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Does AI Enhance or Replace Human Productivity? Evidence from Service and Manufacturing Sectors

Vo Phuoc Tai
Ho Chi Minh City University of Economics and Finance (UEF), Vietnam

* Corresponding Author: **Vo Phuoc Tai**

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Abstract
Artificial intelligence (AI) has become a central technology in debates on productivity, employment, and organizational competitiveness. This desk-based qualitative study examines whether AI primarily enhances or replaces human productivity in service and manufacturing sectors. Drawing mainly on recent studies from 2021–2026, the paper synthesizes empirical, theoretical, and policy literature on generative AI, industrial AI, robotics, human–AI collaboration, and task automation. Evidence from service-sector experiments shows that AI can substantially increase productivity in customer service, professional writing, software development, consulting, and administrative work, particularly when tasks are structured, information-intensive, and supported by clear performance metrics. However, gains are uneven and depend on worker skill, task type, data quality, organizational redesign, and human judgment. Manufacturing evidence suggests that AI and robotics can enhance productivity through predictive maintenance, quality control, scheduling, process optimization, and human–machine coordination, but short-term adoption costs, workforce disruption, and integration complexity may delay productivity gains. The analysis concludes that AI neither universally enhances nor simply replaces human productivity. Rather, AI restructures productivity by automating routine tasks, augmenting cognitive and operational decision-making, and shifting human value toward judgment, creativity, coordination, accountability, and socio-technical problem solving.

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Keywords: artificial intelligence, productivity, human–AI collaboration, automation, augmentation, service sector, manufacturing, desk-based qualitative research

Introduction

Background

Artificial intelligence has rapidly shifted from a specialized computational technology to a general-purpose business capability. Earlier waves of automation were concentrated in physical production, logistics, and routine clerical work. Recent advances in machine learning and generative AI have expanded automation and augmentation into knowledge-intensive activities such as writing, customer service, software development, document analysis, design, marketing, finance, engineering, and decision support. This expansion has revived a central question in labor economics and management studies: does AI enhance human productivity, or does it replace human productive capacity?

The answer is increasingly important for both service and manufacturing sectors. In services, AI systems are used in chatbots, virtual assistants, recommendation engines, fraud detection, customer relationship management, legal drafting, medical triage, financial analysis, and software development. In manufacturing, AI is embedded in robotics, predictive maintenance, quality inspection, digital twins, supply-chain optimization, computer vision, production scheduling, and smart factories. Although the two sectors differ, both show a similar pattern: AI changes the task composition of work rather than simply eliminating entire

occupations. The International Labour Organization's global analysis of generative AI concludes that the dominant effect of generative AI is more likely to be occupational augmentation than full automation, although exposure is uneven across occupations, income groups, and gendered job structures.

Recent empirical evidence shows substantial productivity gains in some service-sector tasks. Noy and Zhang (2023) [8] found that access to ChatGPT reduced average completion time by 40% and increased output quality by 18% in professional writing tasks. Brynjolfsson, Li, and Raymond's workplace study of customer-support agents found that generative AI increased productivity by around 14–15%, with the largest benefits for less experienced workers. Peng *et al*. (2023) [11] found that developers using GitHub Copilot completed a programming task 55.8% faster than the control group. These studies support the view that AI can enhance human productivity, especially where tasks are text-based, rules-informed, data-rich, and measurable.

However, recent research also challenges simplistic optimism. Dell'Acqua *et al*. describe a "jagged technological frontier," meaning AI improves performance on some tasks but can reduce performance on others when users apply it outside its capability boundary. Acemoglu's macroeconomic analysis is also cautious, estimating modest aggregate total factor productivity gains from AI over the next decade compared with more optimistic projections. The OECD similarly emphasizes that AI could raise productivity, but only when firms redesign processes, develop complementary skills, and manage organizational change effectively.

