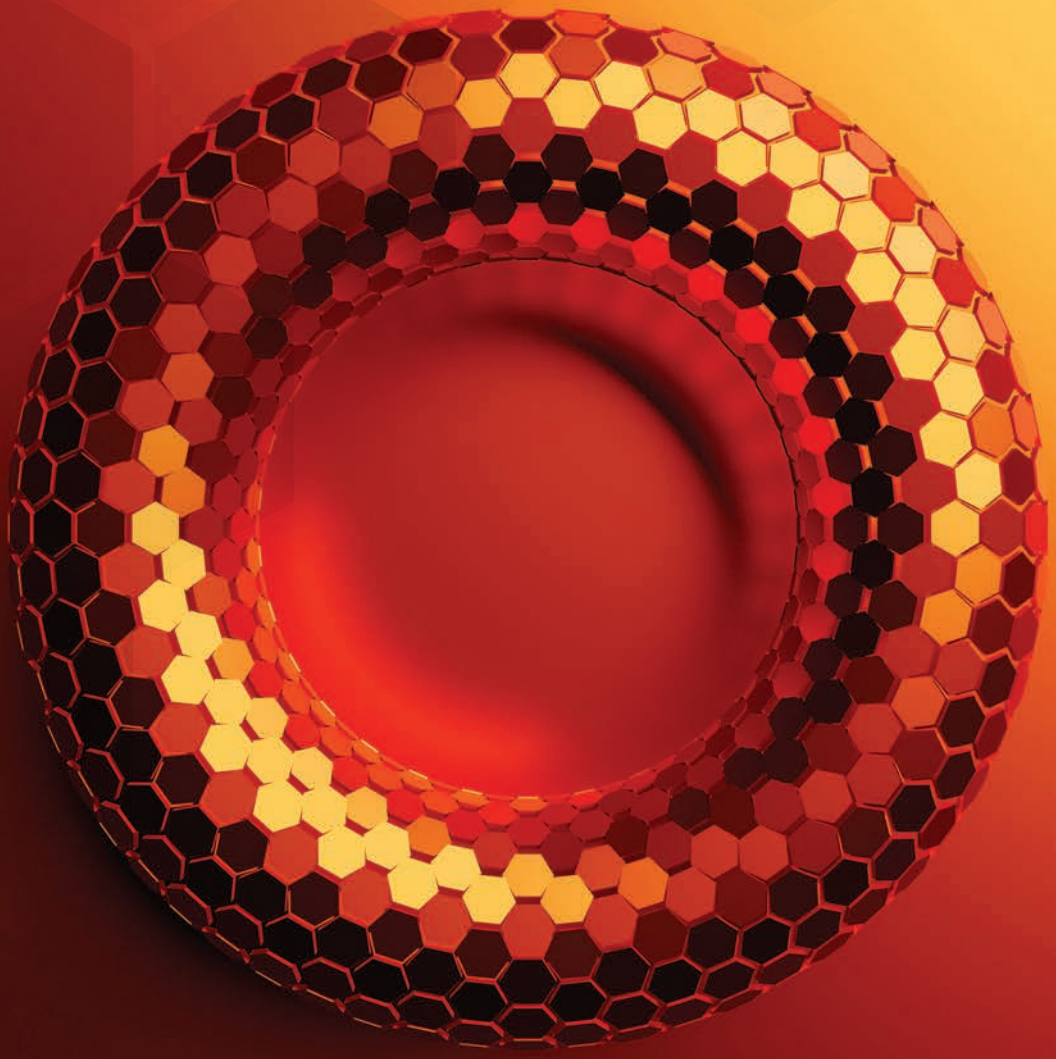
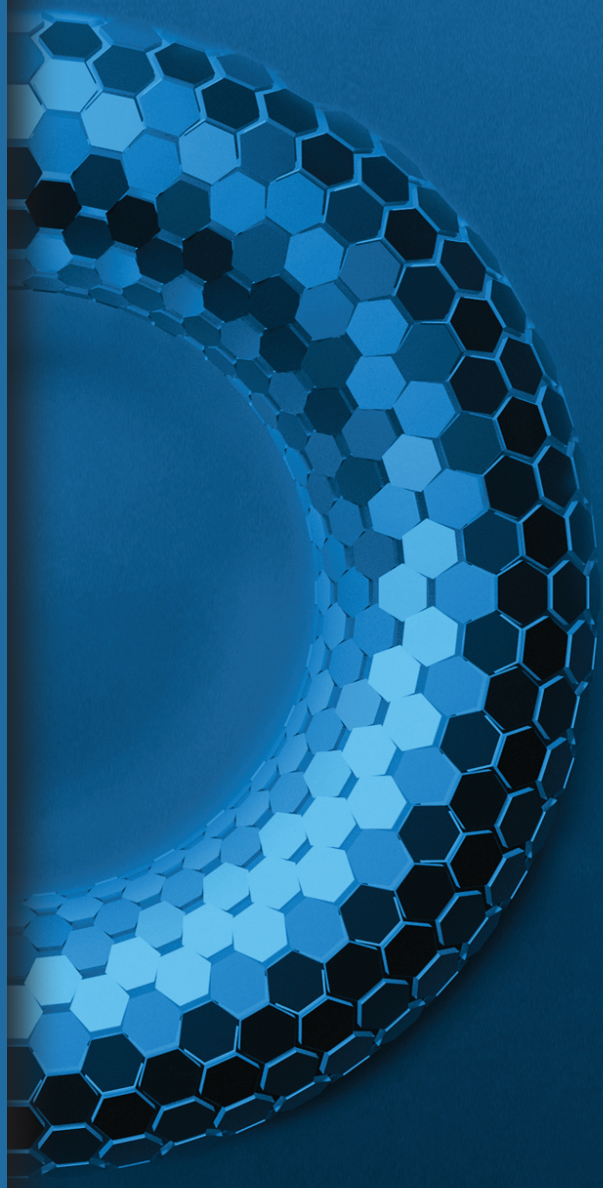


DIGITAL READINESS ASSESSMENT

METHODOLOGY & FRAMEWORK

The Asian Productivity Organization (APO) is an intergovernmental organization that promotes productivity as a key enabler for socioeconomic development and organizational and enterprise growth. It promotes productivity improvement tools, techniques, and methodologies; supports the National Productivity Organizations of its members; conducts research on productivity trends; and disseminates productivity information, analyses, and data. The APO was established in 1961 and comprises 21 member countries.

APO members
Bangladesh, Cambodia, Republic of China, Fiji, Hong Kong, India, Indonesia, Islamic Republic of Iran, Japan, Republic of Korea, Lao PDR, Malaysia, Mongolia, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Thailand, Turkey, and Vietnam.



DIGITAL READINESS ASSESSMENT: METHODOLOGY & FRAMEWORK

METHODOLOGY & FRAMEWORK

FEBRUARY 2022 | ASIAN PRODUCTIVITY ORGANIZATION

DIGITAL READINESS ASSESSMENT: Methodology & Framework
Methodology & Framework

Dr. Matthias Kuenzel and Dr. Ernst Andreas Hartmann are volume editors.

First edition published in Japan
by the Asian Productivity Organization
1-24-1 Hongo, Bunkyo-ku
Tokyo 113-0033, Japan
www.apo-tokyo.org

© 2022 Asian Productivity Organization

The views expressed in this publication do not necessarily reflect the official views of the Asian Productivity Organization (APO) or any APO member.
All rights reserved. None of the contents of this publication may be used, reproduced, stored, or transferred in any form or by any means for commercial purposes without prior written permission from the APO.

Designed by Word By Design Creacomm

CONTENTS

FOREWORD iv

ACKNOWLEDGMENTS v

EXECUTIVE SUMMARY 1

DEVELOPMENT PROCESS 2

METHODOLOGY AND FRAMEWORK 3

- **Digitization Between Disruption and Transformation** 3
- **Industrial Policy on Digitization** 4
- **Analysis: Indicator System** 6
- **Analysis: The Digitization Dashboard** 10
- **Toolbox - Support Measures** 10
- **Scaling Services** 13

IMPLEMENTATION OF PROCESS RECOMMENDATIONS 15

ANNEX A: QUESTIONNAIRE 16

ANNEX B: EXAMPLES OF RESULT CALCULATION 23

ANNEX C: EXPLANATION OF OVERALL RESULTS 25

REFERENCES 28

LIST OF FIGURES 30

FOREWORD

Rapid technological change is encompassing diverse business operations and is fundamentally altering the way enterprises function. Amid the rise of Industry 4.0, relatively few SMEs have adopted digital technologies and digitalization processes. There is no ready-made strategy for implementing Industry 4.0 in every company. Businesses, especially SMEs, are struggling to define their starting points in the complex Industry 4.0 journey.

Assessing readiness before embarking on transformation is necessary for all enterprises. Self-positioning in terms of maturity level enables the identification of strengths and weaknesses as the foundation for strategies to enhance efficiency and unlock opportunities for future growth. To assist in the assessment, the APO is publishing DIGITAL READINESS ASSESSMENT: Methodology & Framework, a handbook containing a methodology framework based on the practical experience of the APO Center of Excellence (COE) on IT for Industry 4.0 and Institute for Innovation and Technology (IIT) Berlin. This handbook explains the fundamentals of and framework for determining readiness and technological maturity levels for undertaking digital transformation in the Asia-Pacific context. Utilizing this handbook, the COE on IT for Industry 4.0 under the National Productivity Council (NPC), India, launched its own Bharat 4.0: DIGITAL READINESS ASSESSMENT: Methodology & Framework Tool to support Indian enterprises in gauging their readiness levels, determining focus areas, and prioritizing digital initiatives for accelerating transformation.

Insights from DIGITAL READINESS ASSESSMENT: Methodology & Framework are expected to be useful inputs for APO member countries in designing their own readiness indexes for enterprises and guiding businesses in identifying appropriate approaches to adopting Industry 4.0 digital technologies. The support of the COE on IT for Industry 4.0 under the NPC, India, and collaboration of the expert team of IIT Berlin during the publication process were invaluable.

