TOYOTA'S LAST SECRET?

Radical decentralization, target costing, and Japanese management accounting has supercharged Toyota's development and production operations.

THOMAS JACKSON AND JEFFREY ARMFIELD

Toyota has many secrets. In 1990, Womack, Jones, and Roos revealed Toyota's "secret weapon:" lean production, aka the Toyota Production System (TPS).[1] John Shook tells us that Toyota's secret is a one-page report known as the "A3."[2] Daniel Mathews says Toyota's secret is how it "teaches people to see."[3]

In his recent book, *The Secret Behind the Success of Toyota*, lean consultant Takao Sakai tells us that Toyota's real secret is Toyota Product Development (TPD) and its chief engineer, the *shusa*, and the method of target costing. Toyota's strategy for a new product is defined by the *shusa's* concept paper, which contains his vision, or *hoshin*, for the product. The concept paper is the *shusa's* quality and financial playbook for TPD, TPS, and Toyota's powerful suppliers. Sakai states that up to 99 percent of Toyota's profits derive from TPD. TPS plays a supporting role, ensuring that the design information created by TPD is mapped faithfully into the physical media of metal, glass, plastic, fabric, and silicon.[4]

What's in the *shusa's hoshin*? The word *hoshin* can mean both "compass" and "strategy." As expressed in the *shusa's* concept paper, his *hoshin* is as much a strategic vision of Toyota's financial performance as it is an image of a beautiful and useful product. The concept paper rarely exceeds 25 pages[5] and describes:

- customer and market needs;
- competitive analyses;
- product targets;
- timelines; and
- expected financial outcomes.

Ultimately, the concept paper strives to clarify what is value added in the eyes of the customer and what is important for the business.[6]

While not exactly new, Sakai's claims are presented with new clarity and force.[7] His model of TPD and TPS is loaded with important implications for the lean movement, which, as most would agree, is far from complete. Sakai's model has its limitations, however, starting with a lack of evidence for the assertion that TPD is responsible for effectively all of Toyota's profits. The purpose of this article is to develop the model by addressing these limitations in light of current research and practice. We restate the model and explore its broad implications for lean practitioners.

Sakai's model of Toyota

In the first two chapters of his book, Sakai develops an interesting model of what he calls the Total Toyota Management System (TTMS). Exhibit 1 illustrates Sakai's geographical picture of how TTMS integrates TPD and TPS into a single management system.

TPD and TPS are located physically side by side, with TPD on the east side and TPS

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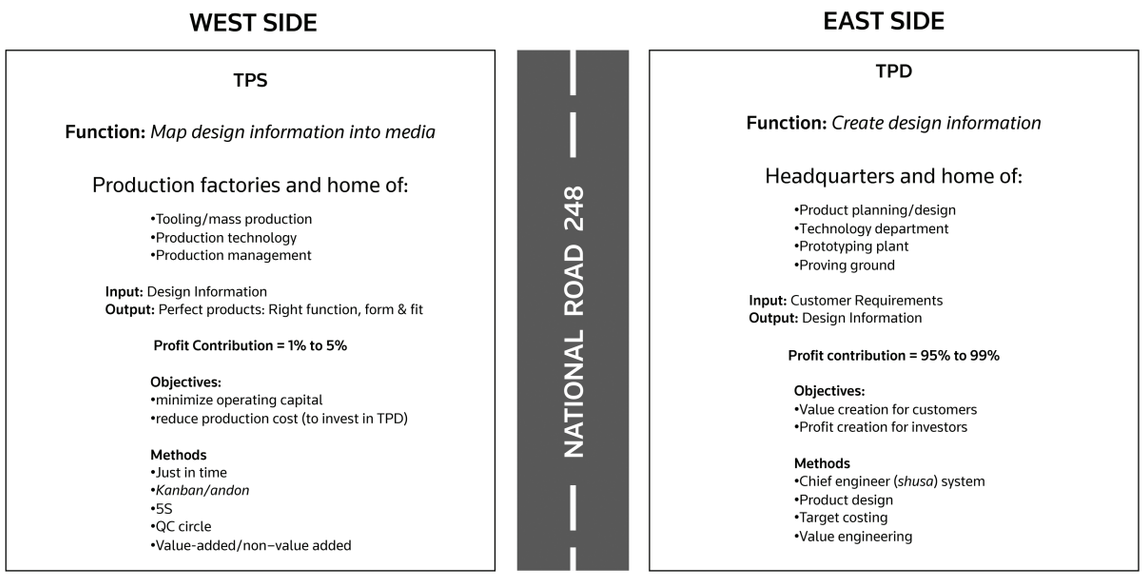
EXHIBIT 1
Total Toyota Management System



Data from: Sakai, T., *The Secret Behind the Success of Toyota: How the Original Chief Engineer System Works to Generate Most of the Product Value & Profit*. (Monee, IL: Takana Sakai, 2018).

on the west side of National Road 248 (NR 248), which runs through Japan's Aichi Prefecture, home to Toyota City. Apparently, there are no secrets on the west side of the road. The secret is on the east side. The heart of TTMS is TPD's *shusa*. According to Eiji Toyoda, former president and later chairman of Toyota, the "*shusa* is the president of his product and the corporate president takes the role of helping all the *shusas*."[8]

The output of Toyota's development process is a package of design information that provides manufacturability to TPS and its suppliers, value to the customer, and profitability to Toyota and its investors. In creating the design information, the *shusa* is guided by the target cost equation:

target or allowable cost = market price – target profit.[9]

This equation is the axis that marks both the north and south poles of Toyota's world. Improvement is what makes that world turn. To understand the role of target costing in that world's rotation, it may be helpful to state the equation as part of a formal problem of constrained optimization:

Optimize $C_{Tx} = P_{Mx} - P_{Tx}$,
subject to the constraint: $x = f(v_1, v_2, v_3, \ldots, v_n,)$,
where

x = the product proposed in the *shusa's* concept paper,

C_{Tx} = the target cost of product x,

P_{Mx} = a constant, the expected market price of product x,

P_{Tx} = a constant, the target profit per unit of x required by Toyota's board of directors,

v_i = a product value or quality function, given to TPD by Toyota Sales, and

n = total number of product values or quality functions required by customers in the target market.

The creative process of the *shusa* and TPD can be likened to Michelangelo's celebrated process as a sculptor. The *shusa* must see "David in the stone" — that is, he must hold the entire problem firmly in his mind's eye. Through a careful process of elimination, he optimizes the target cost (C_{Tx}) by removing anything from the design information that does not contribute to the

description of a merchantable, profitable product (x). The *shusa* and Toyota's engineers use value engineering to whittle away non–value added features, materials, processing, labor, and capital investment while investing in those product values v that will result in customer satisfaction at market price (P_{Mx}) and generate the desired profit (P_{Tx}).

The plausibility of 95 percent to 99 percent cost determination

To achieve Toyota's target profit, the *shusa* must determine — insofar as possible — the cost of the new product, including its capital and production costs in advance of launch. Sakai claims that the *shusa* and TPD are so good at cost determination that they are responsible for up to 99 percent of Toyota's profits. Is this plausible? Studies done by General Motors, Rolls-Royce, Ford, and other leading manufacturers claim that 70 percent to 80 percent of their new product costs are determined in the design phase of the product life cycle.[10] More recent studies throw even these claims into question.[11] We conclude that Sakai's claim is not based on evidence, at least not on evidence that we can ascertain.

