ORGANIZATIONAL LEADERSHIP

Strategic Engineering Leadership and Technology-Driven Organisational Transformation for Sustainable Industrial Growth in Australia

Hasan Aijaz

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Abstract

Australian industry faces a demanding combination of pressures: a manufacturing base dominated by smaller firms serving the domestic market, a resources sector confronting deeper and lower-grade deposits, rising expectations on carbon performance, and rapid advances in digital and automated production. Technology alone does not resolve these pressures; what matters is how leaders translate it into organisational change. This review examines how strategic and engineering leadership shape technology-driven organisational transformation and how that transformation can be directed towards sustainable industrial growth in Australia. Using a systematic integrative design, the review synthesised 30 peer-reviewed journal articles from 2020 to 2025, starting from an interview study of advanced Australian manufacturers implementing Industry 4.0 and a survey of innovation culture in Australian firms. Nine of the articles report Australian evidence. The synthesis indicates that Australian transformation is constrained less by access to technology than by the scale of firms, limited strategic framing and neglect of governance, standards and data protection. Leadership effects are specific rather than generic: executive experience and certain governance arrangements are associated with better carbon performance, entrepreneurial and ambidextrous behaviours matter more for transformation than broad leadership styles, and, in large listed firms, explicit top-level support is less common than the rhetoric of digitalisation suggests. Culture, dynamic capabilities, ambidextrous learning and workforce participation are the mechanisms through which leadership converts technology into resilience, innovation and sustainability. The paper proposes a three-tier leadership orchestration framework, a mechanism-to-action guide and a three-horizon transformation pathway, and sets out an agenda for research on Australian industrial leadership.

1 Introduction

Industrial transformation is usually described in terms of technologies: sensors, robotics, additive manufacturing, data platforms and artificial intelligence. Yet the same technologies produce very different results in different organisations. Some firms use them to redesign processes, products and business models; others install them and see little change. The difference lies largely in leadership, that is, in how senior executives frame the purpose of change, how engineering and technical leaders translate strategy into operational redesign, and how frontline leaders bring employees with them. The review by Stornelli et al. (2021) of advanced manufacturing technology adoption makes the point clearly: barriers and enablers operate at different stages of the adoption process, and their configuration is related to whether adoption yields product, process, service or business model innovation.

Australia offers a distinctive setting for this question. Its manufacturing sector is dominated by smaller firms that serve the domestic market and have limited budgets for technology and research

(Mason et al., 2022). Its mining industry must process lower-grade ore at greater depths under tighter social and environmental constraints, and increasingly looks to automation and information technology to do so (Jang and Topal, 2020). Research on its listed companies links executive characteristics and ownership to carbon performance and sustainability practices (Elsayih et al., 2021; Fernández-Méndez and Arrondo-García, 2021). A twenty-year scoping study of Australian manufacturing research identified digital transformation, sustainable service-integrated operations and the interplay between socio-economic characteristics and critical success factors as the main directions for future work (Tortorella et al., 2021). Each of these directions is, at heart, a leadership challenge.

Despite this, the literatures on leadership, digital transformation and industrial sustainability remain largely separate, and Australian evidence is scattered across sectors and disciplines. Leadership studies often test general styles such as transformational leadership without asking which behaviours matter at which stage of transformation. Digital transformation studies frequently treat leadership as one antecedent among many. Sustainability studies examine executive characteristics and governance but seldom connect them with technology programmes. This review brings these strands together. It argues that strategic engineering leadership should be understood as an orchestration task performed across three tiers, executive, engineering and frontline, and that its effect on sustainable growth runs through identifiable organisational mechanisms rather than through leadership style alone.

The remainder of the paper is organised as follows. The aim, objectives and research questions are stated first, followed by the review method. The paper then examines the Australian industrial context and what it implies for leaders, and analyses leadership at the executive level and at the engineering interface. It next examines the organisational mechanisms through which leadership operates and presents the integrated framework and transformation pathway. The discussion sets out a research agenda and acknowledges limitations, and the conclusion closes the paper.

2 Aim, objectives and research questions

This review aims to explain how strategic and engineering leadership shape technology-driven organisational transformation in Australian industry, and to show how that transformation can be directed towards growth that is economically, socially and environmentally sustainable. Four objectives give effect to this aim. The first is to characterise the Australian industrial context and the specific barriers and opportunities it creates for technology-driven change. The second is to evaluate evidence on how leaders at the executive and engineering levels influence transformation, innovation and sustainability outcomes. The third is to identify the organisational mechanisms, including culture, dynamic capabilities, ambidextrous learning and workforce development, through which leadership effects are transmitted. The fourth is to integrate these findings into a framework, an action guide and a staged pathway that Australian industrial leaders and researchers can use and test.

