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Reconfiguring Industrial Systems in the Era of the Fourth Industrial Revolution: The Role of Artificial Intelligence and Virtual Reality

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Artificial Intelligence; Virtual Reality; Industry 4.0; Industrial Systems; Productivity; Competitiveness; Digital Transformation; Workforce Skills; Innovation; Industrial Policy

Abstract

The Fourth Industrial Revolution is fundamentally reshaping industrial systems through the diffusion of advanced digital technologies, with profound implications for productivity, competitiveness, and structural transformation. This paper examines the economic role of Artificial Intelligence (AI) and Virtual Reality (VR) in the reconfiguration of industrial systems within the industry 4.0 framework. From an economic perspective, the study analyzes how AI contributes to predictive maintenance, process optimization, and intelligent resource allocation, thereby reducing operational costs and enhancing production efficiency. At the same time, VR supports workforce training, product development, and process simulation, improving human capital formation and accelerating innovation cycles. The interaction between AI-driven analytics and immersive VR environments strengthens firms' innovation capacity and operational flexibility, enabling faster adaptation to market and technological changes. Furthermore, the paper discusses broader economic implications related to labor market adjustments, skill upgrading requirements, and investment patterns in digital technologies. By integrating technological and economic dimensions, the study highlights how AI and VR act as complementary drivers of industrial upgrading and competitiveness, offering important insights for industrial policy and strategies aimed at fostering sustainable growth in digitally transforming economies

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1 Introduction

1.1. Definition and Overview of the Fourth Industrial Revolution

The Fourth Industrial Revolution, or Industry 4.0, marks a new era in manufacturing by integrating advanced digital technologies with production processes. It builds on earlier revolutions like mechanization, electrification, and automation, aiming to create smart factories where cyber-physical systems, the Internet of Things (IoT), and artificial intelligence enhance productivity and streamline operations.

Industry 4.0 connects machines, devices, sensors, and people through extensive networks, enabling real-time communication across the value chain. This interconnectivity allows systems to monitor and adjust physical processes autonomously. While automation remains central, this revolution also encourages closer collaboration between humans and machines.

Originating in Germany as a strategic plan to lead advanced manufacturing, Industry 4.0 has become a global model for industrial progress. Key components include cyber-physical systems that merge physical workflows with digital data, IoT for constant data exchange, cloud computing for scalability, and AI-driven analytics that offer actionable insights.

These technologies help industries optimize production through predictive maintenance and improve flexibility, essential to keeping pace in rapidly changing markets. Smart factories use data-driven decisions to foster innovation and boost efficiency.

Industry 4.0 also relies on big data analytics to analyze the vast information produced in industrial environments. This capability aids in optimizing supply chains, enhancing product quality, and reducing costs.

By adopting Industry 4.0 strategies, companies can improve operational performance, meet evolving market demands, and address sustainability challenges. The focus on intelligent systems supports ongoing refinement and integration into daily business.

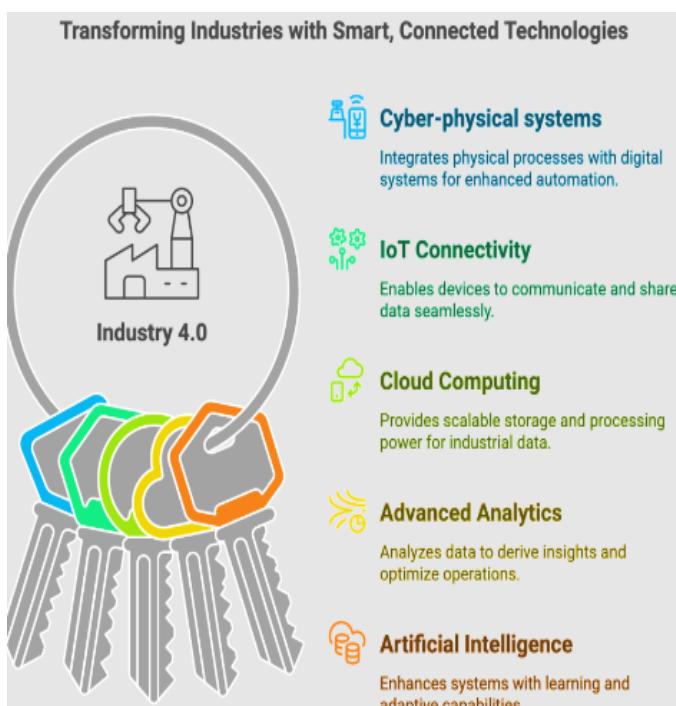


Figure 1: Components of Industry 4.0 (source: reference (Industry 4.0, 2025)



Figure 2: Four Industrial Revolutions and their foundations. (source: reference (Rashid & Kausik, 2024)

Additionally, this revolution embraces advanced robotics and machine learning to customize products to diverse customer needs. This adaptability is vital for serving varied markets with agility.