ACCORDING TO TARGET-COSTING EXPERT ROBIN COOPER, THE DIFFERENCE BETWEEN TARGET COSTING IN JAPAN AND EVERYWHERE ELSE IS THAT THE JAPANESE HIT THEIR TARGETS.

However, while the 99-percent figure may be exceedingly high, it is not entirely misleading. Whatever the upper limit of cost determination may be for other companies, there are two reasons to believe that it might be higher for Toyota. First, TPD and the development operations of cooperating suppliers apply target costing and value engineering in the joint development of components and processes.[12] Second, through just-in-time, "zero-defect" manufacturing, TPS and Toyota's suppliers shore up any prior contribution made by TPD. According to target-costing expert Robin Cooper, the difference between target costing in Japan and everywhere else is that the Japanese hit their targets.[13]

Limitations of Sakai's model

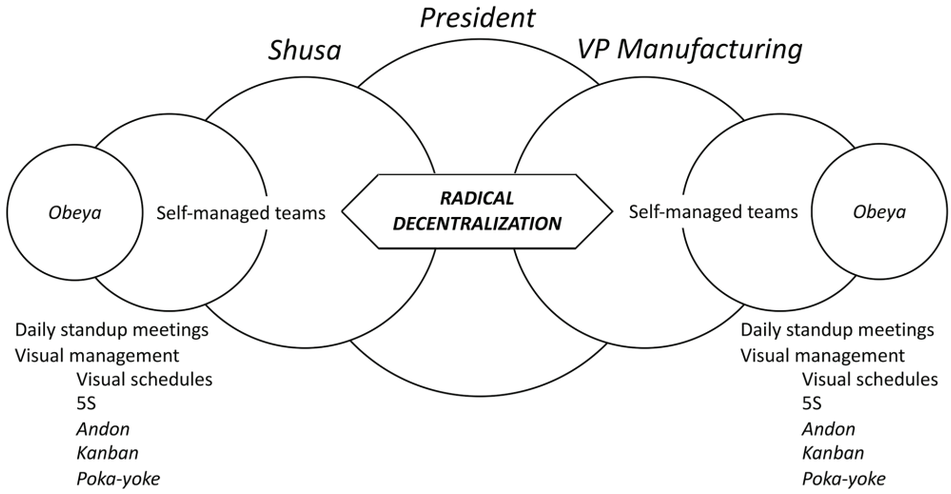
Apart from the likely exaggeration of cost determination, Sakai's model has more serious limitations:

1. While Sakai adequately describes the power of the *shusa*, he does not explain it. The *shusa* stands at the apex of a network of radically decentralized, self-managed teams that give TPD, shall we say, a learning advantage over its competitors. Meanwhile, TPS is structured in the same decentralized manner and employs similar self-managed teams.
2. Sakai fails to observe that target costing is part of Toyota's powerful system of management accounting — a system perfectly adapted to radical decentralization, which Toyota uses to establish, communicate, and audit financial and other performance targets for TPD and TPS.
3. By ignoring set-based concurrent engineering (SBCE), Sakai's treatment of Toyota's product development process is incomplete.
4. Sakai understates the contribution of just-in-time production to cost determination.
5. Sakai's model neglects the role of supply chain partners and interorganizational cost management.

We discuss each limitation separately.

What is radical decentralization? A radically decentralized organization is a coherent collection of self-managed teams focused on a common purpose. Radical decentralization of this type first took shape in the early 1960s, with the invention of quality circles by Kaoru Ishikawa. In quality circles, small teams of frontline workers were tasked with discovering and solving problems of various types "under the guidance of a teacher," but largely without management intervention. Toyota extended this idea to its application of takt time (the rate at which a product must be completed to meet customer demand) in the famous practice of "stop the line." Nippondenso (now Denso) extended the practice to maintenance, where it became known as "autonomous" maintenance, which involves machine operators in the daily inspection and repair of their equipment. The term "radical decentralization" has appeared recently in articles on accounting.[14] More recently, the self-managed teams have been described as a "radical alternative" to corporate command-and-control.[15] Most radically decentralized structures employ a central office to train new practitioners and guide improvement projects. The first of these was Ishikawa's quality circle promotion office. Toyota's *kaizen* promotion office was probably patterned after the quality circle promotion office. Six Sigma offices and offices of continuous improvement and operational excellence are organized in the same way. Agile promotion and transformation offices are the latest example of this device used to teach and guide members of self-managed teams "at the lowest possible level" of their respective organizations.

EXHIBIT 2
Organizational Structure of TTMS



Neglect of organizational structure

Sakai describes the *shusa* system and gives illuminating examples from Toyota's history. However, he does not fully explain why the system is so effective. The quote from Eiji Toyoda describes what is in fact a very decentralized system of product development. Toyota devolves decision-making power from its president to its "president of the product" to a very surprising degree. Decentralization does not stop with the *shusa*. During the development and launch of the Prius, Toyota worked with Japanese Management Association consultants to develop the *obeya*, meaning "big room." The *obeya* combines daily standup meetings with standard knowledge work supported by visual management that includes 5S methodology (translated from Japanese to sort, set in order, shine, standardize, and sustain), large visual schedules, andon (systematic notification of problems during the manufacturing process), and *poka-yoke* (mistake-proofing). With Toyota's adoption of the *obeya*, autonomous decision-making power was extended to self-managed project teams that meet daily in front of detailed, wall-size project schedules to review work completed and work to be done. The *shusa's hoshin* is prominently displayed together with detailed drawings of the specific product, component, or part that the team is designing. Team members analyze defects and the non–value added elements of their own work. Issue boards are used to track work on simple problems. Teams break down more complex problems with advanced visual problem-solving tools.[16]

In the *obeya* created for the Prius, Toyota's *shusa* replicated many practices followed in production, where visual management and daily standup meetings were born.[17] In fact, the word *obeya* is used today to refer to any center of visual management where self-managed teams hold scheduled review meetings and practice the plan-do-check-act method (PDCA). There are striking parallels in the structure of TPD and TPS. In TPD, parts and components are designed by discrete development teams. In TPS, the production of those parts and components is organized into discrete value streams with mostly dedicated equipment. Whether in TPD or TPS, at the extremities of TTMS, we find self-managed teams practicing visual management in *obeyas* (see Exhibit 2). In their *obeyas*, leaders, managers, project team members, and machine operators all follow what many readers know as "Rule 4 of lean DNA:" "Any improvement must be made in accordance with the scientific method, under the guidance of a teacher, at the lowest possible level in the organization."[18]

HOW MUCH BETTER ARE RADICALLY DECENTRALIZED ORGANIZATIONS LIKE TOYOTA AT LEARNING THAN THEIR RELATIVELY CENTRALIZED COMPETITORS? THE ANSWER TO THIS QUESTION CAN BE MEASURED IN TERMS OF REDUCTIONS IN LEAD TIME, INVENTORIES, LABOR HOURS, AND DEFECTS.

Both TPD and TPS practice continuous improvement, whereby frontline developers in TPD and frontline operators in TPS are empowered to find and fix problems, often without management intervention.

