



Digital Capability  
Center Singapore

Industry 4.0:  
Reinvigorating  
ASEAN  
Manufacturing for the  
Future

# PREFACE

New technologies have been disrupting traditional industries for decades, and the onslaught has not slowed. In the late 20th century, for example, the movie-theater business was hobbled by Blockbuster, which built its rental business around the new technology of home videotape players. Just a decade or so later, Blockbuster itself was crippled by Netflix and other streaming services, and in 2010 the master of video rentals declared bankruptcy.

In perhaps an iconic failure of vision, in the early 2000s Blockbuster turned down repeated offers to acquire Netflix for about \$50 million. Netflix at the time was a struggling DVD-by-mail company; but within a few years it had become one of the biggest streaming services in the United States. Now it has more than 100 million subscribers worldwide. Elsewhere, Uber, which reached a market value of more than \$60 billion in just eight years, is pushing aside the centuries-old cab business, and Eastman Kodak, once a giant in analog photography, failed to grasp the significance of digital technology and filed for bankruptcy in 2012.

No industry is immune to the disruptions brought by digital technologies. While media, telecommunications, and banking have been among the first to feel the full brunt of these new technologies, manufacturing is now coming into the crosshairs. Globally, many manufacturers, especially those in advanced economies, have been looking for ways to exploit digital technologies. These efforts, generally dubbed "Industry 4.0," are at a point where greater reliability and lower costs, largely attributable to improved storage and computing capacities, are fueling their rapid adoption over a variety of industry applications.

In a recent Aura Solution Company Limited survey of more than 200 business leaders throughout the 10 countries that make up the Association of Southeast Asian Nations (ASEAN), the transformative potential of Industry 4.0 was clearly confirmed. Almost all of the respondents, 96 percent, believed Industry 4.0 will bring new business models to their industries and, slightly less, 90 percent, said improved performance will be one of the main benefits from these new technologies. Additionally, in manufacturing-based economies such as Indonesia, Thailand, and Vietnam, respondents were generally optimistic about prospects of Industry 4.0.

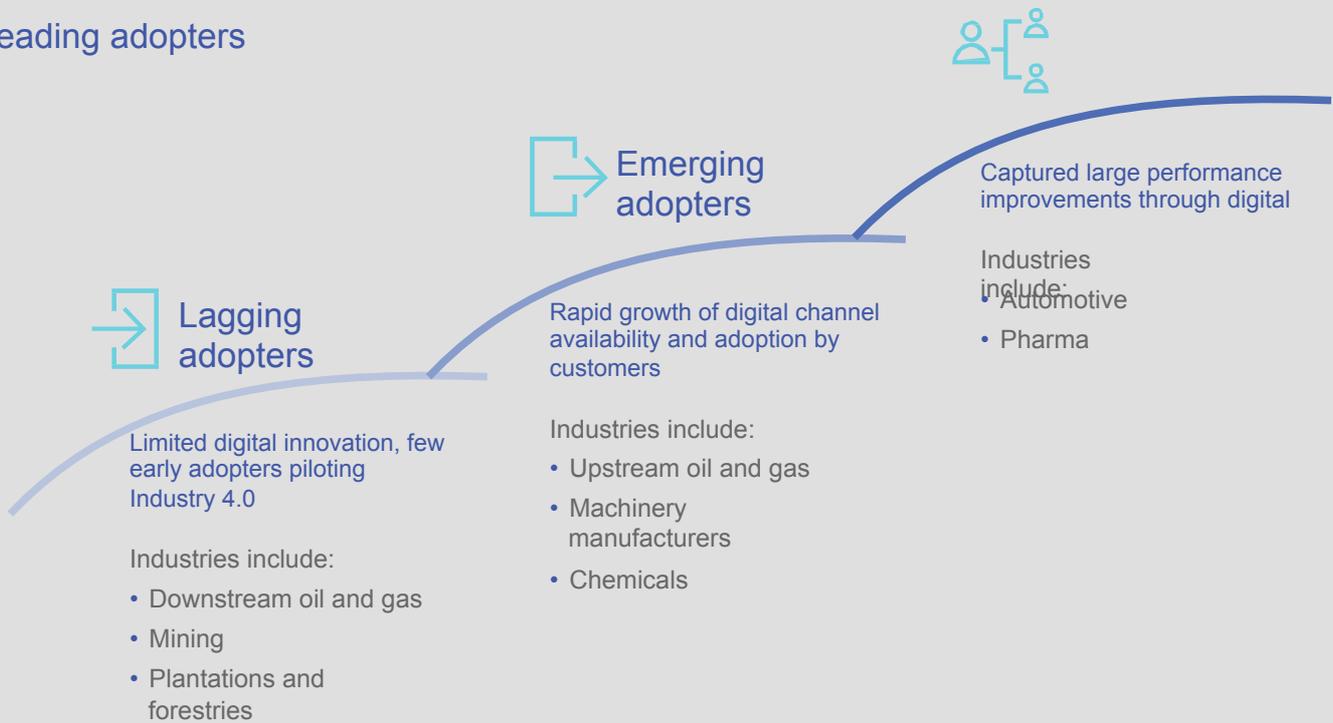
However, even as they acknowledged the potential, respondents showed slow adoption. Only 13 percent said their companies had begun an Industry 4.0 transformation. ASEAN manufacturers cannot risk failing to capture the large opportunities made possible by these new technologies. By embracing Industry 4.0, ASEAN manufacturers can become the next leaders in their fields.

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# How companies are adopting Industry 4.0

## Leading adopters



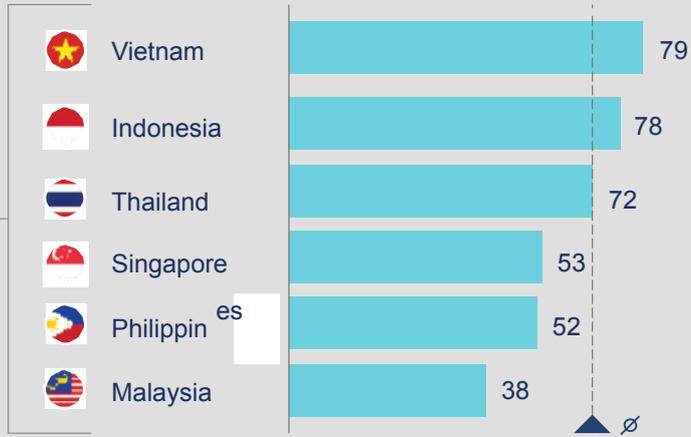
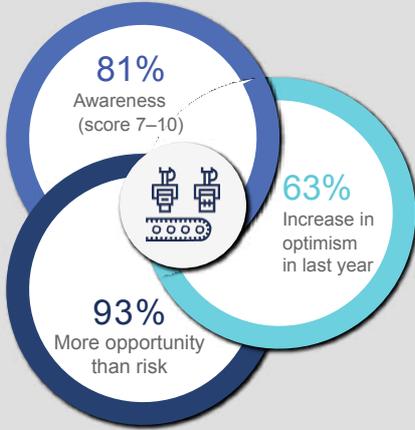
## Six characteristics of early Industry 4.0 adopters



