SMART INDUSTRY READINESS INDEX

WORLD ECONOMIC FORUM

In collaboration with Singapore Economic Development Board

The Global Smart Industry Readiness Index Initiative:
Manufacturing Transformation Insights Report 2022

WHITE PAPER

FEBRUARY 2022

Contents

Foreword

Jeremy Jurgens
Managing Director,
World Economic Forum,
Switzerland

Beh Swan Gin
Chairman, Singapore
Economic Development
Board, Singapore

Just two years have passed since the publication of the inaugural *Manufacturing Transformation Insights Report 2019.* The landmark paper, published by the Singapore Economic Development Board (EDB), shed light on the state of global manufacturing transformation by leveraging insights from the Smart Industry Readiness Index (SIRI) programme, the world's first independent digital maturity assessment for manufacturing companies. By offering an objective, data-driven approach, SIRI has boosted industrial transformation across geographies and sectors.

The world has changed dramatically since, with COVID-19 upending our lives and disrupting economies worldwide. Despite the upheaval, SIRI went global as the international manufacturing community urgently sought data-driven approaches to transform and thrive in a "new normal".

This led to the launch of the Global SIRI Initiative in September 2020 – a collaboration between the World Economic Forum (the Forum) and the Singapore EDB to accelerate the adoption of SIRI as the internationally-recognized standard for Industry 4.0 benchmarking and transformation. Thanks to this partnership, over 600 manufacturers, governments and industry associations across 30 countries have adopted SIRI as part of their Industry 4.0 efforts over the last year, facilitated by a fast-growing global network of 150 Certified SIRI Assessors (CSA) and counting.

To bring SIRI to the next level, the International Centre for Industrial Transformation (INCIT) was established in 2021. INCIT is a new, independent, non-governmental, not-for-profit organization that will take over management and coordination of the SIRI programme. Supported by the Forum and other international organizations, INCIT will work closely with partners from both the public and private sectors to catalyse industrial transformation at a global scale.

We have come a long way from SIRI's humble beginnings: in 2017, a group of passionate public service officers from Singapore began a ground-up effort to create and pilot an accessible, data-driven approach towards industrial transformation. To all who have helped bring SIRI to where it is today, we thank you. We now look to the leadership of INCIT and our international partners to bring SIRI into the next stage of development.

Even as manufacturers adapt to a fast-changing, volatile and dynamic global situation, they are energized by the endless opportunities that digitalization offers. We trust the 2022 edition of the *Manufacturing Transformation Insights Report* will support companies and governments as they accelerate transformation, helping them unlock the vast potential of new technologies, innovative business models and new partnerships that drive lasting economic and societal impact.

Executive summary

As manufacturers embrace digitalization with renewed urgency, this report offers data-backed insights to set them on the right trajectory for transformation.

The Smart Industry Readiness Index (SIRI) comprises a suite of frameworks and tools to help manufacturers – regardless of size or industry – start, scale and sustain their digital transformation journeys. The ongoing COVID-19 pandemic and the reshaping of production value chains globally are spurring the manufacturing community to embrace digitalization with greater focus and urgency, motivated not only by potential gains in efficiency, but also by operational resilience. This renewed drive is further powered by the ongoing data revolution, where decision-makers increasingly expect key business commitments, plans and interventions to be supported through big data.

Under the Global SIRI Initiative, the World Economic Forum (the Forum), in collaboration with the Singapore Economic Development Board (EDB), started building the world's largest datasets and benchmarks on the current state of manufacturing. In 2021, the International Centre for Industrial Transformation (INCIT) was established as an independent, non-governmental, not-for-profit organization (NPO) to bring the Initiative to the next level. By democratizing this knowledge, we aim to fundamentally reform the manufacturing community's approach to industrial transformation, from one that is ad-hoc and anecdote-based to one that relies on a standardized methodology supported by data.

Building on the above, this insights report draws on data from around 600 manufacturers across 30 countries to give an update that includes:

1. Insights on the current state of industrial transformation across multiple manufacturing sectors.

2. An overview of the benefits of adopting and applying SIRI.

3. Case studies on how different manufacturing stakeholders are leveraging the SIRI programme to accelerate their digital transformation journeys.

The findings reinforce the notion that the pace of digitalization differs across sectors and companies, with multi-national corporation (MNC) -dominated industries like *Semiconductors, Electronics* and *Pharmaceuticals* ahead of small and medium-sized enterprise (SME) -dominated sectors. This suggests that more tailored approaches are required to better support industry transformation. One key insight is that companies ahead of the digitalization curve (Best-in-Class) have focused significantly on plant/factory connectivity, underscoring the importance of this in helping firms to better leverage data to generate new insights and facilitate more real-time decision-making; these activities are critical for success in the Fourth Industrial Revolution.

Through real-life case studies, this report illustrates how the SIRI programme can benefit manufacturing stakeholders in three primary ways: by helping manufacturers with their transformation strategies; bolstering the efforts of technology and advisory firms to catalyse digital transformation among manufacturers, and supporting governments and industry associations in their sectoral planning.

We hope that, after reading this report, the manufacturing community will be energized to take decisive action in leveraging the SIRI programme, to set themselves on the right trajectory for transformation and collectively define the future of manufacturing.

Introduction:
Where we are today

In a fast-moving, data-driven world, the SIRI programme can help manufacturers to accelerate their digital transformation journeys.

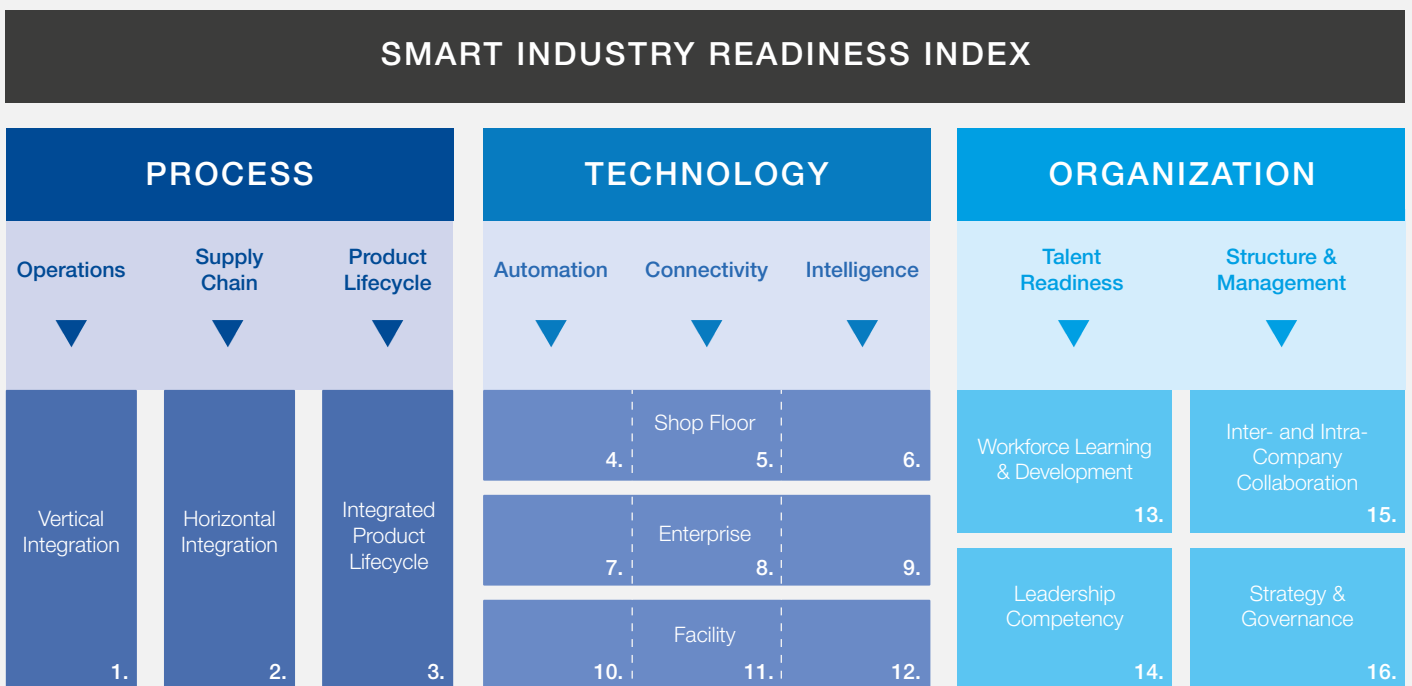## The Smart Industry Readiness Index (SIRI)

SIRI comprises a suite of frameworks and tools to help manufacturers – regardless of size and industry – start, scale and sustain their transformation journeys in digitalization. It was created in partnership with a network of leading technology companies, consultancy firms and experts from industry and academia. The SIRI framework comprises three layers:

1. The topmost layer identifies three fundamental **building blocks** of Industry 4.0: *Process, Technology* and *Organization*. A company's transformation plans must touch on all three to harness the full potential of digital transformation.

2. The second layer breaks these three building blocks down into eight **pillars**, which represent critical aspects that ompanies must focus on to become future-ready organizations.

3. The third layer comprises 16 **dimensions** that should be referenced when evaluating the current maturity levels of manufacturing facilities

Today, the SIRI programme is managed and governed by the International Centre for Industrial Transformation (INCIT), an independent, non-governmental, not-for-profit organization.

FIGURE 1 | **The Smart Industry Readiness Index framework**

SMART INDUSTRY READINESS INDEX

PROCESS			TECHNOLOGY			ORGANIZATION	
Operations ▼	Supply Chain ▼	Product Lifecycle ▼	Automation ▼	Connectivity ▼	Intelligence ▼	Talent Readiness ▼	Structure & Management ▼
Vertical Integration 1.	Horizontal Integration 2.	Integrated Product Lifecycle 3.	Shop Floor 4. / Enterprise 7. / Facility 10.	5. / 8. / 11.	6. / 9. / 12.	Workforce Learning & Development 13. / Leadership Competency 14.	Inter- and Intra-Company Collaboration 15. / Strategy & Governance 16.

Source: International Centre for Industrial Transformation

BOX 1 | **What is the International Centre for Industrial Transformation (INCIT)?**

As a neutral, objective entity, INCIT is an internationally-recognized institution that works with both public and private sector manufacturing-related organizations to catalyse and support industrial transformation across geographies and industries. Starting with SIRI, INCIT will:

A. Develop and introduce internationally-referenced frameworks, concepts and programmes for the international manufacturing community, to raise awareness of trends and developments.

B. Design, conduct and publish qualitative and quantitative international benchmarks to help inform companies' and governments' strategies.

C. Facilitate sharing of learning points, best practices and insights, to help the industrial community tackle challenges and drive progress on the digital transformation journey.

