James Martin Institute for Public Policy

Policy Insights Paper

Recharging SME manufacturing in NSW

Opportunities for government to boost adoption of Industry 4.0 technologies

Associate Professor Dilupa Nakandala

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About the author

Dr Dilupa Nakandala is an Associate Professor of Management and Associate Dean-Graduate Studies at the School of Business, Western Sydney University (WSU). This Policy Insights Paper was produced as part of her JMI Policy Fellowship.

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For further information, contact D.Nakandala@westernsydney.edu.au

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Executive summary

The Australian economy faces a productivity slowdown. In recent decades, productivity growth has diminished and domestic manufacturing has declined.

In response to these trends, the NSW Government has announced plans to develop a new Industry Policy and an Innovation Blueprint led by the NSW Minister for Industry and Trade's vision – with manufacturing as a key enabler for increasing productivity and economic resilience. A Minister for Domestic Manufacturing and Government Procurement has been appointed to drive the return to domestic manufacturing within the state.

At the Commonwealth Government level, the Albanese Government has committed to a Future Made in Australia Act, which aims to bring together a package of new and existing initiatives to boost investment, create jobs, and seize economic opportunities. [1]

Small and medium enterprises (SMEs) are critical to the manufacturing landscape of NSW and vital to its economic renewal. In 2021-22, 30 per cent of Australia's total manufacturing income was from NSW, and NSW-based manufacturers employed nearly 30 per cent of Australia's manufacturing labour.[2] Much of Australia and NSW's manufacturing industry is dominated by SMEs with few large firms.[3]

Industry 4.0 technologies offer manufacturing SMEs the chance to improve performance and become more efficient, resilient, and sustainable. Industry 4.0 is the name used for the 'fourth industrial revolution' and refers to the digitalisation of manufacturing industry technologies and processes.[4] Despite the widely acknowledged benefits of such technologies, manufacturing SMEs have been slow to adopt them due to a range of factors. This represents a missed opportunity. There is an urgent need to advance technology adoption in manufacturing SMEs. This will benefit individual firms and the wider NSW and Australian economy.

Improving the performance of manufacturing SMEs could result in economic benefits, and increased resilience and sustainability. The adoption of advanced technologies by manufacturing SMEs would also improve their image and their ability to attract technology-savvy youth in response to skills shortages. The adoption of Industry 4.0 technologies has the potential to boost operations and supply chain resilience in volatile and uncertain

environments and support the development and implementation of circular economy strategies to achieve Net Zero environmental performance.

There are a range of organisational capabilities that support the adoption of Industry 4.0 technologies, but SMEs face challenges linked to these. These challenges include specific leadership capabilities, people, skills and experience, financial capability, and innovation capability. This has contributed to a significant digital readiness gap between large and small firms. From a resource perspective, the lack of financial resources, in-house digital expertise and time constraints limit managerial capabilities to drive digital transformation. SME managers need to develop more confidence in the benefits of advanced digital technologies for their operations.

> *Despite the widely acknowledged benefits of [advanced] technologies, manufacturing SMEs have been slow to adopt them due to a range of factors. This represents a missed opportunity.*

Technology adoption decisions are complicated by the diversity of manufacturing SMEs and off-the-shelf products that may not meet the requirements of an individual firm. This diversity is characterised by a mix of ownership and organisational structures and varying relationships with stakeholders, as well as low standardisation in SME operations, processes, and technologies. SMEs are disadvantaged in bargaining with technology suppliers and in their ability to invest in technology due to their comparatively small product volumes and market demand.

For NSW and Australia to reap the potential economic benefits and innovation that SMEs could leverage, action is required to address the lag in technology adoption and to support manufacturing SMEs to develop the capabilities to embrace Industry 4.0 technologies.

This report identifies opportunities for NSW Government action that could increase the adoption of Industry 4.0 technologies and generate state-wide productivity gains. It is based on emerging research and a review of existing research studies. The actions proposed aim to:

- improve perceptions of the benefits of Industry 4.0 technologies in manufacturing SMEs;
- provide greater, customised, end-to-end support for manufacturing SMEs to adopt Industry 4.0 technologies;
- facilitate the sharing of Industry 4.0 technological expertise across the manufacturing business community in NSW; and
- increase the accessibility of Industry 4.0 technologies to manufacturing SMEs.

The success of these initiatives will depend on effective collaboration and partnerships between different actors within the NSW manufacturing ecosystem, including the NSW Government particularly Investment NSW, alongside councils, SMEs and large manufacturing firms and their networks, higher education and vocational education institutes, financial institutions, and technology providers.

Policy opportunities

1) Establish a "NSW-SME-Centric Manufacturing Technology Centre" for tailored demonstrations of SME-specific technologies

A Technology Centre could be established to improve SMEs' confidence, knowledge, and perceptions of advanced manufacturing front-end technologies and their usefulness. This Centre could work with local government areas with a high density of SME manufacturing or high-tech industries with SMEs that have a strong growth appetite. SME networks/associations, councils, and vocational and higher education institutes could help share knowledge and build networks among SMEs. This could also have other benefits, including fostering young people's' interest in manufacturing SMEs as desirable, innovative workplaces.

2) Provide a technology advisory program for SME's spanning technology selection to implementation

A technology advisory program could provide unbiased technology specialists to guide SMEs in a way that is responsive to the diversity of SME operations, technology readiness, and firm-specific requirements. To maximise impact, onsite support should be prioritised. Vocational and higher education institutes could provide technology specialist services alongside industry experts with corresponding toolkits to help SMEs with technology selection and implementation.

3) Enhance knowledge exchange through an industry secondment program

An industry secondment program would support cooperation and knowledge exchange, enabling technology experts from large firms with experience of technology implementation to work with SMEs to assess where technology could be better leveraged, or upgraded, to maximise the growth and scalability of the business.

This could help strengthen SMEs' participation in local and global value chains and benefit large firms with a strong local supply base. In addition, it could be a valuable professional development opportunity for the individuals involved. The NSW Government could partner with relevant industries to co-fund or facilitate a pilot industry sabbatical program to share expertise on Industry 4.0 technologies between large firms and SMEs.

