

Dynamics in the Development of the Firm's Dynamic

Capabilities

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Abstract

This study uncovers hidden dynamics and policies in the development of what is referred to as the dynamic capabilities of the firm. In a quasi-experimental setting, i.e., on the basis of a model using differential equations various relationships and dynamics of knowledge accumulations in so-called *search and renewal capabilities* are studied, how they influence different levels of *organizational capabilities and core competencies*, which in turn determine the firm's value-adding potential under various scenarios via computer simulation. The study focuses on firm endogenous dynamics and demonstrates the interdependency of various likely influences leading to firm survival or failure. Interestingly, exogenous influences such as competitive pressures, the business cycle, and other external influences are not necessarily the main causes for early firm decay. Rather endogenous influences by themselves can be powerful inhibitors of a firm's long-term survival.

Introduction

How well private-sector organizations fare throughout their span of existence it is believed hinges upon the ends they are managed for regardless of industry sector or geography. For example, Rothschild remarked more than half a century ago that whether the firm is geared for maximum profit in a short-term sense or for secure, long-term profits will lead to different outcomes both short- and long-term (Rothschild, 1947). The better developed a firm's dynamic capabilities, i.e., its search and self-renewal as well as its daily-routine organizational capabilities and core competencies, the better are the prospects for its survival and wellbeing (Conner, 1991; Conner & Prahalad, 1996; Rumelt, 1984; Rumelt, 1995; Schumpeter, 1950; Schumpeter & Opie, 1934). In the same vein, competitive advantage as studied in the strategic management literature can be

understood in two ways, short-term (as most of the literature implicitly does) or long-term. In the latter case, one would speak of sustained competitive advantage, which is essentially equivalent to long-term firm survival.

The paper is organized as follows: It first reviews the contributing literatures of various theories of the firm including stakeholder theory. It then discusses an integrated perspective of these theories and particularly the relationships between the dynamic capabilities of the firm, its relative effectiveness in terms of added value on the one hand, and the dependency of a firm's success on sufficient confidence on the part of internal stakeholders on the other hand, by means of a model using differential equations. It finally presents and evaluates the results of simulations under various scenarios. The results are confronted with claims made by IT-based knowledge management regarding sustained firm success. Figures showing results from experiments are presented in the Appendix.

Related Literature

The Economic, Strategic Management, and Organizational Theory (OT) based Literature of the Firm

The literature can be grouped into two broad groups:

- (1) The traditional strands, that is, the neoclassical, transaction-cost, principal-agent based economic literature and the cognitivist/connectionist organizational theory (OT) and its behavioral theory of the firm, (cf., for example, (Agarwal & Gort, 1996; Agarwal & Gort, 1999; Alchian, 1950; Alchian, 1977; Alchian, 1993; Alchian & Demsetz, 1972; Audretsch, 1995; Audretsch & Mata, 1995; Caves, 1980; Coase, 1937; Coase, 1991; Cyert & March, 1963; Eisenhardt, 1988; Eisenhardt, 1989; Evans, 1987; Foss, 1994; Holmstrom & Tirole, 1989; Hopenhayn, 1992; Jensen, 2000; Jensen & Meckling, 1976; Jovanovic, 1982; Jovanovic & Lach, 1989; Jovanovic & MacDonald, 1994; Kaplan & Brookings Institution., 1964; Klepper, 1996; Knight, 1921; Laffont & Martimort, 1997; March & Simon, 1958; Mata & Portugal, 1994; Mowery, 1983; Mowery, 1984; Prietula & Watson, 2000; Richardson, 1972; Rothschild, 1947; Simon, 1951; Simon, 1957; Williamson, 1963; Williamson, 1975; Williamson, 1987; Williamson, Winter, & Coase, 1991)), and
- (2) The Schumpeterian/neo-Schumpeterian and postmodern strands, that is, the evolutionary, resource, and knowledge-based economic literature, the latter two of which blend with the strategic management literature (cf., for example, (1999; Barney, 1989; Barney, 1991a; Barney, 1991b; Barney, 1996; Barney, 2001; Bianchi, 1995; Bogner, Mahoney, & Thomas, 1998; Chandler, 1977; Chandler, 1992; Cohen & Cyert, 1965; Conner, 1991; Conner & Prahalad, 1996; Demsetz, 1991; Dimock, 1959; Dosi, Nelson, & Winter, 2000a; Dosi, Nelson, & Winter, 2000b; Grant, 1996; Hall, 1991; Hamel & Prahalad, 1994; Hunt, 1997; Kogut & Zander, 1995; Kotter & Heskett, 1992; Langlois & Foss, 1999; Levinthal, 2000; Loasby, 1998; Mahoney,

1995; Makadok, 2001; Montgomery, 1995; Morgan, 1986; Nelson, 1991; Nelson & Winter, 1982; Nonaka & Takeuchi, 1995; Penrose, 1959; Pfeffer, 1994; Pfeffer & Salancik, 1978; Porter Liebeskind, 1996; Radner, 1996; Rumelt, 1984; Rumelt, 1987; Rumelt, 1991; Rumelt, 1995; Schein, 1992; Schumpeter, 1950; Schumpeter & Opie, 1934; Simon, 1979; Simon, 1991; Simon, Egidi, & Marris, 1995; Spender, 1996; Spender, 1998; Stinchcombe, 1990; Teece, Pisano, & Shuen, 1997; Tsoukas, 1996; Wernerfelt, 1984; Winter, 1991; Zander & Kogut, 1996). Into this broad category also fall the OT literature which views the firm as an emergent phenomenon based on the interaction of individual actors or agents (Taylor & Van Every, 2000) as well as what I propose to call the Holistic Theory of the firm as presented by de Geus (Geus, 1997a; Geus, 1997b)) in the tradition of Chester Barnard's epochal work (Barnard, 1960).

While the traditional strands emphasize the physical or, at least, tangible and quantifiable aspects of economic action and of organization, the neo-Schumpeterian and postmodern strands (without abandoning the tangible aspects) highlight evolutionary and emergent phenomena, which include intangible, tacit (cf., (Polanyi, 1966)), and hard-to-quantify aspects, and attempt to capture their interplay. The two strands are, however, anything but monolithic within themselves.

While neoclassical theory, for example, assumes perfect rationality on behalf of homogeneous economic actors who combine inputs in order to maximize profits, exercise given decision rules with which they pick well-defined choices in equilibrium and homogeneous markets, Williamsonian transaction-cost theory assumes an environment of uncertainty in which self-interested actors commanding specific and heterogeneous assets have only bounded rationality at their disposal but seek to minimize transaction costs through effective contracting.

The postmodern strand emphasizes the heterogeneity of those resources a firm controls, hence, firms cannot be seen as homogeneous entities. However, this strand of literature is not in agreement on what is defined by the term "resource." While some scholars subsume both physical and non-physical assets under the term, others also include firm-specific knowledge, cultural capacities, and dynamic capabilities under this rubric. OT scholars emphasizing the emergent nature of organizations support this latter view.

The OT literature is less concerned with microeconomics' dependent variable, that is, firm success and performance; rather it is more focused on organizational structure and process. However, according to the resource-based view of the firm these variables co-determine the economic outcome. As Rothschild pointed out long ago, a firm

Finally, the holistic theory of the firm as presented by de Geus and Barnard may be viewed as integrating major key concepts of both the traditional and postmodern literatures.

Strand	Main Focus	Key Assumptions	Survival depends on
Traditional Theory	<ul style="list-style-type: none"> • Tangible assets and quantifiable processes 	<ul style="list-style-type: none"> • (Rather narrow-minded) human individual self-interest • Rationality or bounded rationality as predominant dimensions underlying actor's behavior 	<ul style="list-style-type: none"> • Initial endowments • Learning-by-doing • Effective contracting • Effective standard routines
Postmodern Theory	<ul style="list-style-type: none"> • Idiosyncratic resources • Dynamic capabilities • Competencies 	<ul style="list-style-type: none"> • Rents grow from idiosyncratic resources and their skillful (re-) combinations • Innovation hinges on dynamic search and change capabilities • The tacit part of knowledge and capabilities is the main source of rents and competitive advantage • Human actors have a vested interest in collaboration 	<ul style="list-style-type: none"> • Competitive advantage • Sustainable rents through ongoing innovation
Holistic Theory	<ul style="list-style-type: none"> • Firm survival • Organizational flexibility • Self-renewal and adaptation • Firm as social entity providing 	<ul style="list-style-type: none"> • Firms are living systems • Firms are idiosyncratic • Firms survive or decay depending on the ends they are managed for 	<ul style="list-style-type: none"> • Conservatism in financing • Organizational and cultural cohesion • Sensitivity to environment

	acceptable returns for all involved	are managed for <ul style="list-style-type: none"> Secure profits are an inevitable result of management for survival 	<ul style="list-style-type: none"> Openness and capability to change
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Table 1 Overview of Economic and OT Theories

The Stakeholder Theory Literature

While the resource-based perspective of the strategic management literature has produced large overlaps with the economic literature on the firm, stakeholder theory, which originated as another research tradition in the strategic management literature has not made a comparable imprint on economic theory like, for example, principal-agent theory with which it competes (Donaldson & Preston, 1995; Key, 1999). Stakeholder theory proposes that beyond shareholders and their managerial agents other constituents such as employees, customers, suppliers, and others are critically important for the firm’s success since these groups or individuals may impact or be impacted by the firm’s pursuit of its objectives (Freeman, 1983; Freeman, 1984; Freeman, 1999; Freeman & Evan, 1990; Frooman, 1999; Mitroff, 1983). Two research traditions have evolved: (1) the social science track and (2) the business ethics track (Donaldson, 1999; Donaldson & Preston, 1995; Mitchell, Agle, & Wood, 1997) which are supported by different justifications (Clarkson, 1994; Clarkson, 1995; Donaldson, 1999; Jones, 1997; Jones, 1995; Jones & Wicks, 1999; Maren & Wicks, 1999; Phillips, 1997; Reed, 1999). Clarkson holds that firms as a going concern can only survive as long as their primary stakeholders continuously support the firm secured by acceptable, or “adequate”–not equal–returns as he calls it (Clarkson, 1995, 110).

Strand	Main Focus	Key Assumptions	Survival depends on
Social Science	<ul style="list-style-type: none"> Stakeholder salience Stakeholder influence Firm’s influence on stakeholders 	<ul style="list-style-type: none"> The firm is not only an economic but at the same time also a social entity Stakeholder management improves economic outcome Conflict resolution and alignment of interests is 	<ul style="list-style-type: none"> Continued confidence and support of primary stakeholders maintained through <i>adequate</i> returns to this group Understanding the socio-economic nature of firms

		possible in principle	
Business Ethics	<ul style="list-style-type: none"> • Norms governing stakeholder participation and firm behavior 	<ul style="list-style-type: none"> • Beyond existing contracts or laws a firm's stakeholders possess certain rights • Firms have to obey such codified or non-codified norms 	<ul style="list-style-type: none"> • <i>The business ethics strand is uninterested in answering this question</i>

Table 2 Overview of Stakeholder Theory

Related Theories on Survival (Autopoiesis, Autonomy, and Syn-Reference)

Metaphors and analogies from life sciences permeate other sciences including economics, for example, with the life cycle concept in economics as the case in point. Some authors such as Miller or de Geus go as far as declaring organizations and firms living systems. Edith Penrose persuasively dismissed such analogies more than half a century ago (Penrose, 1952). When compared with the modern biological theory of the living (Maturana, 1981; Maturana & Varela, 1980; Maturana & Varela, 1987; Mingers, 1995; Varela, 1984; Varela, 1979; Varela, 1981; Varela, 1992; Varela, 1996; Varela & Bourguine, 1992; Varela & Dupuy, 1992; Varela, Thompson, & Rosch, 1991; Von Foerster, Zopf, & United States. Office of Naval Research. [from old catalog], 1962) the analogy of firms as living systems does not hold.

