TOWARDS AN INTEGRATION OF THE LEAN ENTERPRISE SYSTEM, TOTAL QUALITY MANAGEMENT, SIX SIGMA AND RELATED ENTERPRISE PROCESS IMPROVEMENT METHODS[+]

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Abstract: The lean enterprise system, total quality management, six sigma, theory of constraints, agile manufacturing, and business process reengineering have been introduced as universally applicable best methods to improve the performance of enterprise operations through continuous process improvement and systemic planned enterprise change. Generally speaking, they represent practice-based, rather than theory-grounded, methods with common roots in manufacturing. Most of the literature on them is descriptive and prescriptive, aimed largely at a practitioner audience. Despite certain differences among them, they potentially complement each other in important ways. The lean enterprise system, total quality management and six sigma, in particular, are tightly interconnected as highly complementary approaches and can be brought together to define a first-approximation "core" integrated management system, with the lean enterprise system serving as the central organizing framework. Specific elements of the other approaches can be selectively incorporated into the "core" enterprise system to enrich its effectiveness. Concrete theoretical and computational developments in the future through an interdisciplinary research agenda centered on the design and development of networked enterprises as complex adaptive socio-technical systems, as well as the creation of a readily accessible observatory of evidence-based management practices, would represent important steps forward.

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1 INTRODUCTION

This chapter builds upon and extends Chapter eae371 devoted to a discussion of the evolution of the *lean enterprise system*. This chapter concentrates on an exploration of whether, to what extent, where and how the *lean enterprise system*, *total quality management (TQM),* and *six sigma* – as well as other methods, such as *theory of constraints (TOC), agile manufacturing*, and *business process reengineering (BPR)* -- can be brought together, by exploiting the potential complementary relationships among them, to evolve a more effective "core" integrated enterprise management system, with the *lean enterprise system* serving as the central organizing framework. The aim is not to evolve a unified approach that fits all needs but rather to help create, ultimately, a menu of options in the form of various extensions of the "core" management system, where the key to success would be choosing the most appropriate approach for the type of enterprise change under consideration in light of the prevailing or expected external environmental contingency conditions.

These approaches were introduced or became popular in the 1980s and early 1990s as unique methods for providing the best and universally applicable answers to perceived enterprise performance problems. They were adopted at a time of a major shift in management philosophy and practice – catalyzed by the dissolution of the prevalent mass production system and intensifying market competition -- concentrating on process management to achieve significant improvements in terms of operational efficiency, flexibility and responsiveness. The new market realities required viewing enterprises no longer as hierarchically organized functional silos but rather as systems of interconnected processes across multiple functions and organizational boundaries that had to be streamlined and managed to boost productivity and competitiveness.

The six specific approaches discussed here can be referred to as operational improvement methods, enterprise change initiatives, planned change models, or intervention approaches, reflecting the various ways in which they can be interpreted. There has been a common misconception in the past that they represent distinctly different, mutually exclusive, and competing methods for accomplishing the same end result. The general approach adopted in this chapter is that the differences among them are dwarfed by the potential common elements and synergies among them. Despite certain differences that separate them, they share common roots in manufacturing, focus almost exclusively on enterprise operations, and concentrate on process improvement. They collectively represent, with only minor differences, basically a top-down directive strategy to the implementation of enterprise change.

In recent years, lean enterprise practices and *six sigma* methods have been increasingly merged into a harmonized implementation "package" generally known as the *lean six sigma (LSS) continuous process improvement (CPI) toolset.* Although seemingly desirable on the surface, this development has had an unfortunate consequence. In effect, lean enterprise concepts, especially, have been reduced into a fairly mechanical implementation toolset, in the service of a virtually exclusive emphasis on process improvement at the tactical and operational levels. In part because of this, in general enterprise performance improvement and change initiatives have had mixed success. The benefits obtained from the use of the various approaches, including those examined here, appear to be highly limited, isolated or short-lived.[1] Based on the available empirical

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[1] Even though there have been numerous individual cases of tangible and even dramatic operational improvements, these improvements are often found to slow down and vanish after a short period of time (Hall, Rosenthal & Wade 1993). The adoption of lean production practices is generally found to result in incremental improvements in such operational measures as cost, quality and cycle time (e.g., Sakakibara *et al.* 1997; White *et al.* 1999). However, Murman *et al.* (2002:114-116) report that the main result of the

evidence, the broad verdict in the literature is that most enterprise change initiatives are doomed to failure (Hammer & Champy 1993:200; Spector & Beer 1994:63; Kotter 1995:59; Beer & Nohria 2000:133; Burnes 2004:886). The very small number of available systematic or scholarly analyses using formal statistical techniques (e.g., Powell 1995; Flynn, Schroeder & Sakakibara 1995; Sakakibara *et al.* 1997; Hendricks & Singhal 1997, 2001; Samson & Terziovski 1999; Ahire & Dreyfus 2000) are either largely inconclusive or suffer from serious methodological problems.

These disappointing results explain the basic motivation for the present chapter. That is, there is an urgent need to start working towards the development of more effective enterprise management systems. A good place to start, as a first-approximation, is to explore the common elements and complementary relationships that link together the *lean enterprise system, total quality management TQM),* and *six sigma,* which represent closely interconnected approaches. A working hypothesis is that these three approaches, taken together, form a highly complementary and cohesive cluster of precepts, practices and methods that can be integrated to define a "core" integrated enterprise management system, with the *lean enterprise system* serving as the central organizing framework. It is argued that among the various approaches, the *lean enterprise system*, in its contemporary formulation, comes closest to providing a holistic view of enterprises embodying a tightly knit set of mutually supportive precepts and practices driving its central value-creating operations. By comparison, TQM, *six sigma* and the other approaches generally lack such a broad, internally consistent, holistic conceptual orientation. The remaining approaches – *theory of constraints (TOC), agile manufacturing*, and *business process reengineering (BPR)* – offer specific features that can be integrated into the resulting "core" enterprise management system on a selective basis to enhance its overall effectiveness.

The discussion below is organized as follows. The next section (Section 2) gives a highly abbreviated description of the various approaches. Sections 3 concentrates on the key complementary relationships that link together the *lean enterprise system*, *total quality management (TQM),* and *six sigma*. Specific elements of the other approaches are incorporated into the discussion on a selective basis, where appropriate. Section 4 concludes with a summary of main findings and future perspectives.