4) Introduce a technology leasing program for increased technology accessibility by eligible SME manufacturers

SMEs' reluctance to invest in advanced technologies is often due to financial risk aversion, a situation exacerbated by COVID-19. A technology leasing program supported by the NSW Government, complemented by a lease guarantee scheme, would encourage wider adoption. This program could be an extended service linked to the proposed Technology Centre. The success of this scheme would require the active participation of financial institutions, technology providers and independent technology advisors.

Introduction

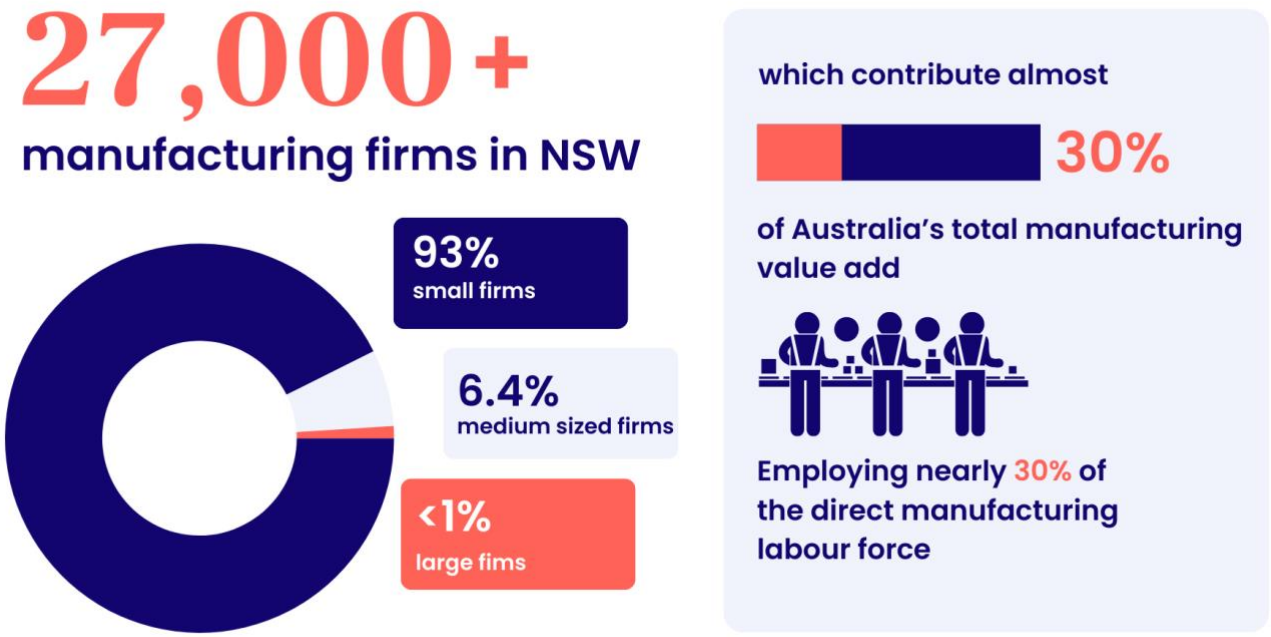
The Australian economy faces a productivity slowdown.

The 2023 Intergenerational Report projected slow growth of the Australian economy, predicting real GDP growth at an average of 2.2 per cent per year over the next 40 years compared to 3.1 per cent over the past 40 years.[5]

Manufacturing is a core industry for NSW and wider Australia so maximising the performance of the manufacturing sector is crucial for driving productivity and economic growth.

SMEs are the primary contributors to NSW manufacturing.[6] The NSW manufacturing industry comprises over 27,000 manufacturing firms[7] and contributes almost 30 per cent of Australia's total manufacturing value-add, employing nearly 30 per cent of the direct manufacturing labour force.[8] 93 per cent are small firms (< 20 employees), 6.4 per cent are medium-sized (20-199 employees), and the remainder (<1 per cent) are large firms.[9] Supporting manufacturing SMEs to be as successful and resilient as possible is key to driving improvements in manufacturing productivity.

Figure 1: Overview of SME Manufacturing in Australia



Within this overall productivity slowdown, the Australian manufacturing industry has demonstrated some resilience by reporting strong growth in performance in 2021-22 after a decline in 2019-20 during the pandemic. The value added to the manufacturing industry increased by 15.2 per cent from $108 billion in 2020-21 to $124 billion in 2021-22.[10] There is potential to build on this resilience and growth.

The Fourth Industrial Revolution, commonly referred to as Industry 4.0/Industrie 4.0/ Industrial Internet of Things (IIoT), is a digital transformation from technology-embedded systems such as computer numerical control machines and programmable logic controllers to cyber-physical systems such as autonomous manufacturing systems with the application of a range of digital technologies. Around the world, Industry 4.0 technologies have underpinned manufacturing industry advances.

These technologies embody digital and autonomous connections within and among firms, enabling efficient product and service delivery to consumers.[11] In the wake of the COVID-19 pandemic, many businesses have accelerated the adoption of Industry 4.0 technologies and, latterly, Industry 5.0 technologies, which extend to human centricity, resilience, and sustainability.

The NSW Chief Scientist's Research & Development (R&D) Roadmap highlights the state's competitive advantages in R&D-driven technology applications and emphasises the potential for NSW to increase productivity and develop more competitive products and services by harnessing new technologies.[12]

However, many firms in NSW – especially SMEs – have been slow to adopt Industry 4.0 technologies. Supporting manufacturing SMEs to effectively harness advanced technology offers a significant opportunity to drive economic performance and boost productivity across the state. This, in turn, will benefit the national economy.

The productivity challenges faced by the NSW manufacturing industry are not new and successive governments have attempted to address them.