Organizations unlike living systems do not reproduce themselves in a circularly closed, self-maintaining, and self-referential fashion. Even a relaxed version in terms of firms as autonomous non-living systems can hardly be maintained since the full recursiveness of organization as demanded by autonomy cannot be demonstrated, on the contrary. However, the sociological adaptation of partially self-referential, in Hejl's definition "syn-referential," organization allows to adapt a process view of organization which accounts for its emergent nature, its path dependence, and its increasing degrees of freedom for innovation and change the more complex the organization becomes (Glaserfeld, 1995; Heidegger, 1962; Heidegger, 1971; Hejl, 1980; Hejl, 1981; Hejl, 1982; Hejl, 1984; Hejl, 1988; Hejl, 1989; Hejl, 1998; Hejl & Universität-Gesamthochschule-Siegen. Institut für Empirische Literatur- und Medienforschung., 1985). Individual members of organizations modulate each other's states, and by doing so, they modulate the state of the organization but not in its totality as in the case of living or non-living autonomous systems. Syn-reference, hence, defines a concept of coordinated behavior of individuals and groups, which maintains the notion of organizational closure in a relaxed fashion. Hejl's definition does not refer to technical task-coordination alone but also to cultural, value, and belief coordination of individuals and groups. A strong organizational culture then marks a high degree of syn-referential

coordination while a weak culture does not. The discussion of whether the firm is a living system or (only) a syn-referential system is of central importance for any analysis or prediction regarding survival or management.

Living systems' processes, since they are circularly organized and closed once uncovered can highly be predicted while syn-referential processes with n degrees of freedom can obviously not. Firm survival hence cannot be seen as a biological phenomenon, in which bootstrapped and unchangeable circular processes have to be maintained, but rather as the successful maintenance of syn-referential processes, that is, the organizational and individual modulations based on the interactions of individual members, with n degrees of freedom.

In other words, while the first task would make firm survival management more or less a medical task, the second does not. Hejl also makes the point that syn-referential human interaction and coordination is inherently directed towards individual self-preservation and survival. Individual self-preservation, though, rests on syn-reference. This notion stands in stark contrast to neoclassical economic assumptions of predominant opportunism and overwhelmingly self-interested behavior at the expense of others. In Hejl's framework the mode for individual survival is coordination and cooperation through a multitude of social and societal organizations including the firm.

Strand	Main Focus	Key Assumptions	Survival depends on
Sociological Theory of Syn-reference	<ul style="list-style-type: none"> • Individual interaction and social reality produced by individual interaction • Modulation of individual and organizational behavior through syn-referential interaction 	<ul style="list-style-type: none"> • Organization are (partially) organizationally closed • Social reality and coordination of behavior arises from syn-referential interaction • Social systems are emergent 	<ul style="list-style-type: none"> • Continued syn-referential coordination in social systems

Table 3 Overview of the Theory of Syn-reference

Proposing an Integrated Theory of Firm Survival

The three literatures used in this study allow viewing firm survival through different lenses. Except for a few areas, however, the theories presented do not contradict but rather complement each other. One of the few exceptions is the neoclassical assumption of individual opportunism and even guilefulness as basic mode of human nature. Economists themselves have criticized this assumption as grossly overstated and outright

wrong in its absolute version for a long time (cf., for example, (Conner, 1991; Dobson, 1994)).

Resource-based theory, stakeholder theory, and most strongly the sociological theory of syn-reference provide a contrasting picture claiming to match up with both intuitive and scientific observation. Self-preservation as the main self-interest in this view leads individuals to engage into collaboration and coordinated behavior because such coordination provides for superior chances of self-preservation with the firm as a case in point. The first Holmstrom & Tirole question, hence, can also be answered from a socio-economic point of view: Firms as purposeful human organizations in this view might be formed because they are perceived (at least by a large number of constituents) to help serve the most fundamental self-interest of self-preservation by those individuals who engage into them. Firms that promise economic success serve this fundamental interest. Those that do not are unlikely to be formed or maintained. The initial appeal of the Coasian transaction cost argument does not really stand the test of historical accounts of firm formation (cf. (Chandler, 1962; Chandler, 1977; Cowling & Sugden, 1998)).

The reach of the three literatures outlined is limited for the purpose of understanding firm survival as long as they are kept in isolation. However, once the various economic strands are augmented by and connected to the other two theories, a new perspective on firm survival emerges that ties economic success to the long-term interest of individual and group self-preservation as it is formulated by stakeholder theory and the theory of syn-reference.

As discussed above, de Geus's holistic theory of firm survival can be viewed as implicitly assuming such an integration of contributing theories without theoretically developing this foundation of such an integration as pursued by this research. However, though the theoretical foundations were not developed by de Geus, the four characteristics of survivor firms that he proposes can nevertheless be used for testing the explanatory power of an integrated theory of firm survival, which leads to the following three propositions (cf., (Geus, 1997a; Geus, 1997b)):

Proposition 1: Firms that maintain sufficient search and renewal capabilities are less likely to decay early than those that do not.

According to de Geus, the tolerance to internal experimentation and risk-taking in terms of deviating from known procedures and established processes is crucial for firm survival. De Geus also proposes that firms, which are sensitive to their environment, extend their response times significantly and, thus, enjoy better survival prospects. These two notions of (1) tolerance to new ideas and (2) sensitivity to the environment are mainly captured by the accumulation of search and renewal capabilities in the model presented below. Starvation of these capabilities hence should lead to the modeled firm's decay over time.

Proposition 2: Firms that continually provide for discretionary funds are less likely to decay early than those that do not

De Geus emphasizes the necessity to accumulate discretionary funds in order to be able to weather difficult times and build capabilities when external funding may be

constrained or even unavailable. He emphasizes the importance of conservative financing and also warns against too excessive growth, which may result in financial stretch and outside control. Unavailability of discretionary funds should lead to decay of the modeled firm.

Proposition 3: Firms that are cohesive are less likely to decay early than those that are not

Firm cohesion (or awareness of their identity) is another prerequisite for firm survival in de Geus's view. This is in a sense the "softest" of all concepts in his holistic theory. However, both stakeholder theory and the theory of syn-reference provide a handle for this concept. Cohesion without confidence of internal primary stakeholders (or interacting and mutually modulating individuals) is unconceivable. Whether or not the confidence accumulation of internal constituents in the model presented below captures all facets of this concept (for example, cultural alignment and coordination to name just one) may be debatable. For this research it is taken as a proxy for de Geus's concept of cohesion. If the confidence level of internal constituents (as modeled) is drastically depleted negative impacts on the survival chance of the modeled firm should be observable.

Proposition 4: Firms, which maintain sufficient search and renewal capabilities AND provide for discretionary funds AND are cohesive, are less likely to decay early than those which do not fulfill these three conditions.

This fourth proposition explicitly tests both the necessity and the sufficiency of concurrence of all three characteristics for long-term survival, and, hence must be seen as the strongest test of the superior explanatory power of an integrated theory of firm survival.

The Integrated Model of the Generic Firm (The COSID Model)

As Dierickx and Cool have demonstrated, firms can be viewed as asset accumulations of various kinds. These accumulations or stocks cannot be increased or decreased immediately as the two authors explained. Changes to them occur only on the basis of inflows and outflows over time (Dierickx & Cool, 1989), which is why the impact of managerial intervention becomes observable not immediately, but only after some time has elapsed. At any given point in time, though, the state of the firm can be determined by the state of its stocks.

In the following, the model of the generic firm and its various sectors are laid out in more detail. In it, the trajectory of a generic firm from its inception is tracked over time. This model of differential equations is of 8th order (disregarding four three-level trend integrations). Its time unit is one year, its time step one eighth of a year, and simulations are run for one hundred time units (years). Variables referred to as stocks are integrals over time while variables labeled as flows (inflows and outflows) are the first derivatives of such integrals. All other variables are auxiliaries or constants. Effects are modeled as

nonlinear graphical functions (represented in look-up tables). However, for reasons of less restricted readability I chose a non-mathematical presentation format of the model for this paper.

The so-called COSID model comprises five sectors: (1) the sector of physical assets (capital, material, and labor), (2) the sector of organizational capabilities and core competencies, (3) the sector of search and renewal capabilities, (4) the sector of internal constituents' confidence, and finally (5) the sector of discretionary funds.

While the physical side of the firm's input combining activity and its basic circular organization are described in the capital, material, and labor sector, its organizational capabilities and core competencies as modeled in the respective sectors determine the amount of value added by combining those inputs of capital, material, and labor. Since organizational capabilities and core competencies diminish over time for various reasons, they are replenished by the firm's search and renewal capabilities. Both types of capabilities, the organizational capabilities, for example, standard routines, and core competencies along with the search and renewal capabilities compose what has been named the dynamic capabilities of a firm. Depending on the firm's internal constituents' confidence, these dynamic capabilities can have different degrees of effectiveness over time. Finally, the availability of discretionary funds as modeled in the respective sector influences the firm's continued access to funds regardless of external or internal capital supply. Discretionary funds are conceived as routinely being used for acquisition and replenishment whenever the ratio between search and renewal capabilities and the physical assets or the ratio between organizational capabilities and core competencies and the physical assets degrades.

Not included in the model are sectors covering (a) the capital, material, and labor supplier side, (b) the buyer side, and (c) the competitive/industry side. These influences are taken into account through parameter inputs. These three sectors may be included into future versions of the model.

(1) The Capital, Material, and Labor Sector

This sector represents the physical side of assets combined by the generic firm. In this sector, the firm's basic cyclical feedback is represented involving the physical asset stocks, the combining of these inputs in a value-added fashion, the gaining of surpluses after sales, and the re-investment of a surplus fraction and of new investments into these stocks of physical assets, which are then re-combined, and so forth.

On a high level of aggregation, two basic stocks can be viewed as common to every firm, small and large, manufacturer, service firm, or trader: (a) novel assets of capital, material, and labor (*NCML*), and (b) mature assets of capital, material, an labor (*MCML*). Though accounting practice distinguishes between these three components, their aggregation into a cluster of capital, material, and labor (*CML*) reflects the interdependence between these elements.

No labor (skilled or unskilled) can bear any productive results without quantitatively and qualitatively corresponding material and capital. An industrial analyst without a functioning networked computer, for example, is not capable of performing at the same level of sophistication as with such a device. Likewise, the most advanced tool is rendered worthless if not operated by a skillful mind or hand. In other words, assets of capital, material, and labor correspond. If they do not correspond, they cannot be combined efficiently in a value-adding fashion as purposively done within a firm.