2 AN OVERVIEW OF THE VARIOUS APPROACHES

This section presents a highly condensed description of the various approaches to outline their main features and summarize their key differentiating as well as common and potentially complementary characteristics. These approaches differ from each other in terms of their underlying *mental models* or the cause-effect relationships they posit to explain the main sources of organizational inefficiency and ineffectiveness they are best suited to address (e.g., waste, poor quality, process variation, inefficient processes, lack of responsiveness), even though this is not always explicitly articulated. They exhibit further differences, such as in terms of the *scale* (i.e., strategic, tactical, operational) at which they can be deployed to bring about change, their *scope* of coverage of enterprise operations (e.g., plant, company division, end-to-end enterprise operations extending across supplier networks), their primary *focus* for planned change (e.g., discrete processes, all operations, core values, organizational culture), the implementation

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application of lean principles in the aerospace context has been "islands of success" within the organizations that have adopted them, often confined to specific plants, programs or processes. Sustained enterprise-wide change has been rare.

methods they employ (e.g., value stream mapping to identify and eliminate waste, "clean-sheet" redesign of processes), and *mode* of change or improvement they can be expected to produce (e.g., small-step or large-step incremental change). Despite these differences, however, they share important overlapping, common and complementary elements that can be exploited to evolve a more effective integrated enterprise management system.

The various approaches are first briefly described below. They are discussed roughly in the historical order in which they have been introduced or gained prominence. A comparative summary of their key characteristics is next presented.

2.1 A brief description of the various approaches

2.1.1 Lean enterprise system

Earlier known principally as *just-in-time (JIT) manufacturing*, *the Toyota Production System (TPS), or the lean production system,* the *lean enterprise system* has been characterized as a fundamentally new and different way of thinking about and managing modern industrial enterprises. With its roots at Toyota, it has evolved since the 1950s through a process of experimentation, learning and adaptation. Early attention concentrated primarily on manufacturing and related operations, focused on elimination of waste, continuous flow, striving for perfect first-time quality, continuous improvement, and long-term relationships based on mutual trust and commitment. More recently, basic lean concepts have been expanded in several new directions and continue to evolve through an ongoing research-based discovery process. What makes the basic *lean enterprise system* compelling – alone among the various approaches discussed here -- is that it adopts a holistic view of the networked enterprise spanning the end-to-end enterprise value stream, stresses long-term thinking, encompasses all enterprise operations (e.g., strategic, tactical, operational), and embodies a tightly-interwoven set of mutually supportive and highly complementary principles and practices fostering continuous improvement, organizational learning, and building of dynamic organizational capabilities throughout the value stream that enable creation of value for multiple enterprise stakeholders.

2.1.2 Total quality management (TQM)

Although TQM became extremely popular in the 1980s, its genesis can be traced back to the development of statistical process control (SPC) concepts and methods in the 1930s. At the height of its popularity, much of its appeal derived from its being credited for the growing prominence of Japanese producers. The "quality revolution" led to the establishment of the Malcolm Baldrige National Quality Award Program in 1988 to recognize performance excellence by U.S. organizations toward improving national competitiveness. Since 1997, a system of international quality standards has been developed and codified in the form of the ISO 9000 family of quality standards, adopted by thousands of organizations throughout the world (Hoyle 2009).

TQM encompasses a set of precepts, practices, methods and techniques (e.g., statistical process control (SPC), error-proofing (*poka-yoke)*, quality circles, quality function deployment, robust design) to improve quality and ensure customer satisfaction. However, TQM has no single, unified, or cohesive definition and generally lacks an integrative conceptual framework. Instead, it encompasses a number of distinctive perspectives reflecting not only the main ideas of key figures shaping the quality movement (e.g., W. Edwards Deming, Joseph M. Juran, Philip B. Crosby, Genichi Taguchi) but also evolving notions of quality, as the definition of quality has shifted over time from *conformance-to-specifications* to *value* to *meeting-and-exceeding-customer-expectations*). TQM has gradually outgrown its earlier narrow technical origins to embrace systemic organizational change.

Deming's (1989) management method, presented in the form of fourteen commands, still serves as a broad umbrella covering multiple dimensions of TQM and stands as the centerpiece of TQM as a management system. Basic TQM concepts include meeting and exceeding customer expectations, visionary and engaged leadership, internal and external coordination including strong links both to customers and suppliers, learning, process management, continuous improvement, and employee fulfillment. Improving quality is expected to reduce costs and facilitate the achievement of other organizational objectives, such as increasing market share, operating income, and stock market performance. A key tenet of TQM is that improving quality is primarily the responsibility of management, requiring committed and engaged management at multiple levels. Also, enhancing quality requires the active involvement of the *total* organization. Both tenets call for an "open" organization, empowered and fulfilled employees, collaborative relationships across the organization, and close links to both customers and suppliers. In recent years, a growing number of academic contributions have further defined and refined TQM's various dimensions and conceptual foundations. Also, a number of attempts have been made to frame TQM as a conceptual framework consisting of interacting concepts and practices that work together to achieve desired outcomes.

A main strength of TQM lies in its quest to define quality in order to translate anticipated future customer needs and preferences into measurable characteristics so that products can be designed, produced and sustained to meet customer satisfaction at prices they are willing to pay. As a corollary, TQM sees enterprises as systems encompassing interdependent processes spanning many organizations that must be simultaneously designed, managed and continuously improved. In pursuit of this quest, reducing variability has occupied central attention. Beyond these broad outlines, however, TQM has lacked a clearly articulated conceptual core and a structured implementation methodology, contributing to its somewhat amorphous image and giving rise to such questions as whether it basically represents a method for incremental improvement or strategic change, and whether it favors control over continuous learning. In general, TQM's claim of applicability to a broad range of modern corporate problems -- instrumental to its earlier widespread acceptance -- may have been a major reason for its subsequent decline.

2.1.3 Six sigma

Six sigma can be generally defined as a structured process aimed at reducing all sources of process and product variation throughout an enterprise in order to improve quality, meet customer expectations, and enhance enterprise performance. First introduced in the mid-1980s at Motorola, *six sigma* was later adopted by General Electric and a growing number of other companies and organizations. Despite the great deal of interest in it, much of the available literature on *six sigma* consists of numerous books and papers authored by practitioners, addressing largely "how-to" type questions, with only a handful of publications critically exploring its theoretical properties. In recent years *six sigma* has been advanced as a broadly-based, integrative, and disciplined management system -- well beyond its earlier narrow technical moorings -- for fundamentally changing the way corporations do business to improve the bottom line and create wealth.