Three research questions follow. RQ1 asks what distinguishes the Australian industrial context for technology-driven transformation and what that context demands of leaders. RQ2 asks which leadership attributes and behaviours, at the executive level and at the engineering interface, are associated with successful transformation and with sustainability outcomes. RQ3 asks through which organisational mechanisms leadership converts technology investment into resilience, innovation and sustainable growth.

Several terms are used in a defined sense. Strategic engineering leadership denotes leadership that connects technological choices with organisational strategy, exercised by executives with responsibility for technology and operations and by senior engineers and technical managers who shape how technologies are selected, integrated and used. Technology-driven organisational transformation refers to change in processes, structures, roles, products and business models that is enabled by digital, automated or advanced manufacturing technologies. Sustainable industrial growth is growth in output, productivity and innovation that is accompanied by improving environmental performance, including carbon performance, and by fair treatment of the workforce.

3 Review methodology

This study followed a systematic integrative review design. Integrative reviews combine studies that use different designs, including surveys, case studies, archival analyses and conceptual work, in order to build a fuller understanding of a phenomenon than any single design can provide. This suited the research questions, which span leadership psychology, strategic management, operations and corporate sustainability, and which require Australian evidence to be read alongside international studies of the mechanisms involved. The review protocol defined the questions, search strategy, eligibility rules, appraisal criteria and coding frame before screening began.

Two seed articles anchored the search. Mason et al. (2022) interviewed 20 advanced Australian manufacturers about how they implement Industry 4.0, and Bašić et al. (2025) surveyed Australian firms to identify the elements of innovation culture that support open innovation under different degrees of internationalisation. The first anchors the review in the realities of Australian manufacturing; the second brings evidence on the managerial skills and cultural foundations of innovation in Australian organisations. Their keywords, constructs and reference lists were used to refine the search vocabulary.

The search drew on a multidisciplinary index of scholarly metadata and covered journal articles that appeared between January 2020 and December 2025, combining terms from three groups. The leadership group included "top management support", "digital leadership", "transformational leadership", "entrepreneurial leadership", "ambidextrous leadership", "green leadership", "upper echelons" and "CEO characteristics". The transformation group included "Industry 4.0", "digital transformation", "advanced manufacturing technology", "dynamic capabilities", "organisational culture", "reskilling", "employee resistance" and "roadmapping". The outcome and context group included "sustainable performance", "carbon performance", "net zero", "organisational resilience", "high-growth firms", Australia, Australian, manufacturing and mining. Because Australian studies are dispersed, dedicated searches pairing Australia or Australian with each transformation and outcome term were also run.

Studies were included if they were peer-reviewed journal articles with complete bibliographic metadata and a resolvable digital object identifier, if both their online and print publication dates fell between 2020 and 2025, and if they addressed leadership, organisational transformation or sustainability outcomes in industrial or comparable organisational settings. Commentaries, conference papers, theses and articles whose abstracts could not be obtained were excluded, as were studies focused on education, health care or public administration without an industrial dimension. A log recorded every screening decision together with the reason for any exclusion. Each retained study was appraised for how directly it bore on the research questions, how transparently its method was reported, whether its conclusions were proportionate to its evidence, and how readily its setting transferred to Australian industry.

The final corpus contains 30 articles. Fourteen are quantitative empirical studies based on surveys, panels or archival data; nine are qualitative or interview-based studies, including case studies and content analyses; and seven are literature reviews, conceptual studies or method-development papers. Nine articles report Australian evidence, drawn from manufacturing, mining, construction, telecommunications, horticulture and listed companies. Each study was coded for the leadership tier addressed (executive, engineering or technical, frontline), the transformation mechanism examined, the outcome measured and the setting. The synthesis moved from Australian context, through leadership effects, to mechanisms, and finally to the integrated framework and pathway presented in the section on organisational mechanisms.