The Official SIRI Assessment (OSA)

One of the key programmes under SIRI is the Official SIRI Assessment (OSA).[1] The OSA is a two-day independent review of a factory or plant, designed to balance technical rigour and practical applicability. It includes:
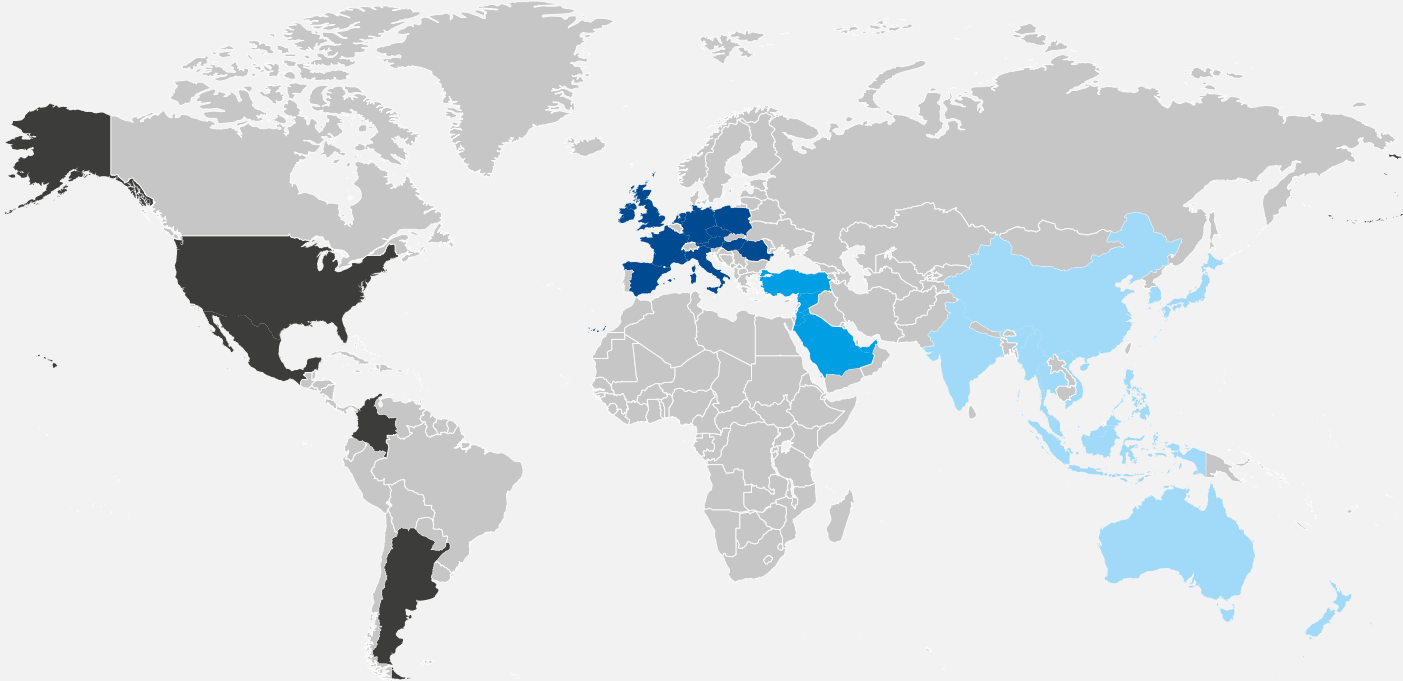
1. An **assessment component**, where the company's factory/plant is evaluated based on its maturity across the 16 dimensions of the SIRI framework. Post-evaluation, for each of the 16 dimensions, the factory/plant is classified into one of six maturity bands, with Band 0 representing the lowest level of maturity and Band 6 representing the highest.

2. A **prioritization component**, also known as the Prioritization Matrix exercise, which draws on information provided by the company, such as their cost profile and priority key performance indicators (KPI).

After the OSA, companies receive a formal report with the following insights to help them start, scale and sustain their transformation journeys:

A. Characterization of the current state of their manufacturing plants/factories.

B. Benchmarks against industry peers or other companies within a given geography.

C. Identification of high-impact areas that they can prioritize for improvement.

The OSAs are conducted by qualified individuals known as Certified SIRI Assessors (CSA). The CSAs are industry practitioners who are formally trained and qualified to conduct the reviews accurately and objectively. Today, SIRI counts on an impressive network of over 150 CSAs across more than 30 countries and we continue to welcome experts from the global manufacturing community to join this growing pool.

FIGURE 2 | Global distribution of the CSA network

Countries with Certified SIRI Assessors

⬤ Americas	⬤ Europe		⬤ Middle East	⬤ Asia Pacific	
Argentina	Austria	Italy	Jordan	Australia	New Zealand
Colombia	Czechia	Netherlands	Saudi Arabia	China	Philippines
Mexico	France	Poland	Turkey	India	South Korea
United States of America	Germany	Romania	United Arab Emirates	Indonesia	Singapore
	Hungary	Spain		Japan	Thailand
	Ireland	United Kingdom		Malaysia	Vietnam

Source: International Centre for Industrial Transformation

TABLE 1	Meet Certified SIRI Assessors (CSA)

	Shridhar Ravikumar, Senior Consultant Singapore-based CSA from TÜV SÜD	**Laura Requeno, Engagement Manager** United Arab Emirates-based CSA from McKinsey & Company
Why did your company decide to train CSAs?	Companies strongly desire to adopt new processes and technologies to make their facilities more advanced and digitalized. But many have not taken the plunge because they lack confidence and support. TÜV SÜD decided to train CSAs because we saw how the OSA could be a powerful tool for manufacturers; it could help them better understand their current state of industrial transformation and reduce their risk of pouring resources and effort into the wrong areas. As an organization with a mandate to support the business community in deploying new solutions in a safe and scalable fashion, we felt the programme aligned well with our core competencies.	McKinsey pushes for constant innovation to help clients create change that matters. With this in mind, we saw SIRI as a natural complement to our "value at stake" approach to identifying and providing manufacturers with a holistic perspective on the various Industry 4.0 use cases and enablers in the community today. More specifically, SIRI supports our advisory work in three ways: 1. It provides a holistic maturity assessment across the three key areas: *Process, Technology* and *Organization.* 2. It is quick to perform and easy to access, without the need to provide sensitive data. 3. It is a third-party assessment that allows for the publication of neutral and objective maturity benchmarks.
How has the experience of facilitating OSAs for manufacturers been?	It has been meaningful. I have personally participated in over 50 OSAs to date and many companies have said that the two-day time commitment is very manageable. They also appreciate how the OSA's prioritization exercise takes an impact-led, rather than technology-led, approach. This helps their digitalization teams target areas that matter most, instead of just adopting new technologies. Several clients have since used their OSA reports as launchpads to develop company-wide digital transformation strategies.	I work with many diverse clients in Europe, the Middle East and Africa, and I have been able to witness first-hand how the OSA has helped them refine their Industry 4.0 aspirations. Clients usually come with a pre-established roadmap of initiatives, but they are not often linked to areas with the greatest impact potential. Through the OSA, clients can validate and reprioritize their plans by objectively linking their key initiatives with their business goals, profit and loss status, and industry dynamics. Many clients have shared with us their early wins from using the OSA. For example, one manufacturing conglomerate is now using SIRI for internal reference, to cross-compare the maturity levels of their global production sites. Another client informed us that the OSA results and accompanying benchmarks gave their leadership assurance and the confidence to pursue an information technology-operational technology (IT/OT) integration programme to improve their existing asset management systems.

Source: TÜV SÜD and McKinsey & Company

The *Manufacturing Transformation Insights Report 2022*

COVID-19 has taken millions of lives, caused tectonic shifts in public policy, created unprecedented economic disruptions, increased climate change concerns, and reshaped the way we live and work. Manufacturing has not been spared and every facet of our global production systems has been fundamentally transformed.

In the early days of the pandemic, lockdowns and movement restriction orders saw a plunge in global demand for non-essential products, with many manufacturing facilities reducing capacity and rationalizing headcounts. Today, as the world tackles COVID-19 variants and adapts to a "new normal", manufacturers are actively restructuring their production systems to pivot or expand business offerings, reviewing their manufacturing footprints, and re-recognizing supply chain networks to address logistical challenges and business uncertainties.

These shifts have spurred the manufacturing community to embrace digital transformation with greater focus and urgency, now motivated not only by potential gains in efficiency, but also by operational resilience. This renewed drive is further powered by the ongoing data revolution, where more and more decision-makers increasingly expect key business commitments, plans and interventions to be supported through big data. The *Manufacturing Transformation Insights Report 2022* builds on these key considerations.

By drawing on data from about 600 companies - across 30 countries - that have undergone OSAs since 2018, this report provides all industrial sector stakeholders with:

1. Insights on the current state of industrial transformation across multiple manufacturing sectors.

2. An overview of the benefits of adopting and applying SIRI.

3. Case studies on how different manufacturing stakeholders are leveraging the SIRI programme to accelerate their digital transformation journeys.

We hope these data-driven insights will be useful to manufacturers, technology providers, governments, trade associations and other stakeholders in developing new solutions that will accelerate global industrial transformation, build resilience and power growth in a new digital era.

❝ The effects of the pandemic have fundamentally transformed every facet of our global production systems and its impact will continue to resonate in the years ahead.

① Insights: The current state of industrial transformation

Digitalization is gaining momentum across all manufacturing industries, but the progress and pace of transformation differ across geographies and sectors.

1.1 | Understanding the SIRI Maturity profiles of 14 industry groups

The global manufacturing community is actively seeking data-driven insights to better understand how different industry sectors across geographies are incorporating advanced manufacturing concepts and technology into their digital transformation strategies. Understanding the maturity profile of each sector can help companies, trade associations, business chambers, governments, and even developmental banks identify company- and sector-specific opportunities that lead to more customized interventions.

The following are two sources of insights into the current digital maturity levels of 14 manufacturing industry groups:

A. **The archetypes of transformation map**, which describes the four main transformation profiles that a manufacturing sector can fall within, based on the SIRI Maturity and SIRI Variance of the given sector.

– **SIRI Maturity** is a ranking measure[2] of how companies within an industry sector have collectively performed in the OSA across all 16 dimensions, as compared to other sectors. A higher ranking indicates that the industry is likely to be further ahead and more mature in its industrial transformation journey.

– **SIRI Variance** measures the degree of dispersion among SIRI Maturity levels of companies within a given industry sector. The lower the SIRI Variance, the more uniform the pace of industrial transformation in the sector. The higher the SIRI Variance, the greater the disparity in transformation levels within the sector.

B. **Industry Performance Cards (IPC)**, which are industry-specific benchmarks that offer an "apples-to-apples" comparison for companies to assess their performance against industry peers. The IPCs for each of the 14 industry groups can be found in the Appendix of this report.

TABLE 2	The four archetypes of transformation
Rainforest	The rainforest is a habitat with year-round rainfall, ample sunlight and comfortable temperatures, all of which facilitate the growth of lush vegetation. Yet, despite such favourable conditions, some plants still falter. The "Rainforest" archetype describes industries that rank high in both SIRI Maturity and SIRI Variance. While most firms in a Rainforest archetype industry are ahead of the pack in terms of their digital transformation journeys, a small group has not kept pace.
Coniferous forest	A coniferous forest is associated with rows of uniform-looking pine trees growing tall and strong. The "Coniferous forest" archetype describes industries that rank high in SIRI Maturity and low in SIRI Variance. Companies from these industries are generally ahead in their digital transformation journeys as compared to their peers in different industries, and largely similar in their pace of transformation.
Savanna	The savanna is a semi-arid habitat scattered with shrubs and isolated trees. The "Savanna" archetype describes industries that rank low in SIRI Maturity but exhibit high SIRI Variance. While most companies within these industries are in the early stages of digital transformation, a small number have forged ahead, like the occasional large trees that rise above grasslands. An industry in this archetype usually has a large base of SMEs.
Tundra	The tundra habitat is associated with a harsh climate – strong winds, low temperatures and limited rainfall. The "Tundra" archetype characterizes industries that rank low in both SIRI Maturity and Variance. Just as wildlife in the tundra battles formidable conditions to survive, industries in this archetype may face greater challenges in industrial transformation. Often, this can be due to company size, or the nature of their products or manufacturing processes, all of which may limit the ease and feasibility of deploying certain advanced manufacturing concepts and technologies.