Please refer again to Exhibit 2. Economists classify business organizations according to their degree of decentralization. For example, in 1920, the Ford Motor Corporation was a highly centralized, unified or U-form organization. At about the same time, GM invented the multidivisional or M-form organization. GM's CEO, Alfred Sloan, decentralized GM into roughly ten divisions, each with its own autonomous divisional leader.[19] Historians and economists credit the M-form corporation for GM's ascendancy over Ford in 1927.[20] By the end of the 20th century, nearly all the world's major business corporations were M-form.

Toyota's management system yokes together hundreds or even thousands of self-managed teams. That is why, compared to GM's system of roughly ten autonomous divisions, Toyota is radically decentralized. In 1919, because GM had over ten autonomous divisions,[21] and Ford Motor Company had no autonomous divisions, GM was decentralized by roughly one order of magnitude. Toyota has driven decentralization deep into all its functions, including development and production and, beyond that, into its suppliers. Compared to GM, Toyota is more decentralized by three or four orders of magnitude. Jackson has argued that Toyota exhibits a cybernetic or C-form of organization.[22]

The advantage to any type of decentralization is improved organizational learning. For this reason, the history of organizational structure since the rise of big business in the 19th century has been a movement, however slow, from centralized to ever more decentralized structures. Centralized organizations are led by standard-setters who spend much of their time enforcing those standards instead of thinking about the future. As a result, centralized organizations are capable only of single loop learning: learning that does not involve much questioning by the rank and file about how the work is done or why it is done in a particular way. Decentralized organizations delegate decision-making and then trust those to whom decision-making power has been delegated to self-enforce or audit their own performance. Decentralization prefers to trust and verify rather than to command and control. Consequently, decentralized organizations are capable of double loop learning, which involves questioning the underlying values and assumptions of how things are typically done. (What we call continuous improvement is an excellent example of double loop learning in action.) When empowered decision makers live up to the high expectations of self-control, decentralized organizations can find defects and fix them faster than their centralized counterparts. Here we must understand "defect" in very broad terms because, truth be told, defects occur at every level of activity. Defects include flaws in corporate strategy as well as dented fenders, bent chair legs, and miscoded algorithms.[23]

As the result of double loop learning by its CEO and divisional leaders, GM was able to respond strategically to the affluent consumer markets of the Roaring '20s, which called for style, color, options, and of course, bigger engines. Alfred Sloan's strategy for GM was to make a car "for every purse and purpose." GM's decentralized structure improved organizational learning enough to do exactly that. Meanwhile, Ford pursued a losing strategy focused on providing basic transportation, summed up in a statement often attributed to Henry Ford: "Give them any color they want, so long as it's black." Toyota's radically decentralized structure permitted it to organize flexible, small-lot production in pursuit of Japan's diverse and fragmented internal markets in the wake of World War II. Later, the same structure had improved Toyota's learning capacity enough to successfully challenge GM, Ford, and all the world's automotive giants in their own markets.

How much better are radically decentralized organizations like Toyota at learning than their relatively centralized competitors? The answer to this question can be measured in terms of reductions in lead time, inventories, labor hours, and defects. An excellent example of these advantages is found in the box score on the lean transformation of German automaker Porsche (see Exhibit 3). Between the years 1991 and 1997, under the guidance of the Japanese consulting

EXHIBIT 3
Partial Box Score on Porsche's Lean Transformation

	Pre-transformation 1991	Post-transformation 1997
Time		
Concept to launch	7 years	3 years
Welding to finished car	6 weeks	3 days
Inventories (days of supply on hand)	17 days	3.2 days
Effort (direct and indirect hours to assemble a 911)	120 hours	45 hours
Errors		
Supplied parts (defective parts per million)	10,000	100
Defects per vehicle off the assembly line	100	25

Data from: Womack, J.P. and Jones, D.T, *Lean Thinking: Banish Waste and Create Wealth in your Organization*. (New York: Simon & Shuster, 1996): 213.

firm Shingijutsu, Porsche dramatically avoided bankruptcy by simultaneously decentralizing its organization, adopting lean development and lean production methods, and reorganizing its supply chain.

Neglect of management accounting

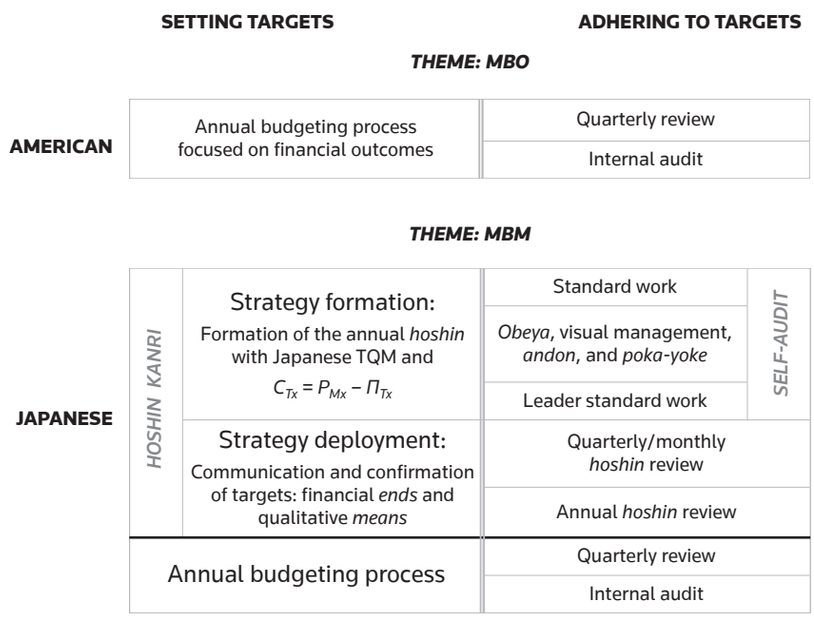
While Sakai rightly emphasizes target costing in his explanation of Toyota's success, he fails to mention its role in Toyota's overall accounting system. We are not speaking here of lean accounting, which changes the treatment of inventories, quick changeovers, and other novel elements of lean manufacturing's small lot production paradigm. Neither are we speaking of Toyota's system of allocating indirect costs more or less directly to each product, a practice that supplants traditional standard costing.[24] We are speaking of Toyota's management accounting, a system designed to (1) communicate financial and other performance targets to self-managed teams and (2) audit team performance as it occurs instead of months or years after the fact.

Why did Toyota create a new type of management accounting? Decentralization obviously has its advantages, but they come with risks. The risk arises because of the separation of ownership and control in large business organizations. This separation creates what is known as agency risk, the risk that managers (who are agents of the corporations they serve) will pursue their own private agendas instead of maximizing the profits of their shareholders. If a solution to the agency problem can be found, the risk is worth it. Historically speaking, classic management accounting is that solution.

Wittingly or not, at the same time Toyota invented target costing in the early 1960s, it made certain additions to classic management accounting to address the heightened agency risks associated with guiding myriads of self-managed teams. As seen in Exhibit 4, management accounting can be viewed as two independent subsystems, one that sets financial and other performance targets and another that ensures that those targets are adhered to. At GM, management accounting used the annual budget to set and communicate targets to autonomous divisional leaders. The internal audit carried out by GM's large staff of accountants ensured that those leaders would adhere to their targets. Toyota made important adjustments to the target setting, target communication, and auditing activities of management accounting.