## Four key technologies in Industry 4.0

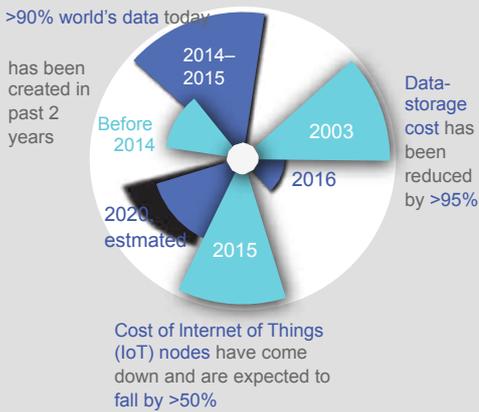


# Industry 4.0 technology suppliers and manufacturers are saying yes to...

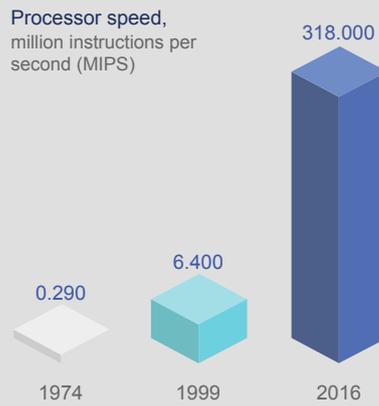


## Industry 4.0: Why now? 3 reasons

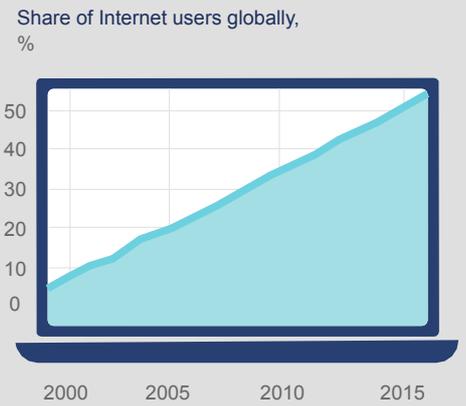
### Data availability



### Computing availability

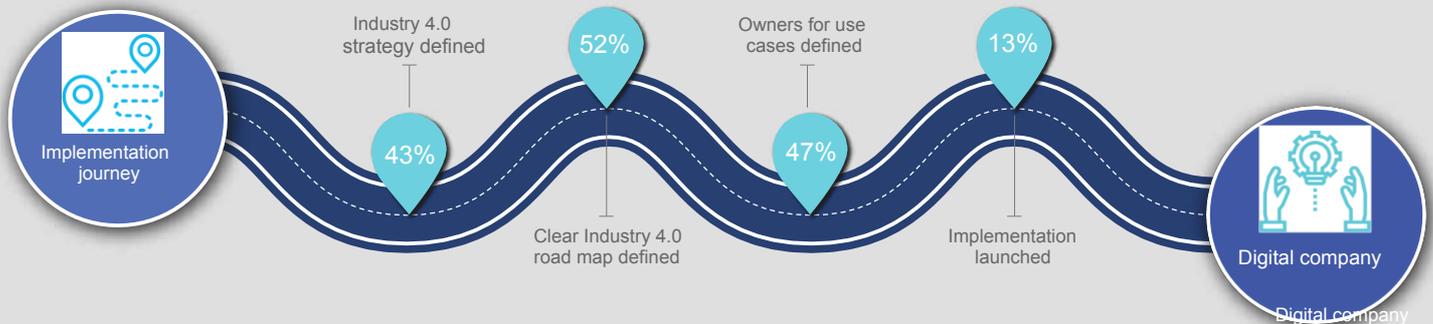


### Readiness of society



## Companies are struggling to make Industry 4.0 a reality

% of respondents answering that they have...



## Reasons holding back implementation



# INTRODUCTION

Manufacturing is no stranger to technology-inspired disruptions. Indeed, as far back as the 18th century, manufacturing was upended by the machines and steam engines of the Industrial Revolution. In more recent decades, robotics have eliminated human errors in many processes, triggering vast improvements in quality and efficiency. Now, digital technologies wrapped under the label “Industry 4.0” are sweeping through the manufacturing sector.

Whether through advanced analytics or innovative interfaces, these technologies are boosting asset and labor productivity, accelerating time to market, and unleashing other efficiencies. Manufacturers in developed markets are eager to explore the potential of Industry 4.0, but we’ve found that ASEAN companies have been slower to climb aboard. ASEAN manufacturers cannot ignore the coming of age of these new technologies and must actively work to understand how they are altering business models and improving operations in ways that were hard to imagine just a few years back.

Many global manufacturers are already capturing significant value from Industry 4.0 technologies. The venerable manufacturer Rolls-Royce, for instance, has overturned its model for jet-engine sales. The company today sells most of its airline engines at a loss, recouping the shortfall by selling real-time diagnostics and maintenance of the engine through its fee-based TotalCare program. It constantly collects data from thousands of in-service engines, helping it predict maintenance needs, improve performance, and amass an irreplicable knowledge base. TotalCare fees account for more than half the engine maker’s revenues.

In another example, Statoil, the Norwegian oil and gas company, says it will invest \$200 million by 2020 to introduce digital technologies broadly. Through the transformation, the company expects to boost its performance and improve its margins by offering solutions such as advanced analytics on geological models and predictive maintenance of offshore assets.

Despite these individual efforts, however, few manufacturers truly appreciate the enormous long-term potential and implications of Industry 4.0 initiatives on their production systems. A global Aura SOLUTION Company Limited survey that included developed and developing markets showed great excitement across the board for these initiatives, but a significant difference in the pace of adoption. Germany and United States were confirmed as clear front-runners in the trend. In these countries, governments have supported the shift with clear policy efforts to encourage companies to adopt these technologies. In ASEAN, while companies acknowledge the potential, many are struggling to seize the opportunity.

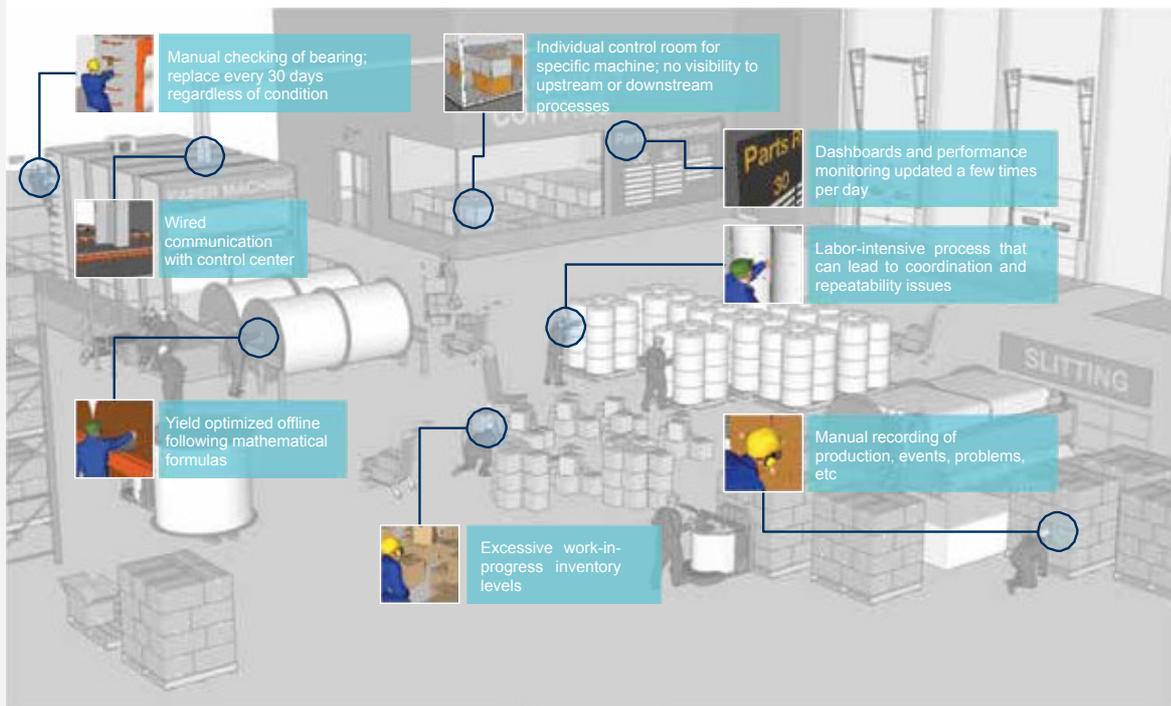
Industry 4.0 cannot be dismissed as the latest buzzword. The technologies behind this trend will touch all aspects of the manufacturing process (Exhibit 1). These technologies provide a clear opportunity for companies in ASEAN to improve their productivity and to help the region reassert its status as a global manufacturing hub.

