Intersect, Vol 18, No 3 (2025)

Artificial Intelligence in Brazil: Impacts on Economic Growth, Productivity, and Inequality

Fernando C. Gabas Filho
Avenues The World School: Advanced Economics, Dr. Zahran, São Paulo, Brazil

Introduction

The artificial intelligence (AI) industry is growing exponentially. Estimates show AI could contribute USD 13 trillion to the global economy by 2030 (Banerjee et al, 2023). Research extensively examines AI's economic potential, but its implementation in Brazil remains limited. This paper examines AI's economic implications in Brazil, focusing on its integration into key sectors and the associated challenges. By analyzing sector-specific data and trends, the study aims to provide insights into AI's role in shaping Brazil's economy and its impact on growth and equity.

Background Information

Economic Composition

Agriculture, services, and industry mainly contribute to Brazil's GDP (IBGE, 2024b; IMF, 2024b). The service sector dominates, accounting for 67.5% of GDP (1.7 trillion BRL) as of 2023 (IBGE, 2024b; IMF, 2024b). It also accounts for 71% of total employment (Delivorias, 2022). The public service sector encompasses government agencies at both national and local levels, public utilities, and numerous specialized organizations. Meanwhile, the private sector consists of industries, such as tourism, financial services, transportation, maintenance, and retail (Delivorias, 2022). Agriculture contributes 8.9% to the GDP (IBGE, 2024b). The country leads in soybeans, coffee, and beef exports—47.3% of the soybeans exported internationally come from Brazil (De Maria et al., 2022).

Industry accounts for 24.6% of GDP (619.7 billion BRL), with mining and manufacturing as key contributors (IBGE, 2024b; IMF, 2024b). Brazil leads the world in niobium production and ranks second in iron ore production. It also produces the third-highest amount of bauxite and the fifth-highest tin globally (IBRAM, 2023). In 2021, Brazil produced 18.9% of the world's total iron ore production (IBRAM, 2023). Brazil's manufacturing sector has experienced a decline in competitiveness, attributed to factors such as high production costs and limited adoption of emerging technologies (Urraca-Ruiz et al., 2023). The sector's share in the Gross Domestic Product (GDP) decreased from 20% historically to approximately 11% in recent years (Morceiro & Guilhoto, 2023). The country's manufacturing output also fell by 1.2% in the first quarter of 2023, placing Brazil 66th out of 112 economies in global manufacturing performance rankings (IEDI, 2023). Table 1 and Figure 1 provide a visual representation of Brazil's GDP components.

Indicators	Current values (Trimester 2, 2024)
Nominal GDP	2.9 Trillion R$
Agriculture	199.9 Billion R$
Industry	619.7 Billion R$
Services	1.7 Trillion R$
Gross Fixed Capital Formation	484.4 Billion R$
Household Consumption Expenditure	1.8 Trillion R$
Government Consumption Expenditure	532.8 Billion R$

Table 1. Brazilian GDP Component Breakdown.

Note: values are presented in Brazilian reais. Reprinted from Agência IBGE notícias by IBGE. (2024, September 3). GDP grows by 1.4% in Q2 2024 | news agency. Agência de Notícias - IBGE.

Brazilian GDP by production sector

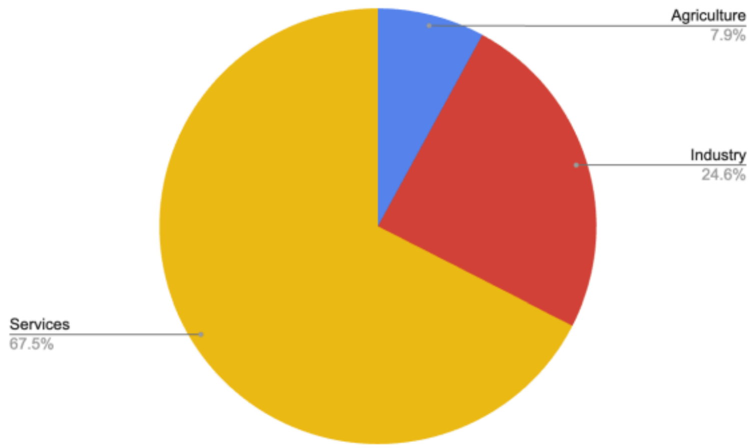

FIGURE 1. Brazilian GDP by Production Sector.

Note: (2024, September 3). GDP grows by 1.4% in Q2 2024 | news agency. Data adapted from Agência de Notícias - IBGE.