In summary, Industry 4.0 transforms manufacturing by embedding technology throughout the process. It promotes smarter, more flexible production that supports sustainable growth as economic conditions change. See references: (Rashid & Kausik, 2024) , (Industry 4.0 - Everything you need to know!, 2026) and (Industry 4.0, 2025).

1.2. Key Technologies Driving Change

The Fourth Industrial Revolution, or Industry 4.0, integrates advanced technologies into production and business. Artificial Intelligence (AI) and Virtual Reality (VR) play key roles in this transformation by enhancing efficiency and changing workforce management and product development.

AI supports Industry 4.0 by learning from data, predicting results, and automating tasks. For instance, AI-driven predictive maintenance uses sensor data to detect possible equipment failures before they occur. This approach reduces downtime and increases productivity. AI also optimizes manufacturing by adjusting machines in real time. Digital twins, virtual copies of physical assets, allow companies to simulate changes and forecast effects without stopping production. These tools promote continuous improvement and help businesses respond quickly to market demands.

VR complements AI by improving training and design processes. It provides immersive, safe environments for employees to practice complex skills, leading to faster and more effective learning compared to traditional methods. VR also helps reveal design flaws early through virtual prototypes and supports collaboration among distributed teams. This teamwork speeds up development and enhances product evaluation.

Together, AI and VR boost innovation and operational flexibility. Combining AI's data insights with VR's simulations accelerates prototyping and enriches decisions by applying past knowledge. This synergy streamlines workflows and encourages creativity in development.

Financially, these technologies drive productivity gains and better resource use. Increasingly, companies invest in AI automation and VR training to remain competitive and support sustainable growth.

The labor market is also evolving. Demand for tech-savvy workers grows, urging retraining of existing employees and creating new roles focused on human-technology collaboration.

AI and VR embody the transformative force of Industry 4.0, enabling organizations to excel in the evolving technological landscape. See references: (Rashid & Kausik, 2024)[1], (Industry 4.0 - Everything you need to know!, 2026), (Maisonneuve et al., 2024, pp. 6-10) and (Szeszák et al., 2025).

2. Impact of AI on Industrial Systems

2.1. Predictive Maintenance

Predictive maintenance stands out as a game-changer in applying artificial intelligence (AI) within industrial systems. It moves maintenance practices away from reactive fixes toward anticipatory, proactive care. By using machine learning and data analytics, this approach spots potential equipment issues before they arise. As a result, companies cut down on unexpected downtime and lower maintenance costs. Beyond just boosting efficiency, predictive maintenance also helps extend the life of machines and equipment.

At the heart of predictive maintenance lie machine learning algorithms that sift through extensive data from sensors placed on machinery. These sensors track vital signs like temperature, vibration, and pressure around the clock. Analyzing this information with statistical tools and pattern recognition enables early detection of anomalies. This way, teams can act swiftly to prevent breakdowns rather than reacting after the fact.

One popular method involves time-series analysis, which looks at past data to uncover trends or recurring patterns signaling potential failures. Regression models also come into play, forecasting future outcomes based on historical data. More advanced solutions employ deep learning networks to capture intricate patterns hidden in massive datasets, sharpening prediction abilities.

Real-world successes highlight the power of predictive maintenance. For example, a top automotive firm applied AI to its robotic assembly lines. By processing sensor data in real time, the company predicted equipment malfunctions with over 90% accuracy. This allowed maintenance during off-peak hours, slashing downtime by nearly a third over one year.

In the oil and gas industry, an international energy firm used AI-driven predictive maintenance on drilling rigs. They created digital twins—virtual copies of physical assets—to simulate different conditions and anticipate mechanical failures. This effort improved safety while boosting operational efficiency by minimizing unexpected halts.

The Internet of Things (IoT) further strengthens these systems by enabling constant communication between machines and monitoring centers. Operators receive instant updates about equipment status, making it easier to address problems quickly. Cloud computing supports this flow by handling vast amounts of data efficiently.

As Industry 4.0 technologies gain traction, more companies see that investing in AI-powered predictive maintenance does more than keep machines running. It encourages a mindset of continuous improvement, helping organizations stay resilient amid surprises while optimizing resource use. In this new industrial landscape, such forward-looking strategies have become a must for staying ahead. See references: (George, 2024) , (Industry 4.0 - Everything you need to know!, 2026), (Finio & Downie, 2015) and (Industry 4.0, 2025).