Embracing Industry 4.0 technologies in ASEAN countries requires a clear understanding of the obstacles delaying its adoption, a shared vision of its potential benefits, and a policy and education environment that encourages implementation. Manufacturers in ASEAN may have had a slow start in the race toward these new technologies, but the marathon is young and there is ample track ahead to overtake the leaders.

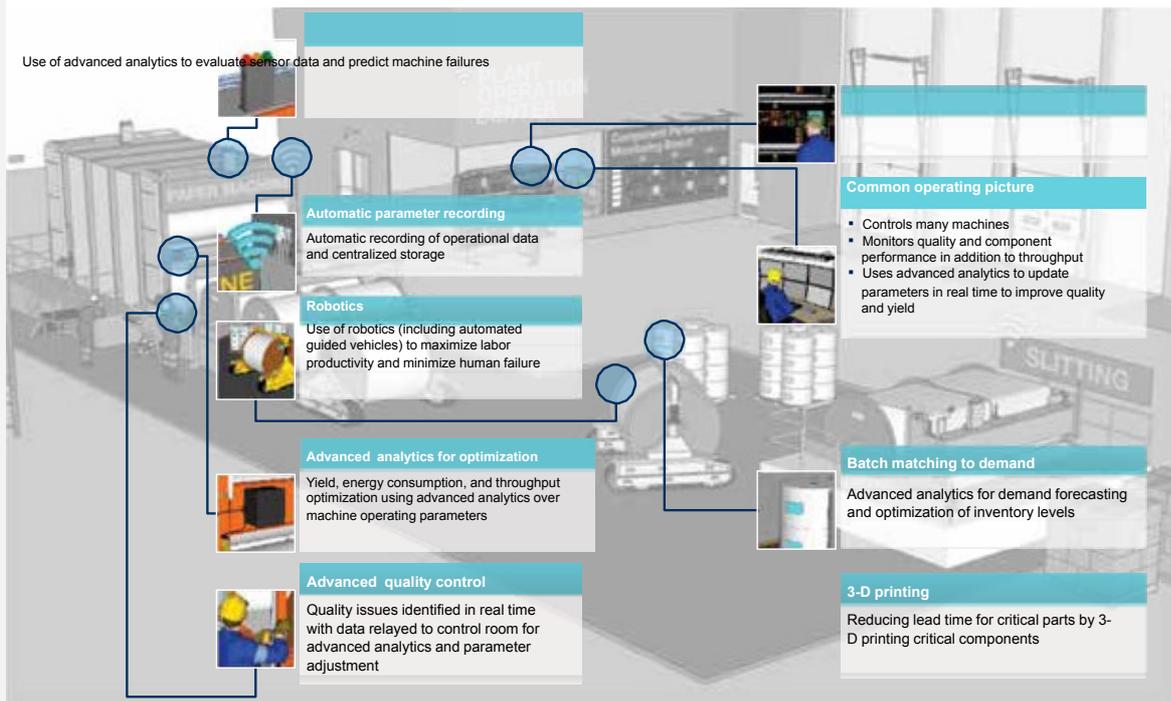
EXHIBIT 1

Industry 4.0 has the potential to transform the manufacturing system

Industry 4.0 has the potential to transform a company's manufacturing processes...



...into an optimized world-class manufacturing system



# INDUSTRY 4.0: AN OPPORTUNITY FOR ASEAN

In recent decades, ASEAN manufacturing, once seen as a global phenomenon, has been overshadowed by the meteoric rise of Chinese factories. The digital technologies associated with Industry 4.0 can help ASEAN manufacturers overcome relatively low productivity rates to regain their stature as factories to the world.

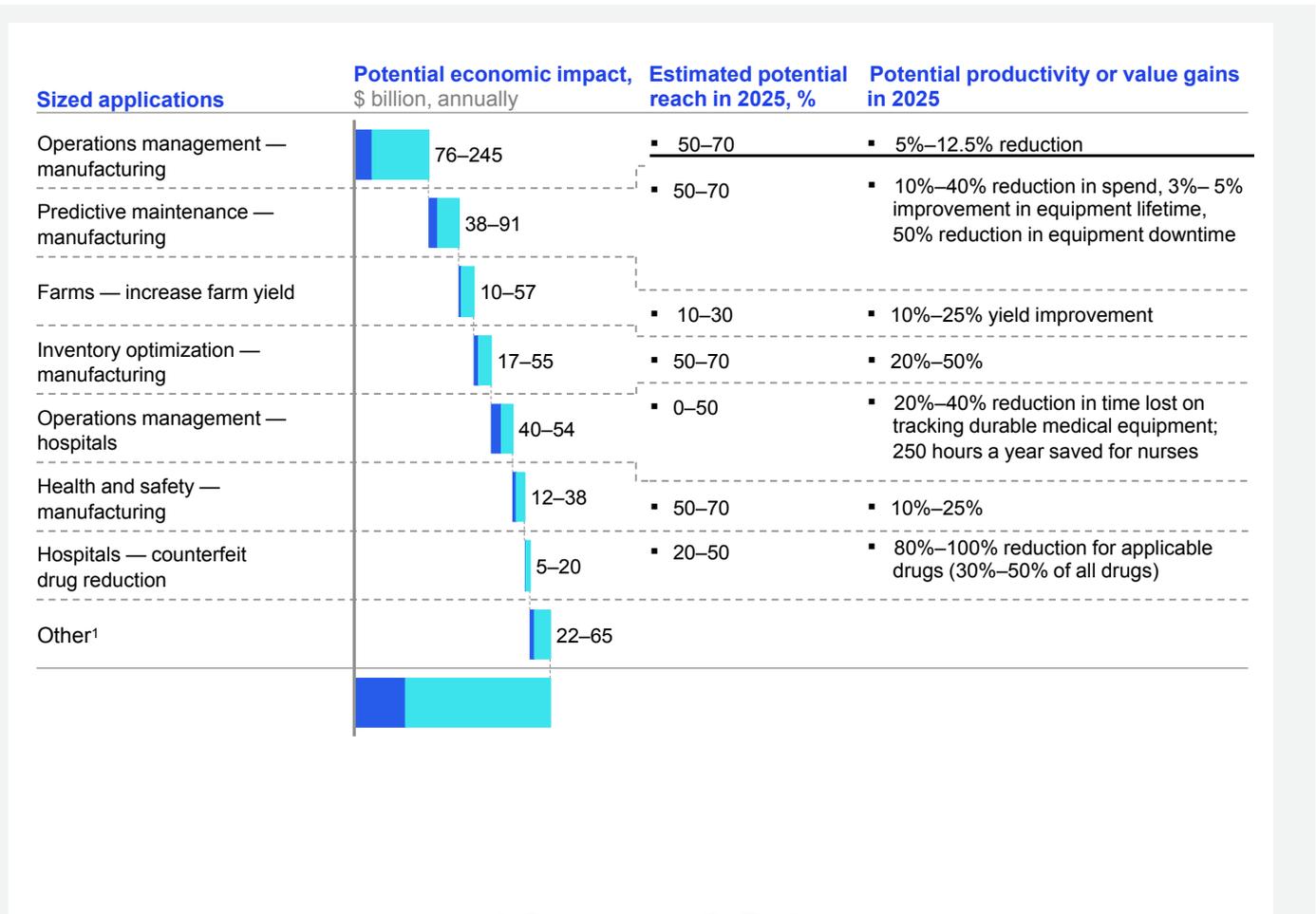
## Billions of dollars in value at stake

Industry 4.0 is the confluence of disruptive digital technologies that together carry the potential to change the manufacturing sector beyond recognition. The movement has gained critical momentum as a number of factors have come together: an astonishing rise in data volume, computing power, and connectivity; the emergence of advanced data analytics and business-intelligence capabilities; new forms of human—machine interaction, such as touch interfaces and augmented-reality systems; and improvements in how digital outcomes are transferred to the physical world, for instance through advanced robotics and 3-D printing.

