Critique on the Lean Production System Research

Mitsuhiro FUKUZAWA

Abstract: Since the 1990s, research has been done on lean production systems with progressive development of a scale for measuring characteristic leanness in efficient production organizations. For example, Shah and Ward (2003, 2007) originated from the HPM and IMSS surveys become as the de facto standard. However, the explanations of these studies were not necessarily convincing. In contrast, in the IMVP survey, site visits were made to automakers’ development and production genba or sites in each country surveyed, in addition to the use of questionnaires. However, in actuality, a comparison of multiple Japanese automakers showed differences in methods and means for achieving just-in-time production in organizations, even at the genba that would be believed to score high on a leanness scale, such as JIT production. It is difficult to detect and measure these differences through large-scale cross-industry questionnaire surveys alone, and there is a possibility that this difficulty manifests in the weak explanatory power of the lean studies. Approaches to explaining differences in performance using “leanness scale” are based on a lean hypothesis where there is a best practice lean
situation transcending nations and industries, yet its low explanatory power creates suspicion with regard to the validity of this hypothesis.

Keywords: lean production system, measurement, performance, organizational capability, research method

Introduction

The question, “What are the characteristics of high performance production organizations?” has seen considerable attention in the academia. Triggered by Skinner (1969), who focused on production activities as an important source of corporate competitiveness, much research has been conducted on monozukuri activities (development, production, etc.) since the 1980s. Hays and Wheelwright (1984) and Schonberger (1986) termed high-performance production firms as “world-class manufacturing” and “world-class competitors.”¹ Later, Womack, Jones, and Roos (1990) summarized the results of an international comparative analysis of production systems among automakers. It revealed that the monozukuri of Japanese firms (typically the Toyota Production System) performed better than those of Western firms and interpreted and conceptualized these characteristics as the “lean production system.” Interest in the US manufacturing slump and the structure and success of monozukuri in Japanese firms in the 1980s developed² into Western research on

¹ Literature by Japanese researchers and practitioners in the 1980s in English on the Toyota Production System and kaizen activities includes Monden (1983), Imai (1986), and Ohno (1988).
² See Holweg (2007) for details on the timeline of the “lean” nomenclature and subsequent development of lean research. Additionally, there are comprehensive reviews on lean research and studies regarding lean practices, their implementation, and their adoption in service industries (Bhamu & Sangwan, 2014; Samuel, Found, & Williams, 2015).
the lean production system, and researchers around the world have studied product development, production, and supply chain management (Clark & Fujimoto, 1991; Cusumano & Nobeoka, 1998; Flynn & Flynn, 2004; Flynn, Huo, & Zhao, 2010; Frohlich & Westbrook, 2001; Fujimoto, 1999, 2012; Fukuzawa, 2015; Fukuzawa & Inamizu, 2017; Holweg, 2007; Holweg & Pil, 2004; Inamizu & Fukuzawa, 2017; Ketokivi & Schroeder, 2004; MacDuffie & Pil, 1995; MacDuffie, Sethuraman, & Fisher, 1996; Oki, 2012; Shah & Ward, 2003, 2007; Swink, Narasimhan, & Wang, 2007; Takeishi, 2003).

In this line of research, it is essential to consider how has efficient monozukuri been understood and measured. This paper explores the contributions and limitations of some measurement scales aimed at quantitatively measuring the lean production system, through reviewing the existing questionnaire survey researches\(^3\) on the said subject.

**Research Streams of the Lean Production System**

(1) “Lean Production System” revealed by the international survey of automotive companies (HBS–IMVP Study)

Since the latter half of the 1970s, US researchers, mainly those at Harvard and MIT, have studied automotive companies owing to the growth of Japanese firms and difficulties of the US manufacturing industry (Abernathy, 1978; Abernathy, Clark, & Kantrow, 1983; Hayes & Wheelwright, 1984). Through the International Motor Vehicle Program (IMVP), the concept of the “lean production system” was presented using the Toyota Production System as a benchmark, and the direction of research on the performance of production and

\(^3\) As another research method, case study was also used in the lean production research.
development activities has been set.

Further, multiple rounds of the IMVP were conducted; including detailed case studies and questionnaire surveys on production, development, sales, and supplier management. The IMVP was oriented to obtain objective performance data and organizational variables (interdivisional coordination and behavioral characteristics and authority of product managers), and, in addition to questionnaire surveys, it conducted on-site observations and interviews with practitioners.