The current NSW Government has made rebuilding the state's manufacturing industry a key priority with a new ministerial portfolio focused explicitly on domestic manufacturing.[13] Key initiatives include a commitment to develop a new Industry Policy and an Innovation Blueprint, the Boosting Business Innovation Program[14] and the Net Zero Manufacturing Initiative.[15]

At the federal level, the Albanese Government's proposed Future Made in Australia Act seeks to allocate substantial investments in local manufacturing and presents a significant opportunity for local manufacturing capability development. Manufacturing SMEs play an integral role in supporting the Commonwealth Government's commitment to economic resilience, sovereignty, and growth.[16]

Australia has comparatively low R&D expenditure for an advanced economy and aspires to increase its investment in research to 3 per cent of GDP.[17] SMEs contribute significantly to innovation in Australia, as they spend 24 per cent more on R&D than large firms,[18] the largest differential in decades. Manufacturing SMEs are among the most likely to innovate.[19]

Previous government initiatives

Earlier government initiatives have also underlined the important role of the manufacturing industry and the potential for wider technology adoption.

The Australian Government's Reigniting Productivity Growth White Paper (2023) highlighted the potential to deliver productivity gains by "improving how our workforce makes use of new technology and machines, underscoring the potential for future gains from increased uptake and better use of new technologies."[20]

The 2022 Adaptive NSW report highlighted that NSW has a major opportunity to respond to productivity challenges by successfully encouraging sectors to widely adopt Industry 4.0 technologies.[21] The report concluded that that the broad adoption of Industry 4.0 technology by firms would increase the state's productivity growth from 1.2 per cent to 2.0 per cent per year.

The 2022 Making it in NSW report from the NSW Modern Manufacturing Taskforce highlighted the importance of collaboration, coordination, and promotion in driving manufacturing growth in NSW and the Advanced Manufacturing Research Facility (AMRF) as an enabler of the manufacturing industry to foster deeper collaboration between researchers and manufacturers.[22]

The 2018 NSW Advanced Manufacturing Industry Development Strategy identified that SMEs that have the potential to quickly engage with technology will also play an important role in driving the adoption of advanced manufacturing processes.[23]

Other government programs have focused on supporting SMEs' digital capacity and capability development. Examples include the "Empowering Business to Go Digital" program 2019-2022, which implemented the recommendations of the Small Business Digital Taskforce report.[24]

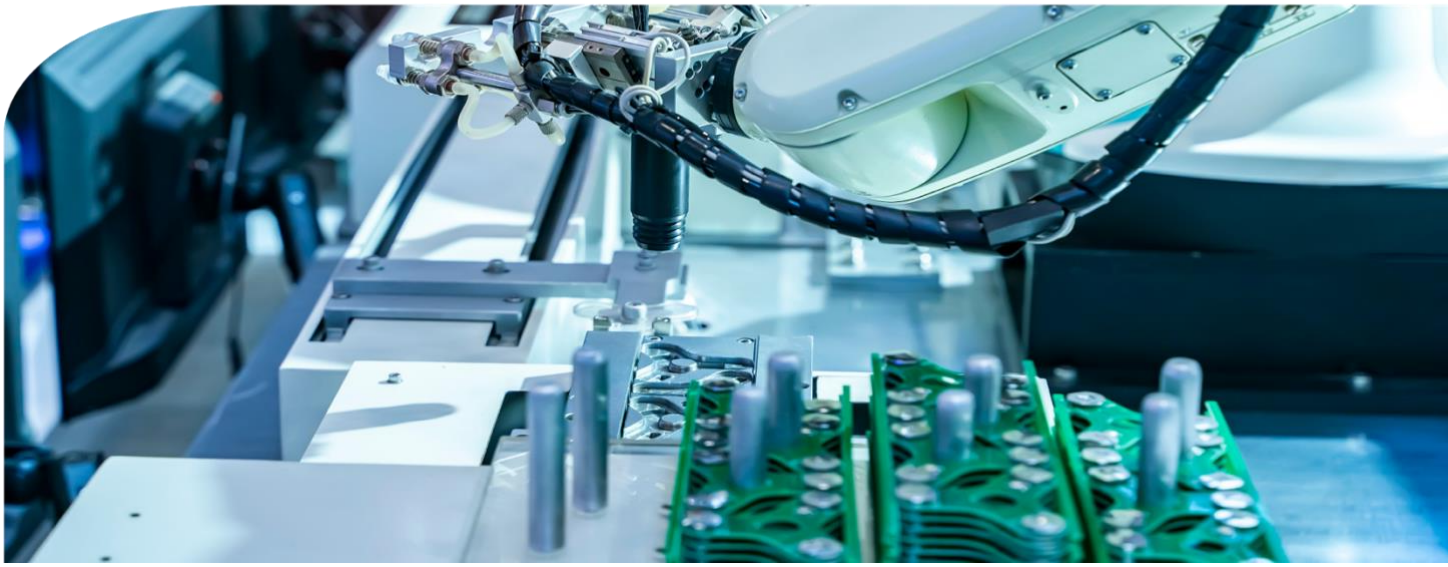
Australia is not alone in facing slowing productivity. Many developed economies have experienced similar trends in recent years and initiatives overseas may offer useful insights for the NSW Government. Increased productivity in R&D-driven innovations, innovation commercialisation and adoption and diffusion remain the focus of innovation agencies such as Fraunhofer in Germany,[25] Innovate UK,[26] and the Catapults network in the UK,[27] the National Science Foundation (NSF) in the US,[28] and VINNOVA in Sweden.[29] The NSF Regional Innovation Engines promote place-based R&D in key tech areas.[30] The UK's High Value Manufacturing Catapult focuses on upskilling and reskilling the manufacturing workforce in priority areas, and the Digital Catapult focuses on innovations in emerging technologies in priority sectors.[31] In the Dutch Smart Industry Field Labs, innovative smart industry solutions are produced mainly using technologies at different technology readiness levels (TRL).[32]

Figure 2: Global Technology Adoption and Digital Transition for Productivity Growth

Many developed economies have focused explicitly on technology adoption and digital transition for productivity growth. For example, Germany's Industrie 4.0 platform highlights initiatives such as the *Mittelstand* 4.0 Centres of Excellence which are responsive to the technology adoption needs of SMEs.[33] Canada recently announced funding commitments to develop AI capabilities and infrastructure and support AI adoption through the AI Compute Access Fund.[34] The US state of Michigan has the Industry 4.0 Technology Implementation Grant, which promotes the adoption of transformative technologies such as AI, additive manufacturing and advanced materials and robotics,[35] and the Massachusetts Manufacturing Accelerate Program assists SME manufacturers to progress towards Industry 4.0.[36] The Made Smarter program in the UK targeted manufacturers and supported them to adopt digital tools to improve their operations. This program achieved particular success in the Liverpool region of the UK's North West.[37]

