Selected problems of the Industry 4.0 implementation in automotive SMEs in Poland

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1. Introduction

The idea of the fourth industrial revolution was officially announced for the first time in 2011 in Hanover. It is a program of strategic reindustrialization of Europe, representing a response to the phenomenon of production migration to countries offering lower production costs. It is based on an assumption of continuous optimization of the way in which businesses function based on mutual real-time communication via cyber-physical systems, thanks to which analytical and decision-making tasks can be performed by both people and IT systems. It all boils down to abandoning the evolutionary optimization or upgrading of the former operating model by shifting toward seeking innovative areas of new activity. This entails changes to the current model of functioning of businesses, and concerns both the sphere of the technologies in use as well as management in the broad understanding of this notion. According to J. A. Schumpeter's theory of creative destruction[1], in order to grow, businesses must be ready for some drastic and fundamental changes, partially ruining the foundations of their former success, while their openness to innovation is prerequisite for survival and further development.

1.2. Advances in the implementation of Industry 4.0

The country which is commonly considered to lead the implementation of the Industry 4.0 concept is Germany. With the aid of the federal government, works aimed at developing a strategic growth program of "Industrie 4.0" have been launched there. But also other countries have noticed that the efforts undertaken in relation to the fourth industrial revolution must have priority. The United States have deployed the "Advanced Manufacturing" program, China have their "Made in China 2025" initiative, while the "Smart Nation" strategy is being implemented in Singapore.

Compared to other countries, Poland appears to be managing rather poorly in this respect. In terms of such factors as the advancement of production processes, automation of manufacturing plants, preparation of the workforce, level of innovation, share of value added

[1] Compare: Schumpeter J. A. (2011), *Kapitalizm, socjalizm, demokracja (Capitalism, socialism, democracy)*, PWN.

in industrial production, and the relation between foreign trade and production value, our country is considered to be one of the least prepared to changes.

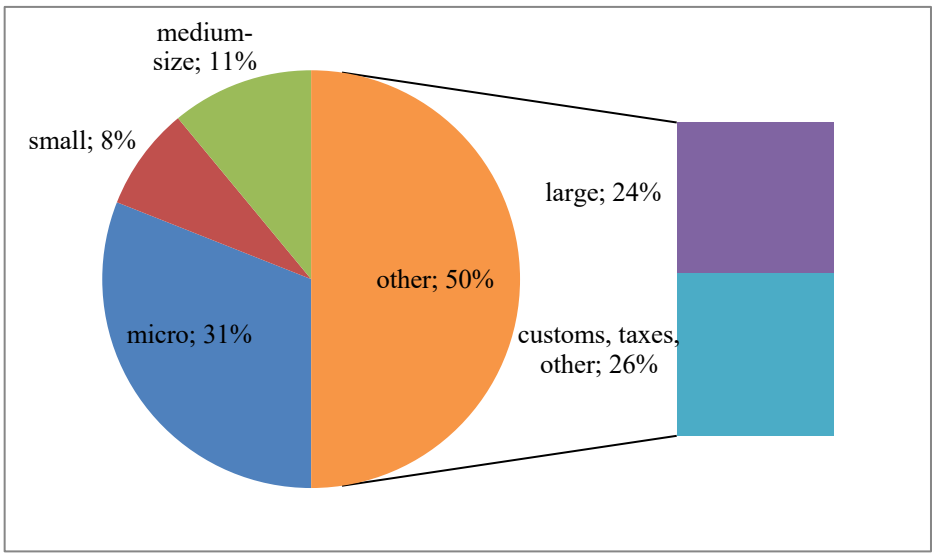
Over the recent years, Poland has invariably been mentioned as one of efficiency-oriented economies, only aspiring to join the group of innovation-oriented states.