Source: International Centre for Industrial Transformation

FIGURE 3 | **The archetypes of transformation map featuring the 14 industry groups**
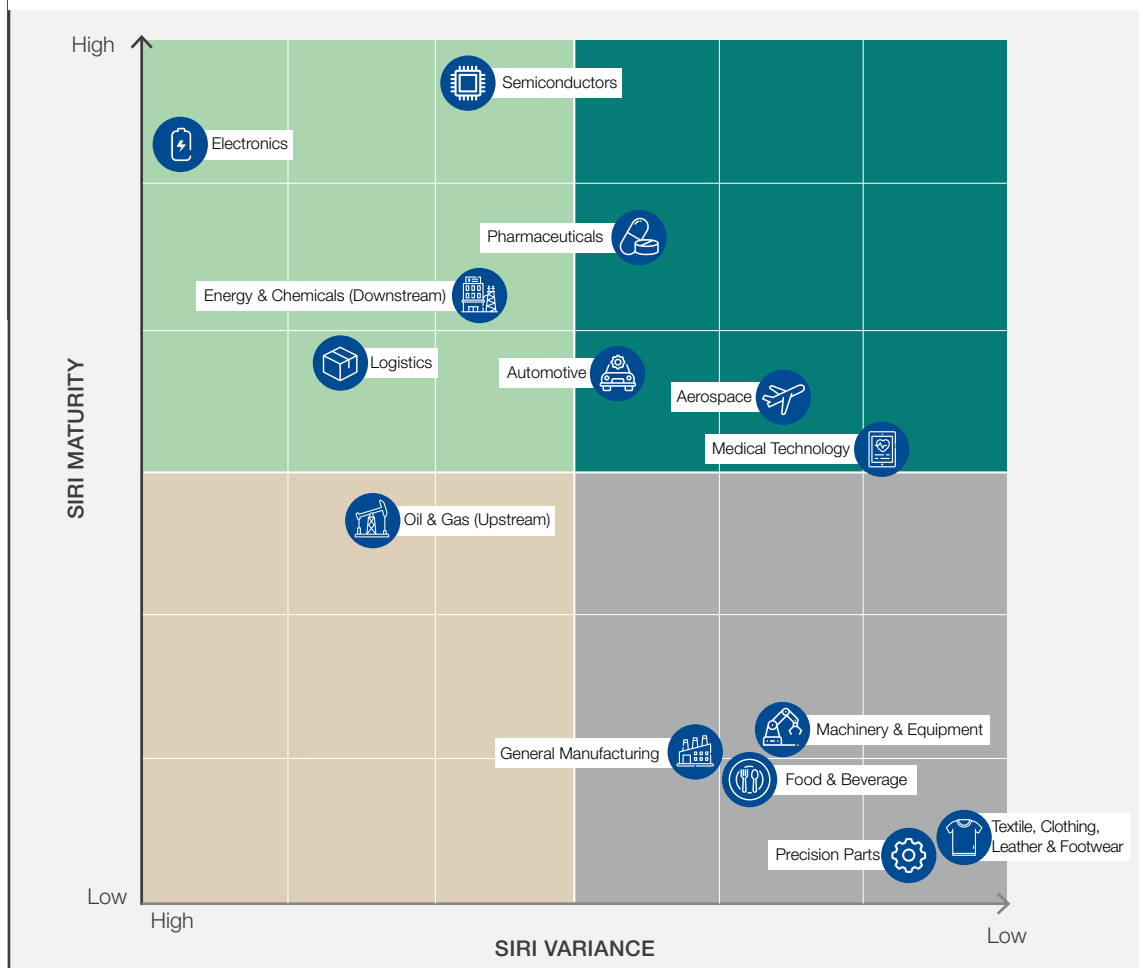
Source: International Centre for Industrial Transformation

Semiconductors, Electronics and **Pharmaceuticals** lead the 2022 SIRI Maturity rankings, with **Logistics** making gains

The top three most mature industry groups in 2022 are *Semiconductors, Electronics* and *Pharmaceuticals*. The latter two traded between the second and third spots from the previous rankings published in November 2019.[3] In spite of their frontrunning positions, these top three industries – predominantly comprising multinational conglomerates – are not shielded from present-day challenges like the ongoing value-chain disruptions, global chip shortage and industrial decarbonization. These mega-trends will reshape the global manufacturing landscape and companies from these leading sectors – as long-standing pioneers of innovation and adopters of advanced manufacturing

concepts, technologies and applications – must confront these topics proactively to redefine them into opportunities for all.

Over the last three years, the *Logistics* industry group has made progress to claim fifth place. *Logistics* operations have evolved significantly, mainly due to two factors. Firstly, the unparalleled growth of online shopping has mobilized the industry to upgrade and enhance its operations to cope with expanding requirements. Secondly, the emergence of e-commerce leaders such as Amazon, Alibaba and JD.com has compelled traditional logistics companies to become more agile, flexible and efficient. With COVID-19 further fuelling online shopping globally, digital transformation of the *Logistics* industry is expected to accelerate in the coming years.

TABLE 3 | **The top five most digitally mature sectors in 2019 and 2022**

Rankings		
Ranking	2019	2022
1	*Semiconductors*	*Semiconductors*
2	*Pharmaceuticals*	*Electronics*
3	*Electronics*	*Pharmaceuticals*
4	*Energy & Chemicals (Downstream)*	*Energy & Chemicals (Downstream)*
5	*Medical Technology*	*Logistics*

Source: International Centre for Industrial Transformation (Analysis by the Singapore Economic Development Board)

SME-dominated sectors are less mature than MNC-dominated sectors

The industries in the bottom five have one thing in common: they are all dominated by SMEs. This might not surprise many; anecdotes abound regarding SMEs' intense short-term business pressures, limited expertise and tight resources, all of which hinder the adoption of new manufacturing processes and advanced technologies. SIRI insights validate this long-standing narrative.

However, even within SME-heavy sectors, SIRI insights uncovered notable differences in SIRI Variance. For instance, while *Textile, Clothing, Leather & Footwear* has a low SIRI Variance, suggesting that companies within the sector are collectively low in maturity, others such as *Food & Beverage* have a medium level of variance, implying that while the collective average is low, there are some companies with relatively high maturity. This

is noteworthy because it highlights the existence potential SME champions and role models.

Given the highly diverse profiles of various industry sectors, more tailored approaches are required to better support industry transformation

Today, there are no lack of well-meaning organizations that seek to help manufacturers – particularly SMEs – kickstart and/or accelerate their transformation journeys. Such institutions include governments, consulting firms, business chambers, technology providers and multilateral organizations. However, we have observed that many organizations tend to apply "one-size-fits-all" approaches in their support. Common initiatives include state-level subsidies for the adoption of new automation equipment or industry-led forums that study use cases of global companies. Based on our observations, the impact and efficacy of such blanket interventions have been limited.

❝ The archetypes of transformation map and Industry Performance Cards show that sectors have fundamentally different maturity profiles.

The archetypes of transformation map and IPCs show that sectors have fundamentally different maturity profiles. To best support transformation, governments, solutions providers and developmental organizations alike must adapt their programmes to suit the current maturity level of each industry group and specific company. For instance, in sectors with low variance (i.e. *Coniferous forest, Tundra*) where companies have relatively similar maturity, one possible intervention is to first identify shared challenges and opportunities and subsequently create supporting tools or programmes that target these specific areas.

Conversely, sectors with high variance (i.e. *Rainforest, Savanna*) require different approaches. For example, the *Electronics* landscape is dominated by industrial giants like Sony, Samsung, Intel, Haier and Huawei - the result of two decades of consolidation. While these international conglomerates typically have highly digitalized facilities, a good number of legacy companies in the industry have not kept pace. Given the differences, interventions would need to adapt accordingly. For example, MNCs could work with partners in data analytics to improve operations at their highly advanced manufacturing sites, while legacy companies could consider partnering with system integrators to design modular, turnkey, Internet of Things (IoT) solutions for their machinery and systems.
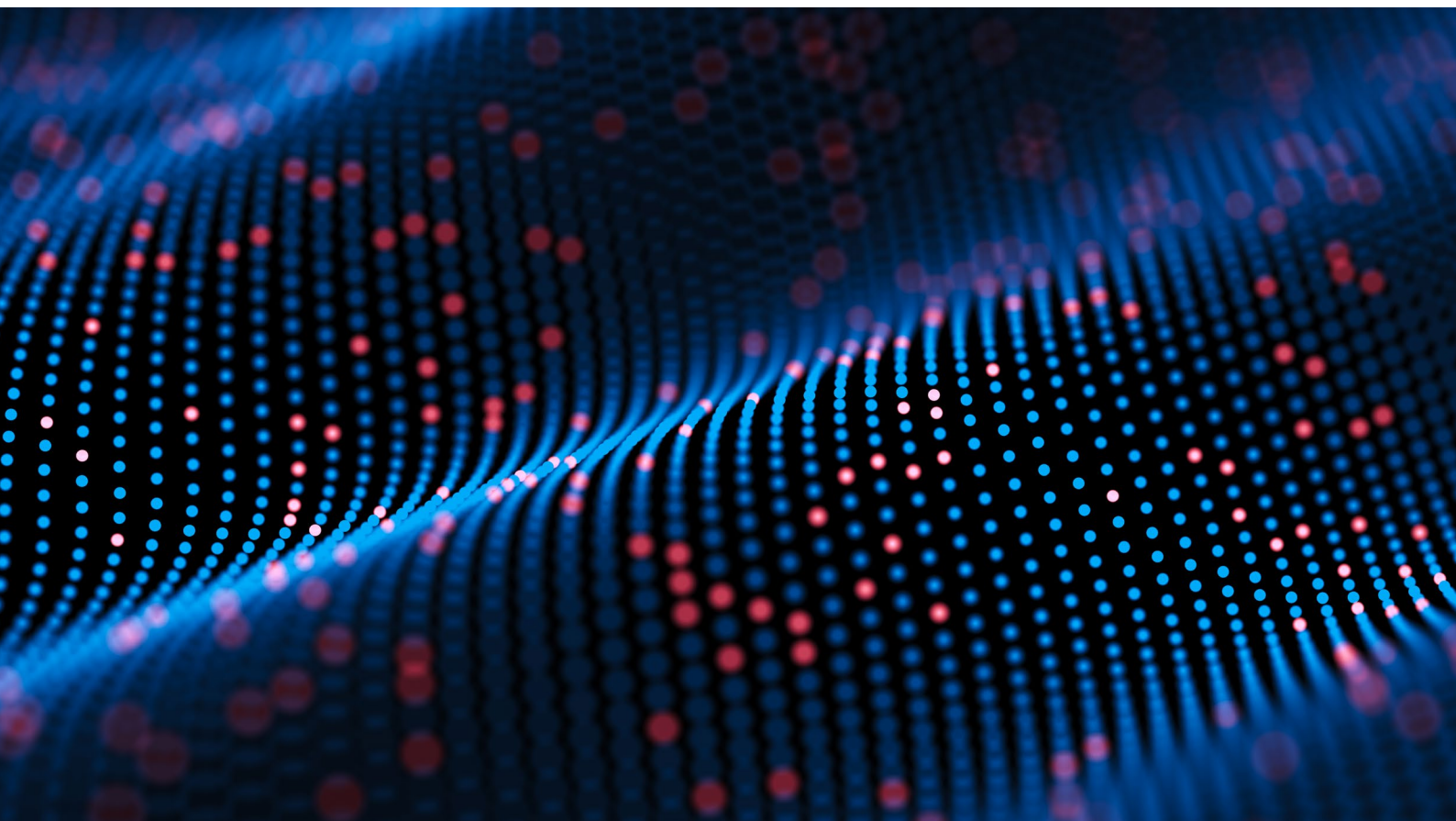
1.2 | Analysing SIRI Maturity profiles at the company level

The 3B Maturity Benchmark aims to show what the general maturity profile of a production site looks like, depending on whether it is highly advanced, average or rudimentary by today's standards. These quantitative reference points are obtained by ranking - according to SIRI Maturity - all companies that have taken the OSA and classifying them into three groups:

1. **Best-in-Class**, representing the top 10% of companies.

2. **Broad Middle**, representing the middle 80% of companies.

3. **Bottom Performers**, representing the bottom 10% of companies.

