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White Paper

Accelerating the Impact of Industrial IoT in Small and Medium-Sized Enterprises: A Protocol for Action

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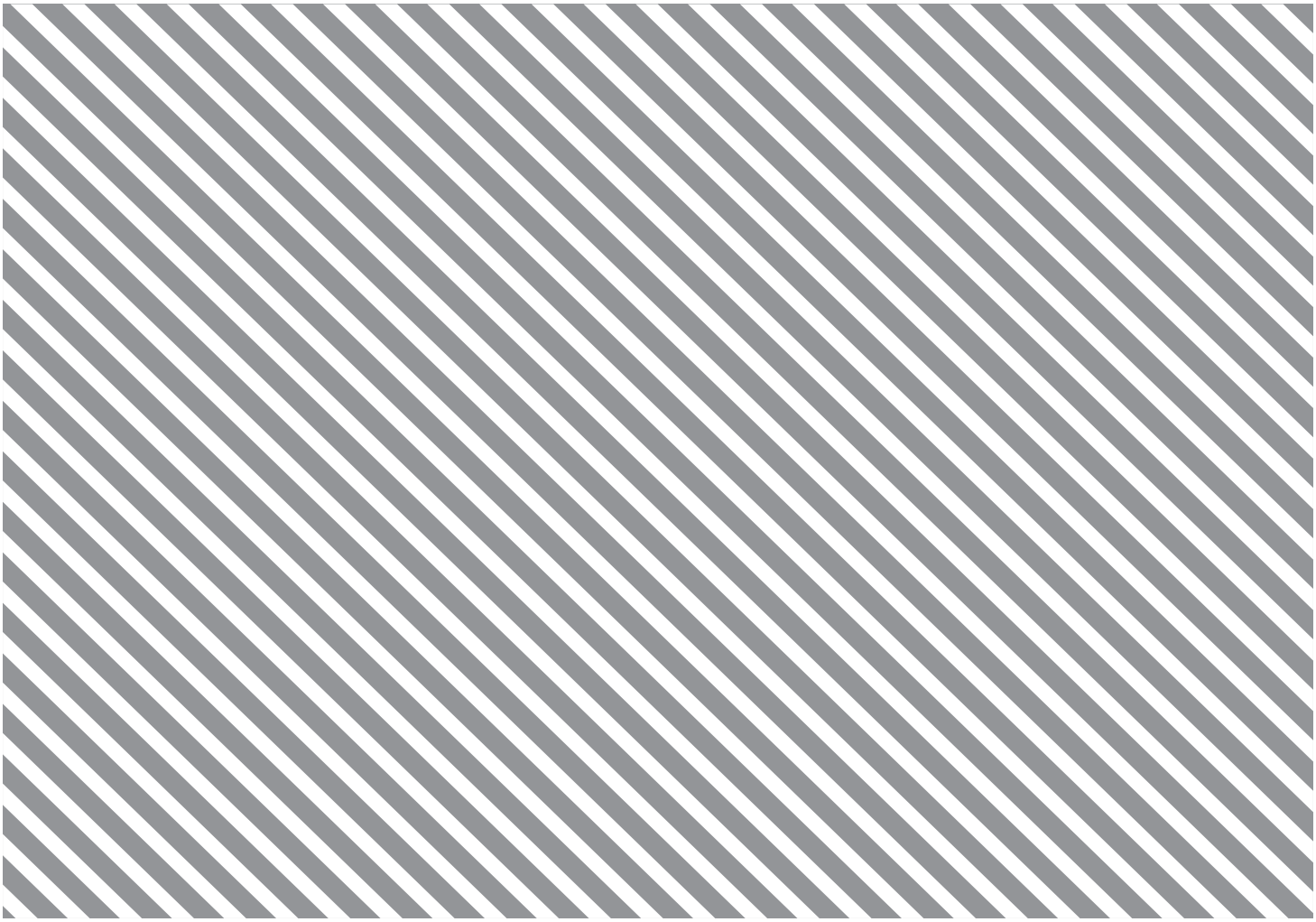

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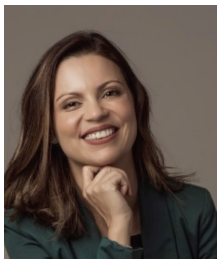


Patricia Ellen da Silva, Secretary of Economic Development of the State of São Paulo, Brazil

At the Inaugural Meeting of the Global Fourth Industrial Revolution Councils in May 2019, global leaders of the Internet of Things industry called for more economically inclusive use of technology in the Fourth Industrial Revolution. Heeding this demand, the World Economic Forum, Ministry of Economy of Brazil and Brazilian State of São Paulo partnered to develop solutions that will bring the benefits of emerging technology to more people and enterprises. Over six months from June to November 2019, this partnership worked together to co-design, prototype and pilot a Policy Protocol that aims to lower barriers and encourages adoption of Fourth Industrial Revolution Technology, particularly the Industrial Internet of Things, by small and medium-sized manufacturing businesses.

The Policy Protocol builds on Brazil's National Plan for the Internet of Things and Programa Brasil Mais (More Brazil Programme) initiatives, grounding the project in successful national policy frameworks and providing valuable expertise and resources. The effort was co-designed with the State of Sao Paulo's aerospace and automotive manufacturing sectors. The state's leading industrial research institutes – Technological Research Institute of São Paulo (IPT) and Aeronautics Institute of Technology (ITA) – were critical project partners, hosting design workshops, providing research and expert insight as well as project management support.

The project drew on innovative approaches to agile governance to quickly develop and refine project outcomes. Findings were developed through a series of multistakeholder workshops as well as direct interviews, surveys and factory visits. Initial hypotheses and recommendations were prototype tested with 10 companies to provide rapid feedback on the draft Policy Protocol, which is being pilot tested with 120 companies starting in November 2019.

The Policy Protocol included in this white paper provides a fact base for policy-makers to learn from, adapt and deploy in their own jurisdictions. It includes a brief case study on the learnings and outcomes of the prototype in São Paulo, Brazil, and shares examples of leading policies in practice around the world. The white paper also outlines some of the key opportunities and challenges facing small and medium-sized enterprises in the Fourth Industrial Revolution, particularly in the manufacturing sector.

The Policy Protocol forms the basis of the pilot programme being launched by the State of São Paulo. In 2020 the pilot programme will scale up in partnership with federal government initiatives, which aims to support over 2,000 small and medium-sized manufacturing companies across Brazil by 2021. However, the learnings from this work are applicable well beyond Brazil's borders. The World Economic Forum is in discussions with industry leaders and policy-makers around the world to adapt the learnings from Brazil to their own context and deliver on the promise of a more inclusive Fourth Industrial Revolution.

Executive Summary

Small and medium-sized enterprises (SMEs) in the manufacturing sector are being left behind in the Fourth Industrial Revolution. This worrying trend is exacerbating economic inequality, stifling opportunities for social mobility and dragging down global industrial productivity. To benefit from the technological advancements of the Fourth Industrial Revolution, SMEs will need to overcome a range of challenges including a dearth of skilled employees, lack of access to capital and unclear returns on investment, a need to revamp their firm's infrastructure and processes, a need to update information technology and operational technology, and navigate a nascent technology landscape that is currently poised to serve larger companies.

As a result of these barriers, SMEs are much less likely to adopt emerging technologies. For example, analysis of Eurostat data indicates that firms with over 250 employees in the EU are six times more likely to benefit from analysis of data collected from smart devices or sensors. These devices and sensors are the edge devices of the Industrial Internet of Things (IIoT), one of the foundational technologies of the Fourth Industrial Revolution.

Resolving these barriers and bringing SMEs more in line with their larger corporate counterparts could unlock benefits for a broad set of stakeholders, including increased firm profitability, larger addressable markets for technology companies, expanded tax revenue for governments, and improved environmental and social outcomes for the general public. The World Economic Forum, in partnership with the Ministry of Economy of Brazil and the Brazilian State of São Paulo, has developed a Policy Protocol to help policy-makers deliver on a more inclusive Fourth Industrial Revolution. The protocol describes specific interventions in four areas:

1. Raising awareness of emerging technology, and IIoT in particular
2. Providing expert support to SMEs
3. Providing financial support to SMEs
4. Fostering collaboration environments for SMEs to learn from one another and build trusted business partnerships

The Policy Protocol was initially protype tested with 10 SMEs in the automotive and aeronautics manufacturing sector in the state of São Paulo, after a series of multistakeholder co-design workshops, interviews and surveys. Findings from the prototype are now being piloted with 120 companies across the state, with an additional 2,000 companies targeted for support across Brazil in 2021. The World Economic Forum intends on scaling the Policy Protocol globally, and is preparing to pilot the protocol and the project methodology in three more global jurisdictions in 2020.