2. SMEs

All over the world, micro-, small and medium-size enterprises (SME) play a significant part in the structure of economy. In Poland too, they are major, if not the most important economic entities. Micro-enterprises, small enterprises and medium-size enterprises employ 69% of the professionally active population, while the micro-enterprises account for as much as 40% themselves.

SMEs contribute significantly to the Polish GDP, as a half of it is generated by this group of businesses.

Figure 1. Breakdown of the 2017 Polish GDP in per cent



Source: Authors' own study based on data from a report by the Polish Agency for Enterprise Development (PARP)[2]

The role of SMEs cannot be limited to their contribution to the GDP. This sector employs 69% of all professionally active people, thus forming the very social fabric with all the functions the society requires. It is on their standing and condition that further growth of our country depends.

[2] PARP (2018), *Report on the situation of the small and medium business sector in Poland*,

The concepts of Industry 4.0 encompass the entire sector – not only global corporations, but also their sub-suppliers, including Polish SMEs.

3. Polish automotive industry

The automotive industry is the most automated and robotized sector of the economy. This is where more than 1/3 of all the robots installed in the industry operate (165 units per 10,000 employees, with the industry average being 24 units per 10,000 employees).[3]

Poland is among major automotive manufacturers, and in terms of the technology used in this sector it is also one of the most highly developed European countries.

Below are some figures illustrating the industry.[4]

- Automotive production output: PLN 140.1 billion (2016: 9.6% y/y)
- Share in total industry: 10.1% (2016)
- Persons employed by the sector: 181.6 thousand (2016: 6.1% y/y)
- Number of businesses: 1,363 (2016)
- Number of IATF 16949:2016 certified companies: 660
- Annual production volume: 689.7 thousand vehicles: 514.7 thousand passenger cars, 169.8 thousand commercial vehicles (vans and lorries), and 5.3 thousand buses
- Export: EUR 25.22 billion (9.75% y/y), including EUR 11.24 billion in export of parts and accessories (10.39% y/y)

What is specific about the sector is the clear division into manufacturers of complete vehicles and suppliers of components for assembly, i.e. TIER 1 and TIER 2 suppliers.

4. Authors' own research into the industry

The problems of the fourth industrial revolution and its impact on the Polish economy, and particularly on the micro-, small and medium-size enterprises from the perspective of the opportunities and threats they face, have already been discussed in the authors' previous publications.

At Siemens Polska, the authors initiated and conducted a series of surveys addressing the condition of the Polish automotive industry, and especially the company's preparations for the fourth industrial revolution.

The research was conducted in collaboration with Millword Brown, under the scientific supervision of the AGH University of Science and Technology in 2016 and the

[3] International Federation of Robotics (2018), *2018 Report*
[4] Polish Investment and Trade Agency (PAiH) (2019), *Raport Sektor Motoryzacja*

Warsaw School of Economics (SGH) in 2017–2018, along with the Ministry of Development/Ministry of Enterprise and Technology.

Individual series of the surveys concerned different spheres of the Polish industry:

- Smart Industry 2016 – large businesses (> 250 employees)
- Smart Industry 2017 – micro-, small and medium-sized enterprises (SMEs)
- Smart Industry 2018 – micro-, small and medium-sized enterprises (SMEs)

Selected results of the 2017 and 2018 surveys concerning the SMEs have been provided and elaborated further on in this paper.

4.1. Smart Industry 2017

The purpose of the survey was to diagnose the progress of adaptation of innovation in the operations of micro-, small and medium-size production enterprises in Poland[5].

The survey was conducted on an all-Poland sample of SMEs representing the industry comprising 251 businesses broken down into micro-, small and medium-size enterprises through pre-arranged interviews using the CATI technique.