FIGURE 4 | The 3B Maturity Benchmark for 2022
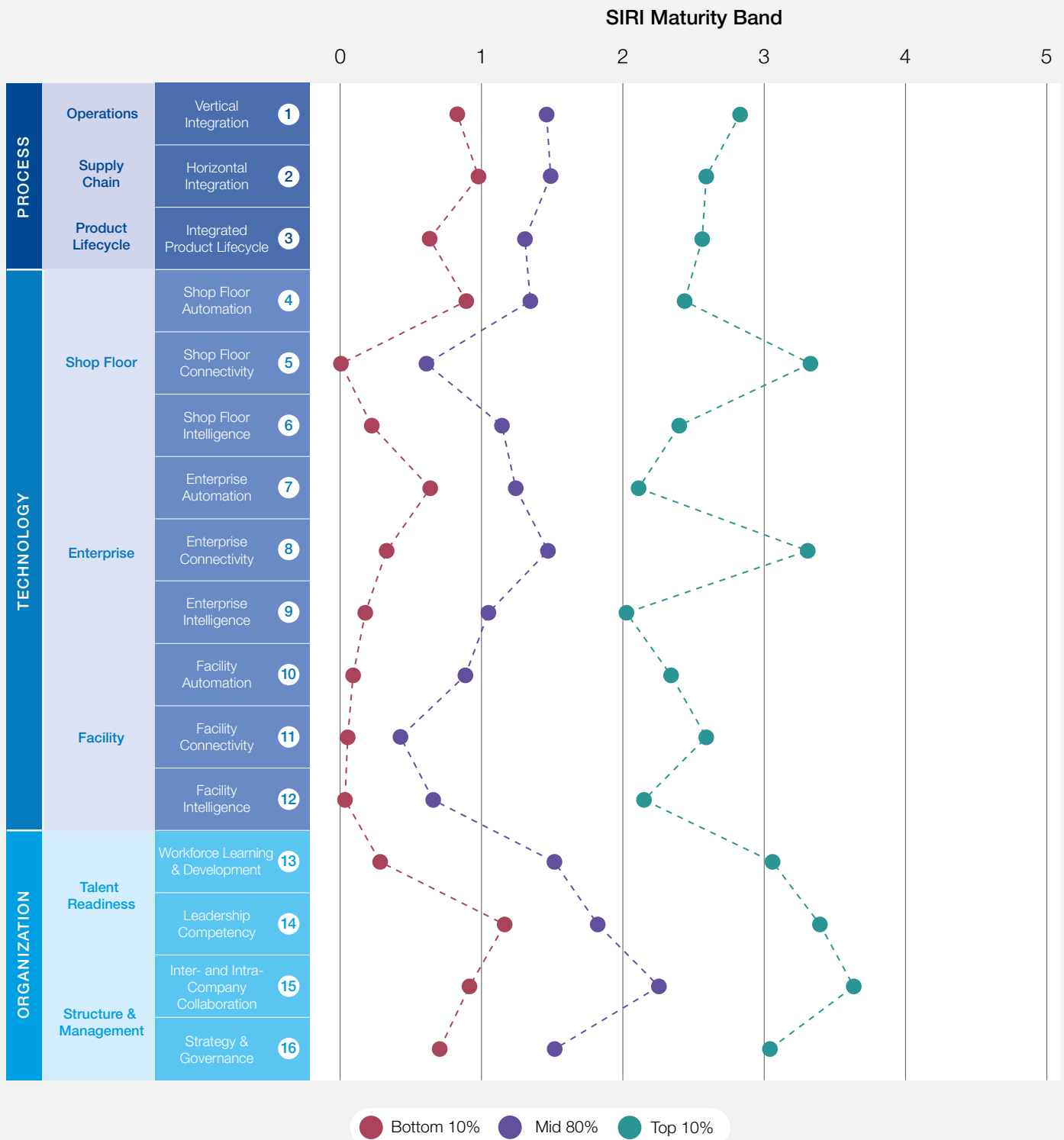
Source: International Centre for Industrial Transformation (Analysis by the Singapore Economic Development Board)

Best-in-Class companies are consistently more mature across all 16 SIRI dimensions

As indicated in Figure 4, the 2022 benchmarking exercise showed that, on average, the Best-in-Class manufacturing companies are one full maturity band ahead of the Broad Middle, and at least two maturity bands ahead of the Bottom Performers across all 16 SIRI dimensions. This highlights that today's top companies are undertaking comprehensive initiatives across the three SIRI building blocks of industry transformation – *Process, Technology* and *Organization* – rather than only tackling a few specific areas. Here, we offer some insights into how manufacturers have been approaching transformation across the three SIRI building blocks.

1. *Process*: The Broad Middle are currently digitizing their processes, while the Best-in-Class are seeking to integrate their already-digitized processes.

Over the last five years, the discourse around creating highly integrated, digital environments in manufacturing has matured considerably. By now, almost everyone in manufacturing has at least a passing awareness of how digital and hardware technologies, coupled with integrative design principles, have opened a world of new possibilities.

Among many companies, this awareness has been replaced by action in response to pandemic-related challenges over the last two years. Many manufacturers are taking active steps to digitize processes across *Operations, Supply Chain* and *Product Lifecycle*. Best-in-Class companies, many of which started their journey earlier and have already completed digitalization, are now progressing to the next level of integrating digitized processes.

2. *Technology*: Best-in-Class companies have focused significantly on *Connectivity* (one of the SIRI framework's eight pillars) to enable greater integration and insights generation.

In the Third Industrial Revolution, automation was regarded as the central engine for industry transformation. But in today's digital economy, the phrase "data is the new oil" holds true and connectivity is fast joining automation as another key driver of success. A highly connected factory where all assets (machines, products, materials and workforce) are linked via a common network helps a company in two important ways; it enables more extensive and effective machine-to-machine and human-to-machine communications and helps firms leverage data better to generate new insights and facilitate more real-time decision-making.

Best-in-Class companies today acknowledge the importance of *Connectivity*. Many have already established interoperable and secure networks within their production sites, where equipment, machinery and computer-based systems can interact and exchange information with few restrictions. Several firms are now actively engaged in making these exchanges in real time, to reduce the lag in receiving new data and insights.

Yet, SIRI insights reveal that only a small group of companies are truly focused on *Connectivity*. Comprehensive, highly connected Industrial IoT (IIoT) architecture can greatly enhance collaboration and synchronization throughout a firm's manufacturing sites; but the average company today is still far from achieving this. While many manufacturers have some basic network that connects across their *Enterprise* systems, they have yet to successfully introduce *Connectivity* to the *Shop Floor* and *Facility* domains of the factory/plant.

The implications are significant: in many other sectors the days of remote stations and dial-up, where the internet moved at a glacial pace, are but a distant memory. If *Connectivity* in the manufacturing sector remains nascent, companies will miss out on myriad applications that improve productivity and cut waste. For many SMEs, this could mean being vulnerable to disruption and future obsolescence. Looking ahead, it is paramount that manufacturers, with the support of technology companies, multilateral organizations and trade associations, double down their efforts to level up maturity in the *Connectivity* dimension.

3. *Organization*: Manufacturers should put more emphasis on refreshing and broadening their strategies for digitalization and workforce retraining.

Beyond making *Process* and *Technology* enhancements, companies must adapt both their organizational structures and workforce competencies, to enable their transformation and give them a competitive edge. The American economist Ben Bernanke said it best: "No economy can succeed without a high-quality workforce, particularly in an age of globalization and technical change."[4] This holds true in manufacturing. Yet, surprisingly, the average manufacturer today still relies on very basic learning and development (L&D) programmes. Such programmes typically have clear start and finish points and the single objective of equipping a worker with the necessary skills to perform a job based on today's requirements.

However, with the advent of digitalization, IT/OT convergence and advanced automation, job scopes and work arrangements are rapidly evolving. Beyond reviewing L&D programmes to incorporate broader or continuous learning components, manufacturers may also need to re-examine the way by which they organize their workforce and workspaces as remote working becomes more prevalent in the digital era.

The situation is similar for *Strategy & Governance*. Findings show that while most manufacturers have a strategic focus on digital transformation, geared towards a factory/plant-of-the-future, few have set aside resources to develop an actual strategy or game plan. Through the OSA and the publication of global benchmarks in this report, we hope that more companies will gain the confidence and realise the urgency to transform intentions into actions.

❝ Today's top companies are undertaking comprehensive initiatives across the three SIRI building blocks of industry transformation – *Process, Technology and Organization*.

Comparing different segments of the manufacturing community

MNC and SME maturity profiles follow similar patterns across the 16 dimensions, with some key differences

To provide a different perspective in our analysis, we compared the maturity of MNCs and SMEs, which made up 44% and 56% respectively of the companies surveyed. As shown in Figure 5, the maturity profiles of MNCs and SMEs follow similar patterns across the 16 dimensions. MNCs are ahead of SMEs by either one half or one full maturity band in most dimensions, aside from *Shop Floor Automation* and *Leadership Competency* where the disparities are noticeably less pronounced.

FIGURE 5 | **The SIRI Maturity profiles of MNCs and SMEs[5]**
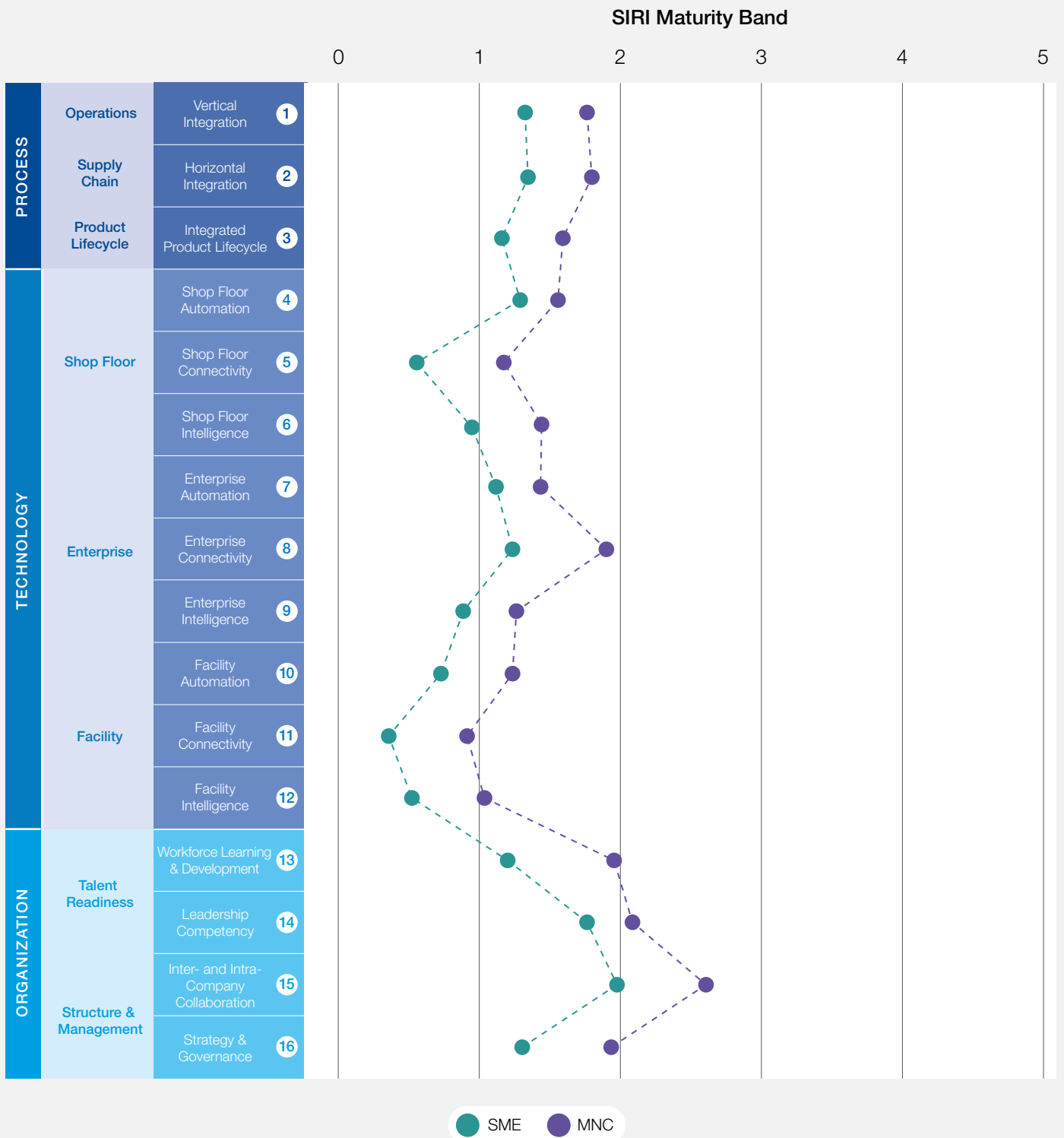
Source: International Centre for Industrial Transformation (Analysis by the Singapore Economic Development Board)

There are two likely reasons for the relative closeness in *Shop Floor Automation* maturity levels. Firstly, there has been an overwhelming focus on the narrative of shop floor automation in the last 20 years. SMEs have thus concentrated on implementing new automation systems – starting with sensors, actuators and controls, and progressing to conveyor systems and collaborative robotics in more recent times. This willingness to invest in automation is also attributed to the highly visible nature of these solutions, making them more relatable to the average SME.