The aggregation of clusters of corresponding assets of capital, material, and labor can be seen as a defining characteristic of the firm. Along a traditional Coaseian line of argument, it is this corresponding nature of capital, material, and labor accumulated in an asset stock, which provides the firm's transaction cost advantage over the exchange market.

The distinction between novel and mature *CML* establishes that corresponding physical assets undergo a maturation process before they reach their full potential and finally age. One could have argued in favor of a further disaggregation into three stocks of corresponding physical assets of novel, mature, and old *CML*. For reasons of simplicity I opted in favor of skipping this degree of complexity for this study.

When these *NCML* and *MCML* are set into action, that is, when they are combined within a firm, value is supposed to be added and realized through sales in a process, which offsets the cost of both combining these assets and the assets' depreciation. Before detailing this process, however, the inflows and outflows to the two *CML* stocks have to be discussed. The *NCML* stock has one inflow (*Acquisition of Novel CML, anc*) and two outflows, the *Loss and Discard of NCML (lnc)* and the *Maturation of NCML (mnc)*.

As in the case of *NCML* also *MCML* can be acquired from outside the firm. This is represented by the inflow of acquisition of *MCML (amc)*. *MCML*, however, will predominantly be increased by the maturation of *NCML (mnc)*, since this provides typically the superior cost position and improved control. Mature assets, of course, also are subject to intended and unintended loss, which is represented by the outflow of *Loss and Discard of MCML (lmc)*.

The sum of the two physical asset stocks of *NCML* and *MCML* is what the firm puts into use at any given point, that is *Total CML in Use (tcu)*. Each single *CML* cluster, that is, each single *CML* unit in these two stocks, if combined in a value-adding fashion, leads to a firm's total output potential (*f_{top}*). This potential output, then, can be represented on the basis of an average dollar value per *CML* unit (which reflects the cost for combining these inputs and for depreciation of their depreciable parts), which then renders the total cost of *CML* in use (*tccu*).

The more *CML* units combined and the higher the total value added (*tva*), the higher is the firm's total output potential. The firm then may sell any fraction of its potential output, that is, *Actual Sales (as)*. In the current implementation of the model, I disregard order backlogs or overcapacity. These two phenomena have been widely studied (cf., for example, (Forrester, 1961; Sterman, 2000)). Nowhere in the literature they were

attributed to the systemic decay of a firm or the loss of its long-term competitiveness, which is why they are not included in this version of the model.

From *Actual Sales (as) Surplus (s)* is generated, which then is directed into (a) the payment of *Dividends (div)*, that is, leaving the firm's physical self-feeding and self-producing cycle, (b) *Discretionary Funds (df)*, or (c) *Total Re-investments (tr)*. *Total Re-investments*, in turn, can be increased by *New Investments (ni)* from firm-external sources.

The total re-investments are directed toward the acquisition of both *NCML* and *MCML*, the ratio of which is subject to managerial discretion. Through the parameter of *NCML acquisition fraction (naf)*, the ratio of *NCML*-to-*MCML* acquisition can be determined. A *Premium for Acquiring MCML (pam)* is assumed, since more mature clusters of *CML* typically bear a higher market price. If IBM, for example, hires a new CEO from outside, at the time of acquisition it consumes a higher amount of available funds than hiring a junior sales representative who may need decades until he matures to become eligible for the position through internal promotion. In the model, this premium is not accounted for as increasing the average cost per *CML* unit, since this aspect adds unnecessary complexity without changing the model endogenous dynamics. Its sole purpose is to reflect the unequal amounts of *CML* units that can be acquired for the two different stocks at the time of acquisition.

In this sector, the dynamic behavior can be influenced through the settings of the five parameters described above: *Fractional Loss and Discard of NCML (lnc)*, *Maturation of NCML (mnc)*, *Fractional Loss and Discard of MCML (lmc)*, *NCML acquisition fraction (naf)*, and the *Premium for Acquiring MCML (pam)*. In the conducted quasi-experiments (simulation runs) the parameters are varied within the interval of 0 and 1. High settings are those at 0.9, low settings are those at the 0.1. In the former case, a parameter setting for *lmc*, for example, leads to a 90 percent decrease of the *MCML* stock per time unit (year), in the latter case it only yields a 10 percent decrease of the same stock over a year.

(2) The Organizational Capabilities and Core Competencies Sector

Organizational Capabilities (cf., (Chandler, 1992)) and Core Competencies (Hamel & Prahalad), or *OCCCs*, are those tangible and intangible assets and skills that set the firm apart from competitors in creating a unique value proposition and, hence, a sustainable competitive advantage. We combine Chandler's and Hamel and Prahalad's terms, since they widely overlap and are intertwined. Organizational capabilities rest on core competencies, core competencies require certain organizational capabilities. As Hamel & Prahalad emphasized these competencies are bundles "of skills and technologies rather than a single discrete skill or technology" (Hamel & Prahalad, 1994, 223). In order to be considered a core competence, the authors argue, it "must make a disproportionate contribution to customer-perceived value" (p. 224) and "must also be competitively unique" (p. 226). Further, it needs to have the capacity of extendability such that "it forms the basis for entry into new product markets" (p. 228). The *Total Value Added (tva)*, its amount, and its development therefore is dependent on the number of *OCCCs* per *CML*

that the firm continues to possess and to use. Hence, it is theorized that the more *OCCCs* per *CML* a firm sustains, the more value is added at any given time to any given *CML* cluster. Once the *OCCC/CML* ratio deteriorates, however, the total value added in the firm's effort of combining its inputs is going to suffer.

While physical characteristics such as unique location, exclusive access to rare resources, secret recipes, trade secrets, or patents to name a few represent an important part of *OCCCs* enabling the firm to earn Ricardian rents, in the modern firm the most prominent part of *OCCCs* has been attributed to idiosyncratic "standard procedures" (Nelson & Winter) or "isolating mechanisms" (Rumelt) which are predominantly based on what Polanyi calls the tacit dimension (Polanyi, 1966). Spender illustrated that such tacit-knowledge based capabilities do not only reside in individuals, but also in groups and clusters of individuals in a manner, that is unique to this particular group or cluster of individuals (Spender, 1996).

These tacit elements of know-how and know-what elude textual or other forms of codification. They can be transferred in part, but only on the basis of apprenticeship-like processes over long periods of time. An undeterminable amount of this tacit, individual or group-owned know-how and know-what is not transferable at all. It perishes once the individual or the group ceases to exist. For groups such loss can occur even through re-composition of the group. The existence and uniqueness of tacit knowing has been illustrated particularly regarding combinations of cognitive and motor skills (Polanyi's pianist example) or in pro sports (cf., (Gallwey, 1997)). Even if the master verbally describes and practically demonstrates the disciple in detail how to perform a task to perfection, the most disciples will never be able to perform it at the same level as the master. For a group context, Riley gives rich accounts of how vulnerable a team's tacit knowing is to its re-composition or partial decomposition (Riley, 1988; Riley, 1993). Tacit knowing does not only elude codification, it also resists quantification and, hence, can best be managed indirectly. This may also explain why tacit knowing has rarely been dealt with in quantitative models.

The firm's *OCCCs* along with the search and renewal capabilities detailed in the next section are conceptualized as a composition of idiosyncratic, hard-to-imitate, physical and non-physical, tacit and non-tacit capabilities that every firm possesses to some extent and that serve as the basis for its value proposition, in general, and the total value added in the input combining process, in particular. The ratio of tacit-to-non-tacit *OCCCs* remains undetermined. However, as a number of scholars suggested, the tacit portions forming dynamic capabilities may be the most essential.

Two stocks of *OCCCs* are assumed in the model, *New Organizational Capabilities and Core Competencies (NOCCCs)* and *Mature Organizational Capabilities and Core Competencies (MOCCCs)*. These two stocks have various inflows and outflows. As in the case of *CMLs*, one outflow from *NOCCCs* serves as an inflow to *MOCCCs*, which is the *Increase of MOCCCs through Aging (ima)*. Other outflows from *NOCCCs* are (1) the *Depletion of NOCCC through CML Discard & Loss (dncl)*, (2) *Depletion of New OCCCs*

through Innovation, Imitation, & Obsolescence (*dniio*), and (3) the Depletion of NOCCC through Loss of ICC (*dnli*).

If the firm loses *CMLs*, it is obvious that it also loses *NOCCCs*. This can be assumed, for example, when losing key individual human talent to competitors, but also more visibly when being forced to withdraw from business areas by selling whole units to other businesses, represented by the *dncl* outflow. Another source of continuous *NOCCC* depletion comes from innovation, imitation, and other ways of aging. A competitor's innovation can render a firm's formerly most productive organizational capabilities and core competencies far less productive in a rather short period of time as captured by the *dniio* outflow. Finally, as discussed in more detail in the Internal Constituents' Confidence section below, how confident in the firm's prospects both managers and employees are at any given point in time, influences whether or not *NOCCCs* can unfold their full potential. If a firm continues to lack success over time it is theorized the confidence of internal constituents (managers and employees alike) is going to suffer by increasingly diminishing the effectiveness of *NOCCC* as modeled through the *dnli* outflow.

The *NOCCC* stock has two inflows, (1) the *Increase of New OC & CC through S&R Capabilities* (*insr*), and (2) *Increase of New OC & CC through CML Acquisition and Std. Routine Effectiveness* (*inca*). The first inflow, *insr*, takes account of the firm's internal replenishment of *NOCCC* through its own search and renewal capabilities. Since the *NOCCCs* are the most productive *OCCCs* in terms of value added, their depletion if not matched or exceeded by the two inflows (*insr* and *inca*) may have devastating effects on the firm's competitive position. It would leave the firm only with the less productive, aging *MOCCCs*. With respects to Chandler's as well as Hamel and Prahalad's observations, hence, the *insr* inflow might be most crucial to the whole *OCCC* sector and, therefore, for the long-term competitiveness of the firm, particularly, because the continued acquisition of *NOCCCs* through the acquisition of *CML* from the outside may not be sustainable in the long run.

Current theory does not provide a clear understanding of the distribution of *OCCCs* over *CML*. It cannot be assumed that the most productive *OCCCs*, the *NOCCCs*, are proportional to *NCML*. For example, rookie workers cannot be assumed to be associated with the most productive *OCCCs*, however, the most experienced workforce, as represented in the *MCML* stock among other mature *CML* elements, cannot be exclusively related to those either. Rather *NOCCCs* (as well as *MOCCCs*) are spread over both *CML* stocks, since *NCMLs* and *MCMLs* are put into action together. Via a parameter, the effects of a higher concentration in one of the two *CML* stocks or the other can be studied (*Fraction of NOCCC-related Acquisition and Depletion through CML Acquisition and Depletion—fnadcad*).

If the firm loses *NOCCCs* through the loss of *CMLs*, it is obvious that it can also gain *NOCCCs* by the acquisition of *CMLs*. Again, this can occur on the basis of any combination of *CML*, individual or cluster, contributing to the *inca* inflow. Also, as seen above, Nelson & Winter and others have made the case that organizational capabilities,

for example, via standard routines, enable a firm to routinely perform complex tasks in an increasingly effective fashion leading to a higher effectiveness of *NOCCCs*. These influences, the fractional increases through both *CML* and standard routine effectiveness, are captured by the *inca* inflow, which fractionally increases the *NOCCC* stock.

