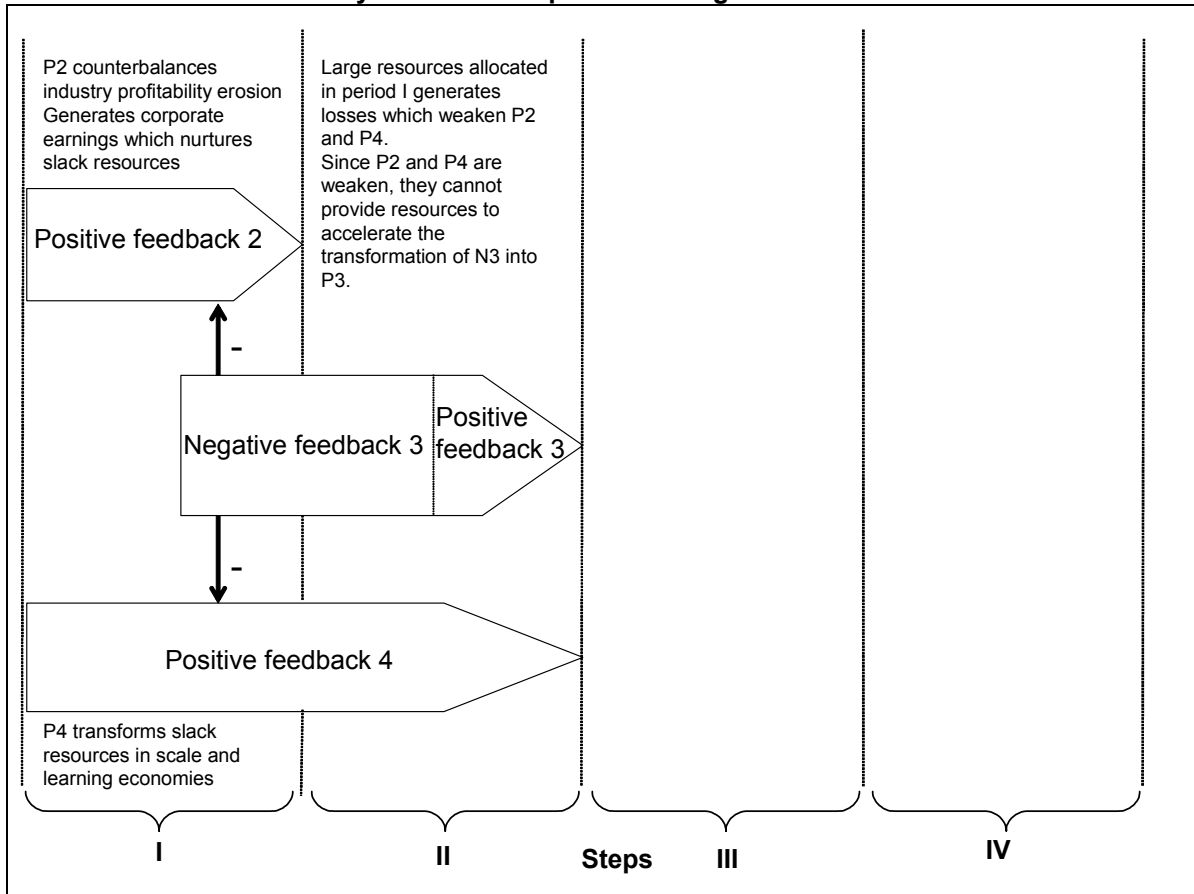**Dynamic of Routine Resource Allocation Pattern**

Figure 14
Dynamics of Earnings in Non-Core Business

Figure 15
Dynamics of Corporate Strategic Renewal

Figure 16
Dynamics of Corporate Strategic Renewal

P2 counterbalances industry profitability erosion Generates corporate earnings which nurtures slack resources

Large resources allocated in period I generates losses which weaken P2 and P4.
Since P2 and P4 are weaken, they cannot provide resources to accelerate the transformation of N3 into P3.