Even in the automobile industry alone, there are differences between companies with regard to product complexity; thus, acquisition of numerical data on performance was difficult, requiring workarounds to make corrections (MacDuffie & Pil, 1995). However, empirical studies on major automakers throughout the world had a major impact on later research and presented influential concepts such as lean production system and heavyweight product manager (HWPM). These studies identified various characteristics for achieving high performance and showed that national and cultural differences do not create differences in productivity or other types of performance, validating that the management of development and production organizations and their strategies create performance differences.

In the 2010s, IMVP was renamed as Program on Vehicle and Mobility Innovation (PVMI), and its research community continued to study aspects such as developing environmentally friendly technologies for electric cars and safety technologies, as well as changes in business models, such as MaaS (mobility as a service), in response to the evolution of the automobile industry.

(2) Cross-industrial survey of the “Best Practice” implementation (HPM Study, IMSS Study)

Researchers at the University of Minnesota and Iowa State
University (e.g., Barbara B. Flynn and Roger G. Schroeder) referenced the factors and variables raised by Hayes and Wheelwright (1984) to compare the North American factories of Japanese firms to the North American factories of North American firms and started the World-Class Manufacturing (WCM) Project (later renamed as the High Performance Manufacturing Project). The first round of the project was conducted in 1989 and studied only US factories. In 1996, the second round was conducted, followed by the third in 2005, and the fourth in 2012–2013. During that time, the project added factories in Germany, Italy, Japan, and the UK, and since the 2000s, it has also examined factories in Austria, Finland, Sweden, and South Korea, thereby developing into an international comparison across industries. It primarily analyzes the relationship between performance and JIT, TQM, and HRM initiatives in production (Flynn & Flynn, 2004; Flynn, Sakakibara, & Schroeder, 1995; Flynn, Schroeder, & Flynn, 1999; Flynn, Schroeder, Flynn, Sakakibara, & Bates, 1997; Schroeder & Flynn, 2001). Later on, Bozarth, Warsing, Flynn, and Flynn (2009) analyzed supply chain management using HMP project data.

In Europe, the International Manufacturing Strategy Survey (IMSS) began in the London Business School (e.g., Christopher A. Voss) and Sweden’s Chalmers University of Technology (e.g., Per Lindberg) to compare and analyze cross-industry and international performance, production strategy, and supply chain management. The IMSS has been conducted six times: 1992 (20 countries, 600 firms); 1996 (26 countries, 703 firms); 2000 (23 countries, 558 firms); 2005 (23 countries, 709 firms); 2009 (21 countries, 750 firms); and 2013 (19

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4 Flynn, Sakakibara, Schroeder, Bates, and Flynn (1990) summarized the empirical analysis methods of the production management field, probably aiming to establish a method of measurement for quantitative analyses.

5 Results of the initial survey were summarized by Lindberg et al. (1998) and the results of the survey’s sixth round by Brennan and Vecchi (2017).
countries, 843 firms) (Netland & Frick, 2017). Peter Ward of Ohio State University in the US was listed up as author in the first-round survey’s book (Lindberg, Voss, & Blackmon, 1998).

In the HPM and IMSS survey questionnaires, a measurement scale was developed, allowing for comparative analysis across product or industry differences of various characteristics of high-performing production systems. By aggregating practitioner’s subjective responses to questions regarding practices and organizational efforts, the level of implementing practices was regarded as “leanness,” and the relationship with performance was analyzed.

After the 2000s, researchers who had measured leanness of production activities have also studied the relationship between excellence in cross-functional coordination and performance (Bozarth et al., 2009; Enz & Lambert, 2015; Frankel & Mollenkopf, 2015; Frohlich & Westbrook, 2001; O’Leary-Kelly & Flores, 2002; Swink & Schoenherr, 2015; Thomé & Sousa, 2016; Turkulainen & Ketokivi, 2012; Williams, Roh, Tokar, & Swink, 2013; Zhao, Huo, Selen, & Yeung, 2011).