At a technical level, *six sigma* represents the application of probability theory to process quality control and management. It is aimed at achieving virtually defect-free operations, where parts or components can be built to very exacting performance specifications. Underlying *six sigma* as a statistical concept is the construct of *standard deviation* (denoted by the Greek letter σ, or *sigma*), which is a measure of variance, or distribution around the mean. Reducing variation to the *six sigma* level means reaching a performance level of 99.99966 percent perfection (3.4 defects or nonconformances per million opportunities – DPMO). DPMO indicates how many defects would be observed if an activity were repeated a million times. This means virtually defect-free production, where a defect is defined as any instance or event in which the product fails to meet a customer requirement (Pande, Neuman & Cavanagh 2000:28). To appreciate the power of six sigma level of performance, it should be noted that three sigma, considered normal in the past, results in 66,810 DPMO or 93.3% process yield (Linderman *et al*. 2003:194; Kwak & Anbari 2006:709).[2]

The main implementation method used by *six sigma* is DMAIC (define-measure-analyze-improve-control), which involves a five-phase cycle: (1) *define* – define customer requirements and develop a map of the process to be improved); (2) *measure* -- identify key measures of effectiveness and efficiency, and translate them into the concept of sigma; (3) *analyze* – analyze the causes of the problem requiring improvement; (4) *improve* --generate, select and implement solutions; and (5) *control* -- ensure that improvement is sustained over time (Eckes 2001:10). This process – or DMAIC – is grounded in the well-known Deming Plan-Do-Check-Act cycle (PDCA), which describes the basic data-based improvement process. DMAIC uses a sequence of highly focused and mutually supporting set of tools and techniques.[3]

Six sigma offers a number of distinct and important advancements over TQM. *First*, it employs a structured and disciplined approach to quality improvement, such as the use of the DMAIC method. *Second*, it makes an explicit effort to train a skilled cadre of process improvement personnel with highly differentiated skills and well-defined career tracks. These highly trained personnel are directly engaged in mentoring, managing, designing and implementing concrete improvement projects. *Third*, it is a fact-based process improvement approach that uses a variety of metrics. These include performance metrics (e.g., process capability metrics, critical-to-quality metrics), customer-oriented metrics (e.g., measuring customer needs, requirements and expectations), and financial metrics (e.g., measurable financial returns to specific improvement projects). *Fourth*, *six sigma* makes use of a well-designed organizational structure for the implementation of process improvement projects. These have been called "meso-structures," representing a vertical or multilevel organizational integration mechanism in executing *six sigma* projects (Schroeder *et al.* 2008:540).

The main strength of *six sigma* stems from its highly disciplined and structured set of methods, tools, and implementation processes to improve quality. However, the central thrust of *six sigma* remains an emphasis on discrete projects, processes or problems. Whether or how the aggregation of benefits from a large number of essentially localized improvements might actually scale up to generate sustainable enterprise-level improvements or systemic change is an open question.

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[2] The sigma level is also used as a measure of the manufacturing capability level of individual enterprises, denoted by c_{pk} -- the manufacturing capability index, which is a gauge of the degree to which the system can produce defect-free products. For example, the six sigma level of performance corresponds to a c_{pk} level of 2. A more detailed technical review of six sigma and the manufacturing capability index, c_{pk}, is given in Harry & Lawson (1992) and in Eckes (2001). A table showing the correspondence between the sigma level and the manufacturing capability index can be found in Eckes (2001:266-267).

[3] These include statistical process control (SPC) and control charts for *problem identification*; tests of statistical significance (e.g., Chi-Square, t-tests, ANOVA) for *problem identification and root cause analysis*; correlation and regression analysis for *root cause analysis and prediction of results*; design of experiments (DOE) for *identifying optimal solutions and validating results*; failure modes and effects analysis (FMEA) for *problem prioritization and prevention*; *poka yoke* (mistake-proofing) for *defect detection and process improvement*; and quality function deployment (QFD) for *product, service and process design* (see Pande, Neuman & Cavanagh 2000:355-377).

Basically, it represents largely a “how to” approach lacking a larger theoretical foundation. *Six sigma* is fundamentally an approach for achieving process improvement rather than a method for strategic change management. On balance, it is driven by a central logic of control rather than experimentation and learning. Rather than being directly concerned with “doing the right thing” it stresses “doing it right” by following a prefigured structured process and specific implementation tools.

2.1.4 Theory of constraints (TOC)

Theory of constraints (TOC) was introduced in the 1980s to focus attention on throughput on the factory floor, mostly out of some dissatisfaction with the JIT and TQM approaches. The reason given was that both JIT and TQM concentrated on cost-related, rather than on throughput-related problems. Thus, the basic rationale of TOC is that focusing on *throughput* would provide far greater benefits in terms of improving overall enterprise performance. *Throughput,* defined as a financial construct, measures the rate at which a production system generates money through sales. It is interrelated with two other key variables: *operating expense* and *inventory*, where *inventory* is roughly the cost of purchased goods and services and *operating expense* is the internal cost of turning *inventory* into *throughput*, such that *throughput* minus *operating cost* is net profits, which is the central measure of enterprise performance. Thus, TOC focuses directly on increasing *throughput,* in the belief that reducing operating expense or inventory would yield at best marginal benefits.

TOC is hence offered as a systematic method for the identification and removal of constraints impeding *throughput* in interdependent production systems, where the constraints are thought to flag critical bottlenecks representing the weakest links in the interdependent production chain. The bottlenecks (e.g., physical, logistical, behavioral, managerial) are perceived as critical leverage points for introducing changes affecting the operation and performance of the entire system. Partly responsible for the emphasis on increasing throughput by eliminating system constraints has been a certain amount of skepticism about the ability of enterprises to create continuous flow, a central feature of *just-in-time (JIT)* manufacturing. Instead of continuous flow, TOC offers a production scheduling and management method (i.e., drum-buffer-rope) to manage the pace of production flow and to protect the manufacturing line against unknown disturbances. Despite its surface emphasis on systems thinking, however, TOC offers no systematic basis for identifying and eliminating system constraints. Also, a closer scrutiny of the definition of its central constructs and the accounting relationships among them has raised some questions concerning its conceptual validity and operational usefulness.