4 The Australian industrial context for transformation

The defining feature of Australian manufacturing, for the purposes of transformation, is its structure. Mason et al. (2022) observe that the sector is dominated by smaller firms serving the domestic market, firms that have little money to spend on new technology or on research and development. The advanced manufacturers they interviewed were using Industry 4.0 technologies chiefly to automate how data are collected, combined and analysed, and they were reorganising roles and building new skill sets to do so. Knowledge sharing and collaboration, within and across organisations, were regarded as especially important for small manufacturers seeking to stay globally competitive. Strikingly, however, few participants discussed supply chain applications, smart products and services, or the need for a strategy-led approach, and even fewer raised governance, standards and data security. The authors conclude that these gaps call for policy and investment that reach beyond individual manufacturers to lift capability across domestic supply chains.

These findings carry an important implication for leadership. Many of the Australian manufacturers interviewed appear to approach transformation as a sequence of operational improvements rather than as a strategic repositioning. Data capture and automation are valuable, but without a strategy that links them to new products, services and supply chain relationships, their effect on growth is likely to be limited. The scoping study by Tortorella et al. (2021) reinforces this reading: across two decades of research, it identified eight barriers and eight opportunities for Australian manufacturing, and its proposed research directions, digital transformation, sustainable service-integrated operations and the link between socio-economic characteristics and success factors, all require leaders who can connect technology with strategy and with the wider economic context.

Evidence on firm growth supports the same point. Analysing firm-level data, Majeed et al. (2021) found that most Australian high-growth firms remain in a high-growth phase only briefly, that the proportion of such firms declined after the Global Financial Crisis, and that turnover growth in high-growth firms responds far more strongly to innovation in goods and services than it does in the average firm. Business focus on innovation contributed to turnover growth across all firms, and high-growth firms earned greater returns on research and development. Sustained growth thus depends on product and service innovation, yet the development of smart products and services was rarely mentioned by the manufacturers interviewed by Mason et al. (2022).

The resources sector presents a different but related picture. Jang and Topal (2020) describe an Australian mining industry facing low-grade ore, greater depths, climate change and stringent social and environmental constraints, and argue that these challenges can be met through technical improvement and optimisation of the whole mining value chain using information and communication technologies and automation. Their review of major mining companies' initiatives points to transforma-

tion that is system-wide rather than local, demanding leaders who can coordinate technology programmes across geology, extraction, processing and logistics while responding to community and environmental expectations.

Read against the review by Stornelli et al. (2021), which classifies five types of barrier and four types of enabler across a three-stage adoption process and calls for more research on what happens after installation, the Australian evidence suggests that many firms are progressing through adoption without the managerial routines that turn installed technology into product, service or business model innovation. That review links particular categories of barriers and enablers to particular innovation outcomes, which implies that leaders can influence the kind of innovation that adoption produces, not merely whether adoption occurs. The structural features of Australian industry therefore do not make transformation impossible, but they raise the premium on leaders who can compensate for limited scale through partnership, sequencing and focus.

Transformation also changes work. Ejsmont (2021), combining a literature review with structured interviews in Australian horticulture, found that the impact of Industry 4.0 on employees is significant and spans many categories of human work, at both the labour-market and the job level. Combining a literature review with interpretive structural modelling et al. (2021) identified eleven determinants of digital transformation success in manufacturing small and medium-sized enterprises and found that external support for digitalisation is the first step towards success, whereas operations technology readiness is the hardest determinant to reach. For Australia's small manufacturers, this suggests that leaders should combine external partnerships with patient investment in operational technology, and that the workforce consequences of change should be managed from the outset. Table 1 summarises the Australian evidence and its implications for leaders.

Table 1. Australian evidence on industrial transformation and its implications for leaders.

Study	Setting and method	Principal finding	Implication for leaders
Mason et al. (2022)	20 advanced manufacturers; interviews	Focus on automated data capture, role redesign and collaboration; little attention to strategy, smart products, governance or data security	Move from operational automation to strategy-led transformation; address governance early
Tortorella et al. (2021)	Manufacturing research over two decades; scoping review	Eight barriers and eight opportunities; priorities in digital transformation and sustainable service-integrated operations	Connect technology choices with megatrends and service strategy
Majeed et al. (2021)	Firm-level data; econometric analysis	High growth is short-lived; goods and services innovation drives growth most strongly in high-growth firms	Prioritise product and service innovation, not only process efficiency
Jang and Topal (2020)	Mining industry; review	Low-grade ore, depth and social constraints require value-chain optimisation through technology and automation	Coordinate transformation across the whole value chain
Ejsmont (2021)	Horticulture; review and structured interviews	Industry 4.0 significantly affects many categories of work at labour-market and job levels	Plan for workforce effects from the outset