This report comes at a critical time and identifies opportunities for NSW Government action to improve productivity by boosting technology adoption by manufacturing SMEs. It aligns with the emerging shift in global value chains applying reshoring and nearshoring strategies after the pandemic,[38] with the aspirations of the Albanese Government's Future Made in Australia Act,[39] and with the NSW Government's commitment to support an NSW innovation and technology ecosystem.[40]

The paper is informed by research studies based on primary data collected from domestic firms, published research as well as consultation with several industry, government, and academic stakeholders who have contributed to efforts to strengthen manufacturing in NSW. This paper is not an analysis or assessment of previous policies and initiatives, but instead highlights the policy opportunities that could be seized today to stimulate productivity through the adoption of Industry 4.0 technology by manufacturing SMEs.



Leveraging technology to boost productivity and other performance benefits

The benefits of Industry 4.0 technologies are multifaceted and include operational efficiencies, supply chain resilience, and sustainable business practices which all contribute to firms' increased competitiveness.[41] The 2022 Adaptive NSW report highlights that broad adoption of Industry 4.0 technologies has the potential to increase the state's productivity growth from 1.2 per cent to 2.0 per cent per year.[42]

Technologies like robotics, autonomous mobile robots, infrared technology, machine-to-machine communication, and the Industrial Internet of Things have revolutionised operations through mass product customisation, predictive maintenance of machinery and systems, real-time monitoring of operations to minimise plant downtime, and data-driven decisions.[43]

Technological capabilities improve process optimisation, proactivity, and real-time responses, thereby enhancing efficiency, agility, resilience, and reliability.[44] Moreover, when Industry 4.0 technologies are integrated, they play a crucial role in promoting circular economy practices, monitoring product life cycles, and optimising natural resource utilisation to improve sustainability performance.[45]

Industry 4.0 technologies also bring other sustainability and resilience benefits. For instance, 3D printing and Internet of Things solutions contribute to material efficiency and waste reduction. AI and digital twins[46] boost organisational resilience through predictive analytics and scenario planning.[47] The positive effects of Industry 4.0 technology adoption on the resilience of Australian manufacturing firms, in their operations and value chains, are now increasingly accepted.[48]

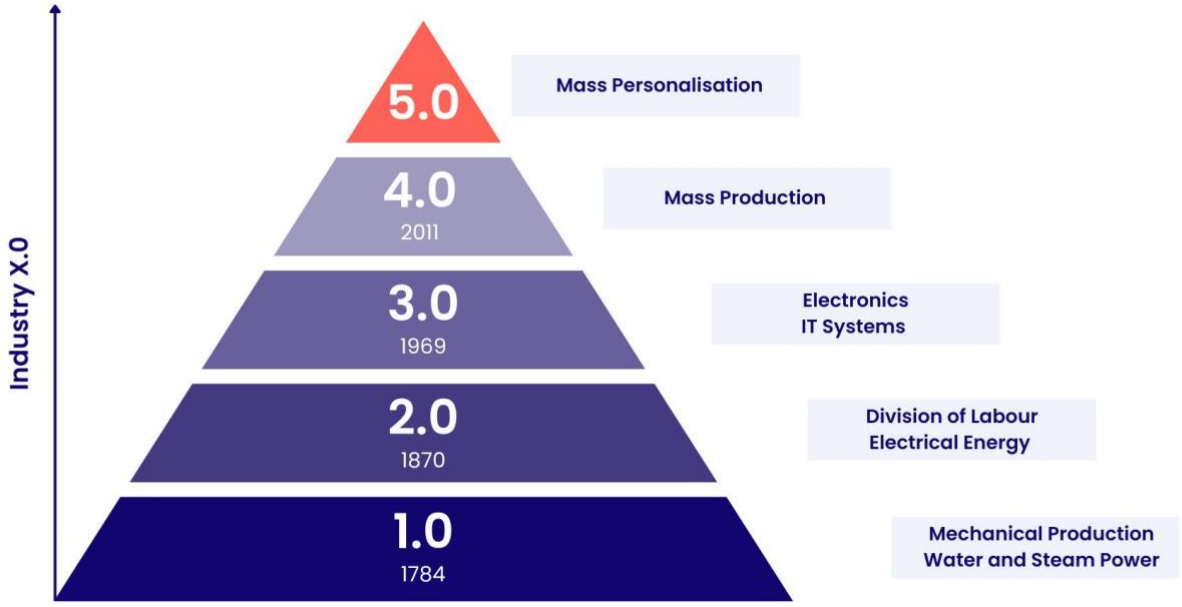
Technology is constantly evolving, providing multiple opportunities for firms. Industry 4.0 marks a significant evolution from automation in the third industrial revolution to the integration of cyber-physical systems. The digital transformation of manufacturing processes has been facilitated by the Internet of Things, with the emergence of cutting-edge technologies such as 3D printing, artificial intelligence (AI), advanced robotics, autonomous systems, and big data analytics.

Despite the gradual and slow adoption of Industry 4.0 technologies, particularly among SMEs, the European Commission has already announced Industry 5.0 as a transition from the perceived technology-centric approach of Industry 4.0 to a value-driven model, focusing on social and environmental objectives.[49]

The human-centric approach in Industry 5.0 has catalysed the adoption of technologies that augment human capabilities in the workplace. For example, collaborative robotics (cobots), wearable technologies, and augmented reality devices are increasingly used to enhance worker safety, efficiency, and wellbeing.[50]

With technology constantly evolving, manufacturing SMEs will continue to require the right capabilities to harness technological advances beyond Industry 4.0. The following section will explore the capabilities required and analyse the current capability gaps in manufacturing SMEs.