Dr. AKP Mochtan
Secretary-General
Asian Productivity Organization
February 2022

ACKNOWLEDGMENTS

The handbook of DIGITAL READINESS ASSESSMENT: Methodology & Framework Methodology Framework is the result of the consulting process of APO Center of Excellence on IT for Industry 4.0, hosted under the auspices of National Productivity Council (NPC) India, the Asian Productivity Organization (APO) secretariat, and the Institute of Innovation & Technology VDI/VDE Innovation + Technik GmbH. It serves as the basis in forming the building blocks and finalizing the Bharat 4.0: DIGITAL READINESS ASSESSMENT: Methodology & Framework Index launched by the COE on IT for Industry 4.0, NPC, India.

The support throughout the development journey and inputs provided by the experts, Dr. Matthias Kuenzel, Dr. Ernst Andreas Hartmann, and Lene Ganschow from the Institute of Innovation & Technology VDI/VDE-Innovation + Technik GmbH were invaluable.

Without the fruitful partnership, the methodology framework would not have been completed.

EXECUTIVE SUMMARY

Production technology is an important economic component for many countries all over the world, including India and other Asian Productivity Organization (APO) member countries. The digitalization of production, often summarized under the buzzword Industry 4.0, poses completely new challenges for production technology. Industry 4.0 induces extensive qualitative changes in the manufacturing sector with significant impact on existing and future value chains.

At the same time, small and medium-sized enterprises (SMEs) in dynamically developing and changing value chains could be major stakeholders in this new paradigm. SMEs are specifically challenged by Industry 4.0, as it is often unclear to them what this form of industrial transformation process means, or when and how they can best meet it. A lack of dedicated resources and competencies at the management level on the one hand and a seemingly endless bundle of methods on the other open up a host of opportunities and risks. Supporting SMEs in the transformation process is a core element of modern industry policy. Experiences from the developments in Germany, the birthplace of the term "Industry 4.0", were used to discuss and develop methods for digital transformation in Asian countries, especially India. Digitization of production looks beyond use of data for enterprise resource planning, purchase and sales, or intralogistics. But these first easy-to-achieve results in digitization are already opening the door to disrupt existing workflows and processes, to do more of the same, only digitally. The complex portfolio of means and opportunities in digitization also includes the human factor: experience and creativity are the basis for new business models, new product ideas, and production methods. This still involves brainwork and not artificial intelligence (AI). The perspective of future engineering shows that routine work can be automated, but not innovative ideas.

To support enterprises, especially SMEs, in assessing its readiness for the transformation journey, the APO Center of Excellence on IT for Industry 4.0, hosted under the auspices of the National Productivity Council (NPC) India developed this handbook, "DIGITAL READINESS ASSESSMENT: Methodology & Framework: Methodology & Framework". The comprehensive consulting process between the National Productivity Council (NPC), the APO secretariat, and the experts from the Institute of Innovation & Technology (iit) VDI/VDE Innovation + Technik GmbH resulted in this handbook. The framework highlights three layers with three main drivers, nine subpillars, and 49 dimensions with the questionnaire and results interpretation are formulated to assess a company's readiness and the strategies it should undertake toward the Industry 4.0 transformation journey.

The handbook covers the overall approach of innovation support methodology and respective measures concerning digitization in industry. The analysis focuses on the management level as well as the operational level and the respective means of digitization. It takes into account how a company is integrated into it. The analysis of the degree of digitization is the first step for the transformation of a company with the perspective of readiness for Industry 4.0. The handbook serves as the basis in forming the building blocks and finalizing the Bharat 4.0: DIGITAL READINESS ASSESSMENT: Methodology & Framework Index launched by the COE on IT for Industry 4.0, NPC, India.

DEVELOPMENT PROCESS

This methodology framework is the result of a consulting process for developing a toolkit to assess the degree of digitization in industry. The consulting process was carried out from November 2020 to February 2021. Due to the COVID-19-pandemic, the consulting process was carried out remotely with video conferences.

Based on a draft from the National Productivity Council (NPC), the systematic approach was expanded in the early sessions. The Institute for Innovation and Technology (IIT) proposed, based on its experience in supporting industrial and innovation policy for SMEs, to develop a three-stage model for enterprise digitization support. The NPC and iit jointly developed a standardized questionnaire to systematically collect information on all elements. It was a challenge to find a balance between detailed insight and the limited time available to fill such a questionnaire. Thus the decision to implement a one-stage model to allow fully automated use. For aggregation, the results of single questions were weighted according to the Analytic Hierarchy Process (AHP), a powerful yet simple method for weighting multiple decision criteria that is used for project prioritization and selection.

The analysis focuses on management and operational levels as well as the respective means of digitization. It takes into account production processes, logistics, and human resources. It also examines and evaluates the value chain the respective company is integrated in. The analysis on the degree of digitization is the first step for the transformation of a company with the perspective of readiness for Industry 4.0. The focus is on the use of digitization, not on becoming a 100% digital company (platform operator), dropping the classic in-house production processes and operate as a contractor for third parties.

For industry and innovation policy, it is important to get an overview of the overall situation of the digitization of enterprises, especially SMEs, regions, sectors, and many other factors and views. Therefore, in the course of a session, the implementation of a digitization dashboard was discussed. To produce a practical example, iit designed a mock-up of a digitization dashboard using 500 fictitious data sets (software: Tableau®).

The application methodology is based on the results and experiences of the INNO-Partnering Forum, a multinational coordination and support project in PRO INNO Europe [1] that is funded by the European Union. It focuses on several national and regional funding programs [2] and non-financial support measures [3]. Last but not least, the application methodology also incorporates the experiences of the Accompanying Research Projects to the national funding programs on digital technologies PAiCE [4], Smart Services Worlds [5], and Smart Data Economy [6].

METHODOLOGY AND FRAMEWORK

Digitization between Disruption and Transformation

Production technology is an important economic component to a country's economy. The digitalization of production, often summarized under the buzzword "Industry 4.0", poses completely new challenges to production technology. Industry 4.0 induces extensive qualitative changes in the manufacturing sector with significant impact on existing and future value chains.

Industry 4.0 also particularly challenges small and medium-sized enterprises (SMEs), as it is often unclear to them what this form of industrial transformation process means, or when and how they can best meet it. They could become a major driver of this new paradigm, but it could also disrupt their existing value chains and business models.

The "Industry 4.0" concept and the implementation of the fourth industrial revolution were first introduced at the Hannover Fair in 2011 [7]. It should be noted that the idea of future production was developed from the perspective of ICT, not production science. "Industry 4.0" describes the implementation and use of autonomous, self-controlling, knowledge-based, and sensor-based production systems. The availability of all relevant information in real time through networking is just as much a prerequisite as the ability to use the data to determine the value-added flow at any point in time [8].

In retrospect, the understanding of "Industry 4.0" developed over the years. With time, it was replaced by "digitization", taking into account upcoming trends in business models (business models of the platform economy) and upcoming production methods, especially additive manufacturing.

The digitization of production could mean to use ICT-related methods (IoT, AI, etc.) to transform an existing production and optimize the production process. It may also open the door for individualized products at reasonable prices, instead of mass production. This is to be understood as transformation through digitization.

A striking example of disruption through digitization is still cameras and photography, where digital methods (including progress in semiconductor hardware) were the base for a complete turnaround of photography based on chemical processes to a completely new product landscape with digital cameras, digital image processing, image platforms, etc. Probably the only parts of this value chain that are more transformational, rather than disruptive, are the optical components of a camera.

General lessons concerning the implementation and use of digitization in manufacturing are (in no particular order):

- Use digitization of production not only for cost reduction, but to implement additional competitive advantages or unique selling propositions (USPs)
- Success factors: Open for new partnering structures and collaboration, customer integration by digitization

- Innovation needs not only technology development, but also organizational innovations and change management
- Digitization strategy is a leadership task, to be implemented by the management and staff
- Therefore: Invest in (digital) competencies of the staff

Digitization is a typical strategy topic and therefore a leadership/management task. The typical strategy circle is a fine base for a process model (see Figure 1).

FIGURE 1

SIMPLE STRATEGY CIRCLE FOR DIGITIZATION

As with all quality management processes, the feedback process is an important element. The time frames highlighted for the different phases are more symbolic and show that the implementation phase requires a longer time scale.

Larger and mid-sized enterprises often have a Chief Digital Officer (CDO) who is responsible in managing and organizing the respective processes and corresponding specialized work teams. In SMEs, especially in small outfits, it becomes one of the manifolds of core management tasks that compete for resources and attention.

Industrial Policy on Digitization

The dynamic development of digitization described in the previous chapter poses significant challenges to the production industry, while independent of the sector, but somehow specific to it. In contrast to large enterprises with their own strategies, roadmaps, and resources for forecasting economic developments, smaller enterprises operate more on a day-to-day basis. Here, the definition of SMEs

used by the European Union (EU) should be taken into account that there is a significant difference between a company with 25 and 200 employees.

In Asia as well as in Europe and the USA, most of the production is realized by SMEs. Eurostat shows that more than 99% of the enterprises in the 28 members in the EU (including UK) that falls under the "C Manufacturing" of NACE Rev. 2 category are SMEs. In 2019, EUR775 billion out of EUR2,138 billion GDP was contributed by the SMEs (at factor cost) for the EU-28 [9].

Many manufacturing SMEs are highly specialized with distinctive niche. Many suppliers are unsettled and fear that they will be left behind by developments, or be forced into economically risky dependencies, or their business models will no longer operate well.

Digitalization and networking are impacting on all aspects of a business. For example, from products and services to working, production, and communication processes. Studies have shown that SMEs are lagging behind big companies when it comes to digitizing their working and business practices. SMEs need to face up to this digitalization, harness the opportunities, and master the challenges linked to it in order to keep their business viable and competitive in the long term [10].

The ICT skills needed to capitalize on the potential of Industry 4.0 (apart from correspondingly oriented companies) are not usually part of the core business of manufacturing SMEs. In addition, the ICT-culture-dominated conceptual world of Industry 4.0 has a limited link to the everyday operations of manufacturing companies, and there is a high degree of uncertainty among employees.

Further, interested stakeholders are confronted with a multitude of information, training offers, and events, whose quality and conformity with the respective company's needs are questionable and can hardly be determined in advance [11].

