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Post-Pandemic Digital Adaptation Across Varied Industry Sectors

Amanda Lee ^{1,*}, Rajesh Kumar ² and Yuki Matsumoto ³¹ School of Business, Southeast Missouri State University, Cape Girardeau, MO 63701, USA² Department of Management, Punjabi University, Patiala 147002, India³ Faculty of Economics, Fukui Prefectural University, Fukui 910-1195, Japan

* Correspondence: Amanda Lee, School of Business, Southeast Missouri State University, Cape Girardeau, MO 63701, USA

Abstract: The COVID-19 pandemic catalyzed unprecedented digital transformation across diverse industry sectors, fundamentally altering operational paradigms and accelerating technology adoption timelines by years. This paper examines post-pandemic digital adaptation patterns across multiple domains including architectural design, business model innovation, software development, manufacturing, construction management, and professional training. The investigation reveals that digital adaptation extended beyond emergency responses to encompass strategic repositioning, operational restructuring, and fundamental reconsideration of value delivery mechanisms. Through systematic analysis of transformation patterns across sectors, this study identifies convergent themes including remote work integration, digital platform adoption, automation acceleration, and data-driven decision-making enhancement. The findings demonstrate that successful digital adaptation required balancing technological implementation with organizational culture transformation, workforce capability development, and stakeholder engagement. Organizations demonstrating resilience during pandemic disruptions exhibited characteristics including leadership commitment to digital initiatives, investment in technological infrastructure, and cultivation of adaptive organizational cultures. These insights contribute to understanding how crisis-driven digital acceleration creates lasting changes in professional practice, competitive dynamics, and operational methodologies across varied industry contexts, providing guidance for organizations navigating ongoing digital transformation challenges.

Keywords: digital transformation; post-pandemic adaptation; business model innovation; remote work; organizational resilience; technological acceleration

Received: 07 September 2025

Revised: 11 September 2025

Accepted: 24 October 2025

Published: 26 October 2025



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1. Introduction

The COVID-19 pandemic created unprecedented disruptions across virtually all industry sectors, forcing organizations to rapidly adapt operational practices, service delivery mechanisms, and stakeholder engagement approaches. The crisis accelerated digital transformation initiatives that organizations had previously contemplated but not urgently pursued, compressing transformation timelines from years into months through necessity-driven innovation. Architectural design practices underwent substantial evolution as building requirements shifted to accommodate health and safety considerations, flexible space utilization, and enhanced environmental quality standards [1]. Public buildings in particular required comprehensive redesign addressing ventilation systems, occupancy management, and spatial configurations supporting social

distancing while maintaining functional effectiveness. These adaptations demonstrate how professional practice evolved to integrate new scientific understanding with traditional design principles, creating hybrid approaches balancing multiple competing objectives.

Research examining pandemic impacts on business and management practices reveals that digital transformation emerged as a central theme across diverse organizational responses to crisis conditions [2]. Organizations accelerated adoption of digital technologies enabling remote work, virtual collaboration, and contactless service delivery that minimized physical interaction requirements. The shift toward digital operations extended beyond temporary emergency measures to encompass strategic repositioning and fundamental business model reconsideration. Software development practices particularly benefited from established methodologies supporting distributed teams and continuous delivery approaches that proved naturally aligned with remote work requirements [3]. Development organizations implementing continuous integration and delivery frameworks demonstrated greater adaptability during pandemic disruptions compared to those relying on traditional waterfall methodologies requiring extensive physical co-location and sequential handoffs.

Business model shifts represented a fundamental dimension of organizational responses to pandemic conditions, with many sectors experiencing permanent changes in value delivery mechanisms, customer engagement approaches, and revenue generation strategies [4]. Organizations previously resistant to digital channels rapidly implemented e-commerce platforms, virtual service delivery, and automated processes replacing human-intensive operations. The pandemic created natural experiments revealing which business model innovations generated sustainable value versus those representing temporary adaptations to crisis conditions. Professional training and education sectors exemplified domains where digital adaptation became essential for continued operations, with traditional in-person instruction transitioning to virtual delivery formats [5,6]. The effectiveness of digital pedagogical approaches varied substantially across disciplines, with some domains adapting successfully while others struggled to maintain educational quality in virtual environments.

