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# Sustainable Operational Excellence: Between Standards, Culture, and Digitalization.

A Case Study of a Manufacturing Site

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# Abstract

This thesis develops the concept of Sustainable Operational Excellence (SOE), defined as the dynamic capability of an organization to align principles, systems, and learning processes in a continuous cycle of reflection and renewal. Despite decades of evolution from Taylorist efficiency through Lean Thinking to Industry 4.0, the three domains constituting OpEx ( process standardization, cultural maturity, and digitalization) have largely advanced in isolation, generating improvement initiatives that produce temporary results but fail to consolidate into durable organizational capability.

The research follows a dual trajectory: a theoretical review of the Lean, OpEx, and Industry 4.0 literature, and a six-month reflective internship within the Operational Excellence department of a multinational manufacturing company. The analysis produces a three-coherence conceptual model (behavioral, systemic, and temporal) integrating the Shingo Model, EFQM, Baldrige, and Dynamic Capabilities Theory. Empirical findings illustrate how this triadic equilibrium manifests in daily industrial practice. SOE is proposed not as a method but as a mindset: an ongoing dialogue between people, processes, and technology that transforms improvement from a project into a culture.

# Chapter 1 – Introduction

## 1.1 Background and Rationale

Over the last century, the pursuit of operational excellence has shifted from a primary concern with technical efficiency and standardized control toward a more integrated ambition: sustaining high performance through the continuous alignment of process discipline, human development, and digital intelligence. Successive improvement paradigms redirected managerial attention from mechanistic productivity toward learning-oriented systems in which performance is maintained through ongoing renewal rather than episodic optimization (Melton, 2005; Found et al., 2018). This transition reflects a deeper change in managerial logic: whereas efficiency is classically associated with "doing things right" under stable conditions, sustainable excellence emphasizes the capacity to "learn to do the right things" continuously, through sensemaking, experimentation, and capability renewal (Found et al., 2018).

Systems optimized for stability tend to struggle when complexity increases or competitive conditions evolve. Lean Thinking addressed this by embedding improvement into daily work: value designed into processes, standards treated as provisional hypotheses rather than fixed prescriptions, and waste elimination as an ongoing practice rather than a one-time event. Operational Excellence (OpEx) extended this logic further, integrating process discipline, participative culture, and leadership alignment into a coherent management philosophy that shifts improvement from episodic initiatives toward long-term capability building (Found et al., 2018).

The digital expansion brought by Industry 4.0 alters the meaning of excellence once more (Table 1). Technologies such as cyber-physical systems, real-time analytics, and connected production environments extend the reach of operational visibility and responsiveness (Sanders et al., 2016). Yet their contribution to sustainable performance is conditional: Pagliosa et al. (2020) show empirically that Lean and Industry 4.0 maturity are not uniformly distributed across organizational units, and that the highest synergistic returns materialize only where process standardization, cultural readiness, and digital capability develop in concert. An organization that adopts digital tools faster than it develops the cultural maturity to interpret and act on their outputs does not become more excellent; it risks automating its existing inefficiencies at higher cost.

This thesis is grounded in the rationale that sustainable excellence cannot be achieved by treating process discipline, cultural maturity, and digitalization as parallel but separate initiatives. Each dimension depends on the other two to fulfill its function, and their interaction produces an organizational property, Sustainable Operational Excellence (SOE), that none could generate independently. Accordingly, the thesis is organized around these three interdependent domains, understood throughout as constitutive elements of a single, enduring system.

*Table 1 Evolution from Efficiency to Sustainable Excellence.*

| Era | Paradigm | Core Logic | Human Role | Technological Context | Learning Orientation |
|---|---|---|---|---|---|
| Early 1900s | Taylorism | Standardization, measurement, control | Passive executor | Mechanization and time studies | Knowledge centralized in management |
| 1930–1950 | Fordism | Mass production, economies of scale | Controlled operator | Assembly line | Repetitive learning by imitation |
| 1950–1980 | TQM/Kaizen | Quality and continuous improvement | Active contributor | Statistical control, early automation | Team-based problem-solving |
| 1980–2000 | Lean Thinking | Value creation, waste elimination, respect for people | Problem-solver and learner | Digital control and early data systems | Continuous improvement (Kaizen) |
| 2000–2020 | Operational Excellence | Alignment of principles, systems, and behaviors | Empowered change agent | Integrated process systems and analytics | Organizational learning and reflective leadership |
| 2020-Today | SOE | Adaptive balance of process, culture, and digital intelligence | Empowered innovator and collaborator | Cyber-physical systems, AI, and data ecosystems | Continuous renewal and adaptive stability |

## 1.2 Research Gap and Objectives

Although the literature offers extensive insight into Lean and process improvement, culture and leadership development, and Industry 4.0 digital technologies, these three domains have largely advanced in relative isolation. Found et al. (2018) demonstrate through a systematic literature review that no single unifying theory of Operational Excellence currently exists: common practices and regularities have been identified, but they remain fragmented across methodologies and conceptual traditions, without a mechanism that ties them into predictable, teachable, and testable propositions. The consequence is that organizations repeatedly deploy improvement initiatives that generate temporary results but fail to sustain performance, because the tools adopted are not anchored in principles, nor embedded in systems designed to reinforce the behaviors that produce lasting change.

The cultural and leadership dimension represents a second gap. She (2019) shows that managerial coaching, a primary mechanism through which leadership principles are enacted in daily practice, operates as a double-edged instrument: it can foster engagement and capability development, but when misapplied or unsupported by the organization it reproduces control dynamics and generates resource depletion that undermines the very conditions it is meant to create. The conditions under which coaching sustains rather than exhausts improvement are therefore a central design challenge, not a peripheral concern.

On the digital side, Pagliosa et al. (2020) show that digitalization produces performance gains only when complemented by human interpretation and reflective decision-making. Organizations can demonstrate higher maturity in digital tools while remaining comparatively immature in cultural and leadership readiness, an imbalance that prevents the synergistic

potential of the two approaches from consolidating into sustainable performance gains. This is the core gap this thesis addresses: the mechanisms by which process standardization, cultural readiness, and digital capability reinforce each other, and the conditions under which any one dimension, developed in isolation, generates characteristic failure modes rather than sustained excellence.

To respond to this gap, the thesis pursues three objectives:

- Trace the theoretical evolution of Operational Excellence from efficiency-based paradigms toward learning-based ones, identifying the mechanisms through which each transition expanded the scope and ambition of the excellence concept.
- Analyze the interdependence among process, culture, and digitalization as constitutive dimensions of SOE, clarifying how the three pillars reinforce one another and how imbalance among them produces fragility.
- Integrate the Shingo Model, EFQM, Baldrige, and Dynamic Capabilities Theory into a unified conceptual model that explains the behavioral, systemic, and temporal conditions under which SOE is achieved and continuously renewed.

These objectives correspond to three research questions: How has Operational Excellence evolved from Lean Thinking to the digital era, and what does that evolution reveal about the conditions for sustainable performance? What is the role of culture, leadership, and coaching in sustaining continuous improvement, and under what organizational conditions does this role succeed or fail? How can digitalization enhance or hinder the achievement of sustainable excellence, and what determines whether digital tools function as learning amplifiers or as sources of new fragility?

## 1.3 Methodological Approach

This thesis follows a dual trajectory: a theoretical investigation of the SOE literature, and a reflective empirical experience developed within a real industrial environment. The theoretical dimension examines the evolution of the excellence paradigm through academic sources. The empirical component draws on the author's internship within the Operational Excellence department of a multinational tire manufacturing company, and is approached through Schön's (1983) notion of the reflective practitioner: a professional who learns through cycles of action and reflection, treating practical situations not merely as occasions for applying established theory but as sources of new understanding that can challenge and enrich it.

### 1.3.1 Empirical Experience and Evidence Collection

The internship lasted approximately six months and provided access to multiple organizational levels. As a member of the OpEx department, a cross-functional office whose mandate was to facilitate improvement across all production areas, the author participated actively in the plant's daily management system. Responsibilities included contributing to the plant-level direction review (n-1), a daily cross-functional meeting involving all department heads, the

maintenance manager, the finance representative, quality and scheduling leads, and the zone director. The author's specific role within this meeting covered the standards section of the seven-face management framework, a structured digital platform used at all cascade levels to track availability, flow, quality, safety, costs, standards, and machines. Preparatory work involved reviewing standards-related data across all departments before each session, identifying anomalies, and preparing analytical briefs for the supervising tutor.

Beyond the n-1 meeting, the internship involved accompanying area managers across all production departments during morning floor walks and the lower cascade levels: the n-3, held at area level with operator-led presentations, and the n-2, held at department level. Observations covered all three shifts, providing exposure to the full operational cycle and to the significant variation in team maturity and cultural dynamics across areas. Additional activities included supporting the development of KPI dashboards, participating in three-day operational excellence workshops attended by a cross-functional mix of employees, completing internal Lean methodology training, and participating in a structured one-week improvement work site alongside production operators.

Evidence was gathered through four channels: direct observation of meetings and shop-floor activities; informal conversations with operators, area managers, department heads, and maintenance staff; participation in structured training events; and review of internal documents including standard operating procedures, KPI formats, and improvement idea records. No formal interviews were conducted; the empirical contribution is based on reflective observation rather than systematic data collection

### 1.3.2 Limitations and Scope of Generalization

Several limitations should be acknowledged. The evidence was gathered at a single manufacturing site during a defined period, capturing a snapshot of an organization in active transition. Some dynamics described, such as the three-year managerial rotation policy, were reported by colleagues rather than directly observed. Similarly, accounts of earlier management styles were reconstructed through informal conversations rather than direct evidence.

The author's institutional position within the OpEx office shaped the perspective available. The view from a cross-functional improvement department differs from that of a production supervisor or a night-shift operator, and this positional bias should be considered when interpreting the findings. Furthermore, the patterns observed cannot be generalized uniformly: significant variation was noted even within the same plant, with some areas having reached full team autonomy in daily management while others showed limited engagement with the same structures. Excellence, even within a single site, is not a uniform condition but an ongoing organizational aspiration.

No measurements were taken systematically, and no statistical claims are made. The contribution is interpretive: it seeks to illuminate how the principles and frameworks of the theoretical chapters manifest, and are complicated, in a real operational context.

### 1.3.3 Structure and Expected Contribution

The thesis is structured into five chapters that progressively develop SOE from foundational concepts to an integrated theoretical model and its ground-level interpretation.

- Chapter 2 reconstructs the historical trajectory of improvement paradigms, from Taylor and Ford through Lean Thinking, Operational Excellence, and Lean 4.0, showing how each transition expanded the scope of excellence toward learning and adaptability.
- Chapter 3 develops the three pillars of SOE, process and standardization, culture and leadership, and digital excellence, and analyzes their bilateral interdependencies, culminating in a synthesis of the triadic equilibrium that emerges from their mutual alignment.
- Chapter 4 integrates the Shingo Model, EFQM, Baldrige, and Dynamic Capabilities Theory into a unified conceptual model organized around three dimensions of coherence: behavioral, systemic, and temporal.
- Chapter 5 examines how the three pillars and the three coherences manifest in the daily life of the observed manufacturing plant, discussing the cascade meeting system, improvement cantiere, cultural dynamics, the digital transition from Excel to Power BI, and the managerial implications that emerge from the encounter between theory and organizational reality.
- Chapter 6 synthesizes the core argument, reflects on the personal dimensions of the research experience, and outlines broader implications for the future of Operational Excellence.

The thesis contributes by bridging three academic domains that have advanced largely in isolation: Lean and process improvement, human-centered leadership and culture, and Industry 4.0 digital transformation. Its primary theoretical contribution is the triadic equilibrium framework and the three-coherence architecture of Chapter 4, which explain not only what makes excellence sustainable but why it is fragile when any one dimension is consistently underdeveloped. Its practical contribution is an interpretive, ground-level account of how SOE is enacted, challenged, and renewed in the daily routines of an organization actively building its improvement capability.

# Chapter 2 The Evolution of Operational Excellence: From Lean to the Digital Era

## 2.1 From Industrial Efficiency to Lean Thinking

As established in Chapter 1, the pursuit of operational excellence has evolved from a fragmented focus on technical speed toward a holistic, socio-technical-digital integration. To

understand this transition, it is necessary to examine how the early definitions of "efficiency" centered almost exclusively on physical effort and individual tasks.

The technical foundations of industrial productivity are deeply rooted in the "Scientific Management" movement, whose principles were pioneered by Frederick Taylor. As documented in the historical analysis provided by Liker (2004), this approach focused on the optimization of individual tasks through rigorous time studies and the specialization of labor. In this paradigm, waste was primarily viewed as a "waste of motion": any unnecessary physical movement by the worker that did not contribute directly to the task was to be eliminated through standardized procedures. This logic effectively separated the "planning" (done by engineers) from the "work" (performed by operators), treating the human element as a mechanistic component of the production line.

Henry Ford further evolved this concept by introducing the moving assembly line, which allowed for unprecedented economies of scale. However, while Ford broke the tradition of craft production, his system introduced a different form of waste: the "batch-and-queue" method. As highlighted in the comparison between production systems by Melton (2005), Fordism created huge buffers of work-in-process (WIP) inventory. While individual machines and workers appeared highly "efficient" in terms of output per hour, the system as a whole was burdened by hidden wastes of time and material.

The fundamental shift from "Waste of Motion" to "Waste of Flow" was pioneered by Taiichi Ohno and the development of the Toyota Production System (TPS). As described by Liker (2004), Ohno realized that the inherent flaw in mass production was its lack of flexibility and its tendency to overproduce. Toyota determined that efficiency should not be measured by how fast an individual worker moves, but by how smoothly the product flows toward the customer.

This led to the conceptualization of "One-Piece Flow," where the ideal is to eliminate interruptions and ensure that a product proceeds from raw material to the customer without stoppages. Under this paradigm, waste (Muda) was redefined as any activity that uses resources without adding value from the customer’s perspective.

Initially, Ohno identified seven categories of physical waste, transportation, inventory, motion, waiting, over-processing, overproduction, and defects, redefining muda as any activity that consumes resources without adding value from the customer's perspective. This redefinition marked a decisive shift: waste was no longer located in the individual worker's body, but in the structure of the system as a whole. By redirecting attention from the worker's motion to the progressive achievement of tasks along the value stream, Lean Thinking established that the greatest efficiency is achieved through the continuous flow of value. This evolution from static efficiency to dynamic flow sets the stage for the five guiding principles of Lean, examined in Section 2.2, which provide the operational and cultural roadmap for the modern pursuit of

excellence. The trajectory from control-based to learning-based industrial management is illustrated in Figure 1.

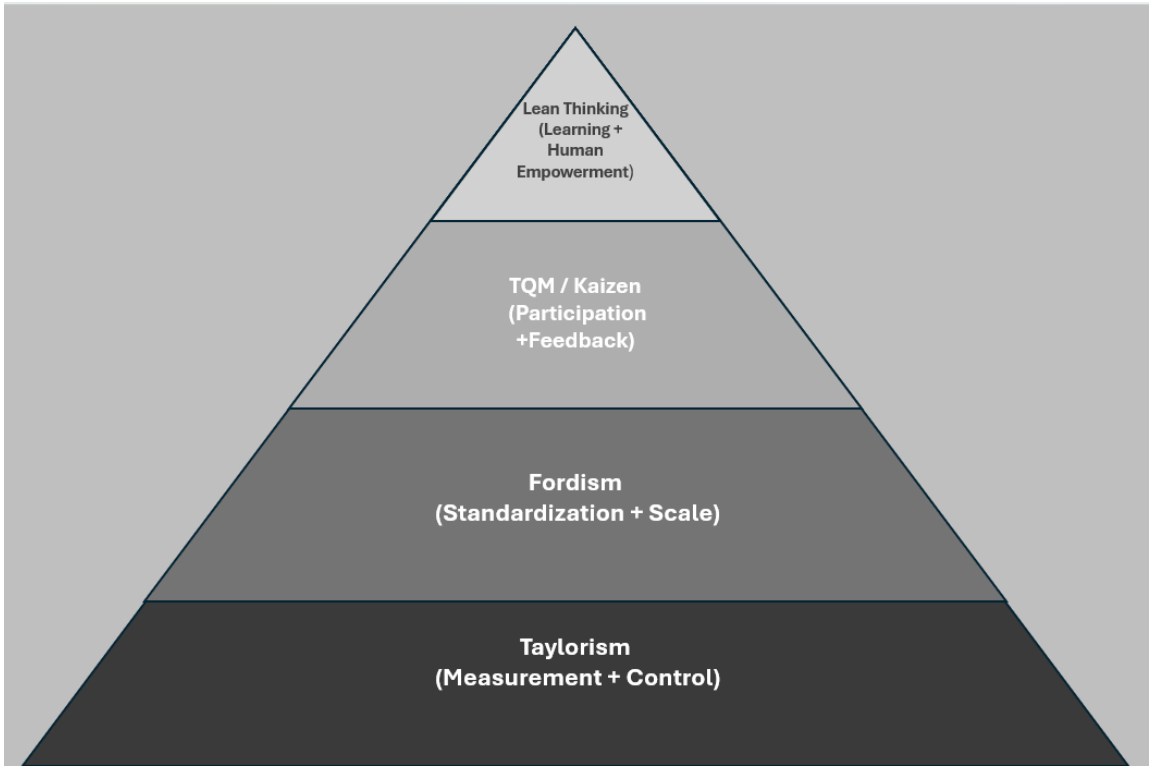



*Figure 1 From Control to Learning: The Capability-Building Path in Industrial Evolution.*

## 2.2 Lean Principles and Continuous Improvement

The foundation of Lean Thinking lies in the belief that excellence is not an end state but a continuous journey of learning and improvement. While early industrial systems sought stability through standardization and control, Lean reframed stability as a precondition for learning, a baseline that enables systematic experimentation and reflection. This paradigm recognizes that waste elimination, value creation, and human development are inseparable dimensions of sustainable performance.

According to Womack and Jones (2003), Lean rests on five fundamental principles:

- specify value
- identify the value stream
- make value flow
- let the customer pull
- pursue perfection

Rather than serving as a mere checklist, these principles act as a strategic "roadmap" that profoundly shifts organizational focus. Instead of concentrating on the localized efficiency of individual machines or isolated departments, a remnant of the mass production era, this roadmap redirects attention to the speed and fluidity of the value flow across the entire system.

Each principle builds upon the previous one, transforming isolated efficiency efforts into a coherent management system. Value defines what the customer truly requires; value stream mapping exposes all non-value-adding steps; flow removes interruptions and bottlenecks; pull ensures that production is driven by actual demand; and perfection commits the organization to continuous improvement (Kaizen). Together, these principles convert improvement from a reactive activity into a proactive culture.

At the core of this logic lies the notion of Kaizen, or continuous improvement. As Liker (2004) explains, Kaizen combines two complementary dynamics: standardization, which creates clarity and repeatability, and innovation, which challenges standards through daily problem-solving. Improvement is not limited to large-scale projects but embedded in everyday work through small, incremental changes. In this sense, Lean organizations operate as "learning laboratories" where mistakes are not penalized but analyzed to generate collective insight. This perspective resonates with Schön's (1983) concept of reflection-in-action, where practitioners learn by observing, questioning, and adjusting their actions in real time.

Lean's contribution extends beyond process optimization; it redefines the relationship between people and systems. The principle of Respect for People, often considered the second pillar of the Toyota Production System, affirms that sustainable improvement requires trust, psychological safety, and distributed responsibility. Workers are not passive executors of predefined tasks but active contributors capable of diagnosing problems, proposing solutions, and leading change within their sphere of influence. This human dimension transforms Lean from a toolkit into a cultural and behavioral system. The Shingo Model further develops this view by positioning Respect and Humility as Cultural Enablers, the foundation upon which every technical and leadership system must rest.

In practical terms, Lean integrates a set of structured routines designed to foster learning at all organizational levels. Daily management meetings, visual performance boards, and A3 problem-solving are examples of how reflection becomes institutionalized. Each routine creates a feedback loop: information flows from the shop floor to leadership and back, ensuring that strategic objectives remain aligned with operational reality. Found et al. (2018) describe this as the essence of Operational Excellence: a behavioral system where improvement is continuous because learning is continuous.

The concept of standardized work illustrates this duality. In traditional systems, standards are used to impose control; in Lean, they serve as the best-known method at a given time, meant to be improved through experimentation. When a better way is found, the standard evolves. This cyclical relationship between standardization and innovation generates adaptive stability: a state where consistency and creativity coexist. It is precisely this mechanism that enables Lean organizations to remain resilient amid volatility and change.

Another distinctive feature of Lean is its deliberate design for problem visibility. While organizations often adopt specific artifacts such as visual management boards, Andon systems, or gemba walks, their true strategic purpose is to make operational abnormalities

immediately transparent and actionable. This continuous surfacing of problems forces a shift in management dynamics, moving from traditional command-and-control supervision to active facilitation. Leaders are tasked with guiding teams through root-cause analysis and shared learning directly at the source of the issue. Ultimately, as Liker (2004) and the Shingo Institute (2025) suggest, it is this behavioral alignment to underlying principles, rather than the mechanical application of operational tools, that separates a mature Lean enterprise from superficial implementations.

Ultimately, Lean Thinking embodies a philosophy of continuous alignment between purpose, process, and people. The pursuit of perfection is not a call for flawless outcomes but for an ever-improving system that develops human capability alongside process capability. Lean's power lies in its ability to integrate the rational and the relational, to turn improvement from a technical act into a social process. This dynamic balance forms the intellectual bridge between Lean and the broader notion of Operational Excellence, where principles, systems, and behaviors converge to sustain performance over time.

## 2.3 From Lean to Operational Excellence

The emergence of Operational Excellence (OpEx) represents the natural evolution of Lean Thinking from a process improvement philosophy to a holistic management system encompassing culture, leadership, and strategy. While Lean revolutionized the way organizations understood value and waste, Operational Excellence broadened the lens, shifting the focus from efficiency within processes to coherence across the entire enterprise. As Found et al. (2018) argue, OpEx does not replace Lean but integrates and extends it, turning improvement from a local initiative into a systemic capability.

The transition from Lean to OpEx can be understood as a movement from doing Lean to being Lean. In many organizations, early Lean deployments focused on tools and events, 5S campaigns, kaizen workshops, value stream mapping, often yielding rapid but short-lived results. What was missing was an underlying system of behaviors, principles, and leadership habits capable of sustaining improvement once external momentum faded. Operational Excellence arose precisely to fill this void. It reframes Lean tools as expressions of deeper principles that must be internalized culturally and behaviorally.

In this sense, OpEx represents the institutionalization of Lean learning. According to Found et al. (2018), a true excellence system aligns three layers:

- Principles – the fundamental beliefs about how value is created and sustained;
- Systems – the structured routines and processes that operationalize these principles;
- Tools and Techniques – the tangible practices that make systems visible and actionable.

This triadic model establishes a hierarchy of coherence: tools must serve systems, and systems must serve principles. When organizations invert this logic (applying tools without an understanding of their governing principles) they may achieve temporary efficiency but not sustainable excellence.

The Shingo Model provides one of the most widely recognized frameworks for understanding this evolution. Developed from decades of research into high-performing organizations, the model articulates ten guiding principles grouped into three dimensions: Cultural Enablers (Respect and Humility), Continuous Improvement (Flow, Scientific Thinking, Process Focus, Quality at the Source), and Enterprise Alignment (Constancy of Purpose, Systemic Thinking, and Value for the Customer). At the foundation lie the Cultural Enablers, which shape behaviors and sustain engagement; the middle layer concerns improvement routines; and the top layer connects daily operations with long-term strategy.

What distinguishes OpEx from Lean is precisely this systemic orientation. Lean focused on value creation and waste elimination within processes; OpEx focuses on alignment and consistency across the organization. It recognizes that excellence is not achieved when individual areas perform well, but when all functions act coherently toward a shared purpose. As Found and Bicheno (2017) note, Operational Excellence transforms improvement from a collection of initiatives into a behavioral infrastructure, an organizational "way of being" where people at every level understand, own, and improve their work.

This shift also elevates the role of leadership. In a Lean environment, leaders are expected to coach and support problem-solving at the operational level. In an OpEx system, they become architects of culture: their responsibility extends beyond process performance to shaping the conditions under which improvement can thrive. She (2019) emphasizes that managerial coaching plays a double-edged role, it can empower or constrain depending on how it is applied. Effective leaders build trust and psychological safety, enabling employees to take initiative and reflect on their actions. Poorly designed coaching, on the other hand, degenerates into micromanagement. Operational Excellence therefore relies on coaching maturity: the leader's ability to balance guidance with autonomy, direction with inquiry.

The Shingo Model's behavioral dimension provides a practical framework for cultivating this maturity. It defines behavior as the observable expression of culture and proposes that systems should be deliberately designed to reinforce desired behaviors. For example, if an organization values continuous learning, it must establish mechanisms, visual boards, daily huddles, and cross-functional problem-solving, that make learning a visible, repeatable process. Behavior is thus not left to chance; it becomes engineered through the structure of work. In this sense, OpEx redefines management systems as behavioral enablers, not bureaucratic controls.

Another crucial evolution concerns strategic alignment. Traditional Lean programs often operated in isolation, disconnected from business objectives. Operational Excellence bridges this gap by linking daily improvement activities to long-term strategic intent. Frameworks such as Hoshin Kanri (policy deployment) ensure that each employee's efforts contribute to organizational goals, creating a "line of sight" from the shop floor to the boardroom. This alignment prevents the fragmentation that often undermines continuous improvement efforts. As ProAction International (PAI, 2022) observes, excellence becomes sustainable when leadership behaviors, management systems, and strategic objectives reinforce one another through consistent reflection and feedback.

The integration of culture, leadership, and systems also changes how success is measured. Rather than focusing solely on traditional performance indicators (cost, quality, delivery), OpEx incorporates qualitative metrics that assess engagement, learning, and problem-solving capability. This multidimensional view mirrors the concept of dynamic capabilities introduced by Teece (2007), the ability to sense, seize, and reconfigure organizational resources in response to change. Operational Excellence can thus be interpreted as the dynamic capability of improvement: the organizational skill to continuously realign purpose, process, and people amid complexity.

Ultimately, the movement from Lean to Operational Excellence signifies a philosophical deepening rather than a methodological replacement. It expands Lean's technical discipline into a living culture of excellence, where principles guide behavior, systems sustain learning, and leadership ensures alignment. In this framework, improvement is no longer an intervention but an identity, an organizational way of thinking and acting that endures beyond projects and programs (Figure 2).

The next chapter extends this evolution further by examining how the advent of digital transformation and Industry 4.0 reshapes the pursuit of excellence, introducing new forms of visibility, interconnection, and learning that challenge even the most mature Lean-OpEx systems.

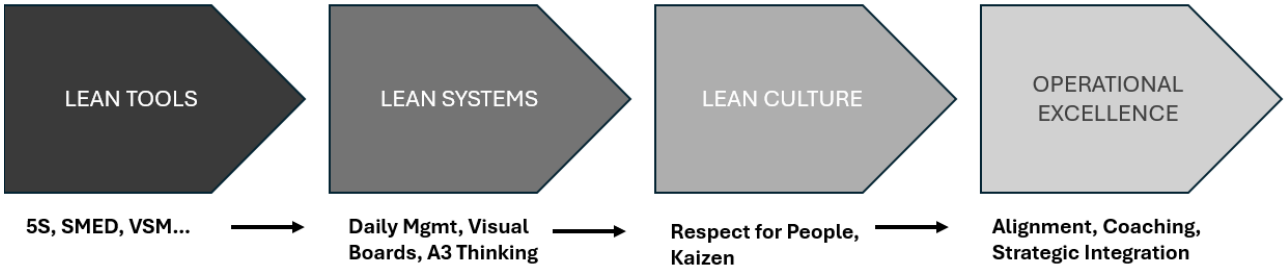



*Figure 2 From Doing Lean to Being Lean: The Evolution Toward Operational Excellence*

## 2.4 The Digital Turn: Toward Lean 4.0

The fourth industrial revolution has introduced a new paradigm that reshapes the way organizations pursue excellence. While Lean and Operational Excellence (OpEx) focused on human-centered processes and behavioral alignment, the advent of Industry 4.0 adds a digital layer of connectivity, intelligence, and speed. The challenge for modern enterprises is no longer to choose between Lean and digitalization, but to integrate them into a coherent socio-technical system, what scholars increasingly refer to as Lean 4.0.

According to Sanders et al. (2016), Industry 4.0 is not a rupture with Lean, but its natural continuation: the digital infrastructure enables Lean principles to operate at higher levels of precision, transparency, and responsiveness. Technologies such as cyber-physical systems (CPS), Internet of Things (IoT), artificial intelligence (AI), and advanced analytics provide real-time feedback loops that extend the traditional concept of visual management into an

integrated data ecosystem. The result is an environment where information flows seamlessly between machines, people, and processes, turning the factory into a self-learning network capable of adaptive decision-making.

This digital augmentation of Lean creates new possibilities for improvement. Predictive maintenance, for instance, replaces reactive interventions with data-driven foresight, reducing downtime and variability. Digital twins simulate entire production systems, allowing engineers to test process changes virtually before implementation. Augmented reality assists operators in training and complex tasks, while advanced dashboards and real-time analytics give leaders a dynamic view of performance, helping them identify deviations instantaneously. As Pagliosa et al. (2020) argue, these technologies amplify Lean's original intent, eliminating waste and enhancing value creation, by transforming data into actionable insight.

However, technological integration alone does not guarantee excellence. The digital transformation introduces new forms of complexity that require equally advanced managerial and cultural capabilities. As Freitas and Machado (2020) note, Industry 4.0 implies not only automation but also a deep reconfiguration of organizational processes, skills, and mindsets. The traditional factory hierarchy, designed for stability and control, must evolve into a networked organization that values flexibility, collaboration, and continuous learning. In such systems, human operators shift from executors to decision partners: interpreting data, diagnosing anomalies, and improving algorithms through experiential knowledge.

This convergence of human and digital intelligence gives rise to the concept of the Operator 4.0 (Romero et al., 2016), which embodies the new balance between technology and autonomy. Operators in smart factories use digital tools not as substitutes for skill but as amplifiers of capability. Wearable sensors, augmented interfaces, and collaborative robots ("cobots") enhance physical and cognitive performance, enabling safer, faster, and more adaptive work. The human role becomes increasingly strategic: rather than executing standardized routines, the operator orchestrates an ecosystem of data and machines, blending intuition with algorithmic support. This evolution reinforces Lean's principle of respect for people by elevating human contribution from manual execution to digital decision-making.