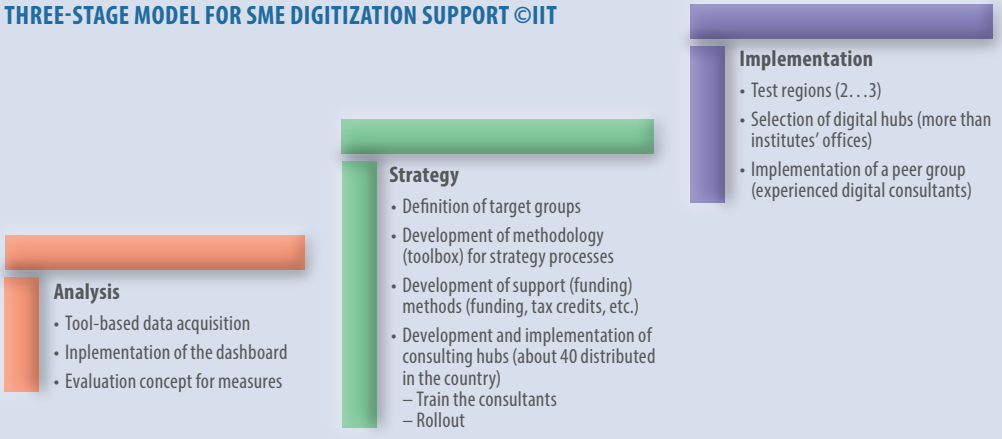
Based on that short analysis, the implementation of a "SME digitization policy" is in the focus of relevant ministries all over the world. Thus respective support measures are designed and implemented.

Applying its experiences obtained from different projects supporting industrial and innovation policy for SMEs, iit developed a three-stage model for SME digitization support (see Figure 2).

The model in Figure 2 is used as one of the guidelines for the consulting process carried out in the described project.

FIGURE 2

THREE-STAGE MODEL FOR SME DIGITIZATION SUPPORT ©IIT



Analysis: Indicator System

The development of the indicator system was the core element of the consulting project. Based on a draft from the NPC, the systematic approach was expanded in the first sessions (see Figure 3).

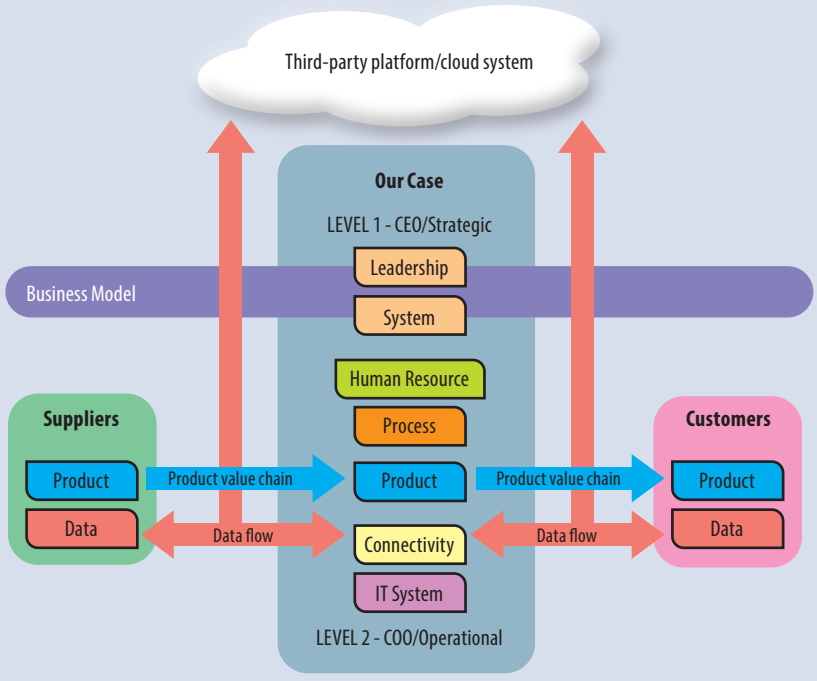
This structure takes into account that any enterprise pursuing digitization to not only address internal aspects but also consider the value chain(s) in which it is integrated. For both the supplier and customer (where the analyzed company is the supplier), the elements of digitization in the respective products/components as well as the data exchange parallel to the physical products (e.g., engineering/design, business processes) are taken into account.

Within individual enterprises, two levels of digitization were identified - the operational (shop floor) level with its processes and IT systems, while the strategic level looks into business models and leadership tasks are allocated. Human resources fall somewhere in between.

A third "connector to the digital world" are links to third-party platforms and cloud services. This could be sales or buyers platforms, enterprise resource planning, and technically oriented platforms supporting distributed engineering, production operation, or offering services like predictive maintenance (e.g., Siemens Mindsphere).

FIGURE 3

SYSTEMATIC STRUCTURE OF THE INDICATOR SYSTEM



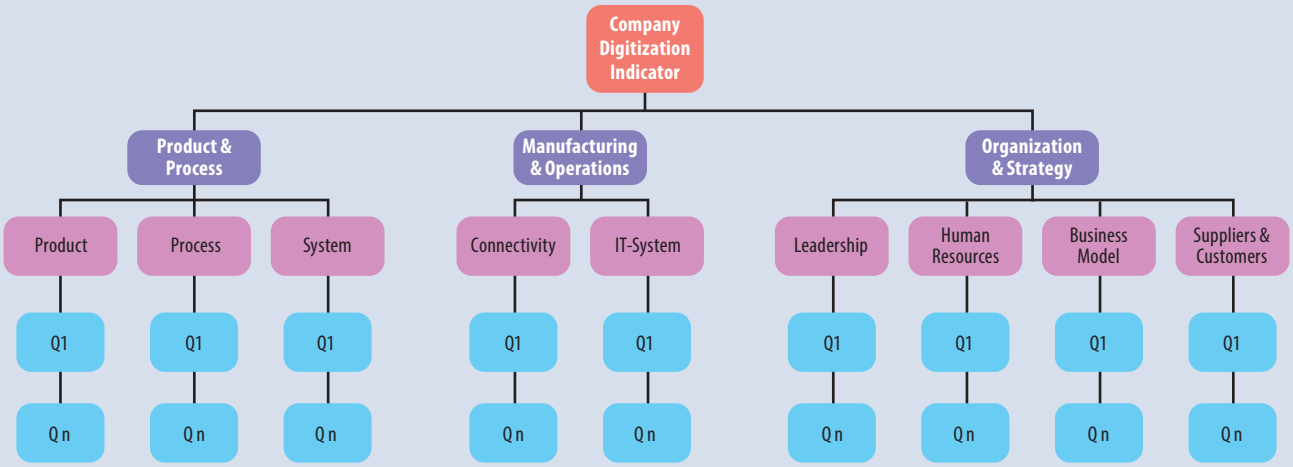
The NPC and iit jointly developed a standardized questionnaire to systematically collect information on all the elements introduced in Figure 3. The challenge lay in finding a balance between obtaining a detailed insight and the limited time available to fill up the questionnaire. To overcome this, a decision was made to implement a one-stage model to allow fully automated use. Other methods use a two-stage model in which a decision is made after answering a limited set of questions (level 1) by selecting a few topics by going in-depth. This two-stage model is dependent on an experienced interviewer,

who decides with the interviewee on the most interesting areas or bear the most potential for a select company.

In detail, the indicator system consists of three chapters covering two to four subareas each (for detailed indicator system, see Annex A) and with three to eight dedicated questions (see Figure 4) for each of the subareas.

FIGURE 4

OVERALL STRUCTURE OF THE QUESTIONNAIRE



It has to be emphasized that there is no order of priority to the chapters. Single questions might end up with a low result as there may be no requirement for digitization to certain aspects. The three areas in the questionnaire are briefly presented below:

Product and Process

This area analyzes the role of digitization features in companies' products and processes, the level and degree of product customization, and the use of digital methods (e.g., dynamic resource planning) in the shop floor. Further, the digitization of the supply chain prior to the company is analyzed. Demands and the degree of production flexibility are additional topics that are taken into consideration. The third focus area is the time-to-market process and the role of digitization in this process as well as the use of frontrunner digital technologies (e.g., AI and blockchain). Figures 7 and 8 demonstrate fictive results from this chapter and some subareas.

Manufacturing and Operations

The second area deals more with the IT-backbone of the company. It is analyzed to what degree the machines on the shop floor use automated production methods, are operated autonomously, and last but not least, use sophisticated methods of operation (e.g., predictive maintenance). The second subarea of this chapter looks at data management and infrastructure, including storage methods, data analysis, data verification, and IT-security means.

Organization and Strategy

The third area of the questionnaire considers typical leadership and management tasks. Starting with the IT-strategy of a company, the involvement and commitment of the management, partnerships, investment strategies, and risk management, the first subarea closely covers management tasks. The second view covers human resources, including present readiness of staff, necessary skill upgrades as well as human-machine collaboration and digital sovereignty. Finally, an important aspect, the

business model(s) are evaluated. Building on the demands of the addressed market(s) and its typical product life cycles, the use of digital engineering and their integration with enterprise management tools are evaluated. The use of automated feedback from the products in use is also discussed. The last subarea covers the digital relation of suppliers and customers. Two levels are taken into account - the digital capabilities of the products and their use for new products or services.

For aggregation, the results of the single questions are weighted according to the Analytic Hierarchy Process (AHP). The AHP is an effective method that weighs multiple decision criteria that is used for project prioritization and selection. Figure 5 shows an example for the use of AHP in the evaluation of the questionnaire. More details are in Annex B.

FIGURE 5

EXAMPLE OF USING AHP: WEIGHT OF SUBTOPICS IN "PRODUCTION PROCESS" AREA ©NPC

	Process											
	Supply Chain Visibility	Supply Chain Integration	Supply Chain Flexibility	Production Flexibility	Production Scheduling	Normalized					Total	Average Weights
Supply Chain Visibility	1	1/2	1/2	1	1/2	0.13	0.13	0.14	0.17	0.08	0.64	0.13
Supply Chain Integration	2	1	1	1	2	0.25	0.25	0.29	0.17	0.31	1.26	0.25
Supply Chain Flexibility	2	1	1	2	2	0.25	0.25	0.29	0.33	0.31	1.43	0.29
Production Flexibility	1	1	1/2	1	1	0.13	0.25	0.14	0.17	0.15	0.84	0.17
Production Scheduling	2	1/2	1/2	1	1	0.25	0.13	0.14	0.17	0.15	0.84	0.17
Sum	8.00	4.00	3.50	6.00	6.50							

In the second step, the subindicators are aggregated to the overall "Company Digitization Indicator" using AHP as well. This indicator is used to classify each company into one of the digitization grades, as shown in Figure 6.