The second reason is linked to government support programmes over the last two decades, which have leaned heavily towards subsidizing capital investment in automation solutions, compared to other important elements like workforce retraining, process design, and connectivity. These incentive programmes have in turn shaped SME priorities.

The other intriguing finding is that SMEs and MNCs display similar maturity levels in Leadership Competency; the average SME executive is generally as familiar with the latest advanced manufacturing concepts as an MNC executive, yet SME factories and plants still lag behind their MNC peers in overall maturity. This could be due to practical considerations, financial and manpower limitations, or a conservative outlook that prevents SME leadership from doing more.

TABLE 4 | **Key KPIs selected by manufacturers of different profiles**

Top KPIs	MNCs	SMEs	Best-in-Class (Top 10%)	Broad Middle (Middle 80%)	Bottom Performers (Bottom 10%)
1	Asset and Equipment Efficiency	Product Quality	Product Quality	Product Quality	Workforce Efficiency
2	Product Quality	Asset and Equipment Efficiency	Asset and Equipment Efficiency	Asset and Equipment Efficiency	Product Quality
3	Planning and Scheduling Effectiveness	Workforce Efficiency	Planning and Scheduling Effectiveness	Planning and Scheduling Effectiveness	Asset and Equipment Efficiency
4	Material Efficiency	Planning and Scheduling Effectiveness	Time to Delivery	Workforce Efficiency	Process Quality
5	Time to Delivery	Inventory Efficiency	Material Efficiency	Time to Delivery	Inventory Efficiency

KPI category   ● Productivity   ● Quality   ● Speed   ● Flexibility

Source: International Centre for Industrial Transformation (Analysis by the Singapore Economic Development Board)

Productivity- and quality-linked KPIs are still the key focus of MNCs and SMEs, but flexibility and speed are fast-emerging areas of attention

An important component of the OSA is the Prioritization Matrix exercise, where companies report their top five key KPIs. The KPIs are factored into the maturity calculation alongside other parameters. Ultimately, this exercise provides companies with suggestions on which aspects of SIRI to prioritize in their digital transformation.

Table 4 highlights the top five most-selected KPIs by companies across five different profiles. From the findings, we see that productivity and quality-linked KPIs (e.g. *Asset and Equipment Efficiency* and *Product Quality*) dominate the top two positions across almost all profiles.

However, radical change may be needed amid the exponential demand growth and changing consumer patterns. During the COVID-19 pandemic, various "stay-at-home" requirements and an increased reliance on remote working and learning have created a sharp increase in demand for computers, network peripherals and other consumer electronics with chips. This sudden surge in demand, which coincided with COVID-related market disruptions and the ongoing US-China trade tensions, created a chip shortage crisis internationally.

This situation, coupled with ongoing efforts to diversify supply chains for resiliency, has seen certain types of companies shifting to focus on flexibility and speed-related KPIs (e.g. *Planning and Scheduling Effectiveness* and *Time to Delivery*). Initiatives that demonstrate such shifts include efforts by manufacturers to reorganize their supply-chains based on regional geographical markets, practicing dual/triple sourcing, and even adopting hybrid inventory management models that includes elements of both "just-in-time" and "just-in-case" strategies. The change in priorities is particularly evident for certain segments (e.g. MNCs and Best-in-Class) that have already achieved reasonably high consistency in operational efficiency and quality.

TABLE 5 | **Planning horizon selected by manufacturers of different profiles**

Planning horizon	Strategic	Tactical	Operational
MNCs	68.3%	17.1%	14.6%
SMEs	38.7%	27.6%	33.7%
Best-in-Class (Top 10%)	85.7%	10.7%	3.6%
Broad Middle (Middle 80%)	52.2%	23.2%	24.6%
Bottom Performers (Bottom 10%)	14%	33%	53%

Source: International Centre for Industrial Transformation (Analysis by the Singapore Economic Development Board)

Many companies now understand that digitalization is a phenomenon they need to respond to quickly. Their action - or inaction - influences their ability to continue delivering quality products and defines levels of customer trust and loyalty. Nearly all industries are being disrupted and organizations must either transform or risk replacement by more innovative competitors.

While most companies are charting their transformation roadmaps, we have observed that manufacturers, depending on their size and maturity profile, tend to vary in their planning horizons. Companies that are larger or further ahead in the digitalization journey tend to think longer-term than smaller companies, or those still early in the journey.

This is somewhat expected, as larger firms and those that are further ahead tend to have more resources, experience and confidence to detail longer-term roadmaps. But there is a worry that, in time, this will widen the maturity divide between those that are ahead and resource rich, and those that are not. This is particularly true during global socio-economic crises, like the ongoing COVID-19 pandemic, which disproportionately affects the more vulnerable segments of the business community, such as smaller-sized firms and those less exposed to new technologies.

As digitalization becomes pervasive and the "norm", governments and community leaders alike must ensure they provide the right assistance for SMEs and latecomers to look beyond present-day issues and stretch their aspirations and imaginations.

2 | Applications: Harnessing SIRI to unlock the future of manufacturing

There are three key ways in which the international manufacturing community can leverage SIRI insights to accelerate company and sectoral digital transformation.

2.1 | Applying SIRI insights

Data and information are only as useful as their application. SIRI insights offers guidance to manufacturing stakeholders in three primary ways, by:

1. Supporting **manufacturers** to develop and strengthen their transformation strategies on a.) a single site or b.) across multiple sites and/or at an organization-wide level.

2. Bolstering the efforts of **technology and advisory firms** to catalyse digital transformation among manufacturers.

3. Informing sectoral planning and industrial development efforts by **governments and industry associations**.

Section 2 describes these three applications and presents real-world case studies which illustrate how various manufacturing stakeholders have been utilizing SIRI to tangibly transform their own production sites and sectors.

2.2 | Supporting manufacturers to develop and strengthen their transformation strategies

❝ By comparing OSA insights from individual sites, decision-makers can gain a bird's eye view of the company's entire manufacturing operations.

The first, most intuitive application of SIRI insights is to support manufacturers in developing and strengthening their digital transformation strategies (or initiatives - in the case of smaller companies). Firms can apply these insights across single or multiple sites, and/or maximize their impact by applying them across the entire organization.

When companies use SIRI insights to shape single-site transformation strategies or roadmaps, they should answer these questions to reach informed decisions about targeted areas and desired improvements:

1. **Where are we today?** *Referencing the current maturity of their manufacturing operations across the 16 dimensions, and their position in the SIRI benchmarks*

2. **Where do we want to be?** *Characterizing the "what" and "why" of their desired future state*

3. **How urgent/important is this to us?** *Identifying the immediate push or pull factors that influence their start and completion dates and assessing the amount of work needed*

4. **How much resource can we dedicate to this?** *Making sense of the level of resources they can commit*

5. **Which areas we should focus on?** *Gaining guidance on the recommended focus areas from the OSA Prioritization Matrix exercise*

Larger companies with regional and/or international operations can further utilize SIRI to support multi-site reviews. By aggregating and comparing OSA results and insights from individual sites, decision-makers can gain a bird's eye view of the company's entire manufacturing operations, helping them single out site-specific weaknesses, promote peaks of excellence and address organization-wide challenges and opportunities.

The following case studies focus on two different companies and the ways they have used the SIRI programme to develop and execute transformation strategies.

Case Study 1 | **Single-site review - Pepperl+Fuchs**

Pepperl+Fuchs' transformation ambitions

Pepperl+Fuchs (P+F) is a German industrial technology company that specializes in sensor technology and electrical explosion protection. As a manufacturer, P+F aims to be a reference point for customers in the areas of automation and digitalization by deploying new processes and technologies to transform its production facilities. P+F's leadership team decided to leverage the SIRI programme in 2018 to comprehensively evaluate the Industry 4.0 readiness of its manufacturing sites.

(1) **Site selection: P+F pilots the OSA at its Singapore site**

Singapore was the first production site selected by P+F to pilot the OSA. The Singapore site – P+F's headquarters for Asian production and one of four key production facilities globally – was chosen because the production facility, established in 1991, was relatively dated. The leadership team identified brownfield opportunities which would transform and modernize this important facility.

In addition, P+F had recently set up an IoT-enabled global distribution centre in Singapore in 2016 to increase production capacity and strengthen supply chain and logistical processes. Upgrading the company's Singapore site would pave the way for greater integration between its production and supply chain functions.

(2) **Conducting the first OSA (2018)**

P+F engaged a CSA to conduct an OSA for its Singapore site in 2018. The OSA report highlighted the following learning points:

1. **The general maturity profile of the Singapore Site was below the 80% Broad Middle average.** This maturity profile, which was expected for a 30-year-old facility, reinforced the company's decision to upgrade and modernize the Singapore site. Based on this assessment, the organization set a three-year goal of uplifting the Singapore site's overall maturity profile to be on par with or better than the industry average.

2. *Vertical* and *Horizontal Integration*, **as well as** *Workforce Learning & Development*, **were key areas to focus on.** Based on the OSA Prioritization Matrix exercise, which considered P+F's business needs, the final report recommended that the Singapore site strengthened integration among its various production and supply chain processes to enable better communication between different technology layers on the shop floor and the new distribution centre. The report also recommended upgrading L&D programmes so that engineers and technicians, many of whom had been with the company for many years years, could refresh their skillsets and be better placed to support P+F's digitalization aspirations.

(3) **Executing the transformation initiative (2019–2020)**

P+F leveraged insights from its 2018 OSA report to design and execute its transformation roadmap. Over two years, the company implemented a series of initiatives:

1. **Digitalizing shop floor processes.** The production team reviewed all existing processes before streamlining workflows and commencing a site-wide exercise to digitalize all remaining processes. P+F also set up a centralized management system for newly digitalized workflows. In doing so, the company reduced the total number of workflows from 10 to 6 and increased its production efficiency in two major product units (photoelectric and ultrasonic sensors) by 5-10%.

2. **Introducing new supply chain management tools:** To increase supply chain responsiveness, P+F integrated two new supply chain planning tools into its existing enterprise resource planning system:

   i. M3 Scheduling Workbench (SWB), a near-term scheduling tool that integrates supply chain and procurement business functions to help manufacturers create more reliable production plans. The M3 SWB increased P+F's operational resilience by around 50%, by identifying and accounting for potential raw material bottlenecks due to supply chain disruptions and pre-alerting P+F to any sudden customer order changes.

ii. o9 Digital Brain, an integrated business planning platform that will eventually allow P+F to connect multiple planning levels across its supply value chain, including external sources such as suppliers. This platform – which is expected to be fully implemented by mid-2023 – will more than double P+F's visibility over its entire production value chain and enable the supply chain team to identify data connections and insights that will drive better decision-making and planning.

