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FROM LEAN PRODUCTION TO OPERATIONAL EXCELLENCE

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1 Introduction

Production and Operations Management has seen many changes since it first emerged as an academic discipline. One of the most significant of these changes was the emergence of Lean Production and the worldwide interest in Japanese manufacturing processes. John Krafcik, a researcher from the Massachusetts Institute of Technology (MIT), first introduced the term “Lean Production” to the management lexicon (Krafcik 1988). Two years later, Womack et al. (1990) popularized it in the best-selling book *The Machine That Changed the World*, a book that is commonly referred to as the starting point of the Lean movement. In reality, however, many of the concepts of Japanese manufacturing, the foundations of Lean, were already well established in the US by the early 1980s, albeit under different names. In *The Machine That Changed the World*, the authors contend that their findings revealed that there was a dramatic performance gap between Japanese and Western car producers and asserted that Lean production should be universally adopted, writing that “Our conclusion is simple: Lean production is a superior way for humans to make things. . . . It follows that the whole world should adopt Lean production, and as quickly as possible” (Womack et al. 1990, p. 225).

Lean is a term that is used to describe a demand-driven systems approach that is based on the shared experiences at Toyota Motor Corporation of developing the Toyota Production System (TPS) and integrating it with Total Quality Control (TQC) and Total Productive Maintenance (TPM) in a unique way to deliver customer value at the shortest lead-time. Lean is simply a system of time-compression developed by focusing on the end-to-end efficiency of flow, rather than the efficiency of resources, to deliver high-quality products and services that customers value in a way that shows respect for people (Modig and Åhlström 2015; Schonberger 2015). Despite the fact that there is evidence that the terminology of Lean is considered in some quarters to be dated and misunderstood due to its polymorphic nature, Lean has made a huge and significant contribution to OM studies. As seen by its successes, the concepts behind Lean are as valid in the 21st century as they were when the first mainstream usage of the term emerged twenty-five years ago.

In this chapter, we will look at the emergence and evolution of Lean Production through to the concepts of Operational Excellence that companies are striving to achieve today.
The term “Lean” emerged from the study of the Toyota Production System (TPS) by researchers on the International Motor Vehicle Program (IMVP), a program that was founded at MIT in 1980. IMVP was, at that time, the largest international research consortium aimed at understanding the challenges facing the global automotive industry. Lean production is described as a counter-intuitive alternative to mass production that uses less of everything (i.e., resources, energy, manpower). It is derived from TPS, a system that had developed over a number of years from the collective and shared experiences of the people who had created the system and focuses on time-based competition (Stalk 1988) and systematic innovation (Spear 2009) through increasing the efficiencies of flow (Modig and Åhlström 2015). Whilst many of the principles behind TPS and the associated concepts of TQM and TPM originated in the US, the principles of Just-in-Time (JIT) and Jidoka derived from the original founders of Toyota.

2.1 Toyota Production System (TPS)

Sakichi Toyoda, the inventor of Japan’s first power loom, is acknowledged to have developed the philosophy and methods of Jidoka: mistake-proofing (Poka-yoke) and autonomation (automation with a human touch). These principles influenced Sakichi’s son Kiichiro Toyoda, causing him to develop the fully automated loom, something which led to the opening of The Toyota Automatic Loom Works in 1926 and, from his interest in automobiles, to his founding the Toyota Motor Corporation in the late 1930s. The Just-in-Time (JIT) method derives from a comment by Kiichiro Toyoda on the best way to gather parts for automobile manufacturing. The Second World War reconstruction of Japanese manufacturing, with its lack of available capital resources and severe economic slump saw these ideas extended and combined with a discipline of daily improvements (Kaizen). The new approach, created by Taiichi Ohno (1978; 1988), became known as the Toyota Production System (TPS) in the 1970s after twenty years’ of trial and error experimentation by Ohno and colleagues. One such colleague was Kikuo Suzumura, a production engineer who was responsible for translating Ohno’s ideas of a JIT pull system into practice (Shimokawa and Fujimoto 2009). Kanban, named by Toyota in 1964, is an enabling tool that underpins JIT by acting as an inventory control system (Monden 1983; Sugimori et al. 1977; Hopp and Spearman 2000). TPS is a management concept based upon JIT and Jidoka, which, according to Ohno, was focused initially on the goal of time-compression from order to cash, by the relentless elimination of waste to increase flow (Figure 12.1). During the post-war reconstruction of Japan Toyota faced financial difficulty and industrial unrest. TPS, with its focus on total cost management (Monden 1989) and respect for people, was part of the turnaround.

A strong focus of TPS was on eliminating all forms of waste—a process termed muda, mura, and muri. Muda is a Japanese term for futility that is used by Toyota to describe waste in the production process. Initially, Taiichi Ohno and Shigeo Shingo identified seven wastes (overproduction, over-processing, excessive motion, excessive inventory, excessive waiting time, excessive conveyancing transport, and defects) as targets for elimination. Mura is a word to describe unevenness that was addressed by leveled production, Heijunka, and the concept of Takt time (the rate of production required to meet the rate of demand). The third term used to describe waste is muri, a Japanese term for unreasonableness or over-burden. Muri can be avoided by implementing standardized work and having respect for people.