2.1.5 Agile manufacturing

Agile manufacturing, which came into prominence in the early 1990s, has been advanced as a new future-looking, rather than an empirically-grounded, set of concepts and best practices for guiding manufacturing enterprises to enhance their competitiveness in a new fast-paced market environment following the unraveling of the mass production system and the industrial order associated with it. The introduction of *agile manufacturing*, too, can be traced to some disenchantment with both TQM and lean production ideas. It has been presented as a new management system to go well beyond lean production to introduce concepts of highly efficient, adaptive and flexible manufacturing enterprises thriving in a fast-moving competitive environment. An agile enterprise has been defined as one engaged in high-volume, made-to-order, arbitrary-lot-size production enabled by an information-technology-intensive flexible production capability. *Agile manufacturing* has thus been advanced as the answer to the imperatives of a new industrial paradigm characterized by an unpredictably changing market environment. The notion of *virtual organizations*, formed on an as-needed basis, provides an important organizing vehicle for building agile enterprises.

In general, *agile manufacturing* suffers from the vagaries of theorizing about the future by pulling together a patchwork of plausible concepts and methods. It basically consists of a collection of seemingly desirable practices supporting an idealized end-state picture of organizational arrangements. It borrows heavily from lean ideas but lacks an internally consistent set of organizing principles derived from either experience or the extant literature on effective organizational architectures in turbulent environments. Nevertheless, agile manufacturing at least makes a case for industrial organization in an environment of rapid change and uncertainty, an environmental contingency generally missing in discussions of the other approaches. Finally, *agile manufacturing* suggests certain future directions for the further evolution of the *lean enterprise system* to help enterprises develop capabilities to thrive in fast-changing and uncertain environmental conditions.

2.1.6 Business process reengineering (BPR)

Business process reengineering (BPR), introduced with some fanfare in the early 1990s, pursues radical "clean-sheet" rethinking and redesign of enterprise business processes to bring about dramatic performance improvements to help enhance customer satisfaction and achieve both greater efficiency and flexibility in an emerging new market environment. The declared goal of BPR, since its introduction, has been to reverse or remake the industrial revolution – to "retire" prevailing business principles and workflow practices. Tradition has no value. BPR is not about *fixing* anything, downsizing, automation or taking small and cautious steps; it is, rather, about starting from scratch with a clean sheet of paper. BPR represents a new beginning in the life of an organization implementing it.

BPR focuses on business processes -- defined as a collection of activities which, taken together, takes one or more kinds of resources as inputs and creates outputs that are of value to the customer. A central idea is *discontinuous thinking,* focused on completely replacing existing processes, not by taking small and cautious steps but by pursuing radical changes, aimed at reunifying the tasks performed by corporations into coherent business *processes.* Information technology is a critical enabler in redesigning work. The emphasis is on identifying and abandoning outdated rules governing the organization of work and the fundamental assumptions driving business operations, in an effort to achieve dramatic improvements in clock time, productivity, and efficiency.

However, BPR suffers from a number of serious omissions and theoretical limitations. A particular weakness has been the sheer lack of any conceptual means for managing complexity (e.g., managing interrelated change projects, anticipating the chain reaction of complex changes ensuing from various BPR actions in order to mitigate negative unintended consequences). One-time "breakthrough" operational improvements are not accompanied by subsequent continuous improvement. Cultural and behavioral issues are given scant attention. Despite the rhetoric that an organization's reigning values and beliefs are crucial to the success of reengineering efforts, in reality cultural and behavioral issues play an incidental role. Finally, BPR is fundamentally a top-down process, displaying a basic ambivalence between stressing control *versus* fostering empowerment, adaptation and learning. The available evidence suggests that the dominant top-down-driven reengineering process, enacted by empowered process owners and teams, essentially marginalizes workers and their immediate workplace supervisors.

2.2 A comparative summary review of the various approaches

Tables 1 and 2 give a top-level comparative summary of the various approaches, in terms of their key characteristics. Table 1 summarizes them in terms of their historical origins, goal, defining features, and core concepts. Table 2 focuses on their implementation aspects: their focus, implementation strategy, and mode of targeted (expected) improvement and change.

It can be seen from Table 1 that four of the six approaches discussed here are relatively new, having been introduced since the mid-1980s. These are *six sigma*, *theory of constraints, agile manufacturing,* and *business process reengineering*. Among them, the *lean enterprise system* has the longest unbroken lineage, going back to the late 1940s and early 1950s. Although *total quality management (TQM)* became highly popular in the 1980s, its origins can be traced to the development of process control concepts and methods in the 1930s. TQM became popular in the 1980s in response to the inroads made by Japanese electronics producers into the U.S. market and, more generally, to counter the erosion of U.S. competitiveness. However, its hold on the corporate world as a novel management system has declined significantly in recent years. *Six sigma*, as well, was introduced in the 1980s, generally out of a general frustration with the lackluster success of early TQM initiatives. It offered a structured process for improving quality by reducing all sources of variation that TQM lacked.

Theory of constraints (TOC) was introduced to overcome the perceived shortcomings of both the *lean enterprise system* and TQM. Both were thought to concentrate on “the cost world” rather than on the “throughput world,” where the latter was considered to provide greater benefits in terms of improving an organization’s financial performance. *Agile manufacturing* was advanced in the early 1990s as the answer to the needs of a new industrial order replacing the decades-long mass production system. It was put forward as a new management method going beyond lean production ideas to help companies thrive in a fast-paced and unpredictably changing market environment. Finally, *business process reengineering (BPR)* was introduced in the early 1990s as a radical departure from continuous improvement to bring about not incremental but dramatic improvements through radical redesign of existing enterprise processes.

