Commentaries on “The Lenses of Lean”

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JOM Forum: Commentaries on "The Lenses of Lean"

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Editors' Note:

The phenomenon of the Toyota Production System (TPS) and the term "Lean" have received much attention from researchers and especially practitioners over the past 40 years. As scholarly perspectives on these topics continue to evolve, we invited Wally Hopp and Mark Spearman to contribute an essay to the *JOM* Forum that became "The Lenses of Lean," and we invited several other prominent authors affiliated with Lean to react to that article and share their perspectives on Lean. We are delighted to have received four such contributions, which we have assembled here with the hope of furthering this important conversation. (Note: For consistency of exposition, we have capitalized the term "Lean" throughout these commentaries when it is used in the phenomenological sense.)

—Suzanne de Treville and Tyson Browning

Michael A. Cusumano

The "Lenses of Lean" article by Hopp and Spearman (2020) is a useful analysis for both researchers (what to study) and practitioners (how to implement). The focus on process (eliminate waste), work flow (reduce costs), the network (reduce system bottlenecks), and the organization (change the culture) reflect the sequencing and feedback loops needed to introduce Lean concepts. That said, identifying four lenses is an academic exercise done in hindsight. It is a bit like reading an expert commentary on the New Testament that mostly reflects how modern theologians interpret the original Gospels and provide advice on how to live a better life. My understanding of what we now call Lean (and I was there at the "creation") has been simpler, and mostly in line with the Process view. My understanding is now expanded. The four lenses reflect different levers to achieve the same goal.

As noted in Hopp and Spearman (2020), as well as in the excellent history by Holweg (2007), the term Lean began as an abstraction for the bundle of practices used in the TPS during the 1980s. Several articles and books had earlier revealed Toyota's "secret sauce"—a few in English (e.g., Sugimori, et al. 1977; Monden 1981a,b,c; Schonberger, 1982; and Cusumano, 1985) and others in Japanese (e.g., Ohno 1978; Shingo, 1980). Everyone agreed that the key figure in the Toyota story was Taiichi Ohno (1912-1990). But Ohno and other early observers did not use the word "Lean." Indeed, John Krafcik (currently CEO of Google Waymo) coined that term in 1988. Krafcik had entered the MIT Sloan School of Management in 1986 after working as an engineer for Toyota's assembly plant venture with General Motors in California, called NUMMI (New United Motor Manufacturing, Inc.). Research director of the MIT International Motor Vehicle Program (IMVP), James Womack, recruited Krafcik to work as a program researcher.

For his master's thesis, and with help from several MIT faculty and researchers, Krafcik designed an assembly plant survey and visited automakers around the world to collect data and compare the results (Krafcik, 1988a). As documented in Holweg (2007), Krafcik initially thought of using the term "fragile" to label Toyota's approach because the company used so few buffer inventories. A 1987 working paper by two other IMVP researchers, Haruo Shimada and John Paul MacDuffie, had created a scheme to classify production systems at the Japanese auto factories in the United States from "fragile" (little or no buffer inventory) to "robust" (fully buffered) (Shimada and MacDuffie, 1987). Eventually, Krafcik chose "Lean" as a more descriptive and positive term. In 1988, Krafcik and I published companion articles in the *MIT Sloan Management Review*. I had been studying Toyota since 1980 and summarized the step-by-step evolution of Toyota's manufacturing innovations (Cusumano, 1988). Krafcik summarized his thesis research and introduced the world to "The Triumph of Lean Production" (Krafcik, 1988b).

I had interviewed Taichi Ohno at Toyota headquarters in March 1983 for my doctoral thesis, published in book form as *The Japanese Automobile Industry: Technology and Management at Nissan and Toyota* (Cusumano, 1985). I then joined MIT in 1986 and became an IMVP faculty member and Krafcik's thesis co-supervisor. My data, compiled at the company level from Japan's equivalent of 10K reports, indicated that Toyota in the 1970s and 1980s was already producing more than twice as many vehicles per worker compared to GM, Ford, and Chrysler—adjusted for differences in vertical integration, capacity utilization, and labor hours (see Table 1). My analysis also indicated that Toyota's productivity advantage existed as early as 1965, when it was producing 50% more vehicles per worker (though only 49% of the value added) compared to the U.S. average, and with fewer fixed assets per labor hour or per vehicle. In 1983, however, compared to the American automakers, Toyota required 13 percent more fixed assets per vehicle and 150%

more fixed assets per labor hour.

From one perspective, we can say that Toyota gradually became more capital-intensive. From another perspective, though, we can say that, by the early 1980s, Toyota had caught up to American companies in robotics and fixed automation so that it now required about the same amount of capital investment to produce a vehicle in Japan and the United States. At this point, it stands out that Toyota required less than half the number of workers to produce the same number of vehicles as U.S. competitors. I also tracked when Toyota introduced specific practices, going back to the 1940s, and examined changes in productivity as well as inventory turnover (see Table 2). My conclusion, mirrored in the Lean literature, was that Toyota's productivity advantage was primarily in a "system" that required fewer people as well as, among other things, less in-process inventory. We already saw this in the 1960s data, which shows that Toyota used less capital equipment per vehicle, worker, or labor hour but produced 50% more vehicles per worker. As an aside, I also described how Nissan followed American-style mass production techniques and equipment from the 1930s through the 1950s until gradually imitating Toyota and coming closer to its productivity levels by around 1970, though Nissan still trailed in inventory turnover rates.

Table 1: Historical Productivity Comparisons between U.S. Automakers and Toyota

	U.S. Automakers Index	***Toyota***			
	General Motors, Ford, & Chrysler Average	*Vehicle Units Per Worker*	*Value Added Per Worker*	*Fixed Assets Per Labor Hour*	*Fixed Assets Per Vehicle*
1965	1.00	1.5	0.49	0.8	0.55
1970	1.00	2.4	0.82	1.3	0.55
1975	1.00	2.6	0.74	1.7	0.65
1983	1.00	2.2	1.48	2.5	1.13

Notes: Data adjusted for vertical integration, capacity utilization, labor hours, and exchange rates.
Source: Compiled from tables in M. A. Cusumano, *The Japanese Automobile Industry* (1985), 199-213.

Table 2: Historical Inventory Turnover Comparisons

Period	**Toyota**	**Nissan**	**GM**	**Ford**	**Chrysler**
1955-1959	11	7	7	9	9
1960-1964	15	14	7	8	9
1965-1969	26	14	7	7	8
1970-1974	23	14	6	7	6
1975-1979	26	14	8	9	6
1980	23	17	8	7	5
1983	36	19	12	11	11

Source: Table 75 in M. A. Cusumano, *The Japanese Automobile Industry* (1985), 302.