Figure 3: The evolution of Industry 1.0 to Industry 5.0



Source: Maddikunta et al. (2022)[51]

Capabilities for technology adoption

Research has shown that successful technology adoption by manufacturing SMEs requires certain capabilities (see Figure 4). This section explores the capabilities that will enable manufacturing SMEs in NSW to harness the benefits of Industry 4.0 technologies. It also highlights where existing capabilities are falling short due to challenges faced by SME manufacturers. These shortfalls offer an opportunity for NSW Government action to support manufacturing SMEs in harnessing Industry 4.0 technologies more effectively.

SMEs lag significantly behind large firms in adopting advanced technologies, including the Internet of Things, virtual reality and AI.[52] Only 33.2 per cent of Australian manufacturing firms have adopted ICT for production/ service operations and only 25.6 per cent for stock control activities.[53] The adoption rates for advanced technologies were even lower in other areas: virtual reality (1 per cent), data analytics (3.8 per cent), Internet of Things (9.2 per cent), AI (1.5 per cent), and blockchain technology (0 per cent).[54]

Recent studies show that larger Australian firms were more digitally ready than smaller firms[55] and that manufacturing firms had older front-end manufacturing technology implementations and lagged in the implementation of advanced manufacturing front-end technology.[56] The widening technology gap between frontier firms and others[57] demonstrates the need for a technology boost for SME manufacturers.

With technology continuing to advance at pace, further delays in responding to the technology gap between manufacturing SMEs and front runners will further hamper manufacturing SMEs in NSW. NSW Government action to support manufacturing SMEs to develop the capabilities necessary for successful technology adoption could help reduce this technology gap and drive manufacturing productivity across the state.

Organisational capabilities for technology adoption

Manufacturing SMEs require a range of capabilities to adopt advanced technologies successfully. Industry 4.0 technologies demand higher capabilities and skills than conventional manufacturing. They require a reassessment of organisational structures and leadership, strategic capabilities, stakeholder relationships, innovation capabilities and culture, processes, and skills.

Figure 4 highlights a unified framework of organisational capabilities derived from a detailed literature review.[58] A range of capabilities, including technological, strategic, innovation, networking, cultural, leadership, financial resources, and people and skills, are identified together. Despite the rapid pace of technological advances, emerging research indicates the capabilities outlined in Figure 4 will continue to be critical during the transition to Industry 5.0 technologies.[59] Ensuring that manufacturing SMEs possess these capabilities will enable them to harness constantly evolving technologies.

Figure 4: Framework of Organisational Capabilities for Industry 4.0 Technology Adoption

Source: Nakandala et al. "Organisational Capabilities for Industry 4.0 Technology Adoption"[60]

Leadership capability

The degree to which managers understand advanced technologies and their benefits influences both their intention to adopt advanced technologies and their perception of the usefulness of Industry 4.0 technologies.

Managers' intentions to adopt advanced technologies and managers' perceived usefulness of Industry 4.0 technologies

Managers play a strategic role in the adoption and implementation of technology. In the modern business environment, it is increasingly recognised that technological competency extends beyond information technology and engineering managers, encompassing all managerial roles within organisations.[61]

Emerging research in Australia underscores the significant and positive impact of managers' digital expertise on their intention to adopt Industry 4.0 technologies.

Research also suggests that the perceived usefulness of these technologies plays a role in mediating the relationship between managers' digital expertise and their intention to adopt that technology.[62]

The significance of digital expertise among managers in technology adoption is well-established, particularly in enhancing their awareness of the potential advantages offered by new technological solutions.[63] Several recent studies have demonstrated the impact of perceived usefulness in contexts ranging from the adoption of big data analytics to the implementation of 3D modelling.[64]

It is therefore crucial that managers in manufacturing SMEs understand how advanced technology can support their organisations. The NSW Government has an opportunity to develop mechanisms to foster greater knowledge of technological solutions in manufacturing SMEs.

People, skills, and experience

The adoption of Industry 4.0 technologies requires the right skills to be in place, particularly digital expertise.

Digital expertise of managers

Managers with digital expertise have more awareness of the potential benefits of technologies, enhancing their intention to adopt technology.[65] Studies have shown that limited digital knowledge and expertise at the managerial level contributes to a low number of digital implementations.[66] Furthermore, high digital expertise in managers increases their confidence in addressing issues that arise during the digitisation process and reduces the uncertainty that could lead to managers being sceptical of technology.[67]

The potential benefits of technology cannot be fully perceived when managers lack digital knowledge and expertise.[68] For example, despite the massive benefits identified for AI systems in business organisations, their adoption has been slow due to limited expertise at the managerial level.[69]

The digital expertise of managers significantly influences their perception of the potential benefits of these technologies, thereby enhancing their inclination towards technology adoption.[70] Conversely, the lack of digital knowledge and expertise among managers is a key factor in the limited adoption of technology in organisations.[71] Research highlights the need for policies and strategies that foster digital expertise and positive perceptions of technology among managers, thereby facilitating the effective integration of Industry 4.0 technologies in organisations.

The lack of in-house technological skills, capabilities and expertise and the lack of in-house dedicated personnel and management expertise required to assess, acquire, implement, and maintain advanced technological solutions are holding back SMEs. This presents NSW Government with an opportunity to support SMEs to boost their in-house digital expertise.

Financial capability

SMEs have often been impeded from investing in and adopting advanced technologies due to a range of financial factors. These include:

- a lack of financial resources to invest in new technologies;
- difficulties in accessing credit;
- a perceived lack of market demand for products produced by advanced technologies;
- lack of scale (low production volumes) to recover technology investments; and
- low bargaining power with large technology suppliers.

There is a clear opportunity for NSW Government to develop financial support mechanisms that could facilitate access to advanced technologies for manufacturing SMEs.

Innovation capability

Research has shown that innovation capability is also critical to the successful adoption of advanced technologies.