Central to and underpinning TPS was the concept of Kaizen, a concept that was adopted to facilitate the relentless pursuit of waste elimination and continuous improvement. Kaizen, which
Pillars of TPS

Main Tools and Techniques

Purpose

Kanban
Reduce the Waste of Overproduction

Heijunka
Reduce the Waste of Excessive Transport

Reduced Batch Size
Reduce the Waste of Excessive Inventory

Standardized Work
Reduce the Waste of Waiting

Multi-skilled Operators
Reduce the Waste of Over-processing

Multi-process Handling
Reduce the Waste of Excessive Motion

Flexible Staffing
Reduce the Waste of Producing Defects

Poka-Yo ke/Mistake-Proofing

Automatic Problem Detection

Line-stop Switches

Activities to support improving productivity and quality (Kaizen)

Figure 12.1 Schematic Representation of TPS

Source: Adapted from Shimokawa and Fujimoto 2009. © Copyright 2009, The Birth of Lean, p. 206, Lean Enterprise Institute, Inc., Cambridge, MA, lean.org. All rights reserved. Used with permission.

quite literally means change or changing (kai) for the better or good (zen), entered popular Western management terminology in the 1980s. Masaaki Imai first disseminated Kaizen within the field of OM (Imai 1986). Kaizen, as demonstrated by Imai at Toyota, represents both a philosophy and a set of tools. Many Japanese and, increasingly, Western facilities regard Kaizen as one of the main vehicles of problem solving and continuous improvement.

The philosophy and methods of TPS, which extended to Toyota's supply base in the 1970s and to its distribution and sales operations in the 1980s, became a competitive weapon as Toyota competed openly with US and European automakers by providing quality products and services that customers valued. However, it was not until the mid-1980s when Toyota went into a joint venture with GM to develop New United Motor Manufacturing Inc. (NUMMI) that US automakers and OM researchers really started to take notice. Toyota's business success and world-leading product quality are now established facts. This success is often attributed to the production system that Toyota developed during the 1950s and 1960s as a result of intense post-war competition.

Detailed chronologies of the events and publications that led up to the emergence of the TPS and subsequent Lean phenomena have been well documented. Table 12.1 offers a synthesis of these works and includes those events and publications considered to be the most important.
Table 12.1 Publications and Events Leading up to the Emergence of Lean

<table>
<thead>
<tr>
<th>Year</th>
<th>Publications/Events</th>
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</thead>
<tbody>
<tr>
<td>1925</td>
<td>Frank Woollard publishes “Some Notes on British Methods of Continuous Production.”</td>
</tr>
<tr>
<td>1932</td>
<td>Taiichi Ohno joins Toyoda Loom Works as an engineer.</td>
</tr>
<tr>
<td>1937</td>
<td>Toyota Motor Corp. founded.</td>
</tr>
<tr>
<td>1937</td>
<td>Kiichiro Toyoda visits the US, in particular Ford, and begins TPS.</td>
</tr>
<tr>
<td>1940</td>
<td>Training Within Industry (TWI) program introduced for US military.</td>
</tr>
<tr>
<td>1930–1945</td>
<td>Ford use flow production to produce bombers at Willow Run.</td>
</tr>
<tr>
<td>1948</td>
<td>W. Edwards Deming first sent to Japan.</td>
</tr>
<tr>
<td>1950</td>
<td>Labor strikes bring Toyota to near bankruptcy. Kiichiro Toyoda resigns and hands business over to cousin Eiji Toyoda who visits Ford River Rouge plant.</td>
</tr>
<tr>
<td>1956</td>
<td>Ohno visits Ford River Rouge plant.</td>
</tr>
<tr>
<td>1970s</td>
<td>Business press identifies that Japan’s exports are wreaking havoc.</td>
</tr>
<tr>
<td>1973</td>
<td>First oil crisis occurs.</td>
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<tr>
<td>1977</td>
<td>First English-language academic articles on TPS appeared.</td>
</tr>
<tr>
<td>1979</td>
<td>Second oil crisis occurs.</td>
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<tr>
<td>1979</td>
<td>IMVP starts at MIT.</td>
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<tr>
<td>1979</td>
<td>The Repetitive Manufacturing Group (RMG) is established by the American Production and Inventory Control Society (APICS) and included Schonberger and Hall.</td>
</tr>
<tr>
<td>1983</td>
<td>Hall publishes Zero Inventories. Hewlett-Packard produce their widely sold and copied Stockless Production at Greenly Division video. Monden publishes Toyota Production System.</td>
</tr>
<tr>
<td>1984</td>
<td>Toyota enters into the New United Motor Manufacturing Inc. (NUMMI) joint venture with GM. First output of IMVP The Future of the Automobile published.</td>
</tr>
<tr>
<td>1985</td>
<td>The RMG splits from APICS and forms the Association for Manufacturing Excellence (AME).</td>
</tr>
<tr>
<td>1986</td>
<td>Imai publishes Kaizen: The Key to Japan’s Competitive Success.</td>
</tr>
<tr>
<td>1989</td>
<td>Shigeo Shingo publishes A Study of the Toyota Production System.</td>
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</table>