Of course, Ohno benefitted from trial and error over many years; he and other Toyota managers could not have planned all these process innovations in advance and they did not fully anticipate the results, as it might seem in retrospect (Fujimoto, 1999). Still, Ohno's core idea, as noted in Hopp and Spearman (2020) as well as in all the early Toyota literature, was to reduce waste (*muda* in Japanese) in the production process. Although this idea was not new in operations management, Ohno brought a set of fresh eyes to automobile manufacturing.

Ohno started his career in Toyoda Spinning and Weaving in 1932, after graduating from a technical high school in Nagoya, nearby Toyoda City. Textile manufacturing with automatic looms used a continuous process flow, somewhat like at Ford's initial Red Rouge plant. His company merged temporarily with Toyota in 1943, to ramp up wartime truck production. Ohno saw at Toyota a haphazard and inefficient process, with stockpiles of components and unfinished vehicles, as well as defects not caught until final assembly weeks or months later. There was lots of idle time as workers waited for parts deliveries and machine set ups. Quality was poor, with long feedback loops from parts production to final assembly and inspection.

When I interviewed Ohno, the way he talked about production processes, machine layouts, and worker steps reminded me of Frederick Taylor, the famous industrial engineer and "Father" of Scientific Management in the 1880s. But Ohno did more than Taylor-like time and motion studies. One of the first things he did, starting with an engine machining shop, was to introduce "small-lot production," such as making only one day's worth of parts at a time. Then he reversed the flow of information to control production more precisely with a "pull" system. He used the manual transfer of production tickets (*Kanban*) attached to pallets to trigger the workflow "just-in-time" (JIT), backwards (at least conceptually) from forward stations and later from final assembly. Ohno said he got the inspiration for Kanban from reading about American-style supermarkets, which replaced items only when customers made a purchase. He may also have heard about pull systems from reports on how the United States rapidly scaled up aircraft assembly during World War II.

The rapid feedback loops from small-lot production controlled through the pull system, combined with asking employees to inspect their own work before handing it off to the next station, led to faster learning, reduced defects, and fewer inspection staff—*improving quality and productivity simultaneously*. Toyota's productivity and inventory turnover rates continued to rise as Ohno experimented with these and other techniques in more parts departments, assembly plants, and suppliers. Value-added productivity rose as Toyota gradually produced higher-profit vehicles. These and other Toyota practices are now well-known, but it is often forgotten how important cooperation was from the company union. Labor unions in the United States and Europe, as well as in Nissan and other Japanese companies, initially prohibited or restricted many of Ohno's practices, making it difficult for competitors in Japan and abroad to copy Toyota.

The extension of Lean concepts after Krafcik's article depended initially on how the IMVP directors popularized the term. *The Machine That Changed the World* (Womack, Jones, and Roos, 1990) summarized what our team had learned about automobile manufacturing and international comparisons, such as from the assembly-plant survey. *Lean Thinking* (Womack and Jones, 1996) suggested broader applications, beginning with the elimination of waste and then using the concept of a "value stream" to analyze how to bring any product or service to market more efficiently.

In product development, some people had already started to apply the term Lean to how Toyota and other Japanese automakers were designing new vehicles faster and with fewer engineering hours than their American or European counterparts. The best book on this subject is by Kim Clark and Takahiro Fujimoto, *Product Development Performance* (Clark and Fujimoto, 1991). Clark and Fujimoto did not use the term Lean but called the Japanese projects "heavyweight" because they were led by powerful program managers with full authority over budgets and staff. MIT researchers, however, heard that Toyota and other Japanese companies considered their heavyweight projects to be wasteful—*not lean.* Projects did not systematically reuse engines, electronics, suspensions, and other expensive subsystems. That type of reuse required upfront investment in planning and extra engineering time for certain lead projects and components or subsystems development. Systematic reuse was more efficient when viewing product development performance from the corporate level as a portfolio of projects.

Kentaro Nobeoka, a former Mazda engineer and Sloan classmate of Krafcik, documented this "multi-project management" approach in his doctoral thesis (Nobeoka, 1993). He and I then published the book *Thinking Beyond Lean* (Cusumano and Nobeoka, 1998) that compared approaches to product development across all the major automakers over a decade. The point we made is that Lean thinking taken too far can become wasteful, as in optimizing one project at a time without optimizing across a portfolio of projects. In fact, I had earlier written an article on "The Limits of Lean" that described the negative extremes in product development as well as other areas (Cusumano, 1994). For example, Japan was experiencing massive traffic jams and breakdowns in supply chains when too many companies relied on just-in-time deliveries, with insufficient buffer stock in case something went wrong.

Another source of confusion came in that some practitioners in the computer field had started to call any iterative or agile practices "Lean software development" (Poppendieck and Cusumano, 2012). I had been studying iterative practices in software engineering for many years, first at Microsoft and then other companies (Cusumano and Selby, 1995). Indeed, there were similarities to Lean thinking and Toyota-style production in the sense of focusing on small teams, catching defects in-process through "daily builds" and continuous integration testing, and using more flexible and overlapping processes than in sequential, "waterfall-style" software engineering. However, the same negative extremes can apply: Projects that do not reuse components systematically or pay attention upfront to architecture and design may waste project engineering resources in the long run and prove inefficient at the corporate level when viewing multiple projects.

Today, we have Lean everything—startups, healthcare, supply chains, Six Sigma, investment management, software projects, and more. With the term applied so widely, it is difficult to remember the essence. Between the 1940s and 1960s, when Toyota refined its production system and manufacturing culture, Ohno was not thinking of "efficiency management" in such broad terms (so I would not use this phrase to define Lean, as Hopp and Spearman suggest). Nor did Ohno seem to think in terms of abstract lenses. Rather, Ohno focused on specific production practices, controlled through a pull system, with the goal of using less of most everything, compared to American-style mass production—fewer buffer inventories, workers, inspectors, and work-in-process. Nonetheless, Ohno clearly would have understood what each of Hopp and Spearman's lenses represented and agreed with their importance and sequencing.

In conclusion, I believe Taichi Ohno would be pleased with how modern researchers have interpreted and extended his core idea and process innovations. I also believe Ohno would have cautioned us to avoid extremes. For example, JIT production should improve efficiency and quality, but zero buffer inventories in a volatile environment can be disastrous if something goes wrong in the network and causes the production system to go down. And optimizing performance at the project level is not the same as optimizing performance at the corporate level. Whatever caveats we add, though, it should still be possible to see Ohno's simple philosophy at work: The goal of Lean is to reduce waste. Amen.

Peter Ward, John Shook, James Womack, and Josh Howell

Hopp and Spearman provide a good starting point for a discussion on clarifying the definition of Lean in a way that will encourage more scholarly research on the topic. In particular, the multifaceted approach represented by the four lenses is indicative of the layered nature of Lean thinking and practice. In fact, from the term's introduction, Lean was meant to describe a multifaceted phenomenon observed through careful empirical study of the world auto industry. Specifically, *The Machine that Changed the World* (Womack, Jones, and Roos, 1990) traced a pattern of thinking, action, and performance through the automotive value chain in Lean auto makers (most notably Toyota) that was clearly distinct, particularly from western counterparts. Womack and his colleagues analyzed five facets of what they named Lean production: fulfilment, supplier management, customer management, product development, and management.