Problem Statement

Despite widespread enthusiasm about AI, the productivity debate remains unresolved. Many business reports describe AI as a productivity accelerator, while labor-market analyses warn that AI may substitute workers, polarize employment, increase inequality, and degrade job quality. The problem is not simply whether AI is "good" or "bad" for productivity. The more precise issue is under what conditions AI enhances human productivity, under what conditions it replaces human tasks, and how these effects differ between service and manufacturing sectors.

Existing studies are often fragmented. Some focus on generative AI in knowledge work; others examine robotics in manufacturing; others analyze occupational exposure or macroeconomic effects. A synthesized qualitative study is needed to integrate these strands and clarify the mechanisms through which AI enhances, replaces, or restructures productivity.

This study addresses the following research question:

Does AI enhance or replace human productivity in service and manufacturing sectors?

Three supporting questions guide the analysis:

1. What forms of productivity enhancement are observed in service and manufacturing sectors?
2. Which types of human tasks are most exposed to AI-based replacement?
3. What organizational and human factors determine whether AI becomes augmentative or substitutive?

Literature Review

AI and Productivity: From Automation to Augmentation

The productivity impact of AI can be understood through two mechanisms: automation and augmentation. Automation occurs when AI performs a task previously completed by humans. Augmentation occurs when AI supports humans by improving speed, accuracy, decision quality, learning, coordination, or creativity. In practice, these mechanisms overlap. A customer-service chatbot may automate routine inquiries while helping human agents solve complex cases. A manufacturing vision system may automate defect detection while enabling technicians to focus on root-cause analysis. A generative AI tool may draft text automatically while leaving humans responsible for judgment, verification, tone, ethics, and final accountability.

The ILO's 2023 and 2025 analyses emphasize that exposure to generative AI does not automatically mean job elimination. Rather, exposure often means that a significant share of tasks within an occupation can be transformed, partially automated, or supported by AI. The strongest exposure appears in clerical, administrative, media, software, finance, and information-processing occupations, while many physical, interpersonal, and context-dependent jobs remain less fully automatable.

Evidence from Service Sectors

Service-sector evidence is currently the strongest because generative AI directly targets language, information processing, customer interaction, and knowledge work. Brynjolfsson *et al*. (2025) [2] studied a generative AI assistant deployed among more than 5,000 customer-support agents and found that AI increased productivity, measured by issues resolved per hour. Importantly, the gains were not evenly distributed: novice and lower-skilled agents benefited more than experienced agents. This suggests that AI may compress performance differences by transferring tacit knowledge embedded in historical data and expert responses to less experienced workers.

Noy and Zhang (2023) [8] provided experimental evidence from professional writing tasks. They found that ChatGPT reduced completion time and improved output quality, suggesting that AI can enhance productivity when tasks involve drafting, summarizing, structuring, and revising text. This finding is highly relevant to service industries because much service-sector productivity depends on communication, documentation, reporting, analysis, and client-facing content.

Software development provides another strong example. Peng *et al*. (2023) [11] found that GitHub Copilot helped developers complete a programming task 55.8% faster. This does not mean AI replaced software engineers. Rather, the AI acted as a coding assistant, accelerating routine code generation while humans retained responsibility for problem formulation, debugging, integration, security, architecture, and final judgment.

Professional services also reveal the limits of AI. Dell'Acqua *et al*. found that AI improved performance for tasks within its capability frontier but could reduce performance when used for tasks outside that frontier. This is especially important for consulting, law, finance, auditing, healthcare, and education, where outputs require contextual reasoning, ethical judgment, domain expertise, and client-specific interpretation.

Evidence from Manufacturing Sectors

Manufacturing AI differs from service-sector generative AI because it is often embedded in cyber-physical systems. It includes machine vision, robotics, sensors, industrial Internet

of Things, digital twins, autonomous guided vehicles, production analytics, predictive maintenance, process control, and supply-chain optimization. These applications can enhance productivity by reducing downtime, improving quality, minimizing waste, increasing throughput, and enabling real-time decision-making.