Absorptive capacity

An important issue is the lack of absorptive capacity (AC) within SMEs to effectively integrate and leverage new technologies.[72] AC is the ability to recognise the value of, and then assimilate and apply, new knowledge and technologies.[73]

Limited AC affects the immediate implementation of such technologies and hinders the long-term benefits that could be derived from technological acquisitions. It is important that policymakers and industry stakeholders recognise and address this challenge. Targeted strategies and support mechanisms are needed to address the unique constraints of SMEs and

enhance their capacity to acquire, assimilate, and utilise advanced technologies. An organisation's prior knowledge is vital to its absorptive capacity development, where those with R&D capabilities surpass others, such as SMEs.[74]

SMEs can harness their external networks to gain exposure to new technologies and their benefits and challenges, as well as share their experiences.[75] Research on Australian small firms has reported that vertical networks - with suppliers and customers - and horizontal knowledge networks - with universities and other knowledge partners – can support the development of absorptive capacity but have differential effects on exploratory and exploitative innovation.[76] Hence, SMEs operating in a dynamic technology and innovation ecosystem with diverse networks are better positioned to benefit from technology revolutions.

NSW Government support for SMEs to improve their absorptive capacity and develop diverse networks could positively impact their ability to leverage new technologies and drive productivity gains.

Dynamic capabilities

Dynamic capabilities play an important role in achieving performance improvement through technology implementations. They focus on the capacity to sense and seize opportunities in a dynamic environment and sustain competitiveness by reconfiguring internal and external resources and competencies.[77] The possession of resources and operational capabilities is insufficient for firms to survive when the environment is rapidly changing. Firms need to develop capabilities that enable them to respond effectively to changing environments.

Research shows that dynamic capabilities mediate the impacts of Industry 4.0 on the competitive performance of manufacturing firms.[78] While the primary focus of implementing Industry 4.0 technologies is to improve productivity, resilience, and sustainability, technologies such as big data analytics, AI, the Industrial Internet of Things, and digital twins enable digital dynamic capabilities for sustaining competitiveness. In 2023, Australian manufacturing firms reported weak average dynamic capability scores.[79] There is an opportunity for the NSW Government to enable SMEs to develop and expand their dynamic capabilities that, in turn, could enhance their ability to leverage new technologies.

Strategic capability

Research indicates that lean processes can lead to increased benefits from digital investments.

Harnessing lean, agile and learning capabilities for technology adoption

Lean and agile practices enable advanced technology implementations. Lean manufacturing and agile practices, as well as the hybrid implementation of "leagile" strategies, are critical for manufacturing firms. The digitalisation of lean processes with minimum waste and maximum efficiency leads to higher benefits of digital investments.[80] Integrating lean and agile practices is a strategic way for firms to be efficient and flexible.[81]

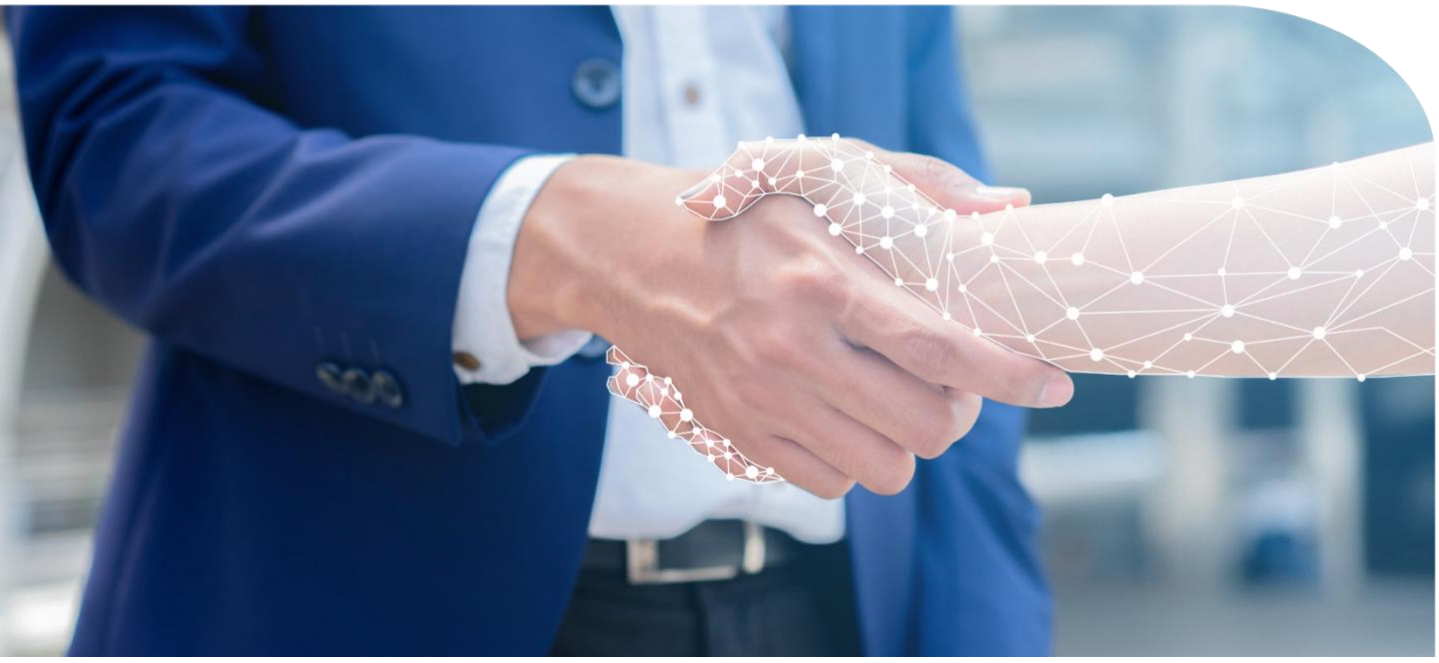
Lean methods streamline production processes and reduce costs, while agility enables firms to be responsive and adaptable to market changes. This combination is increasingly regarded as a key driver for competitiveness and success in the manufacturing sector.

Emerging research provides empirical evidence of the effect of lean practices on Industry 4.0 adoptions in Australian firms. It reports significant direct effects on Industry 4.0 adoptions and indirect effects through exploitative learning practices.[82] It also shows that exploitative learning fully mediates the relationship between agile practices and Industry 4.0 adoptions. However, the effects of exploratory learning on Industry 4.0 adoption are not empirically confirmed.[83]

The combination of agility, lean and exploitative learning for positive technology adoption indicates that firms capable of leveraging their existing capabilities and responding to consumer needs in an agile way are more likely to implement advanced technologies.