What is *hoshin kanri*? The word *hoshin* can be translated as compass or strategic direction. The word *kanri* means management or control. *Hoshin*

EXHIBIT 4
Comparison of American and Japanese Management Accounting



kanri or strategy management is a method of TQM that employs the scientific method (often in the form of PDCA) and TQM's seven management tools (see Exhibit 6) to set, communicate, confirm, and review or audit strategic initiatives and related performance targets for quality circles and the self-managed teams of lean development and production, Six Sigma, design for Six Sigma, and agile methods.

Target setting. In 1954, in his book, *The Practice of Management,* Peter Drucker articulated the method of management by objectives (MBO), which extended the idea of performance targets for divisional leaders to targets for managers throughout the corporation.[25] Toyota's system of management accounting relies on target costing in development and *kaizen* costing in production to set targets for autonomous *shusas*, their self-managed development teams, and suppliers.[26] Instead of relying on the traditional budgeting process to dictate financial targets for the organization, Toyota relies on *hoshin kanri*'s process of communication and confirmation to deploy targets.[27] Through the same deployment process, Toyota opens an extensive negotiation with managers at every level of the organization about the specific means by which financial objectives will be achieved. Such means may involve, for example, major changes in infrastructure or simple improvement projects focused on minor changes to production processes. To contrast it sharply with MBO, H.T. Johnson and Anders Bröms characterize Toyota's approach as management by means (MBM). In TTMS, all conversations about ends and means ultimately refer back to the *shusa*'s original *hoshin* for the product in question, whether before or after launch. We can see even more clearly how the target cost equation forms the spindle around which Toyota's world of organizational learning and continuous improvement revolves.

From MBO to MBM. In Japan, MBO and *hoshin kanri* co-evolved during the 1950s and 1960s.[28] MBO was adapted to serve TQM in the form of *hoshin kanri.* The result was a disciplined approach to setting targets for the financial ends of strategy but also for the operative means to those ends. Importantly, through *hoshin kanri* targets were set not only for divisional leaders but for all managers of quality circles and other self-managed teams. In the early 1960s, Toyota adopted *hoshin kanri* as part of its implementation of TQM. Fortuitously or not, Toyota adopted *hoshin kanri* and invented target costing and kaizen costing at the same time. It used *hoshin kanri* to deploy and audit both its cost and quality targets as expressed in the *hoshins* of its various *shusas*. As a result, Toyota was the first organization to aim *hoshin* effectively at the means as well as the ends of financial performance, which were likely the beginnings of MBM.

Self-audits. What happens once the *hoshin* has been deployed? The self-auditing functions of visual management and daily standup meetings in the *obeyas* of development and production are supplemented by a system of monthly or quarterly *hoshin kanri* review meetings in special obeyas constructed for that purpose. The semi-annual audit by staff accountants (or accounting firms) provides a final check on overall system health. Assuming that the organization conducts its formal, internal audit on a two-year cycle, this speeds up the process of discovery and correction by a factor of 8 to 24, depending on whether the *hoshin* review cycle is quarterly or monthly. In the *obeya* and on the shop floor, the review cycle is either daily or by shift. With visual control, *andon*, and *poka-yoke*, the review cycle — always focused on means as well as ends — can be conducted either manually or automatically in close to real time. This speed is a spectacular advantage in organizational learning.

Incomplete treatment of product development

The third limitation of Sakai's model is its treatment of Toyota's product development process. Sakai calls out three major elements of TPD: the *shusa* and two development methods, target costing and value engineering. However, Sakai fails to mention Toyota's SBCE process. According to the Lean Enterprise Institute, SBCE is

> [a]n approach to the design of products and services in which developers consider sets of ideas rather than single ideas. To do this, developers:
>
> - Use trade-off curves and design guidelines to characterize (or describe) known feasible design sets, and thus focus the search for designs.
> - Identify and develop multiple alternatives, and eliminate alternatives only when proven inferior or infeasible.
> - Start with design targets, and allow the actual specifications and tolerances to emerge through analysis and testing.
> - Delay selecting the final design or establishing the final specifications until the team knows enough to make a good decision.
>
> This approach yields substantial organizational learning. It takes less time and costs less in the long term than typical point-based engineering systems that select a design solution early in the development process, with the typical consequence of false starts, rework, failed projects, and minimal learning.[29]

SBCE ensures that the self-managed teams of TPD and Toyota's suppliers work efficiently to explore the best options for product design that may optimize target cost and customer satisfaction. SBCE's rapid prototyping and testing narrow down those options while providing an important mechanism for market feedback to be incorporated into the development process.

Neglect of just-in-time production and the value stream system

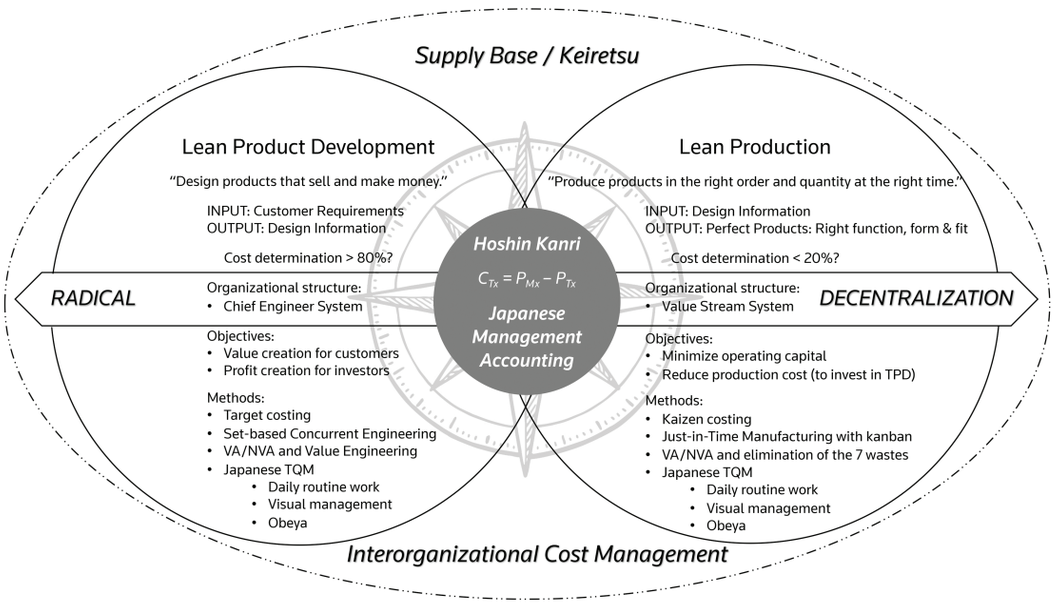
Although Sakai identifies TPS as the principal customer of the design information created by TPD, he does not give TPS enough credit for what happens next. Design information is, after all, only conceptual. The *shusa* may "see David in the stone," but the hand of TPS holds the chisel. The chisel is very sharp. Self-managed production teams work in dedicated value streams capable of hitting the *shusa*'s target cost for every component and part. After the launch of a new vehicle, TPS manages production cost through what Johnson and Bröms call "order line profitability analysis."[30] This practice ensures that once the target cost is met at launch the target cost remains embedded in the product's design information throughout its life cycle. The original target cost for each part and component is continually reduced year after year through *kaizen* costing. Every year, new *kaizen* cost (and quality) targets are set. Every year, these new targets are met by TPS through standard work, takt time adherence, and continuous improvement activities. Toyota's moving targets for both ends and means are so well articulated and communicated, and adherence through self-audits is so effective, that Toyota is apparently able to calculate the cost and profitability of each vehicle at the order line. In other words, Toyota knows the actual cost of each vehicle at the time it is produced.