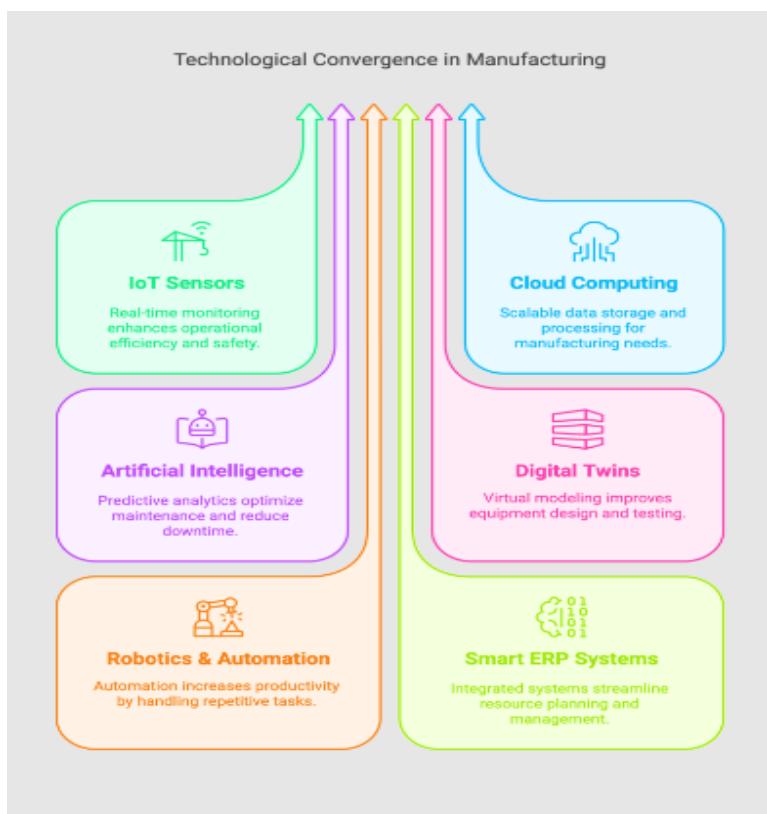


Figure 3: Convergence of Industry 4.0 and Manufacturing (source: reference (Industry 4.0, 2025).

2.2. Process Optimization

Artificial intelligence (AI) has become a vital asset in streamlining industrial processes across diverse manufacturing settings. By tapping into large volumes of data generated by machines and workflows, AI-powered methods help fine-tune operations, cut waste, and lower costs. Machine learning algorithms detect hidden patterns in production activities, allowing companies to foresee equipment breakdowns, schedule maintenance effectively, and enhance operational flows.

A standout breakthrough in AI-assisted process improvement is predictive analytics. This technology forecasts demand by blending historical records with live data from connected IoT devices. Knowing usage trends and anticipating shifts in demand lets manufacturers avoid excess inventory or overproduction. This approach not only saves money but also boosts how efficiently resources are used. Some reports note that overall equipment effectiveness (OEE) can climb by more than a quarter thanks to such insights.

Additionally, AI boosts production adaptability through smart control systems that respond instantly to real-time information. These systems tweak settings like throughput, energy use, and product standards automatically. For example,

machine learning models continuously assess production runs, finding the sweet spot between high-quality output and energy savings without needing human input.

Beyond factory floors, AI improvements extend to logistics by refining supply chain management with smart routing and freight optimization. A well-oiled supply chain ensures materials arrive just in time while trimming transport expenses—an essential factor for staying competitive in today's fast-moving markets.

The use of digital twins—virtual models of physical equipment—further highlights AI's influence on optimization. These simulations let businesses explore 'what-if' scenarios to see how adjustments might affect overall efficiency before applying changes live. This foresight helps reduce risks by testing plans without causing costly downtime.

Quality assurance also receives a boost from AI through advanced vision systems that spot defects more accurately than humans. Automated inspections combine high-resolution imaging with deep learning to catch tiny flaws quickly during production, raising product reliability.

Together, these AI-driven advances nurture a mindset of ongoing improvement within industrial operations. They deliver practical insights into every stage—from raw material processing to final assembly—accelerating productivity and shaping more sustainable and successful business models for the long run. See references: (Finio & Downie, 2015), (Rashid & Kausik, 2024), (Khan et al., 2025), (George, 2024) and (Industry 4.0 - Everything you need to know!, 2026).

3. Role of VR in Industrial Systems Reconfiguration

3.1. Workforce Training Applications

Bringing Virtual Reality (VR) into employee training marks a major leap in how companies get their workforce ready for real-world tasks. By creating immersive simulations, VR lets workers practice realistic job situations without facing the hazards of on-site training. This method is especially valuable in areas like manufacturing and maintenance, where errors can be costly or dangerous.

VR-based training builds lifelike scenarios tailored to industry-specific tasks. Trainees interact with virtual tools, machinery, and protocols they will use on the job. This hands-on approach lets employees build skills such as machine operation, safety procedures, and emergency responses—all without physical risks or resource constraints.

One big plus of VR training is its engaging, interactive nature. Users handle virtual equipment and explore environments that closely resemble their work surroundings. This type of involvement improves information retention more effectively than traditional classroom lessons. Research shows VR learners stay more motivated and perform better on tests.

VR training also cuts down the time needed to master new skills while boosting employee competence. With the need for skilled workers outstripping availability, these efficient programs help organizations prepare staff quickly for demanding roles.