Study	Setting and method	Principal finding	Implication for leaders
Elsayih et al. (2021)	Listed firms in a carbon disclosure programme; panel	Executive experience and CEO duality relate positively, and tenure negatively, to carbon performance	Value breadth of executive experience in decarbonisation
Fernández-Méndez and Arrondo-García (2021)	166 listed companies; panel	Family firms score lower on sustainability; later generations perform better than founders	Address ownership and succession in sustainability leadership
Coelho et al. (2022)	Construction organisations; survey	Market cultures dominate; hierarchy hinders, and adhocracy–market mixes support, quality management	Balance cultures deliberately to support improvement
Bašić et al. (2025)	Telecommunications firms; survey	Resilience, competence and globalism shape innovation practices	Develop managerial skills that match innovation strategy

5 Leadership at the executive level and the engineering interface

Executive leadership sets the purpose, priority and resources of transformation. Yet explicit executive commitment is less common than might be expected. Garcia-Ortega et al. (2021) analysed the letters of chief executives and other senior managers of 159 companies listed on the five main stock indices of the European Union and found that barely half expressed strong support for Industry 4.0 and digitalisation. The authors interpret this as a form of spatial myopia that acts as a meta-barrier to implementation, and they note that executive support was mostly motivated by business and customer considerations, with sustainability rarely presented as a principal motive. If large listed European firms display this pattern, Australian firms with smaller leadership teams and tighter budgets may be at least as exposed to it.

Executive characteristics also matter for environmental outcomes. Using data on Australian companies that reported to a voluntary carbon disclosure programme between 2011 and 2014, Elsayih et al. (2021) found that executive experience and CEO duality were positively associated with carbon performance, whereas CEO tenure, functional background experience and industry experience were negatively associated with it, and CEO ownership was unrelated. The results caution against assuming that long-serving insiders are best placed to lead decarbonisation; broader executive experience may be more valuable than deep familiarity with one industry. Fernández-Méndez and Arrondo-García (2021), studying 166 listed Australian companies, found that family firms had lower sustainability scores than non-family firms, but that multi-generational family firms performed better than founder-managed ones. Ownership and succession thus shape the sustainability orientation that leaders bring to transformation.

Executive values and cognition influence innovation even where formal research is absent. Drawing on 40 interviews in innovative German small and medium-sized firms without formal research and development et al. (2022) found that the chief executive acts as both moderator and mediator between learning by doing, using and interacting and innovation performance, with the executive's values and cognitive base helping to increase employees' innovation activity. This finding is significant for Australia, where many small manufacturers innovate through practical problem-solving rather than laboratory research. Net-zero strategy displays similar contingency. Interviewing representatives of 30 firms, Berger-Schmitz et al. (2023) found that institutional and competitive

pressures propelled the adoption of net-zero targets, but that the substance of commitments and the strategic positioning of firms varied widely, shaped by firm-specific and sectoral factors, and that positions changed over time.

At the interface between strategy and operations, the evidence favours specific behaviours over general styles. Heubeck (2023), studying German Industry 4.0 firms, found that managers' entrepreneurial skills facilitated digital business model transformation and, through it, firm performance, whereas leadership skills had no effect on performance either directly or through transformation; social capital strengthened, and higher cognition weakened, the effect of entrepreneurial skills. Gerlach et al. (2020), following employees through an innovation project, found that instrumental leadership and ambidextrous opening and closing behaviours were positively related to innovation performance, whereas transformational and transactional leadership and leader-member exchange were not. Wu et al. (2021), using matched data from 73 chief executives and 377 middle managers in China, showed that entrepreneurial leadership fosters ambidextrous learning, which in turn mediates its effect on organisational performance during digital transformation.

Other studies do find benefits from transformational leadership, but typically through intermediate mechanisms. Among 305 managers in manufacturing, Gun et al. (2024) found that transformational leadership and employee self-efficacy were positively related to digital transformation, which was associated with operational and financial performance. Asif et al. (2024), surveying Chinese manufacturing organisations, found that transformational leadership, corporate culture and digital transformation each affected sustainable performance, with innovation capability mediating the effects of leadership and digital transformation. Ullah Khan et al. (2023) showed that green leadership improves environmental knowledge sharing, which in turn mediates its effect on the sustainable performance of manufacturing firms. Read together, these studies suggest that the label attached to a leader's style matters less than whether leadership activates the learning, innovation and knowledge-sharing processes that transformation requires.