It has to be emphasized that displaying an overall "Company Digitization Indicator" is accompanied by a loss of significant detailed information on strengths and weaknesses. Therefore, the results of the different subindicators are important for later steps and the benchmarks can be shown in a spider chart. Figure 7 shows a fictional example for the subtopics in the analysis area of "Product & Process". They will be an integrated part of the report on the respective company.

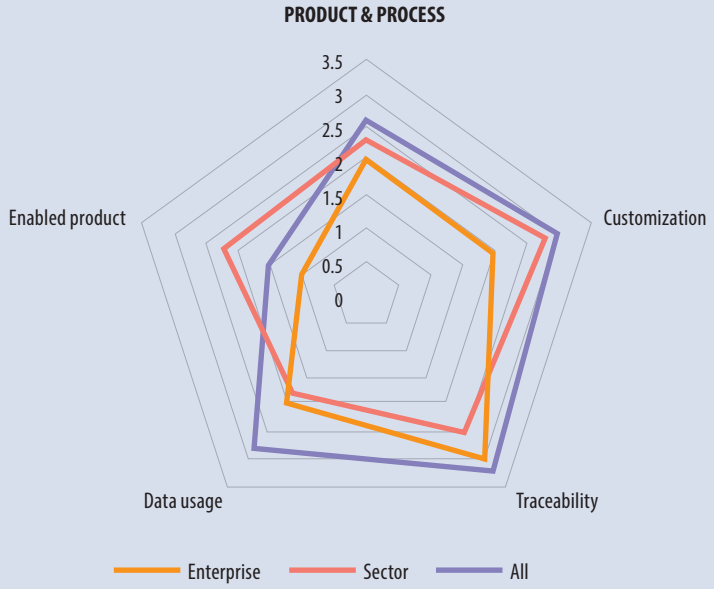
Other methods of graphic display such as boxplots are feasible as well. The final questionnaire and the AHP weighting are documented separately and shown as Annexes A, B, and C in this report.

FIGURE 6

GRADES OF DIGITIZATION

FIGURE 7

PRESENTATION OF RESULTS: EXAMPLE OF A SPIDER GRAPHIC FOR BENCHMARKING



Finally, the indicator system delivers input to the analysis in two aspects: on the company level to generate an analysis report as shown before, and for the dashboard on the aggregate level (see next chapter).

Analysis: The Digitization Dashboard

For industry and innovation policy, it is important to get an overview of the overall situation concerning the digitization of the SME, depending on regions or sectors, and many more selections or views. Therefore, during one of the sessions, the implementation of a digitization dashboard was discussed. To produce a practical example, a set of 500 fictitious data sets was generated and a mockup (see Figure 8) of a digitization dashboard was designed by iit (used software: Tableau®).

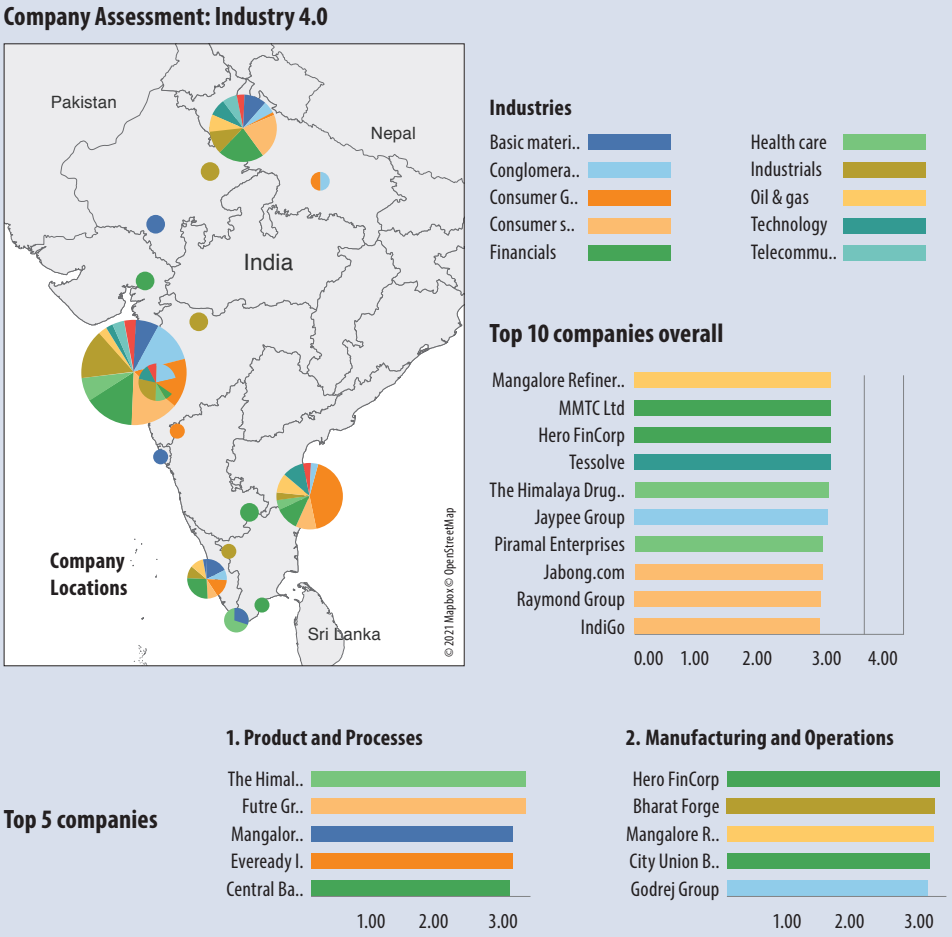
Toolbox - Support Measures

Analyzing the degree of digitization in companies, sectors, and regions is the first step in a digitization of industry policy. As shown in Figure 2, the digitization policy strategy (in this report, specifically on SMES) and the implementation of support measures is imperative for a rapid and sustainable improvement of the degree of digitization.

The support measures must be adapted to the overall level of digitization of individual companies (see Figure 6) and the culture of the industrial sector. Innovation support measures described below will address the lower levels of digitization compared to higher levels, taking into account that enterprises at a high level are usually able to help themselves or know where to turn to in the event the need for support is required.

FIGURE 8

MOCKUP OF A DIGITIZATION DASHBOARD (©iit USING TABLEAU®)



At the beginning, one lesson was learnt 10 years ago at the INNO-Partnering Forum, an EC-funded project that focused on SME support measures - **SMEs need more than funding.**

In designing the digitization support measures, the multiple experiences on innovation support activities that were collected over many years should be taken into account. Here are some examples:

- Use digitization of production not only for cost reduction, but also to implement additional competitive advantages or USPs
- Success factors: To be open to new partnering structures and collaboration; customer integration by digitization
- Innovation needs not only technology development, but also organizational innovation and change management
- Digitization strategy is a leadership task, to be implemented by both management and staff
- Therefore: Invest in (digital) competences of the staff

In SMEs, daily business consumes existing resources, having neither an ICT department nor an ICT strategy. They also do not have a department for acquisition of grants. They need support measures at their own point in time, not necessarily when a call is ready at the ministry. Funding in terms of money is helpful, but it is only one element of the support concerto. Mentoring, consulting, and good practice cases are as important as government money. Though these facts were originally stated when it comes to R&D, they appear to apply only as part of digitization support.

Taking this into account, the portfolio of support measures should be designed according to these findings, employing mid- and long-term engagement. An evaluation will help to adjust single measures. A few selected aspects and methods are highlighted below:

Mentoring vs. Consulting

Mentoring is understood as a long-term process supporting the enterprises and not merely a single project. It is like the "family doctor" identifying problems, imparting advice, and conveying to the "specialists". Mentor should be located in the regions the companies operate in, especially in large countries like India.

Consulting is dedicated to a single problem or challenge. Experienced, independent persons with technical expertise in one (or better) different sectors of ICT fulfill this second level of support task.

Voucher Scheme Funding

Often there is the need for rather small amounts of public money to reach easy goals in digitization. Classic funding schemes are characterized by significant process time between applying for funding and decision. Especially in the UK and the Netherlands, innovation vouchers has proven to work in the long term. Innovation vouchers were developed to improve efficiency and process time. They are limited to smaller amounts of money (e.g., GBP2,500 [12]) with clear and simple rules. The UK experience is of special interest to India, as the Indian legal system includes parts of the UK common law model.

About 10 years ago, this model was transferred to Germany for innovation and support measures as part of resource efficiency, and later on digitization. The German go-digital program consists of three modules: Digitized Business Processes, Digital Market Development, and IT Security. The go-digital funding program not only supports SMEs in optimizing processes and developing additional market share through digitization, but also finances measures to protect the companies against loss of sensitive data [2].

All German voucher programs address consulting as the only supported form of costs (based on limited daily rates) in the way as explained in the chapter before. To guarantee the quality and the independence of the consultants, an authorization and quality check process is applied. The consulting firms also take care of the applications for funding, accounting, and reporting.

Digital Hubs

Digital hubs could act as core elements of future support strategy as they offer a portfolio of services in a highly efficient manner. They should be closely connected to research facilities for knowledge transfer (train the trainers) and collaborative activities. The portfolio of services could include:

- Information events (online/offline) on various digitization topics
- Training measures
- Laboratories and test sites for demonstration and training

Further, they allow concentrating a critical mass of expertise for the operation of services and any support measures. Hubs should be designed with a two-stage-support toolbox. Basic services could be offered by any of these hubs which are spread across the country. Advanced services (e.g., according to regional industry sector focus areas) allow to offer in-depth services needing more sophisticated or expensive equipment and knowledge.

At this stage, these are only some first remarks on the design and services of digital hubs. In Europe, there is a competition to implement more than 100 European Digital Innovation Hubs distributed all over the 27 member states [13]. Although they are more dedicated to digital innovation than to support measures, there are many learnings from this process.