From an organizational perspective, Lean 4.0 redefines flow and value in digital terms. Whereas traditional Lean sought to synchronize physical processes, the digital era synchronizes information. Big Data analytics replaces visual boards as the main source of process visibility, while automation ensures real-time pull systems across supply chains. In this context, the classic Lean concept of waste (muda) gains new meaning: information delay, data redundancy, and algorithmic bias are now forms of digital waste that hinder responsiveness. Thus, Lean 4.0 expands the traditional seven wastes into an eighth: waste of data potential, the failure to convert information into learning.

Despite its promise, the transition to Lean 4.0 also exposes tensions. Sanders et al. (2016) and Tortorella et al. (2020) highlight that many companies adopting Industry 4.0 technologies do not achieve proportional gains in productivity or agility. The main obstacle is cultural

misalignment: digital systems evolve faster than the people and routines meant to use them. In many cases, data abundance creates information overload, while operators and managers lack the analytical literacy to interpret complex metrics. As a result, technology becomes a new form of "waste", a sophisticated system producing little real value. This risk confirms that Lean culture remains the foundation of any digital transformation: without respect, teamwork, and disciplined learning, digital tools merely automate inefficiency.

To achieve genuine integration, organizations must therefore pursue a dual transformation:

- Technological transformation, through the adoption of smart, connected, and data-driven systems; and
- Cultural transformation, through the development of human capabilities, reflective leadership, and cross-functional collaboration.

These two trajectories converge in the notion of socio-technical excellence, where people and technology co-create value through mutual adaptation. As Found et al. (2018) emphasize, the essence of Operational Excellence lies in coherence, ensuring that technological systems reinforce, rather than replace, human purpose. Lean 4.0 exemplifies this principle: it uses digital intelligence to strengthen the very mechanisms of learning, reflection, and alignment that define mature excellence systems.

The practical implications of this integration are examined in Chapter 5, which draws on direct observation within a multinational tire manufacturing company to illustrate how the transition from manual to connected digital systems alters both the quality of information available to managers and the organizational preconditions needed to act on it effectively.

Ultimately, Lean 4.0 represents not a technological revolution but a managerial renaissance. It transforms the pursuit of excellence into a digital learning ecosystem, where data replaces intuition without displacing reflection, and where technology serves as the means, not the end, of improvement. As Hamel and Välikangas (2003) remind us, organizational resilience depends on the ability to renew continuously without losing coherence. Lean 4.0 embodies that resilience: a model of excellence that learns, adapts, and evolves by integrating human wisdom with digital intelligence.

*Table 2 Key Concepts and Challenges of Lean 4.0 Integration*

| Dimension | Traditional Lean / OpEx Logic | Transformation in Lean 4.0 (Digital Turn) | New Challenges and Critical Issues |
|---|---|---|---|
| Purpose of Excellence | Achieving stability, flow, and waste elimination through standardized processes and human engagement. | Achieving *adaptive excellence*: continuous learning supported by real-time data and digital connectivity. | Risk of focusing on data collection over learning; loss of human-driven problem-solving mindset. |
| Information Flow | Visual management and manual feedback loops; metrics updated periodically. | Smart, real-time data flow through IoT, CPS, and analytics dashboards. | Data overload; lack of analytical capability; information silos across departments. |

| | | | |
|---|---|---|---|
| Decision-Making | Decentralized problem-solving supported by gemba and A3 thinking. | Semi-autonomous decision-making combining human insight with AI and predictive analytics. | Over-reliance on algorithms; need for *human-in-the-loop* systems and reflective supervision. |
| Role of the Worker | Operator as problem-solver and learner (*Respect for People*). | Operator 4.0: augmented worker using digital tools (wearables, AR, cobots). | Skill gap between technological and cognitive competences; resistance to new human–machine dynamics. |
| Leadership Behavior | Coaching-based leadership fostering engagement and continuous improvement. | Digital leadership integrating coaching with data literacy and technological empathy. | Leaders unprepared for data-driven cultures; difficulty balancing human and digital priorities. |
| Improvement System | Kaizen and standardized work routines enable incremental change. | Digital Kaizen: feedback from sensors and systems enables predictive, rapid-cycle improvement. | Need for hybrid methodologies blending Lean routines with data analytics. |
| Waste Definition | Seven wastes (overproduction, waiting, defects, etc.). | Includes *digital waste*: unused data, redundant information, algorithmic inefficiency. | Identifying and measuring digital waste; integrating it into Lean audits. |
| Cultural Foundation | Learning organization based on respect, humility, and teamwork. | Socio-technical organization integrating digital trust, transparency, and cross-functional collaboration. | Cultural lag behind technological change; fragmentation between IT and operations. |
| Measurement and KPIs | Efficiency, quality, safety, and engagement metrics. | Real-time performance indicators integrating operational and digital parameters. | Misalignment between technical and behavioral KPIs; “vanity metrics” with low learning value. |
| Resilience and Sustainability | Improvement as a behavioral routine and cultural identity. | Improvement as a dynamic capability supported by digital intelligence. | Dependence on technology may erode reflective learning and human adaptability. |

Table 2 summarizes the main conceptual shifts and challenges that define the transition from Lean and Operational Excellence to Lean 4.0. Each row captures a core dimension of excellence, ranging from purpose and information flow to leadership and culture, highlighting how digitalization transforms both the mechanisms and the meaning of improvement. The final column outlines the emerging challenges, emphasizing that technological progress must be matched by equivalent growth in human capability, reflection, and cultural maturity.

## 2.5 Sustainable Excellence and Dynamic Capabilities

The evolution of excellence from Lean to Operational Excellence (OpEx) and Lean 4.0 reveals a fundamental insight: improvement is sustainable only when it becomes a capability, not a project. Organizations that consistently perform well are those capable of learning, adapting, and reconfiguring their systems in response to changing conditions. This capacity for continuous renewal embodies what Teece (2007) defines as dynamic capabilities, the organizational abilities to sense opportunities and threats, seize them through strategic action, and reconfigure resources and competencies to maintain long-term advantage.

In this sense, SOE represents the integration of Lean discipline, cultural coherence, and digital intelligence into a dynamic learning system. While Lean Thinking provides stability through standards and problem-solving routines, and Industry 4.0 adds real-time adaptability through digital feedback, the dynamic capability perspective explains how these elements interact to sustain improvement over time. Sustainable excellence, therefore, is not a fixed state of efficiency but a continuous capability of renewal, the organizational equivalent of Kaizen at the strategic level.

### 2.5.1 From Continuous Improvement to Continuous Renewal

Traditional Lean improvement cycles operate at the process level: identifying waste, implementing countermeasures, and standardizing the new best practice. This logic produces disciplined refinement within stable boundaries. What it does not automatically produce is the capacity to question those boundaries when conditions shift. As Hamel and Välikangas (2003) argue, true resilience arises not from stability but from the ability to renew underlying systems before crisis forces it: to reinterpret purpose, redesign structures, and re-skill people as environments change. In this view, continuous improvement, the iterative refinement of existing processes, is a necessary but insufficient condition for sustainable excellence. What is additionally required is continuous renewal: a higher-order organizational capability that treats the improvement system itself as an object of learning, not just a tool for improving operations.

This distinction has direct consequences for how SOE is conceptualized. Renewal is not simply more improvement; it is improvement turned reflexively on the organization's own management architecture. It asks whether the principles guiding today's improvement routines are still the right principles, whether the systems designed to sustain learning are still well-matched to the organization's current environment, and whether the people responsible for leading improvement have the cognitive range to sense and respond to changes that current metrics do not yet capture. Sustainable excellence, in this sense, is the institutional capacity to ask these questions continuously rather than only when performance has already deteriorated.

### 2.5.2 The Triad of Sustainable Excellence

Drawing on Found et al. (2018) and the Shingo Model, the sustainability of excellence rests on three interdependent capabilities:

- Process Adaptability – the ability to maintain standardized yet flexible processes that evolve through iterative learning. Digital tools, such as predictive analytics and digital twins, enhance this adaptability by enabling faster experimentation and validation.
- Cultural Resilience – the collective capacity to learn, trust, and collaborate under change. This depends on leadership behaviors that balance stability and exploration, creating psychological safety for experimentation (Edmondson, 1999).
- Cognitive Agility – the organizational intelligence to interpret complex data, integrate perspectives, and make reflective decisions. This cognitive dimension links human judgment with digital analytics, ensuring that improvement remains both data-informed and value-driven.

Together, these three capabilities form what this thesis conceptualizes as the Resilience Triangle of Sustainable Operational Excellence, a dynamic equilibrium between structure, culture, and intelligence. When any of these dimensions dominates the others, excellence becomes fragile: excessive structural control suppresses learning; unchecked cultural enthusiasm without standards causes inconsistency; and digitalization without meaning creates technological dependency.

### 2.5.3 Learning as the Engine of Sustainability

At the heart of all three capabilities lies learning, not as training or skill acquisition, but as collective reflection-in-action. Schön (1983) describes professional learning as a process in which practitioners think within action, constantly reframing their understanding through experience. This reflective loop is mirrored in Lean's PDCA cycle and in OpEx's principle–system–behavior model. In a sustainable excellence system, learning occurs at multiple levels:

- Operational learning, where teams solve daily problems and improve standards.
- Managerial learning, where leaders reflect on how systems and behaviors reinforce or inhibit improvement.
- Strategic learning, where the organization reviews its purpose and alignment considering environmental change.

By institutionalizing learning across these layers, organizations develop a meta-capability, the ability to learn how to learn. This recursive dynamic transforms improvement from episodic change into a continuous organizational rhythm.

### 2.5.4 From Efficiency to Resilience

The dynamic capability framework also explains why sustainability transcends traditional efficiency metrics. In turbulent contexts, efficiency alone becomes a liability: systems optimized for today's conditions may lack the flexibility to respond tomorrow. Resilience, therefore, replaces optimization as the true measure of excellence. As Hamel and Välikangas (2003) observe, resilience is not about resisting disruption but about regenerating advantage through innovation and adaptation. Lean and OpEx provide the structure for discipline; Industry

4.0 supplies the technological means; but sustainability emerges only when organizations cultivate the habit of renewal, a proactive stance toward change embedded in their identity.

From this perspective, SOE can be viewed as a dynamic architecture where principles remain stable, but applications evolve. Respect, humility, and value for the customer continue to anchor decision-making, yet the methods to embody these values transform with each technological and social shift. Digital dashboards, collaborative robots, and data ecosystems are simply the latest tools through which the timeless Lean principle of waste elimination is reinterpreted for the digital era. Sustainability, then, lies not in preserving methods but in preserving meaning (Figure 3).

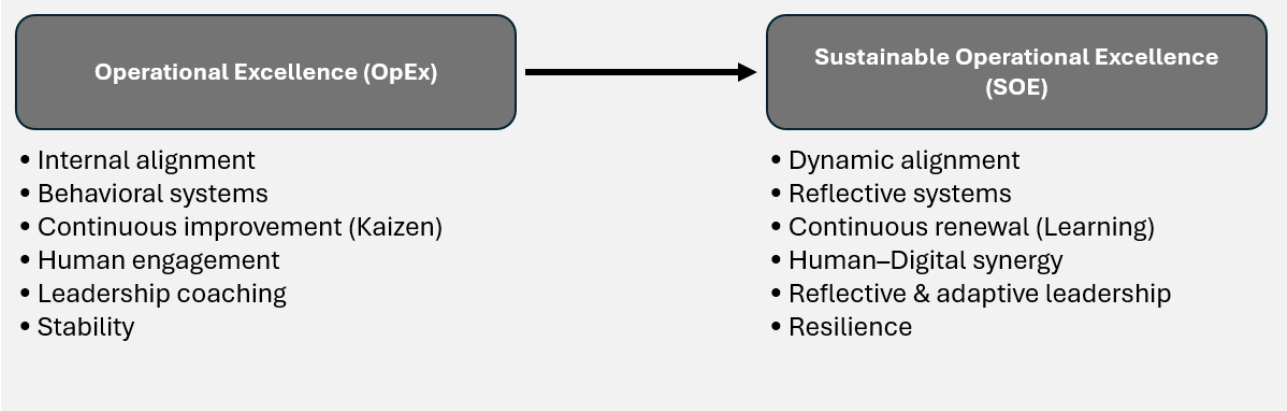



*Figure 3 The Evolution from Operational to Sustainable Operational Excellence.*

### 2.5.5 Managerial Implications

For leaders, the pursuit of sustainable excellence requires a new balance between control and exploration. Traditional management emphasizes performance monitoring and standard adherence; dynamic leadership emphasizes reflection, coaching, and foresight. As the PAI (2022) notes, the role of managers is evolving from controllers of performance to facilitators of learning, creating spaces where teams can experiment safely and align improvement with strategic vision. This shift parallels the concept of ambidextrous leadership: the capacity to manage today's operations while simultaneously preparing for tomorrow's transformations.

Embedding dynamic capabilities also demands cross-functional collaboration. Excellence can no longer reside solely within production or quality departments; it must encompass IT, HR, supply chain, and sustainability functions. Integrative forums (digital huddles, cross-domain kaizen events, or innovation sprints) enable organizations to translate reflection into coordinated action. In this way, the enterprise becomes a learning network, where knowledge circulates horizontally rather than hierarchically.

### 2.5.6 Chapter Conclusion

SOE represents the culmination of a century-long evolution from industrial efficiency to systemic learning. It unites the process discipline of Lean, the cultural coherence of Operational Excellence, and the adaptive intelligence of Industry 4.0 within a dynamic

capability framework. In doing so, it reframes excellence as resilience in motion: the enduring capacity of an organization to renew itself while remaining true to its principles.

The next chapter builds upon this foundation by exploring the core pillars: process, culture, and digitalization that operationalize Sustainable Operational Excellence, examining how each contributes to the creation of resilient, human-centered, and future-ready organizations.

# Chapter 3 – The Core Pillars of Sustainable Operational Excellence

## 3.1 The Conceptual Foundations of Sustainable Operational Excellence

Operational Excellence is widely used as a managerial aspiration, yet its meaning becomes sustainable only when it is grounded in coherent theories that explain why certain practices and improvement laws work in complex organizations (Found et al., 2018; Shingo Institute, 2025). In this view, SOE can be understood as the culmination of a shift from narrow efficiency, interpreted as isolated optimization of operations, to systemic learning, where the organization repeatedly reconfigures its way of working so that improvement becomes a durable capability rather than a time-bounded project (Found et al., 2018; Teece, 2007). Accordingly, the core explanatory challenge is to move beyond collections of tools toward a theoretical logic that unifies principles, systems, and behavioral consequences into predictable operational change, thereby enabling learning and innovation in next-generation management thinking (Teece, 2007; Womack and Jones, 2003; Deming, 2000).

Within this theoretical logic, three interrelated pillars are proposed as the analytical backbone of SOE: process excellence, cultural excellence, and digital excellence, each of which provides a distinct class of enabling mechanisms while remaining inseparable in its real operational effects (Melton, 2005; PAI, 2022). The first foundation is the principle-system-tool alignment logic: SOE does not treat tools as self-sufficient interventions, but as enablers whose intended outcomes emerge only when the management and work systems are aligned to guiding principles and translated into ideal behaviors (Womack and Jones, 2003; Deming, 2000; Shingo Institute, 2025). In parallel, SOE must also be able to orchestrate change in open economies where value creation depends on the enterprise's ability to sense opportunities, seize them through appropriate investments, and reconfigure its assets and routines when conditions evolve (Found et al., 2018; Teece, 2007; Womack and Jones, 2003). For these reasons, the process pillar provides the structural backbone for learning-through-action, the culture pillar provides the behavioral backbone that makes interpersonal risk-taking and continuous improvement feasible over time, and the digital pillar provides the augmented feedback and interpretive capacities that accelerate observation, experimentation, and sensemaking across the system (Melton, 2005; Shingo Institute, 2025; Deming, 2000).

Taken together, these pillars operationalize a systemic view of enterprise performance, where the organization learns not only what to do but also how to coordinate meaning, decisions, and

execution across multiple time horizons and multiple organizational levels (Womack and Jones, 2003; Deming, 2000). Accordingly, the remainder of this chapter develops the pillar-based analytical framework by focusing, in Section 3.2, on how process, standardization, and learning translate improvement laws into repeatable yet evolving operational mechanisms; by focusing, in Section 3.3, on how leadership, psychological safety, and coaching shape the cultural preconditions for learning behaviors; and by focusing, in Section 3.4, on how digital excellence and the augmented operator extend sensing, feedback, and socio-technical alignment (Found et al., 2018; Melton, 2005). Ultimately, Section 3.5 synthesizes these elements by explaining why SOE is best conceptualized as a mutually reinforcing system rather than as three independent domains that merely coexist within the firm (PAI, 2022; Shingo Institute, 2025).

### 3.1.1 From Lean Discipline to Sustainable Capability

Lean thinking offers a customer-centered learning architecture by formalizing how value should be specified, how value streams should be made visible, and how flow, pull, and perfection can drive continuous improvement without losing sight of the customer's ultimate definition of value (Womack and Jones, 2003). In this view, the five Lean principles provide a disciplined way to structure learning cycles around the creation of value for the customer, because specifying value from the perspective of the ultimate customer forces the organization to make its improvement objectives explicit and to interpret results against a meaningful operational target (Womack and Jones, 2003). In parallel, Lean's logic of flow and pull supports a mechanistic discipline for learning through direct observation of disruptions, since eliminating batch-and-queue thinking and pursuing continuous value flow reduces the distance between cause and effect and makes the operational consequences of decisions more legible to those who execute the work (Womack and Jones, 2003; Melton, 2005).

From a dynamic capability perspective, the SOE architecture can be interpreted as an operationalization of the sensing, seizing, and reconfiguring microfoundations that enable long-run enterprise success in open economies (Womack and Jones, 2003). Yet, rather than re-defining the dynamic capability framework already introduced in Chapter 2, the important point for this section is that SOE provides the organizational means through which those microfoundations become operationally realizable inside day-to-day work (Teece, 2007). In particular, sensing becomes embedded in process structures that make reality observable and deviations analyzable, seizing becomes embedded in decision and investment routines that align resources with the chosen improvement direction, and reconfiguring becomes embedded in the evolution of standards and systems so that learning can be sustained as conditions change (Teece, 2007; Womack and Jones, 2003). Found et al. (2018) further clarifies why this pillar-based logic is necessary: OpEx is described as a convergence where operational excellence draws from operations management laws and human resource philosophies, thereby creating a framework capable of guiding for learning and enabling innovation rather than merely promoting change (Found et al., 2018).

Accordingly, the move from Lean discipline toward sustainable capability is not a semantic change but a theoretical re-framing (Found and Bicheno, 2017). Lean contributes the

disciplined operational grammar of value, flow, and perfection, while SOE extends that grammar into an enterprise-level capability system that can be sustained through principle-led alignment and asset orchestration in environments characterized by uncertainty and rapid innovation (Womack and Jones, 2003; Deming, 2000). This shift establishes the rationale for the three-pillar framework that follows: process excellence as the learning backbone, culture as the behavioral backbone, and digital excellence as the sensing and feedback amplifier that sustains the organization's ability to interpret and act on operational reality over time (Found et al., 2018; Deming, 2000).

### 3.1.2 The Systemic Nature of Sustainable Excellence

SOE can be understood as a systemic achievement rather than the outcome of isolated improvements, because principles only become durable performance when they are translated into aligned systems and used through coherent tool selection (Deming, 2000; Shingo Institute, 2025). In this view, organizations do not "install" excellence through a checklist of techniques, but instead design an integrated management, improvement, and work architecture in which principles govern consequences: systems are intentionally configured to shape behavior toward the ideal, while tools serve as enablers that operationalize that intended purpose within the surrounding system (PAI, 2022; Deming, 2000; Shingo Institute, 2025). Accordingly, the central managerial task is to shift from firefighting or programmatic adoption to the deliberate alignment of the whole enterprise system, since when principles are not embedded in the systems that guide daily work, tools tend to become superficial point solutions that cannot reliably generate the intended results (Shingo Institute, 2025; Melton, 2005).

This systemic logic is consistent with Deming's argument that any substantial improvement must come from action on the system, which places responsibility squarely on management rather than on workers' individual compliance (PAI, 2022; Found et al., 2018). Deming emphasizes that quality begins with the intent fixed by management and then translated into the operational definitions and decision conditions through which people can do the right work reliably, since stable results can be predicted only when the system is understood and acted upon as the primary source of variation (Melton, 2005; Found et al., 2018). For these reasons, sustainable excellence cannot be achieved by adding "more control" or by requesting better performance from the same poorly designed system, because wishing and pleading without system change is futile, while continual improvement requires that the system be designed to learn and to evolve rather than be left to chance (Found et al., 2018; PAI, 2022; Shingo Institute, 2025). Ultimately, excellence becomes sustainable when management builds the organizational conditions under which continual learning is embedded in daily processes, so that improvement is not a temporary initiative but a permanent capability (Shingo Institute, 2025).

In complement to these arguments, the pillar-based approach in this thesis is positioned as a socio-technical mechanism for aligning purpose, behavior, and operational outcomes, thereby reinforcing socio-technical harmony between people and the way work is systematized (Found

and Bicheno, 2017; Melton, 2005). In addition, systemic alignment must be sustained over time through ongoing organizational learning and managerial commitment rather than through short-term tool deployment (PAI, 2022; Shingo Institute, 2025).

### 3.1.3 Balancing Process, Culture, and Technology

In the logic of SOE, the three pillars must be treated as an integrated system rather than as separable workstreams, because misalignment quickly manifests as waste, stalled improvement, and, critically, organizational initiatives that lose behavioral traction (Melton, 2005; PAI, 2022). Empirical evidence from lean manufacturing shows that value-adding activity is only a small portion of total activity: in manufacturing processes, about 5% of activities add value, 35% are necessary non-value-adding activities, and 60% add no value at all (Found et al., 2018). This decomposition does not only diagnose "process inefficiency"; it implicitly explains why imbalances among process design, the cultural capacity to learn, and the enabling logic of technology translate into persistent performance gaps, since non-value activity accumulates when information, incentives, and everyday work practices do not reinforce one another (PAI, 2022; Shingo Institute, 2025). Accordingly, when process changes are pursued without cultural internalization, operational learning becomes episodic and improvement effects tend to fade as soon as the implementation team moves on, producing the organizational "flavor-of-the-month" pattern that erodes commitment (Shingo Institute, 2025).

PAI (2022) frames this risk as a measurement and management problem: relying only on financial orientation or on surface-level deployment of best practices leads organizations to multiply indicator layers without ensuring that the underlying managerial behaviors and knowledge reflexes are actually embedded in daily work (PAI, 2022). In SOE terms, the result is that process and technology may generate visibility, yet culture fails to sustain the learning behaviors that convert visibility into corrective action (Shingo Institute, 2025).

For these reasons, SOE requires an indicator architecture that can bridge process outcomes and the behaviors through which those outcomes are produced (PAI, 2022). In this view, PAI (2022) emphasizes that while Key Financial Indicators (KFI) provide a strictly financial view of the organization and its results, they overlook the process dimension needed to act on operational objectives, which is why the organization must complement KPIs with knowledge and behavioral layers (Shingo Institute, 2025). In particular, PAI (2022) highlights the role of Key Knowledge Indicators (KKIs), which correlate knowledge and worker engagement to assess whether people have the technical knowledge and willingness to develop themselves, and it further introduces Key Behavior Indicators (KBIs) to measure managerial behaviors that contribute to organizational performance and growth (Melton, 2005; Found et al., 2018; Shingo Institute, 2025). When this behavioral measurement logic is missing or treated as secondary, technology and processes risk becoming "visibility machines" without behavioral follow-through; improvement programs remain managerial deployments rather than habits, and the organization repeatedly starts new initiatives to compensate for the loss of earlier gains (Shingo

Institute, 2025; PAI, 2022). In complement, the same SOE reasoning supports a caution against tool-centric deployment: process excellence depends on continuous learning cycles and the stabilization of improvement logic in practice, which is why tools divorced from guiding principles generate only short-term results and do not reliably produce sustained change (Shingo Institute, 2025).

### 3.1.4 Transition to the Analytical Framework

Therefore, the SOE framework treats the transition from pillar imbalance risk to analytical structuring as a necessary step in Chapter 3's logic (Deming, 2000; Shingo Institute, 2025). Section 3.2 develops process excellence through standardization and learning mechanisms, so that operational change can be made repeatable and observable in the work system rather than as one-off efforts (PAI, 2022; Shingo Institute, 2025). Section 3.3 then addresses cultural excellence by explaining leadership and learning behaviors that make people willing and able to use standards as learning infrastructure, thereby sustaining improvement beyond implementation (Melton, 2005; PAI, 2022). Section 3.4 shifts the lens to digital excellence and the augmented operator, clarifying how technology can extend sensing, feedback, and coordination across the socio-technical system without undermining human agency (Found et al., 2018; Melton, 2005). Finally, Section 3.5 synthesizes these elements by arguing that only the interdependence among process, culture, and digital capabilities produces a triadic equilibrium in which waste is reduced, knowledge is accumulated, and operational performance is resilient over time (Found et al., 2018; PAI, 2022).

## 3.2 Pillar I – Process, Standardization and Learning

Process excellence in SOE is the capability to translate improvement intent into operational learning by clarifying how "principles inform ideal behavior" and how coherent "systems" and "tools" can be selected to realize that behavior in day-to-day work. In the Shingo perspective, process thinking becomes actionable when it is rooted in a relationship among principles, systems, and tools, because principles are "foundational rules that govern consequences," whereas systems and tools are meaningful only insofar as they are deliberately designed to produce intended outcomes. This logic shifts process excellence away from tool-driven compliance and toward a disciplined improvement grammar in which stable causal expectations are first understood and then enacted through appropriate work design. In turn, Lean provides a customer-centered process design grammar that specifies what improvement should be able to deliver to the end user: value, the value stream, flow of value-creating steps, pull driven by customer demand, and the pursuit of perfection (Womack & Jones, 2003). By embedding these five principles into SOE, organizations can treat process excellence as an operational language for creating and sustaining customer value through repeatable learning cycles rather than ad hoc firefighting.

Importantly, SOE requires more than aspirations or slogans about "being efficient" because improvement depends on underpinning theories, laws, and rules that guide learning and

innovation under real constraints (Found et al., 2018). This theoretical stance aligns with Deming's argument that improvement of quality transfers waste into the manufacture of good product and better service, producing a chain reaction of lower costs and better performance that ultimately benefits customers and the workforce. Deming's teaching also frames quality improvement as a system responsibility: because the system is stable, meaningful improvement cannot be delegated to blameworthy worker exhortations, but must be pursued through management action on the operating system itself (Deming, 2000). Consistently, Deming warns that "new machinery and gadgets are not the answer," emphasizing that without redesigning the system of work, hardware adoption risks becoming a costly diversion from the mechanisms that actually generate predictable results.

Within this process-excellence framing, Liker further reinforces that organizations can easily mistake the means for the underlying system. The Toyota experience summarized in Liker's analysis highlights that learning requires understanding what makes tools work together, since "U.S. companies have embraced lean tools but do not understand what makes them work together in a system" (Liker, 2004). Thus, process excellence in SOE is not the accumulation of techniques, but the consistent practice of an integrated approach in which principles, systems, and tools reinforce one another. From a socio-technical standpoint, such a learning-oriented pillar also supports coherence across people and technology, because the organizational transformation from "vision to results" depends not only on designed processes but on the engagement, values, and behaviors of skilled people, while those behaviors must be supported by technologies and techniques that work "together in harmony" (Found et al., 2018).

Finally, resilience in SOE implies that process excellence cannot be reduced to optimization within a fixed design space. Hamel and Välikangas (2003)’s argument highlights that sustainable advantage requires a capacity for continuous reinvention and for generating variety through rapid, low-risk experimentation, rather than relying on grand, static plans or single-cycle change. In this view, process excellence must maintain reliability while also preserving the organizational ability to run structured experiments that expand options and avoid the stagnation associated with an overcommitment to optimization alone (Hamel and Välikangas, 2003). Accordingly, the process pillar is structured to establish learning mechanisms that both standardize the current best-known way of working and enable disciplined adaptation as evidence emerges, so that SOE continuously converts improvement intent into measurable, customer-relevant results.

### 3.2.1 Standardization as a Learning Mechanism

Standardization in a SOE process pillar is not treated as bureaucratic freezing of work, but as the disciplined baseline that makes deviation visible and therefore enables improvement through learning. In the logic advanced by the Shingo Model, improvement depends on shared understanding of what "standard" means in practice: without an agreed reference, gaps between expected and observed performance remain opaque and continuous improvement cannot reliably start. This learning orientation to standardization is directly linked to the daily management system: the point is to enable creativity that is focused and controlled rather than

ad hoc, so that everyday work becomes a structured source of evidence and capability building. Consistently aligned systems matter because, in SOE, leaders design for results but also shape the behavior that produces those results; when executives follow and insist on standard work, they signal that no individual is above continuous improvement, turning standardization into a cultural and managerial commitment rather than merely documentation.

For standardization to work as an improvement mechanism, it must be operationalized in ways that make quality observable and measurable, especially at the points where variation first appears. Deming's lesson is that improvement cannot be achieved by exhortation or by purchasing better outcomes through inspection; instead, organizations need operational definitions and data that allow them to distinguish what is acceptable from what is not. In his example, improvement began by plotting measurable defect information, then acting on the system responsible for producing defects, which reduced defective output without blaming workers. Deming further links quality improvement to waste reduction, arguing that transferring quality improvement into the production system reduces waste of man-hours and machine-time by enabling the manufacture of good product and better service. Importantly, he frames quality as something that must be built into the product and processes, "cease dependence on inspection", so that standards become the reference for preventing defects rather than detecting them after the fact.