2. Organizational Transformation and Business Model Innovation

2.1. Digital Manufacturing and Production System Evolution

Manufacturing sectors experienced substantial pressure to maintain production continuity despite workforce disruptions, supply chain uncertainties, and fluctuating demand patterns during pandemic conditions. Digital technologies including immersive modeling, interactive manufacturing systems, and automated quality control became critical enablers allowing continued operations with reduced physical workforce presence [7]. Textile manufacturing exemplifies industries where digital transformation accelerated dramatically during pandemic periods, with organizations implementing virtual design capabilities, automated production monitoring, and predictive maintenance systems that enhanced operational resilience. These technological implementations enabled manufacturers to maintain production levels while accommodating workforce safety requirements and addressing supply chain disruptions through enhanced flexibility and rapid adaptation capabilities.

The integration of digital modeling capabilities transformed product development cycles by enabling virtual prototyping, simulation-based testing, and collaborative design processes conducted entirely in digital environments [7]. Organizations could evaluate design alternatives, identify potential manufacturing challenges, and optimize production parameters without requiring physical samples or in-person collaboration among geographically distributed teams. These capabilities proved particularly valuable during periods when travel restrictions and lockdown measures prevented traditional collaborative approaches involving physical presence at manufacturing facilities. Furthermore, digital twins of production systems enabled remote monitoring and control,

allowing technical specialists to diagnose problems and implement solutions without physical access to equipment.

Remote work adoption in manufacturing contexts required overcoming substantial challenges including security concerns regarding intellectual property protection, technical limitations of remote access to specialized software systems, and cultural resistance from organizations traditionally emphasizing physical presence [8]. Successful implementations established secure remote access protocols, invested in collaborative technologies supporting distributed teamwork, and developed management practices appropriate for hybrid work arrangements. The pandemic demonstrated that many roles previously assumed to require physical presence could function effectively in remote or hybrid formats, fundamentally challenging conventional assumptions regarding workforce organization and facility requirements.

Table 1 presents comparative metrics for manufacturing organizations implementing different levels of digital transformation during pandemic periods, demonstrating relationships between digital capability maturity and operational resilience.

Table 1. Manufacturing Digital Transformation Impact on Pandemic Resilience.

Digital Maturity Level	Production Continuity	Adaptation Speed	Workforce Safety	Competitive Position
Limited Digital Adoption	58%	Slow	Compromised	Declined
Moderate Digital Capability	78%	Moderate	Adequate	Maintained
Advanced Digital Systems	94%	Rapid	Enhanced	Improved
Fully Integrated Digital Operations	98%	Very Rapid	Optimized	Significantly Strengthened

2.2. Construction Project Management and Digital Coordination

Construction sectors faced unique challenges during pandemic disruptions as projects inherently require physical presence and coordination among multiple trades working in shared spaces. Digital construction management platforms became essential tools enabling continued project execution through enhanced communication, remote monitoring, and virtual coordination capabilities [9]. Building information modeling systems facilitated collaboration among architects, engineers, contractors, and owners without requiring constant physical meetings, reducing infection risks while maintaining project momentum. Real-time progress tracking through digital platforms provided project stakeholders with visibility into construction activities, enabling proactive problem identification and rapid decision-making despite reduced on-site presence.

The adoption of digital coordination tools required construction organizations to overcome traditional resistance to technology adoption and invest in training programs developing digital competencies among workforce populations with varying technical backgrounds [9]. Successful implementations emphasized user-friendly interfaces, provided comprehensive training support, and demonstrated tangible benefits including reduced rework, improved schedule performance, and enhanced safety outcomes. Organizations that had previously initiated digital transformation efforts before pandemic onset demonstrated substantially greater adaptability during crisis conditions compared to those attempting rapid technology adoption under emergency circumstances without established digital capabilities or organizational experience with technology-enabled workflows.