In this comment, we take a more expansive view of Lean than that offered by Hopp and Spearman. We argue that Lean thinking and practice applies beyond operations and also that efficiency is only one desired outcome. The tension between the two views may in itself clarify the conceptual basis of Lean and what it entails from multiple perspectives. Melding views of Lean from the perspective of thinking and practice with those more amenable to research is an important task for moving forward the discussion of Lean.

The following captures our own thoughts about a more general definition of Lean thinking and practice. We believe that understanding and honoring the difference between the thinking and the practice is important. We will then discuss areas of agreement and departure from the lenses of Lean as described by Hopp and Spearman.

What is Lean?

Lean is a way of thinking about creating needed value with fewer resources and less waste. And Lean is a practice, consisting of continuous experimentation to achieve perfect value with zero waste. Lean thinking and practice occur together.

Lean thinking always starts with the customer. What does the customer value? Or, stated differently and in a way that invites concrete action, what problem does the customer need to solve?

Lean practice begins with the work—the actions that directly and indirectly create value for the customer—and the people doing that work. Through ongoing experimentation, workers and managers learn by innovating in their work—be it physical or knowledge work—for increasingly better quality and flow, less time and effort, and lower cost. Therefore, an organization characterized by Lean practice is highly adaptive to its ever-changing environment when compared to its peers.

A Lean enterprise seeks to continuously understand the customer through the three, key, value-creating cycles of product and process development, fulfillment, and use. The enterprise is supported by management systems designed for the specific needs of the organization and its customers, suppliers, community, and employees.

Lean thinking and practice can occur (we believe should occur) wherever products or services are designed, produced, and distributed, regardless of sector. However, there are many failed applications of Lean. These are often marked by early progress followed by back-sliding. Although we can point to many causes of such failure, the most common seems to be applying Lean practice without sufficient Lean thinking. The application of Lean problem-solving tools in isolation often yields quick positive results that prove to be difficult to sustain. In contrast, a more sustainable Lean transformation requires deeper thinking about purpose, process, capabilities, behaviors, and the management system required to make it all work. It also requires reflection about underlying assumptions in the organization and how they might have to change (Lean Enterprise Institute, 2020).

Areas of Agreement

In large part, the lenses of Lean can be trained on the definition provided above without much issue. In fact, the lenses describe an interesting (and researchable) way to deconstruct that definition. The first three lenses are a management hierarchy that is logical and largely consistent with not only our definition but, more generally, practitioner and scholarly literature on Lean:

- Network (or system)
- Flow (or value stream)
- Process (or individual steps in a value creating process)

The fourth lens, organization, is overarching and draws largely on psychology, covering the people dimension of Lean. Hopp and Spearman largely limit their discussion of the organization lens to decision making, drawing on the ground-breaking work of Kahneman. However, as the authors point out, this discussion can be expanded to include a broader array of concepts drawn from psychology including, for example, culture and organizational development. It is our experience that questions from managers most often revolve at least in part on issues like culture and organizational change.

Thinking through each of the first three lenses provides a number of lessons but an overarching insight is that the sequence of problem solving is important. Getting the network (system) right before delving into problem solving at the process or flow (value stream) level leads to less rework and more sustainable improvement. Kaizen performed at low levels when the structure itself is wrong usually leads to waste. However, as in Hopp and Spearman's Motorola example, work often begins at process or flow levels that, in turn, motivates system-level problem solving. MacDuffie (1997) provided case studies comparing approaches to problem solving in auto assembly plants and indicating the benefit of working across organizational levels.

The general insight regarding the importance of system-level improvement is important and consistent with contemporary literature describing Lean thinking and practice. As an example, we point to Morgan and Liker's (2019) *Designing the Future*, which describes innovative and effective methods for contemporaneous product and process development (i.e., network or system first).

Points of Disagreement

The lenses also suggest some important departures from our own view of Lean thinking and practice, inferred through years of research and observation in organizations where managers and others struggle day-to-day to make things better. To keep this comment short, we focus on two areas of disagreement that are particularly important. First, we take some exception to "efficiency science" as a characterization of Lean and, second, we disagree about restricting the domain of Lean only to operations management.

Efficiency is not necessarily the goal. In our view, the first question is always about the nature of the problem at hand—for example, what customer need are we trying to fill? The end is often not efficiency but rather quality, speed to market, delivery reliability, safety or environmental concerns, etc. For example, consider Lean thinking and practice in health care—an area of considerable interest among even among top academic medical centers (see CreateValue.org for information on medical centers engaged in Lean transformations). The most important concern of Lean efforts in health care is improving patient safety and velocity though cycles of diagnosis, treatment, and maintenance rather than efficiency, per se. Of course, there are instances when poor application of Lean practice results in neither improved safety and velocity nor efficiency.

We concede that efficiency can often be a primary concern, particularly in the mature phase of the product-process life-cycle, an argument made long ago by Utterback and Abernathy (1975) and others since. However, we are in an age of constant innovation where managers' focus is often on finding new ways to capture customers by better solving their problems. The key point is that a company needs to understand what the customer wants and reflect that understanding in design of both product or service and process. We also acknowledge that efficiency is often a consequence of both good product and process design and incremental improvements made as the product matures.

It is worth noting that even when efficiency is the goal, Lean thinking and practice requires that workers be involved in both the thinking and the practice. Engaging front-line workers in the design of their work is an important component of Lean practice. Thus, Lean thinking and practice is not a linear descendent of scientific management where an expert designs the work and the worker executes. Standardized work in a Lean organization is developed and revised with participation of the people who do the work, unlike earlier practices described by Taylor (1911) and others. Standardized work designed with worker involvement facilitates continuous, incremental process-level improvement by the people who do the work which can add to significant advantage that is very difficult for competitors to copy.

In short, it does not seem that maximizing efficiency captures the essence of Lean although Lean processes are indeed efficient. Perhaps a resolution lies in Drucker's (2004) distinction between efficiency and effectiveness. Drucker argues that there is a fundamental confusion between effectiveness and efficiency—doing the right things versus doing things right. In pursuit of effectiveness, Lean practices sometimes seem inefficient at first blush. Consider, for example, the notion of "stopping the line" to contain defects. We argue that Lean thinking pursues effectiveness first (effectiveness meaning a focus on achieving the opportunity), and then efficiency (achieving the aim with fewer resources). Importantly, when you break it down, true "efficiency" is of little value without effectiveness.

The second point of departure from the four lenses is expanding Lean thinking and practice beyond operations management. We agree that operations management may be the best fit among traditional academic disciplines for Lean thinking and practice but we argue that many of the important concepts associated with Lean thinking and practice exist at the boundaries of either organizational divides or management disciplines. Although there is no clear consensus on the boundaries that define operations, we adopt the definition of Krajewski et al. (2013, p. 2) that OM "refers to the systematic design, direction, and control of processes that transform inputs into services and products for internal, as well as external customers." As noted by Browning (2020), a number of broader definitions have emerged in literature and practice.

