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Using Integrated Top-down and Bottom-up Dynamic Modeling for Triangulation and Interdisciplinary Theory Integration

The Case of Long-term Firm Performance and Survival

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Abstract

System dynamics (SD) modeling has been classified as a “top-down” approach to modeling dynamic and complex systems, whereas agent-based (AB) modeling techniques are referred to as a “bottom-up” approach. Various papers have recently proposed the use of both approaches when studying complex, dynamic problems in the social; sciences, particularly, when hard data for important variables are hard to find. Furthermore, human and social dynamics typically have been studied through the lenses of various disciplines. When modeling those problems, insights from those various disciplines should be integrated. Dynamic modeling might provide an important instrument for such theory-integration efforts. In this paper, the problem of long-term firm performance is taken as an illustration for such a research design, in which theory-integration is undertaken along with a design, in which top-down and bottom-up modeling are iteratively combined. It is concluded that besides arriving at deeper understanding of the problem through theory-integration, cross-validation and dynamic triangulation may be among the potential benefits in such multi-disciplinary and multi-method research designs.

Introduction

Various techniques have been proposed to model the complexity and dynamics of human

behavior and social interaction. K. Richardson distinguishes between two schools of thought that he labels bottom-up and top-down methods [85]. According to K. Richardson, the system dynamics (SD) approach [34, 84, 97] is the quintessential representative of top-down modeling. In SD studies, researchers model a static structure of feedback relationships between variables, whose dynamic behavior they observe via model simulation at an aggregate level over time. SD modelers try to find “pressure points” in the feedback structure, which allow for policy interventions and structural changes. In contrast, the bottom-up methods rely on modeling individual agents, whose interactions are governed via a set of simple rules. In agent-based modeling (ABM), researchers study the emergent behavior of interaction, when rules and agents are modified over time [85]. Researchers from both modeling schools have discovered the similarities and differences between their approaches [80, 91] and have proposed cross-study and integrated research designs. Comparative research has further underlined the potential benefits of using both methods when modeling the same phenomenon [90]. However, so far, truly integrated research designs using SD and ABM have not been systematically used and evaluated regarding their explanatory potential relative to single-method approaches. In the following, we will illustrate the proposed research approach with the dynamic problem of long-term firm performance as a case in point:

While other types of human organization are long-lived, private sector firms are not. On average, they cease to exist less than two decades after inception. Firms like other human organizations are subject to internal dynamics such as social, organizational, and managerial processes. These processes dynamically interplay in ways that let some firms cope with turbulent environments even over extended periods of time, while others fail. The decay of firms comes at high costs to all parties involved. Not only is capital destroyed, or jobs are lost, but also valuable dynamic capabilities and competencies are forfeited. Three avenues of research might be pursued to better understand the problem:

- (1) The endogenous perspective: Once the dynamics were better understood, it would become clearer whether the phenomenon is an inevitable outcome endogenously rooted in the nature of the firm. Alternatively, if faint warning signals were detected early, they could be understood and dealt with leading to more favorable outcomes. This study perspective involves elements from management science, organizational studies, strategic management, sociology, behavioral sciences, and information science.
- (2) The exogenous perspective: To what extent exogenous pressures imposed by the environment account for the causes of the early mass decay is not well understood, either. This perspective defines a study combining elements of economic science, industrial organization, public policy, and information science. Finally,
- (3) The combined perspective: The third avenue of study would focus on the interplay and the tension between the endogenous and exogenous factors.

This paper first reviews theories from those different fields, which speak to the problem of long-term firm performance. Second, based on those theories, it presents a system

dynamics representation of an integrated theory of long-term firm performance, which covers the endogenous perspective. Then, an agent-based modeling approach designed to mirror the integrated theory is considered. Finally, iterative steps for testing and converging the approaches as well as expanding the model boundaries to capture dynamics in the firms' environment are discussed and proposed for testing.

Present State of Knowledge in the Field

Among the various broad strands of theories contributing to the understanding of firm performance and survival, three strands appear as particularly relevant (1) the economics, business history, strategic management, and organizational theory based literatures of the firm, (2) stakeholder theory, and (3) the sociological theory of syn-reference.