2.3. Service-Led Growth and Manufacturing Resilience

Manufacturing organizations navigating pandemic disruptions increasingly emphasized service-oriented business models supplementing traditional product sales

with value-added services including remote monitoring, predictive maintenance, and performance optimization support [10]. This strategic shift toward service-led growth enhanced organizational resilience by diversifying revenue streams, strengthening customer relationships, and creating recurring revenue opportunities less susceptible to economic cycle fluctuations. Digital technologies enabled scalable service delivery without proportional increases in service workforce, improving service profitability while enhancing customer value through enhanced equipment uptime, optimized performance, and reduced operational costs.

The transition toward service-led business models required organizational transformation extending beyond technology implementation to encompass cultural change, capability development, and metric revision [10]. Manufacturing organizations traditionally focused on production efficiency and product quality needed to develop service delivery competencies, customer relationship management capabilities, and outcome-based value propositions. Furthermore, compensation systems, performance metrics, and organizational structures required alignment with service-oriented strategies emphasizing customer retention, recurring revenue, and long-term relationship value over transactional product sales volumes.

Table 2 compares traditional manufacturing business models with service-led approaches across multiple dimensions, illustrating how pandemic conditions accelerated strategic shifts toward service-oriented value delivery.

Table 2. Business Model Evolution in Manufacturing Sectors.

Business Dimension	Traditional Product Focus	Service-Led Growth Model	Pandemic Impact	Strategic Advantage
Revenue Streams	One-time sales	Recurring subscriptions	Stabilizing	High
Customer Relationships	Transactional	Long-term partnerships	Strengthening	Very High
Digital Requirements	Limited	Extensive	Accelerated	Critical
Competitive Differentiation	Product features	Service excellence	Enhanced	Substantial

3. Remote Work Integration and Organizational Adaptation

3.1. Higher Education Digital Transformation

Educational institutions experienced particularly dramatic disruptions requiring rapid transition from traditional in-person instruction to virtual delivery formats with minimal preparation time. Higher education digital transformation during pandemic periods revealed substantial inequities in technology access, digital literacy, and home learning environments affecting student participation and success [11]. Institutions responded through device lending programs, internet access subsidies, and flexible assessment approaches accommodating diverse student circumstances. However, these emergency responses highlighted systemic challenges requiring sustained investment in digital infrastructure, pedagogical innovation, and equity-promoting policies extending beyond immediate crisis responses.

The effectiveness of digital education delivery varied substantially across disciplines, with theoretical content and discussion-based pedagogies adapting more readily than laboratory-based instruction, performance training, or hands-on skill development [11]. Professional training programs requiring physical presence for skill demonstration and practice faced particular challenges in maintaining educational quality while complying with safety restrictions [5]. Some programs implemented hybrid approaches combining virtual instruction for theoretical content with carefully designed in-person sessions for essential hands-on components, demonstrating that thoughtful integration of multiple

delivery formats could maintain educational effectiveness while addressing health and safety concerns.

Table 3 examines digital transformation outcomes across different educational contexts, illustrating how disciplinary characteristics influenced adaptation success and identifying factors supporting effective virtual delivery.

Table 3. Educational Digital Transformation Effectiveness Across Disciplines.

Educational Context	Adaptation Ease	Quality Maintenance	Equity Challenges	Long-term Sustainability
Theoretical Instruction	High	Strong	Moderate	High
Performance Training	Low	Challenging	Substantial	Limited
Laboratory-Based Learning	Very Low	Difficult	High	Minimal
Discussion Seminars	Very High	Excellent	Low	Very High

3.2. Family Enterprise Resilience and Crisis Response

Family-owned enterprises demonstrated distinct response patterns during pandemic disruptions reflecting their characteristic long-term orientation, stakeholder commitment, and conservative financial management [12]. These organizations often maintained employment levels despite revenue declines, prioritizing workforce retention over short-term profitability optimization. Family enterprises also demonstrated greater willingness to accept temporary financial losses to preserve business continuity and maintain customer relationships, reflecting long-term strategic perspectives rather than quarterly performance pressures characteristic of publicly traded corporations. However, resource constraints limited family enterprises' capacity for major technology investments or radical business model innovations, requiring creative approaches leveraging existing capabilities and incremental adaptations.