Finally, *OCCCs* cannot be assumed (and have not been observed) to grow limitlessly over *CML*. However effective standard routines or search and renewal capabilities may become, there is a ceiling to which the *OCCC-to-CML* ratio can grow. These ceilings may differ from business to business and from industry to industry. For the purpose of this study, it only matters that such a ceiling exists. This ceiling is reflected through two nonlinear effects that slow the increase and accelerate the depletion of *NOCCCs* as the *OCCC-over-CML* ceiling is being approached.

Except for the increase through search and renewal capabilities, the *MOCCC* stock features the equivalent inflows and outflows as in the case of the *NOCCC* stock, which are (1) the *Depletion of MOCCC through CML Discard & Loss (dmcl)*, (2) *Depletion of Mature OCCCs through Innovation, Imitation, & Obsolescence (dmiio)*, and (3) *the Depletion of MOCCC through Loss of ICC (dnli)*, (4) *Increase of Mature OCCC through CML Acquisition and Std. Routine Effectiveness (imas)*. Instead of the increase through search and renewal capabilities as in the case of *NOCCC*, the *MOCCC* stock has (5) the *Increase of Mature OC & CC through Aging (ima)*. The fractional aging of *NOCCCs* is influenced by the parameter *Fractional Maturation of NOCCC (fmn)*.

The ratios of *NOCCCs-over-Total-CML-in-Use* and *MOCCCs-Total-CML-in-Use* then determine the total value added in the process of input combination. The *MOCCC-over-Total-CML-in-Use* ratio is assumed as half as influential as the *NOCCC-over-Total-CML-in-Use*. The higher the sum of these two ratios, the higher is the total value added and vice versa. The impact of the two ratios on total value added decreases the higher values these ratios take.

(3) The Search and Renewal Capabilities Sector

As Schumpeter points out, a firm's innovation occurs along five avenues: (1) product innovation, (2) production (process) innovation, (3) market innovation, (4) supply innovation, and (5) industry innovation (cf., (Schumpeter & Opie, 1934). Since advances through innovation by others can impact its position instantaneously, the successful firm has to be prepared for and anticipate such discrete shocks. It therefore destroys part of its current portfolio by anticipative innovation, also referred to as constructive destruction (cf., (Nelson & Winter, 1982, Andersen, 1995 #644)). The more turbulent an industry is, the more the firm's value-creating capacities (which are its *OCCCs*) have to be replenished by agile search and renewal capabilities. Likewise, the more stable and static an industry is, the less the firm has to rely on rapid responses through agile search and renewal capabilities since *OCCCs* are not rapidly depleted. It may suffice to replenish them by acquisition of *CML*. Rumelt and other scholars point out that search and renewal is more than just (technical) research and development (Rumelt, 1987). It rather

encompasses all aspects of a firm, in particular, its organizational contexts and processes, which have to be subjected to renewal and rearrangement.

As de Geus argues, search and renewal capabilities are essential for keeping a firm alive where particular attention has to be paid to the careful development of human resources who in a framework of cohesion and tolerance to new ideas continuously renew the firm from within (Geus, 1997a; Geus, 1997b). In this process, the most experienced and most mature individuals and groups yield the highest impact in terms of search and renewal. In other words, what I came to call clusters of *CML* provide the highest impact on search and renewal, the more experienced and mature these clusters are. As an example, the industrial engineering and design team that has successfully constructed and implemented a radically new aircraft design before is more likely to do so again than a team of rookie engineers or a team of engineers that has always focused on incremental designs. A similar example could easily be conceived for an organizational change process.

De Geus emphasizes that such individual and group experience of knowing-what and knowing-how including its social underpinnings cannot be acquired from outside but can only be grown on home turf over time. Consequently, cuts and disruptions of the maturation processes that undergird the essential search and renewal capabilities, for example, by not hiring rookie employees for a while, or by firing middle cohorts, can have disastrous consequences for the firm's innovation and renewal capabilities, both technical and organizational.

The capabilities of search and renewal, hence, are conceptualized as closely coupled to the stocks of *CML* clusters and are represented by the two stocks of *Novel and Maturing Search & Renewal Capabilities (NSRC)* and *Mature Search & Renewal Capabilities (MSRC)*. In a technical sense, these two stocks represent attributes of the *CML* stocks and are hence expressed by a co-flow structure of non-conserved co-flows (cf., (Sterman, 2000, 504)), that is, the inflows and outflows of the *NSRC* and *MSRC* stocks are not completely determined by the flows in and out the *CML* stocks.

The *NSRC* stock comprises capabilities, which have a lower effectiveness on and contribution to increase of *NOCCCs* than those accumulated in the *MSRC* stock. The stock is initialized at the *Optimal Number of SRC per CML (onsc)* value, which is set to 20. *NSRC* has two inflows: (1) *NSRC Increase through NCML Increase (nsini)* and (2) *NSRC Increase through Std Routines & Self-Production (nsiss)*, and four outflows (3) *Depletion of NSRC through NCML Loss (dnsnl)*, (4) *Depletion of NSRC through Obsolescence (dnso)*, (5) *Depletion of NSRC through Loss of ICC (dnsli)*, and (6) *Maturation of NSRC (mns)*.

The co-flow-related influences on *NSRC* are (a) the inflow *NSRC Increase through NCML Increase (nsini)* as the product of *Acquisition of Novel CML* (and the *Average NSRC per NCML (ann)*), whereas the outflow (b) *Depletion of NSRC through NCML Loss (dnsnl)* is the product of *Loss and Discard of Novel & Maturing CML (Inc)* and *Average NSRC per NCML (ann)*. Likewise, (c) the *Maturation of NSRC (mns)* is the product of the

Maturation of Novel CML (*anc*) and *Average NSRC per NCML (ann)*. That is, *NSRCs* are gained and lost proportionally to *NCML* gains and losses.

However, as mentioned above, this co-flow structure is non-conserved in *NSRC* through the other three flows. This tends to destroy the static proportionality between *NSRC* and *NCML*. The inflow of *NSRC Increase through Std Routines & Self-Production (nsiss)* increases *NSRC* from within on the basis of the same argument presented in the context of standard-routine based gains of effectiveness in the *OCCC* sector. Like the *NOCCC* and *MOCCC* increases this nonlinear effect on *NSRC* increase can only grow within certain bounds and when approximating these bounds slows down and finally vanishes.

Similar to *OCCCs* also *SRCs* can be depleted by becoming obsolete. What helped solve *n* generations of search and renewal problem classes may not necessarily help solve *n+1* generations of problem classes. As an example, some long-lived firms with previously sufficient search and renewal capabilities had extreme difficulties adapting to rapid changes of business models and industry structures with the sudden advent of Internet-based commerce (for example, Rand McNally, cf. (Laudon & Laudon, 2002, 99-101)). As with *OCCCs* the effectiveness of *SRCs* can be depleted by the depletion of *Internal Constituents' Confidence (ICC)*.

The *MSRC* stock has three inflows, (1) *MSRC Increase through MCML Increase (msimi)*, (2) *MSRC Increase through Std Routines & Self-Production (msiss)*, (3) *Maturation of NSRC (mns)*, and three outflows, (4) *Depletion of MSRC through MCML Discard & Loss (dmsml)*, (5) *Depletion of MSRC Capabilities through Obsolescence (dmsol)*, and (6) *Depletion of MSRC through Loss of ICC (dmsli)*.

MSRC-related flows exert influences on *MSRC* equivalent to those that influence *NSRC* and are therefore not discussed here again. It suffices to mention that the *Maturation of NSRC (mns)* flow is an outflow to *NSRC* while it is an inflow to *MSRC*.

The sum of two ratios of *NSRC over NCML* and *MSRC over MCML* determines the (nonlinear) effect search and renewal capabilities exert on the *Fractional Increase of New OCCC through SRC* where the weight of the former ratio is lower by 50 percent compared with the weight of the latter reflecting the higher effectiveness of experienced *SRCs*.

(3) The Internal Constituents' Confidence Sector

According to both stakeholder theory and theory of syn-reference the sustained human cooperation within any organizational framework heavily relies on the acceptability of returns to the cooperating members. As soon as the acceptability of returns diminishes, for example, if in the most serious case basic needs for individual self-preservation (as proposed by Hejl) are no longer met, the confidence of cooperating individuals in the purposefulness and usefulness of their cooperation diminishes. This then leads over time to a lower effectiveness of the cooperation itself (which, if unchecked, can become a self-

fulfilling prophecy). This phenomenon has been observed and described in various literatures (cf., for example, (Alford, 1994; Freud, 1975; Le Bon, 2002).

Firm *Internal Constituents' Confidence (ICC)* is modeled as a single stock with one inflow, *Increase in ICC (iicc)* and one outflow, *Decrease in ICC (dicc)*. Since no confidence can grow limitlessly, an upper ceiling, *Optimal ICC (oi)*, provides for a nonlinear effect of slowed increase and accelerated decrease if approximated.

Though many more factors arguably influence internal constituents' confidence such as the perceived managerial fairness, perceived acceptability of returns, and perceived leadership capabilities to name just a few rather than just the two major commercial success factors as expressed by the trend of sales and the surplus trend, for again simplicity reasons these two latter trend factors are those by which *ICC* is governed in this version of the model. One can easily argue that these two factors must be considered the most basic ones, since without these no business is technically sustainable for long such that all other influences on confidence are subordinated to these two.

The *Firm's Perceived Success (fpc)* ergo is modeled as the weighted sum of both the sales and surplus trends which allows (as observable in practice) these two trends to go into different directions. The effect of *fpc* is conceptualize as nonlinearly affecting both the increase and the decrease of *ICC*.

The accumulation of *ICC* at any given time exerts a reciprocal influence on the depletion of *NOCCCs*, *MOCCCs*, *NSRCs*, and *MSRCs* as described above. If the confidence level remains relatively high, there is no or only little depletion of the four capabilities stocks, however, as the confidence level goes down, the depletion of the capabilities accelerates.

The *ICC* flows can parametrically be influence by weights that can increase or decrease the confidence related effects symmetrically or asymmetrically for inflow and outflow. Also, the trend reference times for both surplus and sales trend can be varied individually. For the quasi-experiments discussed below, symmetrical influences on the influences are assumed, and the trend reference time is set to one year.

(5) The Discretionary Fund Sector

Conservative financing or relying on internal financial resources along with avoiding fast growth, particularly when financed via debt, is a cornerstone of long firm survival and sustained competitiveness according to de Geus. A firm, hence, has to retain profits and build deep pockets for times that require the unconfined of such funds. Such *Discretionary Funds (DF)* are captures in a single stock in the model with the inflow of *DF Increase (dfi)* and the outflow of *DF Use (dfu)*. Discretionary funds, which are conceived as quick assets, can be increased in two ways, by interest payment (here 7.5 APR) and by monies obtained from surplus and other sources. If used, discretionary funds enter the stream of total re-investments in the *CML* sector.

The DF Use policy is based upon the NOCCC-over-CML and MSRC-over-MCML ratio trends. As soon as these trends indicate a deterioration of the respective ratios, DF are used for re-investments. Via a parameter the trend reference time can be varied.