The appeal of VR training goes beyond a single industry. Sectors from healthcare to aerospace apply VR modules customized to their needs. Surgeons, for example, use VR to practice procedures before working on patients. Engineers tap into virtual scenarios within an industrial metaverse—a connected system blending various immersive techs—to refine processes and promote teamwork among remote teams.

Using simulation-based training encourages ongoing learning cultures at organizations. When combined with AI-driven data analysis and insights from digital twin models mentioned earlier, firms can constantly upgrade their training based on actual job performance and feedback.

From a financial viewpoint, VR programs save money compared to traditional training by reducing downtime from live demos or machine breakdowns. Companies can also run multiple sessions simultaneously without extra labor or material costs common in conventional setups.

Adding AI into VR training raises its impact further through adaptive learning systems. These tailor lessons on the fly according to how each user performs, giving personalized coaching along the way.

In short, VR-powered simulation training offers a safe, cost-effective path for workers to gain the crucial skills needed for today's complex industrial environments. See references: (Maisonneuve et al., 2024, pp. 21-25) and (Zhang et al., 2025).

3.2. Product Development and Testing

Bringing Virtual Reality (VR) into product development and testing has reshaped how companies manage their workflows and improve product quality. VR enables engineers and designers to step inside immersive simulations that mirror real-world settings. This hands-on visualization helps pinpoint design problems early, so teams can tweak concepts before building physical prototypes, saving both time and money.

VR also bridges distances by linking team members spread across various locations. In these virtual spaces, stakeholders can explore and discuss product ideas together in real time. This shared experience encourages open feedback and ensures that diverse perspectives shape the innovation process.

Testing in a virtual realm adds another layer of efficiency. Complex products face virtual stress tests and performance checks without creating costly physical models. For example, automotive firms simulate crash impacts and airflow dynamics digitally, speeding design cycles and lowering expenses by reducing reliance on physical trials.

Beyond function, VR improves user experience evaluations by allowing real users to navigate virtual versions of products before manufacturing starts. These interactions reveal usability and comfort issues that traditional approaches like surveys might miss, offering valuable guidance for refinement.

VR's visualization goes deeper than looks; it extends to manufacturing feasibility. By simulating assembly lines or workflows, companies can fine-tune production plans before any machines run. This foresight uncovers bottlenecks and inefficiencies that could hamper productivity once actual manufacturing begins.

The addition of AI makes these VR simulations smarter. Adaptive systems learn from past design and testing rounds, analyzing data to suggest improvements and flag potential issues ahead of time.

As industries embrace these advantages, digital twins become more common—virtual counterparts of physical products that support continuous monitoring and enhancement throughout a product's life. Together, these technologies signal a shift toward smarter, faster, and more cost-effective product development driven by cutting-edge digital tools. See references: (Maisonneuve et al., 2024, pp. 21-25), (George, 2024), (Maisonneuve et al., 2024, pp. 11-15) and (Maisonneuve et al., 2024, pp. 26-30).

4. Synergy Between AI and VR Technologies

4.1. Enhancing Innovation Capacity

Blending AI with Virtual Reality in industrial settings sparks a wave of innovation that reshapes conventional methods and opens doors to fresh creativity and efficiency. Harnessing AI's power to sift through vast data sets helps industries spot patterns, streamline workflows, and build predictive models that sharpen decision-making. This fusion lets companies experiment with novel product concepts, fine-tune processes, and deliver solutions that once seemed out of reach.

AI fuels innovation by automating complex tasks and speeding up prototype development. For example, generative design tools churn out multiple versions of a product based on set criteria, giving engineers the chance to review numerous choices swiftly. This speeds up design timelines and encourages bold experimentation, often leading to breakthrough ideas. Meanwhile, AI-powered simulations let firms test products digitally before manufacturing starts, cutting down new product launch times considerably.

Meanwhile, VR complements this by offering immersive experiences that boost team collaboration. Designers and engineers can see their ideas in 3D and interact with them live, gaining a richer grasp of how products work and what might go wrong before building anything physical. Virtual spaces also let people from different locations work together seamlessly, breaking down geographical barriers as if everyone were in the same room.

Together, AI and VR also enhance workplace training. Using VR scenarios driven by AI insights, companies craft personalized learning experiences that build skills safely in lifelike settings. This approach improves employee performance and fosters a culture of ongoing growth and adaptability, essential for thriving in fast-changing industries.

Moreover, this tech duo strengthens operational agility through smarter choices. AI-generated insights inform strategic plans by forecasting market trends and pointing out inefficiencies. When paired with VR's interactive visualizations, decision-makers gain a clearer, more hands-on understanding of these insights, helping them create strategies that fit both today's realities and tomorrow's challenges.

As more industries adopt this powerful combination, they stand at the leading edge of innovation within their fields. This partnership not only accelerates product development but also boosts an organization's ability to adapt quickly and unleash its full creative potential. See references: (Maisonneuve et al., 2024, pp. 11-15), (Bukowski & Werbinska-Wojciechowska, 2025), (Maisonneuve et al., 2024, pp. 26-30), (Khan et al., 2025) and (Maisonneuve et al., 2024, pp. 31-35).