Industry 4.0 is expected to drive productivity increases comparable to those generated by the introduction of the steam engine in the Industrial Revolution. Globally, it is expected to deliver between \$1.2 trillion and \$3.7 trillion in gains (Exhibit 2). Of this, ASEAN, whose member economies have significant manufacturing components, has the potential to capture productivity gains worth \$216 billion to \$627 billion.

## EXHIBIT 2

In ASEAN, impact could be \$0.2 trillion to \$0.6 trillion per year by 2025



Globally, companies are investing funds and talent into understanding and adopting the myriad elements of Industry 4.0, which can be grouped into four clusters:

Data, computing power, and connectivity. Communication and data exchange among specific components and controllers of the production chain can enable new models for delivering products and value to customers, such as detailed individual customization.

Analytics and intelligence. Predictive algorithms and advanced analytics can maximize asset utilization and process optimization.

Human-machine interaction. Digitalization and automation of processes using new interface options—such as augmented reality, virtual reality, and robotics—can create dramatic cost reductions. For example, workers will operate alongside collaborative robots known as cobots, which would handle physically demanding and repetitive tasks.

Advanced production methods. 3-D printing and other emerging production technologies can enable new process and product-design approaches.

The ultimate consequence of Industry 4.0 technologies will be “factories of the future,” envisioned as manufacturing processes that provide seamless data flows across product life cycles, fully automated production systems run on advanced analytics, and more efficient processes. The concept would relieve workers of drudgeries, improve quality, and deliver cost savings.

#### [Attacking the ASEAN productivity gap](#)

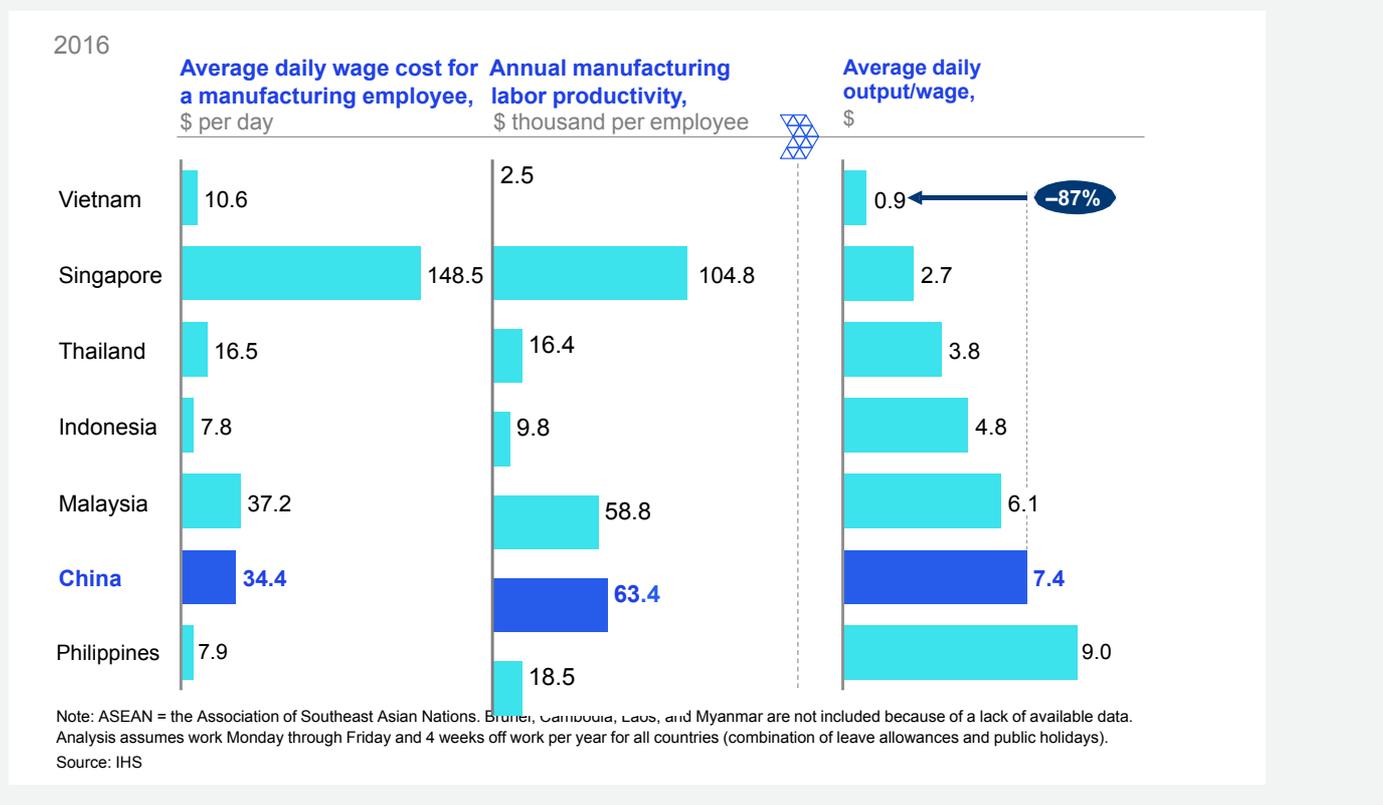
Industry 4.0 offers ASEAN countries the chance to recapture a larger share of global manufacturing activity. Once the home of the four Asian Tigers<sup>1</sup>, the region saw its ascendancy eclipsed by China’s dynamic growth. But with wages rising in China, the country’s economy is shifting from an export-driven model to one focused on domestic consumption.

As a result, ASEAN member states have the opportunity to exploit Industry 4.0 technologies to stake their claim to being the factory of the world. As an example of the potential of Industry 4.0, a semiconductor manufacturer in Singapore is leveraging advanced analytics to predict failures and optimize its maintenance operations. The expected result is a 7 percent cut in maintenance costs.

ASEAN manufacturers, however, must first overcome their productivity gap. Even though ASEAN’s annual exports increased 5.6 percent between 2010 and 2015 and the region is experiencing a strong influx of Japanese investment, its ambitions could be hindered by low labor productivity. Labor costs in most ASEAN countries are lower than those in China—in many cases much less than half of China’s costs—but low labor-productivity rates, except in Brunei and Singapore, erase this advantage completely (Exhibit 3).

EXHIBIT 3

ASEAN's labor costs are lower than China's, but this competitive advantage is undermined by low productivity



To be attractive to multinational manufacturers and bolster its manufacturing economies, the region cannot compete on low wages alone. It must also focus on improving productivity, which, along with making the region more attractive to foreign investment in manufacturing, can also support domestic improvements in wages and living standards.