Further reading

This white paper builds upon previous publications released by the World Economic Forum:

- Industrial Internet of Things: Unleashing the Potential of Connected Products and Services
- Realizing the Internet of Things: A Framework for Collective Action
- Leading through the Fourth Industrial Revolution Putting People at the Centre
- The New Production Workforce: Responding to Shifting Labour Demands
- Readiness for the Future of Production Report 2018
- Fourth Industrial Revolution Beacons of Technology and Innovation in Manufacturing
- Agile Governance: Reimagining Policy-making in the Fourth Industrial Revolution
- The Next Economic Growth Engine: Scaling Fourth Industrial Revolution Technologies in Production

Opportunities and Challenges for SMEs in the Fourth Industrial Revolution

The role of manufacturing SMEs in the Fourth Industrial Revolution

Small and medium-sized enterprises (SMEs) are critical to the global economy, but after decades of relatively stable contributions to global economic growth, SMEs are losing ground to larger corporations in the Fourth Industrial Revolution. For example, SME share of US GDP fell nearly five percentage points from 48% in 1990 to 43.5% in 2014, the latest year for which statistics are available.[1]

This trend should alarm policy-makers. SMEs employ the majority of workers globally and contribute between 50% and 60% of global GDP.[2] In addition to their role as the world's employers, SMEs are important contributors to innovation.[3] Arguably the most important contribution SMEs have made to society is that they provide critical avenues for social mobility – accounting for 95% of new job creation in developing and emerging economies – and enable people to exit poverty and enter the middle class.[4] As many of those people would otherwise not have the opportunity to improve their socioeconomic standing, SMEs help to drive inclusive growth by providing employment opportunities to disadvantaged groups such as women, minorities and migrants.[5] Without a strong economic base of SMEs, countries risk exacerbating economic inequality and stagnating productivity.

In addition to their social impact, SMEs contribute to the health of economies and business productivity around the world. They are critical suppliers, partners and customers in nearly all industries – and this is also true of manufacturing.[6] SMEs in manufacturing are particularly important intermediate suppliers, selling their goods into global value chains though larger local or multinational companies.[7] If manufacturing SMEs cannot keep up with their larger business partners and customers in the Fourth Industrial Revolution, it will act as a drag on global industrial productivity. Thus, even the C-suite of the world's largest industrial conglomerates have a vested interest in the competitiveness of SMEs.

The definition of SMEs varies between governments, agencies and other bodies, creating challenges for having internationally consistent statistics. This report does not offer a competing definition, but will generally consider SMEs as all enterprises with fewer than 250 employees, unless otherwise stated. In Brazil – the host country of the policy prototype case study – the definition of SMEs for policy purposes is fewer than 500 employees.

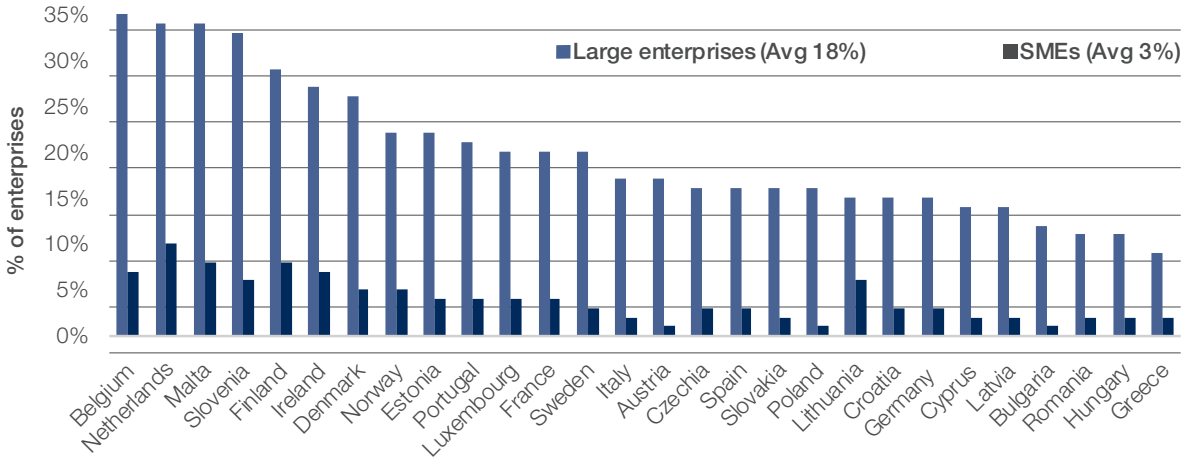
Challenges for SMEs in the Fourth Industrial Revolution

Large corporations have driven global GDP growth post the global financial crisis of 2008. Worker productivity of large companies has outpaced SMEs significantly, in part driven by their ability to invest in Fourth Industrial Revolution technology.[8] One 2015 study of the effects of the Fourth Industrial Revolution on the German manufacturing industry concluded that larger companies are more ready for the Fourth Industrial Revolution and that smaller SMEs are at a higher risk of becoming victims instead of beneficiaries of this revolution.[9]

Analysis of Eurostat data supports this hypothesis, indicating that large corporations in the EU are six times more likely than SMEs to leverage the benefit of data collected from smart devices or sensors. These devices and sensors are the edge devices of the Industrial Internet of Things (IIoT), one of the foundational technologies of the Fourth Industrial Revolution.[10] IIoT enables companies to implement Fourth Industrial Revolution solutions such as inventory tracking, digital instruction and machine vision inspection, among other use cases. Without deploying such IIoT solutions, SMEs are missing out on a significant portion of the promise of the Fourth Industrial Revolution.

This paper will largely focus on policy tools that enable SMEs to deploy sensors, connectivity and analytics for IIoT solutions, while acknowledging that policies that address IIoT tend to also promote other advanced manufacturing technologies (e.g. additive manufacturing or analytics applications that do not rely on physical sensors for data input). See Appendix II for descriptions of some common IIoT use cases. The Forum's Global Lighthouse Network initiative provides a more comprehensive resource on advanced manufacturing technologies and use cases.

Figure 1: Use of big data from enterprise's smart devices or sensors, EU – 28 (2018)



Note: Large Enterprises have > 249 employees, SMEs have <250 employees
Source: Eurostat, Big Data Analysis 2018

This gap in IIoT adoption is the result of varied challenges that SMEs face in the Fourth Industrial Revolution. Manufacturing SMEs are an extremely diverse crowd in terms of end market, value chain position, geography, ownership, revenue, technological advancement, R&D investment, etc. Given this diversity, it is impossible to neatly summarize all of the challenges that manufacturing SMEs face in the Fourth Industrial Revolution; however, research by the World Economic Forum, Ministry of Economy of Brazil and the State of São Paulo has indicated that the challenges can broadly be categorized in five main areas:

Challenge area	Key questions	Supporting quote from Brazilian SME owner/operator
People and capabilities	How might we engage and train employees and managers in industry 4.0? How might we attract and retain the right talent?	*"We have leaders who don't know technology."* *"You don't find the people in the market. You can't find a specialist in Industry 4.0 [for SMEs]. That doesn't exist."*
Business strategy, return on investment and access to capital	How might we make funding less complicated and accessible? How might we measure and guarantee the ROI of each IIoT investment?	*"Funding models are inappropriate…[for example] Sometimes we have to prove we have the money to be granted the funding."* *"When ROI is not clear, it is hard to prioritize."*
Infrastructure and processes	How might we define a roadmap to implement IIoT and keep up the pace of upgrading to new technological developments? How might we determine the right use cases and business cases for IIoT implementation?	*"Is Industrial IoT [the same as] automation?"* *"I can't wait for regulations to change. I have new technologies, but I have standards and requirements I need to follow. People are in between technology and regulation and we need to follow both."*
Technology readiness	How might we experiment with IIoT quickly and cheap? How might we share experiences about successes, failures and best practices)?	*"We started implementing something and then I travelled to Germany and oh… what we are doing is all wrong."*
Ecosystem maturity	How might we define a strategy around the entire value chain? How might we work collaboratively and deal with industrial exposure, competitive advantages and confidentiality issues?	*"The biggest opportunities are in finding common problems that we can solve together."* *"We try to focus on our product and then hire third parties to support on specific stuff. We have no space or time to try to do different things. We have to find people outside."*

The Forum's findings are broadly consistent with findings of the Organisation for Economic Co-operation and Development (OECD), although the names and nuances of the above categories may differ. Some of the key barriers listed by the OECD include lack of managerial awareness and skill (shift to a data-driven decision-making culture), lack of specialists, inability to assess and address digital risks, limited collection and/or storage of data, and access to finance.[11]

In addition to the above structural barriers and challenges, interviews conducted by the Forum with SMEs in Brazil also indicate that technology vendors are less willing to invest in product and account development for smaller firms, instead focusing their resources on larger corporate targets where the returns on a sale are likely to be higher. Similarly, OECD research highlights "lack of SME-tailored solutions" as a key barrier for adoption of data analytics by SMEs.[12] This exacerbates the expertise gap SMEs face compared to their larger industrial competitors, suppliers and customers.