WITH VISUAL CONTROL, *ANDON*, AND *POKA-YOKE*, THE REVIEW CYCLE — ALWAYS FOCUSED ON MEANS AS WELL AS ENDS — CAN BE CONDUCTED EITHER MANUALLY OR AUTOMATICALLY IN CLOSE TO REAL TIME.

Neglect of interorganizational cost management

The fourth limitation of Sakai's model is its emphasis on Toyota as an original equipment manufacturer. TTMS is much bigger

EXHIBIT 5
Techniques of Japanese TQM



NOTE: VA = Value added; NVA = Non–value added

than Toyota. The *shusa* has a huge portfolio of "assets" — 2,000 to 3,000 components and 30,000 parts designed and produced by Toyota and its suppliers. Each of these assets must be designed to perform a specific function at a specific target cost. Sakai devotes only one short chapter to Toyota's *keiretsu*.[31] SBCE, target costing, and value engineering cross many functional and organizational boundaries.[32] We must remember that Toyota's key supply partners are themselves radically decentralized. They all practice lean development and lean production. Suppliers also practice *hoshin kanri* and Japanese management accounting. The *shusa's* hoshin and specifications for the design information are communicated to and self-audited by suppliers in the same way that they are communicated to and self-audited by Toyota's various functional departments.

Restatement of the model

In restating Sakai's model, seen in Exhibit 5, we have incorporated the main elements of TTMS while addressing most of the limitations previously mentioned. To acknowledge the wide adoption of Toyota's TPD and TPS methodologies, we have chosen to call the model the Total Lean Management System (TLMS). In the same spirit, we have also relabeled TPD as Lean Product Development (LPD) and TPS as Lean Production System (LPS). Besides, as we will soon see, the origin of many practices attributed to Toyota have deep roots in Japanese TQM, which is not unique to Toyota.[33]

The new model highlights the parallel decentralization of TPD and TPS and gives us a more robust understanding of the complete system. Under a new heading of "organizational structure," we have included the *shusa* system on the left and the value stream system on the right to highlight that, while the *shusa* is in the lead, both LPD and LPS are organized as collections of self-managed teams. To bring the model into line with the empirical evidence, we have revised "profit contribution" to read "cost determination" and adjusted percentages on both sides of the model.

We have also added several new elements to the model to provide a more balanced

EXHIBIT 6
Techniques of Japanese TQM

Leadership tools	*Hoshin kanri* or strategy management with the A3*
	Daily routine work with visual management, *andon*,* and *poka-yoke**
	Quality circles and the formal promotion of improvement
	Intensive education
	Scientific method (PDCA) in support of radical decentralization
Specialized design tools	*Kano* model of quality**
	QFD**
Seven QC tools	Data collection sheet (check sheet)
	Cause-and-effect diagram
	Histogram
	Pareto diagram
	Stratification analysis
	Scatter diagram
	Control charts
Seven management tools	Affinity diagram
	Relationship diagram
	Tree diagram
	Matrix diagram (including the X-matrix)
	Decision tree (process decision program chart [PDPC])
	Arrow diagram (program evaluation and review technique [PERT])
	Matrix data analysis
Advanced statistical and AI tools	Process capability studies
	Analysis of variance
	Series analysis
	Concentration analysis
	Principal components analysis
	Multiple linear regression analysis
	Design of experiments
	Monte Carlo analysis
	Neural network analysis and other AI tools

Data from: Galgano, A., *Companywide Quality Management*. (Portland, OR: Productivity Press, 1994).

Galgano explains how the tools that appear in the table operate as a management system.

*Tools invented by Toyota—not referenced by Galgano in *Companywide Quality Management*.

**Special design tools are used primarily in the concept and design phases. All other tools are used in all phases, including the production phase, including advanced statistical tools, which are important in equipment maintenance.

picture of TLMS and its components. We have drawn a circle around the entire model to indicate how TLMS integrates suppliers in the practice of interorganizational cost management. On the left-hand side, under the heading of "Methods," we have added SBCE. On the right-hand side of the model, we have just-in-time manufacturing and *kaizen* costing to mirror the methods of SBCE and target costing in LPD.

Japanese TQM

We have added Japanese TQM to the methods on both sides of the model and, because of their role in Japanese management accounting, called out the specific TQM methods of daily routine work and visual management, which are practiced in the *obeyas* of LPD and LPS. Throughout his book, Sakai refers to the importance of "Toyota QC" (quality control) as a factor in Toyota's success. Apart from Toyota's A3 problem-solving report and the visual management techniques of *andon* and *poka-yoke,* Toyota's version of quality control is hardly unique. We prefer the term Japanese TQM, which refers to the full-throated version of quality control that was forged in Japan under the thought leadership of Ishikawa.[34] A categorized list of Japanese TQM methods appears in Exhibit 6. This list includes methods contributed by Toyota because they have been widely adopted both inside and outside of Japan.

THROUGH THE PROCESS OF VALUE ENGINEERING, LPD ENCODES THE TARGET COST EQUATION INTO THE DESIGN INFORMATION OF EVERY PART, COMPONENT, AND FINAL PRODUCT.

Hoshin kanri and Japanese management accounting

One of the major differences between Japanese TQM and its Westernized versions is the central role of the leadership tool of *hoshin kanri.* At the center of Exhibit 5, we have replaced NR 248 with *hoshin kanri*, the target cost equation, and Japanese management accounting. LPD and LPS operate as an integrated management system. The system is guided not by a Vice President of Manufacturing or even by an organization's President or CEO, but by a chief engineer or *shusa.* The heart of the system is the target cost equation and Japanese TQM, which connect both development and production activities to financial success. As we have stated, the MBM deployment process of *hoshin kanri* engages all agents within an organization and its supply chain in vital conversations about how the organization's cost and quality targets will be met. Through the process of value engineering, LPD encodes the target cost equation into the design information of every part, component, and final product. Through *hoshin kanri,* the design information is communicated to all managers and self-managed teams in production. If LPD's target costing and value engineering and LPS's execution of the design information are precise for every part, component, system, and final assembly, then, without unforeseen changes in market price or demand, the organization's profit expectations will be met.

Implications of the restated model

The implications of the TLMS model in Exhibit 5 are quite broad. Some are surprising, others not. Unsurprisingly, using the *shusa* system as a template, organizations wishing to replicate the success of Toyota will need to make continued investments in lean development — including investments in target costing, value engineering, and notably, SBCE. The *shusa*'s *hoshin* of a new product sets organizations up for success, whether in production, customer satisfaction, and financial performance.