Despite some differences among them, the goal of the respective approaches, in terms of expected outcomes they promise to deliver, basically converge around the achievement of customer-focused operational improvements. Their defining features reveal their driving logic, substantive content and scope. A comparative examination of their defining features and core concepts demonstrates that, the *lean enterprise system* clearly represents a more complete, holistic, view of enterprises, by conceptualizing them in terms of their entire end-to-end value streams as networked enterprises (i.e., holistic network perspective). Alone among the various approaches, the *lean enterprise system* explicitly takes a lifecycle view of products and systems, concentrates on creating value for multiple stakeholders, fostering organizational learning, and building network-level dynamic capabilities. By comparison, TQM presents a comparatively narrower version of this conceptualization, focusing primarily on the “core” enterprise, stressing quality improvement, meeting customer expectations, and stressing the need to establish strong links to both customers and suppliers (i.e., “inside-out” perspective). *Six sigma*, with its vaunted focus on process improvement through elimination of all sources of variation, is concerned mostly with bottom-line performance, lacks a lifecycle perspective, and views the “outside” supplier network largely to ensure *process control*, thus exhibiting hardly any of the basic attributes of the *lean enterprise system* related to supply chain design and management. TOC, although it espouses a “system” view, is mostly inward directed, paying little attention to the external supplier network (i.e., essentially a “closed” perspective).

Table 1. Summary overview of major approaches for continuous improvement and planned systemic change: defining characteristics

Approach / Key Dimensions	Lean Enterprise System	Total Quality Management (TQM)	Six Sigma	Theory of Constraints (TOC)	Agile Manufacturing	Business Process Reengineering (BPR)
History	Since late 1940s (emphasis on developments since mid-1990s)	Since early 1980s	Since mid-1980s	Since mid-1980s	Since early 1990s	Since early 1990s
Goal	• Deliver value to multiple stakeholders • Build long-term dynamic network-wide capability for sustained competitive advantage	• Meet customer expectations • Improve profitability and shareholder value	• Increase customer satisfaction • Create economic wealth (higher profitability and shareholder value)	• Maximize throughput • Improve net profits	• Enhance enterprise flexibility and responsiveness • Thrive in a fast-paced, uncertain, environment	• Improve customer satisfaction • Enhance enterprise performance
Defining Feature	• Mutually supportive and reinforcing set of principles, practices and methods for evolving efficient and flexible enterprises as networked systems creating value for multiple stakeholders	• Evolving system of precepts, practices, tools and techniques for improving quality to satisfy customer needs & expectations	• Structured methods, practices and tools for reducing all sources of variation in order to improve quality, satisfy customer needs, and improve the bottom-line	• Set of ordered practices, methods and tools for improving throughput in production systems in order to maximize financial performance, by viewing the production system as "chains of interdependencies"	• Future-looking, aspirational, set of concepts and practices aimed at defining the next industrial paradigm beyond lean enterprise ideas and flexible production systems	• Manifesto for turning the prevailing industrial system on its head; a manifesto for fundamental rethinking and radical redesign of core enterprise processes

Core Concepts	• Adopt a holistic view of the networked enterprise • Stress long-term thinking • Deliver customer-pulled best lifecycle value • Eliminate waste towards the goal of creating value • Ensure stability and synchronized flow • Develop collaborative relationships and mutually-beneficial network-wide governance mechanisms • Foster a culture of continuous learning • Evolve an efficient, flexible & adaptive enterprise	• Understand and fulfill customer expectations • Concentrate on process management to reduce sources of variation • Focus on continuous quality improvement • Ensure heavy leadership involvement • Establish close links to customers & suppliers • Develop an "open" organization • Foster worker training, empowerment and fulfillment	• Adopt customer-focused culture • Reduce all sources of variation • Pursue disciplined, structured, approach to process improvement • Practice proactive, data-driven, management • Emphasize teamwork	• Improve workflow (throughput) in the production system • Concentrate on key leverage points (constraints) offering greatest performance improvements • Protect production line against interruptions • Ensure people learn better and faster	• Anticipate and meet customer needs • Deliver tailored solutions to customers • Evolve adaptive, flexible & efficient enterprise • Establish virtual organizations • Enhance ability to thrive in a fast-paced & uncertain environment	• Reinvent enterprise through fundamental rethinking of enterprise processes • Pursue radical ("clean sheet") redesign of existing business processes • Seek breakthrough process solutions

Table 2. Summary overview of major approaches for continuous improvement and planned systemic change: implementation characteristics

Approach / Key Dimensions	**Lean Enterprise System**	**Total Quality Management (TQM)**	**Six Sigma**	**Theory of Constraints (TOC)**	**Agile Manufacturing**	**Business Process Reengineering (BPR)**
Focus	• Focusing on all enterprise operations, processes and functions • Emphasis on creating robust value propositions and value exchanges among stakeholders • Managing complex interdependencies throughout the networked enterprise (information flows, knowledge sharing, network-wide learning & capability-building)	• Determining customer expectations • Focus on core business processes • Integration of design, development & production operations • Establishing strong links to suppliers	• Concentration on specific prioritized business processes • Focus on reducing all sources of variation to improve quality, increase efficiency & shorten cycle time	• Concentration on production processes • Focus on the *weakest point* (constraint) impeding workflow and causing both delays & inefficiency	• Concentration on effective enterprise integration to support manufacturing • Focus on delivering high-quality, low-cost & innovative tailored solutions to customers • Creating virtual organizations, as needed, to reduce cost & cycle time	• Concentration on enterprise processes, not on organizational structures, tasks, jobs or people • Focus on "clean sheet" redesign of specific processes

Implementation	• Top-down directive process involving strong leadership support & engagement • Using structured process (frameworks, roadmaps) for enterprise-level continuous improvement & planned systemic change • Use of outside experts (providing facilitation, mentoring, training, implementation services) or internally managed process	• Top-down directive process involving heavy multi-level management participation • Using a portfolio of practices, tools & techniques to implement continuous improvement • Use of outside experts (providing facilitation, mentoring, training, implementation services) or internally managed process	• Top-down directive process involving structured management engagement (project champions, sponsors) • Using DMAIC (Define, Measure, Analyze, Improve, Control) as the dominant implementation method • Largely internally managed process with support/facilitation by outside experts	• Top-down directive process involving management participation • Using structured process employing *focusing steps* (to remove constraints), ten-step *Decalogue* for system-wide management, and "drum-buffer-rope" production scheduling method for managing production line • Mostly internally managed process with support/facilitation by outside experts	• Top-down directive process led by top management • Emphasis on enterprise integration, training & education, and empowered teams • Building effective information infrastructure • Forming virtual organizations • Mostly internally managed process, with possible support from outside experts	• Top-down directive process involving management participation (e.g., as process owners) • Generally pursuing a structured multi-step implementation process (Mobilization, Diagnosis, Redesign, Transition) • Facilitation by outside experts or internally managed process
Mode of Improvement and Change	• Continuous process improvement; gradual incremental change; planned systemic enterprise change & realignment	• Continuous process improvement; gradual incremental change	• Continuous process-specific improvement; incremental change (in discrete small or large steps)	• Continuous operational improvement; incremental change	• Continuous process improvement; incremental change (in small or large steps)	• Process-specific continuous improvement; incremental change (in small or large steps)