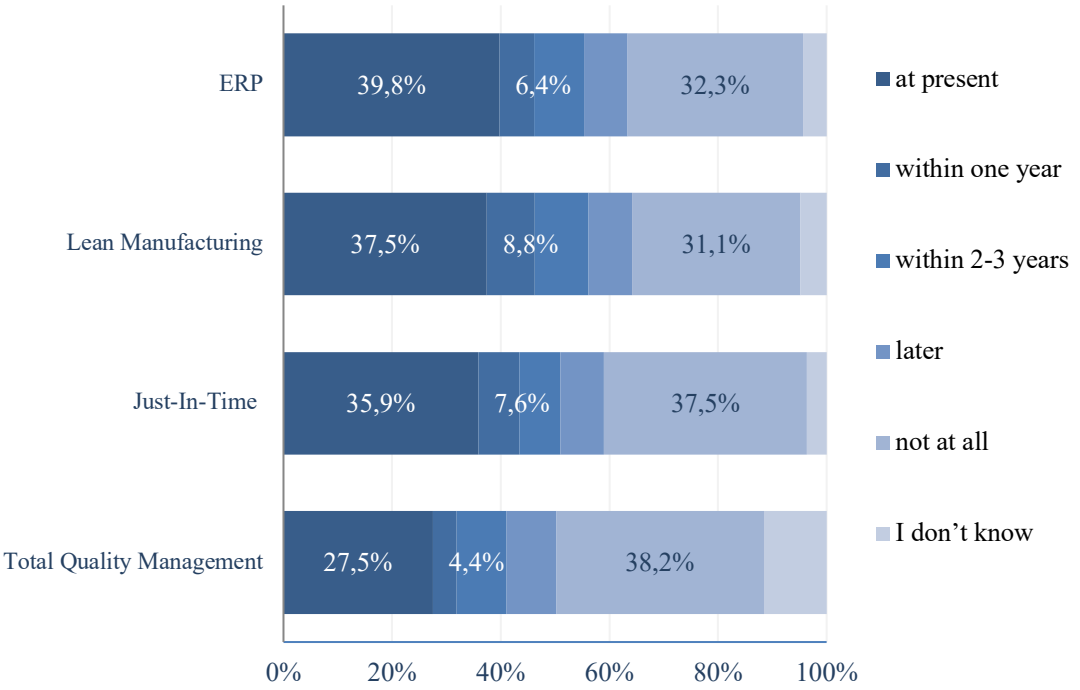
A decided majority of the SMEs (89.6%) were fully Polish capital companies, however, their operations were not limited to the territory of Poland (71.3%), but they were also present in foreign markets, even outside of the European Union.

Interestingly, 60% of the SMEs admitted having never heard of the Industry 4.0 concept, while in 90% of the businesses, the decision on the implementation of new technological solutions was made directly by the owner or the management board.

The most popular of the contemporary management concepts are the ERP (*Enterprises Resource Planning*) systems, Lean Manufacturing and Just-In-Time.

Diagram 1. New technologies used at present and in the future

[5] Ministerstwo Rozwoju, Siemens (2017), *Smart Industry Polska 2017, Adaptacja innowacji w działalności mikro oraz małych i średnich przedsiębiorstw produkcyjnych w Polsce, Raport z badań*



Source: Smart Industry Polska 2017 report, diagram 14.