Economics, Business History, Strategic Management, and Organizational Theory-based Literatures of the Firm

Traditional economic theory, by and large, finds that long-term performance in firms does not correspond to growth rate, size, [98] or industry, rather firms appear to survive longer with the rate of learning-by-doing [52-54] and innovation [40, 56]. Economists observe significant heterogeneity in firms' development [33, 68], which makes industry-level-based survival theories problematic.

Transaction-cost- and Principal-agent-based Theory sees the firm as a nexus of contracts, which produces cost advantage over exchange market contracting [20, 48, 49], contains uncertainty, and checks opportunism [30, 31, 103-107]. According to the theory, survival is justified as long as the firm provides those advantages. Firms, however, also decay, once (managerial) agents excessively serve their self-interest.

Business History accounts present rich evidence that firms are formed for reasons of risk minimization, higher growth potential, and superior task and process coordination [15, 16] leading to the accumulation of administrative experience over time. The firm is portrayed as a unique historical entity, for which management exerts strategic and structural choice [14] and, hence, significantly and individually influences its survival prospects.

Behavioral Theory of the firm [25, 83] attempts to link organizational processes and decision-making, on the one hand, and economic outcomes, on the other hand. The firm is seen as adaptively rational capable of developing standard procedures and ad-hoc decisions in non-routine situations. Firms survive as long as they successfully adapt their procedures and decisions to the environment leading to advantageous economic outcomes.

Evolutionary Economic Theory of the firm sees the firm as an entity geared at anticipative innovation (also referred to as constructive self-destruction) in an environment laden with uncertainty and surprise under conditions of bounded rationality [75, 76, 94, 95]. Firms possess and develop organizational capabilities and competencies [29, 42], which provide them with competitive advantage and the freedom of strategic choice [17]. Obviously, the more and higher quality the organizational capabilities and competencies, the better are the prospects for survival.

Resource-based Theory combines elements of (evolutionary) economic theory with those from strategic management theory [32] and emphasizes the firm's uniqueness as a bundle of heterogeneous resources [8-10, 23, 57, 58, 79, 86, 88, 102, 108]. Capabilities and other strategic resources are firm-idiosyncratic asset stocks, which cannot immediately be influenced or altered [26]. Firm survival and competitiveness hinge upon timely influencing those stocks via appropriate inflows and outflows. In this regard, a fundamental capacity of the firm is its dynamic capability to search for and create new resources and areas of competitive advantage [88, 99] in a timely fashion. However, the operationalization and quantification of such firm resources has been a concern among advocates and critics of the resource-based theory alike [23, 81, 82]. A systemic perspective on the interplay of resources has been proposed to overcome this problem [96].

Elements of a Holistic Theory of the firm and its survival have been presented by two practitioners before. Barnard, for example, presents the firm as a multi-faceted, social entity comprising formal and complementary informal organization, which is aligned through communication, willingness to serve, and common purpose [7]. Motivation and satisfaction of all participants he sees as instrumental for the organization's viability and vitality as a going concern, a notion recently echoed elsewhere [2]. Long-survivor firms have also been found to have in common at least four traits; (1) they were sensitive to their environment; (2) they exposed organizational cohesion and identity; (3) they were tolerant to new ideas from within; and (4) they were conservative in financing.[38, 39]. These results were confirmed in part by other studies on firm performance of long-survivor firms [21].

Stakeholder Theory

Although stakeholder theory may be seen as another or even competing theory of the firm [28, 55], it distinguishes itself from other theories of the firm, or, more generally, of human organization, in that it specifically focuses on the roles and interaction of individuals, groups, and organizations within and around the firm, who have a vested interest based on their own risk in the firm [18] and, hence, can impact the firm or be impacted by its activities [35]. Stakeholders' stance [12] and salience vary and may dynamically change over time [72]. Stakeholder theorists have long claimed that firm performance is critically dependent on effective management and organization of stakeholder relations [4, 50, 51]. Also, stakeholders may have conflicts, which might affect the firm [37]. Stakeholder theory claims that without the support and consent of primary stakeholders, firms cannot survive [19]. While stakeholder theorists have attempted to provide empirical evidence to the claim of superior firm performance, when stakeholder management was effectively applied, so far the results [1, 11, 43, 77] are mixed at best. Stakeholder theory faces the huge problem of operationalization and resolution of complex dynamic feedback regarding the unit of analysis: Stakeholder relations are embedded in the social processes within and around the firm, which then over time, are said to lead to observable differences in organizational performance depending on the effectiveness of stakeholder management, which in turn after further delay are claimed to show up in bottom-line-relevant differences.