This connects standardization to data-driven learning. In the Shingo view, process understanding must be developed to the point where the impact of a change can be predicted and then reconciled with what actually happens in the real process, turning improvement into a disciplined scientific cycle rather than a narrative or politically negotiated exercise. Operational excellence literature reinforces that it is not enough to have practices; they must be systematic, repeatable, and enabled by data and information so that learning can occur as part of everyday work. Baldrige's "system foundation" echoes this in performance-excellence terms, emphasizing that measurement, analysis, and knowledge management support a fact-based, knowledge-driven, agile system for improving performance. Crucially, this requires not only having data, but ensuring the quality of organizational data and information (accuracy, validity, integrity, reliability, and currency), because fact-based improvement depends on trustworthy information (Baldrige Excellence, 2019). In SOE, this means that standards must specify both the work method and the measurable indicators that make results legible, allowing teams to evaluate whether deviations indicate abnormality that should trigger immediate corrective action or whether they reflect stable conditions.

Standardization also becomes the operational vehicle for quality at the source. In the Shingo tradition, the intent behind standard work is to ensure that the "normal" way of performing tasks is reliable enough that problems are discovered immediately as they occur. This aligns with the jidoka logic described within Toyota's management system: quality is built into workplace processes through mistake-proofing and the design of operations so that employees are freed to perform value-adding work while defects are prevented or detected at the point of origin (Liker, 2004). In such a system, deviations from the standard do not simply consume time in

downstream inspection; they are treated as signals that the work system needs correction and that standards must be updated to reflect the best-known method. Where defects or abnormalities appear, the improvement system must support immediate action and rapid learning, which reduces rework and the hidden costs of poor quality.

Beyond quality, standardization anchors disciplined improvement in relation to information visibility. Both Shingo and excellence-oriented frameworks treat visual control and the reduction of information deficits as capabilities that help teams interpret reality consistently and therefore learn from it effectively. In practical terms, standard work supplies a shared "baseline for improvement" against which deviations can be seen, interpreted, and addressed quickly. Toyota's approach illustrates the mechanism: once a standard way of performing tasks exists as a local baseline, front-line teams can see and respond quickly to deviations, and through repeated scientific experiments they update operating procedures and retrain employees in improved standards. This creates a continuous learning loop where standardization is perpetually refined, not replaced by sporadic initiatives.

Finally, standardization distributes responsibility for learning across the organization. When standards are treated as behavioral and social commitments, rather than as inert artefacts, the expectation becomes that every actor at the point of work owns both conformance and improvement. This is why standardization is inseparable from leadership: it operationalizes the principle that management systems should make it easier to do the right thing and should correct drift when it occurs. In SOE, standardization therefore functions as the foundation for a fact-based improvement cycle that couples stable reference points (so deviations can be identified) with a structured learning process (so standards evolve). The result is a process pillar capable of sustaining quality and performance while progressively strengthening the organization’s capability to improve in response to measured evidence, rather than reacting to problems through tool-driven or ad hoc change (Shingo Institute, 2025; Deming, 2000; Baldrige Excellence, 2019; Liker, 2004).

### 3.2.2 Flow and Systemic Alignment

Flow and systemic alignment are treated in SOE as the directional grammar through which process improvement translates customer value into repeatable operational outcomes. In the Shingo perspective, value is highest for customers when it is created in response to real demand and at a continuous and uninterrupted flow (Shingo Institute, 2025). This framing makes time a core performance dimension rather than a background constraint: delays, interruptions, and the fragmentation of work into disconnected batch segments disrupt the continuity through which value is delivered, thereby degrading responsiveness and making performance difficult to interpret causally.

From this standpoint, waste is defined in relation to flow itself. Waste is "anything that disrupts the continuous flow of value to customers," and its identification becomes powerful precisely because it is easily understood as a deviation from value's uninterrupted movement through the end-to-end process (Shingo Institute, 2025). This operational definition also supports a

more rigorous waste classification aligned with value stream thinking. In Lean Thinking, Womack and Jones organize value stream activities into three categories, those that add value, those that do not add value but are currently necessary, and those that add no value and can be eliminated (Womack & Jones, 2003). The first category represents the transformation steps that customers are willing to pay for; the second captures enabling activities that sustain the present state but should be targeted for reduction as flow is redesigned; and the third represents pure waste that can be removed without harming the system's capability to deliver value. Importantly, this classification is meant to expose where the process is deviating from "the perfect process," understood as delivering the customer's desired value without interruption (Netland & Powell, 2017).

A key implication of defining waste as a flow disruption is that waste is not only physical or material. Consistent with Shingo's emphasis on the informational roots of process dysfunction, "much of waste is the result of information deficits," meaning that missing, delayed, or ambiguous signals in the management system can prevent work from progressing in the right sequence and at the right time (Shingo Institute, 2025). When information is not designed to keep the process intelligible, particularly to those executing it, flow breaks down even if physical resources are available. Thus, improving flow requires deliberate information design: the process must carry operational status, abnormalities, priorities, and pull signals with enough clarity to enable timely coordination across steps.

These points converge on value stream thinking as the mechanism of systemic alignment. Shingo's formulation of "improve flow & pull" as a principle explicitly links flow redesign to the need "to necessitate defining value streams and focusing on them" (Shingo Institute, 2025). A value stream is defined as "the collection of all the necessary steps required to deliver value to the customer" (Shingo Institute, 2025), which implies that flow improvement must be planned end-to-end, cutting across departmental and functional boundaries. The production system logic complements this view: Deming's account of production "viewed as a system" emphasizes that improvement in quality and productivity occurs when the entire chain is understood and managed coherently, so that the effects of decisions propagate through the production line rather than staying confined to isolated units (Deming, 2000). Within SOE, this systemic stance supports the organizational requirement to measure and manage improvement at the level of the whole value stream rather than at the level of departmental outputs.

Operationalizing value stream thinking further requires explicit structural support. In practice, pull and kanban mechanisms serve as coordination infrastructure that links production to actual demand and replenishment needs. Lean's broader adoption depends on reorganizing around these value streams and making the work visible and controllable across boundaries, rather than treating flow as a local optimization project. In line with this, benefits associated with lean approaches that sustain flow include reduced lead times and inventories and improved process robustness, reinforcing the systemic nature of flow improvement rather than framing it as a purely tactical exercise.

While flow and value stream thinking provide the qualitative direction, SOE also treats improvement feasibility as constrained by quantitative laws. Found et al. argue that operational excellence relies on theories and laws that can be represented through measurement relationships (Found et al., 2018). Little's Law governs the structural relationships between work-in-progress, cycle time, and throughput, implying that efforts to reduce cycle time must also manage WIP levels explicitly because the variables are interlinked (Found et al., 2018). The law of the experience curve describes how processes involving people naturally improve as individuals become more experienced, which legitimizes repetition and learning-by-doing as intrinsic mechanisms of performance improvement (Found et al., 2018). The law of focus further suggests that operational success depends on committing resources to a limited set of objectives, warning against managerial dispersion across too many performance targets (Found et al., 2018). The law of trade-offs implies that a plant cannot excel simultaneously on all competitive factors, reinforcing the need to choose priorities when designing process systems (Found et al., 2018). Finally, the law of diminishing returns indicates that continuous improvement follows an S-curve pattern, meaning that early gains may be substantial but gradually become harder to sustain without new approaches (Found et al., 2018). Found et al. (2018) represent these relationships visually (see Figure 4), positioning value and time as the two dimensions along which improvement trajectories can be traced.

Taken together, these laws clarify why flow initiatives require systemic alignment and not merely local process tinkering. Quantitative constraints do not replace cultural and managerial elements; rather, they define what is feasible and what mechanisms are likely to produce reliable change (Found et al., 2018; Shingo Institute, 2025).

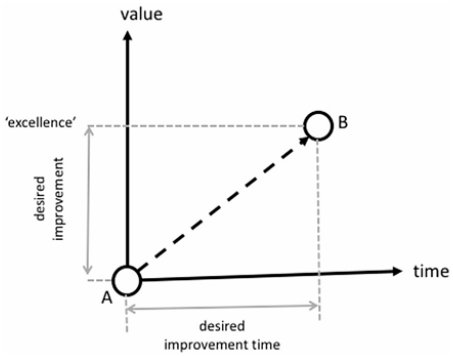



*Figure 4 Fundamental operational improvement. Source from [Towards a theory of operational excellence]*

### 3.2.3 Adaptive Stability and Continuous Experimentation

Adaptive stability and continuous experimentation in a SOE process pillar rests on a disciplined learning logic: standards are provisional hypotheses that should be tested, updated, and stabilized through repeated cycles of experimentation, direct observation, and learning. Rather than treating stability as an either/or choice, Shingo frames stability as an enabling condition for sustained improvement, by making the organization's "actual" process observable, it becomes possible to learn from variation and to refine causal understanding instead of merely reacting to symptoms (Shingo Institute, 2025). This implies that innovation is not conceived as

ad hoc disruption; it is the structured refinement of what "works," performed in the presence of a stable reference point that supports both predictability and reliable detection of meaningful deviations (Shingo Institute, 2025).

At the core of this logic is Shingo's data-driven orientation to learning cycles. Process understanding must be sufficiently thorough that when a change is implemented, its consequences can be predicted; only then does observation and measurement become more than reporting. The learning cycle proceeds through a sequence of prediction, implementation, observation, and reconciliation, so that the evidence produced by data is systematically used to update the standard and the underlying "theory-in-use" that connects cause and effect. Shingo emphasizes that organizations can collect data yet fail to use it properly; therefore, the improvement process must require reconciliation between predicted and actual results to make the improvement truly data-driven (Shingo Institute, 2025).

Netland and Powell (2017) offer a structured operational mechanism that supports exactly this kind of learning cycle in practice. Toyota's improvement system operationalizes PDCA as an institutionalized scientific approach that encourages continuous reflection and improvement and enables updates to standard operating procedures through many small experiments. PDCA is not treated as a bureaucratic loop; rather, it becomes a disciplined way of generating new knowledge, validating it through observation, and then translating it into revised standards that make reliable execution possible.

Schön's concept of reflection-in-action provides a micro-foundation for this learning mechanism by grounding experimentation in the situated activity of practitioners. In this view, the practitioner is not merely executing a known procedure; when reflecting-in-action, the practitioner "becomes a researcher in the practice context," carrying out an "experiment" that simultaneously generates new understanding and changes the situation (Schön, 1983). This mirrors the prediction–observation–reconciliation orientation in Shingo's logic: learning is produced in the moment of practice by reframing the problem setting and testing the implications of new interpretations. Furthermore, Schön stresses that problems do not simply present themselves as given facts; they must be constructed from problematic situations, which means that the organization must treat experimentation as a process of sensemaking as well as execution (Schön, 1983).

At the macro level, Teece's dynamic capabilities frame adaptive stability and continuous experimentation as organizational routines that enable strategic responsiveness under uncertainty. Dynamic capabilities are described through microfoundations that underpin enterprise-level capacities for sensing, seizing, and reconfiguring (Teece, 2007). Integrating this with the SOE process pillar clarifies the bridge between operational learning and enterprise evolution. The process pillar supplies the operational sensing routines, via standards that make work observable and visual management that brings abnormalities into view, so that the organization can detect when performance meaningfully deviates from expectation. It supplies seizing routines, through immediate correction and fast containment practices, so that learning is converted into action rather than remaining as analysis. Finally, it supplies

reconfiguring routines, through revised standards and redesigned value streams, so that learning is translated into durable changes in how value is produced and delivered (Teece, 2007; Shingo Institute, 2025).

Hamel and Välikangas (2003)'s argument about resilience adds the strategic rationale for why this operational learning cannot be optimization-only. He argues that resilience requires continuous micro-experimentation via a swarm of low-risk experiments (stratlets), emphasizing that resilience is blocked not only by practical constraints but also by ideology, specifically, by the doctrine of optimization that discourages variety and experimentation. Hamel characterizes the alternative as a mode of organizational renewal where revolutionary change happens through lightning-quick evolutionary steps, sustained by ongoing exploratory experiments that broaden the space of viable options (Hamel and Välikangas, 2003) .

Finally, the Shingo Model itself provides an institutional argument for evolvability. It explicitly notes that "Because learning is ongoing, the Shingo Model has changed over the years and may continue to do so," which suggests that frameworks for excellence should remain capable of being refined as learning accumulates (Shingo Institute, 2025).

In conclusion, adaptive stability within an SOE process pillar can be defined as the disciplined organizational capacity to revise standards without losing reliability by embedding experimentation, direct observation, and reconciliation into daily management. This reconciles two apparently competing needs: the need for stable references that make deviations meaningful and observable, and the need for continuous experimentation that keeps the system responsive to new evidence and evolving conditions. In doing so, the pillar operationalizes learning at the process level and supplies microfoundations for dynamic capabilities, enabling sensing, seizing, and reconfiguring routines that translate operational insights into enterprise-level adaptability (Shingo Institute, 2025; Teece, 2007).

## 3.3 Pillar II – Culture and People

If the process pillar provides the structural backbone of Sustainable Operational Excellence, the cultural pillar provides its behavioral and relational energy. Culture, in the Shingo Model's formulation, is not an intangible quality but "the sum of all behaviors in an organization" (Shingo Institute, 2025), which means that it is simultaneously the product and the driver of excellence: the systems an organization designs shape the behaviors people enact, and those behaviors, accumulated over time, constitute the culture that either sustains or undermines improvement. In this sense, cultural excellence is not a parallel initiative to process discipline but its necessary complement, because no process system can produce sustainable results unless people internalize the principles that animate it and translate them into daily conduct (Found et al., 2018).

The Shingo Model positions Respect for Every Individual and Lead with Humility as the Cultural Enablers upon which all other dimensions of excellence depend (Shingo Institute, 2025). These enablers are not aspirational slogans but design specifications: they define the behavioral conditions under which continuous improvement can take root. When respect is

operationalized, it manifests as psychological safety, the organizational climate in which individuals feel free to speak up, report problems, and propose ideas without fear of punishment or ridicule (Edmondson, 1999). Psychological safety is therefore not a "soft" value but a structural prerequisite for learning: without it, problems remain hidden, feedback is suppressed, and improvement cycles stall.

Found et al. (2018) reinforce this view by arguing that the transformation from organizational vision to tangible results is "not possible without the full engagement, values and behaviors of skilled and trained people, a committed and capable leadership and a culture of problem-solving, CI and change." This socio-technical interpretation implies that cultural excellence operates as an enabling infrastructure, one that mobilizes human potential through trust, shared purpose, and distributed ownership of improvement.

### 3.3.1 Leadership as a Cultural Enabler: The Role of Managerial Coaching

Within the SOE framework, leadership is understood not as a hierarchical function of command and control but as a facilitative capability that shapes the conditions under which learning and improvement can occur. The Shingo principle of Lead with Humility calls on leaders to listen before directing, to ask before prescribing, and to create environments where others feel empowered to experiment and reflect (Shingo Institute, 2025). This principle reframes the manager from a controller of performance into a facilitator of learning, a transition that the PAI (2022) identifies as one of the most critical shifts in the evolution of operational management.

Managerial coaching is the primary mechanism through which this facilitative leadership is enacted in practice. At its core, coaching is defined as "helping another person reach higher levels of effectiveness by creating a dialogue that leads to awareness and action" (Emerson & Loehr, 2008). This definition highlights two elements that are directly relevant to the SOE framework: awareness, which corresponds to the reflective capacity that Schön (1983) identifies as the foundation of professional learning, and action, which ensures that reflection translates into behavioral change rather than remaining abstract.

The coaching literature further clarifies the mechanism through which this process operates. Individual effectiveness in any task depends on the interplay of three components: Aptitude (the skills and know-how required), Attitude (the motivation, confidence, focus, and determination to apply those skills), and Available Resources (the tools, time, and support at one's disposal) (Emerson & Loehr, 2008). This framework, known as the Success Equation, highlights that Attitude functions as the keystone of performance: even when skills and resources are adequate, a deficit in motivation, confidence, or focus can undermine results in exponential ways (Emerson & Loehr, 2008). Coaching, in this perspective, is the managerial tool specifically designed to address the Attitude dimension, helping employees recognize how their own emotional and cognitive patterns may be blocking their effectiveness, and supporting them in choosing more productive responses.

This perspective also connects coaching to the broader domain of Emotional Intelligence, defined as the "awareness of one's thoughts and feelings as well as those of others so that one

can take the appropriate actions to manage oneself in a way that gets the most out of every interaction" (Emerson & Loehr, 2008). In an operational excellence context, the awareness-action loop of coaching directly reinforces the PDCA cycle at the human level: just as process improvement requires identifying deviations and implementing countermeasures, personal and team development requires surfacing attitudinal barriers and generating adaptive responses.

To structure this process in practice, coaching models such as the W.I.N. B.I.G. framework (Figure 5) provide managers with a repeatable formula for conducting coaching conversations (Emerson & Loehr, 2008).

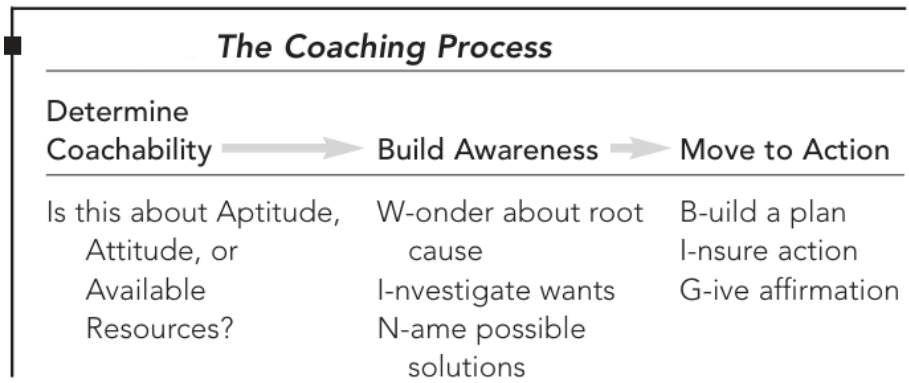



*Figure 5 W.I.N. B.I.G. model. Source from [Manager's Guide to Coaching - Simple and Effective Ways to Get the Best Out of Your Employees]*

The model guides the coach through six sequential stages: Wonder about root cause (exploring the underlying issue), Investigate wants (clarifying what the coachee truly seeks), Name possible solutions (brainstorming options), Build a plan (defining concrete action steps), Insure action (establishing accountability), and Give affirmation (recognizing progress and effort). This structured approach ensures that coaching is not left to intuition or improvisation but is embedded as a disciplined, learnable management practice, consistent with the Shingo principle that systems should be deliberately designed to reinforce desired behaviors (Shingo Institute, 2025).

### 3.3.2 The Double-Edged Nature of Coaching: Benefits, Costs, and Organizational Support

While coaching is widely recognized as a driver of employee engagement and learning, it is not without costs for the managers who practice it. She (2019) provides empirical evidence of this duality through a multisource, time-lagged study of 92 first-line managers and 449 subordinates in a manufacturing enterprise. The findings reveal a dual-path model in which managerial coaching simultaneously generates positive and negative outcomes for the coaches themselves (see Table 3).

On the positive path, coaching was found to be significantly associated with managers' personal accomplishment ($\beta = 0.45$, $p < 0.001$), which in turn positively predicted their job satisfaction ($\beta = 0.66$, $p < 0.001$) (She, 2019). This suggests that when managers invest in

developing their subordinates, they also strengthen their own sense of competence and fulfillment, as they acquire new relational skills, observe tangible improvements in their teams, and receive gratitude and recognition from the employees they coach.

On the negative path, however, coaching was also positively related to managers' role overload ($\beta = 0.43$, $p < 0.001$), which subsequently led to increased work fatigue (She, 2019). Because coaching requires significant investments of time and energy and often extends beyond formally prescribed job duties, managers may struggle to balance coaching responsibilities with their operational tasks, particularly when they lack adequate training or when subordinates are resistant to feedback (She, 2019). This finding resonates with the observation that coaching, as an extra-role behavior, can deplete the very resources it seeks to develop if the organizational context does not compensate for the additional demands it places on managers.

Critically, She (2019) demonstrates that the balance between these two paths is moderated by perceived organizational support. When managers perceive that the organization values their contributions and provides adequate resources, the positive effect of coaching on personal accomplishment is significantly amplified, while the negative effect on role overload is substantially attenuated. Specifically, the interaction between coaching and perceived organizational support was negatively and significantly related to role overload ($\beta = -0.20$, $p < 0.05$), indicating that organizational support acts as a buffer that compensates for the resource depletion inherent in coaching (She, 2019). The interactive pattern is depicted in Figure 6.

*Table 3 Path Coefficient Results. Source from [The double-edged sword of coaching]*

| | Coefficient/Estimate | *SE* | *p* value | 95% confidence interval | Result |
|---|---|---|---|---|---|
| Direct effects | | | | | |
| H1a: MC → PA | 0.45 | 0.10 | <0.001 | [0.26, 0.66] | Supported |
| H1b: PA → JS | 0.66 | 0.07 | <0.001 | [0.51, 0.80] | Supported |
| H2a: MC → RO | 0.43 | 0.10 | <0.001 | [0.22, 0.62] | Supported |
| H2b: RO → WF | 0.65 | 0.09 | <0.001 | [0.44, 0.82] | Supported |
| Indirect effects | | | | | |
| H1c: MC → PA → JS | 0.30 | 0.07 | <0.05 | [0.16, 0.46] | Supported |
| H2c: MC → RO → WF | 0.28 | 0.08 | <0.05 | [0.13, 0.46] | Supported |
| Moderating effects | | | | | |
| H3: MC * POS → PA | 0.32 | 0.09 | <0.001 | [0.17, 0.51] | Supported |
| H4: MC * POS → RO | −0.20 | 0.08 | <0.05 | [−0.38, −0.07] | Supported |
| $R^2$ | | | | | |
| PA | 0.34 | 0.07 | <0.001 | | |
| RO | 0.36 | 0.07 | <0.001 | | |
| JS | 0.52 | 0.07 | <0.001 | | |
| WF | 0.49 | 0.11 | <0.001 | | |

*Note.* Standardized coefficients are reported. JS: job satisfaction; MC: managerial coaching; PA: personal accomplishment; POS: perceived organizational support; RO: role overload; and WF: work fatigue.

Conversely, in the absence of organizational support, coaching intensifies role overload considerably ($\beta = 0.59$, $p < 0.01$ under low support versus $\beta = 0.26$, $p < 0.05$ under high support) (She, 2019).

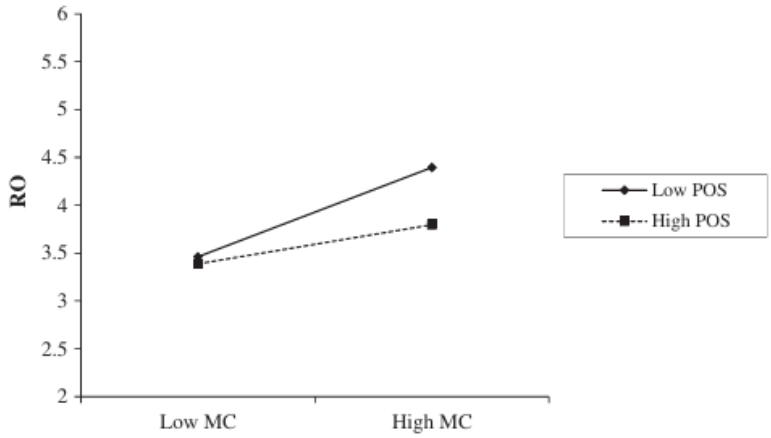



*Figure 6 Moderating effect of POS on the relationship between MC and RO. Note: RO: role overload; POS: perceived organizational support; and MC: managerial coaching. Source from [The double-edged sword of coaching]*

This finding has profound implications for the cultural pillar of SOE. It demonstrates that coaching cannot be treated as an isolated managerial skill to be deployed at the individual level; rather, its sustainability depends on an organizational culture that actively supports, recognizes, and rewards coaching behaviors. In the language of the Shingo Model, the management system must be aligned to reinforce the principle of developing people, through incentive structures, workload design, training investments, and leadership expectations that signal coaching as a core organizational value rather than an optional addition to the manager's already demanding role. Without this systemic alignment, coaching risks becoming precisely the kind of episodic, unsustainable initiative that the SOE framework seeks to transcend.

### 3.3.3 From Training to Behavioral Transformation: The Limits of Knowledge Transfer

The relationship between coaching and organizational support also illuminates a broader challenge in the cultural pillar: the gap between knowledge and behavior. Traditional approaches to developing managerial capability have relied primarily on training, the structured transfer of knowledge through formal programs, and on process optimization, the redesign of workflows through expert-led improvement events (PAI White Paper, 2022). Both approaches generate value, but neither, on its own, produces the lasting behavioral change that sustainable excellence requires.

The PAI (2022) presents a diagnostic framework that distinguishes four levels of organizational performance measurement: Key Financial Indicators (KFIs), which assess financial health; Key Performance Indicators (KPIs), which monitor operational outcomes; Key Knowledge Indicators (KKIs), which evaluate workforce competence and engagement; and Key Behavior Indicators (KBIs), which measure the managerial behaviors that drive sustained performance. This hierarchy reflects an increasing depth of organizational maturity: organizations begin by monitoring financial results, progress to tracking operational processes, and only at more advanced stages develop the capacity to measure and develop the human behaviors that underpin all other dimensions of performance (PAI White Paper, 2022).

The data reported by the PAI White Paper are revealing: 62% of first-line managers demonstrate a weak or very weak understanding of their managerial role and responsibilities (PAI White Paper, 2022). This does not indicate a lack of potential; rather, it reflects the common organizational pattern in which the best technical performers are promoted into managerial roles without adequate preparation for the fundamentally different nature of managerial work, which shifts from creating direct value through individual technical skills to creating indirect value through the development and coordination of others (PAI White Paper, 2022).

The White Paper further describes five stages of managerial maturity, from the basic capacity to assign tasks, through ensuring customer deadlines, to setting performance goals, identifying performance gaps, and ultimately reaching the stage of proactive management, in which the manager systematically identifies recurring variances and eliminates root causes to generate sustainable benefits (PAI White Paper, 2022). Only at this final stage does the manager become a true managerial leader who fully understands the extent of their impact on organizational performance.

Critically, the White Paper argues that training alone cannot sustain the transition through these stages, because "training develops knowledge, but not reflexes and habits" (PAI White Paper, 2022). The adoption of new behaviors during a training session is relatively straightforward; what is difficult is maintaining those behaviors once the manager returns to the pressures and routines of daily work. Without reinforcement, new behaviors fade, and the organization cycles through successive improvement initiatives, each producing only temporary results, a pattern the White Paper describes as the "flavor of the month" effect that erodes team engagement over time (PAI White Paper, 2022).

The solution, according to this perspective, lies in combining training with sustained, on-the-job coaching. "To truly change behaviors and drive lasting results, nothing beats the presence of an outside observer that can offer feedback and perspective in real-time. By accompanying managers in their daily work, coaching is all about transforming knowledge into behaviors and process optimizations into work habits" (PAI White Paper, 2022). This argument directly supports the SOE framework's positioning of coaching as a cultural mechanism rather than a training technique: coaching embeds learning into the flow of work itself, creating the conditions for behavioral change to become habitual and self-sustaining.

This insight also bridges the coaching literature with the Shingo Model's principle–behavior–result logic. Where the Shingo Model establishes that "behaviors flow from the principles that govern results" and that systems must be designed to reinforce those behaviors (Shingo Institute, 2025), the coaching perspective adds the operational mechanism through which this reinforcement occurs in practice: through the daily, dialogic interaction between a leader who asks reflective questions and an employee who discovers, through their own reasoning, the adjustments needed to align their conduct with the organization's guiding principles

### 3.3.4 Cultural Excellence as an Ongoing Aspiration

Taken together, the theoretical and empirical perspectives reviewed in this section converge on a central insight: cultural excellence in the context of SOE is not a state to be achieved but a capability to be continuously cultivated. It depends on leadership behaviors that foster psychological safety (Edmondson, 1999), on coaching practices that develop both the coached and the coach (She, 2019; Emerson & Loehr, 2008), on organizational systems that support and sustain these practices over time (She, 2019; PAI White Paper, 2022), and on measurement frameworks that make behavioral dimensions of performance visible and actionable (PAI White Paper, 2022).

The cultural pillar therefore operates at the intersection of individual behavior and organizational design. It cannot be reduced to leadership training or motivational programs, because its sustainability depends on systemic conditions: reward structures that recognize coaching, workload designs that make time for developmental conversations, and feedback mechanisms that track not only what results are achieved but how they are achieved. When these conditions are present, culture becomes a self-reinforcing enabler of excellence, what the Shingo Model describes as the foundation upon which all other systems rest (Shingo Institute, 2025). When they are absent, even the most sophisticated process systems and digital tools will fail to produce the sustained engagement and adaptive learning that SOE demands.

This understanding sets the stage for the analysis of the third pillar, digitalization, which provides the intelligence and visibility mechanisms through which both process discipline and cultural engagement are amplified, monitored, and continuously refined.