Lean thinking and practice necessarily span the boundaries of operations management (e.g., production) in some important ways. Finding ways to manage activities across, up, and down the organization is a distinctive and necessary attribute of companies pursuing Lean thinking and practice. The Lean enterprise entails multiple means of negotiating the contradictions that inevitably arise in organizations. These mechanisms can include the use of *hoshin kanri* (Priolo, 2019) to achieve deep alignment on the mission or employing the concept of a chief engineer (Shook, 2019) who is charged with accomplishing a major project in large part by exerting influence across organizational silos including those not in operations. To designate Lean as solely an operations responsibility overlooks the extremely important job of achieving and maintaining alignment.

Even within the operations domain, the ability to communicate issues up and down hierarchical levels has been a source of problems and much managerial effort toward building meaningful daily management systems, which have largely been neglected by the academic discipline of operations management. Alignment between tiers of management from supervisor to C-suite requires being able to surface problems at the process level and escalate them upward in the hierarchy when necessary and also to send meaningful policies and advice from upper management to the operation. Although such systems are common in practice, they are infrequently observed in operations management research or teaching.

Conclusion

"The Lenses of Lean" provides a framework that facilitates research by applying a thoughtful specificity to a topic that is by its nature multifaceted. Although we have articulated some disagreements, there is much to agree about and many research questions to address. Hopp and Spearman note that research on Lean has been hampered by the lack of a clear definition with which most scholars can agree. "The Lenses of Lean" provides a useful research perspective that addresses definitional issues. In this commentary, we also provide a definition of Lean thinking and practice that reflects the cumulative observations of the authors as well as numerous other observers at the Lean Enterprise Institute and Lean Global Network (a network of not-for-profit institutes and individuals in 31 countries).

Beyond the need for a stipulative definition, research has lagged practice because Lean thinking and practice cross traditional academic disciplinary boundaries. Just as Lean practice crosses organizational silos by necessity, so there is a need for research that crosses the boundaries of academic disciplines. Hopp and Spearman provide good examples of applying the psychology of decision making to the application of Lean. It will be useful to see more such applications through network, flow, and process lenses. As the boundaries of psychology itself are stretched in exciting ways to include economics, neuroscience, artificial intelligence, and systems engineering among others, Lean thinking will surely benefit from its discoveries if we use the lens to focus appropriately.

More generally, we believe that the most promising research opportunities to advance Lean thinking and practice are at disciplinary intersections. For example, information systems research has thus far had relatively little influence on Lean thinking, at least partly because the implementation of MRP (and its enterprise and supply chain-level progeny) were found to be less than useful for managing production and inventory. As a result, thinking about materials information systems has progressed largely independent of thinking about Lean, with results that make no one happy. Academic research that reflects deep knowledge of systems, supply chains, and Lean thinking and practice has great potential to decrease waste (improve efficiency) and improve agility throughout supply chains.

The area of product and process development is similarly abundant in opportunity largely because relevant research is scattered across disciplines in engineering, ethnography, psychology, marketing, industrial design, operations, and many others. The practical work in customer-focused process and product development described by Morgan and Liker (2019) could be advanced by academic research that is itself informed by Lean thinking.

Similar opportunities exist for advancing Lean thinking and practice by connecting operations with a rich set of new ideas from other disciplines. The Lean Enterprise Institute stands ready to help in making connections and collaborating in ways that will advance Lean thinking and practice.

Rachna Shah and Matthias Holweg

We are pleased by Hopp and Spearman's initiative to revisit Lean and highlight its continued importance. We could not agree more that there remains much to be learnt about Lean, although its lineage has been traced across many decades not just to the TPS, but to the Ford Production System and a string of related process improvement methods of the 20th century. In this context, it is first and foremost noteworthy that Lean has endured, while many other factory-centric process improvement approaches have come and gone[1]. Lean undoubtedly remains the most popular and widely used current avatar of process improvement methods. Over the course of the last three decades, it has continuously evolved as we learnt how to apply it to different contexts. What has remained Lean's True North is the underlying philosophy of the TPS, defined by Taiicho Ohno as providing 'maximum value output for minimum input' (Ohno, 1978: p. 41). This objective of increasing the 'value added' is achieved by reducing the '3Ms'—*muda* (waste, or non-value-added activity from the customer's point of view), *muri* (overburden, or the creation of a safe workplace that enables productive work), and *mura* (unevenness, or the avoidance of irregularity and undesired variation) from the process. Interestingly, this definition is sufficiently general in nature and allows it to incorporate many different improvement approaches. For example, like Six Sigma, Lean also seeks to reduce undesired variation from the process (Schroeder et al., 2008). Yet unlike Six Sigma, it sees the reduction of variation as a means to maximize value, whereas Six Sigma uses it to assess and improve

[1] It is instructive to explore the trends of respective process improvement approaches are featured the literature over time, for example using the Google Ngram viewer. For example, comparing the trends for 'lean', 'agile', 'six sigma', or 'theory of constraints' shows how the interest in Lean has persisted over time, while many others have faded. Other approaches, like 'agile', have seen an initial peak (for 'agile manufacturing' in the mid-1990s, and a resurgence for 'agile development' following the publication of the Agile Manifesto in 2001).

process capability. Specifically, variation will only be reduced to the point where it matters to the customer, and not beyond. Although these two approaches share a common heritage in the quality movement of the 1950s (see for example: Holweg et al. 2018, p.177), Lean practitioners will see the intransigent pursuit of variation as the critical distinction between them.

Hopp and Spearman state that Lean research is dominated by a focus on practices and tools, primarily in a manufacturing setting. We agree, and in fact would posit that the singularly dominant manufacturing-centric attention on shop floor tools/practices has stunted the development of other perspectives, especially the philosophy and principles associated with Lean. Yet, arguably it is the ability to adapt to other contexts that has allowed Lean to endure, evolve, and flourish (Hines et al., 2004). In fact, we propose that equating Lean with efficiency is myopic, and all too often forms the critical point of departure in diverse approaches to understanding Lean. We believe that Lean is broader than a firm's focus on efficiency, both in its approach to implementation and in its desired outcomes. Early writers who described the TPS in detail (e.g. Monden, 1989; Womack et al., 1990), as well as later researchers who contributed to the development of the academic literature on the topic, point to its broad span both in terms of its scope beyond shop floor and waste elimination, and in desired performance outcomes (Shah and Ward, 2007). It is noteworthy that 'running the factory' was only one of five subsystems in Womack et al.'s seminal book in 1990. Other subsystems included were product development, supply chain coordination, distribution, and managing the Lean enterprise that included financial control, personnel management, and global coordination. The importance of the worker and the work *system*, in particular, was highlighted by IMVP researchers early on (cf., MacDuffie, 1995; Pil and MacDuffie, 1996). In short, it is the "*multi-faceted, interdependent, and integrated nature of interrelated elements*" in Lean, which provides it with "*unique character and its superior ability to achieve multiple performance goals*" (Shah and Ward 2007, p.16).