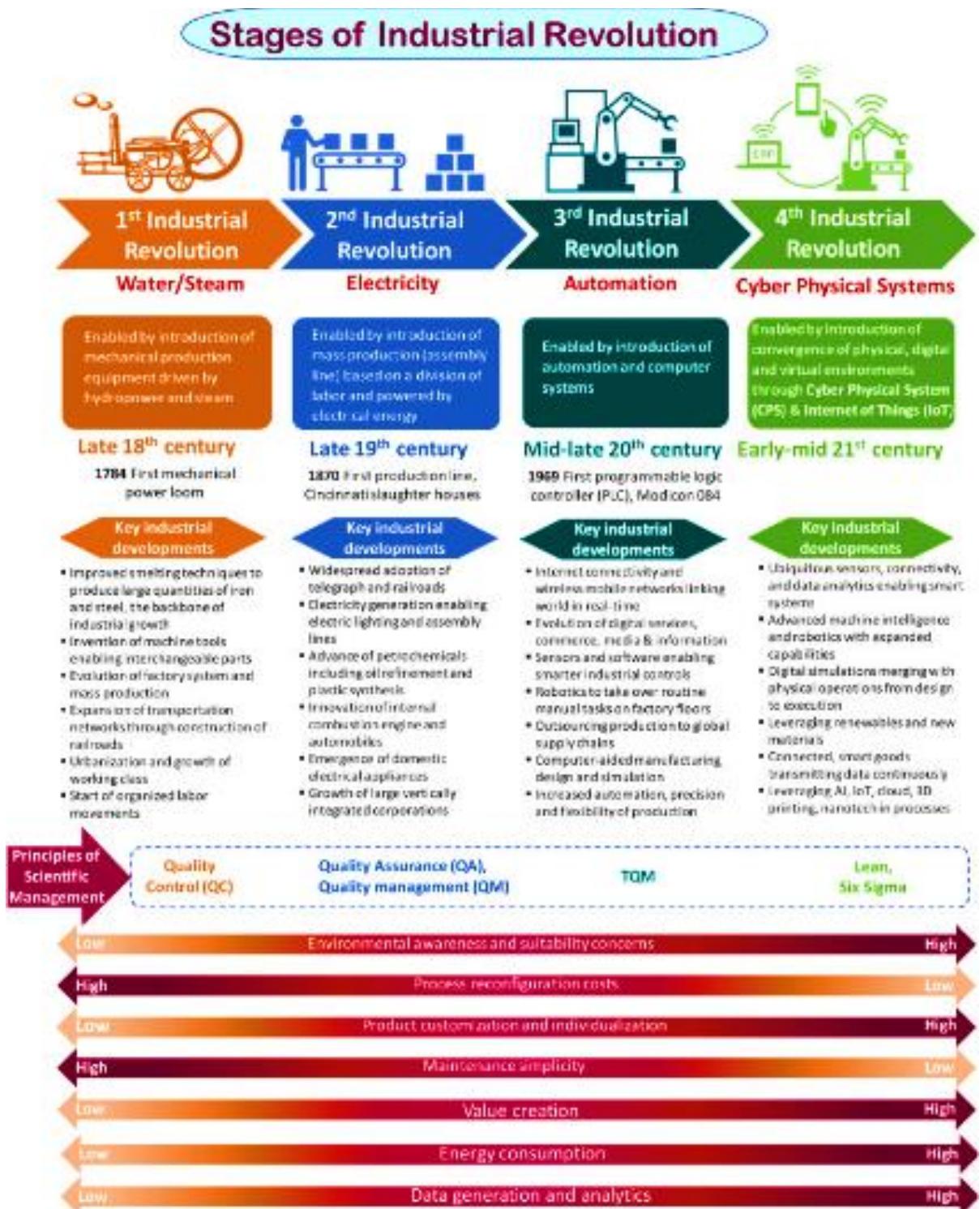


Figure 4: Stages of industrial revolution from Industrial revolution 1 to 4. (source: reference (Khan et al., 2025)