Brazil's productivity growth lags behind other emerging markets (Veloso & Zaourak, 2024; Arias et al., 2017). Brazil's Total Factor Productivity (TFP) growth has been notably negative compared to other emerging and developed economies. Between 1997 and 2019, Brazil's TFP decreased by an average of 1% annually, while China and India experienced annual TFP growth of 2% and 2.3%, respectively (Veloso & Zaourak, 2024).

Total Factor Productivity (TFP) measures an economy's efficiency in generating income from its inputs, primarily labor and capital. It reflects the ability to increase income without additional inputs or to maintain income levels while using fewer resources (Zymek, 2024).

Regional Inequalities and Technological Access

There is inequality among Brazil's states. For instance, São Paulo, the wealthiest state, generates 30.13% of the national GDP, benefiting from high broadband rates compared to the rest of the nation—75,4% of households in the southeast (São Paulo's region) had access to both fixed and mobile broadband (IBGE, 2024b; IBGE, 2024a). Conversely, Acre and Roraima combined contribute 0.46% to GDP, highlighting their limited infrastructure and negligible access to emerging technologies. In the north and northeast, households with access to both fixed and mobile broadband fall to 65.2% and 58.7%, respectively (IBGEa, 2024; IBGEb, 2024). Table 2 represents the relationship between every state and its GDP.

States	GDP in 2021 (1.000.000 R$)	Percent of total GDP (%)
Acre	21.374	0.24
Alagoas	76.266	0.85
Amapá	20.100	0.22
Amazonas	131.531	1.46
Bahia	352.618	3.91
Ceará	194.885	2.16
Distrito Federal	286.944	3.18
Espírito Santo	186.337	2.07
Goiás	269.628	2.99
Maranhão	124.981	1.39
Mato Grosso	233.390	2.59
Mato Grosso do Sul	142.204	1.58
Minas Gerais	857.593	9.51
Paraná	549.973	6.10
Paraíba	77.470	0.86
Pará	262.905	2.92
Pernambuco	220.814	2.45
Piauí	64.028	0.71
Rio de Janeiro	949.301	10.52
Rio Grande do Norte	80.181	0.89
Rio Grande do Sul	581.284	6.44
Rondônia	58.170	0.64
Roraima	18.203	0.20
Santa Catarina	428.571	4.75
Sergipe	51.861	0.57
São Paulo	2.719.751	30.13
Tocantins	51.781	0.57

TABLE 2. Brazilian GDP Breakdown Per State.

Note: Values are presented in Brazilian reais per 1.000.000 BRL. Reprinted from Agência IBGE notícias by IBGE. (2021). Produto Interno Bruto - PIB | IBGE. Ibge.gov.br

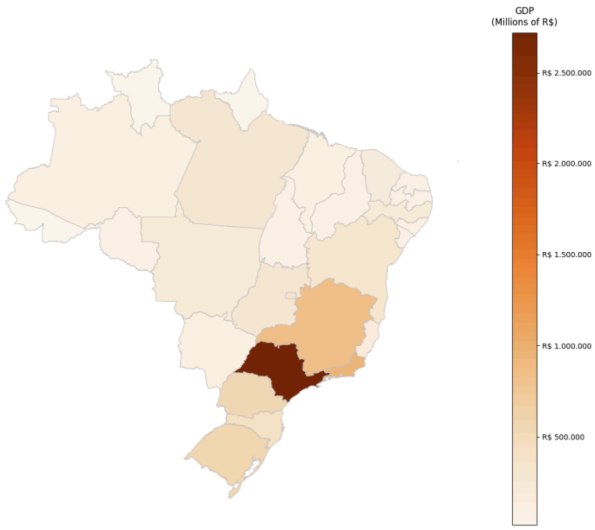

FIGURE 2. Brazilian GDP Breakdown By State.

Note: Values are presented in Brazilian reais per 1.000.000 BRL. Data adapted from Agência IBGE notícias by IBGE. (2021). Produto Interno Bruto - PIB | IBGE. Ibge.gov.br.

Beyond state-to-state discrepancies, there are rural-urban inequality regions in Brazil. While the difference decreased drastically in the past 8 years—from 40 percentage points in 2016 to 13.1 percentage points in 2023—the disparity remains (Agência Gov, 2024b). For instance, urban areas had a 95.3% penetration rate for mobile broadband, compared to 67.4% in rural areas (Agência Gov, 2024b).