Still, the myopic view of equating Lean with efficiency prevails in both academia and practice. We believe that several aspects have contributed to this perspective. Because Toyota never formally defined its production system (apart from the publications of its architects like Ohno and Shingo), its evolution and our understanding of it have developed in a piecemeal manner. While the underlying system may have remained largely unchanged, different elements came to light at different times. Broadening the scope from manufacturing to organizational and enterprise level on one hand, and incorporating behavioral and cultural elements into Lean inquiry on the other, constitute a more recent transformation. However, the cognitive and psychological underpinnings were always present in the Lean system. For instance, pulling the *andon* cord requires a psychologically safe environment and a supportive culture at work. The infamous example of US auto executives observing *andon* cords in action in Japan in the 1990s, and bringing them over to their US plants, is well known (Rother, 2009). Even though the technical installation was identical, US workers refrained from pulling the *andon* cords in fear of repercussions for highlighting a failure or defect, suggesting that the tools can only function within an organizational culture that supports them. Similarly, while there is considerable awareness of and inordinate emphasis on *muda* in the form of seven wastes (or more commonly now, the eight wastes if one includes ‘unused human skills’), *mura* and *muri* have been largely ignored. In fact, most instruction on Lean in industry and higher education alike focuses on the identification and reduction of wastes, greatly simplifying the philosophy of Lean in the process.

Lean is not a singular concept, and it cannot be equated solely to waste elimination or continuous improvement. It is a system that comprises of both the people and the process components, as well as internal (related to the firm) and external (related to supplier and customer) constituents. Lean’s multi-faceted nature consisting of multiple socio-technical elements that are loosely tied together in a configuration is difficult to measure. The configurational interrelationships and the causal ambiguity between Lean and performance further complicates the measurement. Developing a comprehensive understanding beyond manufacturing into the social and technical elements spanning the entire enterprise requires long-term orientation, forcing the researcher to trade off studying one organization in-depth versus multiple organizations for generalizable results. Hence, we posit, it is largely due to the ease of measurement that researchers frequently concentrate on the technical elements both in characterizing Lean and in measuring performance, over the social and behavioral aspects, resulting in their under-representation and the ubiquity of the narrower ‘process lens’ in academic research.

In the earlier years, Lean was commonly seen as synonymous with technical concepts like JIT (Holweg, 2007). While the human aspects of Lean were known from the start (see: Ohno, 1978; Sugimori et al., 1977), scholars only recently began to focus on trying to understand the behavioral and cultural underpinnings of the Lean system. One reason might be that academic publishing typically lags practical implementation and this is especially true of a practice-oriented phenomenon such as Lean. In operations management theory, it is widely accepted that the processes comprise of technical and social elements that form complex socio-technical systems (Holweg et al., 2018). In our view it is this inherent complexity that has made Lean’s behavioral and cognitive roots much harder to observe than shop-floor techniques like *kanban* cards or *andon* cords. To suggest that Lean is expanding to usurp and leverage the recent advent of behavioral research and cognitive biases would be incorrect. It was part and parcel of the original system; its under-representation in academic research does not mean it did not exist. The simple fact is that much of the academic research has focused on a single subsystem (the factory), and largely ignored the other subsystems that comprise Lean, and allow it to operate across contexts beyond manufacturing.

In fact, the one characteristic of Lean that in our opinion is at the heart of the persistent interest in Lean is its ability to adapt. While the philosophy of Lean was developed at Toyota in a manufacturing context, its logic was inherently transferrable and could be adopted beyond repetitive manufacturing. Unlike many other process improvement methodologies that never truly left their ‘factory heritage’ behind, Lean has found applications in the manufacturing and service sectors, and the private and public sectors alike. Some see a danger in this proliferation, referring to Satori's (1970) poignant warning of the dangers inherent in stretching a concept—that is, stretching Lean so far that it becomes synonymous with any process improvement approach. Yet while Lean's 'toolbox' has been adjusted and expanded as part of its adoptions beyond high-volume repetitive manufacturing settings (Bicheno and Holweg, 2016), its underlying philosophy has been the unfazed mainstay. In this conceptual simplicity, Lean can not only be adapted across many contexts, it is also able to incorporate other improvement concepts. In addition to improving a process by reducing undesired variation that sits at the heart of Six Sigma, the concepts of flow, *nemawashi* (to gather support and feedback by talking to all parties involved) and *hansei* (the idea of continuous reflection and improvement) are very complimentary to the Agile Development approach.

What does all this mean going forward? Looking in to the future we have to conclude that Lean is here to stay, even as the world of operations is changing around us by the increasing use of data analytics in operational decision-making, alongside the technologies that merge the physical and digital domains (Holmström et al., 2019). A central question, going forward, in our view, will thus be how we can integrate digital technologies into Lean process improvement activities. Here, the view put forward by some that digital technologies will simply augment Lean initiatives is too simplistic. For one, initial research demonstrates that technologies will have differential impacts on Lean efforts (Cifone et al. 2020). Such undifferentiated discourse is insufficient in guiding either Lean practice or research going forward. Furthermore, it is worth remembering that Toyota has a famously cautious and skeptical approach towards adopting technology, embodied in the waste of 'inappropriate processing' (Womack and Jones, 1996). The concerns here stem from both the rigidities that technology adoption induces into the process, as well as the concern that technology could remove people from the process, thus inhibiting their ability and motivation to engage with continuous improvement activities (Davenport and Brain, 2018). In short, technology adoption bears the danger of separating the 'thinking' from the 'doing', thus impeding effective *kaizen* implementation.

Consider for example the application of augmented reality in warehouse operations, which may reduce picking errors yet at the same time creates a technological barrier between people and process by reducing the scope for human agency in the process. This barrier is likely amplified if the technology implementation was imposed, and not the result of team-based improvement efforts. We do know from the wider field of technology management that an adaptive structuration process takes place when new technology is being adopted within an organization (see for example Barley, 1986, and others). Yet we are only beginning to understand how digital technologies, like machine learning, will interact with operational decision-making in general (Balasubramanian et al., 2020), and process improvement in particular. There is clear precedence that would suggest that digital technologies will also interact with Lean processes, yet how to integrate both towards enhancing operational performance in the long run is an open question. One interesting twist here is that arguably Toyota may not be the best place to observe the interplay between digital technologies and process improvement, but rather, that we need to look to other exemplars (e.g., Tesla) that are embracing new technologies at pace. While academics are still focusing on deciphering the bundles of practices that make Lean work, it is clear that the next research challenge is already upon us.