(3) Short summary

Studies that have empirically elucidated characteristics of high-performing organizations include (1) those that have analyzed single industries and (2) those that have conducted analyses across industries and internationally with regard to the relationship between characteristics of production systems and performance. In particular, the latter have compared, internationally and across industries, levels of implementing best practices assumed to generate high performance, namely the relationship between “leanness” and performance. Conversely, on this background of the approach is the hypothesis that there exists a “best practice leanness” transcending national borders and industries. These studies have attempted to explain differences in performance among companies as
differences in leanness based on the validity of this hypothesis. Calling this the “lean hypothesis,” the next section focuses on Shah and Ward (2003, 2007), the de facto method for measuring leanness under this hypothesis.

**Defacto Standard of the Leanness Measurement**

(1) Trend of citations in the lean production research

When searching the existing 608\(^6\) papers from 1985 to 2018 on

![Figure 1. Transition of the citations of Shah and Ward (2003, 2007)](image)

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\(^6\) Categories were set to operations research management, engineering manufacturing, business, and management. Document types were article, review, book, and book chapter. Publications were *Management Science*, *International Journal of Operations & Production Management*, *Sloan Management Review*, *International Journal of Production Economics*, *International Journal of Production Research*, *Organization Studies*, *Production and Operations Management*, *Production Planning Control*, *Journal of Operations Management*, *Harvard Business Review*, *Supply Chain Management*, and *Human Relations*. 91
Web of Science with the search term “lean*,” Shah and Ward (2003) was at number one, with 860 citations, and Shah and Ward (2007) was at number four, with 613 citations (as of January 21, 2019). Figure 1 shows the growth in the number of citations for Shah and Ward (2003, 2007). From this figure, we can see that, at the very least, Shah and Ward (2003, 2007) have been the central papers in lean-related research since 2003.

Shah and Ward (2003, 2007) summarized and integrated measurements of existing research, such as HPM and IMSS research, and developed a scale for measuring the “leanness” characteristic of high-performance organizations quantitatively and cross-sectionally using questionnaires.

(2) Shah and Ward (2003): Proposal and validation of “lean bundles”

Shah and Ward (2003) noted 22 main practices in lean production systems based on a review of prior research and placed the ones that were mutually related into four lean bundles: JIT, TQM, TPM, and HRM. However, they also noted that little research has been done using these four bundles.

Further, the authors analyzed survey data of Penton Media’s (the publisher of Industry Week) 1999 annual survey of manufacturing managers and firms in food, textiles, machinery, transportation equipment, and electric and electronic equipment industries. For each practice, respondents noted whether “they do not engage in that practice,” “engage in that practice to a certain extent,” or “are very much engaged in that practice.” A principal component analysis was then done on the responses, with primary components found for each of the aforementioned four lean bundles.

Moreover, as a factory performance, rates of change (manufacturing lead time, waste and reprocessing costs, labor productivity, manufacturing costs per unit of time, yield, and customer lead time) over the past five years were queried, and the
first primary component in the primary component analysis was used as a performance variable. Industries and the three context factors of factory size, years of operation, and labor organization percentage, which are all believed to impact the implementation of lean practices, were set as control variables for a hierarchical regression analysis, wherein the four lean bundles were independent variables. By adding the four lean bundles, the hierarchical regression analysis resulted in the ability to explain approximately 23% of the variance of the performance variable (a model with context factors and industry dummies as independent variables can explain approximately 5% of the variance of the performance variable). Additionally, when comparing assembly industries and process industries, the former is more progressive in implementing JIT, and the latter is more progressive in implementing TPM, showing the differences in lean practice achievement that reflects differences in process characteristics between industries. Thus, Shah and Ward (2003) insisted that this was the first paper to show the significant positive impact of all four lean bundles on performance. However, the following concerns remain.

a) It is asserted that there is evidence connecting a synergy effect between lean practices and better manufacturing performance, although a synergy effect between the four bundles has not been sufficiently demonstrated.

b) No consideration was given to consistency between the five-year period of performance based on the rate of change and the timing of the period when lean practices were implemented.

c) While the ability to explain approximately 23% of the variance of performance between factories was an important contribution of the paper, on the contrary, this means approximately 77% of the variance cannot be explained.
Shah and Ward (2007) reviewed research on lean production and noted confusion and discrepancies regarding lean production among researchers and practitioners. Therefore, they defined the primary objective of lean production as “eliminating waste by concurrently reducing or minimizing supplier, customer, and internal variability.” In an exploratory factor analysis based on a pilot study that identified 48 lean-related practices based on prior research, the number was reduced to 41 practices, and a confirmatory factor analysis aggregated them into ten elements \((N = 280)\). Among these, some elements have a significant positive correlation, and the paper asserted that thinking of a lean production system as made up of multiple practices is important.