The Sociological Theory of Syn-reference

A number of scholars have classified social systems as living systems [13, 38, 39, 64-67, 70], while others reject this claim [44-47, 71, 100, 101] by distinguishing both social process and interaction from self-maintaining, self-organized social systems as living in the immediate biological sense. While claiming social systems to be living systems would potentially even more strongly support our main argument, we refrain from relying on it, and rather assume a relaxed degree of self-organization for social systems as presented by the theory of syn-reference, which denies the capacity of self-maintained living in social systems. Individuals, according to this latter view, interact through social processes in order to survive, which necessitates collaboration and coordination of behavior [46]. In so doing, they construct a “socially produced” reality for themselves. Social systems in this context are seen as frames of interaction between individual actors rooted in a social domain. As “system components,” those individual actors have the freedom to leave the social system. Typically, they are part of several social systems at the same time (across which they may assume different roles). Unlike in strictly closed (living) systems, as components of a social system, the individual actors are not produced by that system, although their individual perceptual and mental states are influenced by the system of interaction and coordination. Individual actors usually do not perish, once the social system, which they participate in, ceases to exist. However, through their interactions within the system, individual actors influence and modulate each other’s constructions (“parallelized states”) as well as that of the system. Modulations of individual and system states can also be triggered from the social system’s environment. In other words, the social system is concurrently subjected to internal and external feedbacks. According to Hejl, the phenomenon of social change results from the interplay of those two kinds of feedback. While the inner feedback is seen as the “mostly conservative factor” stabilizing the social system, the outer feedback on both the individual components and the system can trigger social change since it is always the individuals who interact in a social context and who are exposed to incompatible realities through other systems they participate in.

In summary, the theory of syn-reference as a theory of coordinated behavior of components in a social system overcomes the severe limitations of applying concepts of autopoiesis theory (as, for example, attempted by Luhmann) to the social sciences, and in particular to social systems (cf., also, [71, 74, 78], while it maintains the second-order cybernetics approach, which Maturana and Varela also incorporate [69]). In the theory of syn-reference, system autonomy is defined as input-independence of the observed social system relative to an observer. The theory, hence, maintains the principle of organizational closure in a relaxed fashion explaining the feedback relations between individual actors and their internal and external environments. With respect to the firm, the theory of syn-reference strongly underpins findings from stakeholder theory from a sociological perspective and adds to the understanding of the relevance and extent of individual actors’ shaping their mutual social realities and that of the social system they co-create

Integrated Theory of Long-term Firm Performance

An integrated theory has been proposed and tested on the basis of a system dynamics model [92, 93]. This simulation model, its underlying theory integration, and its initial findings serve as a cornerstone of this research proposal. This section provides an overview of the dynamic modeling approach and its current findings.

When kept in isolation, the reach of those three literatures outlined before is limited for the understanding of long-term firm performance. However, once the various economic strands of theory are complemented by stakeholder theory and the theory of syn-reference, a new perspective on long-term firm performance emerges that ties economic success to the interest of individual and group self-preservation. When combined, the three strands complement each other with the one exception of the transaction cost theory-based assumption of individual opportunism and even guilefulness as the basic mode of human nature. However, even economists have criticized this assumption as grossly overstated (cf., for example, [22, 27]). Resource-based theory, stakeholder theory, and most strongly the sociological theory of syn-reference provide a contrasting picture. Self-preservation as the main self-interest in those views leads individuals to engage into collaboration and coordinated behavior because such coordination provides for superior chances of self-preservation with the firm as the case in point. Hence, the integrated-theory perspective provides a different answer to the classical question why firms are formed [48]. Rather than for transaction-cost advantages, a claim not confirmed by historical accounts (cf. [15, 16, 24], firms are formed because they help individuals serve their most fundamental self-interest of self-preservation through purposeful collaboration and coordination in an exchange economy. Firms that promise economic success serve this fundamental interest. Those that do not are unlikely to be formed or maintained.