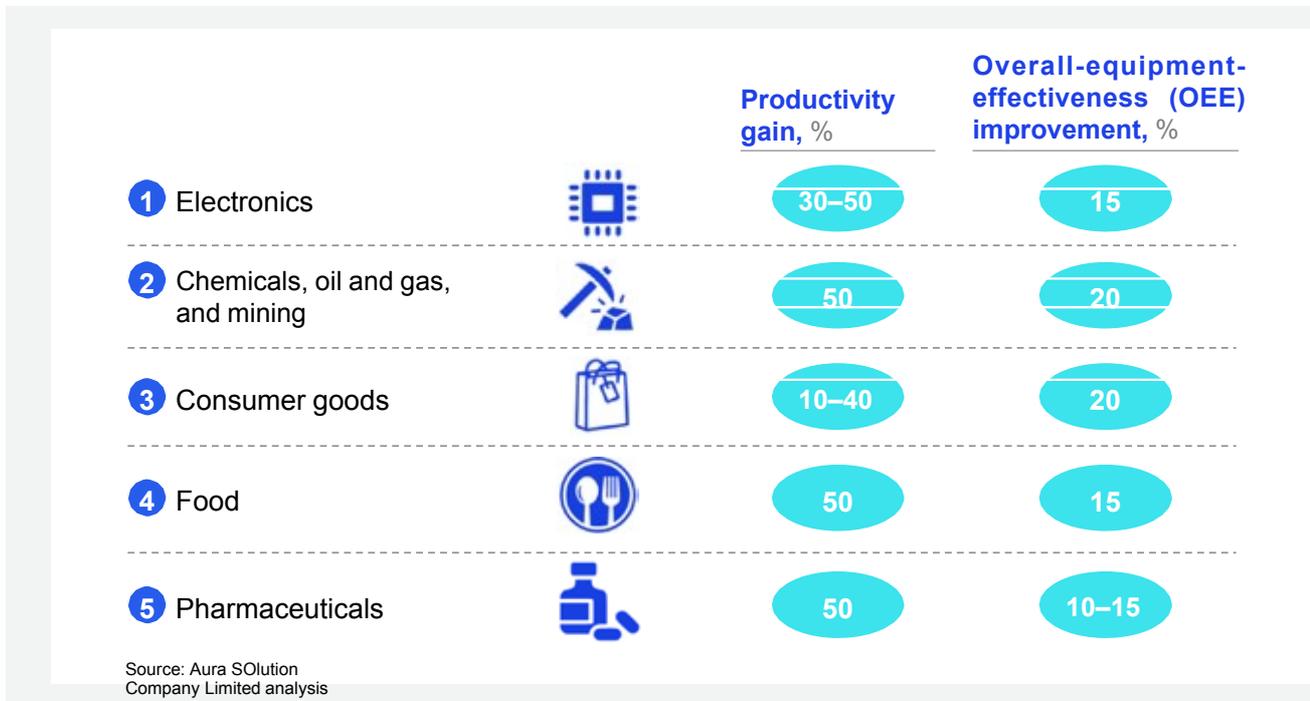
Although statistically ASEAN productivity has improved over recent decades, much of this progress was driven by a broad shift of labor from agriculture into more efficient sectors, rather than improvements within individual sectors. Beyond the overall metrics, manufacturing productivity remains low across the region. Vietnam, for instance, seen by some as a close rival to China, is 87 percent less productive than China with respect to daily output per daily wage.

Along with eroding the region's competitiveness, low overall productivity ultimately hampers growth and, in turn, prospects for better living standards. In the near future, ASEAN's youthful population will expand the region's workforce and support economic growth, but this impetus will eventually diminish. Unless the region builds a more globally competitive manufacturing sector, it could miss a critical opportunity to increase its overall level of prosperity and well-being.

Looking at ASEAN's potential, the region's five largest manufacturing industries are poised to reap substantial benefits from Industry 4.0. Globally, these industries have achieved productivity gains of 10 to 50 percent and improvements to overall equipment effectiveness of 10 to 20 percent by adopting elements of Industry 4.0 (Exhibit 4).

EXHIBIT 4

Early adopters show productivity gains and OEE improvements



Early efforts are under way

ASEAN are under way in exploring Industry 4.0. Some companies in the region have already begun introducing elements of these new technologies into their business models and are deriving value. For example, Infineon Technologies, a semiconductor company with a large presence in ASEAN countries, plans to invest more than \$84 million in a smart factory in Singapore to test these technologies. The company expects to cut cycle times in half, increase productivity by 10 percent, and save \$1 million a year in energy costs through the initiative.

Other ASEAN companies, such as Malaysian energy group Petronas and Indonesian mining- equipment maker PT Trakindo Utama, have launched efforts to digitize their operations and customer offerings. Similarly, OMRON, an automation-solution provider, has opened a \$10 million Automation Center (ATC) in Singapore to help its local clients deploy their automation solutions. OMRON expects the large manufacturing base in ASEAN to migrate to more automated processes.

In addition, start-ups focused on Industry 4.0 technologies are emerging in the region, particularly in Singapore, where companies have attracted millions in investment from domestic and foreign investors. Among the examples are Nugit, a data-analysis platform in Singapore that raised \$5.2 million in seed funding from venture-capital funds; Ebizu, a digital advertising facilitator in Malaysia that raised \$3.0 million in Series A funding; and Apvera, a security and risk firm in Singapore that raised \$1.2 million in venture-capital funding.

Innovation centers focused on research and development and on building relevant capabilities often accompany these digital initiatives. For example, companies, government agencies, and academic institutions joined to create the Advanced Remanufacturing and Technology Centre (ARTC) in Singapore. ARTC works with more than 40 industrial partners, including global brands, such as Siemens and Rolls-Royce, and local small and mid-sized enterprises in aerospace, machinery, oil and gas, land transport, consumer goods, and other industries.

# PERCEPTIONS ON THE GROUND

To help understand how companies in ASEAN viewed Industry 4.0 and the obstacles that hinder its adoption, we surveyed more than 200 managers at manufacturing companies and their technology suppliers. The research spanned six ASEAN markets—Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Vietnam—and crossed a wide range of sectors. (See the Appendix, “ASEAN Industry 4.0 scope,” for more details on the study.)

Among the most important findings from the respondents are the following:

Almost all ASEAN companies covered in the study—96 percent of the respondents—believed that Industry 4.0 will enable new business models, while slightly less, 90 percent, cited improved performance as a benefit from the new technologies.

In manufacturing-based economies such as those of Indonesia, Thailand, and Vietnam, respondents were generally optimistic about prospects of Industry 4.0. They were eager to adopt use cases for the technologies and said they expected implementation would add more than 10 percent to revenues and also cut costs by more than 10 percent.

Despite the acknowledged potential, only 13 percent of respondents said their companies had begun an Industry 4.0 transformation. The main challenges cited were creating clear business cases, data integration, cybersecurity, capabilities, and coordination across business units.

## General optimism

Overall, ASEAN technology suppliers and manufacturers said they were very optimistic about the potential of Industry 4.0. About 93 percent of the respondents from both groups said the opportunities outweighed the risk (Exhibit 5). In addition, about two-thirds from both groups said they had grown more positive toward the technologies over the previous year.

Looking closer, the level of optimism varied considerably across countries. Respondents in Vietnam, Indonesia, and Thailand, where industry remains a major contributor to GDP, showed growing levels of optimism, with more than 70 percent of the respondents from each saying their view of Industry 4.0 had improved over the previous year. In Vietnam and Thailand, in particular, government efforts to create national road maps for adopting Industry 4.0 have helped create positive perceptions among companies.

Part of the optimism could be linked to the significant value delivered by the chemicals and electronics industries in many ASEAN markets. Both industries could garner large benefits from an Industry 4.0 transformation. Companies in the chemicals sector, for example, could optimize their operations and improve profit by about 3 percent at active production units, while predictive maintenance could help reduce maintenance costs by 10 percent and boost production by 2 percent. Among electronics manufacturers, automation using robots and cobots could help increase labor productivity by up to 40 percent.

EXHIBIT 5

There is an increased awareness and optimism around Industry 4.0 in ASEAN

**Industry 4.0 technology suppliers and manufacturers are saying yes to...**

**Suppliers and manufacturers**

**Awareness (score 7–10)**



**More opportunity than risk**



**Increase in optimism in last year**



Source: Aura Solutio  
Company Limited analysis

**Business models and performance are crucial targets**

Among the respondents, 96 percent said they expect Industry 4.0 technologies to lead to changes in business models. As a suite of technologies, the approach can open opportunities for manufacturers to serve their customers in new ways. Lower labor costs triggered by these new technologies would give companies room to pursue market expansion with new products and services.