Table 3. Summary overview of the various approaches: applicability at different enterprise scales and intensity of focus

Enterprise Scale	Lean Enterprise System	Total Quality Management (TQM)	Six Sigma	Theory of Constraints (TOC)	Agile Manufacturing	Business Process Reengineering (BPR)
Strategic	●	⊙	○	○	◉	○
Tactical	●	◉	◉	⊙	●	⊙
Operational	●	●	●	●	●	●

LEGEND (Intensity or degree of focus): ● Full ◉ Moderate ⊙ Partial ○ Very little or none

Table 3. Summary overview of the various approaches: extent of enterprise scope and intensity of focus

Enterprise Scope	Lean Enterprise System	Total Quality Management (TQM)	Six Sigma	Theory of Constraints (TOC)	Agile Manufacturing	Business Process Reengineering (BPR)
Networked enterprise	●	⊙	⊙	○	◉	○
Core Enterprise	●	◉	⊙	⊙	●	⊙
Business Unit	●	●	◉	◉	●	●
Factory Floor	●	●	●	●	●	●

LEGEND (Intensity or degree of focus): ● Full ◉ Moderate ⊙ Partial ○ Very little or none

In contrast with TQM, which visualizes the supplier network as being "outside" the core enterprise, and also with TOC, which recognizes the supplier network primarily as a source of purchased materials, the *lean enterprise system*, at least in theory, makes no "inside-outside" distinctions and considers the supplier network as an integral part, or essential extension, of the core enterprise. *Agile manufacturing*, meanwhile, places a heavy emphasis on developing *virtual organizations,* enabled through the use of information technologies. There seems an assumption, however, that this can be accomplished practically without any friction, in a fairly mechanical manner. It overlooks thorny theoretical issues associated with the establishment of inter-organizational networks to respond quickly to emerging market needs. Finally, *business process engineering,* to the extent that it does pay attention to supplier networks, is concerned primarily with the task of creating "superefficient companies," stressing the need for cross-organizational process redesign to eliminate "prodigious costs of uncoordinated intercompany processes" (Hammer 2001:84).

A review of their implementation-related features given in Table 2 shows that all of the approaches focus on enterprise operations and typically follow a top-down directive implementation strategy. A top-down strategy is a type of intervention method used to execute planned systemic enterprise change in order to achieve the desired future-state performance outcomes.[4] The various approaches typically involve structured implementation processes (e.g., in the form of frameworks, roadmaps, portfolio of practices, tools and techniques), internal training programs, and the use of external experts providing mentoring, facilitation, training, and implementation functions. The common mode of change or improvement involves evolutionary, gradual or *incremental change* (i.e., small-step or large-step operational improvements), not *radical change* involving deep structural enterprise transformation.

Table 3 summarizes, for the various approaches, their applicability at different enterprise scales and intensity of focus. The intensity scale ranges from *full* to *very little or none.* It can be seen that the *lean enterprise system* is fully focused on process improvement, as well as systemic change, at all enterprise scales: *strategic* (e.g., decisions concerning the business model, stakeholder value exchange, investment choices, strategic alliances); *tactical* (e.g., design of business processes, human resource practices, supplier relationships, supporting infrastructure systems); *operational* (e.g., production scheduling, manufacturing operations, procurement, inventory management, order processing). Similarly, *agile manufacturing* focuses with full intensity on improvements particularly at the tactical and operational levels and only partially at the strategic level. By comparison, the other approaches are fully focused on tactical and operational improvements. They either partially address or virtually ignore strategic level issues and concerns.

Finally, Table 4 summarizes the extent of enterprise scope of the various approaches and their intensity of focus. Whereas the *lean enterprise system* addresses with full intensity the entire enterprise "space" from the factory floor to the networked enterprise, the other approaches

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[4] Currently there is no one single, all-embracing, generally accepted, or most effective model of organizational intervention to bring about large-scale change (Dunphy 1996:541; Edmondson 1996:572; By 2005:373). There are, however, a number of approaches to achieving organizational change that have been widely debated in the literature and the key to success is choosing the most appropriate approach for the type of change being contemplated and the circumstances surrounding the change initiative (Burnes 2004:886). There is, at the same time, no generally accepted taxonomy of planned change or intervention models for designing and implementing large-scale enterprise change.

concentrate primarily on improvements at the business unit and factory floor levels and place comparatively little emphasis on improvements at the networked enterprise level. Perhaps the narrowest scope is that displayed by the *theory of constraints (TOC),* which is almost exclusively concerned with factory floor operations. *Agile manufacturing*, like the *lean enterprise system*, embraces a broader scope of the total enterprise; however, its scope is generally limited, in the networked enterprise level, to major suppliers and other partnering organizations in pursuit of the creation of *virtual organizations*. *Business process reengineering (BPR)* might be expected to concentrate with full intensity on factory floor operations. However, the literature on BPR, while containing notable examples of its application in such areas as order fulfillment, accounts receivable, inventory management, and procurement, makes virtually no references, ironically, to its application in manufacturing operations.

The preceding discussion shows that three of the approaches -- the *lean enterprise system*, *total quality management (TQM),* and *six sigma* – have a tightly clustered set of common elements, as well as elements unique to them suggesting highly complementary relationships that link them together. The *lean enterprise system* and TQM share an intertwined history. Many TQM concepts, tools and methods have already become an integral part of the *lean enterprise system.* Meanwhile, *six sigma* is a direct descendant of TQM and strongly complements the *lean enterprise system.* Compared with TQM, *six sigma* brings greater organizational structure, focus, methodological refinement, and discipline to the achievement of continuous quality improvement. Still, neither TQM nor *six sigma* has the intellectual reach and depth of the *lean enterprise system* as an all-embracing holistic enterprise-wide approach.