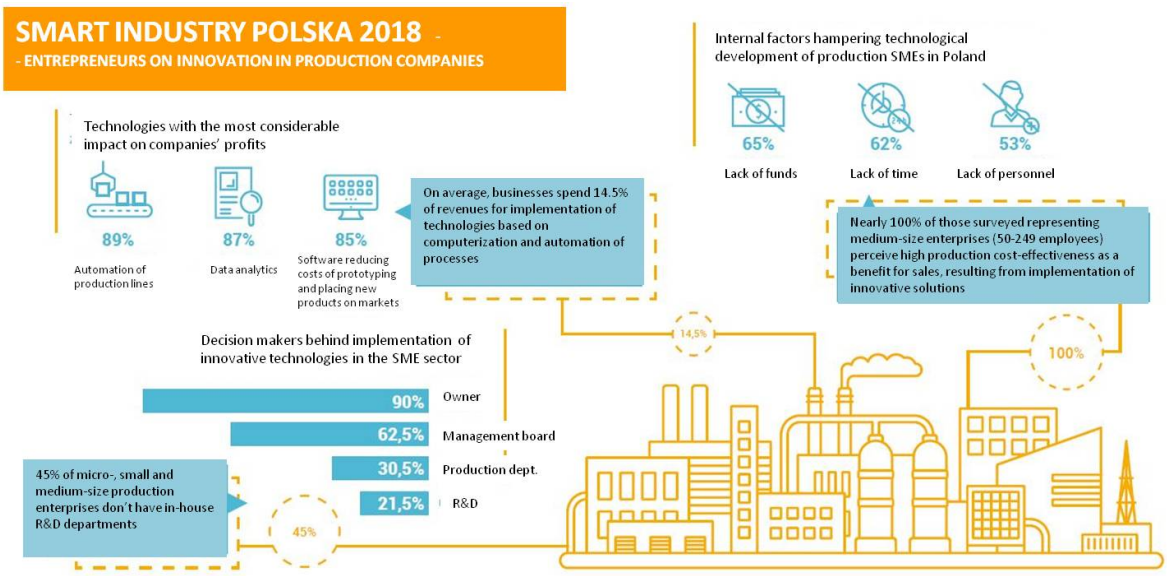
The level of implementation of state-of-the-art management methods in the businesses surveyed was relatively low, although these methods have been known around the world for many years. The detailed results of the survey revealed that foreign equity companies used advanced management methods and elements of the Industry 4.0 concept, such as IoT, Big Data or Cloud Computing, more often than businesses with domestic capital.

4.2. Smart Industry 2018

A follow-up to the survey on the condition of Polish micro-, small and medium-size enterprises was the Smart Industry Polska 2018 research project. Its purpose was to diagnose the factors which accompany implementation of modern technologies supporting innovative development of businesses. Similarly to the preceding year, the survey covered 251 businesses broken down into micro-, small and medium-size enterprises, and it was conducted by pre-arranged interviews using the CATI technique.

The survey's general results have been illustrated in Figure 2.

Figure 2. Smart Industry Polska 2018 – general survey results



Source: Smart Industry Polska 2018 report[6]

Enquired about the main targets of their future operations, the businesses mentioned the following:

- automation of production lines (52%)
- data analytics (51%)
- software for computer aided prototyping (32%)

They also defined the main goals for future investments:

- purchase of production machinery (52.6%)
- purchase of new technologies (17.1%)

The main barriers reported by those surveyed were as follows:

- lack of funds (65%)
- lack of time (62%)
- lack of qualified personnel (53%)

The said report has implied that the SMEs are still at a crossroads. Relying mainly on internal funds, they are afraid of investing in "unknown" information technologies. They are expecting support from the state, but the lack of time of their owners/decision makers and the lack of qualified personnel cause them to withhold strategic decisions. They are expecting support from the state, but they are also often unable to make use of such aid due to the existing formal and barriers. They do not run their own research and development

[6] Ministry of Enterprise and Technology / Siemens (2018), *Smart Industry Polska 2018. Innowacyjność w sektorze mikro oraz małych i średnich przedsiębiorstw produkcyjnych w Polsce. Raport z badań (Innovation in the sector of micro-, small and medium-size production enterprises in Poland – a survey report)*

centers, and yet they are reluctant to collaborate with other entrepreneurs or scientific and research institutions.

4.3. Barrier to investing in R&D in the Polish automotive industry

An analysis of the report by KPMG[7] implies the following threats facing the Polish automotive industry:

- Poor financial standing of Polish companies (mainly SMEs)
- R&D projects implemented by large international corporations outside Poland
- Low effectiveness of collaboration between Polish scientific and research centers
- Limited number of state-of-the-art R&D centers in disposal of highly advanced equipment and well educated personnel
- Trend of using ready-made innovative products (foreign licenses), which is considered to be more effective and less risky in financial terms than in-house R&D
- No collaboration between scientific centers (unwillingness to cooperate), limited collaboration with enterprises and foreign centers. This leads to the reduction of the number of innovative international projects implemented in Poland.