Recent studies suggest that AI and robotics can raise manufacturing productivity, but the effect is neither immediate nor automatic. Research on industrial robots and total factor productivity finds positive effects in many contexts, but productivity gains depend on firm capability, technical complexity, worker training, and human–machine matching. Some evidence also points to a productivity paradox: firms may experience short-term productivity losses during AI adoption because of installation costs, workflow disruption, worker adjustment, and organizational learning before longer-term gains emerge.

The OECD frames AI as a potential general-purpose technology but emphasizes that its productivity effects depend on complementary investments. AI alone does not create productivity transformation. Firms must combine AI with data infrastructure, process redesign, managerial capability, workforce skills, cybersecurity, governance, and organizational learning.

AI, Job Replacement, and Labor-Market Exposure

The replacement debate is strongest where tasks are routine, codifiable, repetitive, and measurable. In services, this includes data entry, basic customer inquiries, claims processing, scheduling, standard report drafting, transcription, compliance screening, and simple document review. In manufacturing, replacement is more visible in repetitive assembly, inspection, packaging, materials handling, and warehouse operations.

However, AI replacement is usually task-based rather than occupation-wide. The ILO cautions that exposure to generative AI reflects the potential for tasks to be performed using AI, not immediate elimination of entire jobs. Similarly, recent labor-market reporting and institutional commentary suggest that large-scale replacement has not yet occurred uniformly, although specific back-office, clerical, and administrative roles are increasingly vulnerable.

The World Economic Forum's Future of Jobs Report 2025 [12] shows that employers expect technology, AI, and information processing to transform skills and job structures between 2025 and 2030. The report highlights both job displacement and job creation, with skill gaps identified as a major barrier to business transformation.

The Productivity Paradox of AI

The productivity paradox refers to the gap between rapid technology adoption and delayed aggregate productivity gains. Although task-level experiments show large gains, macroeconomic effects may be smaller because AI adoption requires complementary investments, organizational redesign, and diffusion across firms. Acemoglu (2024/2025) [1] argues that near-term aggregate productivity gains may be modest because only some tasks can be economically automated and because many hard-to-learn tasks require context-dependent judgment. OECD analyses are more optimistic but still emphasize uncertainty, implementation capability, and complementary innovation.

Theoretical Foundation

Task-Based Theory of Automation

Task-based theory argues that technologies affect tasks rather than occupations as whole units. A job is a bundle of tasks, and AI may automate some tasks, augment others, and leave some unchanged. This theory is useful because it explains why AI can simultaneously enhance productivity and threaten employment within the same occupation. For example, AI may automate first-draft report writing but augment strategic analysis; it may automate defect detection but augment production engineering; it may automate FAQ responses but augment complex customer care.

From this perspective, the central analytical unit is not "job replacement" but task reallocation. Human productivity is enhanced when AI takes over low-value, repetitive, or information-intensive tasks and allows humans to focus on higher-value judgment, creativity, relationship management, and exception handling. Human labor is replaced when the automated task constitutes the core economic value of the job and when human oversight adds little incremental value.

Resource-Based View

The resource-based view suggests that firms gain competitive advantage when they possess valuable, rare, inimitable, and organizationally embedded resources. AI can become a productivity-enhancing resource only when it is integrated with firm-specific data, human expertise, routines, governance, and learning systems. A generic AI tool may be widely available, but its productivity value depends on how effectively the organization embeds it into workflows.

This explains why AI adoption produces uneven results. Two firms may use similar AI tools but experience different outcomes because of differences in data quality, managerial capability, workforce skills, trust, process redesign, and organizational culture. AI enhances productivity when it is not treated as a plug-in technology but as part of a broader socio-technical system.

Human–AI Collaboration Theory

Human–AI collaboration theory emphasizes complementarity between machine intelligence and human intelligence. AI is strong in pattern recognition, prediction, classification, optimization, simulation, language generation, and large-scale data processing. Humans remain strong in contextual interpretation, moral judgment, empathy, creativity, accountability, negotiation, and cross-domain reasoning.

