

**FOSTERING RESILIENCE IN INDUSTRY 5.0:
COLLABORATIVE TALENT MANAGEMENT
AND INTELLIGENCE IN MALAYSIAN
MANUFACTURING AND TECHNOLOGY SMEs**

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by

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**MEMUPUK KETAHANAN DALAM INDUSTRI 5.0: PENGURUSAN BAKAT
KOLABORATIF DAN KECERDASAN DALAM SEKTOR PEMBUATAN
DAN TEKNOLOGI PKS DI MALAYSIA**

ABSTRAK

Seiring dengan peralihan organisasi ke era Industri 5.0, peranan kecerdasan buatan (AI) dalam memperkasa konsep *pengurusan bakat kolaboratif* (CTM) semakin menjadi keutamaan. Kajian ini bertujuan memperdalam pemahaman tentang bagaimana AI dapat mengubah amalan kolaboratif dalam organisasi, sekali gus menyumbang kepada pertumbuhan ekonomi yang inklusif dan mampan, pewujudan guna tenaga penuh, serta pembangunan persekitaran kerja yang bermaruah. Dengan menggunakan pendekatan *grounded theory*, kajian ini meneliti evolusi pengurusan bakat dan peranan penting AI dalam memperkukuh kerjasama manusia. Ia memperkenalkan *Teori Kecerdasan 2IE*, iaitu sebuah kerangka berasaskan AI yang inovatif bagi meningkatkan CTM melalui keseimbangan antara keupayaan analitik AI dengan kebijaksanaan kognitif serta pertimbangan etika manusia. Model ini menekankan pembudayaan kerjasama dalam organisasi dengan memanfaatkan AI untuk analitik ramalan bakat, penyusunan laluan pembelajaran yang diperibadikan, serta saluran komunikasi yang lebih berkesan. Hasil yang dijangkakan ialah pembangunan satu kerangka strategik diperkasa AI yang menawarkan panduan kepada organisasi dalam usaha menjadikan kolaborasi sebagai nilai teras, di samping memacu inovasi dan kelestarian dalam amalan pengurusan bakat. Kajian ini menyumbang kepada wacana akademik tentang persilangan antara AI dan pengurusan bakat, serta

memberikan panduan teori dan praktikal kepada pengamal yang berhasrat memajukan pertumbuhan inklusif, pembangunan mampan, dan inovasi di tempat kerja.

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ABSTRACT

As we transition into the Industry 5.0 phase, the significance of artificial intelligence (AI) in augmenting a novel idea of collaborative talent management (CTM) has become more pronounced. This research aims to enrich our understanding of how AI can transform cooperative endeavours within organisations, playing a crucial role in attaining an inclusive, and sustainable economic growth, comprehensive employment, and decent work environment for everyone in the workplace. By applying a grounded theory approach, this paper investigates the development of talent management and the pivotal role of AI in bolstering human collaboration. It introduces the innovative *2IE Intelligence Theory*, a pioneering AI-based framework designed to enhance collaborative talent management by creating a harmonious balance between AI's technological strengths and human intellect. This model aims to nurture a cooperative culture within organisations, utilising AI for enhanced predictive analytics in identifying talent, crafting personalised learning trajectories, and facilitating more effective communication channels. The expected result is a strategic, AI-powered framework offering insights for organisations striving to foster a collaborative ethos, thereby significantly advancing innovation and sustainability in talent management practices. This research contributes to the scholarly conversation on AI's role in talent management and provides actionable theoretical and practical guidance for professionals, aiding to promote inclusive and sustainable economic development, employment, and workplace innovation.

CHAPTER 1

INTRODUCTION

The chapter begins by setting the stage for the current research, offering a thorough backdrop to the study at hand. Following this, the reasoning behind the problem statement is elaborated upon, which naturally leads to the formulation of the research questions and aims. Next, a preliminary glimpse into the significance of the study is provided, accompanied by an in-depth discussion of the study's key terminologies and a concise research outline of the dissertation is presented.

1.1 Background of the Study

1.1.1 Introduction to Research Context

Malaysia, having recently survived the pandemic, remains renowned for its rich ethnic and cultural heritage; the nation's demographic composition encompasses a broad spectrum of racial groups (Faruqi, 2021). The West of Malaysia predominantly houses the Malays, Chinese, and Indians. In the eastern territories, a diverse array of indigenous people resides, including the Bidayuh, Melanau, Iban, Bajau, Murut, and Kadazan communities. In addition to this, the population of Malaysia also consists of international expats, contributing to a total population that was recorded 32.7 million in 2022, as shown by the Department of Statistics Malaysia (2023, p.1). This multifaceted cultural colour is further enriched by the presence of different religious practices, which includes Islam, Buddhism, Hinduism, and Christianity. Malaysians are firmly rooted in a commitment for mutual respect and understanding, which in turn

forms the bedrock of the nation's harmony and unity. Nonetheless, it is particularly pertinent to investigate the nuanced dynamics within the interaction of such stable and varied cultural demographics, especially against the backdrop of the internationalisation activities of many companies in this modern era. Zain and Ng (2006) argue that this intricate web of commercial fusion is only made possible through the internationalisation strategies pursued by companies, which necessitate the establishment of extensive networks. These networks encompass a wide range of relationships, spanning from acquaintances, family connections, financial institutions, distributors, governmental bodies, competitors, suppliers, and customers.