Three tensions run through this evidence. The first concerns experience: long tenure and deep industry experience, often regarded as assets, were associated with weaker carbon performance in Australian firms (Elsayih et al., 2021), suggesting that executive teams leading transformation may benefit from deliberately broadening the experience they contain. The second concerns style: broad styles such as transformational leadership help mainly when they activate learning and innovation, whereas specific behaviours that open exploration and close it into execution relate directly to innovation performance (Gerlach et al., 2020). The third concerns motive: where executives frame transformation chiefly around efficiency and customers (Garcia-Ortega et al., 2021), sustainability risks becoming an afterthought, even though net-zero commitments have been propelled by institutional and competitive pressures (Berger-Schmitz et al., 2023). Each tension points to choices that boards and executives can make about who leads transformation and how its purpose is defined.

The role of engineering and technical leaders follows from this. Albannai et al. (2025) conceptualise digital leaders as builders of three dynamic capabilities: digital sensing, which involves scanning technological trends and forming a digital vision; digital seizing, which involves organisational agility and the management of a digital portfolio; and transforming, which involves redesigning internal structures and ecosystem partnerships. Engineering leaders are well placed to perform the sensing and seizing roles because they understand both the technical possibilities and the operational constraints. Roadmapping gives them a practical instrument: Phaal et al. (2024) show how a visual, systems-based roadmapping method, refined through six industrial cases and illustrated in additive

manufacturing, can be used to plan the organisation's own strategic planning system and to reduce information asymmetries across complex socio-technical systems. Figure 1 shows how these leadership roles combine across tiers.

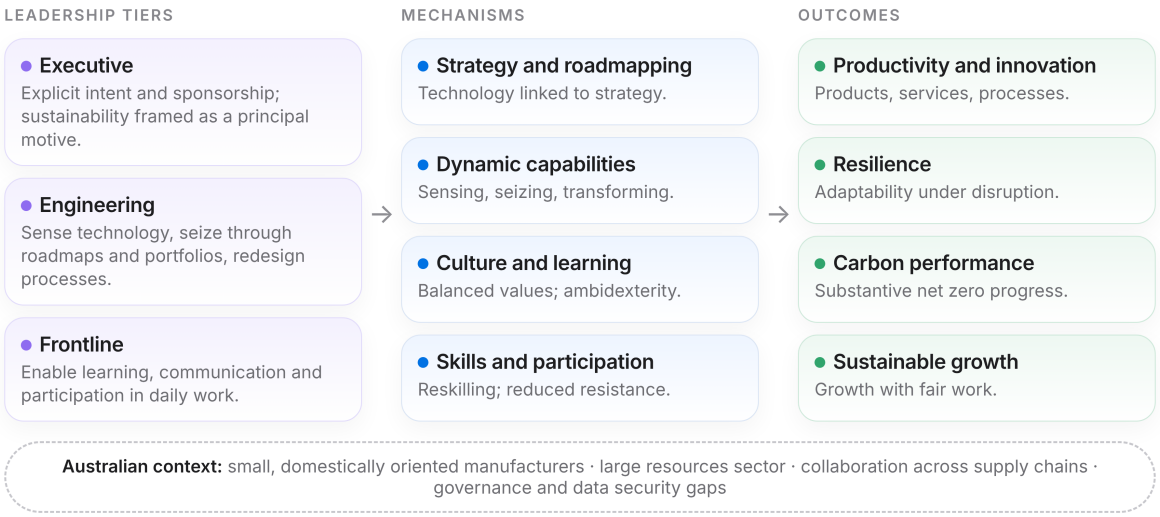


Figure 1. Three-tier leadership orchestration framework for technology-driven transformation in Australian industry.

6 Organisational mechanisms and an integrated framework

Leadership exerts its influence through the organisation it shapes, and culture is the first of these channels. Ziaei Nafchi and Mohelská (2020) found that an innovative organisational culture, regarded as an indicator of readiness for Industry 4.0, did not depend on organisational size but depended to some degree on organisational type. Australian evidence from construction is instructive. Coelho et al. (2022) found that Australian construction organisations were dominated by market and externally focused cultures, that hierarchical cultures provided an unfavourable environment for total quality management, and that a mix of adhocracy and market cultures was more supportive. Wijethilake et al. (2023), studying a multinational garment manufacturer, showed that organisational change towards sustainability was shaped by four competing cultural values, oriented to people, growth, productivity and stability, and that the organisation integrated these values rather than allowing one to dominate. For Australian industrial leaders, the lesson is that transformation requires deliberate cultural balancing, not the replacement of one culture with another.