The Digital Hub-Network Baden-Wuerttemberg is a regional model of hubs and blueprints. It is the "focal point for digital innovation in the regions of Baden-Wuerttemberg. These unique centers are melting pots for different competences, disciplines, ideas, technologies, and creativity. Regional Digital Hubs are points of contact for small and medium-sized enterprises of all sectors concerning questions on digitalization. They offer the opportunity to learn about digitalization on site, to experience digitalization and to develop and test new ideas for digitalization projects in experimental spaces." [14].

Scaling Services

The Regional Aspect

Despite the tool-based first stage of analysis, the following steps to support digitization in the individual enterprises could not be offered in an automated manner. There are measures that could be offered in a 1-to-n-model, like information events or more in-depth information in the web. However, when it comes to designing a digitization strategy, and more so during implementation, it is a one-to-one business. This business could be implemented successfully only with regional expertise. Based on Porter's classic definition of clusters [15], they are geographical concentrations of interconnected companies and institutions in related industries, which are characterized by common exchange relations and activities along one (or more) value chain(s).

Excellent cluster structures (cluster initiatives) extend in a three-dimensional space. This implies that they extend horizontally (up to the manufacturers of complementary products and services) as well as vertically (through the distribution channels to the customer). The geographical component is of great importance. This refers to the regional and spatial proximity of the individual players to one another. Nevertheless, the concentration of the players merely symbolizes the existing cluster potential.

Only when regionality has a favorable effect on working, exchange, and communication processes, the cluster potential is transformed into effective cluster structures. Active cluster management can decisively influence this development. Cluster management or cluster managers are good moderators of the regional and cross-institutional innovation events and processes.

Experience shows that this more general view of regional business development is also a useful facilitator for improving digitization. On the one hand, a cluster management has the trust of the enterprise's management - and anybody dealing with digitization aspects in a company needs this trust to a great extent - on the other hand, a cluster can usually address digitization aspects of the whole value chain (vertically) and in one sector (horizontally) promoting synergies and scale effects.

Finally, localizing the digitization support allows the situation of the regional economy to be taken into account to a large extent and distances to be shortened. In the pandemic era, online became the new hype, but online has its limitations, especially when it comes to going to the shop floor and showing good practice implementations.

Train the Trainers

The current situation is the knowledge of tool-based analysis and the next steps are lodged in the minds of a few people. The next step is to collate and scale this knowledge to benefit companies all over India. Despite the fact that tool-based analysis (see Figure 1) could be done as a self-assessment [16] or by an interviewer within two hours, the subsequent stages will require more human resource. Therefore, it will become necessary to train assessors and - to a much higher degree - to select and train consulting

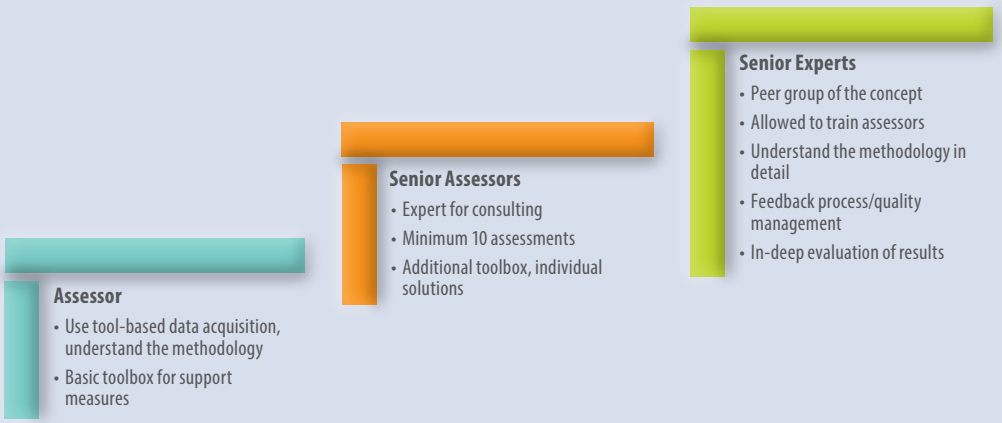
experts. Selecting and training these experts is a core element for the sustainable success of a SME-digitization-support methodology.

In the case of NPC India, for the first phase, the 12 regional directorates of the NPC [17] and their staff are a good place to start. However, the number of people would prove to be insufficient in the long run. For perspective, there are more than 1,000 consulting enterprises (the majority are small firms) are approved in the German go-digital program. Therefore, it will become necessary to integrate external experts into the system. As trainers are providing their services on behalf of the NPC and the government, their quality, their expertise, and their integrity are essential. In addition to training measures, formal qualification, and work experience of individual experts, the integrity of the respective host organization should also be taken into account when labeling experts. Figure 9 shows a rough multistage concept for experts. This system should be refined during implementation with a possibility of adding one or two more levels.

For all levels, the business case for the respective individuals and organizations should be clear, especially if individual experts or hub operators are not paid by the government (e.g., research institutes, business development organization). Compliance rules must be implemented to guarantee neutrality.

FIGURE 9

FIRST SKETCH OF A MULTISTAGE EXPERT CONCEPT ©IIT



Finally, one role should be outlined: the senior experts. They will become the peer group of the methodology. Their experiences will provide their feedback and thus drive the future development of the methodologies at all stages.

IMPLEMENTATION OF PROCESS RECOMMENDATIONS

The implemented consulting process had covered the analysis phase in a detailed manner. Two aspects of data analysis were discussed:

- Analysis for a single enterprise, including benchmarking against the respective industry sector and the overall production sector
- Analysis on the general innovation policy level, including methods like dashboards and other means of statistics

As explained in the Development Process segment, this phase allows a high level of automation. The following phases - strategy building and implementation - can also use a version of the standardized tools out of a box. Nevertheless, the selection of tools and the resulting activities are highly individual and will therefore require a significant number of human resources in the future.

The author recommends continuing the process of digitization support process in India in two directions, which may be adapted to other countries, if relevant:

- Design and implement a "digital hub blueprint for India" concept to supply the country with local lighthouses of digitization and ICT knowledge. Simultaneously, a starter kit of services to support digitization in companies should be developed. The network of the NPC offices is a good starting point. Other locations should be evaluated. Exchange among the hubs will improve their experience
- Design and implement a digital training concept for digitization consultants. This concept has two objectives. The first is to distribute the knowledge gained at the Centre of Excellence in Delhi throughout the country (and beyond), and the second, to ensure the quality of consulting at the local hubs.

ANNEX A: QUESTIONNAIRE

1. PRODUCT AND PROCESSES				
1.1 PRODUCT				
Theme - Industry 4.0 Readiness	**Level 1**	**Level 2**	**Level 3**	**Level 4**
	Starter	**T**ransitional	**E**xperienced	**P**erformer
1.1.1 Product Customization To what extent can your products be customized to end users' requirements?	No mechanism to incorporate individualized requirements. Standardized Bulk Production.	Majority of products are made in large batch sizes with limited Delayed Differentiation.	Products can be largely customized but still have standardized base.	Delayed Differentiation available for most make-to-order (MTO) products ("Single Piece Flow").
1.1.2 Product Traceability What is the degree of visibility of your product?	Little product tracing.	Product can be traceable during the production process.	Product can be traced in production and distribution, and up to customer level.	Product is traceable throughout the product life cycle.
1.1.3 Product Data Usage What is the level of product data usage at your plant?	No data usage.	Only limited data utilization (up to 25% of gathered data).	Moderate data utilization (25%–50% of gathered data).	Data influences the decision-making process (Greater than 50% of gathered data is utilized).
1.1.4 Digitally Enabled Product To what extent is your product digitalized?	Products depict only physical characteristics.	Products show characteristics based only on Intellectual Property (IP).	Products exhibit few characteristics and digital features based on intellectual property (IP).	Products exhibit all characteristics and digital features based on intellectual property (IP).

1.2 PROCESS				
Theme - Industry 4.0 Readiness	**Level 1**	**Level 2**	**Level 3**	**Level 4**
	Starter	**T**ransitional	**E**xperienced	**P**erformer
1.2.1 Visible Supply Chain What is the level of information visibility from suppliers and customers to interlink upstream and downstream supply chain processes for proactive decision-making?	No data exchange with suppliers or customers.	Operational parameters are visible between suppliers and customers.	Operational parameters are visible throughout the supply chain.	Operational parameters is visible in real-time throughout supply chain and used for monitoring and optimization.
1.2.2 Integrated Supply Chain How would you rate the level of digital capability across suppliers, customers, logistics, etc., integration network?	Ad-hoc and reactive communication with suppliers and customers.	Limited communication and data sharing with suppliers and customers.	Data interaction between key strategic suppliers and customers.	Fully integrated real-time systems with suppliers and customers.

1.2 PROCESS				
Theme - Industry 4.0 Readiness	**Level 1**	**Level 2**	**Level 3**	**Level 4**
	Starter	**T**ransitional	**E**xperienced	**P**erformer
1.2.3 Flexible Supply Chain How would you rate the ability of your Supply Chain to respond quickly to customer needs and market changes?	Very slow response to market environment.	Medium response to both market changes and customer requirements shifts.	Medium response to changes in market environment and individual customer requirements.	Instantaneous response to changes in market environment as well as individual customer requirements.
1.2.4 Production Flexibility How would you rate the ability of your production process to respond quickly to customer needs and market changes?	Rigid manufacturing work flow process; extremely difficult to incorporate mid-production changes.	Mildly flexible production system.	Flexible production system based on modularized product design.	Dynamic production flow of work; integrated supply chain based on decentralized production planning enables mid-production changes with ease.
1.2.5 Production Scheduling What is the level of your company's production scheduling?	Manual production planning.	Manual production planning based on ERP (Enterprise Resource Planning) data.	Automatic production planning by APS* (Advanced Planning System or Advanced Planning and Scheduling).	Optimize production planning through the integration of ERP and APS.