Although there was no mention of quality programs in *The Machine That Changed the World* it is clear that Toyota could not have achieved all its success without these. Both Total Quality Management (TQM) and its forerunner Total Quality Control (TQC), along with Total Productive Maintenance (TPM), were fundamentally linked to the high levels of quality and customer focus that are so associated with Toyota’s success.

### 2.2 Total Quality Management (TQM)

Toyota was a relative latecomer to TPM, or as it was known as in 1960s, Total Quality Control (TQC). In contrast to the internally driven TPS, TQC was introduced via the US. The term originated from Armand Feigenbaum, who described TQC as an effective system for integrating the quality development, quality maintenance, and quality improvement efforts of the various groups in an organization to deliver full customer satisfaction (Feigenbaum 1956). However, TQC in the US meant something different to what was implemented by Toyota, which required the direct involvement of senior management across the whole organization, not just in engineering. Four key assumptions underpin TQC: that quality is less costly than poor workmanship, that employees care about quality and will improve it given the ability to do so, that organizations are systems of independent parts, and that senior managers create the system and are responsible for it. During the 1990s, the term TQM emerged from the principles of TQC as a common term among organizations to reflect a style of management that gives everyone in an organization responsibility for delivering quality to the customer (Dahlgaard-Park and Dahlgaard 2007).

Founders of the quality movement in Japan include W. Edwards Deming and Joseph Juran, two statisticians from the US who went to Japan in the 1950s to help with the post-war reconstruction. Whilst Deming focused on the use of statistical process control to reduce variation in processes, Juran started courses in quality management for senior and middle managers. Juran is responsible for introducing the Pareto Principle of the vital few and trivial many, the 80/20 rule, to Japanese manufacturers and demonstrating that it could apply universally to many management functions (Juran and Godfrey 1951).

Walter Shewhart originally developed the learning and improvement cycle that is used in problem solving at Toyota to support Kaizen. This same cycle was later published in a book edited by his student, W. Edwards Deming (Shewhart and Deming 1939). Dr. Deming modified the original cycle into a four-stage approach, which has been summarized as “PDCA” or Plan, Do, Check, and Act (or often, Plan, Do, Study, Act). Essentially, the approach first looks to identify the root cause of problems and then to eliminate the problem and achieve a higher level of performance. The Deming Application Prize for Quality was established in Japan in 1951 to honor W. Edwards Deming, who had contributed so much to Japan’s proliferation of quality control and the philosophy of quality management (Mann 1985).

Nissan and Nippodenso (the company now known as Denso) had won Deming Application Prizes before Toyota formally adopted the TQC methodology as a company-wide program in 1961 and then went on to win the Deming Application Prize in 1965 (Shimokawa and Fujimoto 2009).

Unlike TPS, TQC was implemented as a top-down process and became part of the policy management system, known as *Hoshin Kanri*. TQC reinforced the *Genchi Gembutsu*, fact-based management that checks in the workplace to see the actual situation first-hand. This was built into the Quality Circles, introduced by Japanese quality guru, Ishikawa, and the TPS Kaizen improvements (Mann 1985).
2.3 Total Productive Maintenance (TPM)

Developed by Nakajima (1988), TPM is a systems approach first implemented in Nippodenso that is designed to optimize the performance, reliability, and productivity of plants and equipment by analyzing the reasons for stoppage to improve overall equipment effectiveness (OEE). In a JIT environment, equipment reliability and availability are critical in order to satisfy demand in a low inventory system. TPM is based on eight pillars: focused improvement; autonomous maintenance; planned maintenance; quality maintenance; cost deployment; early equipment management; training and education; and safety, health, and environment (Rich 2001). Elemental to TPM is 5S to reduce stoppages and delays due to searching for tools and other items. 5S is based on five Japanese words: seiri, seiton, seiso, seiketsu, and shitsuke. These words translate into sort, straighten, shine, standardize, and sustain, that represents five aspects of workplace organization.

It was against this backdrop that Lean Production emerged as an alternative to mass production in 1990. Lean, which emphasizes the socio-technical system of eliminating waste in all operational activities to provide value to the customer in the shortest possible lead-time, may be described as an organizational and managerial concept that advocates for the emulation of the systems in place at Toyota to other industries and sectors outside of Toyota and automotive manufacturing. It does this by focusing on customer value and the efficiencies of the “Flow” of products and services, compared to the efficiencies of “Resources”; equipment, either machines or IT systems; and people in a mass environment (Modig and Åhlström 2015). Lean has been one of the dominant logics in operations management since the 1990s and has influenced many organizations in different sectors, improving their production systems through simultaneously focusing on quality, productivity, efficiency, and flexibility by bringing together the concepts of TPS with that of TQM and TPM.