Technology	Category	Description
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Artificial Intelligence (AI)	Digital	AI involves the development of computational systems that can perform tasks normally requiring human intelligence, such as learning, reasoning, and problem-solving. AI technologies such as machine learning, natural language processing, and computer vision enable machines to learn from data and make decisions autonomously or with minimal human intervention.
Industrial Internet of Things (IIoT)	Digital	A network of interconnected devices, sensors, and machines within industrial settings that autonomously collect and exchange data in real-time, enabling enhanced monitoring, control, and optimization of industrial processes without the need for human intervention.
Digital Twins (DT) & Advanced Simulation	Digital	DTs are virtual representations of physical assets, processes, or systems that mirror their real-world counterparts. Advanced simulation techniques leverage these digital models to predict behavior, optimize performance, and test different scenarios in a virtual environment before implementation in the real world.
Big Data Analytics	Digital	Big Data Analytics involves the processing and analysis of large and complex datasets to identify patterns, correlations, market trends, customer preferences, and insights that can inform decision-making. This is achieved through the use of advanced statistical and machine learning techniques, such as predictive modeling, clustering, and decision trees, to uncover hidden relationships and correlations within the data.
Blockchain	Digital	A decentralized, distributed ledger technology that records and verifies transactions across multiple parties (a network of computers) in a secure, transparent, and tamper-proof manner. It enables the creation of a permanent, unalterable record of transactions, enhancing transparency, traceability, and trust in data management, eliminating the need for a central authority.
Cloud and Edge Computing	Digital	A technology that allows for the on-demand availability of a shared pool of configurable computing resources, such as servers, storage, networks, and applications, that can be rapidly provisioned and released with minimal management effort. This allows for scalable, flexible, and cost-effective access to computing resources over the internet.
Cyber-Physical Systems (CPS)	Digital-Physical	Systems that integrate computational elements with physical processes, enabling real-time data exchange, analysis, and optimization of industrial processes, improving safety, efficiency, and productivity.

Augmented Reality (AR) / Virtual Reality (VR)	Physical	AR involves the overlapping of digital information onto the physical environment, enhancing the user experience and improving decision-making, while AR technologies (e.g. smart glasses) enable the visualization of complex data, instructions, and guidance, improving productivity, quality, and safety.
Advanced Industrial Robotics and Automation	Physical	Involves the use of advanced robots and automated systems to perform tasks traditionally done by humans, enhancing efficiency, precision, and safety in industrial environments.
Additive Manufacturing (3D Printing)	Physical	A process of building three-dimensional objects layer-by-layer from a digital design, enabling the rapid production of complex geometries and customized products with minimal material waste.
Advanced Sensors	Physical	Devices that detect and respond to physical inputs from the environment, such as temperature, pressure, or motion, and convert them into digital signals for monitoring and control of industrial processes, allowing for predictive maintenance, quality control, and optimized production.
Drones	Physical	Remotely controlled or autonomous unmanned aerial vehicles (UAVs) equipped with sensors and cameras, used for monitoring, inspection, transportation and data collection in industrial environments, enhancing operational efficiency.

Table 1: Main pillars of industry 4.0 technologies. (source: reference (Khan et al., 2025)

4.2. Operational Flexibility Improvements

Combining AI and VR in industrial systems enhances operational agility, enabling companies to respond swiftly to changing market demands. These technologies create flexible environments where processes, layouts, and production schedules can adjust quickly, reducing downtime and waste.

A key aspect of this flexibility is the rapid reconfiguration of production lines. Advanced simulations, especially digital twins, let manufacturers map and optimize operations before physical changes. This virtual testing detects bottlenecks and inefficiencies early, leading to smarter decisions and lowering costs related to hands-on modifications.

AI processes real-time data from connected machines, enabling adaptable manufacturing. For instance, AI-driven equipment can automatically adjust performance to handle input or supply chain variations. This keeps production running smoothly despite unexpected shifts.

VR improves workforce training by providing immersive scenarios where employees can practice complex tasks safely. Such hands-on virtual experience prepares teams to implement new processes quickly when changes occur.

Flexibility extends beyond factories to supply chains as well. AI analytics give clear insights into supplier performance and capacity. This information helps companies make informed decisions about sourcing and inventory based on predicted demand shifts. AI's forecasting combined with VR's visualizations allows early disruption detection and timely plan adjustments.

Industries facing rapid technological changes benefit greatly from these tools. AI and VR enable fast exploration of innovative designs through virtual testing before costly physical production.

Collaboration also improves with VR platforms, where global teams can meet in shared virtual spaces for real-time problem-solving. This reduces delays and fosters creative teamwork.

Ultimately, integrating AI's data insights with VR's immersive capabilities makes industrial systems more resilient and better prepared to seize future opportunities, aligning with the goals of Industry 4.0. See references: (Maisonneuve et al., 2024, pp. 21-25), (Khan et al., 2025) and (George, 2024).

5. Economic Implications of Reconfiguring Industrial Systems with AI and VR

5.1. Impacts on Productivity, Efficiency, and Competitiveness

Incorporating artificial intelligence (AI) into industrial systems marks a major boost in productivity, efficiency, and competitive edge. AI is rapidly becoming a versatile technology that reshapes traditional manufacturing methods and helps companies reach new heights in output and resource management. By deploying AI-driven tools like machine learning and predictive analytics, businesses can streamline their operations, cut downtime, and make smarter decisions. This evolution not only ramps up productivity but also opens doors to fresh business models built on data insights.

Predictive maintenance stands out as a key area where AI delivers big gains. By analyzing real-time data from machines, AI tools can forecast breakdowns before they happen. This foresight cuts expensive downtime and keeps operations humming along smoothly. Taking this proactive route helps firms save on maintenance costs compared to the old reactive fixes. Plus, better predictions mean resources are used more wisely and waste is trimmed.