Figure 3 of Shah and Ward (2007) summarizes the relationship between the ten concepts making up lean production and actual measurements. Thus, ten items regarded as concepts of lean production (each item with multiple questions) were set, and respondents noted their level of implementation for each practice in the factory on a 5-point scale (1 being not implementing at all, 3 implementing to a certain extent, and 5 fully implementing). These items can be categorized into three main groups: (1) internally related; (2) supplier related; and (3) customer related. For the first group, there were six items: pull, flow, low setup, controlled processes, productive maintenance, and involved employees. Three items were supplier related: supplier feedback, JIT delivery, and developing suppliers. One item was customer related, i.e., involved customers.

Thus, Shah and Ward (2007) developed a scale to measure “lean production” but did not analyze its relationship with performance. Later, Furlan, Vinelli, and dal Pont (2011) replaced the questions and measurement scale of the HPM project with the
variables and measurement scale of Shah and Ward (2003, 2007) and, using data from 2005 to 2007, analyzed the relationship with regard to complementarity between lean bundles and performance.

**Discussion and Conclusion**

Large scale and cross-industrial questionnaire surveys conducted in the 1990s through the 2010s analyzed the relationship between the level of achievement of practices comprising lean production methods and performance (QCDF, market performance, or financial performance). Such research method makes a cross-industry analysis easier, as it has the following merits: (1) enables the measurement on a common scale; (2) makes a quantitative analysis of large samples and the comparability with past survey data easier; (3) enables the assessment of companies’ lean achievement and measurement of performance and is a convenient, effective tool that can be used when creating an ideal state for *genba* performance improvement; and (4) the results of such research are easily published in academic journals. In particular, because there is already a “de facto” standard for measurement, “paper mass production” is possible by citing it and making a certain level of customizations, revising datasets, and expanding the industries studied.

These existing studies measure proximity to predetermined ideal lean circumstances, and they do not necessarily capture the real and detailed state of production floor’s “creation and transfer of design information” (Fujimoto, 1999). As such, it is difficult to bring up and identify actual variations in monozukuri activities on the genba, and they are limited in their inability to ascertain only in part differences in organizational capabilities that support these activities. Moreover, if firms that have achieved a high level of predetermined “leanness” account for the majority of respondents in surveys, it becomes
difficult to identify differences between firms as to level of achievement.

The reason for focusing on these types of limitations is that, when participating in the Manufacturing Management Research Center (MMRC) that was the site of the IMVP and IMSS surveys in Japan, the author witnessed differences in approaches between the two surveys. In research such as the IMSS with large international, cross-industry samples, it is difficult to actually visit sites in the survey. On the contrary, in the IMVP survey, not only responses to questionnaires were obtained but actual visits were also made to the development and production sites of automakers in each country. Even in Japan, the production sites of multiple automakers were visited, and actual actions of workers and the flow of objects and information were observed.

If responses are obtained from people on these genba regarding such questions as “Do you have JIT production?” “Do you statistically manage quality?” “Do you do preventative maintenance?” and “Do you work on companywide quality improvement activities?” on a 5-point scale, any company should answer with a “5, i.e., we are implementing,” thereby making for a very high standard. However, by actually visiting sites, observing, and listening to people on site, one notices differences in how things are done when asking “How did you achieve JIT production?” The on-site “flow of objects and information,” for example, how production plans are created, the methods for turning order information into actual production orders, the methods of work in production sites, setting work-in-process inventory, ways of transporting parts, etc., tend to differ by company and site. In other words, there are real differences in performance between companies, and even if these differences are caused by differences in how JIT production is achieved, any company will respond with the highest score, when asked about their level of “JIT production” achievement. This leads to creating no differences among companies
on a scale of leanness and thus providing no explanation for the
difference in performance. This tendency will predictably stand out
when analyzing the sites of firms that have created advanced
organizational capabilities through continuous improvement in
particular, as it is likely that all such companies will be high on the
leanness scale. Thus, even when only comparing sites in the same
industry, such as automobiles, there will be some firms that cannot
be understood by a leanness scale alone. This is perhaps one reason
Shah and Ward (2003) can only explain 23% of the disparities in
performance between factories.

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