3 Evolution of Lean Production Research

Although Lean started as a description of TPS and focused heavily on Lean tools, evidence in the literature demonstrates that Lean has evolved over time. In doing so, it has spread well beyond the traditional Japanese automotive manufacturing roots to an enterprise-wide system focused on best practice and process improvement methodologies that has been adopted and adapted by both private and public sector organizations around the world. In a three-year study on the diffusion of Lean, Samuel (2012) established that the period between 1987–1995 was dominated by automobile and automotive supply chain publications. From 1995, publications on aerospace and electronics industries emerged. These were soon followed by publications on retail, construction, financial services, and health. This expansion into other areas was fueled by the publication of Lean Thinking (Womack and Jones 1996), which had introduced a core set of principles that could be adapted to any organization and had broadened the concept to other sectors.

The five Lean principles of customer value, value streams, flow, pull at the pace of customer demand, and the pursuit of perfection through continuous improvement represent a roadmap for those organizations attempting to implement Lean, or to emulate TPS. Since 2000, the body of Lean literature in all sectors has increased substantially and has extended from private sector manufacturing and service organizations to the public sector and public services in almost all departments from healthcare to education, welfare, and justice. In addition, more recent publications on innovation and new product/service development, leadership, culture, and IT have taken Lean beyond the traditional fields of operations and process improvement into more enterprise-wide areas from which the concept of operational excellence has emerged.
Over the years, however, many authors have noted a lack of a clear definition of Lean. This lack has contributed to the underdevelopment of Lean in academic research. Karlsson and Åhlström (1996) suggest that commentators on Lean have focused on visible aspects of the process while missing the invisible highly interdependent links of Lean systems as a whole. The conclusion is that this is due to the context-specific origins and the fact that Lean has evolved over time and that, as it continues to advance through experimentation by Toyota and other Lean organizations (Hines et al. 2004), “Lean” can be described as polymorphic, meaning different things to different people, at different moments in time (Samuel et al. 2015).

As with the definition, the scope and objectives of Lean have changed as it has evolved by experimentation. Different authors have different opinions on the characteristics with which it is associated. Shah and Ward (2003) describe four main practices, or bundles, that are part of Lean: JIT, TQM, TPM, and HRM. Pettersen (2009), however, disputes this and states that TQM and other bundles are different and not part of Lean despite the fact that many authors agree that they are critical constituents of the Toyota success story (Schonberger 2015).

Figure 12.2 shows the range of publications (1987–2013) that illustrates the diffusion of Lean publications in all forms of literature.

The period 1987 to 1996 is described as a period of theory building in the evolution of Lean (Lamming 1993; 1996; Womack and Jones 1994; Karlsson and Åhlström 1996; Hines and Rich 1997), which was dominated by academic research. The publication of Lean Thinking (Womack and Jones 1996) preceded a wealth of practitioner-oriented publications including Rother and Shook (1998), Spear and Bowen (1999), Liker (2004), and Bicheno and Holweg (2015). Additionally, there was a shift in empirical research from theory building with an emphasis on Lean tools towards theory testing and case study research to validate the models and concepts (Bhamu and Singh Sangwan 2014). Although Lean is often described as atheoretical, it was during this period that Schmenner and Swink (1998) articulated a theory that, although they did not refer to it as Lean, clearly described and underpinned Lean. It is a theory that seeks to...
explain the phenomenon of why one factory or service operation is more productive, as measured by inputs and outputs, than another. They refer to this as the Theory of Swift, Even Flow, which they define as “the more swift and even the flow of materials through a process, the more productive that process is” (Schmenner and Swink 1998, p. 102). In a later publication, Schmenner (2012, p. 100) describes how the elements of Lean manufacturing fit together into a philosophy that is grounded in swift, even flow.

Lean has since been featured in all types of publication signifying the rise in practitioner interest as more and more organizations adopted Lean and Lean expanded beyond its roots in manufacturing process improvement to private and public sector services, innovation, and environmental studies (Shah and Ward 2003; 2007; Papadopoulou and Ozbayrak 2005; Bhasin and Burcher 2006; Holweg 2007; Hines et al. 2004; 2010; Piercy and Rich, 2009; Spear 2009; Mollenkop et al. 2010). This has been particularly evident in the interest in Lean applied to hospitals and healthcare (Papadopoulou et al. 2011).