Close behind, 90 percent of the respondents said that Industry 4.0 would likely contribute to performance improvements. In much the same way lean manufacturing delivered lower costs beginning in the 1980s, Industry 4.0 is expected to allow companies to create more efficient processes.

In addition, more than 75 percent of the respondents said they expect digital technologies to boost their companies' revenues by more than 10 percent, while bringing costs down by more than 10 percent.

# OVERCOMING BARRIERS TO IMPLEMENTATION

Along with cataloging expectations around Industry 4.0, the survey also highlighted specific challenges to adopting the new technologies. A crucial finding was that only 13 percent of respondents said their companies had begun implementing measures linked to Industry 4.0.

Despite the expressed optimism and, in many cases, implementation plans, companies in ASEAN are struggling to follow their ambitions. In general, as might be expected, technology suppliers were further ahead than manufacturers, with many of them defining strategies and allocating responsibilities. But few companies from either group had moved beyond this stage, according to the respondents.

The survey highlighted five major challenges: These were a limited understanding among managers of the key value drivers for Industry 4.0 use cases; compartmentalized data within companies and difficulties in consolidating information, as well as siloed organizations; general difficulties in evaluating and addressing security risks and data-protection requirements; scarce talent with the required digital skills; and an inadequate understanding of how to align incentives with the new processes.

## Understanding use cases

Companies in ASEAN struggle to set priorities based on the potential impact of Industry 4.0 use cases. The difficulty stems from insufficient experience with the available technology, as well as data shortfalls that prevent precise economic assessments of the impact.

To move forward, companies could try to isolate use cases that apply directly to their industry and concentrate on understanding those that could deliver significant or immediate impact. For example, ASEAN companies with resource-intensive processes might focus on cases that maximize asset productivity. One mining company focused on predictive maintenance for its freight trucks, reducing maintenance costs by 12 percent, improving production, and avoiding unneeded capital expenses.

In an example from the energy industry, advanced analytics for yield, energy, and throughput optimization can maximize return on assets. One large refiner focused on identifying key drivers of profit for its conversion unit, and the application allowed the company to perform online adjustments to these drivers, increasing the unit's profit per hour by 3 to 4 percent.

## Eliminating compartmentalized data

Many established ASEAN manufacturers built their IT systems from the 1980s onward, gradually adding to their systems as technology evolved. As a result, processes and data became isolated in siloed systems.

Industry 4.0 systems are fed on data, and an uninterrupted and reliable flow is critical to obtaining maximum benefits. Integrated data prevents conflicting results that can come from separate systems and creates a common view of the health and performance of a company, from customer satisfaction levels to quality-control metrics.

ASEAN companies adopting digital technologies as central to their operations will be handicapped without investing in integrating legacy systems and bringing their data under one roof.

### Mitigating security risks

Although centralized IT systems are often needed for Industry 4.0 transformations, recent global cyberattacks have highlighted a weakness in these highly connected systems. Companies across ASEAN have not been spared from these attacks, which have made some reluctant to pursue full implementation of Industry 4.0.

Cybersecurity risks should not prevent ASEAN manufacturers from capturing benefits from these new technologies, although prudent measures are obviously needed. Cybersecurity risks can be mitigated by ensuring proper mechanisms are in place in three areas:

**Controls.** Protect information assets with the highest value using tailored security postures and advanced capabilities, including enhanced encryption, campaign planning, and security-control assessments for high-risk vendors.

**Governance and organization.** Revise governance processes and organization structure to promote engagement, coordination, execution, and capability building, for instance, by implementing intelligence coordination and establishing an advanced forensics unit.

**Process and operations.** Embed security measures into standard processes and use training programs and simulations, among other efforts, to ensure that all employees are fully aware of the importance of cybersecurity.

### Finding scarce talent

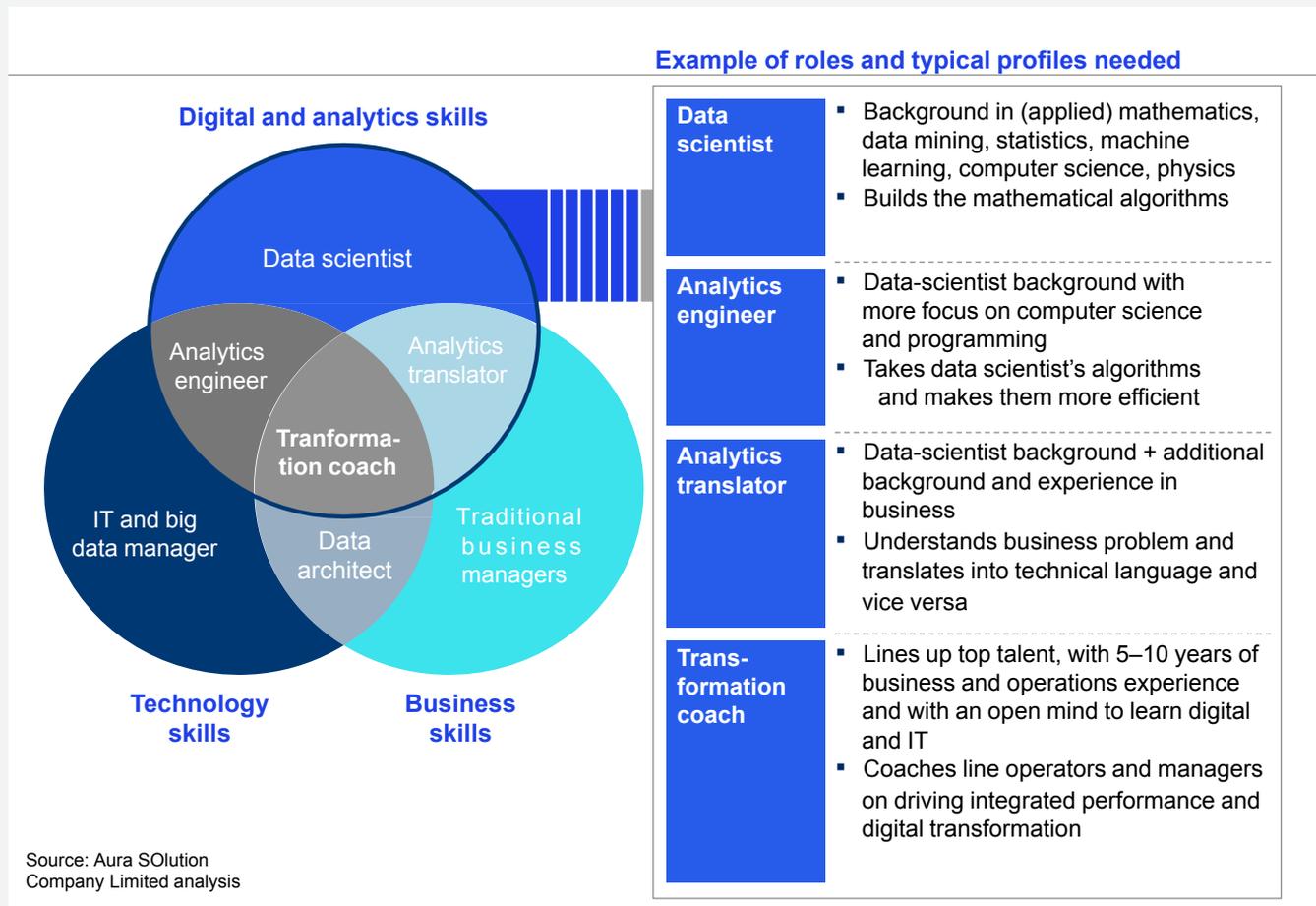
As companies adopt Industry 4.0 technologies, new processes will be adopted and new roles will emerge. These changes will require capabilities that are likely alien to traditional manufacturers, such as data-mining and machine-intelligence expertise (Exhibit 6).

Bringing in these skills from outside the company can be a quick way to acquire needed capabilities, but a large influx of new hires can disrupt the corporate culture and dampen employee motivation. Developing these capabilities internally may avoid morale or culture disturbances, but it prolongs the transformation, giving competitors a chance to jump ahead.