These discrepancies make different regions in Brazil benefit differently from technological innovations such as AI, which might further exacerbate regional inequality in the nation.

Regulatory Framework and Policy Challenges

In 2021, Brazil launched its Artificial Intelligence Strategy (EIA) as a policy framework to guide the ethical deployment of AI, strengthen data governance, and stimulate research and development (Ministry of Science, Technology, and Innovations, 2021).

The strategy builds on Brazil's General Data Protection Law (LGPD), which safeguards data privacy in line with global frameworks such as the GDPR. However, LGPD does not specifically address the unique requirements of AI development, such as large-scale data-sharing agreements necessary for training machine learning models (OECD, 2024).

Fiscal constraints also pose challenges. According to IMF estimates, Brazil's debt is projected to reach 97.6% of the GDP in five years (IMF, 2024). Such elevated levels of public debt constrain the government's ability to invest in AI-related initiatives, such as digital infrastructure and education.

AI Readiness and Global Comparisons

The IMF AI Preparedness Index evaluates countries' preparedness to adopt and implement artificial intelligence in ways that benefit their economies and societies. The index considers government digital infrastructure, human capital, technological innovation, and legal frameworks (IMF, 2023b). Brazil ranks 59th globally in AI readiness, scoring 0.5 out of 1 on the IMF AI Preparedness Index (IMF, 2023a). This places it behind regional peers like Chile (0.63) and far below global leaders like Singapore (0.8) (IMF, 2023a). The low score reflects areas for improvement in digital infrastructure. Furthermore, in 2019, only 21% of 25-34 year-olds had tertiary education degrees, falling far behind the OECD country's 45% average (IMF, 2023a). The adoption of advanced AI technologies typically requires specialized skills and Brazil's lack thereof raises concerns for AI's implementation (OECD, 2020a).

Historical Precedent: Lessons from Brazil's 1990s Tech Transition

In the 1990s, amid a global wave of technological advancement and digitalization, Brazil implemented trade liberalization, macroeconomic reforms (e.g., the Real Plan), and efforts to integrate into the emerging digital economy. The Real Plan, implemented in 1994, was a set of economic reforms aimed at stabilizing Brazil's economy after years of hyperinflation. It introduced a new currency—the real (BRL)—anchored to the U.S. dollar, alongside tight fiscal controls, inflation targeting, and a floating exchange rate. These changes modestly increased economic growth and labor productivity by approximately 1% per year between 1990 and 2009 (Cavalcante & De Negri, 2014; Pinheiro et al., 2001). However, productivity growth in the industrial sector stagnated, declining by an average of 2.3% per year between 1995 and 2002, largely due to structural restrictions such as poor infrastructure, limited R&D investment, and low-skilled labor (Cavalcanti & De Negri, 2014). Brazil's manufacturing share of GDP dropped from over 21.6% in the 1980s to about 15% in the 1990s, and later to 10.6% in the 2000s, reflecting premature deindustrialization (Lara & Prado, 2023). The 1990s tech boom's benefits were concentrated in wealthier regions with resources for digital adoption and skilled workers, raising the skill premium and, thus, exacerbating regional and income inequality (World Bank, 2004; Jung, 2015). Brazil's precedent warns that AI adoption, if not paired with investments in education and digital infrastructure, may replicate similar patterns—yielding limited productivity gains and deepening socio-economic disparities.

AI’s First-Glance Impact

GDP Growth

1. *Agriculture:* Brazil’s agricultural sector contributes 6.9% to GDP and has pilot studies demonstrating the potential of AI technologies (IBGE, 2024b). Advanced technologies, such as machine learning (ML) and artificial intelligence (AI) vision, have revolutionized precision agriculture by enabling the automation of all-terrain vehicles (ATVs) (Padhiary et al., 2024). For instance, ATV-driven agricultural automation improves crop yields by up to 20%, reduces overall investment by 30%, and makes farming more efficient by 25% (Padhiary et al, 2024). However, these successes are not uniformly scalable. Rural areas struggle with inadequate broadband infrastructure, particularly in the North and Northeast, as internet penetration rates fall below 70%. (Agência Gov, 2024b). Such differences inhibit rural farmers from accessing AI tools.
2. *Manufacturing:* Manufacturing accounts for 21.4% of Brazil’s GDP (IBGE, 2024b). Predictive maintenance systems can reduce machinery downtime by up to 51% (PricewaterhouseCoopers [PWC], 2018). Arena et al. (2022) indicates companies experienced a 25–30% reduction in maintenance costs and a 20–25% increase in production after adopting predictive maintenance programs (Arena et al., 2022). However, multinational firms with access to advanced technology and capital concentrate these gains (Sönmez, 2013). Domestic mid-sized manufacturers face challenges, including Brazil’s low R&D investment (1.3% of GDP compared to 2.7% in OECD countries) and a skills gap in AI-specific roles (OECD, 2024; Figueiredo, 2023). Moreover, Brazil's reliance