Important Model Parameters

The following model parameters were varied for the study of model behavior along the four propositions presented above:

Parameter #	Parameter Name	Low Value	High Value
1	<i>Fractional NCML Loss</i>	0.1	0.9
2	<i>Fractional NCML Maturation</i>	0.1	0.9
3	<i>Fractional MCML Loss</i>	0.1	0.9
4	<i>NCML Acquisition Fraction</i>	0.1	0.9
5	<i>Premium for Acquiring Mature CML</i>	0.1	0.9
6	<i>Fractional Maturation of NOCCC</i>	0.1	0.9
7	<i>Fractional Depletion of OCCCs through IIO</i>	0.1	0.9
8	<i>Fraction of NOCCC-related Acquisition and Depletion through CML Acquisition and Depletion</i>	0.1	0.9
9	<i>Fractional Depletion of SRC through Obsolescence</i>	0	0.9
10	<i>Weight of Std. Proc.-related Effect per SRC</i>	1	10
11	<i>Weight on Fractional Increase of NOCCC from SRC</i>	1	10
12	<i>Fraction of Surplus Devoted to DFs</i>	0	0.4

Table 4 Important Model Parameters

Parameters #1 and #3 determine the depletion of the respective *CML* stocks over a year, where a value of 0.1 causes a loss of ten percent of *CML* units and a value of 0.9 a loss of ninety percent. The *CML* maturation parameter (#2) also determines the amount of *NCML* depletion through maturation. A setting of 0.1 means that *NCML* need on average 10 years to mature to *MCML*.

Via parameter #4 the distribution of *CML* acquisitions is controlled. A value of 0.1, for example, leads to the use of 10 percent of total new and re-investments for *NCML* acquisition and 90 percent for the acquisition of *MCML*. As mentioned above, if mature *CML* are acquired, a premium has to be paid, which is set by parameter #5. A value of 0.1, for example, effectuates a premium of 10 percent paid per acquired mature *CML*. In other words, the number of *CML* units acquired through total investments decreases if this parameter is greater than 0.

Parameter #6 affects the aging of *NOCCCs*, where a value of 0.1 leads to a ten-years-on-average maturation of *NOCCC* into *MOCCC*. Parameter #7 determines the *OCCC* stocks' depletion through innovation, imitation, and obsolescence. A parameter setting of 0.1, again, leads to a 10 percent annual depletion of the two *OCCC* stocks.

With parameter #8 it is controlled, what share of *NOCCCs* affected through *CML* acquisition or depletion. For example, a value of 0.9 means that 90 percent of all *CML*-related changes relate to changes in *NOCCC* and only 10 percent in *MOCCC*.

By parameter #9 the depletion of search and renewal capabilities through obsolescence is specified. A value of 0.05, for example, effectuates the annual depletion of 5 percent of search and renewal capabilities.

Parameters #10 and #11 determine the relative weight of search and renewal effects on *NOCCC* increases. Values greater than 1 lead to a higher search and renewal effectiveness, values less than 1 lead to a lower effectiveness.

Finally, parameter #12 effectuates the amounts of available funds from surplus that are directed into discretionary funds. A value of 0.1 would direct 10 percent of surplus into discretionary funds.

Model Experiments

At this point it is in order to issue a caveat and emphasize that the exact and absolute dollar, year, and other values, which the model produces, are of minor interest, if of any at all. Any number given by the model experiments is, hence, only of illustrative purpose. That means, that an outcome, for example, the firm decays at around year 18 (which happens to be the average firm age, cf., (Geus, 1997a)) is coincidental. Further, no claim is made that the exact parameter settings, which lead to this outcome, equal precisely those, which the average firm had had before it decayed. Rather, the experiments are about illuminating certain patterns of model behavior determined through the structure of the model, that is, its feedback loops, when subjected to certain exogenous influences as they were given through the parameters discussed before.

Thus, the model's use is directed toward strategy and policy analysis of influential variables and their interdependence in the real firm rather than any point or interval forecasting. In the experiments, constant dollars are assumed, and the market does not provide a limit to the firm's growth. Obviously, the model could easily be calibrated to meet external scenarios with inflation and a limited, though growing market. However, since these two assumptions do not interfere with the endogenous dynamics that are the focus of this study, these two assumptions were made for simplicity reasons.

The model as described here has been subjected to a multitude of tests for sensitivity and robustness (cf., (Forrester & Senge, 1996)). For reasons of space constraints, these results are not laid out here. Here it suffices to say that basically two patterns of model behavior

were observed: (a) exponential growth and (b) decay. These two basic patterns of behavior were consistent over vast parameter spaces building confidence in the model's robustness. Before I present the tests of testing the proposition, both a base and a worst case that illustrate model behavior are discussed.

A Base Case

Let us assume a generic firm with the following characteristics: Upon inception, the firm has twenty times more *Novel CML* than *Mature CML*. Every year, it loses 10 percent of its novel and mature *CML*, while *Novel CML* mature on average after five years. Investments are made solely on the basis of own surpluses. Three quarters of all investments are directed toward *Novel CML*, the remaining 25 percent, which go into *Mature CML* incur a 50 percent premium. At inception, the ratios of both the firm's most productive *OCCC* over *CML* and its *New SRCs* over *Novel CML* are assumed at 80 percent of the optimal value.

Novel OCCC mature at the same rate as *Novel CML*. Both *OCCC* stocks are depleted through innovation, imitation, and obsolescence at a 10 percent annual rate. *OCCC* are assumed to be evenly distributed over *CML*. Search and renewal capabilities are depleted at a 10 percent annual rate.

Parameter #	Parameter Name	Value
1	<i>Fractional NCML Loss</i>	0.1
2	<i>Fractional NCML Maturation</i>	0.2
3	<i>Fractional MCML Loss</i>	0.1
4	<i>NCML Acquisition Fraction</i>	0.75
5	<i>Premium for Acquiring Mature CML</i>	0.5
6	<i>Fractional Maturation of NOCCC</i>	0.2
7	<i>Fractional Depletion of OCCCs through IIO</i>	0.1
8	<i>Fraction of NOCCC-related Acquisition and Depletion through CML Acquisition and Depletion</i>	0.5
9	<i>Fractional Depletion of SRC through Obsolescence</i>	0.1
10	<i>Weight of Std. Proc.-related Effect per SRC</i>	1
11	<i>Weight on Fractional Increase of NOCCC from SRC</i>	1
12	<i>Fraction of Surplus Devoted to DFs</i>	0

Table 5 Base Case Parameter Settings

In this base experiment, the firm decays between years 12 and 14. While it still has sizeable amounts of *CML*, the surplus turns negative in year 11 and never recovers from

there. Sales are halved in year 12 and at about 20 percent of its highest value reached only six years earlier (cf., Figure 1)

So, what happened? As shown in Figure 2, the most productive *OCCC*, the *Novel OCCC*, begin their decay by year six, the firm still has a growing amount of *Mature OCCC*, which, however, are less productive in terms of value added. Even though, search and renewal capabilities peak even after *OCCC*, the fractional increase of *NOCCC* from *SRC* decreases after a peak in the second year.

As soon as the negative surplus trend sets in, the rates of *OCCC* and *SRC* depletion through *Internal Constituents' Confidence* depletion take a further and growing toll (cf., Figure 3).

Since the decay of *SRC* and, particularly, of *Mature SRC* has a rippling effect first on *Novel OCCC* and then via a lower total value added on *Surplus* and potential investments in *CML*, it can be concluded that the effectiveness of *SRC* has to rise relatively sharply in order to prevent decay (see Figures 5 and 6). In order to achieve the exponential growth and the stable, high *MSRC-to-MCML* ratio as shown, the weight, that is, the effectiveness or productivity of *SRC* needs to be 3.375-fold. Technically, for the firm pushing for such a drastically higher *SRC* effectiveness would be an alternative option. However, reducing the *CML*, *OCCC*, and *SRC*-related depletion flows to sustainable amounts would be the other practical avenue, or, of course, a combination of both. Before I turn to determining the most influential of these depleting outflows, the other end of the spectrum needs to be briefly looked at.

The Worst Case

Suppose our firm has the same initial settings in terms of *NCML Acquisition Fraction*, *Premium for Acquiring Mature CML*, *Fraction of NOCCC-related Acquisition and Depletion through CML Acquisition and Depletion*, *Weight of Std. Proc.-related Effect per SRC*, and *Weight on Fractional Increase of NOCCC from SRC* as in the base case. However, instead of enjoying relatively low depletion and long aging/maturing flows, it now has high flows in and out.

Parameter #	Parameter Name	Value
1	<i>Fractional NCML Loss</i>	0.9
2	<i>Fractional NCML Maturation</i>	0.9
3	<i>Fractional MCML Loss</i>	0.9
4	<i>NCML Acquisition Fraction</i>	0.75
5	<i>Premium for Acquiring Mature CML</i>	0.5
6	<i>Fractional Maturation of NOCCC</i>	0.9
7	<i>Fractional Depletion of OCCCs through IIO</i>	0.9
8	<i>Fraction of NOCCC-related Acquisition and Depletion through CML Acquisition and Depletion</i>	0.5

Parameter #	Parameter Name	Value
9	<i>Fractional Depletion of SRC through Obsolescence</i>	0.9
10	<i>Weight of Std. Proc.-related Effect per SRC</i>	1
11	<i>Weight on Fractional Increase of NOCCC from SRC</i>	1
12	Fraction of Surplus Devoted to DFs	0

Table 6 Worst Case Parameter Settings

The firm almost immediately decays, though in the first few months both sales and surplus rise shortly. However, the depletion in the major six stocks (*CML*, *OCCC*, and *SRC*) is so large and occurs so rapidly, that the firm goes out of business in the second year after its inception at the latest (cf., Figure 7 and 8).

Compensating for these huge losses in essential stocks via enhanced search and renewal capabilities would take unrealistically high effectiveness and productivity factors. Figure 9 shows the 50-fold weights for the two *SRC*-related weights, and the firm would still decay, even though the Total Value Added remains at a very high level.

Testing Proposition #1: The Improved Base Case

In this improved case, we study how a further reduction of *MCML*, *OCCC*, and *SRC* loss impacts the firm's prospects for survival. First the *MCML* depletion is reduced to 5 percent annually (Figure 10), then the *OCCC* depletion is set to half (5 percent) its former value (Figure 11), then the two influences are jointly set at 5 percent (Figure 12). Next, the *SRC* depletion is set to 5 percent (Figure 13), then, all three influences are set to 5 percent (Figure 14). Further, the *SRC* depletion alone is reduced to 3 percent (Figure 15). Finally, the upper neighborhood of this low *SRC* depletion percentage is subjected to a sensitivity analysis with varying weights for *SRC* effectiveness between 1 and 1.25 (Figure 16)

As shown, the reduction of *CML* or *OCCC* depletion, even combined still does not help the firm to grow exponentially. The halving of *SRC* depletion does not help either, nor does the combination of all three reduced influences at the 5 percent level. Only, if the *SRC* depletion is pushed down to 3 percent, the firm grows forever. As the sensitivity analysis for the upper neighborhood of this threshold shows, the firm would also grow at 3.5 or 4 percent given the *SRC* effectiveness is raised by up to 25 percent see Figure 16).