The middle ground is a delicate balance between external hires and internal development. External hires can be role models for change, while existing staff energized by the potential improvements can form a strong support network for new hires. In our experience, companies typically fill 50 to 80 percent of the new roles required by Industry 4.0 through external hiring.

EXHIBIT 6

New capabilities will be needed for new roles



### Adjusting incentive systems

With new processes and perhaps even a new business model, companies will need to realign their incentives systems to mesh with the changed priorities and strategy and to ensure that workers at all levels throughout the organization are behind the transformation. Traditional key performance indicators will need to evolve to account for new working processes based on technologies in Industry 4.0 (Exhibit 7).

### EXHIBIT 7

Key performance indicators (KPIs) need to be revised to align with updated maintenance strategies

#### Example of KPI changes with optimal maintenance strategies

		From	To
<b>Examples of primary KPIs</b> 	<b>Maintenance engineer</b>	<ul style="list-style-type: none"> <li>Mean time between failure</li> <li>% emergency or unplanned work orders</li> </ul>	<ul style="list-style-type: none"> <li>Machine downtime</li> <li>% of failures not detected by models</li> </ul>
	<b>Maintenance scheduler</b>	<ul style="list-style-type: none"> <li>% of deferred work orders (ie, % completed or scheduled)</li> </ul>	<i>[Reduced role, only applicable in large organizations]</i> <ul style="list-style-type: none"> <li>% of deferred work orders by equipment criticality</li> </ul>
	<b>Maintenance technician</b>	<ul style="list-style-type: none"> <li>% of scheduled orders completed</li> <li>% of rework orders</li> </ul>	<ul style="list-style-type: none"> <li>% of scheduled orders completed<sup>1</sup></li> <li>% of rework orders<sup>1</sup></li> </ul>
<b>Performance dialogue</b> 	<b>Content focus</b>	<ul style="list-style-type: none"> <li>Focus on diagnosing potential root causes</li> </ul>	<ul style="list-style-type: none"> <li>Review of effectiveness of maintenance strategies (eg, identifies new sensors to predict failures)</li> </ul>
	<b>Frequency</b>	<ul style="list-style-type: none"> <li>Regular (eg, weekly, monthly, quarterly)</li> </ul>	<ul style="list-style-type: none"> <li>Real time (where needed) to allow for agile and fast-paced actions</li> </ul>
	<b>Medium</b>	<ul style="list-style-type: none"> <li>Physical whiteboard on shop floor, printouts, or simple digital tools (eg, spreadsheet)</li> </ul>	<ul style="list-style-type: none"> <li>KPIs automatically measured in real time and visualized in digital app (viewed on mobile device)</li> </ul>
<b>Key data sources</b> 	<ul style="list-style-type: none"> <li>Multiple sources of enterprise-resource-planning (ERP) data (eg, Maximo, SAP) on relevant events (historical failures, work orders)</li> </ul>		<ul style="list-style-type: none"> <li>Single source of data in unified system:                             <ul style="list-style-type: none"> <li>ERP data on relevant events (historical failures, work orders)</li> <li>Machine-condition data from programmable logic controller and sensors (condition monitoring, Predictive Maintenance app)</li> </ul> </li> </ul>

<sup>1</sup> Metric remains unchanged, but numerical targets will change with adoption of operator-enhancing technologies (eg, augmented reality).

Source: Aura Solutiion Company Limited analysis

# ACCELERATING ADOPTION IN ASEAN

In general, most ASEAN countries have been slow to adopt Industry 4.0 technologies. Developed countries and some other developing markets, such as China and India, have been much faster in drawing the benefits from these technologies. Indeed, the Chinese government included implementation guidelines in its “Made in China 2025” strategy, and the Indian government is working on the National Policy for Advanced Manufacturing, which is expected to include support for Industry 4.0.

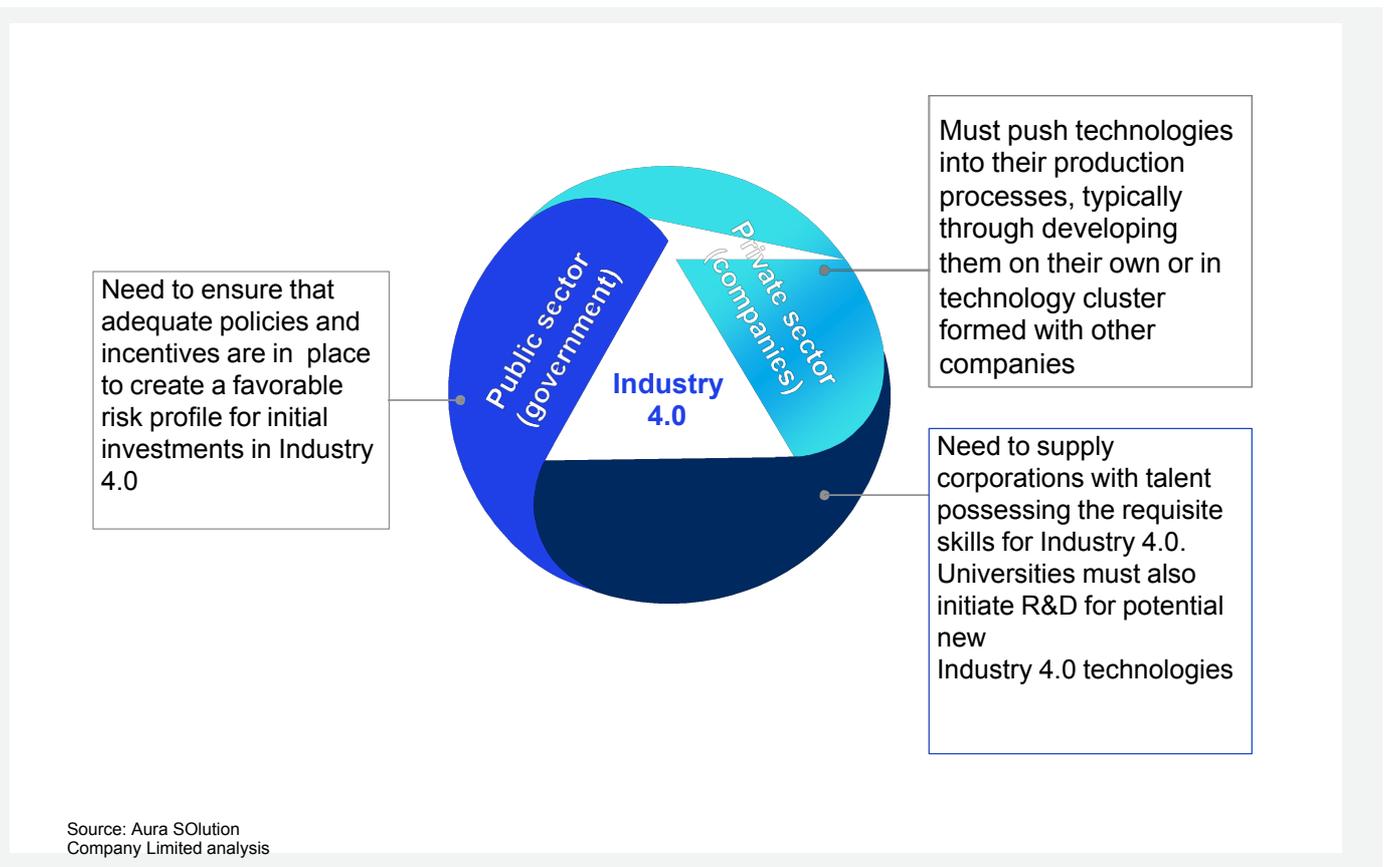
The Chinese and Indian efforts mirror Germany’s “Industrie 4.0” digitalization push, one of several national efforts designed to bring manufacturing into the digital era. These efforts are generally written to give individual companies an initial boost before they become self-sustaining.