The operational integration of the existing theories in a simulation model had to satisfy at least two requirements: It had to (1) accurately represent the stand-alone theories, and (2) conclusively connect those theories, without adding to or subtracting from them. In this theory-integration model, the boundary of the modeled firm has been conceptualized via five internal sectors: (1) Physical assets (capital, material, and labor), (2) organizational capabilities and core competencies, (3) search and renewal capabilities, (4) internal constituents' confidence, and (5) discretionary funds (see figure 1).

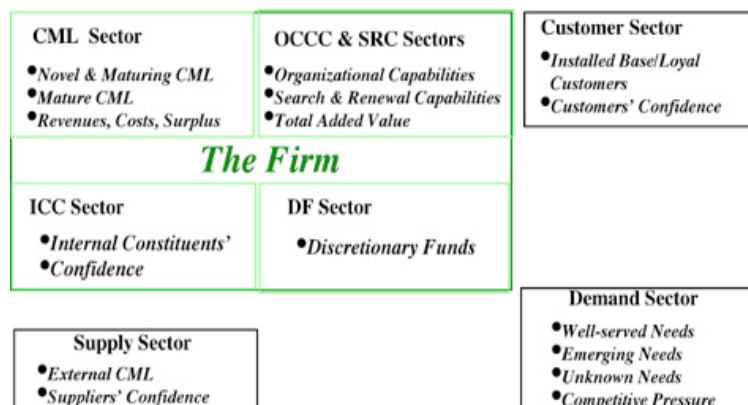


Figure 1 The Boundaries of the Modeled Firm

Defined as external to the firm in this model are the three sectors of (1) suppliers, (2) customers, and (3) market demand and competitive pressure (figure 1). The model sectors were connected by five major feedback loops:

The Basic Growth and Collapse Loop of the Firm

Firms can be viewed as asset accumulations or stocks, which cannot immediately change [26]. The impact of managerial intervention, hence, can only be observed after a while. Those stocks, the authors argue, are typically embedded in feedback loops, through which changes in the inflows and outflows to those stocks are moderated or, more generally, through which the system has a tendency to self-regulate as described in various literatures (including economics and social sciences) [84, 310]. Hence, the firm is a representative of a circularly self-regulating feedback system. Neoclassical economic science describes the reinforcing *Growth (Collapse) Loop*, which is the firm's most basic feedback loop (see figure 2) and involves the stock of capital, material, and labor (*CML*). Those inputs are combined within the boundaries of the firm adding to the firm's potential output. As long as this input combining process can be performed in a value-adding fashion and the demand for the firm's goods or services is sufficient at the asked prices, revenues will result. As long as costs do not exceed revenues, surpluses result, which let the firm either re-invest, pay dividends, or both. Reinvestments, then, lead to an increase in the accumulation of capital, material, and labor. As long as surpluses are generated on the basis of sufficient total value added, this feedback loop lets the firm exponentially grow, otherwise the firm collapses.

The Value Adding Loop

Organizational Capabilities (cf., [17]) 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 or are intertwined. Organizational capabilities rest on core competencies, while core competencies require certain organizational capabilities. As Hamel & Prahalad emphasize these competencies are bundles "of skills and technologies rather than a single discrete skill or technology" [42, 223]. While the physical *CML* assets can be accounted for with relative ease, organizational capabilities and core competencies are intangible or "soft" assets, which are embodied in and through the interplay and combination of the physical assets. In figure 2, the role of these Organizational Capabilities and Core Competencies (*OCCC*) is shown in the reinforcing *Value Adding Loop*. The more *OCCCs* the firm has, the higher is the added value, leading to higher firm output, sales, surplus, and reinvestments, which lead to higher increases in *OCCCs*. The more such *OCCCs* a firm possesses, the more it can add value in its input combining process. However, as the organizational capabilities and core competencies underlie a continuous depletion process through obsolescence, imitation, or innovation, the total value added can only be kept at sufficient levels as long as the replenishment process compensates for the losses.