3. **Updating HR talent development programmes**: Highly qualified talent is the foundation of P+F's success. To encourage P+F employees to embrace the spirit of lifelong learning, the operations and HR departments collaborated to update the existing L&D programme which now:

    i. Allows each employee to enrol in continuous education training courses subsidized by P+F and the Singaporean government.

    ii. Includes a new digital curriculum training course under its own P+F "University Campus" to increase employees' level of exposure to digital technologies.

4 **Reassessing the site (2021)**

Pepperl+Fuchs OSA results		
Dimensions	2018 maturity banding	2021 maturity banding
Vertical Integration	1	2
Horizontal Integration	1	2
Integrated Product Lifecycle	1	2
Enterprise Connectivity	1	2
Workforce Learning & Development	2	3
Inter- & Intra- Company Collaboration	2	4
Strategy & Governance	1	2

Source: Pepperl+Fuchs Asia Pacific

P+F has since taken stock of its progress. As shown in the table above, P+F saw a progression of one maturity band among half of the 16 dimensions. These improvements were observed across all three SIRI building blocks – *Process, Technology* and *Organization*.

Based on 2022 benchmarks, P+F Singapore's current maturity across the eight dimensions (as featured above) now equals or exceeds its industry peers'. P+F has therefore met its objective in the 2018 three-year plan: to upgrade its Singapore site to be on par with the Broad Middle segment.

Looking ahead

Following the successful OSA pilot in Singapore, P+F deployed SIRI at three other production facilities in 2021, across Vietnam, Hungary and the Czech Republic. This has enabled P+F to understand the maturity profileof its other key sites, and facilitated transformation initiatives across the entire P+F group.

Today, P+F has formed an international working group that will leverage the aggregated findings to develop a three-year, group-wide corporate digitalization strategy for rollout across all P+F subsidiaries. This programme, which will focus on four key dimensions, was presented to the P+F management board in December 2021. Rollout will be overseen by P+F's Industry 4.0 steering committee and supported by a digital automation technology group based out of Singapore.

The OSA gave our digital transformation team stronger visibility and guidance in setting transformation targets. It also ensured our initiatives are focused on areas that are most critical to our needs. We're excited to apply this programme at the organization-wide level.

Gunther Kegel, Chief Executive Officer, Pepperl+Fuchs

Case Study 2 | **Multi-site review - Haier**

Haier's global digitalization journey

Founded in 1984, Haier Group (Haier) is a global Chinese company that provides innovative home appliances and consumer electronics to more than 1 billion users across 160 countries. To effectively manufacture and supply high-quality products to its consumers worldwide, Haier has been a pioneer in deploying new innovations into its manufacturing plants. From IoT in the early 2010s to the Fourth Industrial Revolution, Haier's continued efforts to adopt new technologies have enabled its factories to expand production capacity to meet increasing market demand, as well as reducing inefficiencies and wastage.

This proactive spirit towards innovation and transformation has paid dividends. Today, Haier has three factories designated as Lighthouses and included in the World Economic Forum's Global Lighthouse Network. This initiative identifies and features factories and value chains that have deployed the latest advancements in technologies - such as artificial intelligence (AI), advanced robotics and industrial IoT - at scale, to drive compelling financial and operational impacts.

Leveraging SIRI to take stock of Haier's digitalization programme

In the coming years, Haier intends to future-proof its global operations by transferring various solutions and applications that have successfully been deployed across its key sites to more than 120 of its manufacturing facilities worldwide. Before embarking on this ambitious project, the company wanted to confirm that its transformation strategy to date had been effective and holistic, and conducted a multi-site OSA exercise across four of its top production sites in China to:

1. Validate whether its ongoing efforts had enabled these facilities to be more advanced than their competitors'.

2. Identify blind spots and missed opportunities.

Learning points and follow-up actions from the multi-site OSA exercise

① **Haier's ongoing transformation efforts were validated**

Dimension	Average Maturity (Haier)	Top 10% benchmark
Vertical Integration	>4	2.71
Horizontal Integration	>4	2.47
Integrated Product Lifecycle	>4	2.33
Shop Floor Automation	>3	2.31
Shop Floor Connectivity	>4	3.37
Shop Floor Intelligence	>3	2.27
Enterprise Automation	>4	1.96
Enterprise Connectivity	>4	3.22
Enterprise Intelligence	>3	1.82
Facility Automation	>3	2.35
Facility Connectivity	>4	2.45
Facility Intelligence	>3	2.02
Workforce Learning & Development	>4	2.90
Leadership Competency	>4	3.29
Inter- and Intra- Company Collaboration	>4	3.55
Strategy & Governance	>4	2.86

Overview of Haier's OSA results against the top 10% benchmark **Source:** Haier Group

Findings from the OSA showed that Haier's sites consistently performed as well as, or better than, the Best-in-Class (Top 10%) maturity profile under the 3B Maturity Benchmark, across all three SIRI building blocks (*Process, Technology* and *Organization*). This served as a strong validation of Haier's ongoing efforts to create Best-in-Class smart manufacturing plants.

Haier attributed its Best-in-Class maturity profile - particularly in the *Process* building block and *Connectivity* pillar, where average maturities were greater than Band 4 – to the deployment of its *COSMOPlat* industrial internet platform, which was developed in-house. Coupled with advanced technologies such as 5G and edge computing, Haier was able to leverage *COSMOPlat* to restructure and integrate its processes vertically on the factory floor, and horizontally across the entire production value chain.

For example, one of Haier's projects sought to IoT-enable its visual inspection system for modular component testing and to integrate the entire process into its unified network management system to allow 100% of data to be fully traceable. Haier also incorporated AI into its analytics platform, enabling the system to self-calibrate and enhance its inspection ability over time. This project has enabled Haier to increase its defective component detection accuracy and efficiency by 15% and 20% respectively.

(2) Haier was able to identify and address weak points

By doing a comparative analysis of the OSA results across Haier's four sites, the global transformation team were able to identify opportunities to strengthen the company's digitalization programme. These discoveries will help pave the way for interventions that will form part of Haier's future transformation plans.

Site	Dimension and description	Intervention
Haier Refrigerator Production Factory (Hefei) / Haier Drum Washing Machine Company Ltd. (Qingdao)	**Shop Floor Intelligence (Band 3)** Haier noted that its shop floor machinery and assets were well-automated and connected to a highly computerized central platform, but this was only identifying deviations and supporting basic diagnostics. The team realized the missed opportunity to apply predictive analytics that could help identify potential failures before they happened.	To patch this gap, Haier will enhance the equipment management platform (EMP) that monitors and manages all operational assets (such as sensors, measurement instruments and regulators) in two ways: 1. Extending EMP's coverage to include the entire product life cycle of all working assets, from installation to decommissioning. This would enable the production team to integrate their asset replacement workflow into the EMP. 2. Introducing predictive analytics functions within the EMP system, plus leveraging digital twin and AI technologies to sharpen algorithm models which will in turn improve the efficiency and accuracy of the predictions.
Hefei Drum Washing Machine Company Ltd.	**Facility Automation (Band 3)** While the processes that manage utility equipment and systems are fully automated, any changes or disruption to these systems would still require human intervention to review and make updates and/or adjustments.	To reduce reliance on human operators, the facility management (FM) team will be upgrading FM systems by: 1. Centralizing the controls of various facility assets (e.g. lighting, HVAC, compressed air and water units) to be managed by a single remote monitoring and management (RMM) platform. 2. Designing and implementing a data optimization and analysis application within the RMM platform that will help the FM team identify energy saving opportunities and reconfigure FM assets to achieve them.
Across all sites	**Horizontal Integration** The team found untapped opportunities to further integrate and automate their supply-chain and logistics systems, boosting the efficiency and resilience of their distribution networks and channels.	Haier plans to study how to further integrate its warehouse management system and procurement platforms. Beyond productivity gains, the company also hopes to find ways to increase the visibility of materials moving between both systems. Concurrent to the integration exercise, employees will also explore ways to enhance existing internal algorithms and calculation systems to optimize supplier network sourcing strategies.

Source: Haier Group

By analyzing the OSA results, Haier's digital transformation team were able to validate that their ongoing efforts had indeed transformed Haier's production sites to be Best-in-Class, setting the company apart from its peers and competitors. The inter-site comparison also helped the team identify blind spots, enabling them to further fine-tune and strengthen the company's transformation strategy. Armed with greater confidence and a more robust transformation programme, the Haier Group is well-positioned to execute its global digitalization roadmap and future-proof its production sites worldwide.

> **Through the 16 dimensions, SIRI provides manufacturers like us with a structured and comprehensive framework to not only assess the effectiveness of our ongoing transformation initiatives, but also guide us to think systematically about which directions to take for future upgrading. This ensures that we are able to consistently and holistically digitalize our network of production sites globally.**
>
> Liu Yuping, Chief Technology Officer, Advanced Manufacturing, Haier

2.3 | Bolstering the efforts of technology and advisory firms to catalyse digital transformation among manufacturers

While providing the equivalent of a management-level report card, a company's OSA results can also be relevant to technology and advisory firms seeking to offer manufacturers more tailored advice.

SIRI's neutrality may make it easier for technology and solution providers to support a broad range of organizations through digital transformation. In addition, because the OSA findings capture a clear picture of a company's current situation and transformation priorities, its technology and solution partners may be able to guide conversations and formulate proposals with more targeted interventions. In the long term, technology and advisory firms can utilize the data-supported SIRI insights to stay updated about the manufacturing community's evolving profile and needs.

| Case Study 3 | **Supporting manufacturers through SIRI – Yokogawa** |

Yokogawa uses SIRI to guide manufacturers on the digitalization journey

Yokogawa is a globally leading industrial automation company that supports manufacturers worldwide in the digitalization of their production facilities. In their conversations with manufacturers across the globe, Yokogawa has found that many companies are still only venturing into digitalization with a few projects. This cautious approach stems from a lack of understanding about how new technologies can benefit the company's specific operations and uncertainty over which areas will deliver the biggest impact.

To reduce the inertia, Yokogawa has positioned the Official SIRI Assessment (OSA) as an accessible, easily adoptable two-day review of a company's current state of operations, which identifies and prioritizes the areas that require further attention and development. Today, Yokogawa has trained more than 14 CSAs across various geographical regions to build up its capability to administer the OSA as an initial exercise which can help to share the concepts and benefits of digital transformation with manufacturers internationally.

Companies that have taken the OSA with Yokogawa have appreciated its broad scope, which covers areas not previously realized to be important. They have also found the evaluation to be effective in visualizing linkages between their own operations, which they have deep knowledge in, and new digital technologies which they have limited exposure to.

In the longer term, Yokogawa also sees an opportunity to leverage the OSA findings to stay informed about the latest trends shaping the manufacturing sector, at both company and industry level. Ultimately, these insights will guide Yokogawa in refreshing its portfolio of digital enterprise solutions so that it is well-placed to address the ever-changing needs of its customer base.

> The COVID-19 pandemic has shown that manufacturers which embrace digitalization are able to react more quickly and effectively to disruption. Yet many manufacturers still struggle with the full digital transformation, overwhelmed by buzzwords, new terminologies and the sheer breadth of the topic. We're pleased that our knowledge is complemented by the Smart Industry Readiness Index. With its practical methodology and accessible approach, SIRI helps manufacturers take the all-important first steps in understanding their own operations and how they stack up against prevailing benchmarks.

Yu Dai, Director, Senior Vice President,
Digital Solutions Headquarters, Yokogawa Electric Corporation

2.4 | Informing sectoral planning and industrial development efforts by governments and industry associations

> ❝ SIRI insights can help institutions to conceptualize and implement sector-specific, targeted interventions that maximize efficacy and impact.

Many governments and industry associations lack the robust methodologies required to take stock of the manufacturing industry's digital maturity levels. Today, most organizations either rely on anecdotes shared by the general community or self-administered surveys that are periodically issued to collect feedback from a small sample of companies. While these methods provide a broad sense of industry challenges, they lack the rigor needed to formulate institutional policy and programmes.