Positive feedback 2

-

Negative feedback 3   Positive feedback 3

-

Positive feedback 4

P4 transforms slack resources in scale and learning economies

I   II   **Steps** III   IV

Figure 17
Dynamics of Corporate Strategic Renewal

P4 should substitute P2 when this latter slows down. Since P4 is weaken, it cannot create resources to accelerate the transformation of N3 into P3.

Positive feedback 2

Negative feedback 3

Positive feedback 3

+

+

Positive feedback 4

+

P4 is weak and does not transform slack resources into enough scale and learning economies

I

II

Steps

III

IV
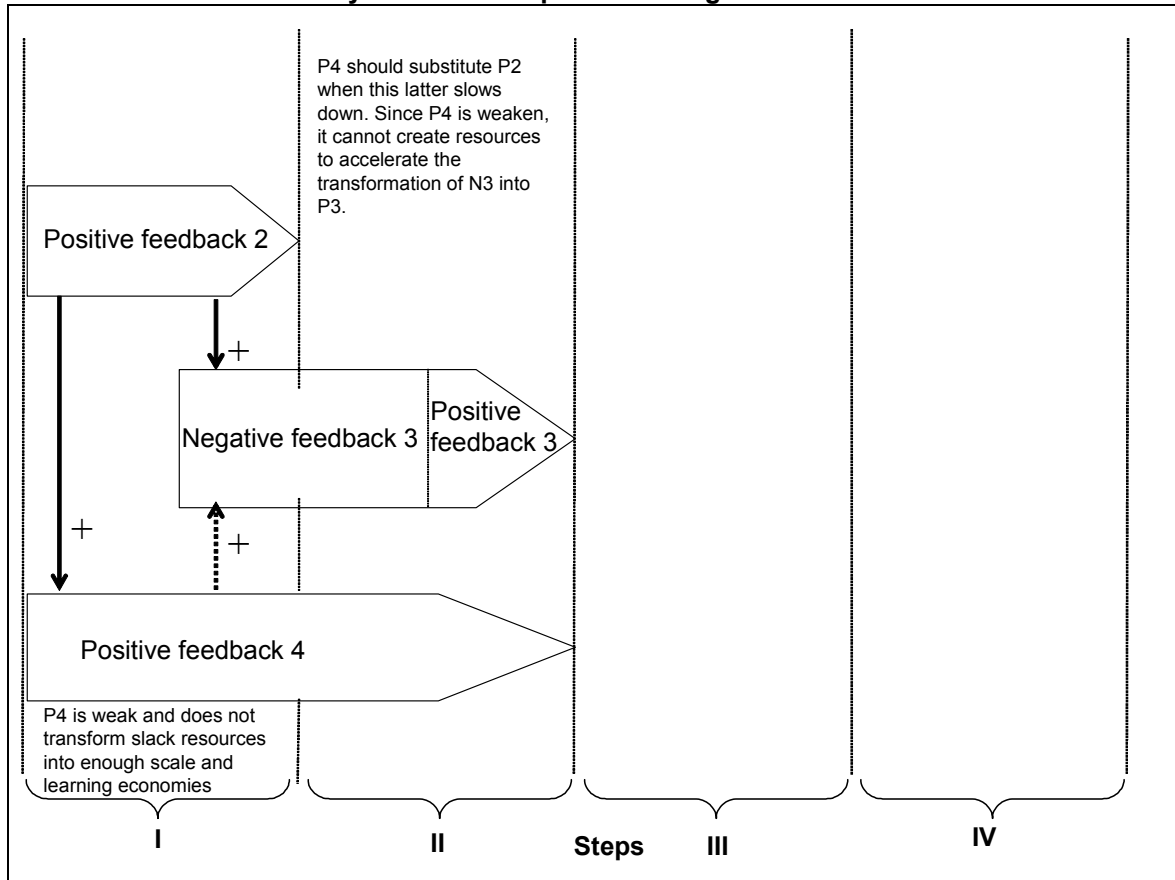
Figure 18
Dynamics of Corporate Strategic Renewal