Results regarding Proposition #1

Search and renewal capabilities play a critical role in the firm's continued success as soon as *OCCC* are continually depleted at significantly high enough a rate, in our first and last

examples, at 10 percent. A low or near zero depletion of OCCC can always be assumed in monopoly-like situations. As long as this position can be maintained, search and renewal capabilities do not play a major role. However, once OCCC depletion becomes high enough such that external acquisition of CML does not provide for their replenishment, then search and renewal capabilities begin to play the demonstrated key role. On their intactness the firm depends heavily, even slight depletions may lead to disaster for the rippling effect they exert on insufficient OCCC replenishment, lower total added value, and lesser funds for re-acquiring OCCC and SRC via CML. This finally leads to the erosion of internal constituents' confidence, which finally made the negative trend irreversible.

The efforts to grow SRC from within by rising their effectiveness meet certain limits. An increase of 25 to 50 percent has to be considered huge, while a 50,000 percent increase as in the worst case are totally unrealistic.

With regard to *proposition 1*, the quasi-experiments confirm the criticality of search and renewal capabilities (as soon as organizational capabilities and core competencies are depleted to an extent, where they cannot be replenished via external acquisition of capital, material, and labor). For the generic, non-monopolist firm, search and renewal capabilities are essential for survival, since no or only marginal depletion of OCCC cannot be assumed. That is, we affirm the claim of the Geusian Holistic Theory, that insufficient search and renewal capabilities, be it in terms of absence of tolerance to new ideas or of insensitivity to the environment, will have fatal consequences for the firm's survival prospects.

Testing Proposition #2

For testing this proposition, let us again assume a slight variation of the base case. Since we now know about the dramatic effects of too high a depletion of search and renewal capabilities, we reduce them to the (still) unsustainable threshold of 5 percent. As we know from discussing the improved base case, the reduction of SRC loss to 5 percent lets the firm still decay (cf., Figure 13). We then observe the effects of (a) treasuring and (b) using discretionary funds applied to this scenario. Various treasuring rates (20, 50, and 60 percent of surplus—while we are well aware of the fact that at least two of these percentages are unrealistically high).

Parameter #	Parameter Name	Value
1	<i>Fractional NCML Loss</i>	0.1
2	<i>Fractional NCML Maturation</i>	0.2
3	<i>Fractional MCML Loss</i>	0.1
4	<i>NCML Acquisition Fraction</i>	0.75
5	<i>Premium for Acquiring Mature CML</i>	0.5
6	<i>Fractional Maturation of NOCCC</i>	0.2
7	<i>Fractional Depletion of OCCCs through IIO</i>	0.1

Parameter #	Parameter Name	Value
8	<i>Fraction of NOCCC-related Acquisition and Depletion through CML Acquisition and Depletion</i>	0.5
9	<i>Fractional Depletion of SRC through Obsolescence</i>	0.05
10	<i>Weight of Std. Proc.-related Effect per SRC</i>	1
11	<i>Weight on Fractional Increase of NOCCC from SRC</i>	1
12	<i>Fraction of Surplus Devoted to DFs</i>	0.2/05/0.6

Table 7 Modified Base Case Parameter Settings for DF Testing

As the graphs in Figures 17 to 19 indicated, none of the treasuring rates helps the firm survive, though it may decay slightly later, but at the expense of lower stocks of CML, OCCC, as well as lower sales and surpluses.

Results regarding Proposition #2

As found before, once the firm is faced with even relatively low depletion rates over the six basic stocks of CML, OCCC, and SRC, such losses cannot be counterbalanced by the use of discretionary funds. Discretionary funds (in this scenario), though used early on (Figure 20), do not even prolong the firm's span of existence. The only effect of these funds lies in the higher value-added rates in early years (cf., Figure 21). However, this marginal improvement comes at the expense of lower thresholds in other areas, while also overly strangling the re-investment process.

In other words, the sheer availability of discretionary funds could not prevent the firm from decaying as long as the loss rates of the six basic stocks, and, in particular, the SRC stocks remain unsustainable.

In numerous other tests, no single case could demonstrate that the sheer availability of discretionary funds in the absence of other critical preconditions such as low depletion of OCCC and SRC could tip the firm back onto a sustainable track.

In terms of *proposition 2*, from testing the COSID model we cannot provide evidence for the critical necessity of such funds for firm survival. We explicitly do not want to speculate, whether or not this finding would remotely support (or be supported by) the Modigliani-Miller theorem according to which in the absence of corporate taxes (which we also assume) "*the market value of any given firm is independent of its capital structure*" (cf., (Modigliani & Miller, 1958, 268). Though the two authors do not focus on firm survival, the notion of market value of a firm encompasses at least an element of firm longevity in terms of the projection of expected returns. Discretionary funds, as de Geus proposes them, are not debt but equity/surplus-financed. His argument rests on the observation that in difficult times, the firm is less likely to secure debt financing in order

to survive. Discretionary funds provide the firm with this independence and freedom of choice even in adverse situations. While this argument is conclusive, we cannot demonstrate the role of discretionary funds it proposes.

Testing Proposition #3

We saw in the three cases discussed before, that internal constituents' confidence erodes, once the firm's sales and surplus decline. In these cases, the confidence is shattered, and since this is so, it in turn, negatively influences the firm's capabilities in terms of lower effectiveness. For the firm in decline, the impact of the diminishing confidence is understood. But how can an eroding confidence of internal constituents impact a successful firm? To study this scenario, let us therefore assume the growing firm from the improved base case. In order to understand the influences of internal constituents' confidence, we now cannot rely on the endogenous dynamics regarding confidence. Since the firm is geared to growing, the confidence which feeds from the perceived firm's success needs to be curtailed through a parametric setting. We assume a decline of confidence (despite the firm's ongoing success) due to some other factors, for example, certain managerial actions may be perceived as unfair or inappropriate.

We will look at three scenarios: the confidence due to this influence (1) gradually decreases for a short while and stays at a lower level, (2) same as under (1), but it decreases for a longer while, and (3) same as under (1) and (2), but it gradually recovers, while not reaching the initial threshold.

Results regarding Proposition #3

In the first scenario, the ICC flows are subjected to a gradual decrease of 20 percent annually over 18 months (between years 15 and 16.5). While the confidence declines, it does not decline enough to reach the threshold where it exerts any negative impact on the firm's capabilities (Figure 22). In a sense, the firm enjoys a surplus of confidence among its internal constituents, which, if remaining at a lower level, is reduced only to a non-harmful degree. However, if the decline of confidence continues for just two more years (from year 15 to year 18.5), it crosses the threshold to harmfulness (Figure 23). Once confidence reaches a critically low level and cannot recover from it, the firm begins to falter (even though capabilities at first only slightly lag compared with the first scenario, see Figure 25).

The other striking phenomenon regarding the confidence-related decay of the firm lies in the fact, that it takes almost a decade from the heavy decline of internal confidence to even observe a slowing of the firm's growth before the sudden decay sets in.

In the third scenario, confidence gradually recovers from year 24 until year 28. The firm has to pay a toll of a lower total value added for over a decade but it eventually recovers and continues to grow.

Confidence levels in the firm may fluctuate. According to these tests, as long as they do so within certain time bounds the firm may suffer only minor losses. However, if, for example, the confidence recovery sets in only a few years later, the firm does not recover from its decay.

Assessing Proposition #4

With the results regarding propositions #1 to #3 in hand, we must reject proposition #4 on the basis of the COSID model, since the necessity of discretionary funds for firm survival could not be demonstrated. However, if proposition #4 is relaxed to

Proposition #4a: Firms, which maintain sufficient search and renewal capabilities AND are cohesive, are less likely to decay early than those which do not fulfill these three conditions,

Then the results from testing propositions #1 and #3 strongly support this proposition. The capabilities of the firm exhibit certain resilience to depletion of confidence at least for some time. However, if the depletion of capabilities can continue without check, then the firm has little prospect of survival. Only, if both capabilities and confidence (and hence cohesion) remain at high levels, the firm can survive.

Discussion (including a Note on Understanding IT-based Knowledge Management)

The results of this study support the claimed criticality of at least three of de Geus's four characteristics of long-lived firms. It further supports claims made by stakeholder theorists, that the firm cannot be sufficiently explained as an economic entity independent of its socio-cultural context and the vested interests of its various internal constituents. It is worthwhile recapping that the COSID model only considers firm-internal influences. However, if firms seem to be relatively sensitive already to internal disturbances, how much more can go wrong as soon as external (mostly fluctuating) influences such as business cycles, customer confidence, supplier confidence, and a limited market size are taken into account.

In recent years, Knowledge Management (KM) has been touted as the key to the firm's competitive advantage, hence, dynamic capabilities' development and maintenance and, hence, as the determinant of the firm's ongoing success. In this context most scholars, however, have defined individual and organizational knowledge as an asset stock, which can best be accumulated and protected by means of information systems (IS) and information technology (IT) (cf., for example, (Ambrose, Ramaprasad, & Rai, 1998, Ruggles, 1998 #653; Ricardo, 2001)). This notion of knowledge sees its most essential portions as codifiable. Codified knowledge then becomes a maintainable, manageable, reusable, and sharable entity advancing organizational goals beyond the initial knowledge

provider's ongoing involvement in the firm's affairs. The focus therefore shifts to technical issues such as search engines, document retrieval, or data mining.

However, when knowledge becomes codified and IS based, it also takes on the characteristics of a physical asset, which can readily be transferred. Various scholars have argued that physical assets generally do not provide the basis for sustainable competitive advantage (cf., for example, (Nelson, 1991; Nelson & Winter, 1982)). In other words, inasmuch as the firm may gain from its own knowledge management systems and despite the fact that knowledge is not depletable by sharing, the firm's competitive position may be weakened nevertheless.

In this paper, we find that the depletion of dynamic capabilities (that is, organizational capabilities and core competencies leading to a firm's value-adding capacity as well as search and renewal capabilities leading to the replenishment of the former) are critical for firm survival. Essential parts of these capabilities defy codifiability according to Polanyi, Nelson, Winter, Dosi, Chandler, and Rumelt. We have also observed how vulnerable such capabilities might be to influences that are relatively intangible such as trust and confidence of firm-internal constituents.

Seen from this perspective the IS and IT-based view of KM appears narrow and, hence, misses essential elements and dynamics of individual and organizational interactions that lead to the idiosyncratic and inimitable knowledge both individuals and organizations develop over time. Without denying the enabling role IS can play in the context of capability development, this role must not be overstated and overestimated. From the perspective of this study, the codifiable portion of knowledge is the least relevant when it comes to competitive advantage and long-term firm success whereas the tacit portion of both individual and organizational knowledge stocks represent the most crucial assets an organization commands.

Current IS can facilitate tacit portions of knowledge only to some minor extent, if at all. Furthermore, the asset stock view clouds the importance of the process view of organizational knowledge, i.e., how organizational knowledge originates, is shared, accumulates, depletes, and is maintained with an emphasis on its tacit portions. Current knowledge management literature holds a socio-technical perspective at best. This paper maintains that cultural and behavioral dynamics in organizations anchored in internal constituents' confidence are concomitant with cognitive processes and cannot be stripped from them. The degree of confidence, which internal constituents or stakeholders have in the firm, influences the asset stocks and flows of search and renewal capabilities as well as those of organizational capabilities and core competencies and, therefore, needs management's utmost attention and care.