This theory is especially relevant to service sectors, where customer trust, empathy, ethical judgment, and communication quality matter. It is also relevant to advanced manufacturing, where operators, engineers, and technicians must interpret AI outputs, respond to anomalies, manage safety, and continuously improve production systems. Human–AI collaboration therefore reframes AI not as a simple substitute for humans but as a system that changes the division of cognitive and operational labor.

Socio-Technical Systems Theory

Socio-technical systems theory argues that productivity emerges from the joint optimization of technology, people, work design, and organizational structure. AI implementation fails when firms optimize the technical system while neglecting human roles, incentives, skills, and governance.

This is why manufacturing firms may suffer short-term productivity losses after AI adoption: new machines, sensors, and algorithms disrupt existing routines before new capabilities are stabilized.

The socio-technical view suggests that the question is not "AI versus humans" but "what work system allows AI and humans to jointly produce higher value?" This foundation supports the present study's core argument: AI enhances human productivity when organizations redesign work around complementarity; AI replaces human productivity when organizations use it narrowly as a labor-cost reduction tool.

Methodology: Desk-Based Qualitative Research Design

This study uses a desk-based qualitative research design. It synthesizes secondary sources, including peer-reviewed journal articles, working papers, international organization reports, empirical experiments, policy reports, and sectoral analyses published mainly between 2021 and 2026. The design is appropriate because the research question requires conceptual integration across multiple bodies of evidence rather than new primary data collection.

Data Sources

The review prioritized five categories of sources:

1. Empirical studies on generative AI and worker productivity.
2. Studies on AI, robotics, and productivity in manufacturing.
3. Reports from international institutions such as the ILO, OECD, IMF, and World Economic Forum.
4. Studies on occupational exposure, task automation, and labor-market transformation.
5. Theoretical and conceptual work on automation, augmentation, human–AI collaboration, and socio-technical change.

Inclusion Criteria

Sources were included if they met at least one of the following criteria:

- Published between 2021 and 2026, with priority given to 2023–2026 sources.
- Directly examined AI, generative AI, robotics, productivity, employment, automation, or human–AI collaboration.
- Provided evidence related to either service or manufacturing sectors.
- Offered theoretical relevance to the automation–augmentation debate.
- Came from credible academic journals, working paper series, or international organizations.

Classic theoretical works outside the 2021–2026 range were used only where necessary to support the conceptual framework.

Analytical Procedure

The study applied thematic synthesis. First, the literature was coded into evidence categories: service productivity, manufacturing productivity, task automation, human–AI collaboration, skill effects, organizational implementation, and labor-market risk. Second, recurring patterns were grouped into themes. Third, the themes were interpreted through task-based theory, resource-based view, human–AI collaboration theory, and socio-technical systems theory. The outcome is a qualitative explanation of when AI enhances productivity, when it replaces tasks, and why sectoral effects differ.

Thematic Analysis: Synthesis of Previous Studies

Theme 1: AI Enhances Productivity Most Strongly in Structured Cognitive Tasks

The strongest evidence of AI productivity enhancement comes from structured cognitive tasks. In writing, customer support, and coding, AI reduces time spent on drafting, searching, summarizing, formatting, and routine problem solving. Noy and Zhang's professional writing experiment and Peng *et al*.'s coding experiment show that AI can produce large task-level productivity gains when outputs are relatively clear and when humans can evaluate and refine AI-generated work.

This theme is particularly relevant to service sectors because much service work involves information processing. AI can help employees respond faster, standardize outputs, reduce cognitive load, and improve consistency. However, productivity enhancement is strongest when humans remain capable of evaluating AI output. Without evaluation capability, AI may generate fluent but incorrect work, leading to hidden quality costs.

Theme 2: AI Benefits Lower-Skilled or Less Experienced Workers Disproportionately

One of the most important findings in recent empirical research is that AI can narrow performance gaps. Brynjolfsson *et al*. found that customer-support productivity gains were largest among novice and lower-skilled workers. This suggests that AI can codify and distribute expert knowledge, helping less experienced employees perform closer to the level of experienced workers.