1.3 SYSTEM				
Theme - Industry 4.0 Readiness	**Level 1**	**Level 2**	**Level 3**	**Level 4**
	Starter	**T**ransitional	**E**xperienced	**P**erformer
1.3.1 Digital Integration What is the level of integration of new digital technologies into existing digital systems, technologies, and processes?	Identified requirements for new digital technologies to be integrated rapidly into existing digital systems, technologies, and processes.	Defined and planned for new digital technologies to be integrated rapidly into existing digital systems, technologies, and processes.	New digital technologies are being integrated rapidly into existing digital systems, technologies, and processes, but not all parts of business.	New digital technologies are being integrated rapidly into existing digital systems, technologies, and processes.
1.3.2 Time to Market What is your understanding with regards to how time to market could reduce as a result of your use of digital systems, technologies, and processes?	Understand how time to market could reduce, but not yet identified how to do so.	Identified how time to market could reduce, but no implementation plan.	Developed plan for reducing time to market through digital systems.	Business model reduces time to market as a result of use of digital systems, technologies, and processes.
1.3.3 Latest Technology Usage What is the level of your business using the latest technologies, namely augmented reality/virtual reality/3D printing /digital twin/predictive maintenance, etc.?	Identified the potential for these technologies within the business.	Pilot project to evaluate technology.	Adoption of technology on some, but not all relevant parts of business.	Fully adopted and integrated technology in the business and delivering results.

1.3 SYSTEM				
Theme - Industry 4.0 Readiness	**Level 1**	**Level 2**	**Level 3**	**Level 4**
	Starter	**T**ransitional	**E**xperienced	**P**erformer
1.3.4 Legacy Technologies As you adopt new digital systems, technologies, and processes, what is the level of dealing with legacy technologies?	Plans for dealing with legacy technologies are at an early stage and not yet implemented formally.	Our plan for adopting new digital systems, technologies, and processes includes dealing with legacy technologies.	Legacy technologies are being replaced or retained, but not integrated with new digital technologies.	Legacy technologies are being integrated with or replaced by new digital technologies.
1.3.5 Communication Channels Do you communicate key information using digital systems, technologies, and processes? *(includes only internal communication)*	Identified the potential for communicating key information using digital systems, technologies, and processes.	Manuals and other published information is communicated using digital systems, technologies, and processes.	Data reports are available on demand through digital systems, technologies, and processes.	All data are available automatically and in real-time through digital systems, technologies, and processes.

2. MANUFACTURING AND OPERATIONS				
2.1 CONNECTIVITY				
Theme - Industry 4.0 Readiness	**Level 1**	**Level 2**	**Level 3**	**Level 4**
	Starter	**T**ransitional	**E**xperienced	**P**erformer
2.1.1 Machine Automation What, according to you, is the level of workflow automation in your plant?	A small number of machines can be controlled through automation.	Some machines and system infrastructures can be controlled through automation.	Most machines and system infrastructures can be controlled through automation.	Machines and systems can be controlled completely through automation.
2.1.2 Connectivity By what degree would you rate the digital integration of machines & systems at plant level?	Machines and systems have no integration.	Machines and systems are, to some extent, interoperable.	Machines and systems are partially integrated.	Machines and systems are fully integrated.
2.1.3 Autonomous Are your company's production machines capable of self-monitoring?	No monitoring.	Operation status record ready for diagnosis.	Capable of machine status prediction.	Capable of autonomous control based on the prediction. Production control cascades down to the local level.
2.1.4 Equipment/Machine Maintenance How does you enterprise perform equipment/ machine maintenance?	Breakdown maintenance based on manual data collection.	Detection of anomaly/fault based on part-manual, part-digital data collection and analysis.	Centralized analysis of anomaly/ fault based on fully digital data. Forecasting techniques employed (Preventive Maintenance).	Data Analytics based on autonomous maintenance for predicting anomaly/ fault (Predictive Maintenance).

2.2 IT Systems				
Theme - Industry 4.0 Readiness	**Level 1**	**Level 2**	**Level 3**	**Level 4**
	Starter	**T**ransitional	**E**xperienced	**P**erformer
2.2.1 Data Identification Have you identified the data collection points needed to support your business performance?	Yet to identify the data collection points needed.	Identified requirements but not implemented the data collection points needed.	Identified and enumerated the data collection points needed.	Continuously improving identification of the data collection points needed.
2.2.2 Data Collection How does your company collect operational data?	Manual data collection, e.g., sampling for quality control.	Data collected digitally in some areas.	Extensive digital data collection in multiple areas.	Extensive (end-to-end) automated digital data collection across the entire process.
2.2.3 Data Storage How do you store operational data?	No data storage.	Data is stored in an information system.	Data is stored in the company's server or premises.	Data is stored in a public cloud outside of the company or in a hybrid cloud (a combination of private and public clouds).
2.2.4 Data Analysis How does your company analyse production data for Predictive/Prescriptive purpose?	No data analysis.	Statistical approaches.	Continuous data feeds for intelligent decision-making, including predictive maintenance via technical assistance and decentralized decision-making.	Deep learning approaches. All data is used not only to optimize processes, but also for decision-making.
2.2.5 Data Verification How do you verify your data?	Sensors and other data collection points are checked for accuracy from time to time.	Sensors and other data collection points are checked for accuracy systematically, according to a well-developed plan.	Data is checked by sampling systematically according to a well-developed plan.	Data is verified against a real-time digital twin.
2.2.6 Digital Modeling How would you rate your level of digital capability for in-plant work process?	No digital exchange of data/information - manual or paper based.	Some processes use digital modelling.	Most processes use digital modelling.	Digitally enabled work processes - smart devices to control the status of production lines, ERP, MES integration for planning of resource, such as, man, machine, raw materials, etc.
2.2.7 IT Security What is the level of IT security network adoption across the entire spectrum?	Standalone IT security network executed as per requirements.	Fragmented execution of IT security network.	Systematic and integrated execution of IT security network.	Framework based systematic and all-encompassing execution of IT security network with rule-based conformance.
2.2.8 Data Security How do you secure data collection points and accuracy of data?	No such assessment done.	Defined requirements, but security of data collection points or accuracy of data not assessed.	Assessed the security of data collection points and accuracy of data.	Assessment of the security of data collection points and accuracy of data being improved on continuous basis.

3. ORGANIZATION AND STRATEGY				
3.1 LEADERSHIP				
Theme - Industry 4.0 Readiness	**Level 1**	**Level 2**	**Level 3**	**Level 4**
	Starter	**T**ransitional	**E**xperienced	**P**erformer
3.1.1 Industry 4.0 Strategy Do you have Industry 4.0 strategy for your plant?	Industry 4.0 is acknowledged, but not integrated into the digital strategy.	Industry 4.0 is included as a part of digital strategy in the business strategy.	Industry 4.0 strategy is conveyed to the business and has wider understanding and acceptability.	Industry 4.0 strategy is executed across the business.
3.1.2 Critical Process Identification Have you identified processes that are critical to digital integration?	Not identified key processes required for digital integration.	Defined requirements and identified processes.	Identified and planned key processes, resources, and capabilities required for digital integration.	Continuously improving key processes, resources, and capabilities required for digital integration.
3.1.3 Communication Do you communicate strategies for developing and using new digital systems, technologies, and processes? (to insiders/outsiders/ suppliers/customers)	Some communication of digital strategies from leaders of some departments.	Formal communication of digital strategies is built into some of the business processes.	Formal communication of digital strategies is included in every business process.	Effective communication of digital strategies is a fundamental principle of our business with a top-to-bottom approach.
3.1.4 Leadership Involvement What is the level of leadership for development of digital technologies in your plant?	No recognition of the value of Industry 4.0 initiatives.	General interest and knowledge among leadership team on potential Industry 4.0 benefits.	Leadership team recognizes the benefits and are planning capital investments.	Extensive support for Industry 4.0 within the leadership team.
3.1.5 Risk Management Have you evaluated risks associated to digital integration?	Risk evaluation and management associated with digital integration is at an early stage and not implemented formally.	Risks associated with digital integration have been identified.	Evaluation and management of risks associated with digital integration is underway.	Evaluation and management of risks associated with digital integration has been made an integral part in our business process.
3.1.6 Partnership How would you gauge the collaboration levels of your plant in the domain of Industry 4.0? **(Internal)**	The business operates in functional silos.	Limited interaction between various departments.	Cross functional collaboration between departments.	Cross-company collaboration to drive improvements.
3.1.7 Investment Describe the level of investments in the domain of Industry 4.0?	No significant Industry 4.0 investments.	Industry 4.0 investments in one business area.	Industry 4.0 investments in multiple business areas.	Industry 4.0 investments across the entire business.

3.2 HUMAN RESOURCES				
Theme - Industry 4.0 Readiness	**Level 1**	**Level 2**	**Level 3**	**Level 4**
	Starter	**T**ransitional	**E**xperienced	**P**erformer
3.2.1 Talent Readiness How would you rate the skill level readiness of your workforce with regards to Industry 4.0 technologies?	Employees have very limited or no exposure to digital technologies.	Employees with some digital skills are limited to technology driven division/areas of unit.	Developed digital and data analysis skills across maximum domains of the business.	Leading digital and analytics skills across the entire business.
3.2.2 Skill Upgradation What programs are in place to address any skill gaps?	Identified gaps and training program is being developed.	Training being imparted to employees in key areas of the business.	Training for employees in key areas of the business and digital champions identified throughout the business.	Training in digital technologies is a requirement for all current and new employees.
3.2.3 Digital Sovereignty of Workers To which degree does the worker is able to use his experiences and knowledge in a digitized production?	Fully automated production; worker becomes fully dependent on AI's decision.	Mainly automated production; workers can organize some segments of the tasks.	Knowledge from workers is used for decision-making.	Explainable AI; worker decides on recommendations from AI; can decide on constraints for AI.
3.2.4 Human-Machine Interaction To what extent is human-machine interaction in your shop floor?	Keyboard, monitor-based machine operations; classic mechanical operations.	Fenced robots; use of RFID or bar code to organize work flows; assisted assembly.	Virtual reality in engineering; semiautonomous vehicles on tracks.	Collaborative robots; use of AR for service, maintenance, etc.; natural language processing; free floating autonomous vehicles.