## 3.4 Pillar III – Digital Excellence and the Augmented Operator

Within the SOE model, the third pillar can be framed as digital excellence: the deliberate development of socio-technical capabilities that connect the physical production system to digital resources through cyber-physical integration and enhanced human–machine interaction, rather than a standalone program of IT modernization or automation. (Sanders et al., 2016) This interpretation is consistent with the Industry 4.0 view of a “fourth industrial revolution” grounded in cyber-physical systems, the Internet, and “smart systems,” explicitly coupled with new paradigms of human–machine interaction. (Sanders et al., 2016) In this paradigm, digitalization changes the informational topology of operations by enabling identity and communication for entities across the value stream, thereby supporting tighter coordination and more responsive decision-making across operational boundaries. (Sanders et al., 2016)

From an operational perspective, digital excellence aims to make the factory a networked “smart environment” by leveraging the Internet of Things and related services to connect processes, data, and action in near real time. (Sanders et al., 2016) When smart machines, warehousing systems, and production facilities are digitally developed, the consequence is end-to-end information and communication systems integration that spans inbound logistics,

production, and service, making digitalization inseparable from process design, control, and improvement. (Sanders et al., 2016) This integration enables a shift away from conventional forecast-based planning toward real-time planning and dynamic self-optimization, which can shorten feedback cycles and reduce the delay between deviation detection and corrective action. (Sanders et al., 2016)

In SOE, however, digital excellence must be judged not only by technical performance but also by whether it creates human-centered work systems that remain robust under variability and complexity. (Romero et al., 2016) The Operator 4.0 literature explicitly argues that Industry 4.0 would be "inconceivable without human beings," implying that the design target is human–automation symbiosis enabled by Human Cyber-Physical Systems (H-CPS) and Adaptive Automation (AA), rather than substitution of human labor. (Romero et al., 2016) At the same time, the automation of monotonous and non-skilled activities reconfigures work content, shifting operators toward calibration, data processing, and other non-repetitive tasks, which makes capability development a constitutive element of digital transformation. (Sanders et al., 2016)

The concept of the augmented operator provides the link between digitalization and sustainable excellence, because Operator 4.0 is described as a "smart and skilled operator" whose work is "aided" by machines "if and as needed," emphasizing support, inclusion, and development rather than displacement. (Romero et al., 2016) This augmentation logic is operationalized through H-CPS—systems engineered to improve humans' dynamic interaction with machines through "intelligent" interfaces tailored to cognitive and physical needs, and to enhance human sensing and cognitive capabilities via enriched technologies such as wearables. (Romero et al., 2016) It is also operationalized through adaptive mechanisms that shift task allocation between humans and automation when predefined conditions are met, aiming to optimize performance while explicitly accounting for both technical/economic benefits and social-human benefits. (Romero et al., 2016)

Finally, digital excellence must be treated as an ongoing capability-building effort because operational and competitive environments are structurally dynamic, with consumer needs, technological opportunities, and competitor activity "constantly in a state of flux." (Teece, 2007) Teece's dynamic capabilities logic highlights that enterprises must employ sensing, seizing, and reconfiguring mechanisms to align resources with marketplace needs, which positions digital excellence as a continuous capacity to adapt socio-technical systems rather than a one-time technology deployment. (Teece, 2007) In parallel, strategic resilience emphasizes that resilience is not about responding to a one-time crisis but about continuously anticipating and adjusting to deep trends that can permanently impair a core business, reinforcing the SOE requirement that digital excellence supports ongoing renewal rather than episodic transformation. (Hamel & Välikangas, 2003)

### 3.4.1 The Digital Dimension of SOE

The digital dimension of SOE begins with an architectural premise: Industry 4.0 connects physical operations and cyber resources through cyber-physical systems and the Internet, enabling “smart systems” and enhanced human–machine interaction paradigms. (Sanders et al., 2016) When identity and communication can be established for each entity in the value stream, the organization gains a practical basis for traceability and coordination that supports faster problem recognition and more timely intervention in cross-functional value creation. (Sanders et al., 2016) This is reinforced when the factory is networked into a “smart environment” through IoT and services, because connectivity becomes embedded in everyday work rather than confined to reporting systems or periodic reviews. (Sanders et al., 2016)

In SOE terms, digital excellence is achieved when this architecture strengthens planning and control without disconnecting from process reality, because Industry 4.0 enables real-time production planning and dynamic self-optimization as an alternative to conventional forecast-based planning. (Sanders et al., 2016) The operational significance is not only speed but also state fidelity: plans can be updated based on current constraints and signals, reducing the latency between operational changes and managerial response. (Sanders et al., 2016) Likewise, the end-to-end integration of smart machines and production facilities across the supply chain implies that operational decisions can be coordinated from inbound logistics to service, which can reduce misalignment costs that otherwise appear as waiting, expediting, and local optimization. (Sanders et al., 2016)

Yet the digital dimension must remain explicitly socio-technical, because Industry 4.0 is described as enabling new types of operator–machine interactions that will transform the industrial workforce to handle increasing variability of production. (Romero et al., 2016) The Operator 4.0 position frames this transformation as a shift from independent automated and human activities toward human–automation symbiosis, characterized by the cooperation of machines with humans in work systems designed not to replace human skills but to co-exist with and assist them in being more efficient and effective. (Romero et al., 2016) Consequently, a digital operating model that optimizes technical metrics while ignoring cognitive workload, interface quality, and worker development risks becoming operationally fragile precisely in the dynamic environments that motivate Industry 4.0 adoption. (Romero et al., 2016)

Digital excellence in SOE is also inseparable from operational learning at the point of work, because smart devices can acquire real-time data, autonomously execute routine tasks, and represent information as figures and graphs, thereby changing how quickly deviations become visible and interpretable. (Sanders et al., 2016) Moreover, production workers can provide immediate feedback on production conditions through real-time data using their own smartphones and tablets, making feedback generation part of daily work rather than a separate reporting burden. (Sanders et al., 2016) These mechanisms support an SOE logic in which improvement is sustained when the system reduces the friction of making problems visible and enables localized, timely responses guided by reliable information. (Sanders et al., 2016)

At the same time, the digital dimension requires disciplined choices about what information is captured, how it is filtered, and how it is translated into action, because the Operator 4.0 discussion notes that the proliferation of sensor devices changes the constraint from information scarcity to the need for intelligent sensing and decision support. (Romero et al., 2016) Specifically, the argument is that the promise of IoT data abundance materializes only if sensor agents become intelligent about what data to register and transmit, and if cooperative learning algorithms enable adaptive filtering of unwanted data while "zooming-in" on faint but relevant signals and negotiating bandwidth for priority communication. (Romero et al., 2016) Therefore, digital excellence is better conceptualized as socio-technical attention design (interfaces, rules, and routines that protect human attention and support situated judgment) than as the simple maximization of data volume. (Romero et al., 2016)

Finally, the digital dimension requires explicit capability development and work redesign because automation shifts job content toward calibration and data processing tasks, making training and learning integral to sustaining performance and well-being. (Sanders et al., 2016) In the Operator 4.0 framing, operator-friendly conditions and learning are linked to human–automation symbiosis via H-CPS and AA, which are intended to reflect established principles of practicability, safety, freedom from impairment, and individualization/personalization through adaptive systems that support the operator and promote learning. (Romero et al., 2016) This implies that the digital dimension of SOE is not merely technical deployment competence but also competence in human-centered system engineering, including the design of "intelligent" interfaces aligned with operators' cognitive and physical needs. (Romero et al., 2016)

### 3.4.2 The Operator 4.0 Framework

The Operator 4.0 framework provides a concrete anchor for Pillar III by connecting Industry 4.0's cyber-physical paradigm to the redesign of operator–machine interaction in the face of increasing production variability. (Romero et al., 2016) Rather than portraying the workforce as a residual constraint, the framework argues that an important part of the Industry 4.0 transition is the emphasis on human-centricity, enabling a shift toward human–automation symbiosis in which machines cooperate with humans and are designed not to replace human skills but to co-exist with and assist them. (Romero et al., 2016) This positions digital excellence as the ability to deliberately blend human and machine agency in work systems, so that flexibility and performance are achieved through complementary strengths rather than through maximal machine autonomy. (Romero et al., 2016)

A central architectural concept is Human Cyber-Physical Systems (H-CPS), defined as systems engineered to (a) improve human ability to dynamically interact with machines in cyber and physical worlds through "intelligent" human–machine interfaces designed to fit operators' cognitive and physical needs, and (b) improve human physical, sensing, and cognitive capabilities through enriched technologies such as wearables. (Romero et al., 2016) In SOE terms, this definition makes interface design and capability enhancement part of operational excellence, because the interface becomes the mechanism through which cyber-physical

information is translated into operator situational awareness and timely action. (Romero et al., 2016) This also aligns with the claim that Industry 4.0 is "inconceivable without human beings," reinforcing that cyber-physical integration must be engineered around human participation rather than solely around automation. (Romero et al., 2016)

The framework operationalizes augmentation further through Adaptive Automation (AA), which aims to optimize human–machine cooperation by allocating cognitive and physical labor efficiently and distributing tasks between automation and humans in the workstations of an adaptive production system. (Romero et al., 2016) AA is described as allowing the human and/or the machine to modify the level of automation by shifting control of specific functions whenever predefined conditions are met, implying that digital excellence requires explicit governance of when autonomy is transferred and why. (Romero et al., 2016) The ultimate goal is a dynamic and seamless transition of task allocation that leverages human skills to provide inclusiveness and job satisfaction while also achieving production objectives, which explicitly links the digital pillar to both performance and social sustainability. (Romero et al., 2016)

Human-in-the-loop (HITL) control models are highlighted as relevant enablers of Operator 4.0, because HITL feedback control systems require human interaction and offer control configurations that include supervisory human control, automation monitoring with intervention, or hybrid models combining human inputs with automation actions. (Romero et al., 2016) For SOE, this implies that "control" in cyber-physical systems should be designed as a cooperative process that supports reliable decisions under variable workload conditions, rather than as a design attempt to remove human discretion entirely. (Romero et al., 2016) It also implies that system designers must explicitly address physiological, sensorial, and cognitive complexity, because HITL models are described as challenging precisely due to the complex nature of human beings. (Romero et al., 2016)

Crucially, the Operator 4.0 framework frames outcomes in dual terms: sustainable technical and economic benefits (e.g., improved quality, increased responsiveness, shorter throughput times, easier planning and control, increased capacity for innovation and continual improvement) and social-human benefits (e.g., quality of working life, job satisfaction through meaningful tasks, personal flexibility and adaptation, improved skills). (Romero et al., 2016) This duality prevents digitalization from collapsing into a narrow productivity discourse and fits a SOE stance in which excellence must remain sustainable by preserving workforce viability and improvement capability over time. (Romero et al., 2016) It also gives practical direction to the human-centric claim: augmentation must be evaluated by whether it improves both operational performance and the conditions that support safe, satisfying, and developable work. (Romero et al., 2016)

Finally, the framework highlights that dynamic factories require cognitive support because upgraded shop floors call for cognitive aids—such as augmented reality technologies or "intelligent" HMIs—to support increased cognitive workload involving diagnosis, situational awareness, decision making, and planning. (Romero et al., 2016) In addition, the same source emphasizes that the promise of IoT sensor proliferation depends on intelligent filtering and

cooperative sense-making, reinforcing that digital excellence must actively manage information abundance to avoid overload and preserve reliable human judgment. (Romero et al., 2016) Synthesizing these elements, the Operator 4.0 framework identifies the augmented operator as the focal point through which Pillar III becomes sustainable, learning-oriented, and robust under variability, because H-CPS, AA, and HITL mechanisms explicitly engineer the human–automation boundary as a site of continuous adjustment and capability development. (Romero et al., 2016)

### 3.4.3 Digital Tools as Learning Amplifiers

Within SOE, digital tools generate sustainable value when they amplify organizational learning—that is, when they shorten the feedback loop between a condition in the process and an informed response, and when they improve the interpretability of operational signals for the people who must act on them. This learning-amplifier view is consistent with the Industry 4.0 shift from conventional forecast-based planning toward real-time planning and dynamic self-optimization, because the operational system can update decisions continuously rather than episodically, thereby reducing latency between observation, decision, and action. At the interface level, the same amplification logic is visible in the use of smart devices that acquire real-time data, autonomously execute routine tasks, and represent information as figures and graphs, which makes deviations easier to interpret during daily work rather than only in retrospective analyses.

A first concrete pathway through which tools amplify learning is process visibility and traceability across the value stream. Industry 4.0 is associated with giving entities in the value stream identity and communication, which makes it possible to follow materials, work-in-progress, and operational states with far greater continuity than in traditional systems. At a more operational level, RFID-based solutions can eliminate inventory errors through exact real-time tracking, which improves the fidelity of "what is happening" signals and therefore increases the quality of improvement problem-framing (e.g., distinguishing genuine flow instability from mere inventory-record inaccuracy). Similarly, when wireless tracking reconciles the manufacturing execution system's recorded inventory with real inventory, faults in production control due to lost kanban can be avoided; this stabilizes pull execution and reduces the need to "debug" the production system based on missing or inconsistent physical signals.

A second pathway is learning from equipment abnormalities and reliability signals rather than merely reacting to breakdowns. In smart factories where machines are interconnected with information and communication systems, equipment can send error notifications to shop-floor and maintenance personnel when breakdowns occur, which reduces the time-to-awareness and helps maintenance activities start with better information (e.g., codes, locations, time stamps). In more advanced configurations, analytics and big-data environments support machines becoming self-aware and self-maintained, shifting maintenance toward anticipatory routines in which degradation patterns can be detected earlier and turned into preventive action. From a SOE perspective, these mechanisms are learning amplifiers because they

transform “downtime events” into structured data points for identifying recurring failure modes and for redesigning maintenance standards and countermeasures.

A third pathway concerns turning data into actionable knowledge rather than producing dashboards that are informationally rich but operationally inert. Advanced analytics is explicitly described as combining business intelligence and process workflow management by computing meaningful trends and relationships from available data, implying that digital tools become learning amplifiers only when they are embedded into decision points and routines (e.g., escalation rules, containment actions, improvement experiments). When the system can compute trends and relationships and present them in usable forms, it becomes easier to sustain evidence-based problem identification and prioritization at the pace required by real-time operations.

A fourth pathway relates to empowerment and participation in improvement. Production workers can provide immediate feedback on production conditions via real-time data through their own smartphones and tablets, lowering the friction of surfacing abnormalities and enabling faster local responses and richer organizational learning from frontline observations. At the same time, smart feedback devices, worker support systems, and improved man–machine interfaces are described as facilitating better empowerment and involvement of employees, indicating that digitalization can expand improvement bandwidth by increasing both voice and visibility in daily operations. Even managerial coordination can be supported by handheld devices enabling managers to check availability and allocate workers across operations, which can reduce coordination losses and allow faster learning about how staffing patterns interact with variability in demand and process conditions.

However, the learning-amplifier role of digital tools depends on how work is redesigned and how learning is supported for the new work content that digitalization creates. As monotonous and non-skilled activities are automated, work shifts toward calibration, data processing, and other non-repetitive tasks, which makes training and capability development a structural requirement for realizing benefits. The Operator 4.0 perspective reinforces this point by emphasizing that Industry 4.0 enables new types of interactions between operators and machines, with significant implications for the nature of work as production becomes more variable. In this context, augmented reality technologies or “intelligent” human–machine interfaces can be understood as cognitive aids intended to support diagnosis, situational awareness, decision making, and planning tasks that become more demanding in dynamic shop floors, thereby protecting learning and reliability under cognitive load. Finally, the Operator 4.0 literature describes assessment tools such as Physical Abilities Tests and Advanced Trained Classifiers (based on machine learning) to measure operator performance in real time and identify when assisted/enhanced operation is necessary, suggesting that learning amplification can also be adaptive and linked to individualized support and safety outcomes.

In sum, digital tools in SOE qualify as “learning amplifiers” when they (i) increase signal fidelity through traceability and inventory accuracy, (ii) turn abnormalities into structured learning

opportunities through connected maintenance and analytics, and (iii) expand improvement participation through feedback channels and support systems, while simultaneously acknowledging that automation shifts the skill profile of work and therefore requires purposeful operator development and cognitive support.

### 3.4.4 Industry 4.0 as Enabler of Lean Manufacturing

Building on the Lean–Industry 4.0 complementarity discussed previously, this section operationalizes that relationship at the level of specific lean dimensions by clarifying the causal mechanisms through which digital technologies reduce integration frictions and tighten feedback loops across the value stream.

A first enabling mechanism is the creation of digital identity and communication for entities in the value stream. By enabling identity and communication for every entity, Industry 4.0 supports IT-enabled mass customisation and more responsive coordination among actors who otherwise operate with partial visibility and asynchronous information flows. Lean supplier-related dimensions (e.g., supplier feedback and JIT delivery) become more feasible when information exchange is faster and less distorted, because coordination is no longer constrained to periodic, manual reporting cycles. This identity/communication layer is strengthened further when smart machines, warehousing systems, and production facilities enable end-to-end information and communication systems-based integration across the supply chain—from inbound logistics to downstream service—since integration expands the scope of coordination from a single plant to the broader value stream.

A second mechanism concerns planning and flow control. Industry 4.0 enables real-time planning of production plans together with dynamic self-optimization, which changes planning from a periodic “batch” activity into a more continuous steering process aligned with actual system states. In lean terms, this supports continuous flow and responsiveness because deviations can be detected and corrected earlier, reducing the accumulation of hidden queues and rework in planning decisions.

A third mechanism is the digitization of pull execution through sensorized replenishment. When wireless information and communication systems track material batches via RFID, and when real inventory matches the value recorded in the manufacturing execution system, faults in production control due to lost kanban can be avoided. Mechanistically, this turns kanban from a fragile physical signaling artifact into a closed-loop cyber-physical control logic where replenishment triggers are traceable, reconcilable, and updateable in real time through system state alignment. For SOE, the implication is a more reliable basis for disciplined problem solving, because process instability is less likely to be misattributed to “operator noncompliance” when the root cause is actually signal loss or state mismatch in the pull system.

A fourth mechanism is real-time inventory accuracy as a stabilizer of continuous flow. RFID solutions help eliminate errors associated with inventory by real-time exact tracking, increasing the fidelity of material availability signals and thereby reducing the need to compensate for

uncertainty with buffers, expediting, or local workarounds that can obscure the true causes of flow interruption. In lean logic, reducing such hidden variability improves the conditions for stable flow and more consistent improvement experimentation, because teams can distinguish process problems from information problems with higher confidence.

A fifth mechanism targets maintenance and equipment effectiveness. In a smart factory, interconnected machines can send error notifications to shop-floor and maintenance personnel when breakdowns occur, enabling faster awareness and more coordinated response routines. With more advanced analytics and big-data environments, machines can become self-aware and self-maintained, supporting the evolution from reactive breakdown response toward anticipatory maintenance routines and earlier detection of degradation patterns. These mechanisms support lean total productive/preventive maintenance by tightening the link between abnormalities and countermeasures and by creating richer learning signals for improving maintenance standards and planning.

A sixth mechanism supports quality control and statistical thinking. Advanced analytics computes meaningful trends and relationships from available data, linking business intelligence with process workflow management, and thereby enabling faster detection of patterns relevant to process control and improvement decisions. This capability is complemented by smart devices that acquire real-time data and represent it visually as figures and graphs, which can make shop-floor quality signals more accessible at the point of work and reduce the delay between deviation detection and containment action.

A seventh mechanism strengthens employee involvement, a central lean dimension that is often limited by frictions in communication and participation. Production workers can provide immediate feedback on production conditions through smartphones and tablets, which lowers the effort required to surface problems and can increase the frequency and granularity of improvement-relevant observations. Smart feedback devices, worker support systems, and improved man–machine interfaces are also described as facilitating better empowerment and involvement of employees, implying that digitalization can broaden participation in improvement when the system is designed around operator usability rather than only around technical automation targets. Additionally, handheld devices can support managerial coordination by enabling managers to check availability and allocate workers across operations, which can reduce coordination waste and support adaptive deployment of skills under variability.

The table below synthesizes these lean-to-Industry 4.0 mechanisms and clarifies their implications for SOE (Table 4).

*Table 4 Lean-To-Industry 4.0 mechanisms and implications for SOE*

| Lean dimension | I4.0 enabling mechanism | SOE implication |
|---|---|---|
| Supplier feedback | Digital identity and communication for entities in the value stream enables faster information exchange. | Faster cross-boundary learning loops that support systemic problem solving across the value stream. |
| JIT delivery | End-to-end information and communication systems-based supply chain integration enables shared visibility across logistics and operations. | More reliable synchronization decisions and fewer coordination losses due to mismatched operational pictures. |
| Customer involvement | Identity/communication in the value stream supports IT-enabled mass customisation and responsiveness to changing requirements. | Higher responsiveness sustained through improved information flow, while still requiring disciplined operational steering via real-time planning. |
| Pull production | RFID-enabled wireless tracking reconciled with manufacturing execution system inventory reduces lost-kanban production control faults. | More accurate pull signals, less firefighting, and improved stability for continuous improvement routines. |
| Continuous flow | RFID real-time exact inventory tracking eliminates inventory errors that disrupt flow. | Lower need for buffers and fewer flow disruptions caused by uncertainty about material status and location. |
| Setup time reduction | Real-time planning with dynamic self-optimization supports faster adaptation of plans and operating conditions. | Reduced changeover losses become more achievable when rapid plan adjustments are paired with re-standardization discipline. |
| TPM | Machine interconnection enables automatic error notifications to maintenance and shop-floor personnel. | Shorter time-to-awareness and better containment of downtime impacts through faster coordination of interventions. |
| Preventive maintenance | Advanced analytics and big-data environments support self-aware, self-maintained machines. | Shift from reactive to anticipatory maintenance routines driven by earlier detection of degradation patterns. |
| SPC | Advanced analytics computes meaningful trends/relationships; smart devices visualize real-time data. | Higher-capacity evidence-based problem framing if analytics is embedded into operational workflows and escalation routines. |
| Employee involvement | Immediate feedback via smart devices; worker support systems and improved interfaces enable empowerment and involvement; handheld devices support staffing coordination. | More inclusive and faster continuous improvement cycles enabled by lower-friction issue capture and more adaptive coordination under variability. |

Finally, this mechanistic mapping clarifies why the Lean–I4.0 synthesis is inseparable from the people-development agenda of Pillar III. As routine activities are automated, workers are shifted toward calibration and data-processing tasks, which presupposes reskilling and learning rather than simple technology deployment. Consistent with this, the Operator 4.0 discourse frames Industry 4.0 as enabling new operator–machine interactions and emphasizes human-centricity and cooperation, where systems are designed not to replace skills but to co-exist with and assist humans in being more efficient and effective. In SOE terms, digital excellence is therefore achieved when Industry 4.0 mechanisms make lean routines easier to execute and improve, while simultaneously strengthening the cognitive and coordination conditions that allow operators and teams to sustain disciplined learning under variability.

## 3.5 The Interdependence of the Three Pillars

SOE can be understood as a socio-technical configuration in which process discipline, learning-oriented culture, and digital systems co-evolve rather than operate as separable improvement "programs" (Teece, 2007; Edmondson, 1999; Sanders et al., 2016). From an organizational-learning standpoint, performance improvement depends on the collective behaviors through which teams obtain and process data to adapt and improve, such as seeking feedback, sharing information, asking for help, talking about errors, and experimenting (Edmondson, 1999). This behavioral learning loop presupposes a climate in which people expect that interpersonal risks will not be punished, because learning behaviors often expose individuals to embarrassment or threat (Edmondson, 1999). At the same time, SOE increasingly relies on Industry 4.0 capabilities that expand what the organization can observe and coordinate through real-time data, smart devices, and interconnected cyber-physical infrastructures (Sanders et al., 2016). Yet, if digital transparency is deployed without an enabling learning climate and knowledge-integration routines, the organization risks generating data without producing learning and capability renewal (Edmondson, 1999; Nonaka, 2007).

### 3.5.1 Process and Culture: Discipline as the Foundation of Learning, Culture as the Soul of Discipline

The relationship between process excellence and cultural excellence is not one of mere coexistence but of deep mutual constitution: neither pillar can produce sustainable results without the other, and the mechanisms through which they interact define the organization's capacity for continuous improvement. Process discipline provides the structural conditions under which learning becomes possible, while culture determines whether those structures generate genuine reflection or merely formal compliance (Deming, 2000; Shingo Institute, 2025). Understanding this interdependence is essential because it explains why organizations that adopt identical tools and standards often achieve radically different outcomes.

At the most fundamental level, standardized processes create the stable baseline that makes improvement visible and actionable. Without a defined standard, deviations cannot be recognized, root causes cannot be isolated, and learning cycles cannot begin (Womack and

Jones, 2003; Liker, 2004). The PDCA cycle, which lies at the heart of Lean methodology, presupposes the existence of a documented current state against which experiments are designed and results evaluated. In this sense, standardization is not the enemy of creativity but its prerequisite: it is precisely because there is a known method that a better method can be identified, tested, and institutionalized (Liker, 2004). As the Shingo Institute (2025) articulates, "where there is no standard, there can be no improvement," a principle that reveals standards as the connective tissue between process discipline and the organizational capacity for learning.

However, standards without cultural support become inert procedures. Deming (2000) argued that any substantial improvement must come from action on the system, placing responsibility on management rather than on workers' individual compliance. This insight reveals a critical interdependence: process structures define what should be done, but culture determines whether people engage with those structures as living instruments of learning or as bureaucratic obligations to be satisfied. When management designs systems that promote fear, blame, or survival behaviors, even technically excellent processes will fail to generate the reflective engagement that improvement requires (Deming, 2000; Shingo Institute, 2025). Conversely, when cultural conditions foster trust and openness, even imperfect processes become platforms for collective experimentation and knowledge creation.

Psychological safety represents the cultural mechanism through which this interdependence operates at the team level. Edmondson (1999) demonstrated that teams characterized by a shared belief that the environment is safe for interpersonal risk-taking exhibit significantly more learning behaviors, including speaking up about errors, asking questions, and proposing new ideas. In the context of process excellence, this finding has direct implications: the identification of deviations, the reporting of defects at the source, and the honest analysis of root causes all require individuals to expose potential vulnerabilities. Without the cultural condition of psychological safety, process systems designed for problem visibility, such as Andon cords, visual management boards, and daily management meetings, lose their diagnostic power because people withhold the very information that these systems are designed to surface (Edmondson, 1999; Liker, 2004).

Leadership behavior constitutes the primary mechanism through which culture is transmitted into the process environment. The Shingo Institute (2025) positions Respect for Every Individual and Lead with Humility as Cultural Enablers, the foundational dimension upon which the entire improvement architecture rests. This hierarchical positioning is deliberate: it reflects the insight that technical systems for continuous improvement can only function when they are sustained by behaviors rooted in respect, trust, and a genuine willingness to listen. Leaders who practice humility create the conditions under which subordinates contribute their knowledge freely, enabling the tacit insights embedded in daily work to become explicit organizational knowledge (Nonaka, 2007). This conversion of individual tacit knowledge into shared explicit knowledge is precisely the mechanism through which process improvements emerge from the shop floor rather than being imposed from above.

The coaching dimension of leadership further deepens this interdependence. She (2019) demonstrated that managerial coaching operates as a double-edged sword: when practiced authentically, it enhances employees' sense of personal accomplishment and strengthens their commitment to improvement; when misapplied or perceived as controlling, it generates role overload and resistance, reproducing the command-and-control dynamics that Lean philosophy explicitly seeks to overcome. This finding illuminates why the same process routines, such as daily stand-up meetings or structured problem-solving sessions, can produce engagement in one context and disengagement in another. The decisive variable is not the process design itself but the leadership behavior that animates it. Coaching that asks open questions, that genuinely invites challenge, and that treats errors as learning opportunities transforms process routines into reflective conversations; coaching that merely checks compliance transforms the same routines into rituals of control (She, 2019).

From a knowledge-creation perspective, the process–culture interdependence can be understood through Nonaka's (2007) model of organizational knowledge conversion. Lean processes generate a continuous stream of operational data: performance indicators, deviation reports, standardized work observations. But data becomes knowledge only when it is interpreted, discussed, and reframed through social interaction. The morning meeting, the gemba walk, and the A3 problem-solving exercise are not merely process tools; they are knowledge-creation rituals that depend on cultural conditions of trust and intellectual curiosity to function effectively. When culture supports genuine dialogue, these routines enable what Nonaka (2007) describes as the conversion from tacit to explicit knowledge: the experienced operator's intuitive understanding of a recurring defect becomes a documented countermeasure that the entire organization can learn from. When culture suppresses dialogue, the same routines produce only surface-level data exchanges that never reach the depth of shared understanding.

Schön's (1983) concept of reflection-in-action provides an additional lens for understanding this interdependence. Schön argued that competent practitioners know more than they can say, and that professional learning occurs not through the application of codified rules but through cycles of action and reflection embedded in practice. In a Lean environment, this means that the most valuable insights emerge not from adherence to standardized procedures but from the reflective moments when practitioners question, reframe, and adapt those procedures in response to unfamiliar situations. Process discipline creates the structure within which reflection-in-action can occur; culture creates the permission. Without structure, reflection has no anchor; without permission, reflection has no voice (Schön, 1983; Found and Bicheno, 2017).

The Shingo Model formalizes this insight through its three-layer architecture: principles inform ideal behaviors, systems are designed to drive those behaviors, and tools operationalize the systems. The critical linkage between process and culture lies in the second layer: systems must be intentionally designed not only to produce operational results but to reinforce the behaviors that sustain improvement over time. A performance measurement system, for

example, can be designed to reward compliance and penalize deviation (a culturally corrosive approach), or it can be designed to reward experimentation and learning from failure (a culturally generative approach). The technical structure of the system is the domain of process excellence; the behavioral intent embedded in it is the domain of cultural excellence. Neither can be designed independently of the other (Shingo Institute, 2025; PAI, 2022).

Found and Bicheno (2017) reinforce this point by describing Operational Excellence as a convergence in which operations management laws and human resource philosophies must work together to create a framework capable of guiding learning and enabling innovation. This convergence implies that processes are not merely technical workflows but socio-technical systems whose effectiveness depends on the quality of human interaction they enable. A value stream map reveals waste; but the willingness to act on what the map reveals, to challenge established practices, to invest in experimentation rather than defaulting to firefighting, is a cultural choice that leadership must actively cultivate (Found and Bicheno, 2017; Womack and Jones, 2003).

The dynamic capability perspective offered by Teece (2007) adds a temporal dimension to this interdependence. Teece's framework distinguishes between ordinary capabilities, which enable efficiency and replication, and dynamic capabilities, which enable renewal and evolution. In the SOE framework, process discipline constitutes the ordinary capability backbone: it ensures that work is performed reliably and that performance is measurable. Culture, however, is what transforms ordinary capabilities into dynamic ones. The capacity to sense emerging opportunities, to seize them through coordinated action, and to reconfigure routines in response to change all depend on human behaviors, leadership commitment, and organizational trust (Teece, 2007). Without cultural readiness, process reconfiguration becomes a source of resistance rather than renewal; without process stability, cultural aspiration lacks the structural scaffolding to translate intention into action.

Hamel and Välikangas (2003) underscore the organizational consequences of this imbalance. They argue that strategic resilience depends on the capacity to reinvent business models and strategies before circumstances force the organization to do so. This proactive renewal requires what they call "zero trauma" transformation: continuous, evolutionary adaptation rather than convulsive crisis-driven change. In the SOE framework, such resilience can only emerge when process structures are flexible enough to accommodate experimentation and when cultural conditions are robust enough to sustain the psychological demands of continuous change. The pursuit of perfection that Lean advocates (Womack and Jones, 2003) is ultimately a cultural aspiration sustained through process mechanisms: it is the culture that refuses to accept the status quo, and it is the process that provides the disciplined pathway for surpassing it.

Ultimately, the interdependence between process and culture can be expressed as a reciprocal enabling relationship. Process excellence without cultural maturity produces compliance without understanding: people follow standards but do not improve them. Cultural aspiration without process discipline produces enthusiasm without consistency: people want to improve but lack the structured mechanisms to do so effectively (Deming, 2000; Shingo Institute, 2025).