Against this multicultural backdrop, Malaysia's manufacturing and technology sectors have become critical engines of economic growth. According to the Malaysian Investment Development Authority (2024), manufacturing contributed 23.4 % of national gross domestic product (GDP) in 2023. In parallel, the Information and Communication Technology (ICT) sector has demonstrated robust and sustained growth, particularly in the wake of the COVID-19 pandemic. As of 2021, the ICT sector accounted for 23.2 % of Malaysia's GDP, with projections indicating a further increase to 25.5 % by 2025 (International Trade Administration, 2024). These upward trajectory highlights the sector's strategic importance in advancing Malaysia's transition towards a high-income, digitalised economy. Yet rapid digitalisation and the onset of Industry 4.0 have exacerbated persistent talent shortages and high employee turnover, particularly within Small and Medium Enterprises (SMEs). Studies reveal that many SMEs in the Malaysian manufacturing sector struggle to integrate talent-management with digital transformation. Kamil et al. (2023) emphasise that the enhancement of talent management alongside the adoption of digital technologies constitutes a vital component of Malaysia's economic development agenda. Similarly,

Krishnan et al. (2020) find that structured talent-management practices significantly improve manager performance in manufacturing SMEs. However, such practices are inconsistently adopted, and most SMEs lack the capacity to build cross-sector networks essential for co-developing talent pipelines—a shortfall relative to larger firms and multinational corporations, which are better able to absorb and utilise collaborative arrangements.

Zhai et al. (2023) have highlighted the significance of adopting the concept of human resilience approach to enhance performance in organisation. The authors emphasise the crucial role of human resilience in overcoming adversity and navigating challenging circumstances. Their meta-analytic evidence further shows that strategic human resource management systems foster psychological empowerment—heightening employees’ sense of meaning, competence, autonomy, and impact—and that this empowerment, in turn, builds individual resilience that buffers organisations against environmental turbulence and sustains performance. In a rapidly changing and unpredictable environment, Azizi et al. (2023) similarly introduce the concept of resilience leadership as an essential skill. They argue that leaders often overlook various challenges, such as recruiting and retaining suitable employees, navigating emerging rivalries in dynamic markets, adapting to technological advancements and ensuring data security, coping with national regulatory amendments, managing economic fluctuations, addressing resource scarcity, and navigating shifting stakeholder dynamics and internal politics. Furthermore, Veer Ramjeawon and Rowley (2017) draw attention to widespread inefficiencies in knowledge management in organisation resulting from poor documentation (Mvula, 2018) and a lack of appropriate organisational culture (Singh & Kant, 2008). These shortcomings hinder effective knowledge sharing and utilisation within organisations, limiting their ability

to adapt and respond to challenges. In recent years, the enhancement of human capital has emerged as a strategic imperative, particularly in the face of unprecedented global disruptions. Lee *et al.* (2022) underscore the critical role of robust global talent management in fostering organisational resilience. Their study highlights how multinational corporations navigated the challenges of the COVID-19 pandemic more effectively by leveraging well-integrated talent management systems supported through international subsidiary networks. This underscores the increasing recognition of talent as not merely a human resource function, but as a strategic asset capable of reinforcing organisational stability and adaptability in volatile contexts.

The academic and practitioner discourse on talent management gained significant momentum with the publication of *The War for Talent* by Michaels *et al.* (2001), which positioned talent as a decisive factor in securing competitive advantage. This seminal work catalysed a paradigm shift in strategic human resource management, promoting the systematic identification, development, and retention of high-performing individuals as a central organisational priority. Building on this foundation, Gallardo-Gallardo *et al.* (2020) argue that the effectiveness of talent management depends heavily on its contextualisation. They define talent management as a dynamic and integrative set of practices encompassing the attraction, identification, engagement, development, retention, and deployment of individuals deemed critical to an organisation's long-term success. This perspective frames talent not as a static category but as a fluid, strategic resource requiring continuous alignment with evolving organisational objectives. More recent scholarship challenges earlier universalist approaches by calling for a more nuanced, context-sensitive understanding of talent management. Caligiuri *et al.* (2024), in their critical review of global talent management, advocate for the adoption of inclusive and ethically grounded

frameworks that reflect the complexity of contemporary global challenges, including cultural diversity, digitalisation, and geopolitical instability. They argue that organisations must move beyond elitist models and instead develop talent strategies that build resilience across the entire workforce. Similarly, Kravariti *et al.* (2025) explore talent management through the lens of employee resilience and agility, particularly in the hospitality and tourism sectors. Their findings highlight the importance of creating environments that support psychological safety, flexibility, and adaptive learning. This view reinforces the shift toward a more human-centred model of talent management—one that supports organisational transformation by cultivating not only top talent, but the capacity for collective responsiveness. Collectively, these contributions reveal a significant reconfiguration in how talent is understood and operationalised within contemporary organisations. Rather than treating talent management as a fixed set of practices centred solely on elite performers, there is a growing emphasis on its strategic, adaptive, and humanistic dimensions. The post-pandemic context, along with the increasing volatility of global business environments, necessitates a reconceptualisation of talent management as a systemic enabler of organisational resilience and innovation. This thesis responds to that call by exploring how collaborative intelligence—particularly the integration of human and artificial capabilities—can be embedded within talent management frameworks to drive sustainable competitive advantage in the era of Industry 5.0. In doing so, it advances both theoretical understanding and practical insight into the evolving nature of work, leadership, and strategic capability development.