Despite the unquestionable success of TPS, questions as to the sustainability of Lean practices were raised. This gave rise to a new wave of research resulting in a new set of literature. In this, many authors noted that successful Lean implementation is dependent on several organizational factors such as leadership and management strategies, employee behaviors, and engagement and investment in training, as well as external forces such as market situations, local and social cultures, and the availability of skilled people (MacDuffie 1995; Hines et al. 2010). Although the concept of “Respect for People” was recognized as a foundational principle of TPS (Sugimori et al. 1977), research interest in the organizational and leadership practices focused many authors on the behavioral concepts of Lean and books on Lean leadership (Emiliani 2007; Koenigsaecker 2009; Liker and Convis 2012) and Lean culture (Mann 2005; Liker and Hoseus 2008) emerged, which concentrated company attention on the management systems that support Lean. However, Ezzamel et al. (2001) question this and contend that the focus on Pokeyo suggests that humans are not trusted to perform the task correctly, suggesting that Lean is based on McGregor’s Theory X, whereas TPM is based on Theory Y.

The concept of Toyota Kata (Rother 2010) builds on the sentiment of Aristotle who said, “We are what we repeatedly do. Excellence, then, is not an act, but a habit” (Cited in Rother 2010, p. 238). Based on an extensive study of Toyota, Rother believes that it is the creation of habits and behaviors in the workforce that are at the root of Toyota’s success as they have been able to create an improvement habit by using PDCA cycles repeatedly to move from the current state to a target condition that progressively moves forward towards an ideal future state that represents “True North,” or perfection.

Throughout this time, there have been fierce critics of Lean. However, these were mainly focused on criticisms of the assertions made in The Machine That Changed the World, rather than on criticism of the concepts behind Lean. Delbridge (1995) criticized the arrogance of the claims made by Womack et al. (1990) and the generalized simplifications based on stereotypes and Western misconceptions. New (2007) takes a similar view, denouncing simple schema that seek to assert bald polarities between TPS and Taylorism. Similarly, Williams et al. (1992; 1994) argue that the “periodization” of craft, mass, and Lean, as used as one of the narrative devices in the book, is misleading.

Coffey (2006) is also critical of empirics within the IMVP study. This is due partly to methodological robustness, but primarily for what he perceives as a poor interpretation of data. He suggests that the role of automation was downplayed and that, if due account had been taken of Europe’s weak overall results, automation would have offered far greater causal explanation. Coffey goes further to suggest that Lean is a historically counterfactual myth, formulated through a collective process of fictionalization, which is essentially politically motivated.
The assumption of universality is disputed by many, and Pettersen (2009) states that if, as claimed by Womack et al. (1990), Lean applies to any industry, then the Japanese would have distributed the knowledge throughout all domestic Japanese industry. The fact that it is represented only by other Japanese automakers—Nissan, Honda, and Mazda—counter this claim.

A number of authors noted the difficulty of measuring the success of Lean implementation efforts. Maskell and Baggaley (2004) argue that Lean implementation often leads to cost avoidance rather than cost reduction and that the accountant community lags behind the operations community in recognizing this. Therefore, the accounting community is often accused of hindering Lean implementation efforts. In particular, criticism revolves around the standard cost accounting methodologies. This is not confined to Western organizations though, as seen in a comment (Ohno 1988) where Ohno stated, “It was not enough to chase out the cost accountants from the plants. The problem was to chase cost accounting from my peoples’ minds” (cited in Bell and Ozen 2016, p. 140). Clearly, this was also an issue that Toyota had to wrestle with.

### 3.1 Lean and the Interactions with Traditional Cost Accounting

Product costing information in traditional management accounting was designed primarily by engineers who understood the product process characteristics of their respective businesses. It was intended to serve two main management purposes: to check whether the product diversity was worthwhile and to check whether a particular division, location, or plant was profitable.

According to Johnson and Kaplan (1987), there was little or no effort made to reconcile financial accounting, reporting to the outside world, with the management accounting used internally to assist decision making and to motivate managers and supervisors. This cost accounting approach to management accounting was developed to support management decision making in the late nineteenth/early twentieth centuries during the beginning of the era of mass production (Johnson and Kaplan 1987; Johnson 1992). Compared with today, the cost structure of manufacturing operations in that era was characterized by a relatively high percentage of direct labor and low indirect costs.

Traditional management accounting conventions that focus on efficiencies and allocation of overheads do not support the Lean paradigm and, whilst alternative accounting approaches, such as Lean Accounting (Maskell and Baggaley 2004) and Flow Accounting (Darlington 2010) have been developed over the last twenty-five years, there is still dissatisfaction amongst academics and practitioners in developing an alternative approach to address this issue fully.

Since the 1980s, the debate in management accounting has become polarized between Activity Based Costing (ABC) and Throughput Accounting (TA). With ABC, managers are required to identify the major activities that pertain to the manufacture of specific products and allocate manufacturing overhead costs to activity cost pools. ABC is the foundation behind Lean Accounting (Maskell and Baggaley 2004). Throughput Accounting (TA) is the use of throughput (the rate at which the system generates money), inventory (all the money the system invests in things it intends to or could sell), and operating expense (all the money the system spends in turning inventory into throughput) as management decision tools to replace traditional cost management reports and analyses. TA is the foundation behind Flow Accounting, which focuses on reducing lead-time by identifying inactivity (IMA 1999; Darlington 2010).