SOE emerges only when both dimensions operate in synchrony, each reinforcing the other in a continuous cycle of standardization, reflection, and renewal. Chapter 4 will further articulate the theoretical frameworks, including the Shingo Model, EFQM and Baldrige systems, and Dynamic Capabilities Theory, that explain the mechanisms through which this synchrony can be designed, assessed, and sustained over time. The Table below synthesizes these mechanisms (Table 5).

*Table 5 Interdependence mechanism between Process and Culture*

| Layer | Process Dimension | Interdependence Mechanism | Culture Dimension |
|---|---|---|---|
| Foundation (Standardization as Learning Baseline) | Process standardization and coherent operational routines provide a stable baseline for learning and experimentation, making capability microfoundations operationally realizable in day-to-day work. | Standardization creates the foundation for meaningful data collection; coherence among routines and engagement enables learning-through-action to work consistently over time. | Culture acts as the behavioral backbone that makes interpersonal risk-taking and continuous improvement feasible over time. |
| Visibility (Problem Surfacing Systems) | A predictable operational rhythm (e.g., morning meetings, visual boards, action tracking) makes issues observable and manageable. | Increased visibility (e.g., dashboards) supports feedback and recognition practices; when digitalization outpaces cultural adaptation, confusion and resistance emerge. | Respect and humility create psychological safety (as described by Edmondson), enabling honest problem reporting and improvement dialogue. |
| Leadership (Coaching as Behavioral Bridge) | Structured management routines provide the structural backbone for learning-through-action, with leaders translating data insights into improvement actions through daily/weekly discussions. | Leaders are expected to coach operational problem-solving and shape the cultural conditions under which improvement can thrive; coaching can either empower or constrain depending on how it is applied. | Cultural norms determine whether managerial coaching empowers or constrains people's autonomy and learning climate. |
| Knowledge (Tacit-to-Explicit Conversion) | Daily/weekly discussions translate data insights into improvement actions, supporting the operational realization of capability micro foundations in day-to-day work. | Cultural openness encourages experimentation so that process innovations can emerge organically, while trust sustains continuous improvement conversations and active contribution to analysis/problem-solving. | A trust-based environment sustains continuous improvement conversations even under pressure, with operators contributing to analysis and problem-solving (not merely executing). |
| Reflection (Learning-in-Action) | A reflective loop embedded in the PDCA cycle and the principle–system–behavior model anchors structured reflection and learning in daily work. | Reflection becomes an operational learning cycle: teams improve standards through daily problem-solving and leaders reflect on how systems and | Trust and psychological safety enable continuous improvement conversations and participation in analysis |

| | | | |
|---|---|---|---|
| | | behaviors reinforce or inhibit improvement. | even under performance pressure. |
| Renewal (Dynamic Capability for Adaptation) | Process and system capabilities enable reconfiguring and institutionalizing successful adaptations, making dynamic capability micro foundations operationally realizable in day-to-day work. | Sensing detects and interprets weak signals; seizing (culture/leadership) transforms insights into decisions and action; reconfiguring (process/systems) institutionalizes successful adaptations. | Cultural and leadership capabilities enable seizing—decisions that transform insights into action—and support experimentation through openness and trust. |

### 3.5.2 Culture-Digital Interdependence

The culture pillar becomes even more critical when organizations pursue digitalization, because digital systems increase visibility and measurement while simultaneously raising the interpersonal stakes of errors, delays, and deviations that become more transparent (Edmondson, 1999; Sanders et al., 2016). Edmondson's model predicts that if individuals expect embarrassment, rejection, or punishment for speaking up, they will withhold information, avoid discussing errors, and reduce experimentation—even when digital systems make such issues objectively more observable (Edmondson, 1999). Therefore, culture moderates whether digital transparency becomes an accelerator of learning or a driver of defensive behavior that suppresses learning behaviors such as feedback seeking and talking about errors (Edmondson, 1999).

Romero and colleagues (Romero et al., 2016) explicitly frame Industry 4.0 as a transformation in operator–machine interaction and workforce design, emphasizing that the Factories of the Future require a "human-centricity" that enables a shift toward "human-automation symbiosis" (human cyber-physical systems) designed "not to replace the skills and abilities of humans, but rather to co-exist with and assist humans" (Romero et al., 2016). This human-centric stance is operationalized via the concept of Human Cyber-Physical Systems (H-CPS), defined as systems engineered to improve humans' ability to dynamically interact with machines through "intelligent" interfaces designed to fit operators' cognitive and physical needs and to enhance human physical, sensing, and cognitive capabilities through enriched technologies such as wearable devices (Romero et al., 2016). In this view, digital excellence is inseparable from cultural design because the operator's willingness to engage with new interfaces, disclose uncertainties, and rely on adaptive support depends on whether the socio-technical system is experienced as enabling rather than punitive (Romero et al., 2016; Edmondson, 1999).

The Operator 4.0 concept also makes the culture–digital link explicit by positioning human-centricity as necessary for performance in increasingly dynamic environments that demand flexibility and adaptability (Romero et al., 2016). Romero et al. (2016) note that upgraded shop floors "call for cognitive aids" such as augmented reality technologies or intelligent human–

machine interfaces to support the increased cognitive workload of diagnosis, situational awareness, decision-making, and planning. Yet, cognitive aids do not eliminate the need for interpersonal learning behaviors; rather, they shift the content of learning from manual execution to higher-level judgment, coordination, and problem framing, which still requires teams to ask for help, share information, and discuss errors openly (Romero et al., 2016; Edmondson, 1999).

A critical cultural risk in digitalization is treating data visibility as a substitute for the relational work of learning, because data can intensify evaluation pressures and thereby increase the perceived interpersonal risk of admitting uncertainty or mistakes (Edmondson, 1999; Sanders et al., 2016). Edmondson's definition clarifies that psychological safety is specifically about the expected interpersonal consequences of speaking up, and she argues that psychological safety alleviates excessive concern about others' reactions to potentially embarrassing actions such as admitting error or asking for help (Edmondson, 1999). Consequently, human-centric digital systems should be coupled with leadership practices that signal that data are used for learning and improvement rather than for blame, thereby protecting the learning behaviors that mediate performance (Edmondson, 1999).

The managerial coaching literature reinforces this coupling challenge because digital tools often increase the frequency and granularity of feedback opportunities, potentially expanding coaching interactions while also increasing managerial workload and role overload (She, 2019; Sanders et al., 2016). She's evidence (She, 2019) that coaching can heighten managers' role overload and lead to work fatigue implies that digital feedback systems must be designed with attention to resource constraints, or they risk creating an improvement infrastructure that is not sustainable for those expected to lead it. Her findings further show that perceived organizational support conditions whether coaching is more beneficial or more burdensome, suggesting that organizations should provide supportive systems (time, recognition, resources) when digital transparency increases the demand for coaching and sensemaking (She, 2019).

Nonaka's knowledge spiral provides a second lens for culture–digital interdependence by clarifying how digital artifacts can support some knowledge conversions while potentially undermining others if deployed as purely information-processing mechanisms (Nonaka, 2007). Nonaka (2007) explicitly cautions against equating knowledge creation with "processing" objective information, arguing instead that knowledge creation depends on tapping tacit insights and making them available for testing and use by the company as a whole. Digital dashboards and analytics can strengthen the "combination" of explicit knowledge by synthesizing information from across the organization, but Nonaka (2007) argues that combination alone does not necessarily extend the organization's knowledge base without interaction with tacit knowledge and personal commitment. Moreover, Nonaka's emphasis on redundancy and frequent dialogue implies that digitalization should not reduce the interpersonal communication channels through which teams build common cognitive ground and transfer tacit know-how (Nonaka, 2007).

Sanders and colleagues (Sanders et al., 2016) describe Industry 4.0 as a CPS-based revolution with enhanced human–machine interaction paradigms, and they highlight that smart devices "acquire real time data," execute routine tasks, and represent data visually, while production workers provide immediate feedback about production conditions via real-time data through smartphones and tablets (Sanders et al., 2016). This capability can enlarge the space of learning behaviors by lowering the friction of feedback and enabling more rapid detection of abnormal conditions, but it also changes the "psychological contract" of shop-floor work by increasing the immediacy of exposure to performance signals (Sanders et al., 2016; Edmondson, 1999). Sanders et al. (2016) also note that monotonous activities are automated, shifting the nature of work toward calibration, data processing, and other non-repetitive tasks, which implies a cultural and capability shift toward higher cognitive involvement and learning at the point of work.

At the same time, digital transformation is constrained by investment and adoption dynamics that are fundamentally social and managerial, not only technical (Sanders et al., 2016). Sanders et al. (2016) state that executing Industry 4.0 is "cost-intensive" and "met with reluctance," and they note that not all SMEs are enthusiastic to pursue Industry 4.0 because the question of whether it is worth the effort remains salient. Under these conditions, a learning-oriented culture becomes a prerequisite for digital excellence because organizations must be able to experiment, learn, and revise their approach without triggering blame cycles that would intensify reluctance and reduce willingness to invest in uncertain innovation paths (Edmondson, 1999; She, 2019).

Finally, the culture–digital coupling reiterates the centrality of people and front-line management in sustaining performance excellence even "in this era of technology," because technology adoption does not automatically translate into performance without the human systems that interpret, act on, and improve based on what the technology makes visible (PAI, 2022). Proaction International's claim that organizations often focus primarily on processes and technology, while "people drive performance," underscores that digital excellence must be enacted through managerial behaviors that support teams in using new digital information for learning rather than for fear-driven compliance (PAI, 2022). In SOE terms, Operator 4.0 human-centricity, psychological safety, and sustainable coaching capacity become inseparable design requirements for deploying digital systems that genuinely amplify organizational learning rather than merely increasing measurement (Romero et al., 2016; Edmondson, 1999; She, 2019).

The key interdependence mechanisms through which culture shapes and is shaped by digitalization are summarized in Table 6.

*Table 6 Interdependence mechanism between Culture and Digitalization*

| Layer | Cultural Dimension | Interdependence Mechanism | Digital Dimension |
|---|---|---|---|
| Psychological climate | Psychological safety: "shared belief that the team is safe for interpersonal risk taking" | Digital visibility either accelerates or suppresses learning depending on whether errors are met with blame or inquiry | Real-time data transparency via smart devices, dashboards, and IoT sensors |
| Human-machine design | Human-centricity: operators as active agents, not passive users of technology | H-CPS and Adaptive Automation designed to augment, not replace, human cognitive and physical capabilities | Operator 4.0: wearables, AR interfaces, intelligent human–machine interaction, cognitive aids |
| Coaching & feedback | Coaching as "double-edged sword": drives accomplishment but risks role overload and fatigue | Digital tools increase feedback frequency and coaching demand; sustainability depends on perceived organizational support | Digital-mediated feedback: smartphones/tablets for real-time production data and performance signals |
| Knowledge conversion | SECI spiral: tacit knowledge requires dialogue, redundancy, and personal commitment | Digital dashboards strengthen combination (explicit→explicit) but cannot substitute for socialization (tacit→tacit) requiring face-to-face dialogue | Analytics and data combination tools; risk of over-digitalization reducing interpersonal communication channels |
| Skills & readiness | Learning-oriented culture: willingness to experiment and revise without blame cycles | Skill gaps and resistance to change act as cultural barriers to digital adoption; culture must enable experimentation under uncertainty | I4.0 adoption is "cost-intensive" and "met with reluctance" especially in SMEs |
| Management systems | "People drive performance" even in the era of technology | Front-line managers must use digital information for learning, not fear-driven compliance; coaching capacity is a system design issue | Technology adoption does not automatically translate into performance without human systems that interpret and improve |

### 3.5.3 Process-Digital Interdependence

Process excellence depends on the ability to detect deviations quickly, coordinate responses across functions, and update decisions as conditions change (Sanders et al., 2016). In this sense, digitalization does not simply “add data”; it changes the temporal logic of operations by moving from forecast-driven planning to real-time, dynamically optimized planning (Sanders et al., 2016). Sanders et al. (2016) describe this shift explicitly, noting that Industry 4.0 enables “real-time planning of production plans, along with dynamic self-optimization,” in contrast to conventional forecast-based planning. For SOE, this matters because improvement routines (problem identification, hypothesis testing, countermeasure implementation) are constrained when the organization receives feedback late or in low resolution; digital infrastructures can

compress that feedback loop by producing higher-frequency signals about flow, quality, and equipment health (Sanders et al., 2016).

A first coupling point between digital and process pillars concerns material flow and production control (Sanders et al., 2016). Sanders et al. (2016) report that RFID-based Industry 4.0 solutions "help to eliminate errors associated with inventory by real-time exact tracking of inventory." More specifically, Sanders et al. (2016) explain that when real inventory and value in the manufacturing execution system match, "faults in production control can be avoided due to lost kanban," and that wireless information and communication systems can track "status, number and location of material batches" using RFID tags. Mechanistically, this means that pull logic becomes less dependent on manual signaling fidelity: the "signal" of consumption can be digitized, time-stamped, and reconciled against system records, reducing the operational noise that typically accumulates between the physical shop floor and planning systems (Sanders et al., 2016).

A second coupling point concerns equipment reliability and maintenance as a prerequisite for stable processes (Sanders et al., 2016). In Sanders et al.'s (2016) depiction of a smart factory, machines interconnected with information and communication systems can send "error notifications to respective shop-floor and maintenance personnel" when breakdowns occur. When this notification layer is combined with "advanced analytics and big data," machines can become "self-aware and self-maintained," while analytics can compute "meaningful trends and relationships from the available data" to support process-workflow management (Sanders et al., 2016). For operational excellence, the significance is that process stability can be protected not only by reactive maintenance but by earlier detection, faster escalation, and better prioritization of interventions, which reduces the duration and propagation of abnormal conditions across downstream processes (Sanders et al., 2016).

A third coupling point is the transformation of shop-floor work and feedback channels (Sanders et al., 2016). Sanders et al. (2016) observe that production workers can provide "immediate feedback of production conditions via real time data through their own smart phones and tablets." Sanders et al. (2016) also note that smart devices can acquire real-time data, execute routine tasks autonomously, and represent information as figures and graphs. Crucially, Sanders et al. (2016) argue that "smart feedback devices, worker support systems and improved man-machine interface facilitates better empowerment and involvement of employees," and that handheld smart devices can support managerial allocation of workers to operations. This is not a purely technical enhancement: it is a process-design choice about where decisions are made (centrally vs. locally), how fast information travels, and which roles are authorized to act on signals (Sanders et al., 2016). Moreover, Sanders et al. (2016) note that automation shifts "monotonous and non-skilled activities" away from humans and toward training for "calibration, data processing and other such non-repetitive tasks," implying that process excellence increasingly depends on cognitive and analytical work performed close to operations.

The Operator 4.0 perspective clarifies why this interdependence must be designed as a human-centered system rather than as a technology overlay (Romero et al., 2016). Romero et al. (2016) argue that Industry 4.0 "enables new types of interactions between operators and machines" and transforms the workforce to handle increased production variability. Romero et al. (2016) emphasize human-centricity and a paradigm shift toward "human-automation symbiosis," where systems are "designed not to replace the skills and abilities of humans, but rather to co-exist with and assist humans." Romero et al. (2016) define Human Cyber-Physical Systems (H-CPS) as engineered systems that improve operators' ability to dynamically interact with machines through "intelligent human-machine interfaces" fitted to cognitive and physical needs, and that enhance physical, sensing, and cognitive capabilities via enriched technologies such as wearables. In parallel, Adaptive Automation aims to optimize human–machine cooperation by allocating cognitive and physical labor between humans and automation within adaptive production systems (Romero et al., 2016). From an SOE standpoint, the implication is that digital tools strengthen process excellence only when they (i) make process conditions more observable in real time (Sanders et al., 2016), (ii) translate signals into actionable decision support for the people responsible for the process (Sanders et al., 2016; Romero et al., 2016), and (iii) dynamically allocate tasks and control to leverage human skills without eroding responsibility or situational awareness (Romero et al., 2016).

Finally, the process–digital interdependence is constrained by the economics and feasibility of adoption (Sanders et al., 2016). Sanders et al. (2016) explicitly note that executing Industry 4.0 is "cost-intensive" and can be met with "reluctance" from manufacturers, while the required investment is "quite intensive." This reinforces the need to treat digitalization as a pillar of excellence only when it strengthens the organization's capability to run and improve processes, not as an end in itself (Sanders et al., 2016). The key interdependence mechanisms through which process excellence and digitalization mutually condition one another are summarized in Table 7.

*Table 7 Interdependence mechanism between Process and Digitalization*

| Layer | Process Dimension | Interdependence Mechanism | Digital Dimension |
|---|---|---|---|
| Material flow & production control | Pull logic, kanban signalling, inventory accuracy, takt adherence | The consumption signal is digitized, time-stamped, and reconciled against system records; pull logic becomes less dependent on manual signaling fidelity (Sanders et al., 2016). IoT serves as the data backbone and CPS as the adaptive control layer, with CPS responsiveness fully mediating the relationship between IoT integration and lean | RFID tracking, e-kanban, MES integration, IoT sensing, CPS real-time control |

| | | | |
|---|---|---|---|
| | | efficiency outcomes. (Habibullah & Hossain, 2021) | |
| Equipment reliability & maintenance | Process stability, TPM, reduction of anomaly propagation to downstream processes | Interconnected machines send automatic error notifications; with analytics and big data they become self-aware and self-maintained, anticipating failures before they occur (Sanders et al., 2016). Digital twins create real-time synchronized virtual replicas for condition monitoring, anomaly detection, and predictive maintenance scheduling (Liu et al., 2023) | Predictive maintenance, big data analytics, digital twin, sensor networks, ERP integration |
| Shop-floor work & feedback channels | Operator empowerment, standard work, real-time feedback,labour allocation | Workers provide immediate feedback via smart devices; intelligent devices autonomously execute routine tasks and represent data as figures and graphs; automation redirects monotonous activities toward cognitive and analytical tasks . | Smart phones/tablets, worker support systems, improved HMI, CPS-assisted workforce allocation |
| Human-centered system design | Situational awareness, skill development, dynamic task allocation, continuous improvement | The Operator 4.0 operates in human-automation symbiosis: H-CPS enhance the operator's physical, sensorial, and cognitive capabilities through intelligent interfaces; Adaptive Automation dynamically allocates control between human and machine while preserving responsibility and situational awareness. | H-CPS, Adaptive Automation, wearable devices, intelligent HMI, HITL control systems |
| Adoption feasibility & constraints | Economic sustainability of investment, skills availability, scalability for SMEs | Industry 4.0 implementation is cost-intensive and met with reluctance; 55 distinct managerial challenges identified include financial resources, skill gaps, data management, and security (Sanders et al., 2016; Bajic et al., 2020). Digitalization should be treated as an | Investment planning, workforce upskilling, data governance, cybersecurity, standardization |

| | | | |
|---|---|---|---|
| | | excellence pillar only when it strengthens the organization's capability to run and improve processes. | |

### 3.5.4 The Triadic Equilibrium

The three interdependences examined in the preceding sections, between process and culture (3.5.1), culture and digitalization (3.5.2), and process and digitalization (3.5.3), are not simply bilateral relationships that happen to coexist. They form a triadic system in which each pillar simultaneously conditions and is conditioned by the other two, producing a dynamic equilibrium that is qualitatively different from what any pair of pillars could generate in isolation (Found et al., 2018; Shingo Institute, 2025; Teece, 2007). SOE emerges from this equilibrium not as the sum of three separate contributions but as a systemic property that only arises when all three pillars are mutually aligned and continuously reinforcing one another.

The internal logic of this equilibrium rests on three complementary functions that the pillars perform together. Process discipline provides the structural backbone: standardized routines make work observable, deviations detectable, and improvement cycles repeatable, establishing the operational reality against which learning can occur (Shingo Institute, 2025; Deming, 2000). Culture provides the behavioral energy: the shared beliefs, psychological safety, and leadership behaviors that determine whether the information produced by process and digital systems is used for genuine inquiry or for defensive compliance (Edmondson, 1999; She, 2019). Digitalization provides the cognitive amplification: by extending sensing, shortening feedback loops, and making previously invisible signals legible at the point of work, it increases the frequency and resolution at which the organization can learn from operational reality (Sanders et al., 2016; Romero et al., 2016). When these three functions operate in synchrony, improvement becomes a continuous organizational rhythm rather than an episodic initiative.

The equilibrium is triadic rather than merely additive because each pillar depends on the other two to fulfill its function. Process discipline without cultural support produces standards that are technically correct but behaviorally inert: people comply with procedures without developing the reflective understanding that enables them to improve those procedures, generating the compliance-without-learning pattern that Deming (2000) identified as the inevitable consequence of managing through fear and exhortation rather than through system design. Process discipline without digital amplification leaves deviations detectable only at low frequency and high latency, reducing the speed of improvement cycles and the resolution at which root causes can be identified (Sanders et al., 2016). Conversely, cultural aspiration without process structure produces enthusiasm without consistency: teams want to improve but lack the stable baselines that make experiments interpretable and learning cumulative (Womack and Jones, 2003; Liker, 2004). Culture without digital capability risks remaining confined to the tacit, relational layer of knowledge, unable to amplify individual insights into organizational learning at scale (Nonaka, 2007). Digital infrastructure without process

discipline produces data abundance without operational meaning: dashboards visualize variance, but without standardized processes and improvement routines, those signals have no normative reference against which to be interpreted or acted upon (Shingo Institute, 2025; PAI, 2022). Digital infrastructure without cultural readiness triggers the defensive behavioral dynamic that Edmondson (1999) identifies as the suppression of learning: when data visibility is not coupled with psychological safety, individuals conceal rather than surface the very anomalies that the technology was deployed to detect.

This mutual dependency implies that the triadic equilibrium is inherently fragile when any one pillar is consistently underdeveloped. PAI (2022) identifies this fragility concretely in the measurement architecture of organizational performance: organizations that track Key Financial Indicators and Key Performance Indicators without developing Key Knowledge Indicators and Key Behavior Indicators are likely to achieve short-term visibility while failing to generate the behavioral change that sustains results. The same logic applies across all three pillars: an organization that invests primarily in digital tools while neglecting process maturity and cultural readiness will generate information that is neither structurally anchored nor behaviorally used, producing precisely the "visibility machines without behavioral follow-through" pattern that the Shingo Institute (2025) describes as the organizational consequence of tool-centric deployment disconnected from guiding principles.

The stability of the triadic equilibrium also has a temporal dimension that the dynamic capabilities framework helps to clarify. Teece (2007) distinguishes between ordinary capabilities, which sustain efficient execution of existing routines, and dynamic capabilities, which enable sensing, seizing, and reconfiguring in response to changing conditions. In the SOE framework, process discipline constitutes the ordinary capability backbone: it ensures reliability, measurability, and operational predictability. Culture and digitalization together constitute the dynamic capability layer: culture provides the trust and leadership behaviors through which the organization can sense weak signals, seize improvement opportunities, and reconfigure routines without generating the resistance that typically accompanies forced change; digitalization provides the sensing infrastructure and feedback architecture that makes those opportunities detectable and their effects traceable over time (Teece, 2007; Romero et al., 2016). Hamel and Välikangas (2003) reinforce this temporal logic by arguing that resilience depends not on responding to crises but on continuously anticipating and adjusting to deep structural shifts, a capacity that requires precisely the triadic alignment described here: the process stability to make change manageable, the cultural openness to make change welcome, and the digital intelligence to make change legible.

The Shingo Model expresses the architecture of this equilibrium through its principle–system–behavior logic: principles define what ideal performance looks like, systems are intentionally designed to reinforce the behaviors that produce it, and tools are selected to operationalize those systems within daily work. Within the triadic equilibrium, this hierarchy maps directly onto the three pillars. Culture operates at the level of principles and behaviors: it constitutes the shared understanding of why improvement matters and the interpersonal conditions under

which improvement-relevant behaviors are enacted consistently (Shingo Institute, 2025; Edmondson, 1999). Process operates at the level of systems: it provides the structured routines, standardized baselines, and improvement cycles through which behavioral intentions are translated into measurable operational outcomes (Deming, 2000; Womack and Jones, 2003). Digitalization operates at the level of tools, extended into a socio-technical layer: it makes systems more responsive, signals more immediate, and learning more distributed, provided that its deployment is governed by the principles and behaviors that the culture sustains (Sanders et al., 2016; Romero et al., 2016). The critical insight is that this hierarchy is not a sequence but a cycle: tools that are well-designed reinforce the systems they serve, systems that are well-aligned reinforce the behaviors they target, and behaviors that are consistently enacted over time constitute and renew the principles that guide the organization's improvement identity (Shingo Institute, 2025; Found and Bicheno, 2017).

From a knowledge-creation perspective, the triadic equilibrium is also the organizational mechanism through which tacit knowledge is converted into explicit, institutionalized learning at scale. Nonaka (2007) argues that knowledge creation depends on the continuous interaction between the tacit insights of individuals and the explicit knowledge structures of the organization, a process that requires both social interaction and systematic codification. In the SOE framework, culture provides the dialogic conditions for this conversion: psychological safety enables practitioners to surface and share the tacit knowledge embedded in daily work, while coaching and leadership behaviors ensure that this knowledge is taken seriously rather than filtered by hierarchy (Nonaka, 2007; She, 2019). Process provides the codification mechanism: standard work, A3 problem-solving, and visual management translate individual insights into organizational standards that persist beyond the individuals who generated them (Liker, 2004; Shingo Institute, 2025). Digitalization extends the reach and speed of this conversion: real-time data and connected feedback systems make tacit signals from the shop floor immediately visible to the broader organization, while analytics and knowledge management platforms enable the combination and diffusion of explicit knowledge across functions and levels (Sanders et al., 2016; Nonaka, 2007).

The synthesis of these interdependences suggests that the SOE equilibrium is not a static configuration to be achieved once and maintained but a dynamic alignment that must be actively managed over time. Found et al. (2018) describe Operational Excellence as a convergence of Operations Management and Human Resource philosophies, a framing that is fully consistent with the triadic architecture developed in this chapter: technical rigor, human development, and digital intelligence are not competing priorities but interdependent dimensions of a single organizational capability. The organization that sustains this equilibrium does not choose between being disciplined and being adaptive, between being data-driven and being human-centered, or between being standardized and being innovative. It develops the systemic coherence to be all of these simultaneously, because it understands that each quality depends on and reinforces the others.

Figure 7 illustrates this synthesis: the three pillars are represented not as sequential stages or independent workstreams but as mutually reinforcing vertices of an ongoing dynamic equilibrium, connected by the interdependence mechanisms analyzed in sections 3.5.1 through 3.5.3. The figure captures the central thesis of this chapter SOE is not the outcome of any single pillar but the emergent property of their continuous alignment. The organization becomes simultaneously machine and organism, structured yet alive, disciplined yet creative, data-driven yet human-centered, and it is precisely this capacity for integration that constitutes the deepest form of operational resilience.




*Figure 7 The three pillars of SOE: process, culture, and digitalization*

# Chapter 4 Conceptual Models and Theoretical Integration

## 4.1 Introduction: From Pillars to Theoretical Integration

Chapter 3 demonstrated that Sustainable Operational Excellence cannot be reduced to any single pillar. Process discipline, cultural maturity, and digital capability are mutually constituting dimensions of a unified improvement system: each pillar depends on the other two to fulfill its function, and their interaction produces a triadic equilibrium that none could generate independently. This conclusion, however, raises a further question that the pillar analysis alone cannot answer: what theoretical mechanisms explain why this equilibrium produces sustainable performance, and how it can be deliberately designed, assessed, and renewed over time?

This is the question Chapter 4 addresses. It does not revisit the three pillars in themselves but examines the theoretical frameworks through which their integration can be understood as a coherent, enduring system. Three bodies of thought are brought into dialogue for this purpose: the Shingo Model, the EFQM and Baldrige Frameworks, and Dynamic Capabilities Theory. Each framework contributes a distinct explanatory dimension that the others cannot provide alone, and their integration produces a conceptual model of Sustainable Operational Excellence that is at once principled, systemic, and adaptive.

The need for such theoretical integration is not merely academic. Found et al. (2018) demonstrated through a systematic literature review that, despite the widespread use of the term Operational Excellence, there is currently no single unifying theory that meets the criteria for a rigorous theoretical framework. The literature has identified common practices and regularities, but these remain fragmented across different methodologies, sectors, and conceptual traditions, without a mechanism that unifies them into predictable, teachable, and testable propositions (Found et al., 2018). The consequence, as Found et al. (2018) note, is that organizations repeatedly implement improvement initiatives that generate temporary results but fail to sustain performance, precisely because the tools they deploy are not anchored in principles, nor embedded in systems designed to reinforce the behaviors that produce lasting change (Found et al., 2018; Shingo Institute, 2025).

The Shingo Model provides the first theoretical anchor by addressing the moral and behavioral dimension of sustainability. It establishes that results are not the direct product of tools or techniques, but of the principles that govern behavior and the systems designed to reinforce ideal conduct (Shingo Institute, 2025). As Found et al. (2018) explain in synthesizing the Shingo logic, excellence understood this way involves five key paradigm shifts: focusing on behaviors and results, recognizing that behaviors flow from governing principles, understanding that principle-based cultures sustain results long-term, requiring alignment of the management system to create such cultures, and treating all improvement tools as strategic enablers rather than ends in themselves. In this sense, the Shingo Model provides the why of the triadic equilibrium: it explains the behavioral preconditions without which process structures and digital systems remain operationally inert (Shingo Institute, 2025; Found et al., 2018).

The EFQM and Baldrige Frameworks provide the second theoretical anchor by addressing the systemic and governance dimension of sustainability. Where Shingo explains what principles must guide behavior, EFQM and Baldrige explain how those principles can be institutionalized into structured management systems that are deployable, assessable, and continuously improvable across the whole organization (EFQM, 2020; Baldrige Performance Excellence Program, 2019). Found et al. (2018) describe the kind of model that addresses the recognized gap in OpEx theory as one focused on "the alignment of vision to deliver results," underpinned by a culture and mindset of improvement, driven by strategy and leadership, with two continuous improvement feedback loops connecting strategy and goals to leadership and change. EFQM and Baldrige operationalize exactly this architecture: they supply the how of the triadic equilibrium, the governance mechanisms through which behavioral principles are translated into organizational routines that can be measured, reviewed, and refined (EFQM, 2020; Baldrige Performance Excellence Program, 2019).