As we steer our workforce through the evolving landscapes of modern society, Ivanov (2023) introduces the notion of Industry 5.0, characterised by a focus on cooperation, coordination, communication, automation, data analytics, and

understanding technological fundamentals. This emerging framework is anchored in four pivotal domains: organisational structure, management practices, technological advancements, and performance evaluation. Exploring Industry 5.0 involves a threefold analytical approach: societal, network, and operational levels. At the societal tier, the emphasis is placed on the overarching consequences and societal repercussions of Industry 5.0, incorporating considerations of economic, social, and cultural dimensions. The network tier examines the synergy and collaboration across a spectrum of entities within the Industry 5.0 framework, scrutinising the interactions and linkages among businesses, industrial conglomerates, academic bodies, and governmental agencies. On the plant level, also known as the operational tier, delves into the tangible implementation of Industry 5.0 within manufacturing environments. This entails a detailed exploration into how cutting-edge technological advancements, automation methods, and data-oriented decision-making approaches are being amalgamated, alongside their repercussions on manufacturing frameworks. Gaining a deep insight into Industry 5.0, through an analysis of its societal influences, the interplay within cooperative networks, and the breakthroughs in operational procedures, is imperative for adeptly manoeuvring through the challenges and leveraging the prospects that Industry 5.0 introduces across various domains and to an extensive array of stakeholders. Such thorough scrutiny is crucial for a complete recognition of the intricate nature and the significant effects of Industry 5.0 on both the employment landscape and the broader community.

1.1.2 The Manufacturing Sector

The global arena acknowledges the significant competitive advantages presented by the digital transition within Industry 4.0, notably in the manufacturing field

(Ghobakhloo et al., 2022; Khin & Kee, 2022). Consequently, it becomes imperative to conduct an in-depth review of technological adoption practices among manufacturing SMEs within the Malaysian manufacturing sector. Wong and Kee (2022) have raised concerns, noting that technology uptake among these Malaysian SMEs is still at a nascent stage. This sluggish advancement is largely due to the absence of fundamental drivers of Industry 4.0, such as the necessary skills, information, the sharing of knowledge, resources, dedication, and the leadership's active pursuit of digital prospects.

Building on these concerns, Almatari et al. (2023) provide a deeper diagnostic of the systemic impediments that constrain digital transformation in Malaysian manufacturing SMEs. Chief among these is the prohibitive cost of acquiring and maintaining emerging technologies, which remains beyond the financial reach of many small firms. Even where financial support is nominally available, there is a prevailing reluctance among SME owners to invest, often rooted in uncertainty regarding returns and the perceived complexity of integrating new technologies into legacy systems. In tandem, a lack of harmonised technical standards and regulatory clarity further discourages adoption. SMEs frequently encounter difficulties navigating issues related to interoperability, data governance, and legal liability—areas where larger firms may have in-house expertise but smaller entities face significant constraints (Almatari et al., 2023). Compounding these structural barriers is a pronounced talent deficiency, particularly in roles requiring advanced digital competencies. While Wong and Kee (2022) highlight the lack of shared knowledge, weak leadership vision, and poor inter-organisational collaboration as critical hindrances, Almatari et al. (2023) reveal that these firms also grapple with limited capacity to attract and retain digitally proficient talent, exacerbated by fears of job redundancy and a lack of internal upskilling

mechanisms. Moreover, concerns surrounding data security and insufficient knowledge management infrastructures further erode trust in digital systems. SMEs, often lacking robust cybersecurity frameworks and data-handling protocols, are understandably wary of exposing themselves to cyber risks without adequate protection. This accumulation of financial, regulatory, and human-capital challenges has created a multifaceted digital inertia—one that will not be resolved through isolated interventions. As such, a coordinated strategy is required, involving not only financial incentives and clearer policy directives, but also collaborative talent management models that facilitate shared resource development, foster industry–institution linkages, and enable smaller firms to build digital capabilities collectively rather than independently.