### 3.2 Other Business Improvement Systems in OM

The most significant of the other improvement methodologies that emerged since 1990 are Six Sigma (SS), Agile Manufacturing (AM), and Theory of Constraints (TOC). They mostly have
common aims (minimizing waste and resources, reducing lead-time, and increasing flow to improve customer satisfaction and financial results) and generally common origins (the quality evolution in Japan after the Second World War). In addition, they all represent ways of achieving a swifter and more even flow (Schmenner and Swink 1998). Most of these other improvement methodologies are both complementary and competitive to Lean. They are complementary in the sense they may be implemented alongside Lean. The competitive aspect comes into play in the sense that they compete with Lean in the market for business improvement methodologies. However, it is interesting to note that, due to the lack of a common definition of Lean, some Lean researchers believe that the concepts of SS, TOC, and Agile are all part of the philosophy of Lean while others see them as unique and separate. Hence, Lean Six Sigma (LSS) is a common term in more recent Lean literature and an accreditation system of belts, similar to that of SS exists for LSS.

Each of these methodologies will be described in the next sections and compared to Lean, before moving on to consider the present and future of Lean research.

3.2.1 Six Sigma

As discussed earlier in Section 2.2, the quality movement was central to Toyota’s success and had been ongoing for many years, with the early focus being the evolution from statistical quality control to quality assurance and TQM.

Compared with TQM, SS is a relatively newer improvement methodology although it is now generally regarded as having overtaken TQM in the broader quality movement. SS was never intended to be a replacement to TQM, although the two concepts have common origins, aims, and other shared characteristics. SS is a data-driven method for achieving near perfect quality, which was originally developed by Motorola in 1987 and made popular by the well-publicized implementation at General Electric by Jack Welch. SS itself is a specific measure of quality, most commonly cited as 3.4% defects per million opportunities. The roots of sigma as a measurement standard can be traced back to Carl Gauss, who introduced the concept of the normal distribution curve, and to Walter Shewhart, who described 3 Sigma as a measure of output variation. The SS quality measure means operating at a level of quality that is defective only 0.0003% of the time. This measure acts as the goal of the SS process improvement methodology, although it is seldom achieved.

The methodology for achieving these process improvements is supported by the deployment of a SS hierarchy with champions referred to as black belts. Black belts are full-time project managers who, armed with knowledge of statistically based process improvement tools, implement improvement projects. Black belts follow a common project cycle known as DMAIC (define, measure, analyze, investigate, and control) which is a refinement of Deming’s PDCA cycle.

After comparing TQM with SS, Schroeder et al. (2008) concluded that they differ in four key ways: first, SS has a greater focus on financial and business results; second, SS insists on following the structured DMAIC cycle; third, SS uses more specific metrics; fourth, SS uses several full-time improvement specialists (black belts).

3.2.2 Agile Manufacturing

Agile Manufacturing (AM) is, like Lean, an improvement strategy that emerged in the 1990s. AM arose from an industry-led team that was facilitated by the Iacocca Institute at Lehigh University, Pennsylvania. In contrast to Lean though, AM is described as focusing strategic efforts to
achieve competitiveness through flexibility and does not have the same relentless commitment to reducing waste. It combines the purpose of Lean to reduce lead-time and achieve speed, with the ability to react to changes in demand quickly and hence more flexibly (Gunasekaran and Yusuf 2002). There is a debate now, however, as to whether this still applies. Lean has been proven to be appropriate to both high- and low-volume operations in both manufacturing and services and, with its focus on batch-size reduction, can respond with flexibility. Without a clear definition of either, it is difficult to discriminate.

However, in the software development arena, Agile methodologies have developed strongly with a clear set of principles around software development and project management that helps teams to respond quickly to unpredictability through incremental, iterative work cadences, known as sprints. Agile methodologies, as described in the Agile Manifesto, have a set of values and principles that represent an alternative to traditional, sequential project planning. Agile methodologies are used increasingly in all forms of innovation and the principles are diffusing into the business process improvement environment. Within an Agile environment, “Scrums” replace project meetings where the Product Owner, Team, and “Scrum Master” meet to build product increments within short iterations through empirical feedback and team self-management principles; Mary and Tom Poppendieck (2013) describe this as a Lean Mindset, and the values and principles of the Agile Manifesto are also argued as being complementary to that of contemporary Lean thinking.

3.2.3 Theory of Constraints (TOC)

TOC is a systems-management philosophy developed and made popular by Dr. Eliyahu Goldratt in the mid-1980s through the best-selling management book, *The Goal* (Goldratt and Cox 1984). The goal, according to Goldratt and Cox (1984), is to make money now as well as in the future. TOC defines three operational measures that determine whether operations are working toward that goal; throughput (T), inventory (I), and operating expense (OE). Of key importance in TOC is capacity management to identify bottlenecks or constrained resources. In a TOC environment, these are the resources that need to be scheduled to run at full capacity; all others have “catch-up capability.” The concept of Drum, Buffer, Rope (DBR) as a means of scheduling production was developed by Goldratt (Goldratt and Cox 1984).