This has two interpretations. From an optimistic perspective, AI democratizes expertise and supports inclusive productivity growth. From a critical perspective, AI may reduce the market value of experience if firms rely on AI to standardize performance. Thus, AI enhances individual productivity but may also change wage structures and career progression.

Theme 3: AI Replaces Tasks More Than Occupations

The literature consistently suggests that AI exposure is primarily task-based. The ILO's global analysis emphasizes that generative AI is more likely to augment jobs than fully automate them, although clerical and administrative occupations are highly exposed. The 2025 refined index also suggests that exposure varies by country income level, occupation, and gender.

In services, replacement risk is concentrated in routine cognitive tasks: data entry, scheduling, document classification, basic customer inquiries, standard email writing, translation, and first-level support. In manufacturing, replacement risk is concentrated in repetitive physical and perceptual tasks: inspection, sorting, packaging, assembly, and materials handling. Yet even where tasks are automated, humans are often needed for supervision, exception management, maintenance, process improvement, safety, and accountability.

Theme 4: Manufacturing Gains Depend on Integration, Not AI Alone

Manufacturing AI has strong productivity potential, but its benefits depend heavily on integration. Unlike generative AI tools that can be quickly adopted by individual service workers, manufacturing AI often requires capital investment, sensor systems, enterprise data integration, robotics, production redesign, and worker reskilling. Evidence on robot adoption suggests positive productivity effects in some settings, while other studies report short-term disruption and delayed gains.

This theme explains why manufacturing firms may not see immediate productivity improvements. AI changes production systems, not just individual tasks. Productivity depends on whether AI is connected to maintenance routines, quality systems, production planning, supply-chain data, and human operators' decision-making.

Theme 5: AI Creates a "Jagged Frontier" of Productivity

The jagged frontier means AI is highly effective for some tasks but unreliable for others. This theme is crucial because it prevents overgeneralization. AI can enhance productivity in tasks involving language generation, summarization, pattern recognition, and structured recommendations. However, it may fail in tasks requiring causal reasoning, tacit context, ethical judgment, ambiguous client needs, physical dexterity, or high-stakes accountability.

In service sectors, this means AI can support consultants, analysts, teachers, lawyers, marketers, and healthcare professionals, but it should not replace professional judgment. In manufacturing, AI can detect defects and predict machine failure, but it may not fully replace experienced technicians who understand machine behavior, production context, and safety constraints.

Theme 6: AI Productivity Depends on Organizational Redesign

A recurring pattern across the literature is that AI does not automatically create productivity. Firms must redesign workflows, incentives, training, governance, and decision rights. The OECD emphasizes that productivity gains from generative AI depend on organizational adaptation, process redesign, and complementary innovation. McKinsey's 2025 [7] workplace report similarly notes that many firms invest in AI, but few consider themselves mature in scaling it.

This theme applies to both sectors. In services, AI must be embedded into workflows for drafting, review, escalation, compliance, and customer interaction. In manufacturing, AI must be connected to production engineering, maintenance, quality assurance, and operator training. Without redesign, AI may increase workload, create monitoring burdens, or produce unreliable outputs.

Discussion: Interpretation of Findings

The evidence suggests that AI both enhances and replaces human productivity, but not in equal measure and not in the same way across sectors. The dominant near-term effect is **productivity restructuring**. AI enhances productivity by increasing speed, improving consistency, reducing routine workload, supporting decision-making, and expanding access to expert-like guidance. AI replaces productivity when it takes over tasks that were previously the main source of human labor value.

In service sectors, the enhancement effect is currently more visible than full replacement. Generative AI can support writing, customer service, programming, marketing, analysis, and administration. Yet the same capabilities also create replacement pressure for routine clerical, back-office, and first-level support roles. Therefore, service-sector AI is best understood as a dual technology: it augments higher-complexity service work while automating lower-complexity service tasks.