For their part, SMEs are often overly cautious about their data being abused by vendors and partners in the IIoT. "SMEs, while key players in industrial value chains, are less willing to collect and share data with suppliers and customers," explains Jefferson Gomes, President of IPT in Brazil. "There is a great fear that more transparency may damage the company's competitive position. To address this challenge, SMEs executives will need to add tech-savviness to their negotiation in order to ensure efficiency gains from integration opportunities."

Opportunities for SMEs in the Fourth Industrial Revolution

Despite these headwinds, SMEs also have advantages that can be deployed to help overcome challenges and drive innovation in the Fourth Industrial Revolution. The single defining feature of SMEs – their smaller size – often means relatively simple organizational structures and lower power distances from owner to operator, enabling them to react faster to market, environmental and technological changes. Initial findings of the Brazilian policy prototype (described in more detail below) suggest that SMEs can adapt their operating model and expedite business decision-making processes to take advantage of Fourth Industrial Revolution opportunities, although it is too early in the pilot project to draw any concrete conclusions. The Forum's Global Lighthouse Network also illustrates that Fourth Industrial Revolution – and IIoT application in particular – are accessible to manufacturing SMEs.

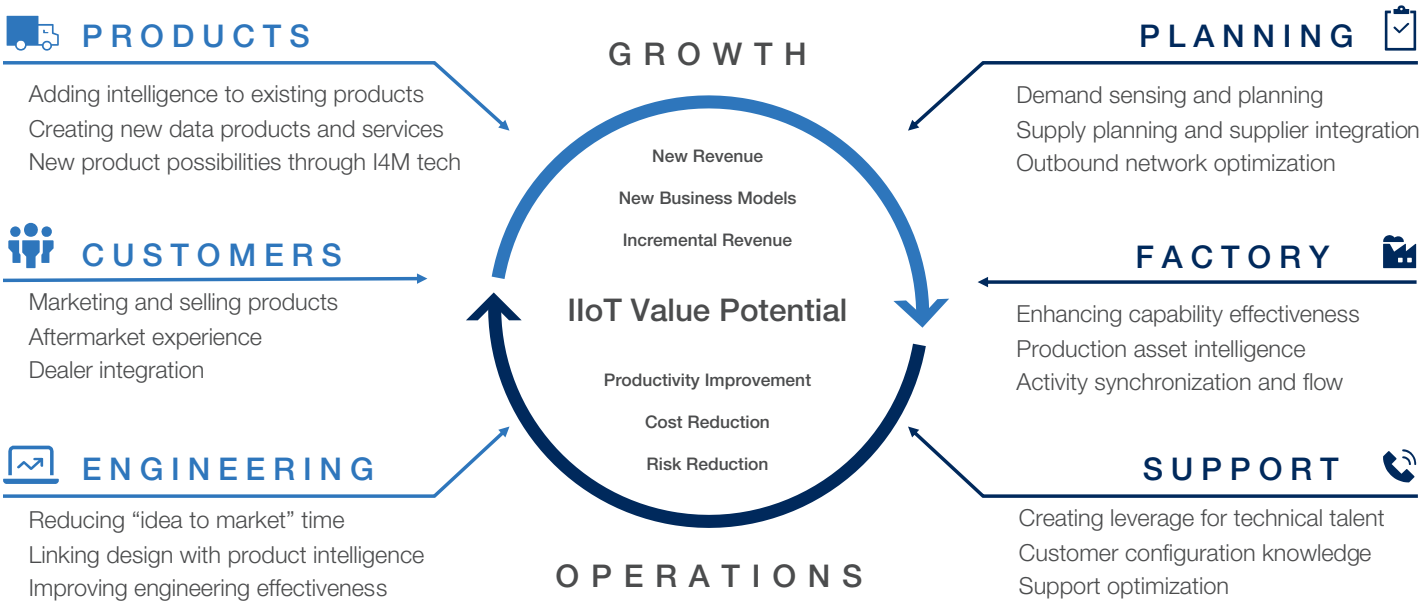
Lighthouse SME case study: Rold – Cerro Maggiore, Italy

Change story: Leverage digital manufacturing to remain competitive and increase production volume.

Top five use cases	Impact		Highlight
Machine alarm aggregation	↓	Reaction time for alarms	**Collaborations with universities support skill building and dedicated events ensure high level of workforce engagemen.**
Digital dashboards to monitor OEE	↑	OEE (11% improvement)	
Sensor-based KPI reporting	↑	Transparency of machine status	
Cost modelling	↑	Accuracy of cost calculation	
Additive manufacturing (3D printing)	↓	Time to market	

While improving productivity is often the first and most tangible benefit of adopting IIoT technology, the impacts for manufacturing SMEs firms can go well beyond that. According to the consulting firm Deloitte, IIoT can create value along multiple dimensions: driving growth through improved products, improved customer service and engineering, while also improving operations via better planning, more efficient factory management and enhanced support functions.

Figure 2: How IIoT creates value



Source: Deloitte

In addition to creating value for firms, Fourth Industrial Revolution technology, and IIoT in particular, tends to create spill-over value for society as well. IIoT enables the measurement and control of "things" across industrial value chains. By connecting things to measure metrics such as inventory turnover, worker safety and energy usage, the enterprise becomes more efficient and less wasteful – aligning firm profits with social and environmental benefits. This is illustrated in an analysis by the Forum of more than 640 IoT deployments, in collaboration with IoT research firm IoT Analytics, which showed that 84% of existing IoT deployments have the potential to also address the UN Sustainable Development Goals.[13]

Addressing collective action problems

Addressing the Fourth Industrial Revolution challenges facing manufacturing SMEs has the potential to unlock shared economic and societal value; however, current industry incentives will need to change to realize this. Perhaps most critical among these problems is the information asymmetry between industrial SMEs and Fourth Industrial Revolution technology vendors. The causes of this information asymmetry are varied and complex and include:

- SME barriers to accessing leading technologically savvy talent
- Lagging SME managerial awareness and familiarity with Fourth Industrial Revolution technology
- Network effects which accrue advantages to larger companies with access to more customers and/or data
- Incentive for vendor firms to create high switching costs for customers, so called "vendor lock-in"

Another critical incentive problem that impedes the Fourth Industrial Revolution journey of SMEs are the barriers faced in accessing financing. The IFC estimated in 2013 that SMEs in emerging economies faced a financing gap of over $2 trillion.[14] While firms' lack of collateral and financial unfamiliarity can hinder their ability to access finance, high transaction, compliance and interest costs can make loans too expensive even for those that do have access.[15] The result is smaller firms often need to rely on retained earnings to finance their operations and growth. Without improved access to capital, it is difficult for SME leaders to prioritize investing in forward-looking Fourth Industrial Revolution technology when there are pressing operational investment needs in the organization.

Addressing these incentive problems and helping industrial SMEs better invest in and adopt Fourth Industrial Revolution technology, such as IIoT, will likely benefit all stakeholders.