The Renewal Loop

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., [94]). 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., [5, 75]). The more turbulent an industry, the more the firm's value-creating capacities (which are its *OCCCs*) have to be replenished by agile search and renewal capabilities. Search and renewal is more than just (technical) research and development [87]. It rather encompasses all aspects of a firm, in particular, its organizational contexts and processes, which have to be subjected to renewal and rearrangement. Figure 2 shows the reinforcing *Renewal Loop*, in which search and renewal capabilities are replenished through reinvestments. Like *OCCCs* these search and renewal capabilities are embodied in the physical assets of the firm. These capabilities themselves replenish the organizational capabilities and core competencies in a unique fashion: They destroy old *OCCC* and create new ones. This "constructive destruction" both depletes and increases (by replacement and by renovation) organizational capabilities and core competencies in a proactive or reactive way. The more *OCCC*, again, the higher are the total value added, the firm's total potential output, sales, surplus, and reinvestments. The higher those reinvestments, the higher is the increase *SRC*.

The Confidence Loop

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, [3, 36, 62]). If in the constituents' perception the organizational framework ceases to promise the desired outcome for a period of time long enough, they will gradually withdraw their full commitment from the framework diminishing dynamic capabilities. The most common measures of both viability and the success are the firm sales and surplus trends. These two trends can obviously go into different directions for a while, which is why both trends shape the confidence of internal and external constituents. Figure 2 shows the reinforcing *Confidence Loop*, in which the stock of Internal Constituents' Confidence (*ICC*) exerts a lower influence on the depletion rates of both *OCCC* and *SRC*, the higher the confidence is. Conversely, the lower the level of confidence, the higher is the rate of depletion in both the *OCCC* and *SRC* accumulations. From our previous discussion we already know that a lower *SRC* accumulation leads to less replenishment of *OCCCs*, which then results in lower total value added etc. spiraling the firm downwards.

The Discretionary Funds Depletion Loop

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 [38]. A firm, hence, has to retain earnings and build deep pockets for times that require the unconfined of such funds. Some economic literature makes the claim that the value of a firm does not depend on its capital structure at all (cf., [73, 268]). However, long-survivor firms seem to systematically accumulate funds for discretionary use as empirical evidence suggests [38] hence, the role of such discretionary funds in long-term firm performance deserve exploration. Figure 2 exhibits the counterbalancing *DF Depletion Loop*. Discretionary funds are accumulated as the fraction of surplus as long as the firm thrives, The more discretionary funds exist, the more can the firm use them for correcting any unwanted depletion of *OCCCs* and *SRCs* leading to reinvestments in *CML*, and by that same token, into both *OCCC* and *SRC*. Such investments then increase the value-adding capability of the firm etc. Conversely, the fewer funds available, the less the depletion process of capabilities and physical assets can be counterbalanced.