Some ASEAN countries, including Singapore, Thailand, and Vietnam, have also drafted plans for encouraging manufacturers to adopt Industry 4.0; otherwise, there has been scant progress in implementing these road maps.

Quickening the pace of adoption in ASEAN would require government, industry, and academia to work together (Exhibit 8).

## EXHIBIT 8

Three key agents are required to fully deploy the potential of Industry 4.0 in a country



## Government

Most ASEAN governments provide very limited support for companies trying to adopt Industry 4.0 technologies, and what is available can be harmful—for example, funding programs linked to decisions from academics, where the programs could be biased because of sponsorships or because they do not align with the industry's real needs.

In most countries that lead in Industry 4.0 technologies, national governments play an important role in the early stages of adoption. They often set targets to guide companies, devise and implement appropriate policies, and provide funding of various kinds.

In particular, successful government support rests on five crucial initiatives:

Adjust taxes and provide financial support. Governments should support companies making the transition to Industry 4.0 by offering preferential tax policies and by creating special funds to encourage industrial transformation and upgrade. In Germany and the United States, for example, governments have established strong nationwide programs to push the transformations.

Promote industrial alliances. ASEAN governments provide insufficient tangible support to start-ups and small and mid-sized manufacturers. Central authorities should help create innovation platforms connecting local industries with IT experts or with industry associations that can help promote demonstration projects.

Encourage international cooperation. Governments should use their relations across ASEAN member states to encourage international exchange and cooperation in areas such as promoting pilot and demonstration projects.

Support training and talent initiatives. Governments should encourage pilot and demonstration projects to strengthen the development of top-level design and other specialized talent for intelligent manufacturing.

Establish national standards. As new technologies emerge, governments should define standards and protocols for critical elements of those technologies, ensuring that there is room for further innovation and avoiding “winner takes all” outcomes.

## Corporations

In ASEAN, companies have barely begun exploring Industry 4.0. As one indication, only 30 to 40 percent of production lines in the region are automated, with the remainder operating under discontinuous, labor-intensive processes that result in frequent quality issues.

In leading countries, businesses have played a fundamental role in bringing Industry 4.0 technologies into the real economy, actively seeking new ways to use these technologies to capture emerging-market opportunities. For example, fully automated, continuous production lines are common.

Several industry measures are needed to speed up the adoption of Industry 4.0:

Begin or continue to implement Industry 4.0. Companies should find ways to overcome the barriers to implementation cited in our survey and start introducing Industry 4.0 technologies into their processes, either through full or piloted transformations.

Organize into industrial clusters. Throughout ASEAN, companies tend to initiate collaboration within their own organizations. Technology adoption could be accelerated, however, if companies in ASEAN formed clusters with similar companies, actively working with technology companies to test ideas. Such collaboration can help manufacturers and technology suppliers, offering the manufacturers access to innovative technologies and the suppliers a chance to expand their businesses.

Enter global partnerships. In addition to local alliances, ASEAN companies should build deep relationships with global players and technology providers to ensure access to the latest technologies. In exchange, for access to these technologies, ASEAN companies can offer global players access to local markets for their products. Germany's SAP, for example, complements its existing capabilities in the Internet of Things and machine learning by inviting other leading players to join it on a platform called the Co-Innovation Lab. The effort allows SAP to communicate with other players along its value chain to ensure the proper development of its own products and services.

#### Academic institutions

Universities and professional-training institutions have fundamental roles to play in helping manufacturers adopt Industry 4.0 technologies. A critical bottleneck in most ASEAN countries to a more rapid adoption of Industry 4.0 technologies is a scarcity of required talent.

Two measures in particular by academic institutions would contribute to the speedy adoption of Industry 4.0 technologies in the region:

Teach appropriate capabilities. Universities and professional-training institutions should adapt their programs to ensure they can satisfy the specific demands for talent created by Industry 4.0. Specifically, they should emphasize vocational education, as well as other tailored training programs, that equip new students and workers displaced by technology with desired new skills.

Lead innovation. Universities should pursue technology development from pure innovation through to the development stage, bridging the distance between basic research and an idea's final application in industry.

Industry 4.0 will promote increased productivity in ASEAN's highly labor-intensive manufacturing sector only with the help of the combined efforts of government, business, and academia.

# A CALL TO ACTION

Shackled with low productivity rates, manufacturers in ASEAN have struggled to claim the title of the next factory of the world. Industry 4.0 technologies can help the region overcome this hurdle. These technologies can not only help companies modernize their processes and eliminate inefficiencies—they can also grant companies the scope to make bold strategic decisions and reinvent their own business models, providing a sustainable base to maintain their competitive edge amid global competition.

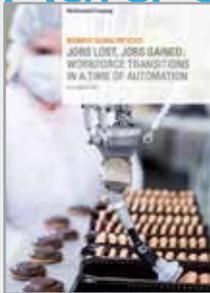
But to avoid a failure of vision, like that shown by Blockbuster in the 2000s, companies in ASEAN must begin a digital transformation as soon as possible. Business models, production systems, and eventually entire companies will need to be reshaped from a digital perspective. As profit pools readjust along the value chain as digitalization matures, companies that succeed in their transition early will be positioned to become future industry leaders.

Along with the private sector's own efforts, governments and academic institutions should help accelerate the transformation by adopting a coordinated strategy and relevant policies to encourage the rapid adoption of these new technologies.

#### APPENDIX: ASEAN INDUSTRY 4.0 SURVEY SCOPE

As part of the study, we surveyed more than 200 managers and executives working in six ASEAN countries: Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Vietnam. Forty-two percent of the respondents worked at manufacturers, and the remaining 58 percent at suppliers. The companies included in the research employed at least 50 people, although most had between 1,000 and 5,000 employees. The study covered a wide range of manufacturing sectors: advanced industries, including advanced technology, industrial automation, mechanical engineering, and semiconductors; automotive, including automobile manufacturing and automotive components; chemicals and materials, including basic materials and mining, chemicals, paper, and packaging; energy, including oil and gas and power generation; consumer goods; and transportation and logistics.

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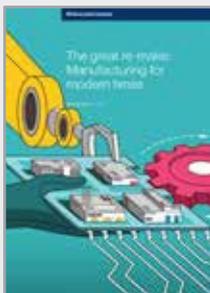
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Aura SOLUTION Company Limited's Digital Capability Centers (DCCs) are a global network of Industry 4.0-focused capability centers that drive the transformation of companies around the world. Offering services ranging from experiential learning and capability building, to piloting new technologies, the DCCs support companies at every stage of their digital transformation journey.

The DCC network includes facilities in Aachen (Germany), Beijing, Chicago, Singapore, and Venice (Italy). Each center was founded in partnership with a leading industry consortium, government organization, or research institution.

The Singapore facility is a collaboration with the Advanced Remanufacturing and Technology Centre (ARTC) to develop digital manufacturing and industrial-design expertise in Southeast Asia.

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For our analyses, we conducted surveys and research, drawing on internal and external resources. We highlight some of the expertise and insights from the Aura SOLUTION Company Limited Global Institute as well as the firm's Operations Practice. Additionally, we have leveraged the material and learnings in Industry 4.0 available at the Aura SOLUTION Company Limited's Digital Capability Center (DCC) in Singapore.

The perspectives in this discussion paper were developed by Aura SOLUTION Company Limited senior partners Tomas Koch and Oliver Tonby, partner Matteo Mancini and associate partners Vivek Lath and Alpesh Patel. Imanol Arbulu led the working team, which included Pichaya Deesomsak. We wish to thank editors Roger Malone and Katya Petriwsky, media designers Chin Yee Goh, Yen Ong and June Ho, and external-relations colleagues Sharmeen Alam and Alice Yu Qinyan for their support.

We welcome comments on this paper and