Appendix

Figure 1 Base Case: CML and OCCC

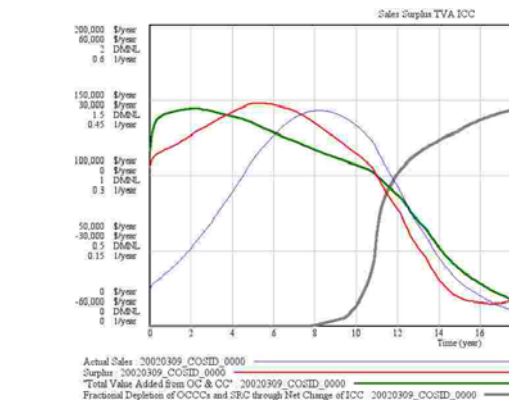


Figure 2 Base Case: Sales, Surplus, Total Value Added

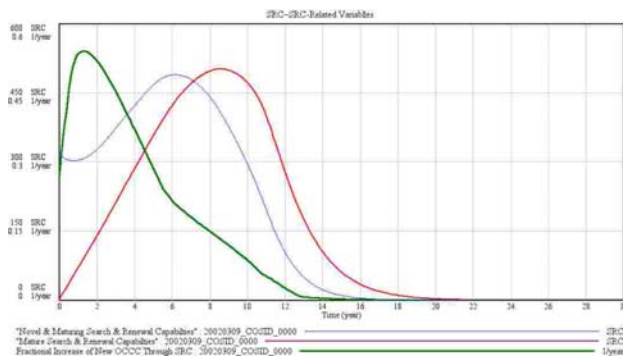


Figure 3 Base Case: SRC, NOCCC Increase

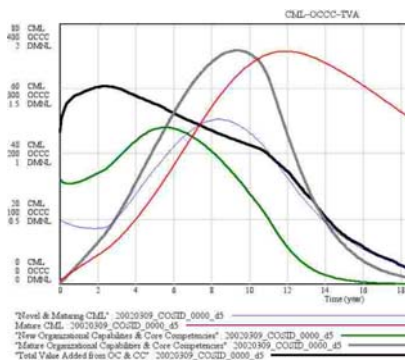


Figure 4 Base Case: 30% Increase in CML

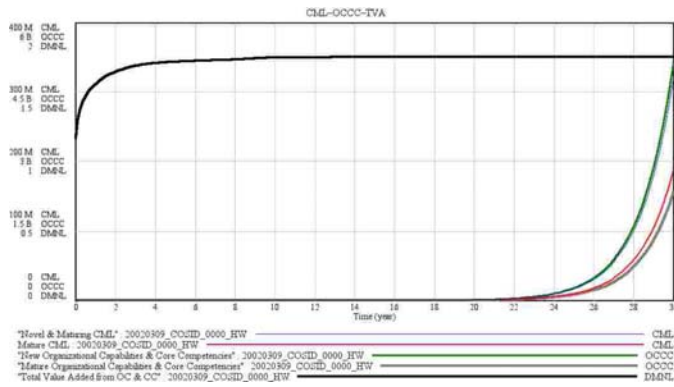


Figure 5 Base Case: High SRC Weights

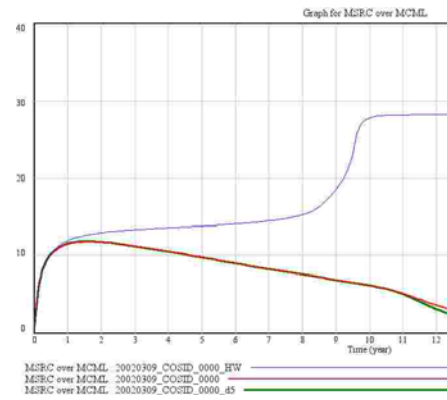


Figure 6 Base Case: MSRC over MCML

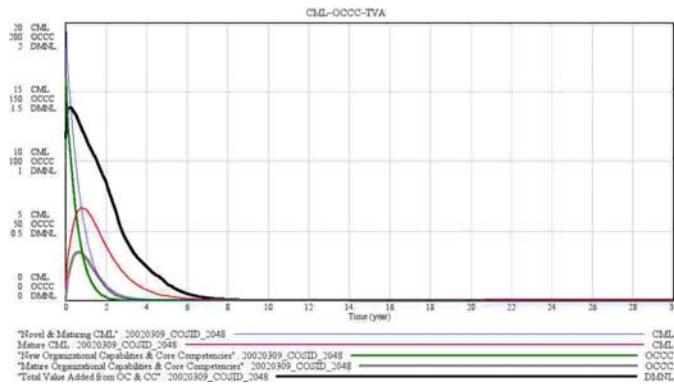


Figure 7 Worst Case: CML and OCCC

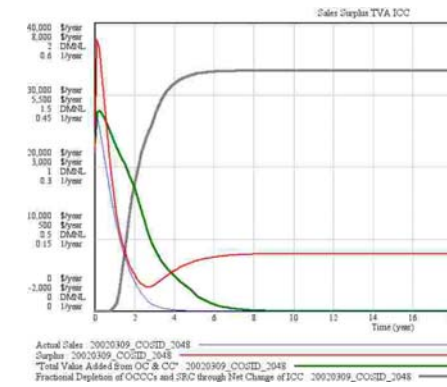


Figure 8 Worst Case: Sales, Surplus, Total Value Added from OC & CC, Fractional Depletion of OCCC's and SRC through Net Change of IOC