> **What about agile?** Most readers will distinguish between lean and agile product development. Yet agile teams are radically decentralized self-managed teams. As we have seen, beginning in the 1960s, many teams in organizations that adopted Japanese TQM became self-managed. Moreover, agile methods owe much to lean manufacturing and Japanese TQM.[35] They owe much to lean development methods, too. For example, most implementations of agile feature their own version of the *obeya*, which was developed by TPD during the design of the Prius.

Given that many Western efforts to implement lean production have either flagged or failed, it is also not surprising that there must be continued investments in just-in-time production. In making bold assertions about the ratio of cost determination prior to launch, Sakai downplays the role of TPS. However, even if TPD's percentage of cost determination in development were 99 percent, it could not be realized if the design information were not mapped faithfully into product media by TPS. A target cost

is only theoretical until the product is produced as anyone connected to the launch of a new product will tell you.

It is also not surprising that, to fully leverage the TLMS model in development and production, there must be continued investments to develop lean supply chains. Many thousands of parts must be designed and manufactured at their respective target costs by hundreds of suppliers in order for lean organizations like Toyota to meet their target costs. For any organization to predetermine costs in development, its suppliers must practice target costing and value engineering with at least as much expertise as the organization does. To manufacture and deliver just-in-time components and parts at their respective target costs, suppliers must also possess capable just-in-time production and distribution systems.

The remaining implications of the TLMS model are more interesting. These include the need to commit to radical decentralization and a corresponding need to adopt *hoshin kanri*, self-audits, and other elements of Japanese management accounting.

Radical decentralization

Organizations wishing to target cost and value engineer their products like Toyota must radically decentralize their development operations by adopting the *shusa* system or some other radically decentralized structure in which the CEO, like Eiji Toyoda, could say, "*Shusa* is the president of the product…" They must establish self-managed teams and *obeyas* to support them. To meet the target cost embedded in the design information, organizations must also radically decentralize their production operations by fully adopting the value stream management paradigm of self-managed production teams. Moreover, they must encourage their supply chain partners to do the same.

Reform of management accounting

Assuming that development and production can be radically decentralized, to make them work as a system will require the reform of management accounting. Traditional management accounting and MBO are too narrowly focused on financial ends to inform self-managed teams and autonomous decision makers of everything — including means as well as ends — that needs to be done. MBO is also far too slow to keep the same teams and decision makers in check. Unlike the finance department's annual budgeting process, *hoshin kanri* permits the *shusa* to communicate — without ambiguity — the target costs and other product values of each component and part directly to hundreds of internal and external suppliers who will fabricate it.[36] Meanwhile, by vesting control at the lowest possible level and by increasing the frequency and efficiency of review (even automating review with *poka-yoke*), MBM is breathtakingly faster than its predecessor, MBO.

To replicate Toyota's success, organizations must encourage their suppliers to adopt Japanese management accounting as well. Neither the promise of lean methodologies nor the challenge of radical decentralization is contained by organizational boundaries. The development and production systems of lean organizations and those of their key suppliers must be actively linked through *hoshin kanri* to form a comprehensive management system focused on creating value and making money.[37] In order to ensure the timely discovery of defects in development or production, attention must also be paid to the quality of suppliers' visual management capabilities and the frequency of self-audits in their *obeyas* and on the shop floor.

Investments in synthetic thinking

Perhaps the most surprising implication of the TLMS model is what it means for how leaders think — not only for the *shusa* but for leaders at every level of the organization. TPS is sometimes referred to as the "thinking production system" because it requires production operators to think about the work they perform.[38] By much the same token, TPD might be called a "thinking development system." Sakai tells us that the *shusa* is much more than a project manager.[39] He must be able to think about more than getting things done. He must be able to think about getting the right things done in the best possible way. Most project managers are focused solely on timeline and deliverables and not on the quality of the design they produce.

IT IS ALSO NOT SURPRISING THAT, TO FULLY LEVERAGE THE TLMS MODEL IN DEVELOPMENT AND PRODUCTION, THERE MUST BE CONTINUED INVESTMENTS TO DEVELOP LEAN SUPPLY CHAINS.

The *shusa's* job is not merely to analyze how to get things done or to plan and coordinate the activities of Toyota's engineers. The thinking required of the *shusa* is not single loop but double loop. His job is to think about how to synthesize the opposing realities of design quality, target cost, customer markets, competitors, the manufacturing capabilities of Toyota and all its suppliers, and of course the financial requirements of Toyota and its investors.

A towering technical competency. *All* of Toyota's engineers must possess what Morgan and Liker call a "towering technical competency."[40] In Toyota's radically decentralized universe, it's not just the *shusa* who must be a double loop thinker. In order to perform double loop thinking to real advantage, all engineers must have command of multiple subjects — marketing, sales, engineering, manufacturing, and supply chain management as well as design engineering and project management.

Just as divisionalization changed the way large organizations process information, radical decentralization changes how leaders think, not just the CEO and a handful of divisional leaders but leaders at every level of the organization. The *shusa* could not exist in an organization that did not give him adequate time for double loop learning on a grand scale. The extra time for the *shusa* exists because, thanks to the radical decentralization of Toyota's engineering processes, its engineers are capable of doing most of their work, including dealing with the many problems that arise, without the *shusa*'s intervention. Like Toyota's production workers, Toyota's engineers have time for double loop learning about the product design and the development process itself.

Conclusion

At the beginning of this article, we set out to present Sakai's TTMS model, review its limitations, reformulate the model, and explore its implications for the lean movement. Sakai's model has not so much revealed a secret as it has forced us to reevaluate target costing and the leading role of development and the supporting role of production in Toyota's success. Except in rare instances, this is not how the Toyota system is taught or practiced by Toyota's imitators.[41] Typically, its elements are taught separately to their respective audiences, audiences that may or may not communicate with one another systematically about design and production. By bringing the two major subsystems of TTMS together and clarifying the roles and responsibilities of development and manufacturing leaders, Sakai has made an important contribution to our understanding of how to teach and practice the way of Toyota.

Reformulating Sakai's model in the light of its limitations, we have highlighted the importance of a TLMS's radically decentralized organizational structure and the complementary roles of Japanese TQM and management accounting. We have recommended that lean practitioners redouble their efforts to become lean not only in their development and production methods but also in their organizational structures. Without self-managed teams and autonomous decision makers, lean methods will not work as advertised in any function. Without a way to guide self-managed teams by setting the right targets for both ends and means, and without a way to ensure that the same teams adhere to those targets in a timely way, lean methods cannot be harnessed effectively to the strategy of the organization. Therefore, we have recommended that readers rethink their organization charts, adopt *hoshin kanri,* and abandon MBO for MBM.

In an odd way, this may be just a case of history repeating. Changes in organizational structure are notoriously difficult to understand and execute. Despite GM's spectacular success and Ford's financial difficulties in the late 1920s, Ford did not adopt the M-form and classic management accounting until 1948, almost 30 years after GM invented them.[42] European firms did not begin to change their centralized U-form structures for another 20 years.[43] Obviously, organizational change on such a large scale is hard.

JUST AS DIVISIONALIZATION CHANGED THE WAY LARGE ORGANIZATIONS PROCESS INFORMATION, RADICAL DECENTRALIZATION CHANGES HOW LEADERS THINK, NOT JUST THE CEO AND A HANDFUL OF DIVISIONAL LEADERS BUT LEADERS AT EVERY LEVEL OF THE ORGANIZATION.