In deepening the discourse on digital inertia among Malaysian manufacturing SMEs, Khin and Kee (2022) argue that the problem extends beyond structural constraints to include significant organisational and behavioural factors. Their empirical findings reveal that while firms may express awareness of Industry 4.0's potential, this recognition does not consistently translate into actionable strategy or technological integration. Crucially, many SMEs demonstrate a disconnection between strategic intent and operational capability, wherein digital adoption is sporadic and often limited to surface-level automation rather than holistic transformation. Moreover, Khin and Kee underscore the pivotal role of absorptive capacity—the ability of a firm to recognise, assimilate and apply external knowledge—as a mediating factor in successful digital implementation. SMEs with limited exposure to external networks or inadequate R&D investment are less likely to internalise and apply the innovations required for Industry 4.0 readiness. This capacity gap reinforces the earlier observations of Wong and Kee (2022) and Almatari

et al. (2023), who highlight how underdeveloped knowledge-sharing mechanisms and leadership ambivalence further restrict the strategic use of digital technologies. These compounded limitations suggest that Industry 4.0 readiness is not merely a function of technological availability but one that is deeply embedded in organisational learning culture, leadership orientation, and the firm's openness to external collaboration. In this context, collaborative talent management becomes not only relevant but essential. By fostering cross-sector partnerships, enabling shared learning infrastructures, and building trust-based knowledge ecosystems, collaborative talent strategies may serve as a conduit for enhancing SMEs' absorptive capacities. Such a transformation requires a paradigm shift—from isolated digital experimentation to coordinated ecosystem-level development—if Malaysian SMEs are to avoid systemic marginalisation in the unfolding digital economy.

Expanding this discussion further, Ardolino et al. (2022) provide a compelling synthesis of how digital technologies were leveraged globally to address the operational disruptions brought on by the COVID-19 pandemic. Their findings reinforce the critical role of digital agility and technological integration in enhancing manufacturing firms' resilience during crises. However, they also expose a marked divergence between firms that were already digitally mature and those that struggled due to underinvestment in digital infrastructure and weak organisational preparedness. In the Malaysian SME context, this global pattern holds particularly true: firms with limited prior engagement in digital transformation found themselves disproportionately affected, lacking the technological and organisational elasticity to pivot in response to rapidly evolving demands. Notably, Ardolino et al. highlight that the successful deployment of digital technologies—such as remote monitoring, advanced data analytics, and cloud-based coordination platforms—relied not solely on

technical infrastructure but on interconnected organisational enablers, including decentralised decision-making, real-time knowledge flow, and workforce digital readiness. These enablers are often underdeveloped within Malaysian SMEs, where hierarchical management structures, siloed knowledge practices, and inconsistent talent development strategies persist. The pandemic, therefore, served as both a stress test and a magnifying lens—revealing entrenched structural and cultural weaknesses that inhibit the scaling of digital initiatives. This reinforces the imperative for more strategic and collaborative responses. Beyond individual firm-level reforms, a shift towards ecosystemic collaboration—including inter-firm partnerships, public–private platforms, and shared digital infrastructures—is necessary to close capability gaps and promote widespread Industry 4.0 adoption. Within this paradigm, collaborative talent management is not merely a human resource tool but a strategic lever that enables knowledge mobilisation, accelerates digital literacy, and fosters adaptive capacity. These qualities are not just desirable in post-pandemic manufacturing environments—they are essential for building resilient, future-ready industrial systems in emerging economies such as Malaysia.

Given its contribution of 24.1 percent to Malaysia’s GDP in 2023, the manufacturing sector continues to anchor the nation’s economic development despite the growing prominence of the service industry (Department of Statistics Malaysia, 2023, p.13). This economic significance has prompted substantial investment in the sector, with RM195.1 billion approved in 2021 alone—92.1 percent of which originated from foreign sources (Malaysian Investment Development Authority, 2021). These figures are not merely economic milestones; they reflect a national strategic intent to drive Industry 4.0 adoption and position manufacturing as a digitally enabled, innovation-led pillar of growth. Numerous policy initiatives have since

emerged to facilitate this shift, including efforts to promote green and resilient production systems, scale automation, foster commercialisation, and support collaborative R&D across industry stakeholders. Yet despite these macro-level efforts, the extent to which SMEs have capitalised on this momentum remains uneven. Sharma et al. (2022a) argue that sustaining competitiveness in volatile environments demands more than capital and infrastructure—it requires human resource agility. Organisations capable of workforce reskilling, rapid structural realignment, and proactive knowledge flow are more likely to withstand disruption. However, such agility is often lacking among Malaysian manufacturing SMEs, where HR systems are frequently disconnected from digital innovation strategies. This misalignment limits the capacity to translate policy support and capital investment into tangible performance gains. Recent studies have substantiated this concern.

For instance, Ahmed et al. (2024) and Kee et al. (2025) reveal that organisational culture, leadership readiness, and financial capacity are critical to determining digital maturity, particularly in SMEs. Meanwhile, a national study of 506 Malaysian SME firms found that, despite moderate strategic readiness, overall workforce capability remained significantly underdeveloped (Techanamurthy et al., 2025). Moreover, Rahman et al. (2025) emphasise that digital transformation success depends not only on infrastructure but also on the firm's dynamic capabilities—its ability to sense, absorb, and operationalise external digital knowledge. Taken together, these findings reinforce the notion that technology deployment alone is insufficient. Without systemic attention to human capital development, investment risks being underutilised. In this context, collaborative talent management—including joint training platforms, industry-academia partnerships, and sector-wide knowledge ecosystems—offers a promising mechanism to close workforce capability gaps. It

enables SMEs to transcend the limitations of size and resources by co-developing talent pipelines, enhancing absorptive capacity, and supporting a more inclusive, networked approach to industrial digitalisation.