Given the limited capabilities to generate innovative products through R&D activity, seeking additional opportunities to grow is prerequisite.

An example of such a path is changing the enterprise's operating model and making the most of the opportunities connected with the Industry 4.0 model.

5. Concept of a model for the Industry 4.0 implementation in SMEs

The analysis of how SMEs function in the automotive industry, referred to in the previous sections of this article, has led the authors to following insights:

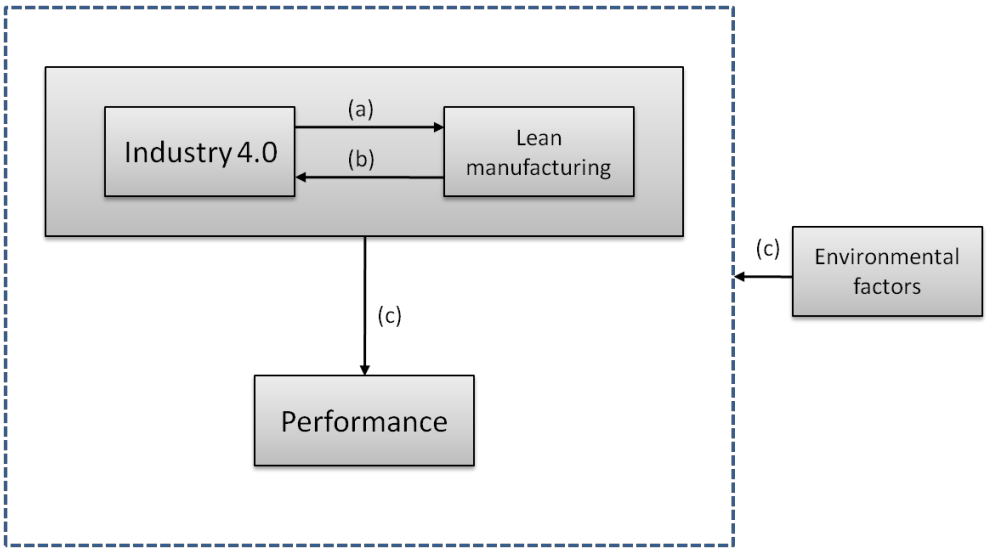
1. The Polish literature of the subject lacks a description of a model which would enable implementation of the Industry 4.0 concept in small and medium-size enterprises.

[7] KPMG (2019), "B+R w sektorze motoryzacyjnym" (*R&D in the automotive industry*)

2. Under the Polish conditions, it is recommended that the implementation of individual Industry 4.0 components should be preceded by deploying Lean Manufacturing (LM) in enterprises. Implementing Industry 4.0 without having prepared the enterprise in managerial and organizational terms may trigger various manifestations of inefficiency and waste. The foregoing has also been confirmed by research conducted in other countries besides Poland.[8]

Some general relations between the implementation of LM and that of Industry 4.0 have been illustrated in Figure 3.

Figure 3. Links between Lean Manufacturing and Industry 4.0



Source: based on Buer, Sven-Vegard, Jan Ola Strandhagen, and Felix TS Chan[9]

where:

(a) Industry 4.0 supports Lean Manufacturing

(b) Manufacturing supports Industry 4.0

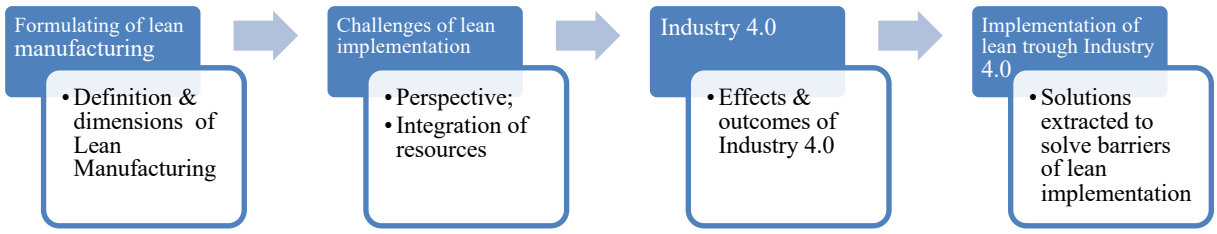
(c) Industry 4.0 and Lean Manufacturing integration has enterprises environmental and performance implication

[8] Buisán, M., Valdés, F. (2017), *La industria conectada 4.0.* "Información Comercial Española, ICE: Revista de economía"

[9] Buer S.V., Strandhagen J.O., Chan F. (2018). *The link between Industry 4.0 and lean manufacturing: mapping current research and establishing a research agenda,* "International Journal of Production Research", No. 56.8: 2924-2940.

Figure 4 depicts the sequence of the actions performed when implementing LM, and Industry 4.0 next.

Figure 4. Sequence of implementation of LM and elements of Industry 4.0



Source: Sanders, Adam, Chola Elangeswaran, and Jens P. Wulfsberg. [10]

Individual Lean Manufacturing tools and methods exert diverse impact on different elements of Industry 4.0. This has been depicted in Table 1, where +, ++, and +++ designate the increasing effect Industry 4.0 components on LM.

Table 1. Impact of LM tools and methods on Industry 4.0 components

	Data Ausition and Data Processig				Machine to Machine Communication (M2M)		Human Machine Interaction (HMI)	
	Sencores and Actuators	Cloud Computing	Big Data	Analitics	Vertical Integration	Horizontal Integration	Virtual Reality	Auguamented Reality
5S	+	+	+	+	+	+	++	+++
KAIZEN	+	++	+++	+++	+++	+++	+++	+++
Just-In-Time	++	++	+++	+++	+++	++	+	++
Jidoka	+	+++	+++	+++	++	++	+	+
Heijunka	++	++	+++	+++	+++	++	++	+
Standardisation	++	+++	+++	+++	++	++	+++	+++
Takt time	+	+	+++	+++	+++	+++	+	+
Pull flow	++	+	+	+	+++	+++	+	+
Man-machine separation	+	+	+	+	+	+	+++	+++
People and team work	+	+	+	+	+	+	+++	+++
Waste Reduction	+	+	++	+++	+++	+++	+	+

Source: based on Wagner, Tobias, Christoph Herrmann, and Sebastian Thiede. [11]