on labor-intensive manufacturing, driven by relatively low wages, reduces the economic incentive to automate (Lara & Prado, 2023). Svanberg et al. (2024) suggests only 23% of manufacturing tasks are technologically and economically viable for AI-driven automation, with even lower feasibility in labor-abundant nations like Brazil (Svanberg et al., 2024). Brazil weakens in the global manufacturing market as India and China effectively leverage AI in their manufacturing sectors. Indian textile manufacturers have integrated AI into production processes, achieving significant productivity gains through automated material handling and predictive analytics, optimizing operations, and reducing defects (Ramos et al., 2023). Chinese industries have aggressively invested in AI-enabled robotics, holding the top position globally in patent applications, 74.7% (Li et al., 2024). These technological advancements position China and India as leaders in manufacturing innovation while Brazil struggles to develop its AI infrastructure.

3. *Services:* The services sector accounts for 58.6% of Brazil's GDP (IBGE, 2024b). Brazil's service sector remains composed of manual labor-intensive activities, such as domestic work, informal retail, and personal care services, which have limited potential for AI-driven transformation (Agência Gov, 2024a). Informal workers are 38.9% of Brazil’s population (Agência Gov, 2024a). An informal economy and low digital penetration diminish AI's impact on the Brazilian service sector (Agência Gov, 2024a; Laricchia, 2022). In financial services, AI tools are increasingly utilized to optimize routine operations, such as fraud detection and payment processing, enhancing efficiency without overhauling traditional service delivery models (Olaseni & Familoni, 2024). AI can also improve banks' annual productivity by an estimated 4.3% by 2035 (Bredt, 2019). Similarly, AI chatbots reduce customer service expenses by approximately 30% in sectors like logistics and supply chain services, and 25% of customer service activities are conducted using chatbots, companies still refer more complex issues to human professionals (Van der Meulen & Pettey, 2017).

Employment Rates

1. *Job Displacement in Routine and Low-Skilled Roles:* AI's automation potential raises concerns about job displacement in low-skilled roles. Studies estimate that up to 14% of jobs worldwide are at high risk of automation, while an additional 32% may experience significant changes due to AI technologies (OECD, 2020b). In Brazil, over 58.1% of jobs may disappear over the next 10 to 20 years due to automation. (Ottoni et al., 2022). However, Brazil's relatively low labor costs often make human labor more economically viable than capital-intensive AI systems, slowing automation adoption compared to high-wage economies (International Labour Organization, 2023).
2. *Job Creation in AI-Driven Industries:* Conversely, AI adoption might create more high-skill jobs with greater pay (Badet, 2021). Research indicates AI will create more jobs than it displaces, with McKinsey & Company (2017) forecasting 555 to 890 million new jobs by 2030 and Van der Meulen & Pettey (2017) expecting to create 2.3 million jobs globally while displacing 1.8 million jobs in 3 years (McKinsey, 2017; Van der Meulen & Pettey, 2017; Badet, 2021). However, Brazilians working in the professional, scientific, and technical sectors represent only 1% of the population (Statista Research Department, 2024b). Therefore, job creation results in high-skilled industries might be minimal.
3. *Opportunities for Upskilling:* There is a discrepancy in skill levels among Brazilian workers. Only 15% of 25-64 year-olds have attained tertiary education in Brazil, far below the OECD average, of 37% (OECD, 2017). This is especially worrying because the average salary for individuals with tertiary education is 3 times professionals without such qualifications (7.094,17 BRL vs. 2.441,16 BRL) (Cortez et al., 2023). AI presents opportunities for skill development and leveler, particularly for workers displaced by automation. Dell'Acqua et al. (2023) indicates low-skilled workers experience a 43% improvement in performance when equipped with AI, compared to a 17% improvement among high-skilled workers (Dell'Acqua et al., 2023). AI tools could bring low-skilled workers in line with more experienced peers, reducing productivity and income disparities, and enhancing overall economic output.