3.3 BUSINESS MODEL				
Theme - Industry 4.0 Readiness	**Level 1**	**Level 2**	**Level 3**	**Level 4**
	Starter	**T**ransitional	**E**xperienced	**P**erformer
3.3.1 Blended Marketing Channels Do you use multiple marketing channels for your product offering to customers?	Traditional approach to marketing (offline).	Online visibility; offline sales (website, newsletters, etc.).	Integrated digital and nondigital channels (web store, e-commerce, etc.).	Integrated marketing channels with individualized customer experience management (after sales service).
3.3.2 Product Life Cycle What is your company's readiness level on information integration spanning the product life cycle?	Manual integration, no information system.	Partial introduction of information system and integrated with production (CAD, CAE).	Data integration of different information systems (Digital Twins, ERP).	Alert notification and decision support based on data from the integrated information system, spanning the entire product life cycle (e.g., Predictive Maintenance).
3.3.3 Feedback for Future Product and Service Development How do you use the data you collect to inform new product and service development?	New product and service development use data, but is mostly subjective.	Data is analyzed to highlight potential scope for product and service developments.	Use data is measured in a targeted way and analyzed to inform decisions on product and service development.	Use data to feed back into the business to drive real-time product and service development.

3.4 SUPPLIERS AND CUSTOMERS				
Theme - Industry 4.0 Readiness	**Level 1**	**Level 2**	**Level 3**	**Level 4**
	Starter	**T**ransitional	**E**xperienced	**P**erformer
3.4.1 Digital Features To what extent does your suppliers deliver components with digital features?	Components being produced without digital technologies.	Defined specifications for digitalized components by using digital technology.	Digitalized IoT components being utilized in some business functions.	Complete IoT integrated components being used in all relevant parts of business.
3.4.2 Collaboration with Suppliers To what degree is your involvement in engineering and development processes of your suppliers?	No/minimum involvement with suppliers.	Identified ways to collaborate with suppliers in engineering and development processes of suppliers.	Plans developed to collaborate with suppliers through use of digital systems, technologies, and processes.	Actively collaborating with suppliers in Engineering/R&D. Integrated supply chain management modelling with suppliers.
3.4.3 Digital Features To what extent do you deliver components with digital features to your customers?	Components being produced without digital technologies.	Defined specifications for digitalized components by using digital technology.	Digitalized IoT components being utilized in some business functions.	Complete IoT integrated components being used in all relevant parts of business.
3.4.4 Customers/Market Demand To what degree does your company respond to customer or market demands?	No dedicated employees for customer services or market demand analysis.	An information system for data collection of customer, market, and service needs.	Analyze and predict production requirements based on data from the information system.	Proactive response to customers' demands based on the prediction of production requirements.
3.4.5 Post-sale Service To which degree do you support post-sale service digitally?	No/minimum after-sales services. Only sell spare parts on request.	On demand request handling for digital support.	Partial digitization for products facilitating customer upgrade/ modification after sales using digital technology.	Automated solutions with significant digital support post sales.
3.4.6 Feedback from Customers How far do you analyze customer data for insights and better user experience?	No data analysis. Information kept in random form and decentralized.	Defined specifications for data analysis using digital technology.	Data analysis being carried out for some products/sales/ customer data using digital technology.	Comprehensive data collection - fed into integrated systems for analyzing/ insights to enhance products, sales, and user experience.
3.4.7 Feedback to Suppliers What is the level of data exchange with suppliers for insights and decision-making?	No data transfer mechanisms; no request from suppliers.	Data transfer on request (e.g,. Excel sheets, data logs).	Online data transfer in real time on selected information.	Agreed KPI system transferred in real time (e.g., alert systems, real-time management of value chains).
3.4.8 Digital Purchase To what extent does your purchase department use digital technologies?	Manual procedures.	Use of digital tools to some extent; not integrated (Offline, Excel, etc.).	Digital platforms-based purchase (e-Commerce).	Rule-based automatic processes (Alert-based integrated purchase modules, dynamic pricing methods).
3.4.9 Partnership How would you gauge the collaboration levels of your plant in the domain of Industry 4.0? **(External)**	No collaboration.	Few collaborations without any strategy.	Significant use of collaborations.	Collaboration strategy on selected key areas; R&D, Engineering.

ANNEX B. EXAMPLES OF RESULT CALCULATION

1. Weight of subtopics in "Product and Processes" concerning system

SYSTEM												
PAIR-WISE COMPARISION MATRIX						**NORMALIZED PAIR-WISE COMPARISION MATRIX**						
	Digital Integration	**Time to Market**	**Latest Technology Usage**	**Legacy Technologies**	**Communication Channels**	**Normalized**					**Total**	**Average Weights Assigned**
Digital Integration	1	1	1	1	1	0.20	0.20	0.22	0.17	0.17	0.96	**0.19**
Time to Market	1	1	1/2	2	2	0.20	0.20	0.11	0.33	0.33	1.18	**0.24**
Latest Technology Usage	1	2	1	1	1	0.20	0.40	0.22	0.17	0.17	1.16	**0.23**
Legacy Technologies	1	1/2	1	1	1	0.20	0.10	0.22	0.17	0.17	0.86	**0.17**
Communication Channels	1	1/2	1	1	1	0.20	0.10	0.22	0.17	0.17	0.86	**0.17**
Sum	5	5	4.5	6	6							

2. Weight of subtopics in "Manufacturing and Operations" concerning connectivity

CONNECTIVITY											
PAIR-WISE COMPARISION MATRIX					**NORMALIZED PAIR-WISE COMPARISION MATRIX**						
	Machine Automation	**Connectivity**	**Autonomous**	**Equipment/ Machine Maintenance**	**Normalized**				**Total**	**Average Weights Assigned**	
Machine Automation	1	1	2	2	0.33	0.33	0.33	0.33	1.32	**0.33**	
Connectivity	1	1	2	2	0.33	0.33	0.33	0.33	1.32	**0.33**	
Autonomous	1/2	1/2	1	1	0.17	0.17	0.17	0.17	0.68	**0.17**	
Equipment/ Machine Maintenance	1/2	1/2	1	1	0.17	0.17	0.17	0.17	0.68	**0.17**	
Sum	3.00	3.00	6.00	6.00							

3. Weight of subtopics in "Organization and Strategy" concerning human resources

HUMAN RESOURCES										
PAIR-WISE COMPARISION MATRIX					**NORMALIZED PAIR-WISE COMPARISION MATRIX**					
	Talent Readiness	**Skill Up-gradation**	**Digital Sovereignty of Workers**	**Human Machine Interaction**	**Normalized**				**Total**	**Average Weights Assigned**
Talent Readiness	1	2	2	3	0.43	0.36	0.44	0.43	1.67	**0.42**
Skill Up-gradation	1/2	1	1/2	2	0.21	0.18	0.11	0.29	0.79	**0.20**
Digital Sovereignty of Workers	1/2	2	1	1	0.21	0.36	0.22	0.14	0.94	**0.23**
Human Machine Interaction	1/3	1/2	1	1	0.14	0.09	0.22	0.14	0.60	**0.15**
Sum	2.33	5.50	4.50	7.00						

4. Grade according to overall aggregated result

Range of Industry 4.0 Maturity	Grade	Grade-Code
1–1.8	1	S
1.81–2.4	2	M
2.41–3.0	3	A
3.01–3.60	4	R
3.61–4.0	5	T

ANNEX C. EXPLANATION OF OVERALL RESULTS

Level	Result	Overall analysis	What does the score mean?	How can you reach the next level?	What benefits would you gain from reaching the next level?	What are the next steps?
1	Grade 1	You have scored an overall readiness score of 1, signifying that your organization has basic awareness about Industry 4.0 and emerging technologies. However, you have the prerequisites to easily adopt basic digital approaches in order to move to the next level and start taking advantage of the opportunities that digitalization can bring.	The low scores in all three pillars of digital readiness show that the leadership has yet to develop a clear vision for adopting digitalization into your business. It is most likely that you are still comfortable relying on using manual or paper-based monitoring and control mechanism. You still run your operations using spreadsheets and basic digital media tools.	For jumping to the next level, we suggest your leadership to start developing digital vision and creating a culture for innovation to create a strong foundation for digital strategy. You would require a strong team on board to drive the changes and make the transition as successful as possible. Collaborate with your customers, suppliers, and peers to learn from successes and failures of their digital journey.	Digitalization would enable to think more digitally helping cultivate a culture of innovation and positive change. The digital vision and thinking would create new ideas about the possibilities that digitalization could provide you. Our experience had been that such companies could leapfrog with new product development, improved productivity, and higher sales conversion rates.	Collaborate, collaborate, and collaborate. Either with your stakeholders or with someone who can handhold you. If you need advice on how to start your digitalization journey, you can approach us or access a list of empanelled consultants who have proven track record in the areas in which you need improvement.
2	Grade 2	Your score of 2 implies that you have started implementing a few standalone digital approaches and processes within your business. Although this is quite encouraging and a good starting point, there is a need for further exploration to identify other processes that promise to quickly deliver advantage of Industry 4.0.	The scores obtained indicate that you likely have understood and are confident of the advantages of digitalizing your business. You have started taking focused efforts in implementing digital approaches within your organization. Your leadership is also getting aligned with the opportunities and has started to identify opportunities that digitalization could bring to your business.	Your graduation to level 3 shall prove to be adventurous and thrilling. For this you need to strike the right balance between bringing the right team on board and imbibing transformative culture into the company through effective change management process. If the whole company is open to the opportunities of digitalization, the transition to next levels will be smoother.	The next level shall create a conducive environment for innovation and impact positive change. The leadership would think more digitally and cultivate a culture of innovation. New ideas for product and process development would emerge, opening up new possibilities for digitalization. This would create enabling environment for higher and improved productivity.	Create an enabling environment for building a strong team and make them responsible for identifying new areas for adopting multiple digital approaches. You should look out for good practices between organizations. Alternatively, you can approach us or access a list of empanelled consultants who have proven track record in the areas in which you need handholding.