Key stakeholder	How they could benefit from resolving collective action challenges
Government	Increased industrial productivity, output and tax revenue
Technology vendors	Expanded addressable SME markets
SME owners	Improved business outcomes and profitability
Industrial labour	More technologically relevant and robust skill set
Large industrial corporations	More robust and competitive SME suppliers, customers and partners
Other members of society	Improved safety, social mobility and environmental outcomes

Policy Protocol

Policy-makers have an important role to play in reducing barriers and aligning incentives to unlock the social and economic potential of the Fourth Industrial Revolution for manufacturing SMEs. The Forum's white paper, "The Next Economic Growth Engine: Scaling Fourth Industrial Revolution Technologies in Production", describes how policy-makers can create the institutions and business environment needed for success of their overall production sector in the Fourth Industrial Revolution.[16] Creating a healthy business environment is a critical input to Fourth Industrial Revolution success; however, overcoming the specific challenges facing SMEs often requires additional targeted policy intervention.

The Forum is now pilot testing a protocol for policy-makers to help SMEs adopt proven Fourth Industrial Revolution manufacturing technology solutions (and IIoT in particular), in partnership with the Ministry of Economy of Brazil and the State of São Paulo. The protocol draws on Forum research of existing global policies targeted at helping SMEs in the Fourth Industrial Revolution (see Appendix I for a summary of this research).

Synthesizing global policy efforts along with the initial findings of the policy protype in Brazil, the Forum found that specific policy tools targeted at helping manufacturing SMEs with Fourth Industrial Revolution technology are concentrated in four key interrelated policy areas: raising awareness, expert support, financial support and collaboration environments. These four policy areas create the framework for a protocol that policy-makers can adapt to pilot and scale solutions that meet SME challenges in their jurisdictions. Each policy tool in the protocol was designed and prioritized to address one or more of these challenges that SMEs face in the Fourth Industrial Revolution. The section below describes these policy tools in further detail.

Figure 3: Mapping policies to SME challenges

Policy protocol		Challenges				
		People and capabilities	Process and infrastructure	Technology readiness	Business strategy, ROI and funding access	Ecosystem maturity
Raising awareness	Fourth Industrial Revolution maturity assessment tool		✓✓			
	Demo factories and lighthouses					✓
	Use case catalogue		✓			
	Online platforms					✓✓
Expert support	Workforce training	✓				
	Management training	✓				
	Open source tools		✓	✓	✓	
	Direct advisory services		✓✓			
Financial support	For proof-of-concept or pilots				✓✓	
	For external expert support			✓✓	✓✓	
	For train workforce	✓			✓	
	For implementation				✓	
Collaboration environments	Online communities			✓		✓
	Collaboration environments			✓		✓✓

Raising awareness

One of the most common issues observed in the policy prototype was a lack of familiarity with IIoT among SME leaders. Policies tools are needed to help create a common understanding about the cost, complexity and impact of Fourth Industrial Revolution technology, including IIoT. The policy tools included in the protocol can broadly be categorized into four areas:

1. **Fourth Industrial Revolution maturity assessment tools**: Benchmarking SMEs against each other and global standards is an important starting point for policy-makers and target companies. Policy-makers can use the aggregated findings of such surveys to better craft and target policy interventions and public investment. SMEs on the other hand can use self-diagnosis or publicly administered surveys to evaluate their readiness along several dimensions and compare their maturity to other companies in the same sector, region or value chain. The findings of such a survey can help inform their Fourth Industrial Revolution investment strategy, identify gaps and strengths, and even help pinpoint potential use cases to prioritize.

2. **Demo factories and lighthouses**: Providing real practical examples of what a smart factory is, how it works, what value it creates and how emerging technologies are deployed can help to make the Fourth Industrial Revolution more tangible for SME decision-makers. Fourth Industrial Revolution technology, including IIoT, can appear complicated or abstract during initial investigation but are often quite intuitive to use once deployed. Demonstrating how Fourth Industrial Revolution technology is deployed on the shop floor is very persuasive to factory workers and business leaders alike.

3. **Use case catalogue**: An online library to describe tried-and-tested IIoT and emerging technology use cases provides a critical reference point for SMEs. Each entry in the library or catalogue should include an overview of the business case, description of the technical solution, quantification of the key performance indicator (KPI) improvements, including return on investment (ROI) estimates, as well as the benefits and challenges from deploying the solution. The catalogue provides a starting point that SMEs can adapt to their own situation, helping them determine the initial assumptions that will underpin a business case. Many existing use case resources accessible to SMEs are created by technology vendors. Having an impartial administrator of the catalogue is important for building trust.

4. **Online platforms**: One-stop-shop websites that share best practices, success stories and useful information about funding and other support services can help address information fragmentation facing SMEs in the Fourth Industrial Revolution. Online platforms reduce research time, highlight and reconcile conflicting information on the web and provide a comprehensive picture of available public policy programmes. Reducing friction and providing a single point of reference should help SMEs create more agile and robust Fourth Industrial Revolution strategies.

Expert support

> **We should reflect on the fact that the Fourth Industrial Revolution might be more about people, than about technology.**

Raphael Alex de Sous, Senior Designer and Agile Technologist, Designit

Improving access to a skilled workforce, building confidence in technology and providing expert assistance are important services that policy-makers can provide to level the Fourth Industrial Revolution playing field for SMEs. The Policy Protocol considers four key categories of expert support:

1. **Workforce training**: Including IIoT and other Fourth Industrial Revolution technologies in manufacturing operations changes the requirements of factory-floor workers in three key ways: workers will be identifying opportunities for Fourth Industrial Revolution technology to improve operations; workers will need to help implement those Fourth Industrial Revolution solutions; and day-to-day operations, responsibilities and working habits will change to employ the technology. As a result, SMEs will need to train workers on tasks as simple as using a tablet for record keeping (instead of a clipboard) to more advanced skills such as programming data analytics solutions to act upon of the copious amounts of data generated from IIoT sensors. Most SMEs do not have the internal expertise or resources to conduct such training. A combination of online, in-person and on-site trainings are needed to bridge this knowledge gap for SME employees.

2. **Management training**: Leaders and investment decision-makers at SMEs also have the challenge of acquiring both business and technological knowledge of IIoT adoption. Compared with workforce training, leadership training will need to focus more on business and economic considerations such as the decision criteria and ROI calculations for IIoT investments, operating model changes as well as how to manage IIoT business partnerships. A combination of online, in-person and on-site trainings are needed to help leadership be Fourth Industrial Revolution-ready.

3. **Open source tools**: Open source tools are IIoT resources that are available to all SMEs. Examples of open source tools includes maturity assessment tools, implementation road maps, reference architectures and procurement guides. Because SMEs are usually resource constrained to develop these necessary inputs by themselves, open source tools often provide a starting point for SMEs to build awareness and are then adapted (either internally or by advisors) to be suited to the individual business. One of the challenges with open sources tools is that they can be either too generic to be helpful to an SME or too specific to be scalable.

4. **Direct advisory services**: Direct expert advice and consulting support provide SMEs with expertise and increased confidence throughout the entire IIoT lifecycle. Each business faces unique challenges related to their operations, customers, industry, culture and financial position. As a result, customized technical and business strategy support can be critical to overcome the challenges that will inevitably arise. Due to the bespoke and labour-intensive nature of providing direct expert support, this solution can be challenging to scale and may prove expensive.

Financial support

Financial support provides SMEs with loans, credit, grants, vouchers, or a combination of those instruments. While funding instruments are a powerful tool for policy-makers to incentivize IIoT adoption and encourage SME competitiveness, they can also distort the true cost of IIoT and thus need to be considered carefully. The application of financial support can be broadly categorized into the below four categories:

1. **Financial support for proof-of-concept or pilots**: Financial support provided for small-scale projects or pilots, often in the form of grants. This financial support does not aim to achieve dramatic operational transformation, but to de-risk and incentivize SMEs to experiment with and learn about IIoT technology adoption. This may encourage SMEs to consider broader technology adoption and bigger investments as less risky going forward.

2. **Financial support for external expert support**: Financial support provided to SMEs to lower the cost of business consultancy services and/or expert technical support, often in the form of grants or vouchers. This approach addresses the scalability challenge and expertise gap of policy-makers developing their own expert support programmes, while also encouraging the development of a robust IIoT ecosystem.

3. **Financial support to train workforce:** Financial support available to train employees or managers at SMEs, often in the form of vouchers. This approach allows SMEs to choose the training programme and vendor best suited to the needs of their business and workforce, while also encouraging the development of a robust IIoT ecosystem.

4. **Financial support for implementation**: Financial support aimed to encourage SME digital transformation and at-scale IIoT projects. Given the larger amount of investment and risk of distorting true cost-benefit analysis for SMEs, this financial support is often best structured as preferential loans and/or credits. This approach helps to address the barriers that SMEs often face in accessing financing.