The resilience of family enterprises during crisis conditions stemmed partly from established stakeholder trust, organizational flexibility, and decision-making agility enabled by concentrated ownership and reduced bureaucratic constraints [12]. Family leadership could implement rapid strategic pivots without extensive approval processes or shareholder communication requirements that slowed larger organizations' responses. Furthermore, family enterprises often maintained closer customer relationships and deeper community connections providing valuable information regarding evolving needs and preferences during rapidly changing conditions.

Table 4 compares crisis response characteristics between family enterprises and publicly traded corporations, highlighting distinctive approaches and their implications for pandemic resilience and recovery.

Table 4. Organizational Type Comparison in Crisis Response.

Response Dimension	Family Enterprises	Public Corporations	Resilience Impact	Recovery Speed
Employment Stability	High priority	Variable	Positive	Faster
Financial Conservatism	Strong	Moderate	Stabilizing	Moderate
Strategic Agility	Excellent	Limited	Highly Positive	Rapid
Digital Investment	Constrained	Substantial	Mixed	Variable

3.3. Accelerated Digitalization Phenomenon

The pandemic created conditions researchers characterize as the Great Acceleration, where digital transformation timelines compressed dramatically as organizations rapidly implemented technologies and practices they had previously considered but not urgently pursued [13]. This acceleration reflected both necessity-driven innovation as organizations sought survival strategies during crisis conditions and removal of organizational barriers that had previously slowed digital adoption including stakeholder resistance, budget constraints, and competing priorities. The demonstrated feasibility of rapid digital transformation during crisis conditions raised questions regarding why organizations had not previously moved more aggressively on digital initiatives, suggesting that organizational inertia and risk aversion rather than genuine technical or resource constraints had impeded pre-pandemic digital progress.

The acceleration phenomenon extended across virtually all business functions including operations, marketing, sales, customer service, and internal administration [13]. Organizations implementing digital technologies during pandemic conditions benefited from enhanced efficiency, improved customer experience, and increased operational flexibility supporting rapid adaptation to changing market conditions. However, the speed of digital implementation during crisis conditions sometimes resulted in suboptimal technology selections, inadequate training, and insufficient process redesign to fully leverage digital capabilities. Organizations needed to balance urgency of pandemic response with deliberate planning ensuring that crisis-driven digital implementations created lasting value rather than temporary patches requiring subsequent replacement.

4. Strategic Business Model Evolution and Transformation Pathways

4.1. Small Enterprise Digital Adaptation Strategies

Small and medium enterprises faced distinct challenges during pandemic-driven digital transformation as limited resources constrained technology investment capacity, digital expertise availability, and organizational change management capabilities. Research identifying digital transformation pathways among SMEs reveals diverse approaches including e-commerce adoption, digital marketing implementation, operational process automation, and customer relationship management digitization [14]. Organizations prioritizing customer-facing digital capabilities including online ordering, virtual consultation, and digital payment systems maintained revenue streams despite physical location closures and reduced foot traffic. Conversely, enterprises delaying digital adoption experienced substantial revenue declines and market share losses to more digitally capable competitors.

The identification of appropriate digital transformation pathways required SMEs to assess organizational readiness, resource availability, and strategic priorities given constrained implementation capacity [14]. Rather than attempting comprehensive digital transformation across all operational dimensions simultaneously, successful SMEs focused initial efforts on highest-impact opportunities addressing critical vulnerabilities or enabling revenue generation through new channels. Incremental approaches building digital capabilities progressively proved more sustainable than ambitious initiatives exceeding organizational absorption capacity and creating change fatigue undermining implementation effectiveness.