Culture is closely tied to the skills and attitudes that managers bring. In the seed study by Bašić et al. (2025), survey data from Australian telecommunications firms revealed three elements of a robust innovation culture, namely resilience, competence and globalism, which shape the firm's innovation model and practices, with resilience particularly important for inbound and globalism for outbound innovation. The authors argue for targeted development of managerial skills aligned with a firm's innovation and internationalisation strategy. This resonates with the finding of Mason et al. (2022) that collaboration is vital for small Australian manufacturers: leaders who wish to draw knowledge into the firm and to take products to wider markets need different capabilities at different points in that journey.

Dynamic capabilities form the second mechanism. Soluk and Kammerlander (2021), drawing on 127 interviews in 15 family-owned manufacturing firms in German-speaking countries, describe digital

transformation as a sequence of three stages, in which firms digitalise first their processes, then their products and services, and finally their business model, each stage with its own triggers and each requiring dynamic capabilities whose development is supported or hindered by particular combinations of enablers and barriers. The sequence is relevant to Australia because the advanced manufacturers studied by Mason et al. (2022) appear, on their own accounts, to be concentrated largely in the first stage. Moving to the later stages calls for capabilities that leaders must build deliberately. Evidence from Taiwanese financial-sector firms shows why strategy matters in this process: Tsou and Chen (2023) found that digital technology usage improved firm performance only through the full mediation of digital transformation strategy and organisational innovation.

Learning and resilience form the third mechanism. Among small and medium-sized enterprises in southern Spain et al. (2024) found that digital technologies enhanced organisational learning and innovation, which in turn increased resilience and adaptability. Ambidextrous learning, combining exploitation of existing knowledge with exploration of new knowledge, is the channel through which entrepreneurial leadership improves performance during digital transformation (Wu et al., 2021). These findings suggest that leaders should evaluate technology programmes partly by their contribution to the organisation's capacity to learn, rather than solely by immediate efficiency gains.

People form the fourth mechanism. Li (2024) argues that lifelong learning should be part of an organisation's strategic goals and that reskilling and upskilling opportunities must be accessible, available and affordable. Jooss et al. (2024), drawing on 34 interviews in 15 organisations, show how matching skills to needs, in both external and internal labour markets, builds dynamic capabilities that underpin strategic sensitivity and resource fluidity, and hence strategic agility. Resistance must also be anticipated. Valtonen and Holopainen (2025), studying ten Finnish industrial companies, identified sources of resistance at individual, organisational and technological levels and found that a mitigation strategy built on learning, communication and participation reduced resistance and supported employee well-being. In Australian settings where Industry 4.0 alters many aspects of work (Ejsmont, 2021), these practices are central to transformation rather than ancillary to it.

Sustainability orientation is not a separate mechanism so much as a direction that runs through all four. Roadmaps can include carbon milestones alongside technology milestones; dynamic capabilities can be used to sense regulatory and market shifts towards low-carbon products; cultural balancing can give people- and growth-oriented values weight alongside productivity and control, as the garment manufacturer studied by Wijethilake et al. (2023) did; and skills programmes can include environmental knowledge, which green leadership helps to circulate (Ullah Khan et al., 2023). In Australian listed companies, ownership and succession also condition this orientation, since multigenerational family firms outperform founder-led ones on sustainability (Fernández-Méndez and Arrondo-García, 2021). Table 2 therefore lists sustainability orientation as a cross-cutting element led from the executive tier.

Figure 1 integrates these findings into a three-tier leadership orchestration framework. At the executive tier, leaders set strategic intent, commit visibly to transformation and frame sustainability as a principal motive rather than a by-product. At the engineering tier, technical leaders sense technological opportunities, seize them through portfolio decisions and roadmaps, and redesign processes and structures. At the frontline tier, team leaders and supervisors enable learning, communication and participation. The three tiers act through four mechanisms, namely strategy and roadmapping, dynamic capabilities, culture and ambidextrous learning, and skills and participation, to produce four outcomes: productivity and innovation, organisational resilience, carbon and

sustainability performance, and sustainable growth. The Australian context, characterised by small firms, a domestic-market orientation, a large resources sector and dependence on collaboration across supply chains, conditions every relationship in the framework.