Manufacturing SMEs can lack the assessment tools to conduct cost versus benefit analyses before new technology investments. They can also lack the tools for road mapping technology implementations to maximise the benefits to their own operations.

NSW Government support to enable manufacturing SMEs to adopt lean and agile approaches would be of benefit.



Technological capability

Within SMEs, existing technological capability has impeded the adoption of more advanced technologies. Contributing factors include:

- The possession of a mix of technology levels and less advanced shop floor equipment;
- Low standardisation in current SME manufacturing operations; and
- Lack of knowledge of the suitability of ready-made digital technology solutions and lack of implementation roadmaps to apply to their own operations.

The capability challenge

The disparity in the adoption of advanced technologies among manufacturing firms is clear. A significant digital readiness gap exists between larger and smaller Australian firms, particularly in the context of Industry 4.0 supply chain technologies.[84] This discrepancy underscores the challenges faced by smaller firms in embracing digital transformation.

Industry 4.0 technologies are characterised by a significant degree of variety, which in turn influences the diverse factors affecting their adoption. This is mirrored in the SME sector, where differences in strategic goals, operations, technology levels, and resource availability, including in-house skills, are prevalent. Despite this, research has identified a range of capability challenges that SMEs face in adopting advanced technologies. These challenges are not novel but have persisted over time, impeding the technological advancement of SMEs.[85]

While specific technological needs may vary depending on a firm's operational context, there is a general lag in the adoption of emerging, advanced technologies. SMEs face a significant digital readiness gap, largely due to a lack of resources, including in-house expertise in Industry 4.0 technologies. This is compounded by uncertainties about the applicability of off-the-shelf digital solutions and limited managerial perceptions of the benefits of Industry 4.0 technologies, where digital expertise is often lacking.

Together, these challenges hinder the effective adoption of advanced technologies, underscoring the need for more focused support from the NSW Government to bridge these gaps. Such support initiatives are essential to ensure a more inclusive and comprehensive adoption of Industry 4.0 technologies, thereby enhancing the overall competitiveness and efficiency of NSW's manufacturing sector.

Design principles for policymakers

There are a range of opportunities for NSW Government action to increase the adoption of Industry 4.0 technologies by manufacturing SMEs. The following design principles have guided the opportunities presented in the next section.

Enhancing SME confidence in technology: Demonstrating the potential impact of advanced manufacturing technologies on productivity, resilience, and sustainability, will bolster SME confidence in advanced technologies and increase their intention to adopt them.

Targeted engagement with SMEs: Acknowledging that SMEs are time-poor and challenged by day-to-day operational demands, it is important to invest in support mechanisms that provide on-site assistance to SMEs. This targeted support will increase their willingness to adopt Industry 4.0 technologies.

Fostering trust across the sector: Building trust between technology providers and SME manufacturing firms through neutral intermediaries will enhance SME participation through a cooperative approach.

Recognising SME differences: It is important that initiatives to increase the adoption of Industry 4.0 technologies recognise the differences between SMEs. These differences include their technology levels, growth aspirations and the relative benefits a specific technology might bring to their operations.

Employing a mix of policy instruments: Identifying a range of opportunities to drive technology adoption will give the best chance of achieving a substantial increase in the uptake of advanced technologies by NSW manufacturing SMEs. In turn, this will increase productivity, resilience, and sustainability.

A location-based approach: Following a phased approach, an initial focus on LGAs with a high density of manufacturing SMEs will increase resource efficiency and development of local technology ecosystems.

Opportunities for NSW Government action

Using the design principles outlined in the previous section, four opportunities for NSW Government action have been identified. These are explored below.

1. Establish a "NSW SME-Centric Manufacturing Technology Centre" for tailored demonstrations of SME-specific technologies.

Change of perceptions: Research shows that managerial perceptions are a significant factor influencing decisions to adopt advanced technologies. To change SME managers' perceptions of advanced technologies, it is important to demonstrate advanced emerging technologies in a setting that represents SME environments and provides opportunities to receive hands-on experience and training. This will enhance awareness and confidence in the appropriateness and usability of such technologies for SMEs.

Strong SME Focus: Even though a NSW Manufacturing SME-Centric Technology Centre can benefit all types of firms irrespective of their size or capabilities, an SME-focused hub with affordable, accessible technologies that can be implemented in SME settings, with limited space and resources, will increase confidence. For example, industrial robots require extensive resources like dedicated floor space, safety fencing, etc. and are more suited to large operations. Cobots could be more suitable for SMEs with higher affordability and human interaction ability. Demonstrating general and specific technologies for selected industries will achieve a more efficient and targeted response.

Co-design and Inclusiveness: Co-designing and co-creating the Technology Centre in partnership with a diverse range of NSW SME manufacturers, especially those seeking to expand and scale, will enhance their involvement and participation in the Technology Centre. Previous programs have often reported low adoption by intended participants, even with a significant number of marketing campaigns. Involving SME manufacturers in the design process will encourage their continued participation.

NSW could also build on international examples of SME-focused technology adoption hubs and platforms. For example, the Korean Technology and Information Promotion Agency for SMEs, established in January 2002, has a series of SME support programs, including a low-cost, high-efficiency cloud-based platform where SMEs can access various technological solutions for free.[86]

The proposed Centre could focus on the four technology areas of Digital, Materials and Chemistry, Biotechnology, and Energy as identified in the Chief Scientist's 2022 R&D Roadmap,[87] and which are identified in the NSW's Minister for Industry and Trade's upcoming NSW industry policy.[88] A similar approach is followed by the NSF's Regional Innovation Engines in the US, which have a place-based approach with a focus on key technology areas.[89]

Implementation of an SME-Centric Technology Centre will involve manufacturing SME associations, technology providers, vocational and tertiary institutes, and the councils of strategic locations where manufacturing SME density is high, such as Liverpool and Blacktown LGAs. The proposed centre would also complement the Advanced Manufacturing Research Facility (and associated hubs) by fostering new networks and connections between manufacturing SMEs, technology experts and knowledge partners in the technology ecosystem.