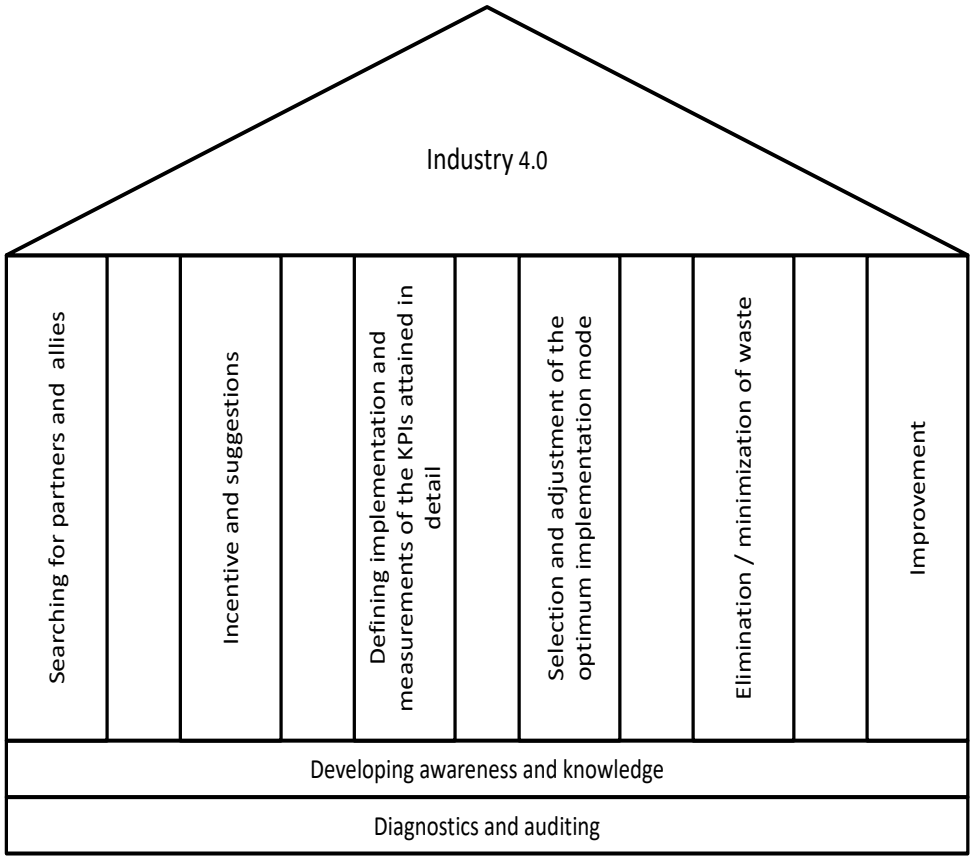
[10]Sanders A., Chola E., Wulfsberg J.P. (2016), *Industry 4.0 implies lean manufacturing: Research activities in industry 4.0 function as enablers for lean manufacturing,* "Journal of Industrial Engineering and Management (JIEM)", No. 9.3: 811-833.

[11] Wagner T., Herrmann Ch., Thiede S. (2017), *Industry 4.0 impacts on lean production systems.* "Procedia CIRP", No. 63: 125-131.

6. Industry 4.0 model proposed for SMEs[12]

With regard to the overall body of problems mentioned above, the authors have proposed a concept of a model for the Industry 4.0 implementation in SMEs, as described further on in this article (Figure 5).

Figure 5. Proposed model for the Industry 4.0 implementation



Source: own

The following assumptions underpin the model in question:

[12] Text includes passages from: Bednarek M. (2015), *Zastosowanie Lean Manufacturing w Polsce i w Meksyku. Modele-praktyka-doświadczenia,* Difin

- What is subject to auditing in an enterprise is the progress of works involved in the implementation of the Lean/Kaizen concepts, being prerequisite of the Industry 4.0 implementation.
- Audit results make it possible to establish the mode, sequence, selection of methods, scope of training and other specific details of the Industry 4.0 implementation project.
- Some post-audit suggestions may evolve as the implementation proceeds and change, thus adapting the methods and ways of acting previously chosen to the changes taking place inside and around the enterprise.
- There are no two identical Industry 4.0 implementations; for many obvious reasons, such as the company location or the personnel's level of education, each implementation may be colloquially referred to as tailor-made.
- Only the starting point of the Industry 4.0 implementation project is pre-set; its completion is never defined in time.
- The model proposed is universal to the extent that it can be applied on different levels of advancement of the Lean/Kaizen deployment for the Industry 4.0 implementation across the enterprise.

The model is based on the following foundations:

- Diagnostics and audit enabling identification of the stage of progress in the application of the Lean/Kaizen principles, and consequently also the onset of the Industry 4.0 implementation in the given enterprise. Results of the diagnostics are the grounds for defining the plan of project activities. The scope of the diagnostics has been discussed below.
- Expanding awareness and knowledge. It is an extensive and comprehensive program which encompasses training, workshops, briefings to explain the Lean/Kaizen and Industry 4.0 concepts to the entire personnel, coaching and mentoring. The forms it assumes, as well as its recipients and lead times vary depending on the implementation advances as well as the progress in creating a supportive corporate culture.