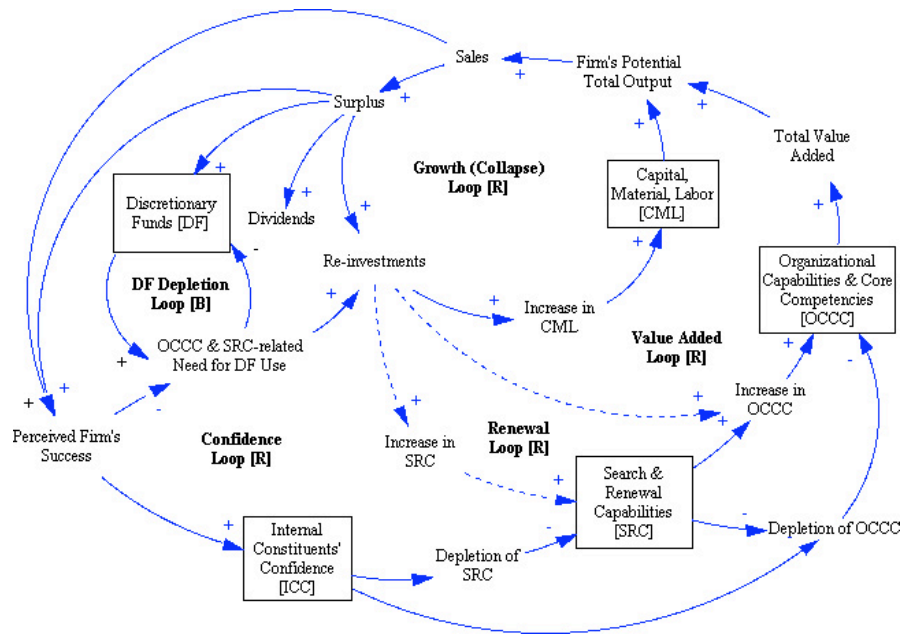


Figure 2 The Five Main Feedback Loops

Findings from Simulation

Through quasi-experiments, the influences of search and renewal capabilities, firm cohesion (in terms of continued stakeholder support), and discretionary funds, as well as the combination of those influences on long-term firm performance were studied. It was found that even low depletion rates over all basic stocks for some time become fatal for a firm, in other words, the firm can not survive at an ever lower level of its main stocks. For the generic, non-monopolist firm (assuming average depletion of capabilities), search and renewal capabilities were found essential for survival. Insufficient search and renewal capabilities, be it in terms of absence of tolerance to new ideas or of insensitivity

to the environment, have fatal consequences for firm survival. In other words, the sheer availability of discretionary funds could not prevent the firm from decaying as long as the loss rates of the basic stocks, and, in particular, the SRC stocks remain unsustainable. In numerous other tests, no single case could demonstrate that the 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. Once, the use of discretionary funds was more directly targeted to replenish search and renewal capabilities, they indeed had the effect described in previous studies [38]. Firms decay also in the wake of diminished cohesion as a consequence of depleted internal constituents' confidence. The 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. Also, in the case of survival, while the causes cease to exert direct influence, the full recovery takes a long time. The remoteness of the demonstrated cause and effect in time may present a major obstacle when attempting to understand and explain the nature of the phenomenon. In summary, the quasi-experiments strongly support the roles and importance of search and renewal capabilities and internal constituents' confidence relative to the long-term performance of the firm as claimed by the integrated theory, while evidence for the role of discretionary funds could only be shown, when directly targeted at search and renewal.

Expanding the Research Design in a Multi-method Fashion

Multi-method dynamic modeling has been proposed before, particularly the cross-study and integrated use of system dynamics and agent-based modeling [80, 91]. Those initial calls have recently been echoed elsewhere [41, 89]. These studies focus on methodological implications of method combination as well as the practical software interfacing between the two major simulation platforms. Although the paradigmatic and conceptual commensurability may need further discussion and investigation, those initiatives can be seen as expression of a more pluralist understanding of the scientific endeavor (see also Lane's arguments [59-61]). In the following some details of such a multi-method research design are discussed.

While the system dynamics-based representation of integrated theory of long-term firm performance yields important new insights regarding the importance and interplay of concepts such as dynamic capabilities and internal stakeholders' confidence, those concepts can hardly be observed directly. The absence and unavailability of hard data, however, may not excuse the exclusion such important aspects of the problem from modeling. Using proxies as is frequently done in static analyses would not solve the problem for a dynamic modeling approach, either. Other avenues of establishing confidence in the findings of simulation results, hence, need to be explored. Such an approach of four sequential steps is sketched out in the following. While the first three steps focus on dynamics inside and between the internal sectors of the firm, in the fourth step, the model boundaries will be expanded to include the dynamics of the suppliers, customers, and market demand/competitive pressure sectors.

Combining Top-down and Bottom-up Modeling (Step 1)

Approach: The dynamic theory sketched out above has been formulated by means of a system dynamics model, which captures the observed feedbacks in the firm at an aggregate level. While important dynamics are observable at this level of aggregation, it would significantly increase the confidence in the model findings, if a bottom-up, agent-based model using the same dynamic theory of influences would exhibit an emergent behavior of decay under certain conditions and survival under other conditions commensurable with the integrated dynamic theory of firm survival. It would be expected that simulation results from an agent-based model might dynamically triangulate those from the system dynamics model.

The cross-study of simulation models has not been well researched in the social sciences. Cross-study is useful because it improves the confidence in the outcomes of both models, "...serves as a sensitivity analysis of model features on model outcomes" [63, p. 2], and might act as a stepping stone to determining the degree of usefulness of integrated research designs.