Thus, these three approaches, taken together, form a highly complementary and cohesive cluster of precepts, practices and methods that can be integrated to define a "core" integrated enterprise management system. The remaining approaches – *theory of constraints (TOC), agile manufacturing*, and *business process reengineering (BPR)* – offer specific features that can be integrated into the resulting "core" enterprise management system on a selective basis to enhance its overall effectiveness.

3 COMPLEMENTARY RELATIONSHIPS BETWEEN THE LEAN ENTERPRISE SYSTEM, TOTAL QUALITY MANAGEMENT AND SIX SIGM

This section concentrates on key complementary relationships between the *lean enterprise system, total quality management (TQM),* and *six sigma*, to explore more closely the proposition that these three tightly-clustered approaches can be integrated into a more effective "core" integrated enterprise management system that would combine the respective strengths of these approaches, where the *lean enterprise system* can serve as the central organizing framework.

Such a "core" integrated enterprise management system could help reverse what appears to have been a serious erosion in the past in the basic understanding and application of these methods. Their reduction in recent years into an implementation toolset for process improvement has already been noted. Two new, corroborating, insights -- based on the top-level review just presented -- point to a deeper historical trend. The first is that TQM itself seems to have been stripped over time of its basic underlying tenets propounded by such founding figures as Deming, Juran and others. What remains is essentially a set of tools and techniques. Another insight is that even though *six sigma* is a direct extension of TQM, there is a remarkable absence, in *six sigma,* of the basic TQM concepts and practices advanced earlier by those same founding figures. *Six sigma* seems to have borrowed from TQM specific tools and techniques but not the basic concepts.

These observations have important implications for the discussion below. Perhaps the most important implication is that such a "core" system must have conceptual "bones" in order for it to be durable; that is, defining such a system mostly by exploring and identifying complementary relationships among them primarily at the tactical or operating levels will most likely not be extremely useful. The discussion is organized into two parts. The first part highlights the main complementary relationships between the *lean enterprise system, total quality management (TQM*), and *six sigma.* The second part summarizes the major results.

3.1 Complementary relationships between the *lean enterprise system, total quality management (TQM),* and *six sigma*

The nature and extent of the complementary relationships between the lean enterprise system, TQM and *six sigma* are explored here in terms of *core principles*, *practices*, and *implementation methods.*[5] These constructs provide a more structured framework for examining such complementary relationships. *Core principles* help define the high-level holistic nature and scope of the enterprise (e.g., focused on operational improvements vs. organizational learning and creation of dynamic organizational capabilities; core-enterprise-centric vs. networked-enterprise-centric). *Practices* define the menu of specific routines, measures or heuristics managers can use for the ongoing or steady state management of enterprise operations, as well as for pursuing continuous improvement and systemic enterprise change at multiple enterprise levels (e.g., enterprise-level, business-unit-level, plant or process level), as well as in defined enterprise domains (e.g., product development, manufacturing, supply chain management).

Practices, through *implementation methods*, translate *core* principles into actions. *Implementation methods* refer to structured deployment approaches, recipes or mechanisms that managers can execute to achieve desired outcomes. While *practices* refer to "what" to do, *implementation methods* refer to both "what to do" and "how to do it." *Implementation methods* typically embody principles, practices, techniques and tools (i.e., both *what* to implement and *how* to implement them). Taking the enterprise as the basic unit of analysis, *practices* and *implementation methods* can be conceptualized at multiple levels (e.g., *strategic*, at the enterprise-level; *tactical,* at the business unit or departmental level; and *operational*, at the plant, program or process level). *Implementation methods* connect core principles and practices to performance outcomes.

Employing these constructs, complementary relationships between the lean enterprise system, TQM and *six sigma* can be summarized as follows.

First, among the three approaches examined closely – *lean enterprise system, TQM and six sigma* -- the *lean enterprise system* offers the broader, more coherent and richer strategic enterprise perspective and conveys an explicit network-centric view of the total end-to-end enterprise value stream. The enterprise value stream spans the upstream supplier network as well as the downstream chain of activities linking the core enterprise to end-use customers. The *lean enterprise system* represents a carefully orchestrated, interconnected, set of principles and practices at multiple levels that imbue it with a certain conceptual unity, gestalt or archetype. It

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[5] The types of distinctions just made are somewhat similar to the differentiation made by Flynn, Sakakibara and Schroeder (1995) between *practices* and *performance* in their examination of the relationships between just-in-time (JIT) production and TQM. However, they do not draw a distinction between principles and practices, nor between practices applicable at different levels. In fact, a clear conceptual distinction between principles and practices is generally lacking in the published literature related to these approaches. As a result, what are considered principles in one publication are treated as practices elsewhere.

also stresses efficiency as well as flexibility, synchronized flow, engaged leadership, optimizing the capabilities of all people, and a culture of continuous improvement and learning. It further takes a dynamic temporal view of the total enterprise, stressing learning and knowledge-creation towards the objective of building long-term network-wide capabilities in order to create value for multiple enterprise stakeholders. Neither TQM nor *six sigma* offers significant complementary improvements over the *lean enterprise system* in terms of its own particular (holistic) enterprise orientation.

Second, although all three approaches have in common many enterprise-level practices (e.g., customer focus, engaged leadership, continuous improvement, integrated design and development of products and processes), TQM and *six sigma* do not appear to have particular enterprise-level practices unique to them that would significantly complement and further strengthen overarching lean enterprise practices.

Third, the *lean enterprise system* offers a differentiated set of *dual-purpose* structured implementation methods that can be used to guide not only continuous improvement efforts but also planned change initiatives at multiple levels (i.e., strategic, at the enterprise-level; tactical, at the business unit or department level; and operational, at the plant or core process level). These structured implementation methods encompass differentiated frameworks, strategies, and implementation roadmaps, including tailored tools designed for use in connection with particular core business processes. In contrast, TQM and *six sigma* make no distinction between continuous improvement and systemic planned enterprise change. Thus, the implementation process they offer is concerned primarily with top-down driven continuous improvement, not with planned multilevel systemic change. TQM offers a somewhat differentiated list of discrete practices that can be used for continuous improvement, but does not offer a structured implementation method. *Six sigma* addresses continuous improvement basically through the application of DMAIC at multiple levels.