Torbjørn Netland

Hopp and Spearman's four lenses conceptualize Lean by seeking its underlying laws and principles, which can form theoretical grounds for Lean research and practice. This positions their article in the epistemological perspective of positivism, which sees science as neutral and aims to explain the true nature of how society operates (Burrell and Morgan, 1979). The four lenses provide insights into how elements of Lean can be operationalized and modeled. My objective is to add an alternative epistemological[2] perspective that should complement this positivistic view and help create a fuller understanding of Lean.

While Lean is not anymore synonymous with the TPS, it emerged on the shop floors of Toyota. The differences in how Toyota organized the manufacturing and supply chain activities relative to global competitors provided a competitive advantage (Womack et al., 1990; Holweg, 2007). According to Jones and Womack (2016, p. 3), "[w]hat distinguishes Lean thinking and practice is that it did not derive from theory, but through observing business practices at Toyota that deliver superior performance in terms of time to market for new products and better product quality using less capital and human effort and hence lower costs in production." Thus, early Lean studies can be classified as *phenomenon-driven research*, as opposed to theory-driven research (von Krogh et al., 2012; Schwarz and Stensaker, 2016). Considering Lean as an "integrated socio-technical system" (Shah and Ward, 2007, p. 791) leads us to expect that it will evolve as the social and technical systems on which it is based change. Arguably, the best way to capture this phenomenological evolution is to go back to the *Gemba* (現場, Japanese for "actual place" or "place where it happens") and study Lean as it evolves in companies across industries.

Lean as an Evolving Business Phenomenon

Lean, defined as a phenomenon, manifests itself in distinct "Lean" cultures, strategies, rules, technologies, work practices, and behaviors that can be observed in companies. Because companies evolve, so does Lean. Taking inspiration from evolutionary theory (Nelson and Winter, 1982; Hannan and Freeman, 1993), the study of an evolving phenomenon can be divided into three phases: the introduction, growth, and

[2] Epistemology is often discussed in relation to *ontology*, that is, the philosophical study of being. Of note, I see no fundamental ontological difference between Hopp and Spearman's approach and the perspective I set forward here. Their four lenses and my alternative lens seem to share the same ontological view that Lean is an actual "thing" that companies pursue to achieve desired outcomes. However, we differ in our understanding of how this thing can be meaningfully studied (i.e., epistemology).

mature phases.

In the 1980s, researchers observed that the TPS differed distinctly from “mass production” (Sugimori et al., 1977; Schonberger, 1982; Hall, 1983). Lean research was then in its *introduction phase*, characterized by uncoordinated and duplicated research efforts that described and explored how Toyota’s business practices differed from those of other companies (e.g., Shingo, 1986; Monden, 1988; Ohno, 1988). The phenomenon was given an identity and conceptualized as JIT (sometimes including total quality control, as in Schonberger, 1982). However, its transfer to Western companies was at first impeded by a myth—that JIT required a uniquely Japanese culture (Hayes, 1981). This myth was dispelled as Western companies began to learn its potential (Sepehri, 1986) and eventually broken when studies proved that Toyota’s transplants and joint ventures were able to replicate the TPS abroad (Krafcik, 1988b)[3]. By the end of the 1980s, Lean was identical to the TPS.

The publication of *The Machine that Changed the World* (Womack et al., 1990) marked Lean’s entry into the *growth phase*. This landmark book moved Lean from a manufacturing recipe with a limited focus on assembly factories to a broader strategy of how to manage operations. The title “Lean” enabled a community of researchers, business writers, consultants, and practitioners to develop an area of thought and action. Although originally equated with the contemporary TPS, Lean immediately came to incorporate other ideas and practices—some of which could not be observed at Toyota. As the field evolved, relationships to other business phenomena were clarified. Some related business phenomena, like Total Productive Maintenance and Total Quality Management, were found to be integral parts of Lean (Flynn et al., 1995; Cua et al., 2001; Shah and Ward, 2003). During the growth phase, conceptual development in the Lean literature helped deepen and broaden the understanding of Lean.

Whether Lean is in the mature phase today is hard to qualify, but—three decades after the inception of the term—one would expect parts of it to have matured. For example, the number of publications covering Lean applications in manufacturing is staggering. Meanwhile, the Lean community has inspired and pursued the application of Lean principles, methods, and tools in a wide span of new areas (e.g., Lean startup, Lean construction, Lean healthcare, Lean government), which begin their own phenomenological lifecycle (for a comprehensive review, see Netland and Powell, 2016). It is clear that Lean, seen as a phenomenon, has not converged over the last decades but has continued to diverge and evolve. While this diffusion obstructs the maturation of the body of Lean knowledge, it also provides new opportunities for phenomenon-based research relevant to practitioners. Even in manufacturing—Lean’s home base—many possibilities for novel Lean research remain. Examples of recent research developments include Lean’s foray into behavioral aspects (including leadership behaviors, learning mechanisms, and cognitive

[3] The article by Krafcik (1988b) was the first to introduce the term “Lean production,” which had been chosen instead of “fragile.”

foundations) and its role in increased digitalization.

What We Can Learn from a Phenomenon-based Perspective

As Hopp and Spearman noted, "There is a difference between a title and a term." It is well accepted that research benefits from clear definitions (terms), which enable the development of meaningful discourse. However, for a socio-technical system like Lean, the boundaries between title and term are not rigid. In a phenomenological perspective, Lean is both a title and a term. As can be observed in practice, Lean takes different forms in different contexts (Netland and Powell, 2016). A model-based view of Lean (i.e., rigid definitions based on reductionism) has limited value when the reality on which the model was built does not match the context in which the model is applied. Our choice is between having a model that enables traditional positivist research methods but risks being out of sync with reality and having observations of emerging and shape-shifting phenomena that makes theoretical development more challenging but is well synced with the developments in organizations. Both choices have merit. Toggling between them will help further our understanding of Lean.

To substantiate the argument for a phenomenon-based perspective, let's use Hopp and Spearman's example of the Danaher Business System (DBS). Regarding Lean as a *title*, note that DBS is Lean for Danaher[4]. However, when companies develop such company-specific production systems modeled on the TPS and other business phenomena (Lean, "operational excellence," Six Sigma, etc.), they take care in defining boundaries and concepts (Netland, 2013). Otherwise, they—just like researchers—could not have a meaningful discourse about the program internally. For example, Danaher is explicit on the elements that make up the DBS (see, for example, Anand et al., 2008). Companies also develop detailed assessments, guidelines, and training materials that describe how the Lean program is supposed to be implemented. Hence, for Danaher, DBS is what Hopp and Spearman refer to as a *term*.