Changing the way leaders think may prove to be harder. Indeed, abandoning cherished notions of strong centralized

leadership (the cult of the CEO is alive and well in the person of Tesla's Elon Musk) for the concepts of distributed leadership and self-managed teams may seem next to impossible. Because it is radical, Japan's brand of decentralization may be especially difficult to adopt, as it requires the intensive and ongoing education of practically every leader, manager, and employee not only within the adopting organization but eventually, throughout its supply chain and, for that matter, across the entire spectrum of partnerships — including partnerships with customers and government agencies.

Fortunately, organizational transformation is not impossible, as Porsche's dramatic turnaround demonstrated conclusively. In the history of lean transformations, Porsche is distinguished for adopting TLMS all at once. It revolutionized its development and production operations at the same time. This superhuman effort produced two extraordinary cars, the innovative Boxter in 1996 and a new 911 in 1998. Both cars were designed from the ground up in less than half normal development time. Prior to adopting lean manufacturing, Porsche's poor quality had pushed the company close to bankruptcy. Porsche is now famous for its quality.

Almost 60 years have passed since the invention of TTMS. Yet there is still much to learn about what Toyota accomplished. Radical decentralization and Japanese management accounting may not be Toyota's last secrets. In this article we have focused on only two of Toyota's seven business functions, all of which are radically decentralized and which practice lean methodologies of their own. Of the functions neglected, two stand out. The first is human resources, which has an indispensable role to play in the hard work of creating lean thinkers. The second is the function of marketing.

Market analysis is particularly interesting because of its role in innovation. Here, Japanese TQM has important contributions to make in the form of the Kano model of quality and quality function deployment (QFD), neither of which Sakai mentions. The Kano model and QFD are the methods behind the "voice of the customer." The voice of the customer emerges in QFD in face-to-face interviews and is analyzed by the Kano model's distinctions of spoken, unspoken, and "dreamt" customer needs. If we review the voice of the customer and derivative approaches to innovation such as the "jobs to be done" theory, we learn that innovation begins with market segmentation and the analysis of the problems that customers are trying to solve.[44] Does Toyota have anything to teach in this regard?

Sakai says that product values are an input derived from Toyota's sales department.[45] However, the *shusa* is directly involved in determining the voice of the customer.[46] How does the *shusa* process what they're saying, thinking, or just dreaming? What explains Toyota's slowness to enter the market for electric vehicles? Based on Porsche's own data and analysis and using its lean capabilities and legendary design expertise, in 2020 they launched the Taycan, a very impressive challenge to Tesla's Model S. Do Toyota's *shusas* have different data? Or different perspectives on the data? Or is Toyota's conservatism showing? (The 14th principle in Jeffrey Liker's *The Toyota Way* is "Use only reliable, thoroughly tested technology that serves your people and processes."[47]) We do not know.

We run businesses to make profit and in turn use that profit for future growth and societal good. There is much good in what Toyota and other adopters of lean methods and Japanese TQM have accomplished since 1960. The brilliance of radical decentralization and Japanese management accounting is that they create time for double loop learning, time to think critically and synthetically. Some might say they create time to be *human* — in development and production or in any business function, even the function of leadership. ■

NOTES

1 Womack, J.P., Jones, D.T., and Roos, D., *The Machine that Changed the World: The Story of Lean Production—Toyota's Secret Weapon in the Global Car Wars That Is Revolutionizing World Industry.* (New York: Free Press, 1990).

2 Shook, J., *Managing to Learn: Using the A3 Management Process to Solve Problems, Gain Agreement, Mentor, and Lead.* (Cambridge, MA: Lean Enterprise Institute, 2008); Shook, J., Toyota's secret—The A3 report, *Sloan Management Review* 50, no. 4 (2009): 30–34.

3 Mathews, D.D., *Teaching People to See: Toyota's Secret to Creating Exceptionally Engaged & Empowered Employees.* (Lexington, KY: Continue 2 Improve, 2017).

4 Sakai, T., *The Secret Behind the Success of Toyota: How the Original Chief Engineer System Works to*

Generate Most of the Product Value & Profit. (Monee, IL: Takana Sakai, 2018).

[5] Morgan, J.M. and Liker, J.K. *The Toyota Product Development System: Integrating People, Process, and Technology.* (New York: Productivity Press, 2006): 30–31.

[6] Drogosz, J., Coach's corner: Understanding the value of a concept paper, *The Lean Post*, (May 12, 2021). Available at: https://www.lean.org/the-lean-post/articles/coachs-corner-understanding-the-value-of-a-concept-paper/.

[7] See, for example, Monden, Y., *Toyota Management System: Linking the Seven Key Functional Areas.* (Portland, OR: Productivity Press, 1993). Monden describes Toyota's management system as an integration of seven functions, including, among others, development and production. Monden highlights the role of target costing in development and *kaizen* costing in production. All seven functions are focused on financial performance.

[8] *Op. cit.* note 4, p. 4.

[9] See, for example, Monden, Y., *Cost Management Systems: Target Costing and Kaizen Costing.* (Portland, OR: Productivity Press, 1995): 19. For a comprehensive treatment of target costing and value engineering, see Cooper, R. and Slagmulder, R., *Target Costing and Value Engineering.* (Portland, OR: Productivity Press, 1997).

[10] See, for example, Symon, R. J. and Danderfield, K. J., Application of design to cost in engineering and manufacturing, *NATO AGARD Lecture Series No. 107.* (Saint Louis, France, May 12–13, 1980; London, UK, May 15–16 , 1980): 7.1–7.17; Corbett, J. and Crookall, J.R., Design for economic manufacture, *CIRP Annals* 35, no. 1 (1986): 93–96; Whitney, D.E., Manufacturing by design, *Harvard Business Review* (Jul 1988): 83–90.

[11] See Barton, J.A., Love, D.M., and Taylor, G.D., Design determines 70% of cost? A review of implications for design evaluation, *Journal of Engineering Design* 12, no. 1 (2001): 47–58.

[12] Anecdotal support for Sakai's claim can be found in the practice of *kaizen* costing, the continuous improvement of product cost by TPS and Toyota's suppliers after the launch of the product. 5 percent is a typical target for *kaizen* cost reduction. On this basis, it might be argued that the remainder of 100 percent and 5 percent — which is 95 percent — is the contribution of TPD, at least at the time of launch.

[13] Robin Cooper shared this observation with Tom Jackson in a private conversation held at Emory University in Atlanta, Georgia, in 1999.

[14] See Hope, H. and Fraser, R., Who needs budgets? *Harvard Business Review* Reprint R0203J (Feb 2003). See Jackson's discussion of Hope and Fraser, *hoshin kanri*, the budgeting process, and the parallel between relative performance contracts and A3s in Jackson, T., Don't shed accounting—Reengineer it with strategy management and A3 thinking, *Cost Management* 23, no. 1 (2009): 31–41.

[15] Rigby, D., Sutherland, J., and Takeuchi, H., Embracing Agile: How to master the process that's transforming management, *Harvard Business Review* Reprint R1605B (May 2016): 4.