Collaboration environments

SMEs have much to learn from each other. They often ask similar questions and have similar concerns in the Fourth Industrial Revolution. Fostering environments to share their experiences and connect with trusted business partners can help to build confidence and to scale technical and policy solutions across industries and value chains.

1. **Online communities**: Online communities provide SMEs with access to potential business partners and peers. SMEs often have lower visibility, negotiating power and a smaller business development workforce to establish Fourth Industrial Revolution partnerships compared to larger companies. Online communities can assist SMEs with business matching, provide services for vendor selection and encourage technology collaboration. They can also provide a safe space for SMEs to share best practices and lessons learned.

2. **Collaboration environments**: There are many policy options available to further encourage industry collaboration and strengthening of the IIoT ecosystem for SMEs. A few examples include consolidation of clusters and hubs for SMEs and IIoT vendors, SME networking services, access to technology-testing and demonstration, specialized information and partner matchmaking.

Case study: the Brazil policy prototype

The World Economic Forum has launched a scalable programme for policy-makers to bring the promise of Fourth Industrial Revolution technology, particularly IIoT, to manufacturing SMEs, in partnership with the Ministry of Economy of Brazil and the State of São Paulo.

Agile co-design approach

In the face of rapid technology change, the World Economic Forum has been advocating for more agile approaches to policy development as described in the "Agile Governance: Reimagining Policy-making in the Fourth Industrial Revolution" white paper.[17] The Policy Protocol outlined above was developed and is currently being pilot tested using agile approaches, enabling a rapid project timeline (from project kick-off to pilot launch tool was 18 weeks). Agile methodology also ensured a robust process by including broad multistakeholder input. The Forum's workshops involved over 115 participants from academia, large and small manufacturing businesses, technology companies, professional services, labour groups, industry associations and government. Policy solutions were designed to address the challenges of all stakeholders, while aligning efforts around the goal of creating a more inclusive Fourth Industrial Revolution.

Policy protocol co-design phasing

Project Phase	Scoping	Co-design	Prototype	Pilot
Timing	**4 weeks**	**6 weeks**	**8 weeks**	**Ongoing**
Objective	– Develop key project assumptions – Assemble diverse co-design community – Secure initial project resources	– Develop deep understanding of the problem statement – Multistakeholder input and research to develop policy protocol	– Test and iterate the policy protocol with a small test group – Focus on testing key hypotheses of the protocol, not designing saleable solutions	– Refine the prototype for scalability – Refine the protocol's four key policy areas into a policy toolkit
Key activities	– Working group virtual webinars – Project plans – Desk-top research	– Two workshops to identify SME challenges and co-design policy solutions	– Working group trail of the protocol with 10 SMEs	– Pilot of the policy tools with 120 SMEs

In addition to the multistakeholder core project working group, multiple stakeholders from government, academia and the private sector were placed in small, cross-functional teams to co-create policy ideas from the experience of the 10 SMEs in rolling out the IIoT. Private sector participants included industry representatives, large manufacturing companies, technology vendors, consultants and IIoT system integrators. Most importantly 10 SMEs from the automotive and aeronautics supply chain were selected in the São Paulo region to be part of the policy co-design and prototype, going through a complete cycle of an IIoT deployment in a period of six months. The findings of these co-design sessions were key inputs to the Policy Protocol described above.

The initial step of the prototype involved the first policy tool of the protocol – assessing each SME's Fourth Industrial Revolution maturity and IIoT readiness level. The assessment methodology drew on global best practice and approaches developed by the Forum, Deloitte and the Technological Research Institute of São Paulo (IPT).

The core group would design and trial different policy tools of the protocol with the SME companies, channelled through 60 hours of expert support from Deloitte, IPT and the Aeronautics Institute of Technology (ITA). While each company's journey was slightly different based on the findings of their assessment and business needs, each SME generally followed this process:

- Discover and develop their IIoT their business case
- Identify the most suitable IIoT use cases and technology solutions
- Evaluate technology vendor options, considering risks such as vendor lock-in, cybersecurity, privacy and data ownership, scalability, etc.
- Deploy the technology, train users and implement the IIoT use case
- Estimate the return on investment
- Evaluate operating model changes needed to take advantage of the IIoT solutions implemented

See Appendices I and II for more details on the prototype, the main challenges faced by SMEs, a summary of findings from the application of the maturity assessment model, the selected uses cases and a list of open source tools and documents available to SMEs and policy-makers.

Brazil Prototype Working Group

- Aeronautics Institute of Technology (ITA)
- Brazilian Association of Internet of Things (ABINC)
- Brazilian Innovation Agency (FINEP)
- National Service for Industrial Training (SENAI)
- Brazilian Ministry of Economy
- Brazilian Ministry of Science, Technology, Innovation and Communication
- Brazilian National Development Bank (BNDES)
- Deloitte
- Designit
- National Association of Brazilian Auto Parts Manufacturers (Sindipeças)
- Secretariat of Economic Development of the Government of São Paulo
- Technological Research Institute of São Paulo (IPT)
- World Economic Forum, Internet of Things, Robotics and Smart Cities Platform

Key findings from policy prototype to pilot

Observations from the prototype	Solutions and key questions for the policy pilot
Funding tools were the main policy instruments to support SME IIoT adoption in Brazil already in place at the start of the prototype. However, most funding tools were specifically targeted at financing the implementation phase of IIoT projects, not helping SMEs during the crucial problem definition and solution design phases of the IIoT lifecycle. Furthermore, funding tools comprised exclusively credit options, which is not aligned with international best practices such as vouchers and grants.	Financial instruments launched in the policy pilot are designed to directly address costs and ROI ambiguity during the problem definition and solution design phases. These will include grants to fund IIoT proof-of-concept and small scale projects and incentive SMEs to invest in new technologies. One important metric that will be evaluated during the policy pilot is how much private investment will be simulated alongside investment made by the government. Will these funding policies be a multiplier for private investment or act as a substitute?
There are currently several online platforms being used to disseminate information about emerging technologies for industrial firms in Brazil – through academic institutions, industry associations, private companies and consortia as well as governments. Nevertheless, SMEs did not have access to a "one-stop-shop" that consolidated best practices, success stories, relevant information about programmes, services or open source tools available to SMEs. This was both inefficient and frustrating for SMEs, creating unnecessary friction for companies researching how to best deploy IIoT in their operations.	For the policy pilot, an online platform is being designed in line with international best practices. The platform will be a single reference point for SMEs to learn about the various policy programmes available to help them on their Fourth Industrial Revolution journey. The online platform will also act as a hub for global best practices and case studies, and facilitate an online community that strengthens business-to- business relationships along the value chain. One outstanding question is how to curate and maintain the platform at scale. The pilot will test whether an arms-length IIoT industry body can maintain the content and impartiality of the platform at a national (or international) scale, or whether government or international organizations are needed to manage these platforms (perhaps with the support of professional service firms).
Governmental institutions lacked the expertise to provide direct advisory services to SMEs. Civil servants may have been able to help on particular issues such as industry economics and funding mechanisms; however, SMEs need support at a much more practical level, for example, identifying which IIoT use cases are most applicable for their operations, developing business cases for investment in new technology and designing the technical architecture to implement IIoT. While there were some funding instruments available to hire consultant services to address these questions, they were only available to companies below 99 employees.	During the pilot, a scalable IIoT consulting methodology is being employed to provide expert assistance for SMEs to experiment with IIoT quickly and cheaply. Critical content for this methodology has been developed, including a business case template, ROI framework and a detailed implementation catalogue of the seven most common IIoT use cases in the prototype. During the prototype phase, consultants were trained to assist SMEs throughout the IIoT implementation cycle. The pilot will test the scalability and effectiveness of using consultants to have "lighter touch" support for SMEs, focused on providing training targeted support at key decisions points on the IoT implementation cycle. Experts will support more than one SME at a time, for example through training seminars, online courses and in-person workshops.