1.1.3 The Tech Sector

The synergy between Malaysia's technology and manufacturing sectors creates a mutually beneficial dynamic, with the former acting as a key driver for the latter's progress. Notably, enterprises operating within the technological sphere, especially those engaged in pioneering areas like advanced robotics, cloud-based manufacturing, and smart manufacturing processes, are pivotal in enhancing the productivity of the manufacturing sector (Backhaus & Nadarajah, 2019). These companies lay the groundwork for Malaysia's leap into Industry 4.0, marking a new era characterised by the digital and automated transformation of manufacturing operations. The influence exerted by technological advancements on Malaysia's manufacturing efficiency significantly boosts the nation's global competitive edge. Additionally, the heightened demand for sophisticated technology by the manufacturing sector promotes further growth and innovation within the technology sector. This interdependent relationship is highlighted by the substantial contribution of electronics and electrical goods to Malaysia's manufacturing export portfolio, which makes up 61% of the total and approximates to 45% of the nation's overall export value (Hobday, 2013). The resultant upsurge in technological activity, overseen by skilled technicians and engineers, has led to an increase in dedicated Research and Development (R&D) departments. Tech innovation activities extend beyond mere product and process enhancements, filling the realms of organisational design and operational applications. This is not a surprising illustration of the tech sector as according to the data provided by the

Department of Statistics Malaysia (2021), the field had contributed as much as 22.6% of the overall GDP. Hence, this implies that the tech sector in Malaysia holds a critical role in economic development, thereby forming the bedrock of the manufacturing industry.

Building on this dynamic interplay between the technology and manufacturing sectors, the Malaysian Investment Development Authority (2018) report emphasised Malaysia's commitment to transforming into a high-tech hub. It detailed initiatives such as the establishment of sector-specific ecosystems—including the Malaysia Automotive, Robotics and IoT Institute (MARii)—and the launch of the Smart Manufacturing Experience Centre under Industry4WRD. These platforms were designed to bolster SME capabilities by providing access to automation testbeds, targeted training, and advisory services, thereby accelerating digital adoption through shared infrastructure and knowledge exchange (EU-Malaysia Chamber of Commerce and Industry, 2022). More recent scholarship reinforces the strategic importance of such governmental ecosystems. Annamalah et al. (2022) identify that collaborative innovation clusters—supported by government facilitation—are significantly associated with improved productivity and accelerated Industry 4.0 integration among Malaysian SMEs. Their econometric analysis shows that firms embedded within these clusters demonstrate significantly greater digital technology absorption than independent firms. Meanwhile, Joukhadar et al. (2023) argue that the synergy between public innovation infrastructure and targeted incentive schemes, such as MARii-led automation grants, not only enhances firm-level readiness but also builds a nurturing environment for sustainable digital transformation. Complementing these insights, the global development discourse has highlighted the necessity of coherent policy integration. The 2021–2023 Malaysia Digital Economy Blueprint (MyDIGITAL) and

the New Industrial Master Plan (NIMP) 2030 underscore multi-agency coordination to deliver national cloud, AI, and semiconductor strategic roadmaps (Tech For Good Institute, 2025). These frameworks are not only shaping Malaysia's emergence as a Southeast Asian technology hub but also creating fertile ground for collaborative talent management initiatives—where government, industry, and educational institutions co-create upskilling pathways, acronyms, and the foundational workforce for advanced manufacturing. In sum, the synergy between technological innovation and governmental orchestration forms the backbone of Malaysia's Industry 4.0 ambition. Yet, as evidenced by SME lagging in HR alignment and practical capability development, policy alone is not sufficient. Embedding collaborative talent ecosystems within these high-tech clusters—leveraging shared R&D, joint training programmes, and public-private partnerships—becomes essential. This strategic approach not only addresses capability mismatches but also ensures that Malaysia's manufacturing sector can sustainably absorb and capitalise on emerging digital technologies, thus safeguarding its position in the global value chain.

Complementing these collaborative policy frameworks, the Malaysian government has also invested significantly in building the digital infrastructure needed to support nationwide digitalisation. Central to these efforts is the enhancement of broadband and internet connectivity, which lays the groundwork for entrepreneurial activity, advanced manufacturing processes, and digital service delivery (Lee et al., 2021). High-speed internet access has proven essential for firms engaged in cloud computing, automation, e-commerce, and digital marketing—functions that are now integral to modern production and business models. However, despite these infrastructure gains, systemic challenges continue to hinder full-scale digital adoption. Persistent shortages in skilled labour, gaps in technical expertise, time constraints on

SMEs, and limited access to capital collectively restrict the operationalisation of digital blueprints. This indicates that while digital infrastructure is a foundational enabler, it must be complemented by targeted human capital development and strategic resource-sharing initiatives between government and private actors. Taken together, these findings underscore that Malaysia's transition into an Industry 4.0-ready economy cannot be realised through technology deployment or infrastructure investment alone. Instead, success hinges on a multifaceted strategy that aligns technological advancement with collaborative talent development, cross-sector partnerships, and inclusive digital governance. Policies that foster innovation ecosystems, support inter-organisational learning, and bridge workforce skill gaps are indispensable. Therefore, the interplay between public investment, institutional support, and private sector participation must continue to evolve in a coordinated and adaptive manner. Only through such systemic alignment can Malaysia fully leverage its technological potential and ensure sustainable growth in its manufacturing and technology sectors.