SIRI aims to address this gap by providing governments and industry associations with a data-supported methodology that generates insights on various industries. As SIRI insights are derived from objective reviews administered by trained professionals, they can help institutions to conceptualize and implement sector-specific, targeted interventions that maximize both efficacy and impact.

To leverage this benefit, these organizations first need their manufacturers to take the OSA to generate insights relating to the overall maturity profile of the community. Two case studies follow, which detail the process and journey taken by different governments and industry associations to realize this ambition and inform more meaningful interventions.

Case Study 4 | **Supporting sectoral level transformation – The Turkish Employers' Association of Metal Industries (MESS)**

Applying SIRI to transform Turkey's automotive sector

The Turkish Employers' Association of Metal Industries (MESS) is one of Turkey's largest and most active industry associations. To help its members leverage Industry 4.0 concepts and technologies, MESS established MEXT, a 10,000m² technology and innovation centre. Equipped with a state-of-the-art digital model factory, MEXT aims to provide direct support and guidance through training, research collaboration and capability development.

To support members in starting their transformation efforts on the right foot, and to gain deeper insights into the maturity profile of the community, the MEXT team turned to SIRI for its comprehensive framework, data-driven methodology and quantitative assessment programme. Through a five-step process, MEXT systemically leveraged SIRI to aid individual manufacturers, organizations (including themselves) and governments in developing more effective and targeted interventions for the broader manufacturing sector.

Phase 1

Building in-house competencies

To support their member companies in undertaking the OSA, seven of MEXT's industry experts were trained as CSAs. By building a pool of in-market CSAs rather than tapping into the existing global network, MEXT could combine SIRI expertise with local context and language to strengthen their engagement with member companies.

Phase 2

Organizing outreach activities to raise awareness

To raise awareness of SIRI among the manufacturing community, MEXT rolled out a communications and outreach campaign that included more than 20 seminars and workshops, together with digital collateral such as web content and promotional videos. Over 1,000 business executives from the Turkish community participated in various activities.

Phase 3

Conducting OSAs for Turkey's automotive manufacturing community

In collaboration with two of the largest automotive original equipment manufacturers in Turkey, MEXT conducted the OSA for over 20 of their suppliers to evaluate the digital maturity of their production sites and provide guidance on next steps.

Phase 4

Analyzing the aggregated results

Upon completing OSAs for manufacturing suppliers, MEXT analysed the aggregated results to uncover new trends, insights and recommendations for the automotive community. The key findings were:

1

Turkey's automotive sector is slightly ahead of the industry average

Based on the comparative chart, the SIRI Maturity of the Turkish automotive manufacturing sector is generally on par with or slightly better than the Automotive IPC, which aligns with the international average. Turkey's automotive sector performs over 10% better than the international average in 7 out of the 16 dimensions.

Dimension	Average Maturity (Automotive - Turkey)	Automotive IPC
Vertical Integration	1.86	1.68
Horizontal Integration	2.41	2.12
Integrated Product Lifecycle	1.82	1.68
Shop Floor Automation	1.50	1.47
Shop Floor Connectivity	1.05	1.00
Shop Floor Intelligence	1.27	1.18
Enterprise Automation	1.73	1.56
Enterprise Connectivity	2.86	2.29
Enterprise Intelligence	1.41	1.21
Facility Automation	0.91	0.79
Facility Connectivity	0.32	0.44
Facility Intelligence	0.68	0.65
Workforce Learning & Development	1.82	1.85
Leadership Competency	2.18	1.94
Inter- and Intra- Company Collaboration	1.95	1.97
Strategy & Governance	2.32	2.03

2 **Gaps in *Leadership Competency* and *Connectivity* represent opportunities for further development**

On average, company leadership is aware of Industry 4.0 developments and opportunities, but still lacks the confidence and experience to apply the principles in develop transformation initiatives.

Similarly, while the average Turkish automotive manufacturer's shop floor machinery and enterprise IT assets are linked to some form of communication protocol, many of these systems are still operating in silos with limited interoperability. This lowers the manufacturer's overall "visibility" over the production site and reduces the ability to exploit data to strengthen operational processes and business workflows.

3 **Enhancing productivity and quality-linked KPIs are key focus areas for the community**

Based on companies' responses to the OSA prioritization exercise, the MEXT CSAs observed that productivity and quality-linked KPIs are key focus areas among the automotive supplier community.

KPIs such as *Asset and Equipment Efficiency, Product Quality* and *Process Quality* continue to be central for these suppliers, enabling them to manage the growing number of unique components that support not only new-generation fuel vehicles, but also growing numbers of hybrid and electric-powered ones. The emphasis on *Inventory Efficiency* and *Planning and Scheduling Effectiveness*, however, is a reaction to the increased frequency of supply chain disruptions and rising raw material costs arising from the COVID-19 pandemic.

Top KPIs	
Category	Ranking
Productivity	1 — Asset and Equipment Efficiency
Productivity	2 — Inventory Efficiency
Quality	3 — Product Quality
Quality	4 — Process Quality
Flexibility	5 — Planning and Scheduling Effectiveness

Phase 5

Designing recommendations and interventions

Based on the learnings distilled from the aggregated SIRI findings, MEXT created a series of programmes and initiatives to support the automotive supplier community:

1. Supporting the development of *Leadership Competenc*y: MEXT established a new advisory team which created a five-week progamme to support SME leaders in designing robust transformation roadmaps and implementing high-impact digital transformation initiatives.

2. Enhancing asset and system connectivity: MEXT developed a modular turnkey solution package to help companies enhance *Shop Floor Connectivity*. Created with open-source software, this module solution will retrofit existing machines to connect with a company's manufacturing executive system to collect, contextualize and display data on digital dashboards.

3. Assisting policy-makers in crafting suitable interventions and incentives for the industry: MEXT released a recommendation paper, *Rapid Digital Transformation in the Industry: Insights to the Automotive Supplier Base*, which was presented to the Turkish Ministry for Industry and Technology.

Future Plans

Following the successful application of SIRI in the *Automotive* sector, MEXT has since replicated the same approach in other manufacturing sectors including *Machinery & Equipment, Electronics*, and *Precision Parts*. Over the next year, MEXT aims to increase its network of CSAs to 15 and, in collaboration with its channel partners, administer at least 200 OSAs across both metal and non-metal industries like *Textile, Clothing, Leather & Footwear* and *Pharmaceuticals* by the end of 2022. Through these efforts, MEXT hopes to take the lead in shaping Turkey's national manufacturing agenda and transforming Turkey's manufacturing ecosystem into one of the world's most advanced sectors.

> We believe that the digital transformation journey of any company should start with a maturity assessment. SIRI's ability to allow companies to evaluate and compare their digital maturity with other companies – across sectors and geographies – is something we find very powerful. With one of the highest numbers of CSAs in the region, we are committed to scaling up the adoption of SIRI in our community and beyond.

Özgür Burak Akkol, Chairman of the Board, MESS

| Case Study 5 | **Catalyzing industry development - The Asian Development Bank and the Department of Trade and Industry - Philippines** |

The collaboration between the Asian Development Bank and the Department of Trade and Industry - Philippines is a powerful case study that illustrates how, through SIRI, multilateral organizations and governments can work together to help the manufacturing community jumpstart their transformation journey.

The **Asian Development Bank (ADB)** is a regional development bank that aims to help developing member countries (DMC) from the Asia Pacific region to reduce poverty and improve quality of life through inclusive economic growth, environmentally sustainable growth and regional integration.

ADB choose SIRI to help drive socio-economic development within the manufacturing sectors of its DMCs

To help DMCs design and implement innovative reform programmes for advanced manufacturing transformation, ADB turned to SIRI for its independent, standardized and data-driven methodology.

ADB saw that SIRI could help DMCs to:

1. Establish a common framework to determine Industry 4.0 maturity.
2. Gain insights into digitalization and the pace of transformation across different industry sectors.
3. Formulate economic and skills development policies and programmes.

ADB builds awareness of SIRI among government leaders

ADB embarked on a series of half-day workshops to explain and promote the SIRI programme to over 110 senior officials from 10 countries, including Bangladesh, Brunei, Cambodia, Indonesia, the Philippines and Vietnam. Among the attendees were representatives from the Department of Trade and Industry - Philippines.

The **Department of Trade and Industry - Philippines (DTI)** is the primary agency of the Philippine Government in the areas of trade, industry and investment. The DTI's new industrial policy, the Inclusive Innovation Industrial Strategy (i3S), aims to leverage innovation to expand economic opportunities in the country and catalyse inclusive, sustainable and resilient industrialization.

The Philippine Government leverages SIRI to accelerate industrial Transformation

ADB's workshop convinced the DTI to incorporate SIRI into its overall digital manufacturing strategy, to better support Philippines-based manufacturers in implementing Industry 4.0 transformation in a structured and targeted fashion.

Promoting SIRI to Philippines-based manufacturers

To promote SIRI to Philippines-based companies, industry organizations, government agencies and academia, the DTI organized a series of webinars. These included explanations of the SIRI methodology and applications, along with fireside chats and panel discussions where speakers from companies that had taken the OSA shared their experiences. The webinars generated strong interest, with over 300 C-level executives from Philippines-based manufacturing MNCs and SMEs attending.

ADB and DTI collaborate to create a subsidy programme for Philippines-based manufacturers to take the OSA

To support manufacturers in leveraging the OSA, the DTI and ADB jointly established a subsidy programme to co-fund the cost of taking the OSAs for a pilot batch of 20 companies. Launched at the DTI's Annual Manufacturing Summit in August 2021, the programme was extremely well-received and oversubscribed two days after its announcement. The pilot companies are expected to complete the OSAs by end of the first quarter of 2022.

Looking ahead

Asian Development Bank	Department of Trade and Industry - Phillippines
To scale up awareness and adoption of SIRI within Asia Pacific, ADB intends to build in-market SIRI assessment capabilities in various DMCs, by supporting governments to send qualified industry practitioners to be trained as CSAs or establishing training centres in select countries. ADB is currently in discussions with the DTI to expand the SIRI collaboration and support training of at least 20 in-country CSAs. In the mid- to long-term, ADB also intends to mine the SIRI data and findings for more insights into individual DMCs across Asia Pacific. This will help ADB develop evidence-based recommendations and knowledge products to support governments in formulating and executing new strategies and policies.	After the 2021 pilot, the DTI aims to increase the number of OSAs conducted in the Philippines to over 100 by the end of 2022. The DTI also intends to grow the pool of local CSAs in response to a greater interest among manufacturers, especially SMEs, in taking the OSA. In the longer term, to ensure that the government's support for industrial transformation is effective and synergistic, the DTI will use the aggregated SIRI benchmarks to identify the level and pace of transformation across different industry sectors and identify linkages to other industry development programmes. To achieve these goals, the DTI will supplement its internal efforts through partnerships and collaborations with international organizations, technology partners and local leaders. For example, the DTI on-boarded business unions like the Semiconductors and Electronic Industries in the Philippines and the Philippine Exporters Confederation to organize SIRI-related outreach and knowledge-sharing across the country's 17 regions.

> **We believe that the Global SIRI Initiative is relevant in supporting our SMEs, which is an important core of the Philippine economy. In the longer term, the insights we gather from our manufacturing base will inform the way we design our advanced manufacturing policies and initiatives to further strengthen our economic competitiveness.**
>
> Rafaelita Aldaba, Undersecretary, DTI Philippines

Conclusion:
The way forward

To everyone in the international manufacturing community, the Global SIRI Initiative and *Manufacturing Transformation Insights Report 2022* represent an exciting evolution in the way we understand and deepen the digitalization agenda within our industrial sectors.

Alongside global partners, we are actively building the world's largest data sets and benchmarks. Through this endeavour, we aspire not only to democratize knowledge relating to the current state of manufacturing (by sharing previously unavailable insights), but also to fundamentally reform the manufacturing community's approach to industrial transformation, from one that is ad-hoc and anecdote-based to one that relies on a standardized methodology supported by data.