Deliverables developed during this step would include:

- (1) The agent-based (bottom-up) model
- (2) Comparative simulations of the top-down and bottom-up models
- (3) An evaluation of (2) regarding the degree of convergence/divergence of results between the two models
- (4) Modifications to both models based on the insights gained from (3)
- (5) A repeat of (2) and (3) with the modified model versions.

Methodological Considerations: We believe this will be one of the first attempts to undertake a study of this kind in the social sciences, despite earlier calls for more integration as well as docking studies in the literature [6, 63]. As such, there are few, if any, methodological guidelines on how such a cross-study should occur. Some of the issues that need to be addressed include:

- (1) Which parts of the system dynamics model represent the variables of interest when building an agent-based model?
- (2) Who are the agents in the model, and how do they interact?
- (3) Does the proposed agent representation capture the intent of the system dynamics model?
- (4) What are appropriate measures of usefulness in integrated research designs with agent-based and system dynamics models?
- (5) When using agent-based and system dynamics models in the study of a phenomenon, what degrees of integration (ranging from no integration to direct docking of models) are practical and useful?
- (6) How similar do the results of the two models have to be to declare validity (i.e., do we accept qualitative similarities versus only strict replications)?
- (7) How does the understanding of a phenomenon improve when using the both approaches in one research design?

- (8) In case model results are converging, over what range should the two models concur to establish validity (i.e., how robust should the results be)?

The design has to provide for the model's gradual extension and calibration to data gathered in step 2, which we believe will help demonstrate the usefulness and proof of concept for these types of research designs.

Given the exploratory nature of this undertaking, we have purposively allocated a certain period of time and a budget for face-to-face meetings to examine these issues.

Gathering Historical and Ethnographical Data on Selected Firms (Step 2)

Approach: Empirical data for the aforementioned important soft factors are difficult to find or produce. Following approach of Collins and Porras,, the trace of firms operating under the same conditions in the same industries over a long period of time will be analyzed for significant perturbations such as

- (1) Layoffs,
- (2) Plant, department, and location shutdowns,
- (3) Revocation/alteration of benefits,
- (4) Alterations in recruiting and dismissal practices and policies,
- (5) Mergers and acquisitions,
- (6) Scandals and public investigations,
- (7) Adverse changes in labor/union relationships,
- (8) Major product failures,
- (9) Loss of talent, attrition rate,
- (10) Organizational restructuring, and
- (11) Frequency and extent of changes in top management.

Also, performance-related data will be sought such as

- (1) Product/service innovation rate,
- (2) Research and development spending,
- (3) Sales promotion/advertising rate, and
- (4) Other key financial and market data over long periods of time.

Historical data from SEC filings will be used as well as firm publications and trade press articles for this portion of the data collection.

Based on the findings, a semi-structured interview protocol will be developed. Long-term employees and managers from various cohorts of those firms will be interviewed regarding the aforementioned perturbations, the perceived success of the firm, and the perceived behavior of management, in order to complement the historical data collection and to provide illustration. For each firm, the empirical data whenever possible will be mapped into time series and compiled into parameter sets, which will then be used to calibrate and test the existing models. The model simulations will then be compared with the historical performance and paths of the firms.

Methodological Considerations: Although the Collins and Porras study was geared at demonstrating the impact of visionary leadership on firm performance and not

specifically designed for elucidating long-term firm performance in more general terms, it produced numerous accounts and data points, which can be directly related to that end. The study was completed in the early 1990s, the results were first published in 1994. Data collected span the time periods from the studied firm's inception to the mid- and end 1980s. Our study will not reproduce or update the Collins and Porras study, it rather focuses on select indicators for internal disturbances and uses that study as an anchor. Our limitation in the data collection to the two most recent decades provides us with newer data than available to Collins and Porras. It also makes it easier to collect rich ethnographic data from managers and employees of those firms regarding the disturbances identified in the historical data. The ethnographic data collection is seen as a safeguard against misinterpretations of the historical material. Interviewees are expected to provide context and rich content when explicitly probed for the outcomes and consequences of observed disturbances. Those accounts will also help illustrate the various cases.