By engaging with Lean as it is defined and used in practice, researchers can contribute relevant and timely fundamental insights on Lean and use rich empirical data to develop or test new theories (cf. von Krogh et al., 2012; Schwarz and Stensaker, 2014). Consider, for example, Browning and Heath (2009), who reported the effects of Lean implementation in a Lockheed Martin factory; Netland and Ferdows (2016), who developed a grounded theory of the performance effects of implementing a Lean program in the Volvo Group; Distelhorst et al. (2016), who examined how Nike's Lean practices relate to labor standards; or Collins and Browning (2019), who studied the deployment of a process improvement program in DevCo. Using a phenomenon-based perspective, authors can also discover new phenomena that should be differentiated from Lean (see, for example, the study on Seru production in Sony and Canon by Yin et al., 2017).

[4] DBS is a well-known Lean company featured in several Lean books. The DBS webpage explicitly mentions Lean, (www.danaher.com/how-we-work/danaher-business-system, [Accessed January 16, 2021])

Viewing Lean as a phenomenon is different from Hopp and Spearman's modeling of Lean as the "science of efficiency." For example, from a phenomenological perspective, Lean is just as much about effectiveness as about efficiency (or more so). This is evidenced by the pervasive customer focus in Lean practice and the Lean literature (see, for example, the explicit focus on customers in DBS, or the first Lean principle in Womack and Jones, 1996). Lean is first concerned with creating and delivering a product to the customer (at the right time and place, in the right quantity, and of the right quality) and second with doing so both cost and time efficiently. Besides, many efficiency-increasing measures, including digitalization and automation, are usually seen as distinct business phenomena that are different from Lean.

Conclusions

I propose the phenomenon-based perspective as a complement to Hopp and Spearman's four lenses. My perspective resonates with general calls for more field-based research in operations management (e.g., Schmenner et al., 2009; Toffel, 2016; Oliva, 2019). The article by Hopp and Spearman prompts us to be mindful of different ways to understand Lean. It reminds us to choose and specify the perspective(s) we apply in our research and writings. Adding the constructivist, phenomenon-based perspective provides researchers with an additional and alternative lens, which can facilitate a more comprehensive understanding of Lean.

References

Anand, B., Collis, D.J., Hood, S., 2008. Danaher Corporation, Harvard Business School Case 708-445, February 2008. (Revised November 2015.)

Balasubramanian, N., Ye, Y., and Xu, M., 2020. Substituting human decision-making with machine learning: Implications for organizational learning. *Academy of Management Review*, forthcoming, doi.org/10.5465/amr.2019.0470

Barley, S.R., 1986. Technology as an occasion for structuring: Evidence from observations of CT scanners and the social order of radiology departments. *Administrative Science Quarterly*, 31(1): 78-108.

Bicheno, J. and Holweg, M., 2016. The lean toolbox: A handbook for lean transformation. Buckingham: PICSIE books.

Browning, T.R., 2020. Operations Management Writ Large. Journal of Operations Management, 66(5), 494-500.

Browning, T.R., Heath, R.D., 2009. Reconceptualizing the effects of lean on production costs with evidence from the F-22 program. *Journal of Operations Management*, *27*(1), 23-44

Burrell, G., Morgan, G., 1979. Sociological paradigms and organisational analysis: Elements of the sociology of corporate life. Heinemann Educational Books, New York, NY

Cifone, F.D., Hoberg, K., Holweg, M. and Portioli Staudacher, A., 2020. 'Lean 4.0': How can digital technologies support lean practices? 21st International Working Seminar on Production Economics, Innsbruck.

Clark, K., and Fujimoto, T. (1991). *Product development performance: Strategy, organization, and management in the world auto industry.* Boston: Harvard Business School Press.

Collins, S.T., Browning, T.R., 2019. It worked there, so it should work here: Sustaining change while improving product development processes. *Journal of Operations Management 65*(3), 216-241

Cua, K.O., McKone, K.E., Schroeder, R.G., 2001. Relationships between implementation of TQM, JIT, and TPM and manufacturing performance. *Journal of Operations Management 19*(6), 675-694

Cusumano, M. (1985). *The Japanese automobile industry: Technology and management at Nissan and Toyota*. Cambridge, MA: Harvard University Press/Council on East Asian Studies.

Cusumano, M. (1988). Manufacturing innovation: Lessons from the Japanese auto industry. *Sloan Management Review*, 30(1), 29-39.

Cusumano, M. (1994). The limits of lean. *Sloan Management Review*, 35 (4), 27-32.

Cusumano, M., and Nobeoka, K. (1998). *Thinking beyond lean: How multi-project management is transforming product development at Toyota and other companies.* New York: Free Press.

Cusumano, M., and Selby, R. (1995). *Microsoft Secrets: How the World's Most Powerful Software Company Creates Technology, Shapes Markets, and Manages People*. New York: Free Press.

Davenport, T.H. and Brain, D., 2018. Before automating your company's processes, find ways to improve them. *Harvard Business Review*, 13 June.

Distelhorst, G., Hainmueller, J., Locke, R.M., 2016. Does lean improve labor standards? Management and social performance in the Nike supply chain. *Management Science 63*(3), 707-728

Drucker, P.F., 2004. What makes an effective executive? *Harvard Business Review* 82(6), 58-63.

Flynn, B.B., Sakakibara, S., Schroeder, R.G., 1995. Relationship between JIT and TQM: Practices and Performance. *The Academy of Management Journal 38*(5), 1325-1360

Fujimoto, T. (1999). *The Evolution of a manufacturing system at Toyota*. New York and Oxford: Oxford University Press.

Hall, R., 1983. Zero Inventories. Dow Jones-Irwin, Homewood, IL

Hannan, M.T., Freeman, J., 1993. Organizational ecology. Harvard University Press, Boston, MT

Hayes, R.H., 1981. Why Japanese factories work. *Harvard Business Review*(July), 56-66

Hines, P.A., Holweg, M. and Rich, N.L., 2004. Learning to evolve: A review of contemporary lean thinking. *International Journal of Operations and Production Management*, 24(10): 994-1011.

Holmström, J., Holweg, M., Lawson, B., Pil, F.K. and Wagner, S.M., 2019. The digitalization of operations and supply chain management: Theoretical and methodological implications. *Journal of Operations Management*, 65(8): 728-734.

Holweg, M. (2007). The genealogy of Lean Production. *Journal of Operations Management*, 25(2), 420-437.

Holweg, M., Davies, J., De Meyer, A., Lawson, B. and Schmenner, R.W., 2018. Process theory: The principles of operations management. Oxford: Oxford University Press.

Hopp, W., and Spearman, M. (2020). The lenses of lean: Visioning the science and practice of efficiency. *Journal of Operations Management*, Online (September), 1-17.

Jones, D.T., Womack, J.P., 2016. The evolution of lean thinking and practice, In: Netland, T.H., Powell, D.J. (Eds), The Routledge Companion to Lean Management. Routledge, New York, pp. 1-7

Krafcik, J. (1988a). *Comparative analysis of performance indicators at world auto assembly plants.* Unpublished Master's Thesis, Massachusetts Institute of Technology, Sloan School of Management.

Krafcik, J. (1988b). Triumph of the lean production system. *Sloan Management Review*, 30(1), 41-52.