We trust that after reading the findings, insights and case studies in this report, manufacturing stakeholders will feel energized to take decisive action by leveraging the SIRI programme to set themselves on the right trajectory for transformation and collectively define the future of manufacturing.

Contributors

Advisory committee

Co-chairs

Beh Swan Gin
Chairman, Singapore Economic
Development Board

Jeremy Jurgens
Managing Director, World Economic Forum

Executive project team

World Economic Forum

Francisco Betti
Head of the Shaping the Future of Advanced
Manufacturing and Value Chains Platform;
Member of the Executive Committee

Elif Ersoy
Project Fellow

Ben Ong
Expert Fellow

Jackie Tan
Project Fellow

Federico Torti
Initiative Lead

Members

Karel Eloot
Senior Partner, McKinsey & Company

Cedrik Neike
Member of the Managing Board and Chief
Executive Officer, Digital Industries, Siemens

Axel Stepken
Chairman of the Board of Management, TÜV SÜD

Partner organizations

Andreas Hauser
Managing Director, TÜV SÜD Digital Service

Raimund Klein
Chief Executive, International Centre
for Industrial Transformation

Matteo Mancini
Senior Partner, McKinsey & Company

Alpesh Patel
Partner, McKinsey & Company

Selina Sia
Manager, Singapore Economic Development Board

Sharon Tan
Assistant Vice President, Singapore Economic
Development Board

Glory Wee
Senior Vice President, Singapore Economic
Development Board

Acknowledgements

On behalf of the World Economic Forum and the Singapore Economic Development Board, the project team would like to thank all of the contributing organizations for openly sharing their transformation stories. We would also like to acknowledge all individuals who have set aside time to provide their thoughts, insights and suggestions.

Contributing organizations

Asian Development Bank

Department of Trade and Industry, Philippines

Haier Group

McKinsey & Company

Pepperl+Fuchs

Turkish Employers' Association of Metal Industries

TÜV SÜD

Yokogawa Electric Corporation

Appendix:
Industry Performance Cards

Industry group	Aerospace		Automotive		Electronics		Energy & Chemicals (Downstream)	
	Average Maturity		Average Maturity		Average Maturity		Average Maturity	
Vertical Integration	1.60	Approaching *Digital*	1.68	Approaching *Digital*	2.07	*Digital*	1.85	Approaching *Digital*
Horizontal Integration	1.60	Approaching *Digital*	2.12	*Digital*	1.91	Approaching *Digital*	1.50	Approaching *Digital*
Integrated Product Lifecycle	1.40	*Defined*	1.68	Approaching *Digital*	2.00	*Digital*	1.29	*Defined*
Shop Floor Automation	1.40	*Basic*	1.47	*Basic*	1.72	Approaching *Advanced*	1.79	Approaching *Advanced*
Shop Floor Connectivity	0.60	Approaching *Connected*	1.00	*Connected*	1.52	Approaching *Interoperable*	1.85	Approaching *Interoperable*
Shop Floor Intelligence	1.30	*Computerized*	1.18	*Computerized*	1.60	Approaching *Visible*	1.52	Approaching *Visible*
Enterprise Automation	1.10	*Basic*	1.56	Approaching *Advanced*	1.60	Approaching *Advanced*	1.33	*Basic*
Enterprise Connectivity	2.40	*Interoperable*	2.29	*Interoperable*	2.21	*Interoperable*	1.90	Approaching *Interoperable*
Enterprise Intelligence	1.20	*Computerized*	1.21	*Computerized*	1.36	*Computerized*	1.19	*Computerized*
Facility Automation	1.30	*Basic*	0.79	Approaching *Basic*	1.31	*Basic*	1.35	*Basic*
Facility Connectivity	0.40	*None*	0.44	*None*	1.10	*Connected*	1.06	*Connected*
Facility Intelligence	0.50	Approaching *Computerized*	0.65	Approaching *Computerized*	1.17	*Computerized*	1.21	*Computerized*
Workforce Learning & Development	2.10	*Continuous*	1.85	Approaching *Continuous*	2.16	*Continuous*	2.10	*Continuous*
Leadership Competency	2.10	*Informed*	1.94	Approaching *Informed*	2.43	*Informed*	2.25	*Informed*
Inter- & Intra-Company Collaboration	2.80	Approaching *Coordinating*	1.97	Approaching *Cooperating*	3.05	*Coordinating*	2.63	Approaching *Coordinating*
Strategy & Governance	2.20	*Development*	2.03	*Development*	2.07	*Development*	1.88	Approaching *Development*

Industry group	Food & Beverage		General Manufacturing		Logistics		Machinery & Equipment	
	Average Maturity		Average Maturity		Average Maturity		Average Maturity	
Vertical Integration	1.24	Defined	1.37	Defined	1.77	Approaching Digital	1.29	Defined
Horizontal Integration	1.33	Defined	1.38	Defined	1.77	Approaching Digital	1.46	Defined
Integrated Product Lifecycle	0.99	Approaching Defined	1.15	Defined	1.46	Defined	1.29	Defined
Shop Floor Automation	1.35	Basic	1.25	Basic	1.38	Basic	0.96	Approaching Basic
Shop Floor Connectivity	0.34	None	0.48	None	1.54	Approaching Interoperable	0.42	None
Shop Floor Intelligence	0.90	Approaching Computerized	0.95	Approaching Computerized	1.08	Computerized	0.75	Approaching Computerized
Enterprise Automation	1.16	Basic	1.16	Basic	1.62	Approaching Advanced	1.25	Basic
Enterprise Connectivity	1.07	Connected	1.32	Connected	1.15	Connected	1.44	Connected
Enterprise Intelligence	0.83	Approaching Computerized	0.96	Approaching Computerized	1.15	Computerized	0.96	Approaching Computerized
Facility Automation	0.83	Approaching Basic	0.65	Approaching Basic	1.38	Basic	0.69	Approaching Basic
Facility Connectivity	0.33	None	0.35	None	0.92	Approaching Connected	0.33	None
Facility Intelligence	0.66	Approaching Computerized	0.49	None	1.08	Computerized	0.54	Approaching Computerized
Workforce Learning & Development	1.17	Structured	1.19	Structured	2.15	Continuous	1.29	Structured
Leadership Competency	1.88	Approaching Informed	1.78	Approaching Informed	2.23	Informed	1.60	Approaching Informed
Inter- & Intra-Company Collaboration	2.05	Cooperating	2.05	Cooperating	2.46	Cooperating	2.00	Cooperating
Strategy & Governance	1.38	Formalization	1.36	Formalization	1.46	Formalization	1.38	Formalization

Industry group	Medical Technology		Oil & Gas (Upstream)		Pharmaceuticals		Precision Parts	
	Average Maturity		Average Maturity		Average Maturity		Average Maturity	
Vertical Integration	1.55	Approaching *Digital*	1.35	*Defined*	1.92	Approaching *Digital*	1.25	*Defined*
Horizontal Integration	1.73	Approaching *Digital*	1.75	Approaching *Digital*	1.76	Approaching *Digital*	1.28	*Defined*
Integrated Product Lifecycle	1.64	Approaching *Digital*	1.75	Approaching *Digital*	1.24	*Defined*	1.30	*Defined*
Shop Floor Automation	1.00	*Basic*	1.30	*Basic*	1.88	Approaching *Advanced*	1.27	*Basic*
Shop Floor Connectivity	0.45	*None*	0.80	Approaching *Connected*	1.96	Approaching *Interoperable*	0.33	*None*
Shop Floor Intelligence	1.45	*Computerized*	1.35	*Computerized*	1.80	Approaching *Visible*	1.22	*Computerized*
Enterprise Automation	1.36	*Basic*	1.25	*Basic*	1.36	*Basic*	1.05	*Basic*
Enterprise Connectivity	0.91	Approaching *Connected*	1.50	Approaching *Interoperable*	2.16	*Interoperable*	1.00	*Connected*
Enterprise Intelligence	1.09	*Computerized*	1.10	*Computerized*	1.48	*Computerized*	0.88	Approaching *Computerized*
Facility Automation	1.73	Approaching *Advanced*	0.65	Approaching *Basic*	2.28	*Advanced*	0.47	*None*
Facility Connectivity	1.36	*Connected*	0.35	*None*	2.32	*Interoperable*	0.07	*None*
Facility Intelligence	1.64	Approaching *Visible*	0.40	*None*	2.04	*Visible*	0.17	*None*
Workforce Learning & Development	2.00	*Continuous*	1.80	Approaching *Continuous*	1.80	Approaching *Continuous*	1.20	*Structured*
Leadership Competency	1.55	Approaching *Informed*	2.10	*Informed*	1.88	Approaching *Informed*	1.62	Approaching *Informed*
Inter- & Intra-Company Collaboration	2.73	Approaching *Coordinating*	2.30	*Cooperating*	2.60	Approaching *Coordinating*	2.00	*Cooperating*
Strategy & Governance	1.73	Approaching *Development*	1.70	Approaching *Development*	1.68	Approaching *Development*	1.35	*Formalization*

Industry group	Semiconductors		Textile, Clothing, Leather & Footwear	
	Average Maturity		Average Maturity	
Vertical Integration	2.75	Approaching *Integrated*	1.21	*Defined*
Horizontal Integration	2.13	*Digital*	1.43	*Defined*
Integrated Product Lifecycle	2.13	*Digital*	1.21	*Defined*
Shop Floor Automation	2.50	Approaching *Full*	1.29	*Basic*
Shop Floor Connectivity	2.63	Approaching *Interoperable and Secure*	0.29	*None*
Shop Floor Intelligence	2.13	*Visible*	0.79	Approaching *Computerized*
Enterprise Automation	1.13	*Basic*	1.14	*Basic*
Enterprise Connectivity	2.38	*Interoperable*	1.50	Approaching *Interoperable*
Enterprise Intelligence	1.38	*Computerized*	0.86	Approaching *Computerized*
Facility Automation	2.63	Approaching *Full*	0.79	Approaching *Basic*
Facility Connectivity	1.88	Approaching *Interoperable*	0.14	*None*
Facility Intelligence	1.88	Approaching *Visible*	0.50	Approaching *Computerized*
Workforce Learning & Development	2.25	*Continuous*	1.21	*Structured*
Leadership Competency	2.38	*Informed*	1.36	*Limited Understanding*
Inter- & Intra- Company Collaboration	2.50	Approaching *Coordinating*	1.64	Approaching *Cooperating*
Strategy & Governance	2.38	*Development*	1.21	*Formalization*

Endnotes

1. For more information on the Official SIRI Assessment and the evaluation scope, please refer to: Singapore Economic Development Board, *The Smart Industry Readiness Index*, 2017, www.edb.gov.sg/en/about-edb/media-releases-publications/advanced-manufacturing-release.html.

2. For more Information on the SIRI Maturity ranking methodology, please refer to: Singapore Economic Development Board, *Manufacturing Transformation Insights Report 2019*, 2019, www.edb.gov.sg/en/about-edb/media-releases-publications/advancedmanufacturing-release.html.

3. The previous rankings can be found in: Singapore Economic Development Board, *Manufacturing Transformation Insights Report 2019*, 2019, www.edb.gov.sg/en/about-edb/media-releases-publications/advancedmanufacturing-release.html. For more information, visit www.incit.org.

4. Committee on the Budget United States Senate, *Concurrent Resolution on the Budget FY 2014: Committee Print to Accompany S. Con. Res. 8 together with additional and minority views*, 2013, https://books.google.ch/books?id=xuhCHGjK9llC (accessed 14/12/21).

5. An SME is defined as any organization with fewer than 250 employees (Source: IFC, the World Bank Group).

WORLD ECONOMIC FORUM

The World Economic Forum,
committed to improving
the state of the world, is the
International Organization for
Public-Private Cooperation.

The Forum engages the
foremost political, business
and other leaders of society
to shape global, regional
and industry agendas.