1.1.4 The Transformation of Industry 4.0

Industry 4.0, as originally envisioned, is fundamentally anchored in the deployment of digital automation technologies and the Internet of Things (IoT) to facilitate the creation of the 'Smart Factory'—a concept conceptualised by Bartodziej (2017). The Smart Factory denotes an intricately connected ecosystem wherein operational components such as mobility systems, logistics, buildings, energy grids, and product life cycles interact seamlessly to create self-regulating and optimised manufacturing environments. This paradigm shift represents not merely technological enhancement but an evolution in industrial intelligence, underpinned by data-driven

optimisation, decentralised decision-making, and real-time monitoring. Looking forward, Möller et al. (2022) forecast a transition from Smart Factories to what they term ‘intelligent manufacturing’, though the term remains somewhat loosely defined. Their proposed framework centres on advanced capabilities such as self-awareness, self-adaptability, condition monitoring, and configurability—traits increasingly enabled by breakthroughs in machine learning and artificial intelligence (AI). The envisioned future posits a manufacturing landscape tightly woven with simulation tools, integrated planning systems, manufacturing execution platforms, and cognitive AI, moving beyond mere automation to proactive, predictive responsiveness.

However, as these technological frontiers expand, so too do the ethical and societal dilemmas they engender. Scholars have begun to voice pointed critiques about the overemphasis on automation inherent in early Industry 4.0 narratives. Demir and Cicibas (2017) and Saniuk et al. (2022) caution that such techno-centric trajectories risk replicating industrial models that overlook critical human, social, and environmental dimensions. This critique is particularly relevant in the original design logic of Industry 4.0, which heavily leaned on removing human involvement from production lines in favour of autonomous AI, as a cost-containment strategy (Szabó-Szentgróti et al., 2021). The prioritisation of efficiency and profitability, while operationally advantageous, often sidelined broader sustainability imperatives and the socio-economic implications of workforce displacement. To address these concerns, a growing body of scholarship advocates for a shift beyond the confines of Industry 4.0. The emergence of Industry 5.0, which we will explore in the next section, reflects this critical reorientation—a framework that places human-centricity, sustainability, and resilience at the core of industrial transformation. Scholars argue that the materialisation of Industry 5.0 is intrinsically linked to the yet-elusive realisation of

‘Society 5.0’ (Demir & Cicibas, 2017; Elim & Zhai, 2020; Fonda & Meneghetti, 2022; Johri et al., 2021; Saniuk et al., 2022), a vision wherein technological advancement is harmonised with inclusive societal development. Nonetheless, the conceptual ambiguity of Society 5.0 continues to pose a challenge, highlighting the complexity of integrating digital-industrial progress with ethical and sustainable governance frameworks.

Recent scholarly contributions further enrich this discourse. For instance, Ghobakhloo et al. (2024) argue that the future of manufacturing will increasingly depend on firms' ability to leverage digital technologies not merely for efficiency but for adaptive resilience and collaborative sustainability. Their systematic review underscores nine core functional imperatives for manufacturing firms—including operational resource efficiency, proactive environmentalism, circular-smart product development, and sustainable business model innovation—all of which support a more holistic and value-driven evolution beyond the limited productivity-focused goals of early Industry 4.0 implementations. Similarly, Lu (2025) reinforces this perspective by advocating for the integration of AI-driven industrial ecosystems with human augmentation principles. Rather than substituting labour, Lu suggests a future in which AI collaborates with humans to enable context-aware decision-making and flexible customisation—features that are vital in volatile and hypercompetitive markets. Lu’s study highlights that emerging technologies, when guided by human-centric principles, can bridge the innovation gap between automation and social accountability. Taken together, the trajectory from Industry 4.0 to Industry 5.0 is not simply a linear technological progression but a paradigmatic recalibration—one that foregrounds resilience, inclusiveness, and ethical responsibility. While the Smart Factory remains an essential milestone, the manufacturing sector’s future success may

well depend on its ability to internalise these evolving priorities and resist the reductive pursuit of automation for automation's sake. Therefore, a more integrative approach—where technology, people, and planet are not siloed but symbiotic—should define the next phase of industrial transformation.

1.1.5 The Rise of Society 5.0 in Industry 5.0

The ongoing transformation of manufacturing is steering the industrial landscape towards a more human-centric paradigm under the conceptual frameworks of Industry 5.0 and Society 5.0. Elangovan (2021) notably advances this trajectory by advocating for the integration of human intelligence into industrial collaborative robotics. This evolution marks a distinct shift from the machine-dominated narrative of Industry 4.0, refocusing attention on the augmentation rather than the replacement of human labour. In doing so, it paves the way for upskilling the workforce into high-value domains such as AI, robotics, analytics, and IoT-driven applications (Wilson & Daugherty, 2018). Rather than a continuation of full automation, Industry 5.0 repositions human values and wellbeing as central to technological innovation.