Observations from the prototype	Solutions and key questions for the policy pilot
Many SMEs do not offer training programmes on IIoT to their managers or/and employees. Those that do offer such training often cannot allocate the resource and time to provide it to more than a handful of "champions" who then often struggle to convince their peers to change entrenched operational habits and business models. While there was one prototype company that charged its COO with IIoT transformation, more often these "champions" are middle managers without the authority to easily make significant investment decisions. This is despite the fact that there is a wide variety of free or inexpensive technical, vocational and business courses on IIoT and Industry 4.0 available to industrial companies in Brazil.[18]	During the pilot phase, short-term training programmes for business leaders will be prioritized to help overcome cultural and awareness barriers that often inhibit IIoT efforts before they even start. Similar "awareness" trainings will also be trialled with managers and workforce to help companies debunk myths as well as create a familiarity and shared vocabulary around IIoT.
During the prototype, information asymmetry between SMEs, value chain partners and technology providers was observed in a few ways. In one example, an automotive parts manufacturer did not want to further connect their operations with IIoT or gain real-time data out of fear that their OEM customer may use that data to negotiate lower margins. In another example, a technology vendor was focused on selling expensive production line optimization and predictive analytics solutions to an SME, while what they appeared to need most was a simpler, lower cost real-time inventory tracking solution. In yet another example, a number of SMEs voiced concerns about not being able to switch IoT service providers (e.g. cloud service providers or data analytics providers) if prices were to rise, service level decreased or the provider went out of business – this reflected reasonable fears about "vendor lock-in" and questions of data ownership, interoperability and control.	During the prototype, an analysis of the Brazilian IIoT landscape was performed to identify stakeholders and communication channels that could play an important role in closing the information gap and bringing SMEs closer to partners along the value chain. For the policy pilot, an online community is being created to foster business-to-business relationships given the changing nature of business partnership in the hyperconnected Fourth Industrial Revolution. The pilot will also test the efficacy of using IIoT procurement guidelines and reference architectures to address the drivers of "vendor lock-in" and increase trust and transparency between SMEs and their business partners.

"Developing countries can accelerate their growth by creating the appropriate business environment to foster the adoption of new technologies," according to Carlos Alexandre Da Costa, Deputy Minister of Productivity, Employment and Competitiveness of the Ministry of the Economy of Brazil. "The Fourth Industrial Revolution is one of these leapfrogging moments for our countries, and for SMEs in particular, that represents a clear challenge for our governments. One of our key priorities is to develop positive, replicable, adoption experiences for SMEs, through pilots, test labs and testbeds. This is a key factor for widespread modernization of our businesses, fast growth and productivity enhancement."

The objective of the Brazilian government is to scale the learnings from the prototype across the country and other industrial sectors. In November 2019, the Government of São Paulo launched the pilot programme to test the policy protocol with 120 manufacturing SMEs by the end of 2020. The findings from the pilot programme will be incorporated into a national policy programme. The Brazilian Ministry of Economy plans to expand the programme to another 2000 SMEs companies by 2022. Targeted outcomes from the initiative include improved worker productivity, more resilient and competitive industrial value chains, a savvier workforce and a more innovative industrial SME sector.

"Without proper industrial policies, Brazilian SMEs will be left behind in the new industrial revolution. The objective of these policies is to give voice to these companies, understanding their challenges and promoting their inclusion in the digital economy," said **Marcia Matsubayashi***, Partner at Deloitte Brazil and Head of the consulting firm's local technology practice. "Many other countries share similar challenges and inequality will only increase if we do not build effective policies under the context of the Fourth Industrial Revolution."*

Conclusion

Bringing the technological advancements of the Fourth Industrial Revolution to more SME manufacturing business has the potential to unlock significant economic and social benefit. The Policy Protocol described in this paper provides policy makers from the public and private sector with some of the tools necessary to accomplish this vision. The World Economic Forum's ambition is to scale the Policy Protocol globally to help deliver a more inclusive Fourth Industrial Revolution. To assist in this effort, the policy co-design methodology and the tools from the Brazilian pilot program are being made available to the Forum's global community. The opportunity to propel this effort goes beyond public policy makers – large corporations, industry associations and technology vendors can also adapt elements of the Protocol to reduce barriers for their SME partners. SMEs also need to take a leading role in the policy development process to ensure that proposed solutions are solving real world problems. The World Economic Forum encourages policy makers and industry stakeholders to experiment with the Policy Protocol and share their findings with the Forum's community.

Appendix 1 – Global policy initiatives

Raising awareness

– *Singapore Smart Industry Readiness Index (Singapore):* The index helps manufacturers take the first step on their transformation journey, identifying three fundamental building blocks of Industry 4.0: technology, process and organization. All three building blocks must be considered to harness the full potential of Industry 4.0. Underpinning the three building blocks are eight key pillars, which represent critical aspects that companies must focus on to become future-ready organizations. Finally, the three building blocks and eight pillars map onto 16 dimensions, which are areas of assessment that companies can use to evaluate the current Industry 4.0 readiness of their facilities, benchmark themselves against known scores of other companies and identify potential gaps in their transformation.[19]

– *Mittelstand 4.0 – Competence Center (Germany):* Supported by the Mittlestand 4.0 Agencies, the centres act as a regional consolidation of information and competence matching to support SMEs in adopting 4.0 technologies. Initially, they help SMEs to first gauge at what stage of digitalization they are currently at, develop together with the company an individual road map and on whether a technical solution is economically viable, and which security aspects must be considered. Existing labs and testbeds are adapted to SME needs. Several activities take place to increase SMEs awareness of the potentialities of adopting digital technologies, such as training courses, webinars, events, roadshows, company visits, conferences on 4.0 topics, workshops, lab tours and meetings with experts.[20]

– *National Awards Connected Industry 4.0 (Spain):* Non-financial tools, these awards aim to distinguish the trajectory of the most active SMEs and large industrial companies in the adoption of digitization projects.[21]

– *Future Industry Alliance (France):* To help companies, especially SMEs, familiarize themselves with the levers of competitiveness and smart industry technologies, the AIF has published the "industry of the future" repository. It details six levers of competitiveness in more than 60 macro-elements and nearly 400 elements of a smart factory, cataloging and classifying all the disciplines and technologies (materials, electronics, automation, digital, etc.). It allows each company to identify the key axes of deploying smart factory technologies.[22]

– *Smart Factory Korea (South Korea):* Part of the South Korean strategy to raise awareness among SMEs about the importance of adopting IoT technologies is the development of model houses and demo factories that demonstrate real smart factory technologies. Factory tours provide SMEs the opportunity to see high-level smart factories that they can approach.

– *Smart Monozukuri (Japan):* The Japanese Ministry of Economy, Trade and Industry (METI) has been encouraging whole sectors of the manufacturing industries to utilize IoT-based technologies. Online use case map collaborating with Platform Industrie 4.0 in Germany and Industrie Du Futur in France enables SMEs to learn from practical examples of IoT use in Japan, Germany and France. IoT self-diagnostic tool and IoT cost-benefit analysis tools provide SMEs with technology maturity assessment comparing with average SMEs in Japan and approximative estimation of cost benefit analysis for IoT investment in automobile, machine tool, steel and food processing industries. To mitigate SMEs' concerns about lack of technical expertise, the Robot Revolution and Industrial IoT Initiative annually showcases affordable and user-friendly IoT tools and recipes specifically for SMEs. As of 2019, 263 tools and 28 recipes have been released with descriptions, vendor information and price ranges.

Expert support and knowledge sharing

– *Apprentice for Industry 4.0 (Germany):* The chambers of commerce and industry (IHKs) have developed an interdisciplinary training programme that is offered to apprentices from the second and third year of apprenticeship in the industrial-technical area. The offer is optional and intends to create acceptance for digital technologies at an early stage, as well as providing young people with crucial skills to meet the needs of Industry 4.0. The IHK training consists of seven modules of at least 40, and a maximum of 64, training hours. In modules 1-4, trainees use information technologies to discover how smart objects capture, process, store and interact with their environment. In module 5 the apprentices are involved in practice-related field studies. In module 6-7, apprentices learn how intelligent tools influence the way of working in the future.[23]

– *Fabricas de productividad (Colombia):* The programme offers technical assistance to companies from experts listed in the regional chambers of commerce. Physical and legal persons can provide their services once approved to be included in the national expert database. Small businesses must contribute to 15% of the total cost of the consulting service, while medium and large companies must contribute to 20% of the cost.[24]

– *Industria Activa 4.0 Programme (Spain):* The specialized and personalized advisory programme offers a consulting methodology which provides companies with a diagnosis and an action plan. This plan will identify and prioritize the areas of improvement and the digital solutions to implement them. The last step includes demonstrative workshops on enabling technologies included in the roadmap that have the greatest impact. In 2018, the programme executed 350 assessments at the cost of €10,500 each.