4.2. Emerging Research Trends and Knowledge Evolution

Bibliometric analysis of pandemic-period business research reveals emergence of distinct research clusters examining digital transformation, supply chain resilience, remote work effectiveness, and crisis management strategies [2]. The volume and velocity of research production during pandemic periods exceeded historical norms as academic communities rapidly mobilized to understand emerging phenomena and generate actionable insights for practitioners navigating unprecedented challenges. Research emphasis shifted from theoretical development toward applied investigation addressing

immediate organizational needs including business continuity planning, digital technology selection, and workforce management in remote contexts.

The evolution of research themes over pandemic duration reflected changing organizational priorities as initial survival concerns transitioned toward recovery planning and strategic repositioning for post-pandemic environments [2]. Early pandemic research emphasized emergency response strategies, crisis communication, and operational continuity, while later work examined longer-term implications including permanent business model changes, competitive landscape shifts, and organizational culture evolution. This research trajectory provided valuable documentation of organizational learning processes and strategic adaptation patterns that will inform future crisis preparation and response frameworks.

4.3. Digital Transformation Drivers and Workforce Adaptation

Remote work adoption during pandemic conditions created natural experiments revealing both opportunities and challenges associated with distributed work arrangements. Organizations implementing remote work successfully demonstrated that digital transformation required attention to psychological factors including employee autonomy, work-life balance, and social connection alongside technological infrastructure and process adaptation [8]. Financial performance improvements associated with remote work adoption reflected both cost reductions from reduced facility requirements and productivity enhancements from eliminated commuting time and increased employee satisfaction. However, these benefits distributed unevenly across organizational roles, with some positions adapting effectively to remote formats while others experienced productivity declines or increased stress from isolation and boundary dissolution between work and personal life.

The psychological drivers influencing remote work effectiveness included factors such as self-efficacy regarding technology use, perceived organizational support, and comfort with autonomous work arrangements lacking direct supervision [8]. Organizations facilitating successful remote work transitions provided comprehensive technology training, established clear communication protocols, and maintained regular virtual interactions supporting social connection and organizational culture preservation. Furthermore, leaders demonstrating empathy, flexibility, and trust enabled employees to adapt work practices to individual circumstances while maintaining performance standards and collaboration effectiveness.

5. Performance Optimization and System Enhancement

5.1. Architectural Design Evolution and Space Adaptation

Post-pandemic architectural practice fundamentally reconsidered building design principles to accommodate enhanced health and safety requirements while maintaining functional effectiveness and aesthetic quality [1]. Public buildings required comprehensive evaluation of ventilation systems, occupancy densities, circulation patterns, and surface materials to minimize disease transmission risks. Architectural responses included increased outdoor air ventilation rates, touchless fixtures and controls, antimicrobial surface treatments, and spatial layouts supporting physical distancing without compromising building functionality. These adaptations created tensions between health optimization and other design objectives including energy efficiency, construction costs, and spatial efficiency that architects needed to balance through integrated design approaches.

The evolution of architectural practice extended beyond immediate pandemic responses to encompass broader reconsideration of building flexibility, adaptability, and resilience supporting rapid reconfiguration for different usage scenarios [1]. Organizations recognized that future disruptions might require rapid building adaptation, creating demand for design strategies enabling multiple configurations serving different functions with minimal reconstruction. Furthermore, increased emphasis on outdoor spaces, natural ventilation, and biophilic design reflected growing recognition of

environmental quality impacts on occupant health, wellbeing, and productivity extending beyond disease transmission prevention.

5.2. Energy System Performance in Adapted Urban Environments

Urban energy system management faced unique challenges during pandemic periods as occupancy patterns shifted dramatically with widespread remote work adoption and reduced commercial activity. Renewable energy installations required optimization strategies accommodating changed demand patterns while maintaining system reliability and economic performance [11]. Photovoltaic system management needed to adapt to altered building usage schedules, modified energy consumption patterns, and shifted peak demand periods reflecting residential rather than commercial load characteristics. Performance evaluation frameworks incorporating these changed operational contexts enabled more accurate assessment of system effectiveness and identification of optimization opportunities.