Deliverables developed during this step:

- (1) For the two-decade period of 1984 to 2003, collect and analyze historical data and accounts on at least twenty firms studied by Collins and Porras before [21];
- (2) Compare those results to the findings derived from simulation in step 1;
- (3) Compare those results to related findings in the original Collins and Porras study;
- (4) Provide ethnographic evidence for the impact of business policies and management practices on the firms' organizational culture and climate, morale, loyalty, and performance

Reformulating and Calibrating the Models (Step 3)

Approach: Based on the additional data collected within step 2 both the system dynamics model and the agent-based models will be reformulated in two ways: (1) by removing and adding structure and rules respectively, (2) by disaggregating and re-aggregating structure (SD model), and (3) by introducing newly found agents and rules (AB model). The simulation results from the initial and the later stages will be compared to each other as well as to the historical performance and paths of those firms studied. We expect deepened insights regarding both long-term firm performance as well as method integration from this pass of the project.

Methodological Considerations: With step 3 the research project reaches the stage a recursion, in which results from previous stages are revisited and re-interpreted. At this stage of the research project, the most appropriate degree of cross-method model integration can be determined more accurately and on a more informed basis. We speculate that docking-type integration between the system dynamics and agent-based models will focus on areas, in which dynamic input is generated in either way between models. We also hypothesize that the parallel process of modeling in the two paradigms will provide a host of new methodological insights within and across the two methods. Finally, we expect to more clearly understand the benefits of either modeling method relative to the problem at hand.

Deliverables from this step include:

- (1) The reformulated models
- (2) Comparison of simulation-based results and with results and evaluations from step 2
- (3) Comparison of the initial results from step 1 with those gained from the reformulated models
- (4) Re-specification of degrees of model integration

Expanding the Model/Problem Scope (Step 4)

Approach: Both the SD and AB models include structure, which are part of the firm's immediate environment such as the supplier sector, the customer sector, and the competitors'/market sectors. Once those sectors are treated model-endogenously, important dynamics and interactions between firm-internal and firm-external dynamics may be come visible. Step 4 will partly address the second and third research perspective.

Methodological Considerations: With the method-related analyses of step 3 in hand, the development of expanded dynamic models, both agent-based and system dynamics-based will we believe unfold, in a more directed fashion. At this stage and based on the growing experience from preceding iterations, we expect to be able to determine the most appropriate degree of method integration in the research design.

Deliverables from this step include:

- (1) Expand the models to include supplier, customer, and demand/market sectors
- (2) Calibrate the models to specific firm, industry, and market dynamics
- (3) Simulate those firms embedded into those dynamic industry/market environments
- (4) Compare endogenous explanations from step 2 with endogenous/exogenous explanations from this simulation.

Concluding Remarks

This paper contributes to the expansion of academic knowledge in the following two ways: (1) It proposes to use dynamic modeling for multi-disciplinary theory integration, and (2) it undertakes this theory-integration by using a multi-method approach (SD, AB modeling, historical data analysis, and ethnographic research) with an emphasis on the potential cross-validation and triangulation of results by using both system dynamics and agent-based modeling for dynamically representing (in this particular case) the integrated theory of long-term firm performance.

Through simulation and computer experiments, new potential insights relevant to long-term firm performance are derived. Those results garnered from simulation of both the system dynamics and agent-based implementation of the integrated then guide the empirical search and exploration directed at a purposive sample of long-term survivor

firms. With the results from data analysis of historical and ethnographic data in hand, a re-conceptualization and re-formulation of the top-down and bottom-up models is performed. Simulation results from those revised models are then again compared and evaluated. At that stage, the degree of usefulness of integrated modeling designs should become more understandable. We expect to be able to clearly identify the degree of cross-validation and dynamic triangulation between the two modeling techniques.

In each case, convergence or divergence of simulation outcomes between the two modeling approaches, the potential of multi-method integration should have become much clearer than from today's (untested) perspective. Also, the utility of iterative designs, which include a simulation-led empirical step at each cycle of iteration, should have become visible. Finally, the gradual expansion of problem (and model) boundaries may help better understand the interplay between (in this case) firm-internal as opposed to firm-external dynamics.

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