– *Korea Smart Factory (Korea):* The Government of Korea and related organizations such as KOSF (Korea Smart Factory Foundation) provide standardized guidelines, expert's consulting for smart factories and support on-site workforce training. The technical support provided by the Korean government is based on reference models, which include the system architecture of 16 industries and all range of ICT systems. Smart factory standards are used to diagnose SMEs' level and promote voluntary upgrading towards smart level where IoT and cyber-physical systems are incorporated into flexible production.

– *Brasil Mais (Brazil):* This programme aims at enhancing the productivity and competitiveness of small and medium Brazilian companies through training and consultancy on best management and production practices, such as lean manufacturing, and by supporting the adoption of digital technologies on the production and managerial processes. The goal is to reach up to 200,000 small and mid-sized companies from all sectors by December 2022. The last phase of the programme is focused on helping companies on the adoption of IIoT technologies, based on the learnings of this pilot with the World Economic Forum.[25]

– *SEBRAETEC (Brazil):* The objective is to bring technology service providers closer to small businesses. The programme allows micro and small businesses to hire technology services from a list of providers certified by SEBRAE with part of the costs subsidized by Sebrae. Among the service covered are metrological services, technology consulting, conformity assessment (certification) and prototyping. The goal is to work for the improvement of existing processes, products and services as well as the introduction of innovations and technologies in companies.[26]

– *SENAI 4.0 (Brazil):* The National Service of Industrial Training provides an online tool to help companies evaluate their maturity level in relation to Industry 4.0 and plan on how to improve it. The agency also provides training courses and technical services to assist companies on their path into the Industry 4.0.[27] _

Financial support

– *Vouchers for data analytics projects (Slovak Republic):* Those vouchers are financial grants (€5,000 with no co-financing required) offered to SMEs interested in testing and implementing small-scale innovations to purchase services from public knowledge institutions.[28]

– *Data Analytics Innovation Vouchers (UK):* These vouchers are a financial grant (£2,000) available to SMEs that want to deepen their understanding of data analytics to access consultancy services from experts or to upskill staff with data analytics training.[29]

– *Go Digital Program (Germany):* Through this programme, funded enterprises can get expertise and support from authorized consulting firms in three areas: process digitization, digital market development and IT security. Funds can represent maximum of 50% of the total value of the project, reaching €16,500 per company. Professional ICT consultant businesses are certified in advance based on technical expertise, economic stability, experience working with SMEs and technological neutrality.[30]

– *R&D Preparatory Incentive Program for Low-Tech Companies (Israel):* Companies applying for the R&D preparatory incentive programme will receive professional consultation to assist them in identifying technological gaps in their current capabilities, locating directions for possible development, identifying flaws in the production process, improving the production process and, when necessary, in preparing for implementation of a more comprehensive R&D programme (together with the support of the Israeli Innovation Authority). Grants are up to 75% of the project costs.[31]

– *Vale Indústria 4.0 (Portugal):* The programme aims to digitally transform SMEs through the adoption of technologies that allow disruptive changes in business models (acquisition of consulting services to identify a strategy leading to the adoption of technologies and processes associated with Industry 4.0); only allows the purchase of specialized services from previously accredited entities. Grant up to 75% of the project with a limit of €7,500.[32]

– *Piano Industria 4.0 (Italy):* One important measure of Italy's strategy to incentivize industry 4.0 is based on tax incentives. Hyper and super-depreciation schemes support companies in their tangible investments in their technological and digital transformation processes. For super-depreciation, the investments costs are increased (for a fiscal reduction purposes) by 40% of their value. In hi-tech, cloud, ultra-broad band, industrial robotics, digital manufacturing, smart sensors, IT security, etc., for tax depreciation a notional increase of the purchase cost of 150% is introduced, known as hyper-depreciation. The mechanism is automatically accessible when preparing the financial statements through self-certifications.[33]

– *Korea Smart Factory (Korea):* Grants to SMEs to incorporated smart factories solutions and key technologies are one of the most important policy tools being implemented in South Korea to turn 30,000 SMEs into smart factories by 2022. Grants vary from $100,000 to $300,000, with a minimum of 20% of financial contribution by the SME, and they can be used to upskill workforce, acquire hardware, software and machinery, hire consulting services and technical support.

- *BNDES (Brazilian National Development Bank, Brazil):* The bank provides adequate funding and grants to investments and RD&I projects related to Industry 4.0 and IoT. As a development bank, BNDES is focused on funding with lower interest rates for investments on infrastructure, machinery and complex services.[34]

- *FINEP Inovacred 4.0 (Brazil):* This offers funding with lower interest rates for investments by SMEs adopting 4.0 solutions and technologies provided by accredited system integrators and technology providers.[35]

Collaboration environment

- *IoT4Industry (European Union):* IoT4Industry is the Horizon 2020 project financing collaborative projects able to imagine the integration of IoT and related components (digital security, cloud computing, Big Data, artificial intelligence, etc.) into manufacturing tools, machines and robots, through the cross-border collaboration between SMEs and other RDI actors of the ICT and advanced manufacturing sectors.[36]

- *Platform Industrie 4.0 (Germany):* Besides collecting knowledge of all topics of Industrie 4.0, the platform provides a roadmap for digital transformation of German industry, an online use case catalogue with 350 use cases mapped in Germany, France and Japan, and a map of testbeds in Germany. The members of Platform Industrie 4.0 want to optimize access to existing testbeds for businesses, especially SMEs, and successively develop the infrastructure available in the testbeds with a comprehensive range of advisory and coordination services.[37]

- *Digital Innovation Hubs (European Union):* Digital Innovation Hubs are one-stop-shops resulting from a regional multi-partner cooperation (including universities, industry associations, chambers of commerce, incubator/accelerators, regional development agencies and even governments) that help companies become more competitive regarding their business/production processes, products or services using digital technologies. They provide access to the latest knowledge, expertise and technology to support their customers with piloting, testing and experimenting with digital innovations. The hubs also provide business and financing support to implement these innovations, if needed across the value chain. They act as a first regional point of contact, a doorway, and strengthen the innovation ecosystem. A catalogue was set up to provide a comprehensive picture of the hubs in the EU across varying competences, structures and service offerings.[38]

- *IoT Acceleration Lab (Japan):* Under the IoT Acceleration Consortium, the lab has accelerated local networking, intelligence sharing and business matching for collaborative IoT, Big Data and AI projects. The IoT Acceleration Local Lab is organized by municipality or local business association and consists of local SMEs, start-ups, academia and investors. As of 2019, 101 labs have been identified and supported by METI.[39]

Appendix 2 - Prototype details

This section provides details on the main challenges addressed in the prototype, a summary of the findings from the maturity assessment model and the selected use cases. For more information, access: www.ipt.br/wef_iiot_

Maturity Assessment Model: The business maturity framework assesses six important dimensions that impact the adoption of IIoT. Preliminary observations were drawn throughout the consulting process conducted by IPT, ITA and Deloitte.

Organization: Identification and alignment of IIoT functions to business strategy and prioritization of investments. How do we deploy IIoT to our organization?

Leadership of the SMEs were aware of the importance of implementing IIoT technologies and processes (identifying the problem and designing the implementation seemed more problematic).

SMEs that have good proximity with industry associations showed higher level of IIoT awareness.

All SMEs were planning to invest in IIoT initiatives in the short term with rapid payback.

Most SMEs still lack the knowledge and resources to define the value of IIoT implementation and to start an IIoT transformation roadmap.

People: Attracting, retaining, structuring and communicating to a digital organization. How do we hire, retain, communicate and organize our IIoT talent?

Only one SME had a dedicated team for IIoT initiatives, the others have only an executive champion supported by one or more technical personnel.

SMEs did not know the necessary roles and skills needed for IIoT.

SMEs did not have training programmes for IIoT capabilities, apart from the IT teams.

Data: Management and delivery of the data necessary to enable digital transformation. What data do we need? How do we catalogue, manage and organize our data assets?

All SMEs had low maturity regarding data-driven culture and still did not know how to leverage data to get insights and drive value.

Only one SME showed the capability to collect and store production data from machines, lines and manufacturing cells in a consistent way, but still was not able to leverage the data to drive value.