[16] See, for example, Tanaka, T. and Tanner, S., "Visualization of purpose: Quickening the pace of executive achievement through the visualization of purpose," Lean Enterprise Academy (June 27, 2011). Available at: https://www.leanuk.org/wp-content/uploads/2020/03/paper_visualization_of_purpose.pdf. The Japan Management Association Consultants (JMAC) *obeya* program is marketed in Europe under the name of Visible Planning. See https://jmaceurope.com/en/metodologie/visible-planning-project-management-tecnique/.

[17] The shopfloor practices of TPS are catalogued and described in detail by David Mann. Mann, D., *Creating a Lean Culture: Tools to Sustain a Lean Conversion.* 3rd ed. (New York: CRC Press, 2015).

[18] Spear, S. and Bowen, H.K., Decoding the DNA of the Toyota Production System, *Harvard Business Review* Reprint 99509 (Sep–Oct 1999): 4.

[19] Chandler, A.,*Strategy & Structure: Chapters in the History of the Industrial Enterprise.* (Cambridge, MA: MIT Press, 1962): 76–77.

[20] *Ibid.,* p. 158.

[21] *Op. cit.* note 18, p. 130–142.

[22] Jackson, T., "The rise of the cybernetic corporation: The new science of resource-based competition" (Mar 2021) (Transoptikon working paper). Available at: https://secureservercdn.net/50.62.174.189/mb9.166.myftpupload.com/wp-content/uploads/2021/03/The-rise-of-the-Cybernetic-Corporation.pdf. "Cybernetic" means self-steering or self-regulating, a characteristic of most high technology after World War II.

[23] The concepts of single and double loop learning first appeared in Argyris, C., *Increasing Leadership Effectiveness.* (New York: John Wiley & Sons, 1976): 211–237. Williamson, O.E., *The Economic Institutions of Capitalism* (New York: Free Press, 1985): 281–83. Williamson presents a sophisticated information processing interpretation of "double feedback" in his explanation of the divisionalized corporation.

[24] This non-standard cost system is outlined by Johnson, H.T. and Bröms, A., *Profit Beyond Measure: Extraordinary Results Through Attention to Work and People.* (New York: Free Press, 2000); Kaplan, R.S. and Anderson, S.R., *Time-Driven Activity-Based Costing: A Simpler and More Powerful Path to Higher Profits.* (Boston: Harvard Business School Press, 2007).

[25] Drucker, P., *The Practice of Management.* (New York: Harper & Row, 1954): Chapter 11.

[26] Jackson has argued that Japanese management accounting involves target costing, *kaizen* costing, *hoshin kanri*, and a comprehensive system of self-audits conducted more or less in real time; *Op. cit.*, note 14 Jackson, p. 31–41; Jackson, T., Decoding value at the source: The ABCs of lean production metrics, *Cost Management* 22, no. 4 (2008). In the latter article, Jackson illustrates Toyota's system of self-audits in production.

[27] Akao, Y., ed., *Hoshin Kanri: Policy Deployment for Successful TQM.* (Portland, OR: Productivity Press, 1991): 192. Appendix Figure 3 demonstrates how *hoshin kanri* tends to displace the traditional budgeting process over time.

[28] *Ibid.,* appendix 2: Chronology of *Hoshin Kanri.*

[29] "Set-Based Concurrent Engineering [definition]," Lean Enterprise Institute. Available at: https://www.lean.org/lexicon-terms/set-based-concurrent-engineering/; See also *op. cit.* note 5, p. 41–51.

[30] *Op. cit.* note 24 Johnson, p. 158–164. Johnson and Bröms avoid referring to order line profitability analysis (OLPA) as "accounting." In effect, OLPA is a type of "actual cost accounting" that replaces standard cost accounting.

[31] *Op. cit.* note 4, p. 227–234.

[32] For a comprehensive treatment of interorganizational cost management, see Cooper, R. and Slagmulder, R., *Supply Chain Development for the Lean Enterprise: Interorganizational Cost Management.* (Portland, OR: Productivity Press, 1999).

[33] Judging from the Union of Japanese Scientists and Engineers' list of Deming Prize winners, Toyota was not even an early adopter of TQM. The first Deming Prizes were awarded in 1951. Toyota began its implementation of TQM in 1960 and won its first Deming Prize in 1965. See "The Deming Prize Winners," Union of Japanese Scientists and Engineers (Dec 2021). Available at: https://www.juse.or.jp/upload/files/e2_DP_2022.pdf.

[34] Ishikawa, K., *What is Total Quality Control: The Japanese Way?* (Englewood Cliffs: Prentice-Hall, 1985): 90–102.

[35] Rigby, D., Sutherland, J., and Takeuchi, H., The Secret History of Agile Innovation, *Harvard Business Review* (Apr 20, 2016). Available at: https://hbr.org/2016/04/the-secret-history-of-agile-innovation.

[36] Johnson, H.T. and Kaplan, R.S., *Relevance Lost: The Rise and Fall of Management Accounting*. (Boston: Harvard Business School Press, 1987): 1–3.

[37] See Jackson, T., *Implementing a Lean Management System*. (Portland, OR: Productivity Press, 1996). See also Jackson, T., *Hoshin Kanri for the Lean Enterprise: Developing Competitive Capabilities and Managing Profit*. (Portland, OR: Productivity Press, 2006). Both of these books contain a detailed example of how to apply *hoshin kanri* to integrate a supplier into the development and execution of strategy.

[38] See, for example, Balle, M., Beauvallet, G., Smalley, A., and Sobek, D.K., The thinking production system, *Reflections: The SoL Journal* 7 (Jan 2006). Available at: https://www.researchgate.net/publication/215608341_The_Thinking_Production_System.

[39] *Op. cit.* note 4, p. 155–162.

[40] *Op. cit.* note 5, p. 163–177.

[41] Porsche's simultaneous implementation of lean development and production in the late 1990s is an outstanding and durable exception. See Womack, J.P. and Jones, D.T., *Lean Thinking: Banish Waste and Create Wealth in Your Corporation*. (New York: Simon and Shuster, 1996): 189–218.

[42] See Servan-Schreiber, J.-J., *The American Challenge*. (New York: Atheneum, 1968).

[43] Waddell, W.H. and Bodek, N., *Rebirth of American Industry: A Study of Lean Management*. (Vancouver, WA: PCS Press, 2005): 79–90. The authors relate the story of Ford's belated adoption of management accounting (and divisionalization) to support their thesis that GM ruined manufacturing with management accounting. Our position is that GM's divisionalization and management accounting and Peter Drucker's MBO were successful, relatively speaking, and laid the foundation for radical decentralization and Japanese management accounting.

[44] Ulwick, A., *Jobs to Be Done: Theory to Practice*. (Idea Bite Press, 2016). Although Ulwick's approach to the voice of the customer begins with surveys rather than interviews, his data analytics are enlightening; Womack, J.P. and Jones, D.T., *Lean Solutions: How Companies and Customers Can Create Value and Wealth Together*. (New York: Free Press, 2005).

[45] *Op. cit.* note 4, p. 166–168.

[46] *Op. cit.* note 5, p. 121–125. This passage describes how a Toyota *shusa* used voice-of-the-customer methods to derive product values for the Lexus.

[47] Liker, J.K., *The Toyota Way: 14 Management Principles from the World's Greatest Manufacturer*. (New York: McGraw-Hill, 2004): 159–168.