The diagnostics, the use of similarities and the development of awareness provide foundations for the following pillars of the model:

- Seeking partners and allies

Industry 4.0 is team work. Joining external forces invested by consultants and internal forces ensured by selected employees as well as collaboration between these parties are the prerequisites of the project's success. They are the said partners and allies. The people employed by the enterprise tend to change or become discouraged. They may be assigned to other, more urgent tasks by managers. The search in question is continuous in nature and its importance is great.

- Motivation and suggestions

Motivating and creating atmosphere supportive of listening to the employees' voice, practical use of their reality-based ideas concerning possible enhancements to the company's operations in combination with efficient system for monitoring of the results attained make it possible to achieve sustainable outcomes and ensure that they are repeatable.

- Defining implementation areas and measuring KPIs

When implementing Industry 4.0, one chooses locations where the concept is to be deployed on a pilot scale, so that the project may then be expanded across the entire enterprise in the follow-up.

It is the choice of the implementation location which determines the selection of methods, whereas the chosen method conditions the options for elimination or minimization of waste. From the very beginning of the Industry 4.0 implementation efforts, one must launch an improvement process and start searching for the most adequate way to implement it, to organize the work, to compose the team and the plan the actions.

- Choosing and adapting the most appropriate implementation method

Variability of the conditions (priorities, emerging disturbances, external circumstances) under which processes are performed in a company makes it necessary to constantly adapt the ways in which the concept is implemented (sequence of works, team composition, scope of training).

- Elimination/minimization of waste

The choice of methods and procedures for implementation and outcome monitoring are prerequisite of continuous waste elimination/minimization in the course of the implementation.

- Improvement

Ongoing care for the outcomes achieved and continuous follow-up to the implementation.

6.1. Principles of diagnostics and auditing

In Lean Manufacturing implementation projects, teams of consultants can make use of the diagnosing and auditing method described below. The following figure illustrates the principles of diagnostics and auditing in different organizational units of an enterprise, comprising both its current status and growth plans.

Figure 6. Principles of diagnostics and auditing

Period	Subject of auditing	Areas audited
Current status	• Top management • Middle management • Operational level	• Basic processes • Auxiliary processes • Administrative processes
Growth perspectives		

Source: authors' own research

The audit is performed in the following scope:

- Assessment of the main factors determining the progress of the Lean/Kaizen implementation in the enterprise
- Assessment of the main factors determining the enterprise's readiness to and potential for implementation of Industry 4.0, including:
    - Strategy
    - Products
        - Degree of customization of products
        - Degree of digitization of products
        - Capability to integrate products – product tying

- Customers, including e.g.
  - Digitization of sales/services
  - Digitization of customer service (multi-channeling)
- Processes
- Environment
- Culture
  - Knowledge management
  - Culture of openness to innovation and new technologies
  - Assessing the value of IT for the organization
- People, including e.g.
  - Personnel competencies
- 4.0 technologies applied

6.3 Resume

What matters a lot when implementing Industry 4.0 is the enterprise's size. SMEs must pay special attention to the following:[13]

- Insecurities, including e.g. data security or maturity of Industry 4.0 technologies
- The benefit of Industry 4.0 has to be transferred from vision level to reality level
- Investments in Industry 4.0 technologies have to be encouraged by public funding in order to lower the barriers explicitly for SMEs
- Internal staff qualification programs and training programs for schools and universities have to be called for
- SMEs have to be supported separately as they are less capable of doping with the financial, technological and staffing challenges than large enterprises

[13] Sommer L (2015), *Industrial revolution-industry 4.0: Are German manufacturing SMEs the first victims of this revolution?,* "Journal of Industrial Engineering and Management", No. 8.5: pp. 1512-1532.

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