All the other SMEs still collected most data manually with an operator writing down reports and appointments on paper; they also stored on paper or digitalized on crude databases like excel sheets.

None of the SMEs have shown advanced analytics capabilities.

Operations: An end-to-end operational model that builds upon latest technology and the seamless integration of IT and OT. How well can you track and trace your products along the entire value chain?

All SMEs have ERP systems, but only three have a MES system.

SMEs with higher lean manufacturing maturity showed better capability to start IIoT initiatives.

Only two SMEs show beginner level maturity on lean manufacturing.

All SMEs have certified quality needed for their sector. Only one is trying to improve their processes to get another certification to be able to reach more markets and provide another services or products.

Technology: Delivery of digital process solutions using tools and technologies. What technologies and tools do we need to support our IIoT capability?

Apart from sensorization and data collection, none of the SMEs have implemented IIoT solutions consistently in the factory.

Two SMEs were evaluating the possibility to use RFID for tracking products and materials in the factory.

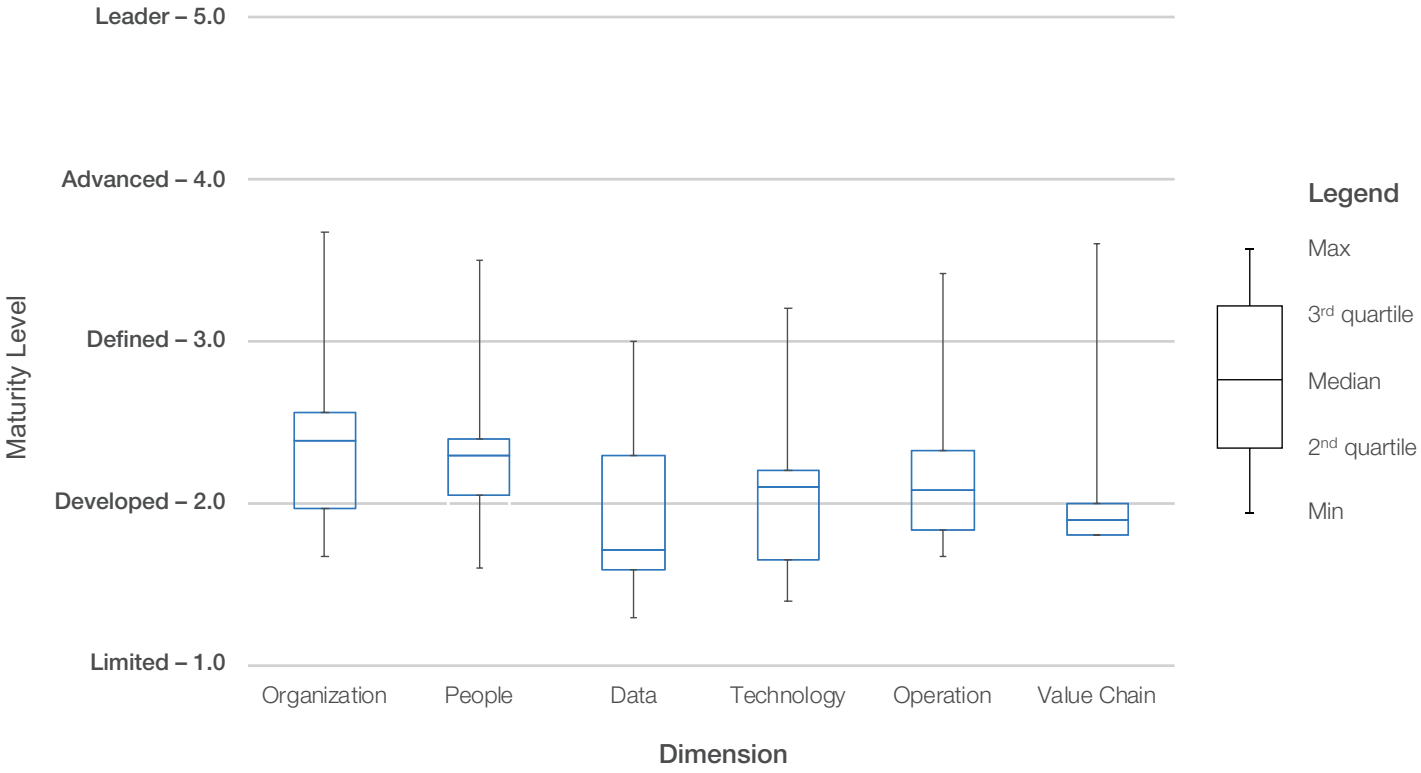
None of the SMEs are using cloud-based solutions consistently.

Value chain: Execution of analysis-based decisions and governance of business processes and controls. Which processes and controls should be part of an agile network supporting the organization's digital business?

Only three SMEs are effectively interconnected with the external stakeholders, most are in the Tier 2, 3 or 4 in their value chain.

Most SMEs have difficulty to interconnect systems with the stakeholders because their clients are too large to accept sharing data and/or their suppliers are too small to be able to implement the technology needed.

The Maturity Assessment Questionnaire was applied in 10 companies (six automotive and four Aerospace companies). At least two visits were made to each of the companies to meet the requirements of each dimension in the most reliable and applicable way. There are five maturity levels – limited (1), developed (2), defined (3), advanced (4) and leader (5) – where each company can be framed considering each dimension, i.e. the firm's maturity level is based on a weighted average of each of the dimensions analysed. The following chart presents the company's results for each dimension:



Use case definitions: Subsequent to the maturity assessment, specific IIoT adoption objectives and use cases were discussed with prototype companies. IIoT use cases were prioritized based on the following boundary conditions: financial return for the company, technology readiness of the solution and potential scalability to different sectors of the company.

Asset tracking (tools and products)

The operator can monitor where the asset is, if it is available, being used and in which stage of the process. Depending on the process type, it also can be applied to automatically define some parameters when the product reaches a defined process stage. In some cases, it can be used to know exactly how long each process step takes. In general cases, the company can reduce the time of searching items, consequently increasing its efficiency.

Sensing (equipment and machinery)

Use of sensors to acquire, store and process equipment/machinery data, providing reports and digital information, such as production cycle, if the machine is stopped and why it stopped, quantity of parts produced. In general, the companies need more precise data from the process to help in the decision-making process regarding production set-up. The data acquired from the machinery also will help in the predictive maintenance.

Quality inspection via computational vision

The digital system must identify quality if the parts are in the defined quality range for different aspects. It is expected to increase the productivity by doing the inspection during the process, reducing the stop-time for manual inspection and human inspection errors. It also can enable a quickly and automatically inspection of the product quality.

Process scanning (paperless)

Replacing printed documents through process scanning, reducing or eliminating paper in production process. It can be applied for check sheet, instruction procedures or maintenance solicitations. Companies can make the instruction accurate and reduce the time of paperwork.

Machine learning (production process optimization)

Use of artificial intelligence to enable optimization of the production process based on analysis of historical data. It also can be applied for automatically configuring the process, such as temperature or production set-up. By using these smart decision-making processes, companies aim to increase process efficiency.

Telemetry and power consumption analysis

Use case to raise data for management of electric power consumption and issue reports. It is intended to evaluate possibilities for energy cost reduction mainly based on the information provided by the system. It is also intended to verify the energy quality and if the contracted demand is adequate.

Appendix 3 – Open source documents

This section list the tools and documents produced during the prototype phase of the project. All the material is available to SMEs and policy-makers. For more information, access: www.ipt.br/wef_iiot.

Name	Description
Design toolkit	A walk-through manual to help organizations design and execute workshop sessions to develop human-centric public policies.
Maturity assessment questionnaire	Self-assessment tool designed to provide SMEs with an understanding of their company's position regarding IIoT and 4.0 technologies along six dimensions (organization, people, data, operations, technology and value chain).
Use case catalogue	Initial set of IIoT used cases implemented in the prototype, describing their ROI and KPIs, operating model aspects, requirements within the IIoT value loop and main stakeholders.
Procurement toolkit	IIoT procurement guidelines and best practices aiming at reducing the information asymmetry between SMEs, tech providers and vendors.
KPIs and economic impact methodology	Methodology accessible for SMEs to measure the impact and value of the IIoT implementation.
Operating model change methodology	A framework for an organization to align itself with the overall business strategy and goals, outlining the governance structure and how it functions as an entity.

Appendix 4 – Acknowledgements: Brazil Prototype Working Group

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