2. Develop a technology advisory program for SMEs spanning technology selection to implementation.

Localised solutions: Large differences exist between SMEs in terms of their strategic business needs, technology levels and technology mixes in their operations. These differences impede the adoption of off-the-shelf technologies . SMEs require customised guidance and advice on technology selection, evaluation, implementation and use that fits their needs. This underscores the need for more involved technology solutions. Localised solutions will enable SMEs to capitalise on effective practices to support their technology transition.

On-site support: Constant business challenges make SMEs time-poor, so providing on-site support for SMEs will enable them to access and benefit from the technology advisory program. A scheme that enables advisors to visit SME operations to develop solutions that suit their specific requirements would be beneficial.

End-to-end support: Given the complexity of adoption processes, it would be insufficient to simply provide SMEs with advice on suitable technologies. End-to-end support that covers technology selection to use after installation would maximise the benefits realised. Providing advisors with lean management training would support SMEs to develop lean and agile capabilities which can enhance technology implementation.

Unbiased and independent advisors: Given that most SMEs need more absorptive capacity for technology adoption, independent external advisors will be critical in building SME trust and confidence in the technology advisory program. There has been scepticism from SMEs on the involvement of consultants in providing guidance. Instead, government involvement and advisors from neutral organisations would be more suitable. Regular reporting to a higher authority would ensure accountability and transparency about what technology solutions have been recommended to SMEs.

There is scope for the NSW Government to learn from similar international programs. Liverpool City Region 4.0 (LCR4.0) in the UK provides a good example of a significant industry-engaged program for SMEs on innovation and technology adoption.[90] LCR4.0 was recognised UK-wide for best practice in 2017 and involved vocational and tertiary education institutes and independent consultants. It was launched with government backing in 2016

in Liverpool, in the UK's largest manufacturing region. The program has been successful, with active engagement by SMEs and the development of an ecosystem conducive to technological development. The pilot LCR4.0 program connected with 3,000 SMEs and collaborated with 600 SMEs. The program successfully engaged SMEs via on-site visits and early engagement with SME business managers with strategic responsibilities alongside technology managers.[91]

The proposed program could be an extension of the recent Boosting Business Innovation Program (BBIP) with a focus on pushing NSW manufacturing SMEs to the technology frontier.[92]

3. Enhance knowledge exchange through an industry secondment program

Technology diffusion through directed skill mobility: The lack of confidence and readiness of SMEs to adopt Industry 4.0 technologies are partly linked to their lack of skills, experience, and dedicated in-house personnel. The recent Microcredentials Pilot in Higher Education program has been utilised with some technology-related courses.[93] Additional support could boost the translation of SME practitioners' skills and knowledge from training programs to real-world application. For example, this can be achieved via access to external experts from large organisations with high technological expertise and technology management experience and no conflicting commercial interest in an individual SME's operation.

In the rapidly changing technological environment, access to external experts with exposure to advanced technologies can contribute to the development of dynamic capabilities within SMEs. Australian firms lack bandwidth beyond business as usual, which challenges their transformation.[94] Further, Australian SMEs need additional support to develop good management practices and behaviours, so external industry experts bring composite knowledge bases to drive advanced technology adoption and management in SMEs.[95]

The NSW Government could facilitate a new model for enabling industry expertise to be shared between firms which would benefit SMEs. Industry secondment or sabbatical systems are emerging and rapidly increasing.[96] An industry secondment program could lead to the temporary assignment of industry experts from large organisations into SMEs, facilitating knowledge transfer through a government-supported scheme.

In NSW, it could be an extension to the recent industry doctoral program funded by the federal government to include a paid secondment program for practitioners, with a focus on developing a technology and knowledge ecosystem with enhanced interactions between large organisations and local SMEs.

The proposed program would be a short-term assignment giving SMEs access to advanced technology adoption knowledge and skills, offering something different to the Australian Research Council's Linkage Projects scheme. Implementation of such a program would require the involvement of government agencies, SMEs, and large employers. The transfer of technological knowledge could bolster the number of manufacturing SMEs harnessing Industry 4.0 technologies.

4. Introduce a technology leasing program for increased technology accessibility by eligible SME manufacturers

Leasing schemes: There are already technology renting/leasing firms and those who provide technology as a service for SMEs in today's market.[97] While these schemes can reduce in-house infrastructure investment and allow the trialling of technologies, there are ongoing challenges with affordability and the lack of technical in-house expertise in implementing rented technology. Introducing a technology leasing scheme with government assistance will make it equitable and widely accessible to SMEs. A technology leasing scheme integrated into the services offered by the Technology Centre proposed earlier will allow participants to trial new technologies on-site with the assistance of advisors prior to making investment decisions.

Financial risk reduction: Lending to SMEs increased by 6 per cent nationally in 2022, and there was government support for some SMEs through the Australian Government's SME loan guarantee schemes until mid-2022. Difficulties in accessing loans through these schemes have been reported.[98]

A few government programs are ongoing, such as the Australian Business Securitisation Fund and the Australian Business Growth Fund. However, increased risk-averse behaviours after COVID-19 demand increased support for SMEs. A government-backed lease guarantee program and a technology leasing scheme would require the involvement of government agencies, technology providers and financial institutions, similar to the government's commitment to providing increased access to capital for innovation-focused SMEs.[99]

Seizing the productivity opportunity for NSW

This report highlights the potential of Industry 4.0 technologies to drive productivity gains across NSW. The policy opportunities identified will increase technology adoption by boosting SMEs' confidence and reducing the risks and uncertainties that have impeded technology adoption to date. The opportunities proposed are interconnected and could be operationalised sequentially through a cohesive strategy.

The successful implementation of these proposals requires an expansion of infrastructure support that is tailored to the requirements of manufacturing SMEs, alongside broad stakeholder engagement across government agencies, research institutions, large manufacturers, technology providers, financial institutions, and SME networks.

Such comprehensive buy-in will enable the significant potential of Industry 4.0 technologies to be realised in manufacturing SMEs across the state, bringing enduring productivity gains and widespread benefits to NSW and wider Australia.

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James Martin Institute for Public Policy

Transforming public policy

Level 1, 60 Martin Place
Sydney, NSW 2000 Australia

E info@jmi.org.au | **W** jmi.org.au