Dynamic Capabilities Theory provides the third theoretical anchor by addressing the temporal and adaptive dimension of sustainability. Operational excellence is not a steady state to be achieved and preserved but a moving equilibrium that must be continuously renewed as competitive, technological, and organizational conditions change (Teece, 2007). As Found & Bicheno (2017) observe, drawing on the broader Lean and OpEx tradition, it is the repeated daily

practice of structured improvement cycles, carried out by thinking people who develop their capabilities through doing, that builds organizational performance over time, not the one-time installation of a system. Dynamic Capabilities Theory formalizes this temporal logic by explaining the organizational mechanisms through which an enterprise senses emerging opportunities and threats, seizes them through coordinated action, and reconfigures its resources and routines accordingly (Teece, 2007). This provides the when of the triadic equilibrium: it explains how the alignment between process, culture, and digitalization is not only achieved but continuously regenerated (Teece, 2007; Hamel & Vlikangas, 2003).

Together, these three frameworks form an integrated theoretical architecture that explains Sustainable Operational Excellence across three dimensions: behavioral depth (Shingo), systemic breadth (EFQM/Baldrige), and adaptive continuity (Dynamic Capabilities). The chapter develops this integration through four steps: Section 4.2 examines the Shingo Model and its principle-behavior-result logic; Section 4.3 analyzes EFQM and Baldrige as governance systems for systemic alignment; Section 4.4 explores Dynamic Capabilities Theory as the mechanism of temporal renewal; and Section 4.5 synthesizes these perspectives into a unified conceptual model that connects theoretical constructs with the empirical patterns observed during the internship.

The objective is to demonstrate that excellence, when sustained over time, emerges not from the accumulation of tools or certifications but from the coherence among principles, structures, and learning mechanisms (Found et al., 2018; Shingo Institute, 2025; Teece, 2007). Each framework analyzed in this chapter represents a different expression of the same underlying logic: that sustainable excellence is a self-reinforcing system that learns, adapts, and endures by continuously realigning what the organization believes, how it is designed, and how it renews itself.

## 4.2 The Shingo Model: Principles, Systems, and Behavior

The Shingo Model occupies a foundational position in the theoretical architecture of this chapter because it addresses a problem that process frameworks and digital tools alone cannot solve: the gap between knowing what to do and actually doing it, consistently, across the entire organization. As the Shingo Institute (2025) states, sustainable results depend not on the sophistication of the tools an organization deploys, but on the degree to which its culture is aligned to specific guiding principles. This alignment is the precondition for every other element of SOE to function as intended.

The Model is structured around three conceptual layers that stand in a precise causal relationship. At the outermost layer are tools and systems, the operational instruments through which work is performed and managed. At the intermediate layer are behaviors, the aggregate of how every individual in the organization actually acts. At the core are principles, which the Shingo Institute (2025) defines as foundational rules that govern consequences: the more deeply one understands principles, the more clearly one understands ideal behavior, and the better one can design systems to drive that behavior toward ideal results. The critical insight is

directional: principles do not follow from results; rather, results follow from behaviors, and behaviors follow from principles. Organizations that focus exclusively on results, managing only by KPIs, are therefore managing lagging indicators, symptoms rather than causes. Sustainable performance requires attending to the leading indicators of culture: what the Shingo Institute (2025) calls Key Behavioral Indicators (KBIs), which measure the degree to which principle-aligned behaviors are actually present in daily work.

This logic is organized through ten Guiding Principles, grouped in three dimensions. The first dimension, Cultural Enablers, encompasses Respect Every Individual and Lead with Humility. These are foundational precisely because they concern the conditions under which people will engage their full cognitive and creative capacity, rather than merely complying with instructions. The Shingo Institute (2025) states that when people feel genuinely respected, they give far more than their hands; they give their minds and hearts as well. Humility is framed as an enabling principle that precedes learning and improvement: a leader's willingness to seek input, listen carefully, and continuously learn creates an environment where team members feel respected and energized and will give freely of their creative abilities. This behavioral dynamic connects directly to Edmondson's (1999) empirical finding that psychological safety, defined as a shared belief that the team is safe for interpersonal risk-taking, is a necessary condition for learning behavior in teams, including the feedback-seeking, error-discussion, and experimentation that continuous improvement requires. Without the cultural foundation that Respect and Humility generate, the behavioral preconditions for learning are absent, and process tools operate in a compliance mode rather than a learning mode.

The second dimension, Continuous Improvement, includes the principles of Seek Perfection, Embrace Scientific Thinking, Focus on Process, Assure Quality at the Source, and Improve Flow and Pull. These principles reflect the understanding that all outcomes are the consequence of a process, and that it is nearly impossible for even good people to consistently produce ideal results with poor processes (Shingo Institute, 2025). The principle of scientific thinking is particularly relevant here: innovation and improvement are the consequence of repeated cycles of experimentation, direct observation, and learning. This frames PDCA not as a bureaucratic procedure but as a behavioral disposition, the habit of treating every deviation from standard as an opportunity to understand reality more precisely. The principle of flow integrates with this: waste is anything that disrupts the continuous flow of value to customers, and its elimination is driven by the same scientific orientation applied to value streams.

The third dimension, Enterprise Alignment, encompasses Think Systemically, Create Constancy of Purpose, and Create Value for the Customer. These principles address the organizational architecture through which individual behaviors are coordinated toward shared ends. The Shingo Institute (2025) emphasizes that an unwavering understanding of why the organization exists, where it is going, and how it will get there enables people to align their actions and to innovate, adapt, and take risks with greater confidence. Policy deployment, standard daily management, and visual measurement systems are the operational expressions of these principles: they make purpose visible, translate strategy into daily behavior, and

provide the feedback loops through which the organization learns whether its actions are moving it toward or away from its goals.

A crucial implication of the Shingo Model for SOE concerns the role of management systems in driving behavior. The Shingo Institute (2025) identifies three types of systems: management systems, which focus on leading the organization and developing system leaders; improvement systems, which focus on making the organization better; and work systems, which focus on improving workflows. The primary role of managers, in this framing, is not firefighting but designing, aligning, and improving these systems so that they make it easier for people to do the right thing. This managerial function corresponds closely to what PAI (2022) describes as the behavioral dimension of management maturity: the transition from reactive task-issuance to proactive management, in which managers identify recurring performance variances and eliminate their root causes. PAI (2022) further documents that 62% of managers have a weak understanding of their roles and responsibilities in this regard, which means that the gap between the Shingo Model's ideal and organizational reality is not primarily a gap in process design but a gap in managerial behavior, measurable through KBIs rather than KPIs.

This distinction between KBIs and KPIs also illuminates a risk that the Shingo Institute (2025) identifies explicitly: organizations that focus only on KPIs are focused on the short term and tend to fight fires to produce temporary results. A principle-based culture, by contrast, focuses on both KPIs and KBIs, understanding that improved KPIs are the downstream consequence of improved KBIs. The implication is that sustainable performance improvement requires a measurement architecture that reaches upstream of results into behaviors, and upstream of behaviors into the systems and principles that drive them.

The double-edged dynamic identified by She (2019) adds an important boundary condition to this picture. Managerial coaching, one of the primary behavioral mechanisms through which Cultural Enablers principles are enacted in practice, is not without costs for the managers who perform it. She (2019) shows that coaching increases managers' sense of personal accomplishment via resource gain, but also increases role overload via resource depletion, with perceived organizational support moderating both pathways. This means that the Shingo Model's Cultural Enablers dimension cannot be sustained by individual managerial effort alone: it requires organizational systems that recognize and support coaching as a valued behavior, not merely an informal practice. The principle of Lead with Humility thus has an organizational as well as an individual expression: it requires that the organization itself demonstrate humility toward its managers by acknowledging their constraints and providing the resources their coaching role demands.

Taken together, the Shingo Model provides SOE with a behavioral theory of sustainability. It explains why organizations with well-designed processes and advanced digital tools can still fail to sustain improvement: the gap is not technical but behavioral, and behavioral change requires principle-aligned systems, not just training or tool deployment. As PAI (2022) demonstrates, training by itself cannot sustain behavioral change because it develops knowledge but not reflexes and habits. Only when the management systems of the organization

are redesigned to consistently reinforce principle-aligned behavior, and when those systems are supported by an organizational culture of respect, humility, and psychological safety, does the improvement process become self-sustaining rather than event-driven.

## 4.3 EFQM and Baldrige: Systemic Integration and Governance for Excellence

The Shingo Model establishes the behavioral and moral foundation of SOE: principles must align with systems, and systems must drive ideal behaviors. Yet the Shingo framework, by design, leaves the question of institutional architecture largely open. It specifies what principles should guide behavior, but it does not prescribe how an organization should structure its governance systems to ensure that those principles are consistently deployed, measured, and reviewed across the whole enterprise. This is precisely the contribution of the EFQM and Baldrige frameworks: they provide the systemic complement to Shingo's behavioral philosophy, translating principles into organizational infrastructure that is assessable, improvable, and scalable.

The two frameworks share a common intellectual heritage rooted in Total Quality Management, but each has evolved toward a more holistic conception of organizational excellence that extends well beyond product quality or process efficiency. The EFQM Excellence Model, first introduced in 1991 and substantially revised in 2020, is recognized as one of the leading Business Excellence Models worldwide, with consistent empirical support for its positive effects on financial and non-financial performance when adopted with genuine commitment (Fonseca, 2021). The Baldrige Performance Excellence Program, developed in the United States from 1987 onward, provides a complementary assessment-oriented architecture organized around seven interdependent categories (Baldrige Performance Excellence Program, 2019). Together, they represent the most developed institutional frameworks for operationalizing excellence as a governance system.

### 4.3.1 The EFQM 2020 Model: Direction, Execution, Results

The 2020 revision of the EFQM Model introduced a significant reconceptualization of excellence. Inspired by Simon Sinek's Golden Circle methodology, the model organizes its seven criteria into three dimensions: Direction (why the organization exists and what it aspires to become), Execution (how it deploys its strategy through culture, people, processes, partnerships, and technology), and Results (what value it creates for stakeholders) (Fonseca, 2021). This Why–How–What structure marks a deliberate shift from a results-first orientation toward a purpose-first one: the 2020 revision reduced the weight assigned to Results criteria from 500 to 400 points, reflecting the recognition that results represent what has already happened, while Direction and Execution capture the causal conditions that determine whether performance will be sustained in the future (Fonseca, 2021).

This reweighting is theoretically significant for SOE. It institutionalizes the same logic that the Shingo Model advances at the behavioral level: sustainable performance cannot be managed by focusing on lagging indicators alone. The EFQM 2020 Model extends this logic to the governance level by requiring organizations to demonstrate not only what results they achieve,

but why their purpose and strategy are coherent, how their culture and leadership enable execution, and how their processes and technology are designed to deliver enduring value. Direction and Execution now account for 60% of the global assessment score, embedding a future orientation into the governance architecture itself (Fonseca, 2021).

A further relevant innovation in the 2020 model is its explicit integration of digital transformation and Industry 4.0. Criteria 5.2 (Transform the Organisation for the Future) and 5.3 (Drive Innovation and Utilise Technology) incorporate digital capabilities as governance requirements, not optional enhancements (Fonseca, 2021). The model thus recognizes what Chapter 3 established empirically: digital capability is not separable from process and cultural maturity; it must be embedded in the governance architecture through which strategy is executed and renewed.

The EFQM assessment tool is RADAR: Results, Approaches, Deployment, Evaluation, and Refinement. RADAR operationalizes a continuous improvement logic at the governance level. Organizations are assessed not only on what approaches they have defined, but on how consistently those approaches are deployed, how rigorously they are evaluated, and how systematically the learning from evaluation is used to refine the approach. This cycle mirrors the PDCA logic familiar from Lean and process improvement, but extends it from the operational to the strategic level, ensuring that governance itself is subject to the same discipline of reflection and improvement that it requires from operations.

### 4.3.2 The Baldrige Framework: Systems Integration and the ADLI Cycle

The Baldrige Performance Excellence Program structures organizational excellence into seven categories: Leadership; Strategy; Customers; Measurement, Analysis, and Knowledge Management; Workforce; Operations; and Results (Baldrige Performance Excellence Program, 2019). The seven categories are explicitly designed as an integrated system: the Baldrige framework places Measurement, Analysis, and Knowledge Management at the foundation of the entire architecture, describing it as critical to effective management and to a fact-based, knowledge-driven, agile system for improving performance and competitiveness (Baldrige Performance Excellence Program, 2019). This positioning is directly relevant to SOE: it means that the ability to collect, analyze, and act on data is not merely a digital capability but a governance requirement that conditions the functioning of every other organizational system.

The Baldrige framework evaluates organizational processes along four dimensions: Approach (how the organization accomplishes its work, and how systematic and effective its key approaches are), Deployment (how consistently those approaches are used across relevant parts of the organization), Learning (how well approaches have been evaluated and improved, and whether improvements have been shared across the organization), and Integration (how well approaches reflect current and future organizational needs, and how processes are harmonized to achieve organization-wide goals) (Baldrige Performance Excellence Program, 2019). This ADLI cycle provides a more granular assessment instrument than EFQM's RADAR, and is particularly powerful because it makes deployment and integration explicit requirements:

it is not enough to have a good approach if it is inconsistently applied or if learning from one part of the organization does not reach others.

The ADLI logic addresses one of the central failure modes that Found et al. (2018) identify in operational excellence practice: the gap between stated principles and actual behavior, which arises when improvement systems are well-designed at the top but poorly deployed at the front line, or when learning remains siloed in individual functions rather than feeding back into organizational-level decision-making. By requiring evidence of Deployment and Integration as distinct assessment dimensions, Baldrige institutionalizes the expectation that excellence is not a corporate narrative but a distributed, embedded reality across the whole organization.

The Leadership category in Baldrige (category 1, weighted at 120 points) also carries a specific governance requirement that connects directly to the Shingo Model's Cultural Enablers dimension. Senior leaders are assessed on how they create an environment for achievement of the organization's mission, reinforce organizational culture and foster workforce engagement, cultivate organizational agility, accountability, organizational and individual learning, innovation, and intelligent risk-taking, and participate in succession planning and the development of future leaders (Baldrige Performance Excellence Program, 2019). This formulation is not merely a description of desirable leadership behaviors; it is a governance standard. Leadership is accountable for the conditions that make behavioral excellence possible, which means that the cultural preconditions Shingo identifies as foundational are embedded in Baldrige's governance assessment architecture as measurable leadership responsibilities.

### 4.3.3 Complementarity and the Logic of Dual Coherence

The relationship between EFQM and Baldrige is not one of redundancy but of complementarity. EFQM's strength lies in its strategic orientation: the Direction–Execution–Results architecture is a business model framework that connects purpose, culture, and stakeholder value in a coherent causal chain. Baldrige's strength lies in its assessment granularity: the seven-category structure and the ADLI evaluation dimensions provide a diagnostic instrument that can identify precisely where an organization's excellence system is strong and where it is fragile. Organizations can benefit from using both: EFQM for strategic alignment and purpose-setting, Baldrige for rigorous self-assessment and deployment evaluation.

Found et al. (2018) describe the kind of unifying model that operational excellence theory requires as one focused on the alignment of vision to deliver results, underpinned by a culture and mindset of improvement, driven by strategy and leadership, with continuous improvement feedback loops connecting strategy and goals to leadership and change. Both EFQM and Baldrige operationalize this architecture. EFQM does so through its Direction–Execution feedback cycle and the RADAR tool. Baldrige does so through the ADLI cycle and the explicit linkage between organizational performance measurement (category 4) and strategic planning

(category 2), creating a feedback loop in which data from results informs strategy revision, and strategy revision drives updated approaches and deployment requirements.

Taken together, EFQM and Baldrige provide what can be termed dual coherence for SOE: cultural coherence (the alignment between values, principles, and daily behaviors, addressed primarily by Shingo) and systemic coherence (the alignment between strategy, processes, measurement, and governance, addressed by EFQM and Baldrige). Without systemic coherence, cultural coherence remains fragile: it depends on individual leadership rather than organizational architecture, and erodes under pressure. Without cultural coherence, systemic coherence degenerates into compliance: organizations document their approaches and deploy their processes, but the behavioral spirit that makes improvement self-sustaining is absent. The two forms of coherence are necessary conditions for each other.

This complementarity also explains a risk that both frameworks share when applied without genuine commitment. EFQM has noted that the number of applicants to Business Excellence Awards has shown a downtrend, potentially related to the perception that excellence programs are often quite bureaucratic when compared to alternative quality tools and methods (Fonseca, 2021). When EFQM or Baldrige assessments become documentation exercises rather than genuine governance dialogues, the frameworks lose their developmental power. The antidote is precisely what the Shingo Model provides: a principle-based culture in which assessment is understood as a structured moment of organizational learning, not an external audit. This is why, in the architecture of SOE, Shingo's behavioral foundation is not simply complementary to EFQM and Baldrige but is a necessary precondition for them to function as intended.

## 4.4 Dynamic Capabilities and Adaptive Excellence

The frameworks analyzed in Sections 4.2 and 4.3 explain how organizations achieve excellence through behavioral alignment and systemic governance. What they do not fully explain is how organizations sustain excellence across time as the conditions under which they operate change. This temporal dimension is the contribution of Dynamic Capabilities Theory. Where Shingo addresses the moral preconditions of sustainable behavior and EFQM/Baldrige address the governance architecture for systematic alignment, Dynamic Capabilities Theory addresses the organizational mechanisms through which the alignment itself is continuously renewed.

Teece (2007) defines dynamic capabilities as the enterprise's capacity to sense opportunities and threats, seize them through investment and commitment, and reconfigure resources and organizational structures accordingly. These three categories, sensing, seizing, and reconfiguring, are not sequential stages but continuously overlapping organizational functions that together constitute what Teece (2007) describes as the foundations of long-run enterprise success. The critical insight is the distinction between ordinary capabilities and dynamic capabilities: ordinary capabilities enable an enterprise to perform its current activities efficiently and consistently; dynamic capabilities enable it to modify those activities as circumstances change. Both are necessary, but only the latter explains why some organizations sustain excellence across competitive disruptions while others do not.

This distinction maps directly onto the tension the SOE framework has encountered throughout this work. Process discipline, standardization, and lean tools are expressions of ordinary capabilities: they enable reliable, consistent performance in a defined operating environment. But the competitive and technological environment is not defined and stable; it evolves, and organizations that mistake the maintenance of their current excellence system for the development of their adaptive capacity risk what Teece (2007) identifies as path dependency: the gradual transformation of successful routines into strategic constraints that prevent recognition of and response to emerging opportunities. An organization that has built its process excellence around a particular configuration of technology, roles, and standards may find that configuration increasingly misaligned with its environment, not because its ordinary capabilities have degraded, but because it never developed the dynamic capabilities needed to reconfigure them.

Hamel & Välikangas (2003) frame the same problem in terms of organizational resilience: the gap between how fast the world is becoming turbulent and how fast organizations are becoming resilient. Their analysis shows that even organizations historically regarded as excellent can experience rapid deterioration when their business models become misaligned with changing conditions, and that the primary obstacle to renewal is not external competition but internal cognitive and political barriers that prevent management from recognizing the need for change until a crisis forces it (Hamel & Välikangas, 2003). Strategic resilience, in their framing, is not about rebounding from setbacks; it is about continuously anticipating and adjusting to deep, secular trends that can permanently impair the earning power of a core business (Hamel & Välikangas, 2003). This is the organizational analogue of the adaptive stability construct developed in Chapter 3: stability that is maintained not by rigidity but by continuous, low-trauma renewal.

### 4.4.1 Sensing: Distributed Awareness as an Organizational Capability

Teece (2007) identifies sensing as encompassing not only formal market intelligence and R&D activity but the broader organizational capacity for scanning, interpretation, and learning: the ability to gather information from diverse sources, filter it, and generate actionable hypotheses about emerging opportunities and threats. A critical aspect of this capability is its distribution across the organization: enterprises that concentrate sensing in a small leadership team are systematically more vulnerable to the cognitive biases and information decay that Teece (2007) documents, including the tendency to discount disconfirming information and to underinvest in exploration relative to exploitation of established positions.

At the operational level, the sensing function requires a clear picture of where the organization currently stands in its integration of process and digital capabilities. Pagliosa et al. (2020) propose a maturity assessment method designed precisely for this purpose: jointly evaluating the maturity level of both Lean and Industry 4.0 in each productive area of a manufacturing organization, in order to identify which areas are most ready for their concomitant implementation. Their method reveals that maturity in Lean and maturity in I4.0 are not uniformly distributed across organizational units, and that areas with high combined maturity,

characterized by low turnover, high knowledge-sharing, and strong process standardization, show the greatest synergistic potential between the two approaches (Pagliosa et al., 2020). This finding has direct implications for the sensing function in SOE: an organization that does not assess its own process-digital integration maturity at the area level lacks the situational awareness needed to prioritize sensing investments and to identify where dynamic reconfiguration is most urgently needed.

In the context of SOE, the digital infrastructure analyzed in Chapter 3 is a sensing enabler at the operational level: real-time dashboards, IoT-connected process data, and digital performance boards make performance deviations immediately visible and create the informational basis for early detection of process drift, emerging bottlenecks, or changing demand patterns. The EFQM 2020 Model operationalizes this at the strategic level through its criteria for organizational transformation and technology utilization (criteria 5.2 and 5.3), which require organizations to explicitly address how digital capabilities support their capacity to anticipate and respond to future conditions (Fonseca, 2021). Sensing, in mature SOE practice, is thus not a specialized function but an organizational disposition embedded in both operational and governance systems.

### 4.4.2 Seizing: From Awareness to Committed Action

Sensing an opportunity or threat is necessary but insufficient; the organization must then commit resources and redesign processes to address it. Teece (2007) describes seizing as involving the selection of viable business models, the alignment of organizational structures and incentives around the chosen direction, and the overriding of internal decision-making biases that tend to favor the established over the new. This last point is particularly important: Teece (2007) documents how committee-based decision structures and program persistence bias in established organizations systematically slow the seizing of new opportunities, because investment in radical change always appears threatening to constituencies that benefit from the status quo.

The cultural preconditions that Shingo and Edmondson identify, respect for individuals, psychological safety, humility in leadership, are precisely the conditions that reduce the internal friction Teece (2007) describes. An organization in which people feel safe to raise concerns, challenge assumptions, and propose alternatives is more capable of seizing opportunities quickly and with less organizational trauma than one in which cultural defensiveness suppresses dissent. Similarly, PAI's (2022) finding that proactive managers who identify recurring performance variances and eliminate their root causes represent the highest level of managerial maturity is, in dynamic capabilities terms, a description of the seizing function exercised at the front-line level: capturing performance gaps and converting them into improvement actions before they escalate.

Hamel & Välikangas (2003) identify four challenges that organizations must overcome to seize opportunities before crises force them to: the cognitive challenge (overcoming denial and arrogance), the strategic challenge (generating genuine alternatives rather than incremental

variations), the political challenge (reallocating resources from declining to emerging priorities), and the ideological challenge (questioning the doctrine of optimization when the model being optimized is becoming irrelevant). These four challenges directly correspond to failure modes that the Shingo Model, EFQM, and Baldrige all address in different registers: the Shingo Model through its insistence on humility and scientific thinking; EFQM through its future-orientation in Direction criteria; Baldrige through its ADLI cycle, which requires demonstrated learning and integration rather than mere approach definition.

### 4.4.3 Reconfiguring: Institutionalizing Learning as Renewal

The third capability, reconfiguring, involves adjusting or transforming the organization's asset base, structures, and routines as the sensing and seizing processes reveal the need for change. Teece (2007) describes this as requiring both cognitive flexibility, the willingness to abAndon established routines, and structural discipline, the capacity to implement change without losing operational coherence. The tension between these two requirements is precisely the tension that the adaptive stability construct addresses: reconfiguration that destroys the process stability and behavioral norms on which ordinary capabilities depend will undermine performance rather than renew it; reconfiguration that never actually changes anything is organizational theater.

Hamel & Välikangas (2003) describe the goal as zero trauma: an organization in which revolutionary change happens in lightning-quick, evolutionary steps, with no calamitous surprises, no convulsive reorganizations, and no colossal write-offs. This aspiration describes an organization that has developed its reconfiguring capability to the point where renewal is continuous and low-cost rather than episodic and crisis-driven. The organizational mechanisms that enable this, in the SOE framework, include the PDCA cycles and continuous improvement routines that process discipline provides, the psychological safety and coaching culture that reduce resistance to change, and the data visibility and feedback loops that digital systems accelerate. Reconfiguring is not a separate organizational initiative; it is what happens when ordinary capabilities and dynamic capabilities are coherently integrated.

Found et al. (2018) observe that the dynamic capability of learning depends on the interconnection between the three pillars of SOE: digital systems extend sensing capacity through data visibility; cultural trust enables people to seize opportunities through experimentation; and process discipline allows reconfiguration without chaos. Dynamic Capabilities Theory provides the temporal logic that explains why this interconnection produces sustained performance: not because it generates a stable equilibrium, but because it generates an adaptive one, an organization capable of continuously renewing the alignment among its principles, systems, and learning mechanisms as the environment changes.

The integration of Dynamic Capabilities with the Shingo Model and EFQM/Baldrige thus completes the theoretical architecture of SOE. Shingo explains why behavioral alignment matters and what principles should guide it. EFQM and Baldrige explain how that alignment can be institutionalized into governance systems that are deployable, assessable, and scalable.

Dynamic Capabilities Theory explains when and how those systems must be renewed to remain relevant. Together, they provide a framework that is behavioral, systemic, and adaptive: the three dimensions that Found et al. (2018) identify as necessary for a rigorous theory of Operational Excellence, and which no single framework provides alone.

## 4.5 Integrated Conceptual Model of Sustainable Operational Excellence

The preceding sections have examined three theoretical frameworks, each addressing a distinct but interdependent dimension of Sustainable Operational Excellence. The Shingo Model explains the behavioral and moral preconditions for excellence: why principles must precede systems, and why behavioral alignment cannot be mandated but must be cultivated. EFQM and Baldrige explain the governance architecture that translates those principles into deployable, assessable, and scalable organizational systems. Dynamic Capabilities Theory explains the adaptive mechanisms through which that architecture remains relevant as competitive, technological, and environmental conditions change. No single framework is sufficient alone; the contribution of each depends on the presence of the others.

The relationship among the three frameworks is not hierarchical but recursive. Shingo's principle-based foundation shapes the culture in which governance systems are designed and used: an organization that lacks behavioral alignment will treat EFQM and Baldrige assessments as compliance exercises rather than developmental ones, evacuating them of their learning function. Conversely, governance systems without a behavioral foundation produce what Found et al. (2018) identify as the central failure mode of operational excellence practice: well-documented processes that are inconsistently practiced, and improvement programs that generate reports without changing behavior. Dynamic Capabilities Theory adds the temporal dimension: it explains not only that adaptation is necessary but how organizations build the institutional mechanisms, sensing, seizing, and reconfiguring, that make renewal continuous rather than episodic.

Taken together, the three frameworks constitute a unified conceptual architecture organized around three dimensions of coherence. The first is *behavioral coherence*: the alignment between stated principles and actual daily behavior, which the Shingo Model addresses through its principle-systems-behaviors logic and which Edmondson's (1999) psychological safety construct identifies as the interpersonal precondition for learning. The second is *systemic coherence*: the alignment between strategy, processes, governance, and measurement, which EFQM operationalizes through its Direction – Execution - Results architecture and RADAR evaluation cycle, and which Baldrige reinforces through its ADLI assessment dimensions and the central role assigned to Measurement, Analysis, and Knowledge Management (Baldrige Performance Excellence Program, 2019). The third is *temporal coherence*: the alignment between the organization's current excellence system and the demands of a changing environment, which Dynamic Capabilities Theory addresses through the sensing - seizing - reconfiguring cycle that Teece (2007) identifies as the micro foundational basis of sustained competitive performance.

These three dimensions are mutually reinforcing rather than additive. Behavioral coherence without systemic coherence produces cultures of genuine intent that cannot scale: improvement depends on individual leaders rather than organizational architecture and erodes when those leaders change. Systemic coherence without behavioral coherence produces what Hamel & Välikangas (2003) describe as the ideological trap of optimization: governance systems that efficiently reproduce an increasingly irrelevant model because no one in the organization feels safe or empowered to challenge it. Temporal coherence without the other two produces change without stability: reconfiguration that destroys the process discipline and behavioral norms that made the organization capable in the first place. It is the simultaneous presence of all three that defines Sustainable Operational Excellence as an organizational property.

This architecture also connects to the three pillars developed in Chapter 3, though not through a simple one-to-one mapping. Each framework speaks to all three pillars to varying degrees: Shingo's cultural enablers underpin both process learning and the human conditions for digital adoption; EFQM's governance logic applies to process standardization, cultural assessment, and digital transformation criteria alike; Dynamic Capabilities' sensing function depends on both digital visibility and cultural openness to disconfirming information. What the theoretical integration adds to the pillar framework of Chapter 3 is precisely the architectural logic: an explanation of why the three pillars interact the way they do, and what organizational mechanisms sustain their coherence over time.

### 4.5.1 The Conceptual Model

The Integrated Conceptual Model of SOE represents the three dimensions of coherence as a self-reinforcing cycle rather than a linear sequence (Figure 8):

- *Principles* (Shingo): establish the behavioral and ethical foundation that determines how systems are designed and used.
- *Systems* (EFQM/Baldrige): institutionalize principles into governance structures that are deployable, assessable, and scalable across the organization.
- *Renewal* (Dynamic Capabilities): enable the organization to sense environmental change, evaluate the adequacy of its current systems and behaviors, and reconfigure them without losing operational coherence.

The cycle closes when the outputs of the renewal process feed back into the principles layer: learning from adaptation updates the organization's understanding of what principles require in a changed context, which in turn reshapes the governance systems through which those principles are operationalized. This is the mechanism through which excellence becomes self-sustaining rather than self-referential. Found et al. (2018) describe this as the alignment of vision to deliver results, underpinned by a culture and mindset of improvement, driven by strategy and leadership, with continuous feedback loops connecting strategy and goals to leadership and change. The integrated model proposed here provides the theoretical grounding

for that alignment: it names the frameworks that operationalize each element and specifies the logic by which they interact.