Table 2 translates the mechanisms into leadership actions and indicators, and Figure 2 arranges those actions into a three-horizon pathway. In the first horizon, foundations, leaders establish visible executive sponsorship, build data capture and operational technology readiness, assess culture and skills, and set baseline measures of carbon and productivity. In the second horizon, integration, they connect data and automation across functions and with suppliers, develop roadmaps and portfolio governance, invest in reskilling and participation, address governance, standards and data security, and bring carbon and energy data into operational decisions. In the third horizon, renewal, they pursue product, service and business model innovation, embed net-zero commitments in strategy and investment, and extend collaboration across domestic supply chains. Movement between horizons depends on capabilities rather than on elapsed time, and organisations may work on several horizons at once.

Table 2. Transformation mechanisms, leadership actions and indicators.

Mechanism	Lead tier	Leadership actions	Supporting evidence	Indicative measures
Strategy and roadmapping	Executive and engineering	State transformation and sustainability intent explicitly; build roadmaps and portfolio governance	Garcia-Ortega et al. (2021); Phaal et al. (2024); Tsou and Chen (2023)	Share of technology spend linked to strategic roadmap; executive communication on transformation
Dynamic capabilities	Engineering	Sense technological trends, seize opportunities through agile portfolio decisions, redesign structures and partnerships	Albannai et al. (2025); Soluk and Kammerlander (2021); Heubeck (2023)	Progress from process to product, service and business model digitalisation
Culture and ambidextrous learning	All tiers	Balance competing cultural values; combine exploitation with exploration; reward experimentation	Coelho et al. (2022); Wijethilake et al. (2023); Wu et al. (2021); Awad and Martín-Rojas (2024)	Culture profile; innovation outputs; recovery time after disruption
Skills and participation	Frontline and human resources	Match skills to needs; provide accessible reskilling; communicate and involve employees	Jooss et al. (2024); Li (2024); Valtonen and Holopainen (2025)	Training participation; internal mobility; retention; employee well-being
Sustainability orientation	Executive	Frame sustainability as a principal motive; embed net-zero targets in investment; broaden executive experience	Elsayih et al. (2021); Berger-Schmitz et al. (2023); Ullah Khan et al. (2023)	Carbon performance; substantive net-zero commitments; sustainability scores

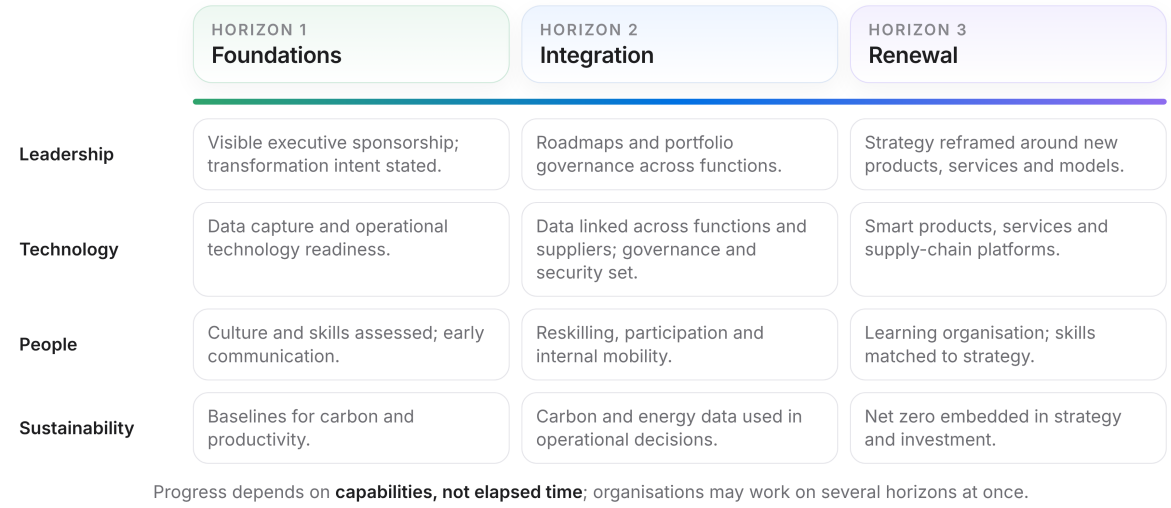


Figure 2. Three-horizon pathway for leadership-orchestrated industrial transformation.