In manufacturing, AI replacement is more visible in physical and repetitive operations, especially when combined with robotics. However, manufacturing productivity gains depend more on capital investment and systems integration. AI may replace certain manual inspection or handling tasks, but it also increases demand for technicians, data analysts, robotics engineers, maintenance specialists, and process improvement experts. Thus, manufacturing AI tends to shift human productivity from direct manual execution toward supervision, system optimization, troubleshooting, and continuous improvement.

The distinction between enhancement and replacement also depends on the level of analysis. At the task level, AI can clearly replace humans in specific activities. At the job level, it often transforms rather than eliminates roles. At the firm level, it can enhance productivity if implemented strategically. At the economy level, aggregate productivity gains may be delayed or modest because adoption is uneven, organizational complements are costly, and some AI uses may not generate high economic value. Acemoglu's cautious estimates and OECD's more optimistic scenarios both imply that productivity outcomes depend on implementation quality rather than technology alone.

The findings also show that AI changes the meaning of human productivity. Traditional productivity often measured output per worker or output per hour. In AI-enabled organizations, human productivity increasingly depends on the ability to collaborate with intelligent systems. Productive workers are not simply those who perform tasks quickly; they are those who can ask good questions, verify outputs, interpret context, integrate AI recommendations, manage exceptions, and make accountable decisions.

This has important implications for skills. Technical AI literacy is necessary, but not sufficient. Workers need domain expertise, critical thinking, data interpretation, ethical reasoning, communication, and process understanding. Organizations that treat AI as a substitute for human judgment may experience errors, trust problems, and quality failures. Organizations that treat AI as a collaborative capability are more likely to realize sustainable productivity gains.

Limitations and Future Research

This study has several limitations. First, it is based on secondary sources and does not include primary interviews, surveys, or firm-level data collection. Second, much of the strongest empirical evidence comes from specific tasks, such as writing, coding, consulting, and customer support. These findings may not generalize to all service occupations or manufacturing environments. Third, many AI productivity studies are short-term. Long-term effects on employment, wages, skill formation, organizational learning, and inequality remain uncertain. Fourth, manufacturing evidence is more heterogeneous because AI adoption varies widely by industry, firm size, capital intensity, and technological maturity.

Future research should examine longitudinal firm-level data to identify whether AI productivity gains persist after initial adoption. More comparative research is needed between service and manufacturing sectors, especially in emerging economies. Future studies should also distinguish between task automation, task augmentation, job redesign, and employment displacement. In addition, research should investigate how AI affects job quality, worker autonomy, stress, surveillance, career development, and wage distribution.

Another important direction is sector-specific analysis. In services, future research should examine AI in banking, insurance, education, healthcare, logistics, tourism, retail, and professional services. In manufacturing, future research should focus on smart factories, predictive maintenance, digital twins, human–robot collaboration, quality control, and supply-chain resilience. Finally, more research is needed on governance: how firms can design responsible AI systems that enhance productivity without undermining fairness, accountability, and human capability.

Conclusion

This study concludes that AI does not simply enhance or replace human productivity. It does both, but through different mechanisms and under different conditions. In service sectors, AI primarily enhances productivity when it supports structured cognitive tasks such as writing, coding, customer service, analysis, and documentation. It replaces human productivity mainly in routine clerical, administrative, and first-level support tasks. In manufacturing, AI enhances productivity through process optimization, predictive maintenance, quality control, robotics, and data-driven decision-making, but it may replace repetitive physical and inspection tasks.

The most accurate conclusion is that AI reconfigures human productivity. It shifts human value away from routine execution and toward judgment, creativity, coordination, ethics, technical supervision, and human–AI collaboration. Whether this transformation benefits workers and firms depends on organizational choices. AI enhances productivity when firms invest in skills, redesign work, maintain human oversight, and align AI with strategic goals. AI replaces productivity destructively when firms use it narrowly to cut labor without redesigning tasks, protecting job quality, or developing complementary human capabilities.

For managers, the implication is clear: the goal should not be to ask whether AI or humans are more productive in general. The better question is: which tasks should be automated, which tasks should be augmented, and which human capabilities must be strengthened to create higher-value work?

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