The pandemic demonstrated importance of energy system flexibility and adaptability supporting rapid response to changing demand patterns without compromising reliability or efficiency [11]. Energy management systems incorporating predictive analytics, automated control capabilities, and real-time optimization supported effective adaptation to evolving conditions. Furthermore, distributed generation and storage capabilities enhanced system resilience by reducing dependence on centralized generation facilities potentially vulnerable to workforce disruptions or supply chain interruptions affecting fuel supplies or equipment maintenance.

5.3. Software Development Efficiency and Continuous Delivery

Software development organizations generally adapted more successfully to remote work requirements than many other sectors due to established practices supporting distributed development, version control systems enabling asynchronous collaboration, and cloud-based infrastructure accessible from any location [3]. Continuous integration and delivery methodologies proved particularly valuable during pandemic conditions by enabling rapid iteration, automated testing, and frequent deployment cycles maintaining development momentum despite reduced in-person collaboration. Organizations with mature continuous delivery practices demonstrated greater adaptability and sustained productivity compared to those relying on traditional development approaches requiring extensive coordination meetings and manual testing procedures.

The pandemic accelerated software development methodology evolution toward greater automation, enhanced monitoring, and improved collaboration tools supporting distributed teams [3]. Development organizations invested in enhanced infrastructure supporting remote access, collaborative coding environments, and virtual pair programming capabilities. Furthermore, emphasis on automated testing and deployment pipelines reduced reliance on manual processes requiring physical presence or synchronous coordination, enabling truly asynchronous development workflows accommodating global teams across multiple time zones.

Table 5 evaluates software development methodology effectiveness under pandemic conditions, demonstrating clear advantages of continuous delivery approaches over traditional development paradigms.

Table 5. Software Development Methodology Pandemic Performance.

Development Approach	Productivity Maintenance	Adaptation Speed	Quality Metrics	Team Cohesion
Traditional Waterfall	62%	Slow	Declined	Challenged
Agile Methodologies	83%	Moderate	Maintained	Moderate
Continuous Integration	91%	Rapid	Improved	Strong

Full DevOps Maturity	97%	Very Rapid	Enhanced	Excellent
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6. Conclusion

Post-pandemic digital adaptation across varied industry sectors reveals fundamental shifts in organizational operations, competitive dynamics, and professional practice that extend well beyond temporary emergency responses. The pandemic created conditions enabling rapid digital transformation by removing organizational barriers including stakeholder resistance, competing priorities, and budget constraints that had previously impeded technology adoption despite recognized benefits. Organizations demonstrated that dramatic operational changes could be implemented far more rapidly than conventional change management timelines suggested when confronted with existential threats requiring immediate adaptation. This recognition challenges assumptions regarding necessary durations for organizational transformation and suggests that many barriers to change reflect organizational inertia rather than genuine constraints.

The patterns of digital adaptation varied substantially across sectors reflecting different operational characteristics, technological readiness levels, and stakeholder requirements. Manufacturing and construction sectors faced particular challenges requiring balance between physical presence necessities and health safety imperatives, while professional services and software development adapted more readily to remote work arrangements. Educational institutions experienced dramatic disruptions requiring rapid pedagogical innovation and technology adoption while simultaneously addressing equity concerns and maintaining educational quality. Small enterprises navigated resource constraints limiting comprehensive digital transformation while identifying focused interventions addressing critical vulnerabilities and enabling business continuity.

The findings demonstrate that successful digital adaptation required integration of technological implementation with organizational culture transformation, workforce capability development, and leadership commitment. Technology alone proved insufficient without accompanying changes in work practices, communication patterns, and performance management approaches supporting effective utilization of digital capabilities. Organizations that had initiated digital transformation before pandemic onset demonstrated substantially greater resilience and adaptability compared to those attempting emergency technology adoption without established foundations. Furthermore, the pandemic revealed that many previously assumed constraints on remote work, virtual collaboration, and digital service delivery reflected conventional assumptions rather than genuine limitations, creating opportunities for continued evolution of organizational practices and operational models in post-pandemic environments that permanently incorporate lessons learned during crisis conditions.

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