7 Discussion, research agenda and limitations

Taken in turn, the three research questions can now be answered. On RQ1, the Australian context is distinguished by the predominance of small, domestically oriented manufacturers with limited resources for technology and research, by a resources sector whose transformation must span the entire value chain, and by growing pressure on carbon and sustainability performance. These conditions demand leaders who can move their organisations beyond operational automation towards strategy-led transformation, who can build collaboration across firm boundaries, and who treat governance, interoperability standards and data security as design requirements rather than afterthoughts. On RQ2, the evidence indicates that specific leadership attributes and behaviours, including explicit executive support, broad executive experience, entrepreneurial skills and ambidextrous opening and closing behaviours, matter more than general leadership styles, and that transformational and green leadership operate mainly through innovation capability and knowledge sharing. On RQ3, leadership converts technology into resilience, innovation and sustainability through the four mechanisms identified in the section on organisational mechanisms, each of which links a leadership tier to a distinct organisational process.

These findings carry theoretical implications. They support an orchestration view of leadership in which outcomes depend on coordination across tiers rather than on the qualities of a single leader. They qualify the frequent emphasis on transformational leadership: two studies in the corpus found that transformational leadership, or general leadership skills, bore no relation to innovation or performance once more specific behaviours or skills were considered, while others found effects that were mediated by innovation capability. The findings also connect upper echelons research on carbon performance with research on digital transformation, suggesting that the executive attributes that support decarbonisation may also support strategy-led technology adoption, a proposition that has yet to be tested.

Four propositions are offered for empirical testing in Australian industry. First, Australian manufacturers whose executives explicitly frame transformation in terms of strategy and sustainability will progress further beyond process digitalisation than those whose executives frame it in terms of efficiency alone. Second, the performance effects of technology investment will be mediated by

transformation strategy and organisational innovation, and the mediation will be stronger in firms with balanced cultures. Third, firms with engineering leaders who use roadmapping and portfolio governance will show greater coherence between technology investment and product or service innovation. Fourth, the combination of reskilling, communication and participation will reduce resistance and improve the retention of skilled employees during transformation.

The review also reveals gaps. Australian evidence on leadership in manufacturing transformation is scarce; the most directly relevant studies are qualitative and based on small samples. Longitudinal studies following Australian firms through successive stages of transformation are needed, as are studies of engineering leaders as a distinct group. The connection between executive characteristics and carbon performance should be re-examined with more recent data and extended to technology adoption. Research in the resources sector should examine how leaders coordinate automation across the value chain while maintaining social licence. Finally, the role of collaboration and supply-chain uplift identified by Mason et al. (2022) warrants study at the level of industrial ecosystems rather than individual firms.

For practitioners, the review suggests four priorities. Boards and executives should make their commitment to transformation explicit and should frame sustainability as a principal motive for it. Engineering leaders should adopt roadmapping and portfolio governance to connect technology choices with strategy. Human resource and frontline leaders should treat reskilling, communication and participation as integral to transformation programmes. Industry bodies and governments should support collaboration across supply chains, which the evidence identifies as particularly important for small Australian manufacturers.

Several limitations should be acknowledged. The corpus comprises only 30 journal articles, and much relevant evidence appears in reports, conference papers and other forms excluded by design. Only nine articles report Australian evidence, so many mechanisms are inferred from studies in Europe and Asia. Several key studies are cross-sectional or based on small qualitative samples, which limits causal inference. Searches were conducted through a single metadata service, supplemented by the seed articles' reference lists, and a single reviewer conducted screening and coding. The framework and pathway rest on synthesis rather than testing and require empirical validation.

8 Conclusion

The starting question was how those who lead Australian industrial organisations, from the boardroom to the plant floor, shape technological change and steer it towards durable growth. The evidence indicates that Australia's challenge lies less in access to technology than in moving from operational automation to strategy-led transformation, in a setting dominated by small firms and shaped by the demands of the resources sector and decarbonisation. Leadership effects are specific: explicit executive commitment, broad experience, entrepreneurial skill and ambidextrous behaviour matter more than generic style, and they take effect through the way organisations plan, build capabilities, learn and involve their people.

The three-tier orchestration framework, the mechanism-to-action guide and the three-horizon pathway offer a structure for applying these insights. Their central message is that transformation is led collectively: executives set purpose and priority, engineering leaders translate them into roadmaps and redesign, and frontline leaders make change workable for the people who carry it out. Australian organisations that coordinate leadership across these tiers, and that measure success in

terms of learning, resilience and carbon performance as well as productivity, are best placed to turn technological change into sustainable industrial growth.

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