AI also shines in optimizing processes across many sectors. It digs into production patterns with advanced algorithms, spots inefficiencies, and suggests changes that boost performance. For instance, AI-powered adaptive scheduling adjusts workforce plans based on current demand, helping companies respond quickly while lowering labor expenses. This gives firms the flexibility to keep pace with market swings, which is crucial in today's fast-moving business world.

Beyond improving current workflows, AI sparks innovation by enriching research and development. These systems analyze huge datasets, uncovering insights that were too complex or time-consuming to find manually. Leveraging this knowledge, companies create new products or enhance existing ones, gaining a stronger position in their markets.

The flexibility AI brings also lets businesses pivot their strategies swiftly when facing competitive pressures. Firms that embrace AI early gain an edge over those slower to adopt, especially during rapid market shifts or uncertain economic times when agility can make all the difference.

Investing in AI reflects a broader push toward digitalization in line with Industry 4.0 principles. Organizations see tech adoption not just for quick wins but as a long-term move to stay competitive amid intense global rivalry.

As more companies implement these advanced systems, future economic growth depends on how well they unlock AI's potential across operations while managing challenges like workforce changes and new skill demands created by automation. See references: (Khan et al., 2025), (Aldasoro et al., 2024), (Filippucci et al., 2024, pp. 6-10) and (Czarnitzki et al., 2023).

5.2. Investment Patterns in Technology Adoption

Investment in AI and VR technologies within industrial systems varies due to industry needs, technological advances, and economic conditions. Companies increasingly recognize these tools' value and invest heavily in infrastructure, software, and training to support data-driven decisions and automation.

Many businesses adopt AI to improve operational efficiency. Predictive maintenance and process optimization have boosted productivity, encouraging industries to allocate larger budgets to AI. The main motivation is to remain competitive, as lagging behind risks losing ground to faster adopters.

Investment approaches differ by sector. Manufacturing and logistics focus on automation to cut costs and increase efficiency. Service industries use AI to enhance customer experience and streamline processes.

Geography also influences adoption rates. Regions with advanced tech ecosystems, like the U.S., show higher AI use—around 18% of companies had adopted AI by 2018, with that number rising steadily. European countries lag behind, near 7.9% adoption, but are actively pushing to increase this by 2030.

Venture capital drives much innovation in AI and VR for industry. Startups attracting investment accelerate development and heighten competition among established firms aiming for market leadership.

Companies must weigh costs against benefits carefully and consider risks. Success stories, such as improved agility through digital twins, illustrate potential gains, but returns depend on specific industries and company contexts. Ongoing maintenance and rapid technological evolution demand ongoing attention.

In summary, AI and VR investment in industrial systems follows a complex path shaped by competition, sectoral priorities, geography, and market forces. Firms need to balance immediate needs with long-term growth when making investment decisions. See references: (Khan et al., 2025), (George, 2024) and (Comunale & Manera, 2024).

6. Labor Market Implications from AI and VR Integration in Industrial Systems

6.1. Skill Upgrading Requirements for Workers

As AI and VR technologies become more common in industry, the need for skilled workers grows rapidly. Automation, advanced data analysis, and immersive training require employees to adopt new tools and methods. Organizations must prioritize skill development to help workers fully utilize these technologies.

Traditional skills may soon be outdated due to swift progress in the Fourth Industrial Revolution. AI enhances processes with predictive maintenance and operational improvements, so employees need to learn how to use AI tools and interpret data effectively. This demands both technical knowledge and confidence in handling complex information.

VR improves training by offering simulation-based learning that lets workers practice real tasks safely and realistically. Regular use of immersive training boosts engagement and helps employees retain knowledge better than traditional methods.

Continuous learning must become standard. Training should cover digital skills, problem-solving, and collaboration with robots, or “cobots.” Hybrid roles that blend human creativity with machine precision will grow as Industry 5.0 emphasizes cooperation between people and intelligent systems.

Businesses should view upskilling not only as a way to improve productivity but also as a way to increase employee satisfaction and loyalty. Investing in training aligned with AI and VR fosters career growth and future-proofs workers. This mindset is especially important where automation disrupts jobs, giving workers a sense of security through clear growth opportunities.

Economic policies also support workforce reskilling amid AI challenges. Governments can offer tax incentives or funding to encourage education investments related to emerging technologies.

Partnerships between schools and industries are essential to close the skills gap caused by rapid technological change. Updating curricula to include hands-on AI and VR experiences prepares students early for future jobs.

Overall, businesses and policymakers must recognize how AI and VR change job demands. Thoughtful, broad strategies are crucial to manage workforce shifts fairly and provide equal opportunities during these transformations. See references: (Filippucci et al., 2024, pp. 46-50), (experts, 2024), (Betti & Boer, 2019, pp. 1-5) and (Khan et al., 2025).