Society 5.0, originally championed by Japan, offers a progressive vision of this integration by placing human needs and societal advancement at the core of technological development (Gladden, 2019; Narvaez Rojas et al., 2021). Within this context, Fonda and Meneghetti (2022) propose that the future manufacturing environment will require not only technological integration but also the active participation of workers in identifying process changes, suggesting improvements, and engaging in continuous training supported by evaluative control systems. Elim and Zhai (2020) reinforce this notion through their proposition of a control model governed by advanced cognitive functions such as comprehension, synthesis, and innovation—

characteristics that are quintessential to Society 5.0. Machine learning and AI thus act as dual enablers: they advance manufacturing intelligence while also acting as interactional bridges between humans and machines. This is evident in the work of Johri et al. (2021), who underscore the importance of psychological and neuroscientific research in developing systems capable of predicting human responses and adapting robotic behaviour accordingly. These arguments coalesce with the vision outlined by Demir and Cicibas (2017), who assert that Industry 5.0 must go beyond the efficiency goals of Industry 4.0 and embrace resilience, collaboration, and sustainability.

Recent contributions further elaborate this shift. Leng et al. (2024) argue that the transformation from Industry 4.0 to Industry 5.0 is not merely a technological evolution but an ontological reconfiguration of production systems in which humans co-create value with intelligent machines. Their findings suggest that smart manufacturing must be enriched with emotional intelligence and contextual awareness if it is to achieve sustainable performance outcomes. Similarly, Yao et al. (2024) posit that the effective implementation of Industry 5.0 depends on the realignment of organisational culture towards participatory leadership and cross-disciplinary collaboration. They contend that the “human-centric” label of Industry 5.0 must be supported by systemic strategies to embed inclusivity, adaptability, and ethical accountability into digital transformations. The empirical work by Deleryd and Fundin (2025) aligns with these arguments, asserting that the manufacturing systems of the future will require a dual focus on technological maturity and human readiness. Their research highlights the need for collaborative decision-making frameworks, real-time transparency, and digital literacy across all organisational layers as preconditions for successful Industry 5.0 deployment.

Despite the promising outlook, Society 5.0 remains a contested and evolving concept. Gladden (2019) projects speculative yet plausible scenarios where AI entities, technologically enhanced humans, or autonomous robots co-inhabit human spaces, akin to companion animals or assistive personnel. These visions, while provocative, highlight the urgency of interdisciplinary inquiry into the socio-ethical ramifications of this technological synthesis. In conclusion, the rise of Society 5.0 within Industry 5.0 reflects a decisive departure from mechanistic automation towards a more integrated, humane, and sustainable model of industrial advancement. However, the transition is fraught with challenges—ranging from workforce reskilling to value alignment between technology and human welfare. As such, future research must not only track technological trajectories but also interrogate the societal infrastructures and governance systems required to nurture this evolution meaningfully.

1.2 Problem Statement

The transition from Industry 4.0 to Industry 5.0 has brought forth renewed calls for human-centricity, resilience, and sustainability as pivotal pillars for advancing social and economic sustainability (Ivanov, 2023; Saniuk et al., 2022). While Industry 4.0 enabled rapid digitalisation, it often resulted in fragmented knowledge dissemination, impeding the collective adoption of shared values and undermining interdisciplinary collaboration (Lee et al., 2014; Palazzeschi et al., 2018). Society 5.0, as envisioned by the Japanese government, seeks to transcend these limitations by embedding AI and cyber-physical systems into the societal fabric, promoting inclusive innovation through knowledge sharing and stakeholder collaboration (Shiroishi et al., 2018; Nakanishi, 2019). However, this human-centric paradigm remains in its

formative stages, and its translation into practical, collaborative capabilities across sectors is far from resolved (Gladden, 2019; Deguchi et al., 2020).

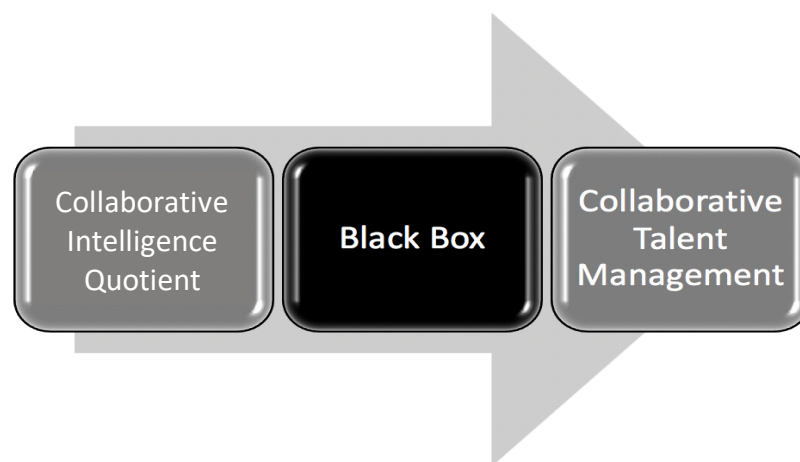
This emerging landscape highlights the need for collaboration between humans and AI systems, where collective intelligence evolves into collaborative intelligence—defined by intentional, synergistic knowledge generation and problem-solving (Malone, 2004; D’Almeida & Ingle, 2020). While the literature on collective intelligence is longstanding, its shift toward collaborative intelligence, particularly within workplace and talent ecosystems, has received limited attention. Markova and McArthur (2015) proposed the Collaborative Intelligence Quotient (CIQ) as a neuroscientific and behavioural model for cross-functional teamwork, integrating ‘mind patterns’, ‘thinking talents’, ‘inquiry’, and ‘mind share’ to enhance alignment and creativity. Yet, CIQ remains under-theorised and empirically underdeveloped, especially within complex organisational settings that demand rapid adaptability (Yalenios & D’Armagnac, 2022).