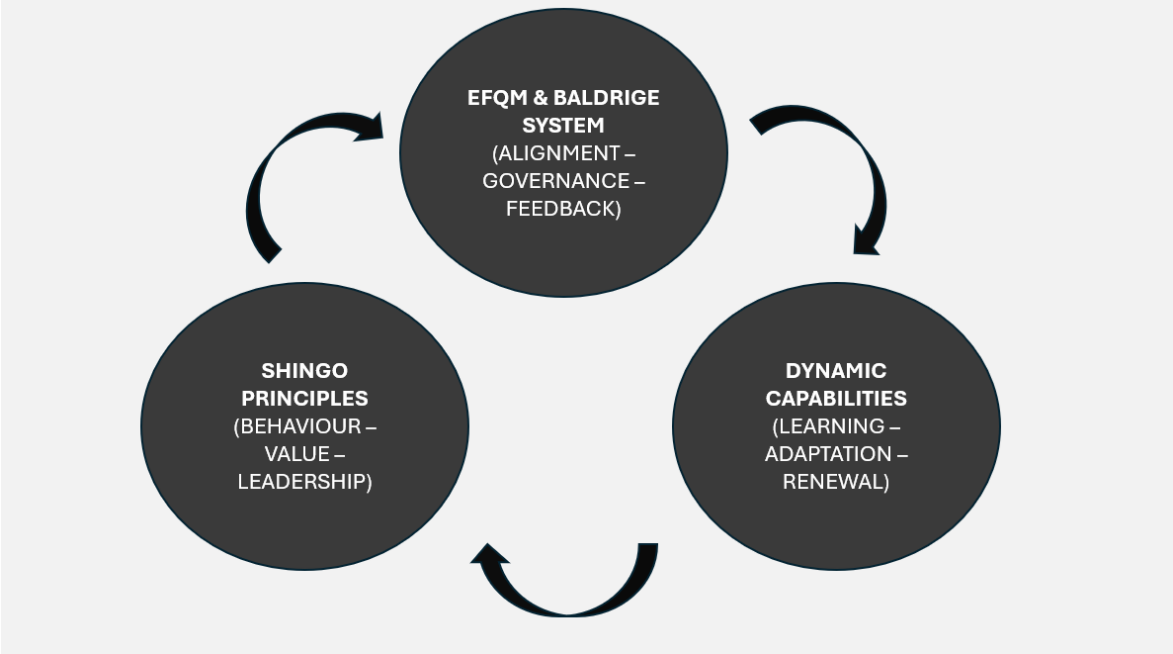



*Figure 8 Integrated Conceptual Model of Sustainable Operational Excellence*

# Chapter 5 Discussion: SOE in Practice

## 5.1 Introduction: Reading Practice Through Theory

The preceding chapters have developed Sustainable Operational Excellence as a theoretical construct: a triadic system in which process discipline, cultural maturity, and digital capability interact to produce a dynamic equilibrium that none of the three pillars could generate independently. Chapter 3 established the internal logic of each pillar and the mechanisms through which they reinforce one another. Chapter 4 integrated three major theoretical frameworks, the Shingo Model, EFQM and Baldrige, and Dynamic Capabilities Theory, into a unified conceptual architecture organized around behavioral, systemic, and temporal coherence. What neither chapter could do is show how this architecture manifests, and is complicated, in the daily life of a real organization.

This chapter provides that ground-level perspective. It draws on approximately six months of direct participation in the Operational Excellence department of a multinational tire manufacturing company, during which the author worked embedded within an OpEx team at a large production plant. The company operates globally and is recognized within its industry for a long-standing commitment to continuous improvement. The specific plant observed employs several hundred people across two macro-production zones: one covering the transformation of raw materials into semi-finished components, and one covering the assembly, curing, verification, and logistics of the finished tire. The empirical observations in

this chapter concern the second zone, from semi-finished to finished product, which encompasses the departments of assembly, curing, verification, preparation, and logistics.

The Operational Excellence department occupied a structurally unusual position within this plant. Rather than belonging to a single function, it operated as a cross-functional support office whose mandate was to facilitate improvement wherever it was needed. This meant that its members, and by extension the author, had legitimate access to every level of the organization: from night-shift floor walks alongside operators to plant-level management meetings attended by department heads, the maintenance manager, the finance representative, and the overall zone director. This positional access was analytically valuable because it made visible both the formal architecture of the improvement system and the informal behavioral dynamics through which that architecture was enacted, adapted, and at times resisted.

The methodological limitations of this empirical contribution have been acknowledged in Chapter 1 and are not repeated in full here. Three are worth restating briefly in the context of this chapter's interpretive purpose. First, the observations represent a snapshot of an organization in active transition: the plant was not a finished model of SOE but a system in the process of building its own capability, unevenly across departments and organizational levels. This transitional character is, analytically, a strength rather than a weakness: it makes the mechanisms of SOE more visible precisely because they are not yet fully consolidated. Second, the author's position within the OpEx office shaped the perspective available, the view from a cross-functional improvement office differs from that of a production supervisor or a night-shift operator, and this positional bias is present throughout the observations. Third, no systematic data were collected, and no statistical claims are made. The contribution is interpretive: it seeks to illuminate how the principles and frameworks of Chapters 3 and 4 appear, and are challenged, when encountered in organizational reality.

The chapter is organized around the main domains of activity observed during the internship. Section 5.2 examines the daily management system, the cascade of meetings running from the shop floor (n-3) through department level (n-2) to plant-level direction (n-1), as the primary institutional architecture through which process discipline, cultural engagement, and data visibility are simultaneously enacted. Section 5.3 analyzes the improvement work site (later on called as “cantiere”), a structured week-long worksite event, as a micro-laboratory in which the interaction among the three pillars becomes especially concentrated and observable. Section 5.4 explores the cultural dynamics of the organization: the variation in psychological safety and team autonomy across areas, the rotation policy as a mechanism of renewal, and the OpEx workshop as an organizational sensemaking event. Section 5.5 examines the digital transition underway at the plant, the migration from manual Excel-based reporting to Power BI, and what the Chinese benchmark plant reveals about the relationship between digital maturity and the triadic equilibrium of SOE. Section 5.6 synthesizes the empirical observations into a set of managerial implications, organized around the three dimensions of coherence developed in Chapter 4.

The analytical thread connecting all five sections is the central proposition of this thesis: that SOE is not the outcome of any single pillar but the emergent property of their continuous alignment. What the following sections show is both how that alignment is built, through daily routines, improvement events, training investments, and deliberate rotation, and how fragile it remains when any one of the three dimensions of coherence is consistently underdeveloped.

## 5.2 The Daily Management System: Cascade Meetings as a Learning Architecture

The most pervasive and structurally significant feature of the plant's operational life was its daily management system: a cascade of three meeting levels, running from the individual production area upward through the department to the plant direction, repeated every working day across all shifts and all departments. This system was not a reporting mechanism in the conventional sense. Its logic, as the author came to understand through both direct participation and formal training, was explicitly learning-oriented: the purpose of the cascade was not to transmit performance data upward to management but to ensure that problems were identified at the lowest possible organizational level, resolved where they arose, and only escalated when the resources or authority needed for resolution exceeded what was available at that level. The architecture of the system

embodied, in institutional form, the Shingo principle of focusing on process and assuring quality at the source (Shingo Institute, 2025), as well as Deming's (2000) argument that improvement must come from action on the system rather than from exhortation directed at individuals.

### 5.2.1 The Seven Faces: Structure, Rhythm, and Visibility

At every level of the cascade the n-3 meeting at area level, the n-2 at department level, and the n-1 at plant direction level the same organizational framework was in use: a digital platform displaying seven predefined sections, or "faces", covering availability, flow, quality, safety, costs, standards, and machines. This framework was not locally designed; it was prescribed by the company's global methodology and therefore not modifiable in its essential structure, though small adjustments in how data was presented within each section were permitted. The consistency of the framework across levels and departments was itself a governance choice: it ensured that information could travel up the cascade without translation loss, and that any manager moving between departments or visiting from another plant would immediately recognize the structure of the review.

Each section displayed its status through a simple visual logic. When the indicators within a section showed no critical deviations, the section header remained green. When a condition arose that could affect the day's production or safety, the header turned red. This color-coding made the health of the operational system immediately readable at a glance, reducing the cognitive load of the opening moments of each meeting and allowing the group's attention to be directed quickly to where it was most needed. The logic mirrors what Sanders et al. (2016) describe as the shift from forecast-based to real-time planning: the platform did not summarize

last week's performance for a monthly review, but displayed the previous night's data, updated before the morning meeting, so that the conversation was anchored in current operational reality rather than retrospective reporting.

One structural feature that the author found particularly revealing was the use of defined time limits at every meeting level. Each n-3 meeting had a fixed preparation window and a fixed presentation window. Exceeding the time indicated that the discussion had drifted from priorities or that the team lacked the clarity to identify what mattered; finishing significantly under time indicated that key issues had been skipped or that the group was not genuinely engaging with the operational picture. This dual-direction norm time pressure as a signal of both overrun and avoidance reflected a sophisticated understanding of meeting discipline as a behavioral indicator in its own right. In PAI's (2022) framework, this kind of structured rhythm corresponds to the difference between a manager who merely assigns tasks and one who proactively identifies recurring variances and ensures that structured reflection actually takes place: the time norm made the quality of the meeting observable, not just its outputs.

The seven-face framework also served a knowledge management function that went beyond daily operations. Because the structure was consistent, stable, and used at every level, it created a shared operational language across the entire plant. A quality problem flagged as red in the n-3 meeting of the curing department arrived at the n-2 meeting already framed in terms that the department head and the other area managers could immediately interpret. This shared language reduced the translation cost of escalation and made the cascade genuinely informational rather than ceremonial.

### 5.2.2 From Data to Dialogue: The n-3 Meeting as Team Learning

The n-3 meeting, held at the individual production area level, was the most operationally intimate of the three cascade levels and, in the author's observation, the one most directly revelatory of the plant's cultural maturity. Its structure was distinctive in a way that set it apart from conventional team briefings: it was not led by the area manager but guided by the operators themselves.

Each production area had, for each shift, a set of designated operator reference roles: one operator responsible for the safety dimension, one for quality, and one for flow. These operators had completed dedicated training programs in their respective areas and served as the primary points of reference for their colleagues on those topics. During the n-3 meeting, it was these operators not the area manager who presented the data for their respective sections of the seven-face platform. The area manager's role was to facilitate, prompt, and resolve escalations, not to deliver the briefing. The stated organizational ambition was full team autonomy: an area in which the n-3 meeting could proceed effectively even in the manager's absence. During the internship, one area within the observed zone had achieved this level of autonomy and was held up informally as the model to emulate.

This design carried a clear behavioral logic. By making operators the presenters of their own performance data, the meeting system created conditions in which front-line workers were not

merely recipients of managerial information but active participants in the daily diagnosis of their work system. The operator responsible for quality was not asked to confirm that the quality targets had been met; she or he was expected to explain what had happened, why, and what was being done about it. This expectation of interpretive ownership, rather than passive compliance, is precisely what Edmondson (1999) identifies as a marker of team psychological safety: an environment in which individuals feel that their contribution is valued and that raising problems will be met with inquiry rather than blame. Where this condition was present and the author observed significant variation across areas the morning meeting was genuinely informative: operators flagged issues early, asked questions freely, and proposed adjustments. Where it was absent, the same format produced a more guarded exchange in which the seven faces were reviewed without genuine diagnostic depth.

The meeting was preceded by the area manager's floor walk, a structured routine in which the manager toured the production area at the start of the shift, interacting directly with operators at their workstations. This walk served multiple functions simultaneously. It allowed the manager to form a direct, sensory picture of the area's condition before encountering the mediated view provided by the platform data. It created an opportunity for informal exchange in which operators could surface concerns that might not reach the formal meeting record. And it enacted, in a physically visible way, the Shingo principle of Lead with Humility (Shingo Institute, 2025): the manager going to the gemba, listening to the people who do the work, before directing the discussion of what the data shows. Over time, the author observed that the floor walk also functioned as a behavioral formation mechanism for operators: when a manager consistently noticed and commented on minor deviations from visual standards a misplaced tool, a cleaning implement outside its designated zone operators in that area gradually internalized the habit of noticing and self-correcting those deviations without prompting. The standard, in Shingo's formulation (2025), was becoming a behavioral norm rather than a documented requirement.

The operator reference role system added a further dimension to this picture. These roles were not salaried promotions; no additional remuneration was attached to taking on the quality, safety, or flow reference function. The motivation was intrinsic: operators accepted these roles because they were genuinely interested in their work and in contributing to its improvement. This voluntariness had two implications that the author found theoretically significant. First, it meant that the reference operators were, in practice, informal cultural carriers: their daily conduct modeled the improvement-oriented behavior that the organization sought to diffuse. Second, it confirmed the PAI (2022) argument that behavioral indicators Key Behavior Indicators, or KBIs, provide a more diagnostically meaningful view of organizational health than Key Performance Indicators alone. Whether an area had engaged, voluntary reference operators who ran their meeting sections with genuine ownership was not visible in the KPI dashboard; it was visible only in the behavioral texture of the daily meeting.

### 5.2.3 Escalation and Systemic Problem Solving: n-2 and n-1

The n-3 meeting was designed to resolve what it could at the area level. Problems that exceeded the area's resources or authority whether in terms of technical expertise, budget, or cross-functional coordination were flagged for escalation to the n-2 meeting, held approximately fifteen to twenty minutes after the n-3 concluded. At n-2, the participants changed: the area managers from all sections of the department joined the department head (capo reparto), together with the shared support roles for maintenance and quality control at the department level. The seven-face platform was again in use, but the scope of the conversation widened: issues that had been unresolved at area level were now visible to the full department, and the department head could deploy resources or authorize actions that no single area manager controlled.

The same time discipline applied. And the same escalation logic continued upward: problems that n-2 could not resolve were carried to the n-1 meeting, the plant-level direction review held later each morning. At n-1, the participants included the department heads of all production departments, the maintenance manager, the finance representative, the quality and scheduling leads, and the zone director responsible for the entire semi-finished to finished product area. The n-1 meeting was the one in which the author participated directly, representing the OpEx office at the request of the supervising tutor.

The author's specific responsibility within the n-1 meeting covered the "standards" section of the seven-face framework. Before each meeting, the task was to review the standards-related data from all departments, identify any anomalies or items requiring attention, and prepare a brief for the tutor so that the OpEx office could raise relevant points during the review. After the meeting, the findings and decisions relevant to the OpEx remit were reported back. This role was modest in formal authority but analytically rich in perspective: it required reading the standards data across all departments simultaneously, which made cross-departmental patterns visible in a way that would not have been apparent from within any single department.

One of the most instructive developments during this period concerned the "standards" face itself. The original format tracked a single, relatively static set of indicators: the number of problems reported across the three meeting levels (n-3, n-2, and n-1) and the number of problems resolved. The plant's direction team had recognized that this format had become repetitive and was generating limited learning value. The decision was made to restructure the standards face so that each day of the working week displayed a different KPI, rotating across five thematic dimensions. One day of the week, for example, was dedicated to problem resolution: the number of formal problem-report forms (detailed modules requiring the operator or supervisor to record the problem, its root cause, and the countermeasure applied) completed across areas. Another day tracked the participation rate in the ideas improvement program: the percentage of employees per department who had submitted at least one improvement idea within the month, measured as a proportion of the total workforce in each department. Any idea qualified, regardless of scale or impact; participation was incentivized

with a small material recognition. Ideas with larger operational impact in terms of cost saving or risk avoidance were rewarded proportionally.

This redesign was still being iterated during the author's time at the plant. The direction team had not finalized which five KPIs best represented the standards dimension, and the selection criteria were actively debated: some proposals emphasized behavioral indicators (idea submission rates, coaching conversation frequency), others operational outcomes (audit scores, standard adherence rates). This iterative, exploratory approach to indicator design was itself a manifestation of the Shingo Model's scientific thinking principle (Shingo Institute, 2025): the organization was treating its own measurement architecture as a hypothesis to be tested and refined, rather than a fixed specification to be implemented. In Baldrige's (2019) ADLI terms, the plant was in the learning and integration phase of its measurement system: approaches had been defined and deployed, but the systematic evaluation and cross-organizational sharing of learning from those approaches was still developing.

The ideas improvement program deserves particular attention because it embodied, in operational form, the distinction between KPIs and KBIs that the Shingo Institute (2025) and PAI (2022) both identify as critical to sustainable excellence. Tracking the percentage of employees who had submitted an idea, irrespective of whether the idea was implemented or its economic value, was a measurement of behavioral engagement rather than operational output. It asked not "did the process improve?" but "are people participating in the improvement process?" The recognition logic reinforced this: a small gift for any submission, a larger reward for high-impact ideas, created an incentive structure that valued participation first and outcome second. This inversion of the typical performance management logic which focuses on outcomes and treats behavior as instrumental reflected a mature understanding of how improvement cultures are built: not by demanding better results, but by rewarding and sustaining the behaviors that, over time, produce them.

## 5.3 The “Cantiere” as a Micro-Laboratory of Socio-Technical Change

If the daily management system represented the plant's continuous, rhythmic improvement infrastructure, the cantiere represented its periodic, concentrated mode of physical and behavioral change. The Italian term for worksite or construction site was used internally to describe a structured improvement event in which a selected production area was subjected to a focused week of physical reorganization, visual management enhancement, and workflow redesign. The author participated in two such events during the internship: initially as an observer, progressively as an active contributor alongside the operator team. Together, these two experiences provided a ground-level view of how the three pillars of SOE process, culture, and digital capability interact when concentrated into a single, time-bounded improvement effort.

### 5.3.1 Structure, Roles, and the Participatory Logic of Improvement

Each cantiere was organized around a defined team and a defined timeline. The core participants were: the area manager, who was formally responsible for the area being worked

on and whose approval and involvement were required for decisions about layout, equipment positioning, and permanent changes; the progress manager, a role present at one per department (and therefore shared across the multiple areas within that department), who coordinated the logistics of the event, including the ordering of materials such as paint, brushes, marking tape, labeling equipment, and any physical fixtures required; a two-person tracking team, typically drawn from the OpEx office or a related support function, whose responsibility was to build and maintain the work list from day one of the event, record estimated and actual completion times for each task, flag activities whose completion was delayed by external dependencies such as material deliveries or machine downtime, and provide general coordination support; and the operator team, drawn from the area's own workforce, who performed the physical work of the cantiere: repainting floor zones, repositioning material staging areas, printing and laminating labels, reorganizing workstation storage, and installing visual fixtures such as information boards.

The work lasted one full working week, after which operators returned to their normal shift rotation. Tasks that remained incomplete at the end of the week became the responsibility of the area manager to close out in the following days. Each morning of the cantiere week began with a brief recap: what had been completed the previous day, what was still in progress expressed as a percentage of completion, and what adjustments to the day's plan were needed in light of any new information or constraints. This daily check-in was structurally identical to the principle underlying the n-3 meeting: a short, focused, information-rich review that allowed the team to continuously reorient their effort toward the highest-priority remaining tasks, rather than simply working through a static list.

The physical outputs of the cantiere were visible and lasting. Repainted floor zones demarcated areas with specific functions: a zone labeled and outlined in yellow meant that a particular piece of equipment or material container always belonged there, making its absence immediately apparent. Labels on storage spaces specified not just the name of the item but its exact placement: a designated corner for the broom and dustpan meant that a worker could identify the cleaning equipment's location at a glance and also knew precisely how to return it. In one area, a small information board was installed at the initiative of the area manager herself: a place where shift-relevant notices, safety reminders, and recognition of operator contributions could be posted and updated without relying on digital systems. These outputs are recognizable as 5S applications Sort, Set in Order, Shine, Standardize, Sustain but their significance in the SOE framework is not merely technical. They are the material expression of the Shingo principle that systems should be designed to make the right behavior easier than the wrong one (Shingo Institute, 2025): when every object has a designated place and that place is visually marked, the standard becomes self-enforcing, reducing the cognitive and motivational load of compliance and making deviations immediately observable.

The spaghetti chart was used in at least one of the observed cantiere to map the movement patterns of operators and materials within the area before deciding how to reposition the material staging racks adjacent to the production lines. These racks small shelving units

holding semi-finished components needed within the next production cycle were not warehouse storage but operational buffers, and their position directly affected the frequency and distance of operator movement. By tracing operator paths on a floor plan before the cantiere and comparing them with the proposed new layout, the team could evaluate whether a repositioning would genuinely reduce movement waste or merely shift it. The use of this tool a visual method for quantifying motion waste borrowed directly from Lean value stream practice demonstrated that the cantiere was not an intuition-driven tidying exercise but a structured analytical event grounded in Lean flow principles (Womack & Jones, 2003).

### 5.3.2 Workers as Sources of Knowledge: From Compliance to Co-Design

The most culturally significant feature of the cantiere, in the author's observation, was its participatory logic. Improvement did not begin with a management diagnosis of what needed to change. It began with a conversation. Before the work plan for each cantiere was finalized, the area manager and the support team consulted the operators who worked in the area: what, in their daily experience, created friction, risk, or confusion? Where were tools consistently misplaced because their designated location was inconvenient? Which material staging positions required unnecessary walking or awkward reaching? Were there any conditions that created safety concerns that operators had noticed but not formally reported?

This consultation produced the primary input for the cantiere's work list. Operators identified the position of a particular rack as causing near-miss incidents when forklifts passed; the rack was moved. Operators noted that the labeling of a storage zone was ambiguous and led to persistent misplacement of items; the label was redesigned with their input. An area manager proposed the installation of the information board not because it appeared in any standard methodology guideline but because she had listened to operators express a desire for a more visible, physical channel of communication within the area. The board was built and populated with content suggested by the team.

This mode of improvement, in which the knowledge held by front-line workers becomes the primary source of design input rather than a secondary validation step, corresponds directly to what Nonaka (2007) describes as the conversion of tacit knowledge into explicit organizational artifacts. The operator who knows, from years of physical experience with a specific workstation, that reaching for a particular tool at a particular moment in the work cycle creates a strain risk possesses a form of knowledge that no process audit or time study would reliably surface. The cantiere consultation created the organizational conditions under which that knowledge could become actionable: a structured moment in which operators were explicitly invited to contribute, in which their contributions were visibly incorporated into the plan, and in which the physical results of their input were realized within the same week. This rapid cycle from knowledge contribution to observable physical change is a powerful behavioral reinforcer: it signals, concretely and tangibly, that the organization respects and values what operators know (Shingo Institute, 2025).

The improvement ideas program observed through the n-1 meeting's standards face operated on a related but distinct logic. Where the cantiere consultation was synchronous and place-specific operators contributing knowledge about their own area in preparation for a specific event the ideas program created an always-on channel through which any employee could submit any improvement suggestion at any time, with recognition guaranteed regardless of impact. The tracking of participation rates as a KBI, rather than counting only implemented or high-value ideas, reflected the same principle: the organization was measuring and rewarding the behavioral disposition to contribute, not just the quality of individual contributions. PAI (2022) describes this as the difference between managing for results and managing for the behaviors that produce results and the ideas program was an institutional expression of this distinction.

However, the author also observed limits to this participatory logic. Not every area manager engaged with the cantiere consultation with the same depth or genuine openness. In some cases, the work list appeared to have been largely pre-determined before operators were consulted, with the consultation serving more as a communication step than a co-design one. In those cases, operators were less actively engaged during the cantiere week itself: the physical work was performed competently, but the sense of collective ownership over the outcome was noticeably lower. The finding by She (2019) that coaching can reproduce control dynamics when misapplied is directly relevant here: a participatory format that is procedurally present but behaviorally controlled does not generate the psychological safety and tacit knowledge mobilization that genuine co-design requires. The cantiere, like the daily meeting, was a vessel whose effectiveness depended on the cultural conditions into which it was placed.

### 5.3.3 Monitoring, Accountability, and the Gap Between Plan and Practice

Alongside the direct participation in cantiere, the author was also assigned a monitoring task of a different character: tracking whether the cantiere planned across the zone's departments had actually been carried out according to schedule. Each area manager had, at the beginning of the period, communicated a planned month for their cantiere: June, July, August, or September. The monitoring task involved contacting area managers to verify whether the planned cantiere had taken place, and updating a tracking file accordingly.

This task was analytically revealing in a way that the author did not initially anticipate. The gap between planned and executed cantiere was not negligible. Several area managers reported delays, citing production pressures, operator availability constraints during summer months, or dependencies on material deliveries that had not arrived in time. A smaller number had completed the cantiere earlier than planned, taking advantage of a quieter production period. The overall picture was one of moderate adherence to the plan, with significant variation by department and by manager.

The significance of this gap, viewed through the lens of Chapter 4's theoretical frameworks, is not primarily operational but diagnostic. In Baldrige's (2019) ADLI framework, the distinction between Approach and Deployment is precisely the distinction between having a good method

and consistently using it. A cantiere plan that is not executed is an Approach that has not been Deployed: the organizational intention to improve a specific area exists, but the conditions, whether motivational, resource-related, or structural, that would translate that intention into action are not reliably present. EFQM's RADAR logic makes the same point from a different angle: organizations are assessed not only on whether their approaches are well-defined but on whether they are consistently applied and whether the gaps between intention and practice are subject to systematic review and refinement (Fonseca, 2021).

From the author's direct observation, the most common explanation for cantiere delays was not the absence of managerial commitment but the pressure of the operational rhythm itself. Area managers who managed a team of approximately thirty operators, coordinated daily with maintenance, quality, and flow support roles, attended three levels of daily meetings, and were responsible for their area's production targets found it genuinely difficult to carve out a full week in which a portion of their operator workforce was diverted from production tasks to improvement work. This tension between the demands of daily production and the investment required for improvements a structural feature of any production environment, and it corresponds to what Hamel & Välikangas (2003) identify as the political challenge of renewal: the difficulty of reallocating resources from the established operating system toward improvement activities, even when the long-term case for doing so is clear. The monitoring task thus revealed, indirectly, a real constraint on the plant's improvement capacity: the cantiere system was well-designed as a methodology, but its deployment depended on conditions of operational slack that were not always available, and the organizational response to deployment gaps was reactive rather than anticipatory.

## 5.4 Cultural Dynamics: Leadership, Safety, and the Unevenness of Excellence

One of the most persistent findings across all the domains of observation described in the preceding sections was that the plant's improvement system was not uniformly effective. The same meeting format, the same seven-face platform, the same cantiere methodology, and the same ideas program were present across all departments and areas. Yet the quality of engagement, the depth of diagnostic conversation, and the degree of operator ownership varied substantially from one area to the next. This unevenness was not a failure of the system's design but a revelation of its nature: the tools and structures provided a consistent framework, but their effectiveness was conditioned by the cultural and leadership dynamics within each area. Understanding this variation is, in many ways, the central cultural insight of the empirical experience.

### 5.4.1 Psychological Safety in Practice: Variation Across Areas

The most direct evidence of cultural variation came from the author's experience of accompanying area managers through their morning routines across all seven production departments. Following different managers over successive weeks made it possible to observe,

in direct comparison, how the same formal structure produced qualitatively different conversations depending on the interpersonal climate of the area.

In the areas where the morning routine was most effective, the floor walk had a genuinely dialogic character. Operators did not wait to be asked; they approached the manager proactively, flagging a noise they had noticed on a machine during the night shift, pointing to a floor marking that had worn away and needed repainting, or raising a question about a standard they were uncertain how to apply. The n-3 meeting that followed was energetic: the operator reference roles were clearly inhabited, the data on the platform was presented with ownership rather than read mechanically, and when a deviation from target appeared, the team offered interpretations before the manager prompted them. In one area, the author observed a night-shift operator staying beyond the end of his shift to explain to the incoming manager a recurring issue he had been tracking informally, having noticed a pattern across several nights that did not yet appear in the formal data. This behavior voluntary, unprompted, oriented toward the system rather than individual recognition is precisely what Edmondson (1999) identifies as the behavioral signature of high psychological safety: the individual's assessment that the interpersonal risk of speaking up is low and the potential benefit to the team is worth taking.

In other areas, the same structure produced a more guarded dynamic. The floor walk was completed efficiently but without the spontaneous exchanges that characterized the high-engagement areas. Operators answered questions but rarely initiated. The n-3 meeting proceeded through the seven faces methodically but without the interpretive depth that distinguished the more engaged teams: deviations were noted, the section turned red or remained green, and the meeting moved on without genuine exploration of root cause or systemic connection. In these areas, the standard format was honored in form but not in spirit, producing what the Shingo Institute (2025) describes as the compliance-without-learning pattern that results when systems are designed correctly but the behavioral preconditions for genuine improvement are absent.

The variation was correlated, in the author's observation, with leadership style rather than with the technical complexity or production volume of the area. Areas with managers who consistently modeled curiosity, acknowledged their own uncertainty publicly, and treated operator contributions as genuinely informative rather than as inputs to be processed tended to develop stronger team autonomy over time. The area that had achieved the organizational benchmark of running its n-3 meeting independently, without the manager's presence, was not the simplest or most stable production environment; it was an area whose manager had, over time, invested heavily in developing the operator reference roles, had delegated progressively more of the meeting facilitation to the team, and had been visibly patient with the learning curve that entailed. This trajectory maps closely onto the Shingo Model's principle of Lead with Humility (Shingo Institute, 2025): the manager's progressive withdrawal from the center of the meeting was not a reduction of commitment but an expression of it, a deliberate act of capability transfer.

The author also observed that psychological safety had a specific relationship with the ideas improvement program. In high-safety areas, the participation rate in the ideas program was higher, and the ideas submitted were more specific, more operationally grounded, and more frequently drawn from direct work experience rather than generic suggestions. In lower-safety areas, participation rates were below the department average, and the ideas that were submitted tended to be more cautious: small, low-visibility suggestions that carried minimal personal risk if they were not implemented or recognized. This pattern is consistent with Edmondson's (1999) prediction that team psychological safety is directly associated with the breadth and quality of learning behaviors, including the willingness to surface novel observations and propose alternatives. The ideas program's KBI logic measuring participation rather than impact created the right incentive structure, but it could not substitute for the cultural conditions that determined whether participation felt safe in the first place.

### 5.4.2 The Rotation Policy and the Logic of Renewal

One of the structural features of the plant's people management system that the author found most theoretically significant was the policy of rotating area managers to a different production department every three years. This rotation was not voluntary; it was a formal organizational rule applied across the entire plant. A manager who had developed deep expertise in the curing department would, after three years, move to assembly or verification, taking their management capability with them but leaving behind the accumulated operational knowledge specific to their former area.