6.2. Future Job Market Trends in Industrial Sectors

The rise of AI and VR within industrial systems is poised to reshape the job landscape across multiple sectors, bringing both new chances and tough challenges for workers. As industries transform, demand will shift toward skills that work in harmony with these technologies rather than compete against them. People skilled in AI, VR, and related areas like data analysis and immersive design will be highly sought after. This trend urges educational institutions and employers to update their training programs to meet evolving needs.

With AI taking over more routine and repetitive tasks, certain jobs may shrink or change significantly. For example, administrative roles focused on repetitive cognitive work might dwindle as companies rely on AI tools to boost efficiency. On the flip side, jobs needing complex problem-solving and creativity—qualities machines can't easily mimic—should remain in strong demand. So, while automation may wipe out some positions, other roles that highlight human creativity and interpersonal skills will rise.

In fields like manufacturing, the arrival of collaborative robots, or cobots, points to teamwork between humans and machines rather than full replacement. This evolution calls for workers who can manage and cooperate with these technologies smoothly. As a result, training programs that focus on working effectively alongside cobots will become increasingly important.

Economic policies will also influence how job markets evolve amid tech advances. Efforts to upskill the workforce can soften the impact of job losses by giving workers the tools they need for new roles. Governments might rethink tax incentives, encouraging investment in technologies that enhance human work instead of completely automating it.

This technological shift raises social concerns too, particularly about growing inequality. Workers without access to retraining or who face hurdles in learning new skills may struggle more as industries move fast. That's why policymakers must not only roll out solid training programs but also make sure everyone has fair access, regardless of background.

Ultimately, the job market will grow more diverse as hybrid roles that mix technology with traditional skills become common across sectors. The labor market won't just stand still—it will adapt and evolve, presenting both hurdles and fresh opportunities as AI and VR become ever more embedded in industry. See references: (Szeszák et al., 2025), (Filippucci et al., 2024, pp. 46-50) and (experts, 2024).

7. Conclusion: The Future Landscape of Industrial Systems with AI and VR Integration

The fusion of AI and VR is reshaping industrial systems and moving industries beyond traditional manufacturing. The Fourth Industrial Revolution introduces fast technological changes, with AI and VR driving progress. Together, they boost productivity, spark innovation, and improve efficiency across sectors.

AI proves valuable in predictive maintenance and optimizing processes. Machine learning predicts equipment failures ahead of time, reducing downtime and costs. Businesses that adopt these technologies run operations more smoothly and invest in digital tools to stay competitive in a rapidly evolving market.

VR is also changing worker training by providing immersive, hands-on experiences without real-world risks. This approach enhances skill development and adapts to individual needs, preparing employees for the flexible demands of modern industries.

Combining AI and VR fuels further innovation. Generative design algorithms speed up prototyping, while VR supports remote collaboration among teams. This synergy promotes continuous improvement and helps companies quickly respond to market changes while streamlining operations.

Economically, adopting AI and VR simplifies operations and enables rapid adjustment to customer preferences and supply chain shifts. Firms face growing pressure to embrace digitalization for sustainable growth in a global market.

However, increased automation demands new technical skills and may transform or eliminate some traditional jobs. Companies must prioritize ongoing training and work with educational institutions to prepare workers for emerging roles.

Leaders should promote responsible use of technology that enhances human work rather than replaces it. Inclusive reskilling and thoughtful policies can reduce inequality and help societies benefit from the digital shift.

Looking ahead, smart factories will feature autonomous machines and advanced tools that help humans make better decisions. The economic impact could reach trillions as industries adopt these innovations. Firms that lag risk falling behind in a data-driven world.

Ultimately, using AI and VR fully will improve efficiency and create new business models aligned with changing consumer needs. Addressing ethical concerns like privacy and bias is essential to ensure fair and transparent benefits for all. See references: (Rashid & Kausik, 2024), (George, 2024), (Maisonneuve et al., 2024, pp. 11-15) and (Ivaldi et al., 2022).

Ethical Considerations

This study is conceptual and analytical in nature and does not involve primary data collection, human participants, experiments, surveys, or personal data. The analysis is based on secondary sources, theoretical models, and previously published empirical findings related to artificial intelligence, virtual reality, and industrial systems. Therefore, ethical approval was not required. Nevertheless, the authors adhered to accepted principles of academic integrity, transparency, and responsible scholarship, including accurate citation of sources and avoidance of plagiarism or data misrepresentation.

Author Contributions

Ben Moussa Bachir contributed to the conceptualization of the study, development of the theoretical framework, and analysis of the economic role of artificial intelligence in industrial systems.

Zeghdi Adel contributed to the literature review, analysis of virtual reality applications, and discussion of workforce skills and training implications.

Zelaci Riad contributed to the integration of AI and VR within the Industry 4.0 framework, as well as to the analysis of productivity, competitiveness, and innovation dynamics.

Azi Khalifa contributed to the discussion of industrial policy implications, investment patterns, and the overall structuring and editing of the manuscript.

All authors jointly reviewed, revised, and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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