Fourth, the greatest source of complementary relationships between the *lean enterprise system*, TQM and *six sigma* reside primarily at the tactical and operational levels, most particularly at the operational level. This involves the use of a large pool of highly complementary practices, techniques and tools that may have once been uniquely or closely associated with TQM but which have since become an integral part of the continuous improvement arsenal of both the *lean enterprise system* and *six sigma.* These range from *poka-yoke* (mistake proofing) and quality circles to quality function deployment and Taguchi methods (quality loss function, robust design, design of experiments). These tools and techniques directly complement and further strengthen standard lean practices and methods that directly support striving for perfect quality, which, in turn, enables continuous flow, *just-in-time (JIT)* production, and greater enterprise flexibility.

The critical complementary relationship between the *lean enterprise system* and *six sigma* should be highlighted in particular. Continuous flow, a central feature of the *lean enterprise system*, can be achieved by tightly integrating both upstream and downstream processes in the extended enterprise value stream and by *striving for perfect first-time quality* to achieve the advantages of *speed.* Materials and information *flow* through the value stream, but defects do not flow by *design,* since defects represent rework and, therefore, constitute a significant source of waste. *Six sigma* stresses the achievement of virtually defect-free *quality* through the elimination of all sources of variation. Thus, *six sigma* practices directly complement lean principles through an emphasis on virtually defect-free products and processes, without which it would not be possible to achieve continuous flow and speed. Consequently, *six sigma* strongly complements the *lean enterprise system.*

Fifth, using DMAIC -- the main *six sigma* implementation method for process improvement -- as part of value stream mapping efforts and also as part of the toolset for addressing many discrete problem-solving situations, would help enhance the effectiveness of lean methods and practices by further reducing variation, improving quality, and speeding up flow. DMAIC is a generic structured problem-solving method. Many of the tools and techniques closely associated with TQM, as well as the advanced statistical methods unique to *six sigma*, are already embedded in DMAIC. The application of DMAIC is likely to be most effective at the operational level, in addressing well-defined and carefully bounded discrete problem situations. The scale, nature and complexity of enterprise problems are often quite different at multiple enterprise levels. Hence, the deployment of DMAIC at the tactical and strategic levels is unlikely to be as effective as its use at the operational level. In the final analysis, *six sigma* offers significant opportunities for complementary relationships with the *lean enterprise system*, primarily at the tactical and operational levels and, most particularly, at the operational level.

Finally, an examination of *theory of constraints (TOC*), *agile manufacturing,* and *business process reengineering (BPR)* suggests that opportunities for complementary links between them and the *lean enterprise system* seem relatively limited. Nevertheless, they offer specific elements that can further complement and strengthen the *lean enterprise system*, mostly at the tactical and operational levels (e.g., applying TOC methods to identify and remove constraints or bottlenecks impeding the production process; using BPR process reengineering methods as part of the value stream mapping approach; adopting agile manufacturing consciousness of external environmental contingency conditions).

4 CONCLUSIONS AND FUTURE PERSPECTIVES

This chapter has concentrated on an exploration of the key complementary relationships between the *lean enterprise system*, *total quality management*, and *six sigma* towards a first-approximation definition of a "core" integrated enterprise management system, with the *lean enterprise system* serving as the central organizing framework. It is shown that such a "core" integrated management system can, in fact, be defined. Such a first-approximation "core" system can serve as the basis for further enhancement through future research focused on developing an improved understanding of the structure and behavioral dynamics of complex large-scale enterprises. The creation of such new knowledge can then serve as the basis for evolving more effective enterprise management systems that managers can use to achieve successful enterprise change and transformation. Two specific future research directions, in particular, can be identified.

First, there is an urgent need for interdisciplinary research aimed at developing new insights into the design, development, and transformation of large-scale enterprises as complex adaptive socio-technical systems. Enterprises, as complex systems, exhibit nonlinear interactions, multilevel nested complexity, and strong emergent properties. The future need is to move away from a linear, sequenced, control-oriented mindset and instead pursue an open, adaptive, spiral learning process, aided by the use of computational modeling and simulation methods addressing emergence properties and complex dynamics of enterprise change and adaptation. A main priority should be to link future research to evolving mainstream organization theory. Two main areas requiring further research include: (a) consideration of external environmental contingency conditions driving enterprise change and transformation; and (b) addressing the tension between incremental change and enterprise transformation, between control and learning, and between the present (i.e., seeking near-term efficiency) and the future (i.e., building dynamic network-level capabilities).

A promising way forward to gain both conceptual traction and practical relevance would be to view enterprises as *purposeful complex adaptive systems* and adopt the construct of *enterprise* *architecture* as a central conceptual framework towards developing a unified understanding of the holistic design of enterprises. Along with the use of computational enterprise modeling and simulation methods, this would serve as an organizing vehicle for designing, testing and evaluating alternative future *enterprise architecture* options, tradeoffs, and effective future transition or transformation strategies– through *in vitro* simulations under virtual laboratory conditions allowing a simultaneous consideration of the multilevel context, content and process of change. The challenge of developing basic principles governing enterprise architectures that can be used to design the "next generation" enterprise architectures, and computational enterprise architecture modeling and simulation methods that can be used to plan and execute successful enterprise transformation efforts, represent the next research frontier.

Second, the need of managers for knowledge on the right type of change management approaches can be addressed by developing a library of evidence-based practices and methods -- reliable and actionable concepts, frameworks, practices, tools – that they can readily access and use. The concept of evidence-based health care is becoming an established part of delivering health care services throughout the world. The concept has begun to spread to fields outside health care, including management. Extending this concept to enterprise change management would represent an important contribution. The emerging new field of implementation science can serve as a good starting point for designing, testing and developing a searchable knowledge observatory on evidence-based management approaches.

Finally, the *lean enterprise system* and the related approaches examined here and in the preceding chapter have been a response to a major shift in management philosophy and practice since the early 1980s -- in the wake of the dissolution of the dominant mass production industrial paradigm -- focused on process management to achieve significant efficiency gains and productivity improvements. The ground has shifted, however, and enterprises no longer compete based on process management and continuous improvement. They must instead create dynamic long-term capabilities, establish inter-organizational networks fostering learning, knowledge-creation and innovation, and evolve adaptive and reconfigurable network architectures to thrive under varying external environmental conditions characterized by increasing complexity, high-velocity change and uncertainty. Accordingly, there is an important opportunity ahead to build upon and expand the findings presented in this chapter by pursuing an interdisciplinary research agenda outlined above.

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