Several studies suggested that manufacturing organizations employing TOC exceed the performance of those using Lean (Mabin and Balderstone 2000). Additionally, several not-for-profit and government agencies around the world have also successfully adopted TOC, most notably parts of the UK National Health Service (NHS), the Israeli Air Force, and the US Department of Defense (Watson et al. 2007). While there are similarities between Lean and TOC, they are fundamentally different paradigms. Lean achieves process improvement through the removal of waste; TOC achieves improvement through increasing throughput. Like AM, however, TOC sees inventory as a way to buffer demand.

4 Contemporary and Future Research in Lean Operations Management

Despite significant research and huge investment of time and money over the past two decades, many organizations have struggled to implement and sustain operational improvement in any meaningful way. As we have seen, the 1990s was a time of paradigm flux as OM moved from a mass production paradigm to adopt the practices of Japanese manufacturing (Bartezzaghi...
1999). This was also a period of convergence as functional silos were challenged as new business philosophies have emerged. In addition, the focus on resource efficiency shifted to that of flow efficiency, or effectiveness (Modig and Åhlström 2015).

The contemporary period has been termed the post-Lean era by OM researchers such as MacCarthy et al. (2013) who argue that the links between quality and process excellence are so well understood by managers today, that it is taken as axiomatic in most progressive organizations. As a result, the starting point of implementing Lean or any other improvement methodology has changed, not just in manufacturing but also in services, in both the public and private sector. There is also a plethora of models, frameworks, and roadmaps to choose, perhaps the most significant of these goes back to the roots of the quality movement and the teaching of Dr. W. Edwards Deming.

4.1 Systems Thinking

Dr. Deming talked of thinking in terms of a system and described the system of profound knowledge. The system of profound knowledge is a management philosophy grounded in systems theory (Mann 1985). The system is made up of interrelated components of people and processes with a clearly defined and shared destination or goal. Everyone shares an understanding of, and commitment to, the aim or purpose of the system. Organizations represent systems, and continuous improvement of the system depends on the leader’s understanding of the interconnectedness and interdependence of the parts. Optimization of a system occurs when all interconnecting components are orchestrated to achieve the organization’s goal.

One particular systems thinking approach commonly associated with Lean is the approach of John Seddon (2005). Seddon’s approach uses a service process improvement methodology, the so-called Vanguard Method, that is based on the work of Deming (1982) and Senge (1990). Seddon argues that “Systems Thinking” underpins Lean and that TPS is a striking example of systems thinking applied to a business organization, which focuses on the interrelationship between the various parts of the organization. Having initially allied himself with the Lean movement by naming his approach “Lean Systems” (Jackson et al. 2008), Seddon is now publicly critical of the movement and has inspired debate and dissent within the Lean movement recently. He argues that by creating the label “Lean” to describe TPS, the movement has overemphasized the deployment of tools and techniques to the detriment of that of deeper understanding.

He concedes that organizations will improve by the use of such tools, but that the level of these improvements are insignificant when compared to the benefits from changing system conditions and norms, writing, “The danger with codifying method as tools is that by ignoring the all-important context it obviates the first requirement to understand the problem and, more importantly, to understand and articulate the problem from a systems perspective” (Seddon 2005, p. 190).

4.2 Operational Excellence

1990–2005 was an era of developing and testing theory around TPS and Lean, and one that saw the rise of career pathways of Lean professionals and the development of Lean teams in organizations. However, the last decade has seen a shift from the term Lean in major organizations towards that of Operational Excellence, a term made popular by the Shingo Institute to cover all improvement methodologies. This is consistent with Schonberger’s thinking when he argued that management terms have a lifecycle approximating an “S” curve and that “Lean” had been
in the ascendancy since “JIT” had started to decline in the late 1980s. He put this down to management fatigue, and suggested that the term Lean is undergoing a similar decline in the 2010s.

The term Operational Excellence was used by the Shingo Institute, as an award for the Shingo Prize, which builds on the work of Shigeo Shingo, one of the architects of Lean, particularly in the development of Single Minute Exchange of Die (SMED) that was fundamental to batch-size reduction and flexibility. One of Shingo’s important contributions was the recognition of the importance of the interrelationship of the principles, systems, and tools. So, in contrast to Seddon’s argument that Lean has focused solely on tools, Shingo and the concept of operational excellence taught the principles behind the tools in five key paradigm shifts:

1. Focus on results and behaviors.
2. Behaviors flow from the principles that govern results.
3. Principles underlie the culture that supports the results long term.
4. Creating principle-based cultures requires alignment of the management system.
5. The tools of Lean, TQM, JIT, SS, etc. are enablers and should be used strategically, appropriately, and cautiously to better drive ideal behavior and excellent results.