The rationale for this policy, as explained by colleagues in the OpEx office and confirmed by conversations with several area managers, was explicitly developmental: the rotation was designed to prevent the stagnation that comes from occupying the same role in the same environment for too long. Managers who had been in an area for many years risked becoming, in the informal language of the plant, "rusted in": so deeply embedded in the established ways of doing things that they could no longer see alternatives, challenge their own assumptions, or bring fresh perspective to persistent problems. The rotation forced a periodic renewal of the managerial layer's cognitive map of the organization.

From the perspective of Dynamic Capabilities Theory, this policy is a deliberate institutional mechanism for managing path dependency. Teece (2007) identifies path dependency the tendency of successful routines to become self-reinforcing constraints on future adaptation as one of the primary structural obstacles to dynamic capability development. Organizations that allow their most capable managers to become too deeply specialized in their current roles may gain operational efficiency in the short run but sacrifice the adaptive flexibility that sustains performance over time. The rotation policy directly addressed this risk by institutionalizing periodic cognitive disruption at the managerial level, ensuring that at least some of the reconfiguring capability that Teece (2007) describes as the third microfoundation of dynamic capabilities was built into the organizational structure rather than left to individual initiative. Hamel and Välikangas (2003) describe the ideal of zero trauma transformation: continuous, low-cost renewal that avoids the convulsive reorganizations and dramatic write-offs that

characterize organizations forced to adapt in crisis mode. The rotation policy was an attempt to operationalize this ideal at the human capital level. By making managerial movement routine and predictable rather than exceptional and disruptive, the organization reduced the psychological and operational cost of each individual transition. Managers knew the rotation was coming; teams knew their manager would eventually move on; the system was designed to be robust to this turnover rather than dependent on individual continuity.

The policy also had observable costs. Several area managers described the initial period in a new department as genuinely disorienting: the technical specifics of curing presses differ substantially from those of assembly lines, and a manager arriving in an unfamiliar department faced a steep learning curve before they could contribute meaningfully to technical problem-solving. During this transition period, the manager's ability to perform the floor walk with genuine diagnostic value was temporarily reduced, as they lacked the experiential reference frame to recognize subtle deviations from normal operating conditions. The operator reference roles became especially important during these periods, providing the continuity of operational knowledge that the rotating manager could not yet supply. This dependence confirmed, from a different angle, the strategic importance of the operator reference role system: it was not merely a development vehicle for operators but a structural buffer that maintained the quality of the daily management system through managerial transitions.

### 5.4.3 The OpEx Workshop as a Behavioral Infrastructure Event

Once during the internship period, the author participated in a three-day operational excellence workshop organized by the OpEx office and attended by a cross-functional mix of participants: production operators, maintenance technicians, project managers, finance staff, area supervisors, and progress managers. The workshop was held on-site and ran as a structured program combining formal presentations, Q&A sessions, group exercises, and applied discussions of real operational situations drawn from the participants' own departments.

The content of the workshop covered the conceptual foundations of the plant's improvement methodology: the purpose and structure of the seven-face platform, what each of the sections measured and why, how the cascade meeting system was designed to work, the principles behind the cantiere approach, and the logic of the ideas program. A significant portion of the three days was dedicated to precisely the kind of knowledge that the author, having undergone formal training before beginning the daily routines, had found essential but that many participants confessed they had never fully understood: not the mechanics of filling in the platform fields, but the reasoning behind the structure, the why beneath the how.

Several participants from the production floor described having used the platform for months or years without understanding its purpose beyond "it's what we're told to do." This admission, offered openly in the workshop setting, was itself a diagnostic signal: it indicated that the plant's deployment of its improvement tools had, in at least some areas, preceded the cultural and cognitive conditions needed to use them reflectively rather than mechanically. PAI (2022)

describes this as one of the most common failure patterns in organizational improvement programs: tools are deployed before the people who use them understand what they are for, generating a compliance dynamic that the tools were designed to transcend. The workshop was a deliberate attempt to close this gap by investing in the meaning-making dimension of improvement, not just its procedural execution.

What distinguished the workshop from a conventional training event, in the author's observation, was its cross-functional composition. Operators sat alongside finance staff; maintenance technicians asked questions of project managers; area supervisors and progress manager engaged in shared exercises on how to read the platform data and what it implied for their respective roles. This mixing of organizational levels and functions created conditions for what Nonaka (2007) describes as socialization: the sharing of tacit knowledge through shared experience, which is not achievable through formal instruction alone. An operator who had developed an intuitive understanding of what a particular pattern in the flow data meant for the next shift's performance could, in the workshop setting, articulate that understanding to a finance colleague who had never spent time on the shop floor. A maintenance technician who had long suspected that a recurring machine fault visible in the "machine" face of the platform was connected to an upstream quality issue could raise this hypothesis with quality and production representatives in the same room.

The author's role in the workshops was primarily supportive: assisting with material preparation, ensuring that handouts and equipment were ready, and contributing to Q&A sessions when relevant. This supporting function was itself illustrative of the OpEx office's organizational positioning: not as the authority that delivers improvement to the rest of the plant, but as the facilitative infrastructure that creates the conditions for improvement to emerge from the people who do the work. This distinction, between driving improvement from above and enabling it from within, is the practical expression of the Shingo principle of Lead with Humility (Shingo Institute, 2025) at the organizational level, and it defined the character of the OpEx function throughout the internship.

## 5.5 Digital Transition in Practice: From Excel to Power BI

The digital dimension of the plant's operational excellence system was, at the time of the internship, in active transition. It was neither a fully realized Industry 4.0 environment nor a pre-digital one: it occupied the intermediate territory of an organization that had built its improvement infrastructure on manual, document-based routines and was now progressively replacing those routines with connected, automatically updated digital systems. This transitional state was analytically valuable precisely because it made visible the mechanisms and frictions of the process–digital interdependence that Chapter 3 described in theoretical terms.

### 5.5.1 The Migration as a Sensing and Feedback Upgrade

The most concrete and operationally significant digital transition underway during the internship was the migration from Excel-based KPI management to Power BI dashboards. The

previous system required area managers or their support staff to manually re-enter data collected at the area level into department-level spreadsheets, which were then consolidated into plant-level files. This manual transcription chain introduced multiple points of potential error, created time delays between the moment data was generated on the shop floor and the moment it became visible to higher levels of the management hierarchy, and placed a recurring administrative burden on the people responsible for the consolidation.

The Power BI migration addressed all three of these constraints simultaneously. Once configured, the dashboards drew data automatically from the digital platform used during the area-level meetings: when an operator or area manager entered a reading into the system, that entry propagated immediately and without manual intervention to the department and plant-level views. The result was a reduction in the latency between data generation and data visibility, moving the system closer to the real-time planning logic that Sanders et al. (2016) identify as one of the defining operational benefits of Industry 4.0 integration. Equally important, the elimination of manual re-entry reduced the noise introduced by transcription errors and formatting inconsistencies, increasing the fidelity of the signals available to managers at the n-2 and n-1 levels.

At the time of the internship, the migration was not yet complete. The office-side teams, including the OpEx department itself, were still working to understand how to connect their Power BI reports to the plant's central digital platform so that the data available in the operational meeting system and the data available in the management reporting layer would draw from the same underlying source. This integration work was not primarily a technical challenge, though it had technical dimensions; it was also an organizational one, requiring agreement on data definitions, indicator naming conventions, and the governance of who was authorized to modify which data flows. The difficulty of this integration illustrates a point that Pagliosa et al. (2020) make at the level of maturity assessment: digital progress is rarely uniform across an organization, and the areas of greatest friction are often not the most technically complex but the boundary zones between previously separate systems and the people responsible for them.

The migration also had an unintended but positive cultural effect that the author observed in the OpEx office's own work. The manual Excel dashboards had required the person responsible for preparing the n-1 meeting materials to spend a significant portion of the morning before the meeting on data compilation rather than data interpretation. With Power BI aggregating the numbers automatically, that time was freed for the more analytically valuable task of reviewing what the data showed, identifying patterns or anomalies worth raising in the meeting, and preparing the interpretive brief for the tutor. This shift from administrative aggregation to analytical interpretation corresponds exactly to the sensing function that Teece (2007) describes as a microfoundation of dynamic capability: the organization's capacity to scan its own operational signals, filter them, and generate actionable hypotheses. Digital tools that reduce the friction of data compilation do not automatically produce this capability, but they

create the preconditions for it by freeing human attention from routine tasks and redirecting it toward judgment-intensive ones.

### 5.5.2 The Chinese Plant as a Benchmark: What Maturity Looks Like

One of the most illuminating points of reference available during the internship was the company's internal benchmark: the Chinese manufacturing plant, which was held up across the organization as the most advanced expression of the company's operational excellence methodology. Employees at the Italian plant who had visited the Chinese site, or who had participated in cross-site exchange programs, described it in consistent terms: meetings that ran with precision, starting and ending within their allocated times without exception; a real-time data infrastructure in which performance indicators were updated continuously and visible to all relevant personnel without manual intervention; and a defect rate that had been brought below one percent of total production, a level that the Italian plant had not yet achieved and which was treated as a concrete, quantified aspiration.

These descriptions, while not the product of the author's direct observation and therefore treated here with appropriate interpretive caution, are analytically significant because they describe a system in which the three pillars of SOE appear to have reached a level of mutual reinforcement that produces measurable systemic outcomes. A defect rate below one percent is not achievable through process discipline alone: it requires a cultural climate in which deviations are reported immediately and without defensiveness, and a digital infrastructure in which those deviations become visible quickly enough that countermeasures can be implemented before they propagate. The meeting discipline described by colleagues the ability to cover all necessary content within the prescribed time, consistently, without external enforcement is a behavioral indicator of exactly the kind of team autonomy and shared understanding that the Italian plant was still building: it implies that the participants have deeply internalized both the purpose of the meeting and the standard of what a well-conducted review looks like, to the point where they no longer need the structure to tell them what to do.

In Pagliosa et al.'s (2020) terms, the Chinese plant appears to represent a case of high combined maturity in both Lean and Industry 4.0: the areas with the greatest synergistic potential between process discipline and digital capability are precisely those where knowledge sharing is strong, standardization is stable, and the workforce has developed the interpretive capability to act on real-time data without requiring managerial intermediation at every step. The defect rate below one percent is the downstream outcome of this combination; it is not, and could not be, the product of digital monitoring alone or of lean discipline alone.

For the Italian plant, the Chinese benchmark served a motivational and directional function: it demonstrated that the methodology being deployed was capable, at maturity, of producing exceptional results. But it also clarified the distance remaining to be covered, and the nature of that distance. The gap between the two plants was not primarily technological: the Italian plant had access to the same digital tools and methodologies. The gap was in the behavioral and cultural consolidation of those tools, in the degree to which the improvement system had

become self-sustaining rather than dependent on external facilitation, and in the consistency of deployment across all areas rather than in the most engaged ones. This diagnosis is consistent with the triadic equilibrium framework developed in Chapter 3: when process and digital capabilities are present but cultural maturity is uneven, the equilibrium is unstable, and the gap between the best-performing areas and the least-performing ones remains wide.

### 5.5.3 The Andon System and Safety by Design

At the level of the individual production machine, the plant had implemented a visual signaling system that the author observed across all departments: a tri-color light mounted on each machine, operating on the logic of a traffic signal. Green indicated normal operation; yellow indicated standby or a minor condition requiring attention; red, accompanied by an audible alarm, indicated a fault or stoppage requiring immediate intervention. This system, known in Lean literature as an Andon system and conceptually rooted in Toyota's jidoka principle, was the most operationally visible expression of the plant's digital and physical infrastructure working in combination.

The Andon logic embodies the Shingo principle of assuring quality at the source (Shingo Institute, 2025): rather than allowing a faulty process to continue until its outputs reach a downstream inspection point, the machine signals its own abnormal condition immediately, halting value-addition and triggering a response before the problem propagates. In the plant observed, the red light was connected to the digital platform used in the cascade meetings: machine stoppages were automatically logged with their time, duration, and location, contributing to the "machine" section of the seven-face framework and feeding into the availability indicators reviewed at every level of the cascade. The connection between the physical signal and the digital record ensured that machine abnormalities did not exist only in the memory of the operator who witnessed them but became part of the organizational learning infrastructure.

Beyond the Andon system, the author observed a broader commitment to safety by design that went beyond compliance signage or procedural rules. Physical barriers had been installed at the perimeter of machines with moving parts, designed to prevent accidental contact during normal operation and positioned at heights and distances calculated to intercept the reach of a worker moving in the normal flow of the task. Emergency stop buttons had been repositioned, in some areas recently, to be reachable from the operator's natural working position without requiring a change of posture or a step away from the primary task. Anti-vibration protection was provided for operators working with tools or machines that produced sustained vibrational load, reflecting the organization's recognition that occupational health risks extend beyond acute injury to long-term physiological effects that accumulate invisibly over time.

These physical design choices embody what Romero et al. (2016) describe as the human-centric dimension of the Operator 4.0 framework: the engineering of the work environment to enhance operator capability, safety, and sustained performance, rather than simply maximizing machine output. The design intent was not to monitor compliance with safety rules but to make

unsafe behavior structurally difficult: a barrier that prevents accidental machine contact is more reliable than a rule that prohibits it, because the barrier does not depend on the operator's sustained attention or behavioral compliance to function. In the SOE framework, this represents the process and digital pillars working in combination to support the cultural pillar's objective of Respect for Every Individual (Shingo Institute, 2025): respect, in this context, is not only a managerial attitude but a design principle embedded in the physical and digital architecture of the workplace.

The combination of the Andon system, the real-time machine data feed to the platform, and the physical safety design also illustrated the relationship between visibility and learning that Chapter 3 identified as the core mechanism through which digital tools function as learning amplifiers. The machine's red light made the stoppage visible immediately; the platform record made it persistent and analyzable; the cascade meeting system made it discussable and actionable. A single machine fault, in this infrastructure, could progress within twenty-four hours from a physical event on the shop floor to a formally recorded item in the n-1 meeting agenda, available for cross-departmental analysis if its frequency or pattern suggested a systemic cause. This is the digital learning loop that Sanders et al. (2016) describe as the operational advantage of connected manufacturing: not the elimination of problems, but the dramatic reduction in the time and organizational friction between a problem's occurrence and the organization's collective awareness of and response to it.

## 5.6 Managerial Implications

The empirical observations presented in the preceding sections do not constitute a systematic study of organizational performance. They represent a period of reflective immersion in a single site, conducted from a specific institutional vantage point, without formal data collection or statistical measurement. The managerial implications derived from them should be read in that spirit: not as prescriptions derived from controlled evidence, but as interpretive propositions that emerged from the encounter between the theoretical framework of Chapters 3 and 4 and the operational reality of a manufacturing organization actively engaged in building its improvement capability.

The observations converge on a set of design principles for leaders and organizations seeking to develop Sustainable Operational Excellence. These principles are organized around the three dimensions of coherence identified in Chapter 4: behavioral coherence, systemic coherence, and temporal coherence. They are not abstract; each is grounded in a specific pattern observed during the internship, and each is connected to the theoretical framework that explains why it matters.

### 5.6.1 Behavioral Coherence: Designing for Participation, Not Compliance

The most consistent finding across all domains of observation was that the effectiveness of the plant's improvement tools was determined less by their technical design than by the cultural and behavioral conditions in which they were used. The same seven-face platform, the same meeting format, the same cantiere methodology produced qualitatively different outcomes

depending on whether the area's cultural climate supported genuine engagement or merely procedural compliance. This finding leads to the first and most fundamental managerial implication: improvement systems should be designed and evaluated not only for their technical logic but for the behavioral conditions they require to function as intended.

In practice, this means that the deployment of any improvement tool or meeting format should be preceded by an honest assessment of whether the psychological safety conditions necessary for its use are present. A daily management meeting format that requires operators to present their own performance data and diagnose their own deviations from standard will generate learning only in an environment where operators believe that raising problems will be met with inquiry rather than blame. Where that belief is absent, the format will be honored formally but not behaviorally, producing what the Shingo Institute (2025) describes as the compliance-without-learning pattern. Leaders must therefore treat the development of psychological safety (Edmondson, 1999) not as a preparatory step before deploying improvement tools but as an ongoing design requirement, one that must be actively maintained through the daily conduct of the floor walk, the meeting facilitation, and the response to operator contributions.

The ideas improvement program offered a particularly instructive model in this regard. By measuring and rewarding participation rather than outcomes, it created an incentive structure aligned with behavioral coherence: the organization signaled that it valued the disposition to contribute, not just the value of individual contributions. This approach directly operationalizes the distinction between KPIs and KBIs that PAI (2022) and the Shingo Institute (2025) identify as essential to sustainable improvement: it used measurement not to monitor output but to sustain engagement. Leaders designing improvement systems should consider whether their measurement architecture rewards the behaviors that produce improvement, or only the improvements themselves.

### 5.6.2 Systemic Coherence: Structure Enables Learning When It Is Understood

The OpEx workshop revealed a gap that is likely common to many organizations deploying structured improvement methodologies: tools were being used by people who understood the procedure but not the purpose. Operators who had filled in the seven-face platform daily for months described their understanding of its rationale as limited to "it's what we're required to do." This compliance without comprehension is not merely an efficiency loss; it is a structural obstacle to the kind of reflective use of the system that generates genuine improvement. A platform that is filled in because it is required will surface the data its designers expected; a platform that is used because it is understood will surface the data the organization actually needs.

The managerial implication is that systemic coherence requires investment in meaning-making, not just tool deployment. The EFQM RADAR cycle (Fonseca, 2021) and the Baldrige ADLI framework (Baldrige Performance Excellence Program, 2019) both embed this logic formally: they require not only that approaches be defined and deployed but that they be evaluated and

that learning from evaluation feeds back into the refinement of the approach. In practice, this means that the deployment of a new meeting format, a new indicator system, or a new improvement methodology should include a mechanism through which the people using the system can understand its purpose, question its design, and contribute to its evolution. The three-day workshop was one such mechanism; the iterative redesign of the standards face at the n-1 level was another. Both created conditions for the system's users to move from procedural operators to reflective participants.

The monitoring of cantiere deployment also illustrated the systemic coherence challenge from a different angle. The gap between planned and executed cantiere was not primarily a motivational problem but a structural one: the operational rhythm of the plant did not consistently create the conditions of slack and resource availability that cantiere execution required. This suggests that improvement system design must account explicitly for the operational constraints that determine whether deployment is feasible, not only for the methodological quality of the approach. A well-designed cantiere methodology that cannot be consistently deployed is, in Baldrige's terms, an Approach without Deployment and the organizational response to that gap should be architectural rather than motivational.

### 5.6.3 Temporal Coherence: Institutionalizing Renewal Before It Becomes Necessary

The rotation policy for area managers was the clearest organizational expression of temporal coherence observed during the internship: a deliberate, institutionalized mechanism for preventing the path dependency that Teece (2007) identifies as the primary structural obstacle to dynamic capability development. By making managerial movement routine and predictable, the organization reduced the psychological cost of each individual transition and built renewal into its people management architecture rather than leaving it to episodic reorganization.

The managerial implication is that organizations seeking to sustain excellence over time should design for renewal at the human capital level, not only at the process and digital levels. This means creating explicit mechanisms through which cognitive diversity is introduced into stable teams at regular intervals: rotation policies, cross-functional secondments, structured visits to benchmark sites, or participation in cross-site communities of practice. The Chinese plant visits served exactly this function at the organizational level: they gave the Italian plant's managers a concrete reference point for what the methodology could produce at full maturity, refreshing their sense of direction and urgency without requiring a crisis to prompt it.

At the same time, the transitional costs of the rotation policy the initial disorientation of managers arriving in unfamiliar departments, the temporary reduction in diagnostic capability during the learning curve illustrate that renewal mechanisms must be designed with continuity buffers. The operator reference role system provided this buffer for the daily management meetings; a comparable mechanism is needed for any organizational domain where managerial transition creates temporary capability gaps. The managerial implication is not to

avoid rotation but to design the organizational system so that essential knowledge and capability are distributed across roles rather than concentrated in any single individual.

Finally, the digital transition underway at the plant the migration from Excel to Power BI, the integration work between the operational platform and the management reporting layer illustrated the temporal dimension of digital excellence. Digital maturity is not achieved through a single implementation event but through a sequence of incremental upgrades, each of which requires organizational learning before its operational benefits are fully realized. Pagliosa et al. (2020) show that Lean and Industry 4.0 maturity develop unevenly across organizational units, and that the highest synergistic returns are available in areas where both dimensions have reached a sufficient threshold simultaneously. The implication for leaders managing a digital transition is to invest in the human and organizational conditions for digital capability data literacy, analytical interpretation, governance of data flows in parallel with the technical infrastructure, rather than treating the latter as the primary deliverable and the former as secondary support.

# Chapter 6 – Conclusions

## 6.1 What This Thesis Has Argued

This thesis set out to conceptualize Sustainable Operational Excellence as something more than the sum of its parts. Process discipline, cultural maturity, and digital capability each contribute to organizational performance, but none of them, pursued in isolation, produces the enduring improvement capacity that the term "excellence" implies. The central argument developed across the five preceding chapters is that SOE is an emergent property: it arises from the continuous, mutually reinforcing alignment of three pillars, and it collapses when any one of them is consistently underdeveloped.

Chapter 2 established the historical and intellectual context for the first research question, how Operational Excellence evolved from Lean Thinking to the digital era, and what that evolution reveals about the conditions for sustainable performance. The answer that emerged is not simply a story of accumulating tools. Each paradigm shift, from Taylor's motion studies to Toyota's flow logic, from process improvement to behavioral alignment, from visual management to real-time digital sensing, expanded the definition of excellence by exposing a limitation in the previous one. Taylorism revealed the waste of motion but ignored the waste of knowledge; Lean revealed the waste of flow but depended on cultural conditions it could not guarantee; Industry 4.0 revealed the waste of invisible data but required human interpretation it could not supply. The consistent finding is that sustainable performance depends not on any single capability but on the coherent integration of structural discipline, human engagement, and adaptive intelligence. Excellence becomes sustainable precisely when organizations stop treating these dimensions as separate workstreams and begin managing their interaction.

Chapter 3 built the analytical core of the thesis and addressed the second and third research questions in complementary ways. On the role of culture, leadership, and coaching: the

evidence reviewed showed that the same process structures, the seven-face platform, the cantiere format, the ideas program, produced qualitatively different outcomes depending on the local cultural climate. Where psychological safety was present, structures were used with genuine diagnostic depth; where it was absent, they produced surface compliance. Coaching emerged as the primary mechanism through which leaders either created or undermined those conditions, but She's (2019) findings made clear that coaching is not self-sustaining: it succeeds when the organization actively supports the coaches through workload design, recognition, and perceived organizational backing, and fails when it is treated as an individual managerial responsibility without systemic support. The condition for success, in short, is that the organization's governance architecture reinforces the behavioral expectations it places on its leaders.

On digitalization: the evidence showed that digital tools function as learning amplifiers when they reduce the latency between a problem's occurrence and the organization's awareness of it, and when they free human attention from administrative aggregation toward analytical interpretation. The migration from Excel to Power BI at the observed plant illustrated both the mechanism and its precondition: the tool upgrade created value not by adding data but by shifting the OpEx team's time from compilation to sensemaking. Conversely, digital tools become sources of fragility when deployed faster than cultural maturity develops, when data visibility is not matched by the psychological safety needed to act on what the data reveals, or when process instability means that the signals the technology generates have no stable normative reference against which to be interpreted. The Chinese benchmark plant's performance advantage was not primarily technological; it reflected the outcome of high combined maturity in all three pillars simultaneously.

Chapter 4 grounded these findings in three theoretical frameworks. The Shingo Model provides the behavioral logic: principles must precede systems, and systems must be designed to reinforce the behaviors that produce results, not the results themselves. EFQM and Baldrige provide the governance logic: principles become sustainable only when institutionalized into assessable, deployable, and continuously refined organizational structures. Dynamic Capabilities Theory provides the temporal logic: governance structures remain relevant only when the organization develops the sensing, seizing, and reconfiguring mechanisms needed to renew them as conditions change. Together, the three frameworks describe SOE as a system organized around three dimensions of coherence, behavioral, systemic, and temporal, each necessary and none sufficient alone.

Chapter 5 brought this architecture into contact with organizational reality. The variation across areas in psychological safety, team autonomy, and ideas program participation confirmed that excellence, even within a single plant using a single methodology, is a function of the local interaction between formal systems and human behaviors. The gap between planned and executed cantiere illustrated that systemic coherence is not achieved by good methodology design alone but requires organizational conditions that make consistent deployment feasible.

The rotation policy demonstrated that temporal coherence must be designed into the human capital architecture, not left to episodic reorganization.

## 6.2 Three Coherences as a Design Principle

The most practically generative insight to emerge from this work is the three-coherence architecture of Chapter 4. Organizations pursuing excellence frequently ask the wrong question: "Which tool should we implement next?" The framework developed here suggests a prior question: "Are we coherent across the three dimensions that make any tool sustainable?"

Behavioral coherence, the alignment between stated principles and actual daily conduct, is the precondition that the Shingo Model identifies as foundational and that the empirical chapters confirm is the most variable and the most consequential. Where behavioral coherence was high in the observed plant, improvement structures were used with genuine diagnostic depth; where it was low, the same structures produced formal compliance without learning. No process redesign or digital upgrade can substitute for this dimension: organizations that invest in systems while neglecting the behavioral conditions that make those systems generative are, as PAI (2022) argues, confusing measurement with management.

Systemic coherence, the alignment between strategy, processes, governance, and measurement, is what converts behavioral intentions into scalable organizational routines. EFQM's RADAR cycle and Baldrige's ADLI dimensions both institutionalize the expectation that excellence is not a local achievement but a distributed organizational reality, and that the gap between approach and deployment is not a natural condition but a design failure requiring a structural response. The gap between planned and executed cantiere observed during the internship was not a motivational problem; it was a systemic one, produced by an operational rhythm that did not reliably create the conditions of slack and resource availability that improvement investment requires.

Temporal coherence, the alignment between the organization's current excellence system and a changing environment, is the dimension that Dynamic Capabilities Theory explains and that the rotation policy illustrated most concretely. Organizations that allow their improvement systems to become self-referential, measuring compliance with established approaches rather than questioning whether those approaches remain the right ones, accumulate the path dependency that Teece (2007) identifies as the primary structural obstacle to adaptive capability. The rotation policy addressed this at the human capital level by institutionalizing periodic cognitive disruption; the broader implication is that organizations must design for renewal, not only for consistency.

## 6.3 Implications for Practice

For leaders and organizations seeking to build and sustain operational excellence, this thesis suggests four connected principles.

First, design for behavior before deploying tools. Every improvement methodology creates behavioral demands: the daily management system requires psychological safety; the cantiere

requires genuine co-design; the ideas program requires a culture in which participation feels safe before it feels rewarding. Deploying the tool without creating the behavioral precondition produces the compliance-without-learning pattern that is the most common and most costly failure mode in excellence practice.

Second, close the deployment gap as a governance priority. Systemic coherence requires that approaches are not only well-designed but consistently applied. Where deployment gaps exist, as they did in the cantiere monitoring data, the organizational response should be architectural: redesign the conditions that make deployment feasible, rather than issuing motivational appeals to close a structural gap through individual effort.

Third, measure behavior alongside performance. The ideas program's logic of tracking participation as a Key Behavior Indicator rather than counting only implemented, high-value ideas reflects a sophisticated understanding of how improvement cultures are built. Organizations that measure only outcomes are managing lagging indicators; organizations that also measure the behaviors that produce outcomes are managing the system itself. PAI's (2022) four-level indicator hierarchy, KFIs, KPIs, KKIs, and KBIs, provides a practical framework for building this measurement depth progressively.

Fourth, institutionalize renewal before it becomes necessary. The organizations most capable of adapting to change are not those that respond most decisively to crisis, but those that have made renewal a continuous, low-cost organizational habit. The rotation policy, the cross-functional OpEx workshop, the benchmark reference to the Chinese plant: each of these was a renewal mechanism, a deliberate investment in the cognitive diversity and shared purpose that prevents the complacency that Hamel and Välikangas (2003) identify as the most dangerous organizational condition, not failure, but the quiet deterioration of relevance.

## 6.4 Personal Reflection

This research has been as much a process of learning as it has been a study of learning organizations. Living within an operational excellence environment for six months made it clear that improvement is not a technical discipline: it is a relational one. The most instructive moments were rarely those in which a well-designed system worked as intended. They were the moments when a manager's floor walk created an unexpected conversation, when an operator's informal observation at a cantiere revised a plan that a formal process had not questioned, when a workshop participant articulated an understanding of the improvement methodology that made it suddenly coherent for the colleagues sitting alongside them.

These moments are not anecdotes. They are the mechanism. They are how tacit knowledge becomes shared, how principles become habits, and how organizations learn. Observing them from within the OpEx office, and then reading them through the theoretical frameworks developed in Chapters 3 and 4, produced the central conviction that this thesis tries to articulate: that the most powerful thing an organization can do for its performance is to create the conditions under which its people can think, speak, and act with genuine ownership of the work.

Professionally, the experience reinforced a view of management that prioritizes facilitation over control, questions over directives, and long-term capability development over short-term performance extraction. These are not values that sit comfortably with every organizational context. But the evidence reviewed in this thesis, from Edmondson's (1999) demonstration that psychological safety is a structural prerequisite for learning, to She's (2019) finding that coaching only sustains itself when the organization actively supports the coaches, suggests that they are not merely aspirational: they are the operating conditions under which excellence becomes self-renewing rather than self-consuming.

## 6.5 Concluding Statement

Sustainable Operational Excellence, as conceptualized across this research, is not a methodology to be implemented or a certification to be achieved. It is a capability: the organizational ability to align principles, systems, and learning processes in a continuous cycle of reflection and renewal, sustaining performance not by resisting change but by continuously absorbing and directing it.

This definition carries a practical demand. It asks organizations to invest not only in the visible architecture of excellence, the dashboards, the meeting formats, the improvement events, but in the invisible infrastructure that makes that architecture alive: the trust that makes problems visible, the leadership that makes visibility safe, and the institutional memory that makes learning cumulative. When these conditions are present, excellence becomes what it was always meant to be, not a project with an end date, but a permanent organizational orientation toward doing better, understanding more, and respecting the people through whom every improvement is ultimately made.

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