ANNEX C. EXPLANATION OF OVERALL RESULTS

Level	Result	Overall analysis	What does the score mean?	How can you reach the next level?	What benefits would you gain from reaching the next level?	What are the next steps?
3	Grade 3	The scores on the spider diagram of your organization is 3 and indicates that you have started to reap the benefits of digitalization from some of the digital transformation interventions that you have taken up. Your leadership has recognized the opportunities and are gradually implementing it in different areas of your business. Although there is a long way to go, you are geared up for an improved operational efficiency using digital technologies.	The scores obtained suggest that you have recognized the benefits of digital transformation and have successfully implemented digitalization in a few identified areas in your company. Although you have yet to figure out and plan for creating value through a company-wide Implementation, you likely have some key digital technologies, processes, and/or systems in place and are probably connecting with external partners to improve your supply chain networks.	To reach Level 4, you need to plan for company-wide improvement opportunities. Your leadership team need to drive this change and begin to actively seek out opportunities for growth. We suggest to identify noncore competencies that could be digitalized and collaborate more closely with your customers and suppliers to create external networks as well as build strong supply chain to drive your business forward. This would require utilizing the data collected from digitalization process for harnessing near real-time monitoring and control for making informed decisions about the business.	Starting to use the data collected for informed decisions, you would be able to have greater visibility on work-in-production and improve customer satisfaction. Your relationships with customers and suppliers will enable you analyzing performance-based data from your systems and processes, and you will be able to start identifying and solving bottlenecks which will create tangible opportunities for your business.	You need to adopt digitalization in a broader way and should also share good practices with your stakeholders and peer organizations for mutual benefit. Alternatively, you can approach us or access a list of empanelled consultants who have proven track record in developing wider supply chain networks and effective data utilization.
4	Grade 4	With a score of 4, you are cruising along on your journey to create a successful business through adoption of emerging technologies. Your organization is committed and has been able to build a well-established digital and Industry 4.0 processes by making informed investments. Your leadership needs to focus on other low scoring competencies as reflected on the spider diagram to build a sustainable business.	Your score reflects that you are committed to digitalization and your leadership has been able to identify most of the opportunities in the business for adoption of Industry 4.0 technologies. Continuous interventions have been taken in making company-wide informed decisions based on effective data utilization, fostering closer relationships with external networks, building positive change environment, etc. However, there are still a few areas of the business in which digital is not fully driving change.	You need to build your competencies on all pillars of the spider diagram to reach Level 5. Your leadership team needs to embody every digitalization opportunity available that could be relevant to your organization and continue implementing digital technologies throughout all areas of business, including HR, finance, sales & marketing, production, and quality. You need to build strong data analytics platform through bringing connectedness in all the processes. To conclude, utilize advanced programs to automate improvement recommendations that your business could adopt.	To bring in sustainable improvements throughout all areas of the business will make your processes autonomous to make recommendations for improving productivity based on previous trends. Your performance would favorably position you to create and expand lucrative markets. Further, the analytics will be enabled to seamlessly collaborate with low-cost, high-quality suppliers across the globe.	You're approaching the realm of highly digitalized companies. You need to start taking intelligence-based decisions while continuously updating awareness on the latest developments in the area of disruptive and emerging technologies to plan for periodic and timely investments. Alternatively, you can approach us or access a list of empanelled consultants who have proven track record in developing wider supply chain networks and effective data utilization

Level	Result	Overall analysis	What does the score mean?	How can you reach the next level?	What benefits would you gain from reaching the next level?	What are the next steps?
5	Grade 5	You are at the pinnacle. Congratulations! Your organization excels in every single aspect of digitalization as shown on the spider diagram. Nonetheless, the most difficult thing is not to reach the top, but to sustain the position and stay there. We strongly suggest your leadership to stay tuned for the latest digital developments to be the early adopter and your people focused on positive change to imbibe the new technology.	Your score reflects that your processes are digitally enabled and also connected. You have been able to create a cyber-physical system and utilizing the data collected through the most efficient data analytics platform. Your leadership team is alert, informed, and fast in adopting change to create sustainability of your business. You are able to seamlessly connect with customers and suppliers, and are capitalizing on the advantages of global economies. Your improvement processes are assisted by intelligence to identify and recommend opportunities for improvement using big data.	You are at the maximum Digital Readiness Level and need to put in place the system for sustaining your position. Always stay vigilant of new technologies that emerge as this field evolves extremely quick. Make the most out of your artificial intelligence programs, and listen to their recommendations for growth opportunities and risk mitigation tasks. Adopt effective design mechanism for planning and creating cyber-physical system at the installation stage itself.	-	You're have successfully adopted digitalization. We suggest you stay tuned to industry trends and the latest digital technologies and innovations. Alternatively, you can approach us or access a list of empanelled consultants who have proven track record on how to capitalize on those opportunities.

REFERENCES

METHODOLOGY AND FRAMEWORK OF ANALYSIS

[1] Närfelt K-H. Improving innovation support to SMEs - the synthesis report from inno-partnering forum (a report). Enterprise Ireland, FFG Austria, Agency NL, TEKES Finland, Technology Strategy Board UK and Vinnova 2013.

[2] Bundesministerium fur Wirtschaft und Klimaschutz (Federal Ministry for Economic Affairs and Climate Action). go-digital: Den Mittelstand auf dem Weg in die digitale Zukunft begleiten (go-digital: accompanying medium-sized companies on their way into the digital future) (in German). Accessed from https://www.innovation-beratung-foerderung.de/INNO/Navigation/DE/go-digital go-digital.html.

[3] Wirtschaft digital Baden-Wurttemberg. Digitization of the economy Baden-Wurttemberg. Accessed from https://www.wirtschaft-digital-bw.de/en/ technologien.de/DT/Navigation/EN/Programme Projekte/AktuelleTechnologieprogramme/PAiCE/PAiCE.html.

[4] Federal Ministry for Economic Affairs and Climate Action (Germany). PAiCE. Accessed from https://www.digitale-technologien.de/DT/Navigation/EN/ProgrammeProjekte/AktuelleTechnologie programme/PAiCE/PAiCE.html.

[5] Federal Ministry for Economic Affairs and Climate Action (Germany). Smart services worlds. Accessed from https://www.digitale-technologien.de/DT/Navigation/EN/ProgrammeProjekte/Aktuelle Technologieprogramme/Smart_Services_Worlds/smart_ services_worlds.html.

[6] Federal Ministry for Economic Affairs and Climate Action (Germany). Smarte Datenwirtschaft (Smart data economy) (in German). Accessed from https://www.digitale- technologien.de/DT/ Navigation/EN/ProgrammeProjekte/AktuelleTechnologieprogramme/Smarte_Datenwirtschaft_/ smart e_datenwirtschaft_en.html.

[7] VDI Nachrichten. Industrie 4.0: Mit dem Internet der Dinge auf dem Weg zur 4. industriellen Revolution (Industry 4.0: with the internet of things on the way to the 4th industrial revolution) (in German). 01 April 2011. Accessed from http://www.wolfgang-wahlster.de/wordpress/wp-content/ uploads/Industrie_4_0_Mit_dem_Internet_der_Dinge_auf_dem_Weg_zur_vierten_industriellen_ Revolution_2.pdf.

[8] Platform Industrie 4.0. What is industrie 4.0. Accessed from https://www.plattform-i40.de/PI40/ Navigation/EN/Industrie40/WhatIsIndustrie40/what-is-industrie40.html.

[9] Eurostat. Expenditure: main results. Accessed from https://appsso.eurostat.ec.europa.eu/nui/ submitViewTableAction.do.

[10] Federal Ministry for Economic Affairs and Climate Action. Taking control of the digital transformation. https://www.bmwi.de/Redaktion/EN/Dossier/digitisation.html. Accessed on 10 March 2021.

[11] Künzel M., Meier zu Köcker G. Werkstattpapier: Industrie 4.0 – die Rolle von Cluster-Initiativen im Wandel der Wertschöpfungsketten. (Workshop paper: industry 4.0 – the role of cluster initiatives in changing value chains) (in German). ClusterAgentur Baden-Württemberg website. Accessed from https://www.clusterportal-bw.de/downloads/publikation/Publikationen/download/ dokument/werkstattpapier-industrie-40/.

[12] Gov.UK. Innovation voucher. Accessed from https://www.gov.uk/business-finance-support/ innovation-voucher.

[13] European Commission. European digital innovation hubs. Accessed from https://ec.europa.eu/digital-single-market/en/european-digital-innovation-hubs-digital-europe-programme-0.

[14] Wirtschaft digital Baden-Wurttemberg. Digital hub-network Baden-Wurttemberg. Accessed from https://www.wirtschaft-digital-bw.de/en/measures/digital-hubs.

[15] Porter M.E. The Competitive Advantage of Nations. New York; Free Press; 1990.

[16] Centre of Excellence for Industry 4.0. Self assessment user registration. Accessed from https://www.coeindustry-4.in/User/SelfAssessementUserRegistrationI4_O.

[17] National Productivity Council (India). Offices. Accessed from https://www.npcindia.org.in/offices/.

LIST OF FIGURES

Figure 1 Simple strategy circle for digitization....4

Figure 2 Three-stage model for SME digitization support ©iit....5

Figure 3 Systematic structure of the indicator system....6

Figure 4 Overall structure of the questionnaire....7

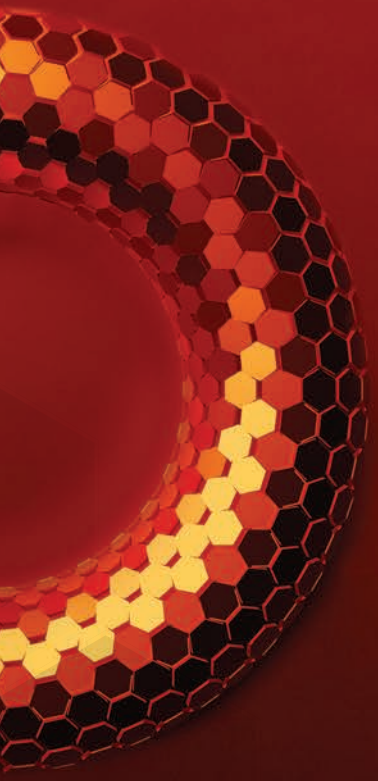
Figure 5 Example of using AHP; Weight of subtopics in the area "Production Process" ©NPC....8

Figure 6 Grades of digitization....9

Figure 7 Presentation of results: Example of a spider graphic for benchmarking....10

Figure 8 Mockup of a digitization dashboard (©iit based on Tableau®)....11

Figure 9 First sketch of a multistage expert concept ©iit....14



DIGITAL READINESS ASSESSMENT

METHODOLOGY & FRAMEWORK