Although not confined to the Shingo Institute, or indeed to the Shingo Model, Operational Excellence (OE) is becoming a business function of 21st century organizations with Operational Excellence (Op Ex) teams replacing the Lean teams of the early 2000s. The research on OE, like Lean, is practice-led, but includes all the business improvement methodologies and represents a coalition of OM and Human Resource (HR) philosophies.

One OE model that has been developed by Boston Scientific in Galway, Ireland, addresses an issue that some of the managers of the company identified over the last decade. This is where the proliferation of models and the incomplete nature of any single method have made it quite difficult for an organization to navigate a sustainable path to deliver OE. Following an extensive study by one of the authors of this chapter (Lyons) on a range of existing OE methodologies and models in relation to their applicability to implementing and sustaining OE, he concluded that:

- There is an absence of an overarching transformation model that clearly identifies all of the necessary elements to implementing and sustaining operational excellence.
- There is an absence of clarity on the critical interdependence of the necessary elements of OE.
- There is a tendency for over-reliance on consultants’ proprietary “big picture” understanding and their tacit experiential knowledge.

It was apparent to him that no one model/method identified all the necessary elements of implementing and sustaining OE. It also became apparent that the collective knowledge across a range of separate models and methodologies could be distilled into a single unified OE model that focused on the transformation of the organization’s vision into results (Figure 12.3) in which the strategy, values, and principles drive the results through the appropriate tools, measures, technologies, supply chain structures, and skills based on a foundation of leadership and change management in a high-engagement culture.

The model, which illustrates clearly the functional convergence of OM with the other business functions and the convergence of all contemporary business improvement methodologies (Lean, Six Sigma, TOC, and Agile) in a systems approach became the foundation for Boston Scientific, Galway’s strategic model and has been used successfully to develop the business and remain competitive in a harsh economic environment.
5 Future Research Directions

Future research into the application of the principles of Lean continue with studies of integrating concepts such as Lean and Green, working to develop a business system that is effective in reducing process waste and reducing the environmental impact (Pampanelli et al. 2014). This builds on the concepts of Compression (Hall 2011). Lean is predicated on the assumption of growth, but as shown by recent economic turmoil and the slowing down of the Chinese economy, the future may not be a growth future. How then can businesses remain competitive? This has serious implications for managers and can drive research into developing new OM business models that compete differently. Technology and innovation will present new research openings in the future with the widespread adoption of advanced manufacturing and Product-Service Systems (PSSs) where organizations will compete on the basis of their integrated product and service offering (Nadurupati et al. 2013).

Of particular interest in the Lean research community is Lean in the Digital Economy. The “Internet of Things” and the coming together of sensors and machines will change the way we operate and interact. This will be a major source of new products and services, created and produced in very different ways. If the introduction of Lean into OM was considered to be disruptive, this is likely to be the next disruption, with huge implications for OM research.

6 Conclusions

Clearly Lean has spread well beyond the traditional Japanese automotive manufacturing roots and has evolved over time from a generic description of TPS to a business improvement methodology focused on best practice and operational excellence. It has been adopted and adapted by
public and private sector organizations around the world. Research in Lean has changed from
theory development in the early 1990s based on understanding the TPS, to theory testing towards
the end of the 20th century where the principles of Lean were tested in other organizations,
both manufacturing and services, in the private and public sector. The early 21st century saw
questions raised as to the sustainability of change and attention moved from the technical to the
social systems. The view of Lean shifted from a tools focus to a management system focus and
to a whole organizational system or philosophy focus (Bhasin and Burcher 2006). The paradigm
shift from mass production was noted by Duguay et al. (1997) who argued that the era of mass
production as the dominant production paradigm ended in the 1980s and was succeeded by a
new customer-focused paradigm. They further argued that the proliferation of improvement
methodologies in the late 1990s could be associated with paradigmatic chaos (Kuhn 1962 cited
in Duguay et al. 1997) from which the new paradigm emerged, writing that “The decline of
US mass producers has given rise to a variety of approaches better adapted to rapid change, such
as flexible production, Lean production, mass customization and agile manufacturing” (Duguay
et al. 1997, p. 1193). They contend that we have now entered the era (21st century) where Lean
and flexible producers dominate.

This chapter builds on this and demonstrates that, despite the many criticisms of Lean and
the lack of formal definition, Lean has emerged as a dominant global OM paradigm focused on
reducing variability and compressing time in order to improve flow. The link between Lean and
the Theory of Swift, Even Flow (Schmenner and Swink 1998) contributes to theory development
in OM.

However, we believe that although managers have continued to pursue “operational excel-
ence,” they have adopted many of the Lean tools and techniques to achieve this. The Lean move-
ment that was supported by governments, researched and criticized by other academics, could
justifiably claim to be a paradigm shift in OM, whether it is called Lean, Operational Excellence,
or simply the contemporary OM.

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Lean Production


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