More recently, Ghobakhloo et al. (2024) argue that AI-driven platforms could amplify collaboration by augmenting human cognitive diversity, yet also caution that such augmentation could exacerbate organisational tensions if not humanely managed. Leng et al. (2024) observe that despite increasing technological integration in the workplace, firms often neglect the socio-cognitive foundations of digital collaboration—leading to superficial adoption without meaningful knowledge co-creation. Likewise, Yao et al. (2024) warn that the lack of standardised digital collaboration protocols has created knowledge silos, eroding employee engagement and collaborative initiative. These concerns underscore Kazemian and Grant’s (2024) findings that knowledge sharing in digital spaces is impeded by emotional reluctance,

time constraints, and resistance to collaboration platforms. Furthermore, organisational resilience in the VUCA-RR environment—marked by volatility, uncertainty, complexity, ambiguity, radical innovation, and rapid response (Akkaya & Ahmed, 2022)—demands a reinvention of leadership and talent management practices (George, 2017; Kotter, 1999; Whysall et al., 2019). Talent management itself is fraught with theoretical fragmentation and definitional ambiguity, lacking consensus on its scope and execution (Collings & Mellahi, 2009; Sparrow, 2019). Despite this, studies confirm that integrated talent strategies leveraging collaboration and data analytics improve firm performance (Schweer et al., 2012), a notion echoed by major consultancies such as IBM and McKinsey.

In the Malaysian manufacturing and technology sectors—especially among SMEs—persistent challenges such as talent shortages, digital inertia, fragmented leadership structures, and limited absorptive capacity have undermined the success of digital transformation initiatives. Despite policy interventions and technological investments, many organisations continue to struggle with integrating human capital

Figure 1.1 The CTM ‘Black Box’



strategies and AI-driven processes into a cohesive, future-ready workforce development model (Wong & Kee, 2022; Almatari et al., 2023; Techanamurthy et al.,

2025). Within this context, the emergence of Collaborative Talent Management (CTM)—anchored in the Collaborative Intelligence Quotient (CIQ) and facilitated by artificial intelligence (AI)—presents a promising yet underdeveloped domain of inquiry. While practitioners have experimented with tools such as network mapping, people analytics, and talent visualisation to support decision-making (Boomer, 2021; Meier, 2022; Woolf, 2014), there remains limited conceptual clarity on how human-AI collaboration can be systematically designed, scaled, and sustained within real-world talent systems. This is particularly acute in resource-constrained environments where organisations lack the infrastructure and frameworks to make sense of AI’s role beyond automation (Wilson & Daugherty, 2018; Pols, 2019). The problem is compounded by the absence of models that translate CIQ from an abstract mindset into a practical capability for organisational learning, leadership, and innovation. As Deleryd and Fundin (2025) argue, rethinking governance models for human-technology partnerships is essential to ensure inclusive participation and innovation equity in the digital economy. At the heart of this challenge lies an unexplored ‘black box’—a theoretical and operational space that obscures the mechanisms through which CIQ, AI, and talent management interact under the principles of Society 5.0. This research contends that until the inner workings of this black box are unpacked—i.e., how collaborative intelligence is activated, how AI and human agents co-create value, and under what conditions CTM can be operationalised—both academic insight and managerial action will remain fragmented. Accordingly, this doctoral inquiry aims to decode the architecture of this black box (refer to Figure 1.1), uncovering the mechanisms, enabling conditions, and contextual nuances of CTM in Malaysian manufacturing and tech SMEs. In doing so, it seeks to close the empirical and

theoretical gaps that currently impede organisations from leveraging AI-human collaboration as a strategic capability for resilience and innovation.

1.3 Research Questions

In line with the rationale to address the identified gaps in both academic literature and real-world application, this study seeks to provide comprehensive answers to the following research questions, focusing specifically on Malaysia's manufacturing and technology sectors:

1. How does collaborative intelligence quotient (CIQ) contribute to the facilitation of collaborative talent management in Society 5.0?
2. What roles do artificial intelligence (AI) in promoting and supporting collaborative talent management within the workplace environment during Industry 5.0?
3. How can we define collaborative talent management (CTM) in a contemporary and meaningful way that captures its evolving dynamics and implications in the modern Industry 5.0 ready workplace?

By addressing these questions, this research aims to offer an enhanced understanding of the interplay between CIQ and talent management, and to develop a contemporary, robust definition of collaborative talent management.

1.4 Research Objectives

In keeping with the research questions posed, this study sets forth several key objectives aimed at deepening our understanding of collaborative talent management within the context of AI and CIQ. These objectives are as follows: