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The HOSHIN KANRI TREE. Cross-Plant Lean Shopfloor Management

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Shopfloor Management (SM) empowerment methodologies have traditionally focused on two aspects: goal achievement following rigid structures, such as SQDCME, or evolutionary aspects of empowerment factors away from strategic goal achievement. Furthermore, SM Methodologies have been organized almost solely around the hierarchical structure of the organization, failing systematically to cope with the challenges that Industry 4.0 is facing. The latter include the growing complexity of value-stream networks, sustainable empowerment of the workforce (Learning Factory), an autonomous and intelligent process management (Smart Factory), the need to cope with the increasing complexity of value-stream networks (VSN) and the leadership paradigm shift to strategic alignment. This paper presents a novel Lean SM Method (LSM) called “HOSHIN KANRI Tree” (HKT), which is based on standardization of the communication patterns among process owners (POs) by PDCA. The standardization of communication patterns by HKT technology should bring enormous benefits in value stream (VS) performance, speed of standardization and learning rates to the Industry 4.0 generation of organizations. These potential advantages of HKT are being tested at present in worldwide research.

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Nomenclature

HK	HOSHIN KANRI
HKT	HOSHIN KANRI Tree
KPI	Key Performance Indicator
LF	Learning Factory
LM	Lean Management
PM	Process Management
PO	Process Owner
SF	Smart Factory
SM	Shopfloor Management
VS	Value Stream
VSN	Value Stream Network

- the need to sustainably empower the workforce (LF) as indicated by Narkhede et al.[1],
- the need to develop an autonomous and intelligent PM (SF) as presented by Lee et al.[2],
- recent research by Schuh et al.[3] shows a need to cope with the increasing complexity of VSN,
- the necessary paradigm shift to strategic alignment pointed out by Covey[4].

It is therefore urgent to study such challenges holistically in order to provide leaders with comprehensive tools to cope with them.

In the context of LF and SF, empowerment can be understood as a systematic way of learning that enables continuous improvement in an autonomous, intelligent, self-organized and systematic manner. Coleman [5] defines empowerment as “the act of enhancing, supporting or not obstructing another’s ability to bring about outcomes that he or she seeks.” An “autonomous” management method should

1. Introduction

The majority of the challenges faced by industrial leaders in the 21st century are addressed by Industry 4.0. Some of these challenges are:

sustainably empower all organizational individuals to align and grow in the direction from which the organization provides value.

A powerful paradigm to empower organizations which focuses on value creation has flourished in the last two decades as LM. LM has been declared to be the industrial paradigm of the 21st century by Shah and Ward [6]. LM can be understood as a socio-technical management system that aims, in the words of Taiichi Ohno, “to systematically reduce non-value adding activities in organizations. It seeks to do this by first understanding their structure and then getting rid of them always, everywhere, relentlessly and unremittingly.” As Hino [7] stated, such non-value adding activities do occur. The LM quest of eliminating or reducing waste in organizations has been mainly understood by scholars, Staats et al. [8], as a problem solving task. As a result, the empowerment efforts of managers, who seek to implement LM, have been focused primarily on empowering and developing people to become good problem-solvers, as described in Sobek II and Smalley [9]. However, as Wick [10] points out, the identification of problems suffers from a social bias. Thus, what organizations or individuals understand to be a problem is subject to a number of cultural, situational and individual dynamic circumstances. The authors believe that the “problems” that LM endeavors to solve, the non-value adding activities, are embedded within processes, and therefore the response-able POs that manage them are in charge of eliminating the non-value adding activities within them. Thus, the task set by LM is mainly a PM task and not a problem-solving one. Each individual of the organization is understood to be a PO, who is acting on his or her process on the shop floor.

The term “shopfloor” has been used by western scholars, de Leeuw and van der Berg [11], to refer to processes close to production or distribution, excluding purposely strategic processes. In this sense, SM can be understood as a management system that can be used to enhance shopfloor performance. The term “shopfloor” is used by Japanese scholars, Suzaki [12], in a broader sense, understanding “shopfloor” or “gembu” as the place, physical or virtual, where the VS is performed. The definition of VS that Womack and Jones [13] gives is a “sequence of activities required to design, produce, and provide a specific good or service, and along which information, materials, and worth flows.”

In an organizational business context of a complex VSN with numerous interdependent POs acting simultaneously on VSs, the POs need to be aligned in a common direction (HOSHIN) given by the strategic goals of the organizations. Furthermore, researchers, Cäker and Siverbo [14], recently argue that not only is support of empowerment management systems necessary, but also they must be aligned with strategic purposes. In other words, they must be in “compliance with strategic plans and targets.” POs need to consider local information, as well as strategic intentions. Studies by Frow et al. [15] show that multiple controls are

needed to balance empowerment of PO and the alignment to strategic goals. HOSHIN KANRI (HK) (management by giving direction) is a comprehensive management system that enables such alignment of complex systems as shown by Jolayemi [16]. ***This paper proposes a novel SM method that provides the tool to operationalize HK by the systematic empowerment of autonomous intelligent POs acting in a complex VSN environment towards common strategic goals.***

This paper is structured as follows: firstly, the state of the art of current SM empowerment methods and a brief HK state of the art are presented. Secondly, this article’s main contribution is presented. It is an explanation of how to cope with the four presented challenges of Industry 4.0. Thirdly, the HKT, a novel SM method to operationalize HK, is presented. Finally, several management implications are discussed, as well as the model limitations and further research that the authors hope to undertake.

2. Background

The authors’ research has identified three schools of thought within SM systems as empowered methods that deal with some or all Industry 4.0 challenges:

- the goal-oriented approach that focuses mainly on providing visualization of goals,
- the evolutionary approach that acknowledges the organizational evolution of SM in a certain direction (HOSHIN) and
- hybrid approaches that combine goal-orientation and evolutionary SM.

2.1. Goal oriented SM

Scholars have integrated concepts of the Balanced Score Card with elements of LM Otsusei [17]. By systematically choosing independent KPIs, BSC aims to holistically describe organizations and align goals with strategy. The result obtained, however, has been KPI-centered SM systems that lead the LSM efforts on KPIs. By focusing solely on KPIs, such systems do not foster a transparent performance dialog between POs that typically empowers the PO achieve results while increasing trust [18].

Other scholars have focused the empowerment efforts around the organizational hierarchical structure or around the functional business units with rigid frameworks, such as SQDCME (Security, Quality, Delivery, Cost, Morale, and Environment) Suzaki [12], Osada [19] and Osada [20]. The standardization of such frameworks along all strategic business units (SBUs) makes the resulting LM system unvarying and less able to evolve as needed. An inability to evolve could have undesirable consequences in the quest for the LM paradigm, as pointed out by Borches and Bonnema [21]. Therefore, this approach lacks the capability to cope with the increasing complexity of VSNs.

2.2. Evolutional SM

Suzaki [12] presents an evolutional direction (HOSHIN) giving approach to SM that is based on PDCA. Explained in four phases - Introduction, Promotion, Expansion and Stabilization - the SM concept should be implemented company-wide. The flaw in Suzaki's approach is that PDCA is understood to be a problem-solving method, rather than a process management approach.

2.3. Hybrid SM Concepts. Goal-oriented and Evolutional SM. Example KATA by Mike Rother.

These two main streams have also engendered hybrid concepts. For instance, Rother [22] describes a hybrid goal-oriented and evolutional empowerment method for SM. Rother's algorithm bases the continuous improvements on individual or local "future states" that should encourage an empowering dialog between the PO and the coach. The individual empowerment concept of Rother is based on task repetition (KATA). The idea of linking KATA and business practices did not originate with Rother as shown by DeMente [23]. The main flaw in this approach is the missing link to the organizational dimension of empowerment. On an organizational level, organizations can be understood to be complex adaptive systems as shown by Schneider and Somers [24], and there is ever increasing structural, functional and organizational complexity in organizations presented by Salado and Nilchiani [25], who make an attempt to organizationally describe "future states" on a VS basis futile.

The hybrid character of SM systems is also described in the 2nd key of Kobayashi's "20 Keys" for shopfloor improvement Kobayashi [26]. The last level of Kobayashi's concept makes the need clear for adaptiveness or an "all-weather-system" that a management system must have. This is central to his argumentation. However, this "goal" oriented view of SM is the main weakness of any management system that attempts to cope with complex environments because no goal breakdown system can be as fast as the changing environment.

2.4. State of the Art HOSHIN KANRI

HK is a hybrid SM system that enables a comprehensive evolutional PM structure, Akao [27]. Jolayemi [16] gives the most complete review of HK so far. HK is a "system's approach to improvement of a company's management process" Akao [27]. It is based on a continuous "negotiated dialog" between the different strategic business units (SBUs) of the organization and is called a "catchball process," Tennant and Roberts [28]. This dialog relies heavily on Plan-Do-Check-Act (PDCA) to build a fractal - or self-similar at different organizational levels - organizational design. This is achieved by the standardization of information exchange of PM by PDCA as shown by scholars in Villalba-Díez and Ordieres-Meré [29].

Hutchins [30] has also presented the HOSHIN KANRI Process as an organizational macroscopic PDCA process. The reference framework presented to operationalize KAIZEN,

however, is not process-oriented, but project and KPI-oriented. Therefore, it fails to provide the benefits of fractality to the organization. Hutchins describes the PDCA as "improvement projects" and indicates that the SM is based on KPI Score Card reporting sheets.

3. Industry 4.0 Challenges

3.1. Coping with VSN complexity and alignment to strategic goals. HOSHIN KANRI as Strategic PDCA.

The previously presented HK as strategic PDCA is expanded by the following the proposed HK macroscopic approach with PDCA as a fractal connecting link between POs. Fig 1 explains the concept visually. For reasons of clarity not all links are represented in the network Do Phase in these and the following pictures.

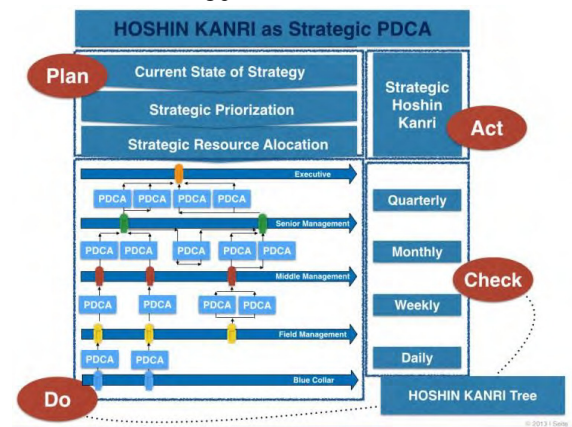


Fig. 1. Hoshin Kanri as Strategic PDCA.

The HK PDCA process that is proposed can be understood as follows:

1. *Do or Inter-Action:* In this Phase Do, the POs will create PDCA bonds to each other. They will first learn to deal with PDCA themselves (individual learning), and then will empower others (organizational learning), through mutual interaction, to adopt the following PDCA behavioral pattern.
2. *Check or Commitment or Consensus.* In this Phase Check, the quality of communication and focus on empowerment is measured. The leadership "catchball" process is visualized at gemba and organizational learning is fostered at all levels of the organization. The Do and Check phases operationalize what may be described as a **Lean Shopfloor Management (LSM) method**: a holistic compound of methodologies that enable the management of resources and empowerment of the people at gemba to systematically reduce non-value adding activities in order to achieve alignment with strategic goals along the VS.
3. *Act or Strategic Hoshin Kanri Standardization.* This phase is well described by Osada [20] and so will not be explained further here.

4. *Plan or Process-Priority-Analysis or Strategic Operationalization.* In this phase, using statistical methods, such as correlation matrices the KPI, and hence the PDCA, structure, is reorganized to meet the strategic challenges ahead.

3.2. LF and SF. Empowerment through PDCA

As described in Villalba-Diez and Ordieres-Mere [29], PDCA is intended to be a PM standard information exchange pattern between POs in organizations. This PDCA concept does not rely on “future states” or a local goal to fuel continuous improvement. It relies solely on the understanding of the current state and the consensus that continuous improvement is a desirable behavioral pattern. This makes the algorithm more robust than those presented by Rother or Akao.

A wide range of experts in different disciplines consider organizations as information processing entities. The former include LM experts Fujimoto [31], Knowledge Management experts Nonaka et al. [32] and Organizational Design experts Burton et al. [33]. In fact, in order for information to become actionable knowledge that creates value, it needs to be processed Yoon et al. [34]. By presenting the LF and SF challenges, Industry 4.0 enhances the information exchange paradigm and deepens the need to develop concepts that enable effective and efficient information processing.

Another perspective of LF and SF is given by Letmathe et al. [35] who recommend following SM structural characteristics to enhance learning on the shop floor:

- an LSM method should foster explicit knowledge creation and transfer. Examples of methods are the process analysis in Phase Plan (creation) or the standardization in the Phase Act (transfer) - “know-why” and not only “know-how.” This “know-why” is given by the strategic goals provided by the organization. This strategic dimension is crucial for LSM.
- an LSM method should enable task automation by repetition of behavioral patterns - such as PDCA - ,
- an LSM method should encourage POs to actively undertake individual learning and self-observation in order to “learn faster and continually improve.- This concept lies at the core of the authors’ PDCA interpretation as each PO is responsible for his or her PDCA.

3.3. HOSHIN KANRI TREE (HKT)

The HKT is proposed as a universal, autonomous intelligent PM LSM method that can sustainably empower POs and create organizational LF capabilities while pursuing strategic alignment in complex VSN environments.

HKT in industrial organizations is implemented in four phases. The first one pretends to grasp VS reality unbiased as it is. The second phase pretends to prepare the ground for planting the empowerment tree. The third phase deals with the management effort of planting the HKT. The fourth phase deals with the leadership effort of taking care of the HKT.

3.3.1. Gemba-Genjitsu-Gembutsu (3G) Current State Value Stream

In the 3G phase, the current (Gembutsu) state of the process (Genjitsu) at Gemba is examined with the intention of choosing an important process for the organization. The goal of this first step is to understand which POs and sub-processes are involved, how they are interlinked by material or information flow and the main sources of waste in the process. This first step indicates the centrality of the VS concept in this management method.

The next phase will qualitatively visualize the KPI ecosystem inherent in the process being studied.

3.3.2. Nemawashi Prepare the ground: Understand the KPI Structure

In the Nemawashi Phase, the ground is prepared to grow the HKT. Efforts will be made to reach a common understanding of the nature of KPIs related to the process. The goal sought when identifying the most influenced and influential KPIs is to be able to cope with the interconnected VSN complexity presented within the strategic process analyzed.

The Nemawashi Phase of the HKT consists of three sub-phases. Firstly, a list is provided of all current and possible KPIs that are being used or could be used to measure VS performance. Secondly, a KPI influence matrix of such KPIs is created with this list in the columns and the same list in the rows. Thirdly, the KPI influence matrix is populated with values 2, 1 or 0 depending on whether the KPI of the j th column depends strongly, weakly or not at all on the KPI of the i th row.

For the i th row each a_{ij} , with $j=1, \dots, i-1, i+1, \dots, n$ indicating the columns, represents the influence that the KPI $_i$ has over the KPI $_j$, and so the sum of the i th row divided by $2*n$ indicates the total influence that the KPI $_i$ has over all the rest of KPIs. For the j th column each a_{ij} , with $i=1, \dots, j-1, j+1, \dots, n$ indicating the rows, represents the influence that the KPI $_j$ receives from the KPI $_i$, and so the sum of the j th column divided by $2*n$ indicates the total influence received by the KPI $_j$ by all the rest of KPIs.

The next phase will operationalize the management effort by visualizing such interconnectedness.

3.3.3. Ueru Management: Planting the HKT

In the Ueru Phase or planting the HKT Phase, the HKT is visualized as closely as possible to the gemba. It is intended to link the POs with the PDCAs. as shown in Fig 2.

The goal of linking the PO-PDCA network and the organizational chart is to operationalize the HKT as LSM method.

The final step of the HKT method describes how to lead the process for a lean leader.

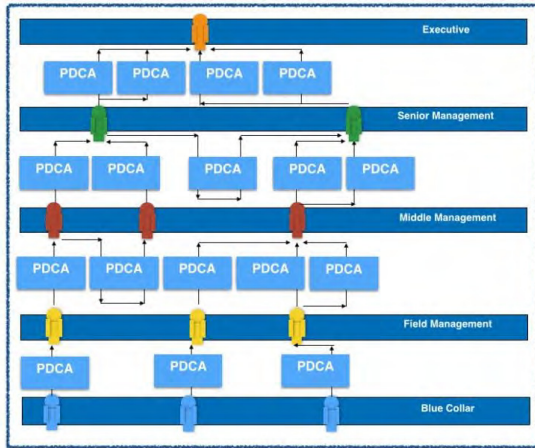


Fig. 2. HKT.

3.3.4. Ueki-Ya Leadership. The Lean Leader as gardener: taking care of the HKT

When the visualization has been completed and several PDCA's have been placed along the organizational structure, it is time to operationalize the HKT. The rule to set the communication frequency is simple and depends on the hierarchical level of the reported node. All PDCA's that are reported to a given hierarchical level will be reported at the same frequency. The recommended frequency is 1 x Shift, 1 x Day, 1 x Week, 1 x Month, 1 x Quarter, 1 x Year, although the system allows for different variations.

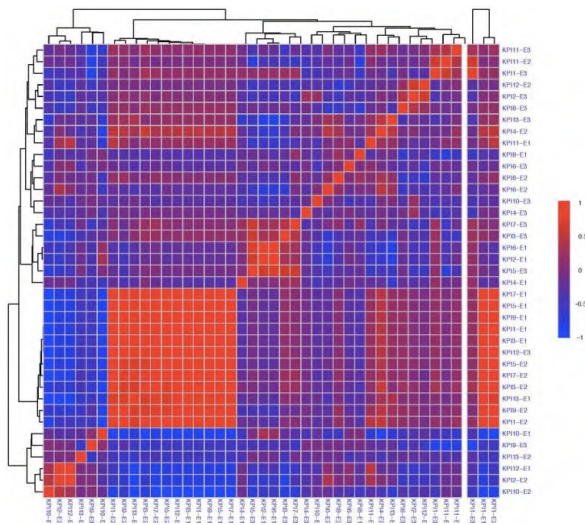


Fig. 3. KPI Correlation heat map

3.3.5. Phase 2 HKT. Alignment Phase.

After completing the HKT (Do and Check in the HK as Strategic PDCA), the workforce has been empowered to perform PM following the PDCA. Several HKTs have been "planted" throughout the plant, but they are disconnected from each other. It is necessary now to let the trees see the forest.

HKT typically provides POs with useful process information that help to prioritize future strategies and therefore to align efforts. Therefore, the Plan Phase of PDCA as a strategic HK deals with aligning the tree with the strategic goals of the organization. In order to facilitate this, the data gathered within the Check phase of all individual PDCA's is combined and correlated.

As shown in Fig. 3, after describing the strategy following Osada [19], the matrix of numerical correlations between all KPIs in the organization is depicted in the form of a heat map to better design future HKT structures. How this evolution is optimally performed is subject of ongoing research.

4. Discussion and Management Implications

After describing HK as a strategic PDCA and HKT, its phases Do and Check, the following propositions are offered as Management Implications:

Proposition 1: Empowerment first, Alignment second. In order to implement a LSM system that holistically copes with VSN complexity and supports alignment with strategic goals, such as HKT, leaders must first empower POs and then align efforts with strategic goals. Leaders should take the time and resources necessary to empower POs to perform proper PM.

Proposition 2: HKT provides the necessary framework to empower POs plant-wide. Because HKT is based on the fractal unit PDCA, the HKT can evolve and is resilient to changes in the environment. Because of these two properties, the HKT is able to cope with VSN complexity.

Proposition 3: In the empowerment Phase of HKT, the behavioral direction (HOSHIN) deals with improving his or her process with every PDCA cycle, instead of achieving a certain numeric local "future state" or "goal."

Proposition 4: In the alignment Phase of HKT, the behavioral direction (HOSHIN) should be guided by strategic numerical goals.

5. Conclusions, model limitations and further steps

The present paper has presented the HKT: a comprehensive holistic LSM model to cope with some of the most important challenges presented by Industry 4.0, such as LF and SF within an environment of increasing value stream network complexity. With this model, which is embedded within a strategic frame such as HK as a strategic PDCA, organizational empowerment towards strategic goals is possible. Furthermore, several propositions have been suggested as Management Implications.

The main implementation difficulty and limitation the authors are facing happens when leaders are not disciplined enough to attach to the PDCA logic.

Ongoing research, which is currently lead by the authors, concentrates on implementing the HKT in several organizations worldwide and strengthening the link between HKT and strategic management

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