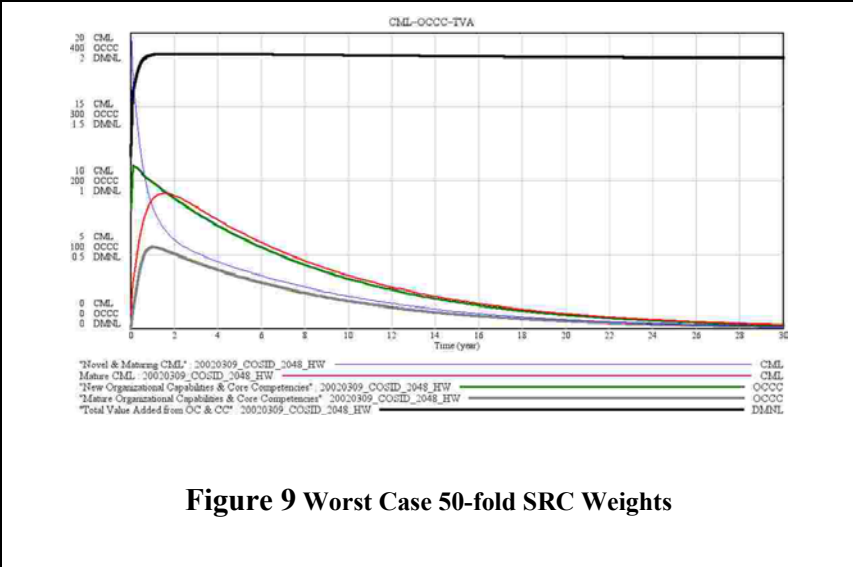


Figure 9 Worst Case 50-fold SRC Weights

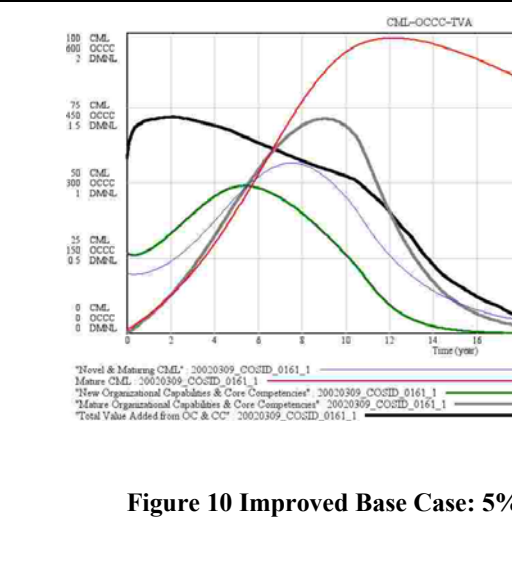


Figure 10 Improved Base Case: 5% OCCC Depletion

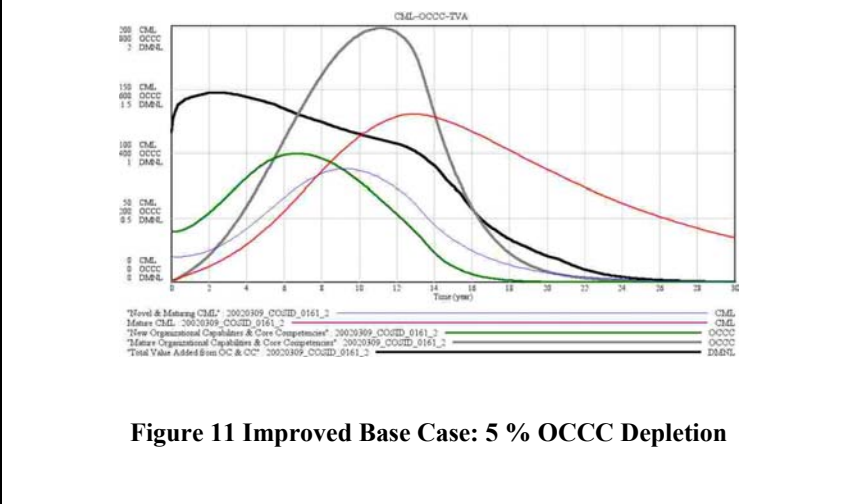


Figure 11 Improved Base Case: 5 % OCCC Depletion

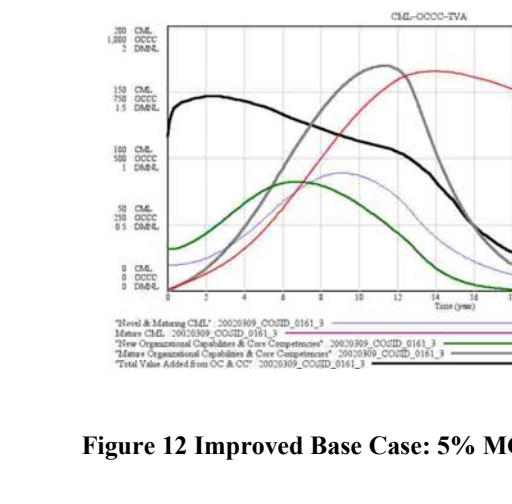


Figure 12 Improved Base Case: 5% Maturity

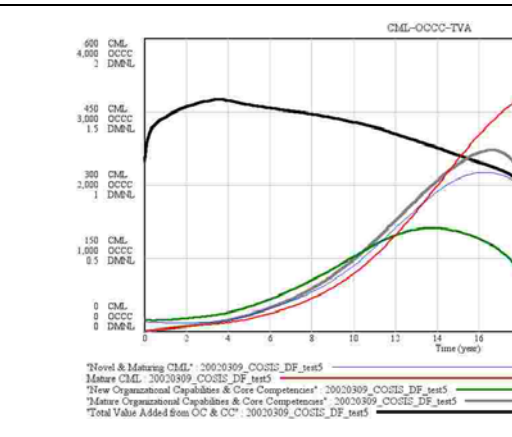
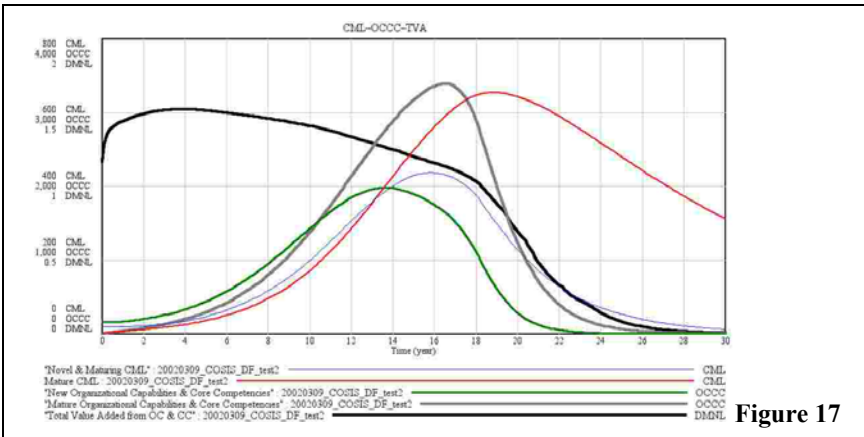
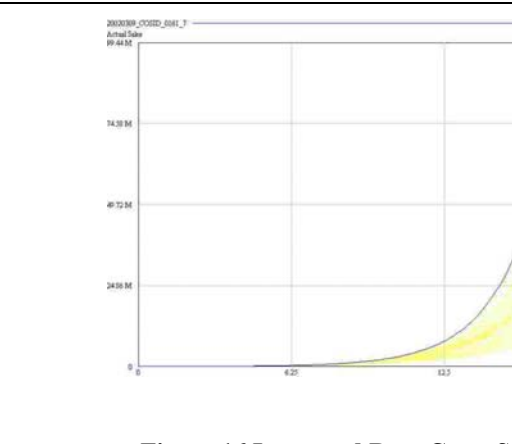
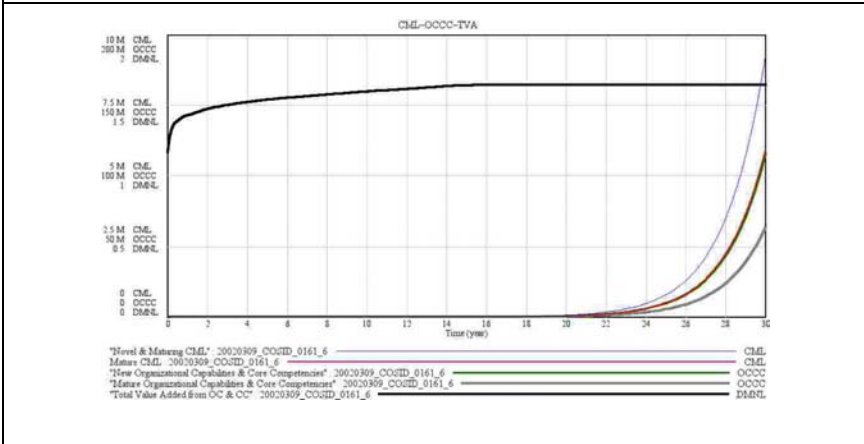
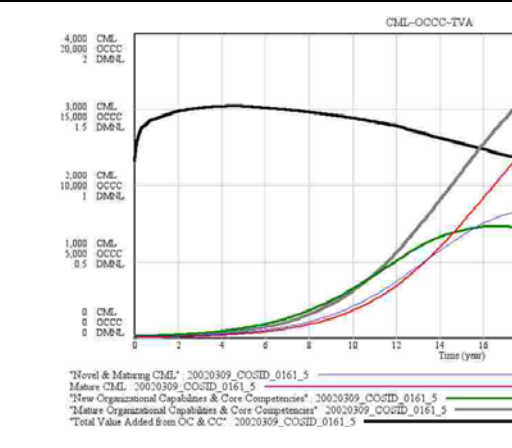
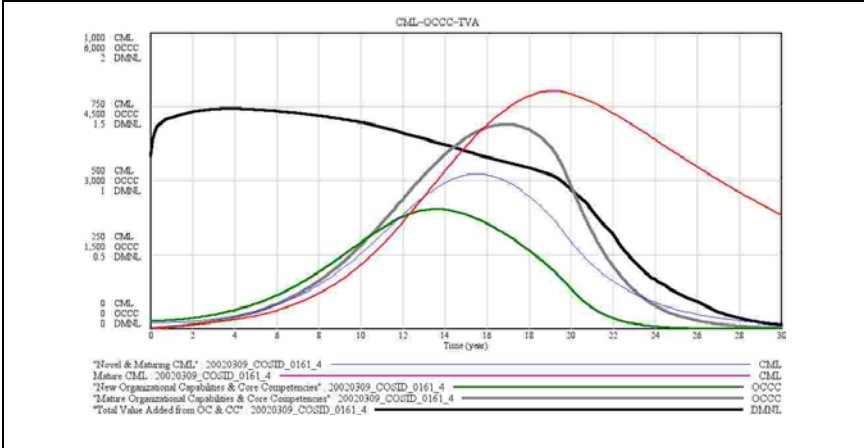


Figure 18 Use of 50% Discr. Funds a

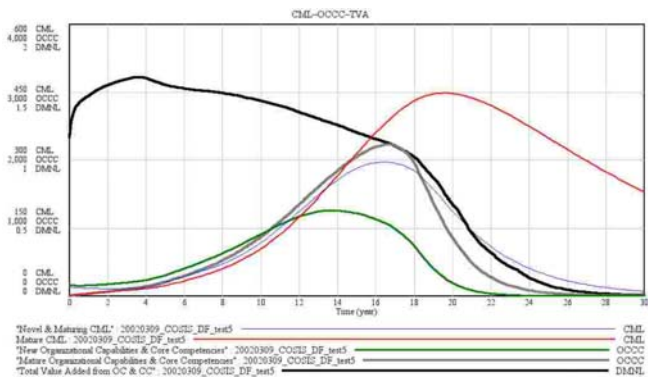


Figure 19 Use of 50% Discr. Funds at 5% SRC Depletion

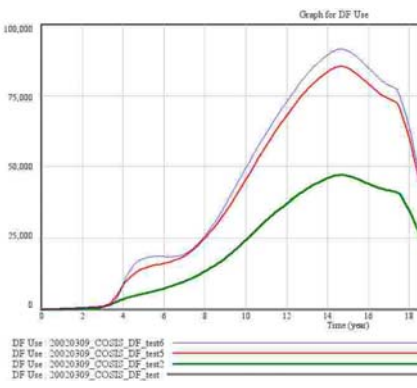


Figure 20 Use of Discretion

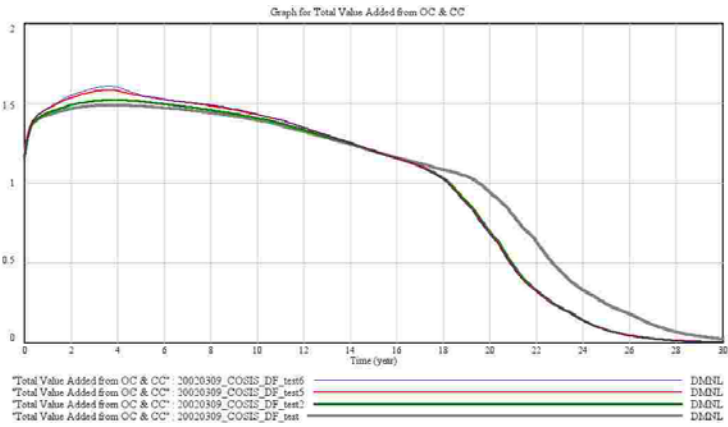


Figure 21 Use of 20% Discr. Funds at 5% SRC Depletion

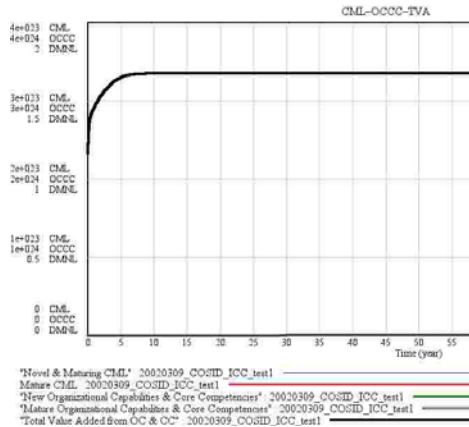


Figure 22 20% ICC Loss Between

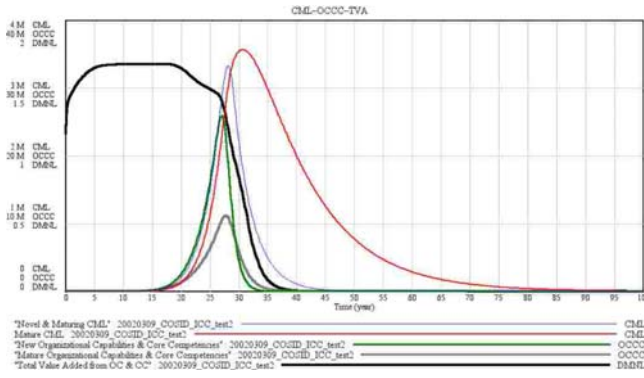


Figure 23 20% ICC Loss Between Years 15 and 18

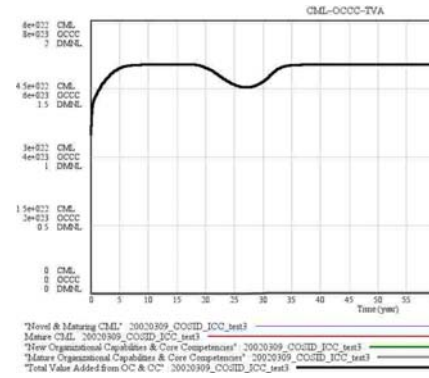


Figure 24 ICC Loss & R

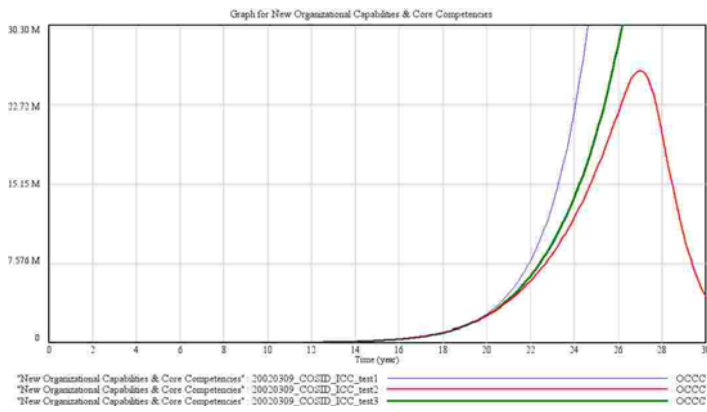


Figure 25 Capabilities Affected by ICC Fluctuations

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