Krajewski, L. J., Ritzman, L. P., & Malhotra, M. K. 2013. *Operations management* (10th ed.). Upper Saddle River, NJ: Pearson.

Lean Enterprise Institute, 2020. The Lean Transformation Framework https://www.lean.org/WhatsLean/TransformationFramework.cfm Accessed February 12, 2021.

MacDuffie, J.P., 1997. The Road to "Root Cause": Shop Floor Problem Solving at Three Auto Assembly Plants. Management Science 43(4), 479-502.

MacDuffie, John P., 1995. Human resource bundles and manufacturing performance: Organizational logic and flexible production systems in the world auto industry, *Industrial and Labor Relations Review*, 48(2): 199-221.

Monden, Y. (1981a). What makes the Toyota production system really tick? *Industrial Engineering* (January), 36-46.

Monden, Y. (1981b). Adaptable Kanban system helps Toyota maintain just-in-time production. *Industrial Engineering* (May), 29-46.

Monden, Y. (1981c). How Toyota shortened supply lot production time, waiting time, and conveyance time. *Industrial Engineering* (September), 22-30.

Monden, Y., 1983. Toyota Production System: A practical approach to production management. Industrial Engineers and Management Press, Norcross, GA.

Monden, Y., 1988. Toyota production system: an integrated approach to just-in-time, Productivity Press, Portland, OR.

Morgan, J., Liker, J., 2019. *Designing the Future: How Ford, Toyota, and other world class organizations use lean product development to drive innovation and transform their business.* New York: McGraw-Hill.

Nelson, R.R., Winter, S.G., 1982. An evolutionary theory of economic change. Belknap Press of Harvard University Press, Cambridge, MA

Netland, T.H., 2013. Exploring the phenomenon of company-specific production systems: One-best-way or own-best-way? *International Journal of Production Research 51*(4), 1084-1097

Netland, T.H., Ferdows, K., 2016. The S-curve effect of lean implementation. *Production and Operations Management 25*(6), 1106-1120

Netland, T.H., Powell, D.J., 2016. The Routledge companion to lean management. Taylor & Francis, New York

Nobeoka, K. (1993). *Multi-Project Management: Strategy and Organization in Automobile Product Development.* Unpublished Ph.D Thesis, Massachusetts Institute of Technology, Sloan School of Management

Ohno, T. (1978), *Toyota seisan hoshiki* [Toyota production system]. Tokyo: Daiyamondo.

Ohno, T., 1988. Toyota Production System: beyond large-scale production. Productivity Press, New York, NY

Oliva, R., 2019. Intervention as a research strategy. *Journal of Operations Management 65*(7), 710-724

Pil, F. K. and MacDuffie, J. P., 1996. The adoption of high-involvement work practices. *Industrial Relations*, 35 (3): 423-455.

Poppendieck, M., and Cusumano, M. (2012) Lean software development: A tutorial. *IEEE Software* (September-October), 30-36.

Priolo, R., 2019. What is Hoshin Kanri? Planet Lean. https://planet-lean.com/what-is-hoshin-kanri/ Accessed November 27, 2020.

Rother, M., 2009. Toyota Kata: Managing people for improvement, adaptiveness and superior results. MacGraw Hill, New York.

Sartori, Giovanni. 1970. Concept misformation in comparative politics. *American Political Science Review* 64:1033–53.

Schmenner, R.W., Wassenhove, L.V., Ketokivi, M., Heyl, J., Lusch, R.F., 2009. Too much theory, not enough understanding. *Journal of Operations Management 27*(5), 339-343

Schonberger, R. (1982). *Japanese manufacturing techniques: Nine hidden lessons in simplicity.* New York: Free Press.

Schroeder, R.G., Linderman, K., Liedtke, C. and Choo, A.S., 2008. Six Sigma: Definition and underlying theory. *Journal of Operations Management*, 26(4): 536-554.

Schwarz, G., Stensaker, I., 2014. Time to Take Off the Theoretical Straightjacket and (Re-)Introduce Phenomenon-Driven Research. *The Journal of Applied Behavioral Science 50*(4), 478-501

Schwarz, G.M., Stensaker, I.G., 2016. Showcasing phenomenon-driven research on organizational change. *Journal of Change Management 16*(4), 245-264

Sepehri, M., 1986. Just-in-time, not just in Japan. *American Production and Inventory Control Society (APICS), Falls Church, VA*

Shah, R. and Ward, P. T., 2003. Lean manufacturing: context, practice bundles, and performance. *Journal of Operations Management*, 21(2): 129-149.

Shah, R. and Ward, P.T., 2007. Defining and developing measures of lean production. *Journal of Operations Management*, 25(2): 785-805.

Shimada. H., and MacDuffie, J.P. (1987). Industrial Relations and ‘‘Humanware’’: Japanese Investments in Automobile Manufacturing in the United States. Cambridge, MA: Unpublished Working paper, Sloan School of Management, Massachusetts Institute of Technology.

Shingo, S. (1980). *Toyota seisan hoshiki no IE-teki kosatsu* [An industrial engineering analysis of the Toyota production system]. Tokyo: Nikkan Kogyo Shinbunsha.

Shingo, S., 1986. Zero quality control: Source inspection and the poka-yoke system. Productivity Press, Cambridge, MS

Shook, J. 2019. The remarkable chief engineer. Lean Enterprise Institute. https://www.lean.org/leanpost/Posting.cfm?LeanPostId=1046.

Spear, S. and Bowen, H. K., 1999. Decoding the DNA of the Toyota Production System. *Harvard Business Review*, 77 (9/10): 97-106.

Sugimori, Y., Kusunoki, K., Cho, F. and Uchikawa, S., 1977. Toyota production system and kanban system materialization of just-in-time and respect-for-human system. *The International Journal of Production Research*, 15(6): 553-564.

Toffel, M.W., 2016. Enhancing the practical relevance of research. *Production and Operations Management 25*(9), 1493-1505

Utterback, J.M., Abernathy, W.j.,1975. A dynamic model of process and product innovation. *Omega* 3(6), 639-656.

von Krogh, G., Rossi-Lamastra, C., Haefliger, S., 2012. Phenomenon-based research in management and organisation science: When is it rigorous and does it matter? *Long Range Planning 45*(4), 277-298

Womack, J., Jones, D., Roos, D., 1990. *The Machine that Changed the World: The Story of Lean Production*. New York: Harper Perennial.

Womack, J.P. and Jones, D.T., 1996. Beyond Toyota: How to root out waste and pursue perfection. *Harvard Business Review*, 74(5): 140-151.

Womack, J. and Jones, D. (1996). *Lean thinking: Banish waste and create wealth in your corporation.* New York: Simon and Schuster.

Yin, Y., Stecke, K.E., Swink, M., Kaku, I., 2017. Lessons from seru production on manufacturing competitively in a high cost environment. *Journal of Operations Management, vol. 49-51, p.* 67-76.

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