Income Inequality

1. *AI's Potential to Reduce Wage Disparities:* AI's role as a "skill leveler" offers a pathway to reduce wage disparities. For instance, AI-assisted workers in call centers achieved 30% higher productivity, narrowing the wage gap between entry-level and experienced employees (Brynjolfsson et al., 2023). In Brazil, deploying AI in retail and customer service could help low-skilled workers achieve higher productivity, reducing wage inequalities.
2. *Risks of Exacerbating Inequality:* However, AI also poses risks of exacerbating inequality. Wealthier regions like São Paulo, with advanced technological ecosystems, are better positioned to benefit from AI (IBGEa, 2024; IBGEb, 2024). In contrast, the North and Northeast face low broadband penetration and inadequate educational resources (IBGE, 2024a). Research by Cazzaniga et al. (2024) emphasizes uneven AI adoption often amplifies existing inequalities. Research suggests between 50% and 70% of the shifts in the U.S. wage structure over the past 40 years can be attributed to the relative wage reductions of worker groups focused on routine tasks in industries undergoing automation (Acemoglu & Restrepo, 2022) Brazil risks similar outcomes unless proactive measures address these disparities

Preliminary Conclusions

Brazil's economy, with its strong focus on agriculture, mining, and manufacturing, is expected to experience a relatively modest impact from AI integration compared to nations with economies more reliant on information-intensive industries (Delivorias, 2022). These sectors have low exposure to generative AI technologies (Hatzius et al., 2023; Delivorias, 2022). While AI-driven innovations like precision farming and predictive maintenance may incrementally improve efficiency, they are unlikely to revolutionize these industries as AI transforms IT and high-skill services in other nations (Hatzius et al., 2023).

The employment effects in Brazil also reflect this limited impact. Jobs in agriculture, mining, and manufacturing are relatively insulated from disruption by generative AI, providing stability for large portions of the workforce (Hatzius et al., 2023). While AI adoption might create some high-skill jobs, the professional, scientific, and technical sectors represent only 1% of the workforce, limiting the scale of job creation (Statista Research Department, 2024). This modest scope of change reduces the potential for structural unemployment but also limits opportunities for economic transformation through high-tech employment. Cyclical unemployment, driven by traditional economic factors, may remain more relevant than AI-induced labor market shifts.

At first glance, AI's impact on Brazil's economy is seemingly insignificant. It raises questions about whether Brazil's modest exposure to AI will ultimately prove advantageous or detrimental in a rapidly evolving global economy. However, AI's impact is more nuanced than it may initially appear. The next section explores less-expected variables where AI could substantially influence Brazil's economy, uncovering areas of opportunity and challenge beyond the obvious sectors.

Exploratory Analysis

Healthcare

1. *Quantitative Analysis of Cost-Saving Potential:* According to the IMF (2022), Brazil is the 20th country with the greatest ratio of government spending to GDP. The nation's government spends 46.38% of the GDP. (IMF, 2022). Healthcare accounts for 9.69% of expenditure (Gov.br, 2024). Research (2022) indicates AI's implementation in healthcare could reduce healthcare spending by 5-10% (Sahni et al., 2023). However, Sahni et al. focuses on the United States of America, AI's cost-saving potential in Brazil's healthcare system is likely less pronounced than in the U.S. due to structural and infrastructural differences. Administrative costs in Brazil account for 10.17% of healthcare spending (Gov.br, 2024). Meanwhile, in the U.S., these costs reach 15-25% (Chernew & Mintz, 2021). This indicates AI-driven efficiencies in administrative processes might yield relatively smaller absolute savings in Brazil. Yet, even a conservative 5% reduction would yield annual savings of up to 8.5 billion BRL (Gov.br, 2024). These funds could be redirected to other national priorities or reduce government debt.
2. *Reinvestment in Human Capital:* The fiscal space created by AI-driven savings offers an opportunity to address structural deficiencies in Brazil's labor market, particularly in education. Reallocating 20% of annual healthcare savings—approximately 1.7 billion BRL—toward education could significantly enhance Brazil's tertiary enrollment rate, currently at 21%, which lags behind the OECD average of 45% (OECD, 2020a). Over a decade,

such investments could increase the proportion of tertiary-educated workers, enhancing Brazil’s productivity and fostering long-term economic growth. Research (2016) indicates higher levels of education correlate with improved labor market outcomes, higher wages, and greater adaptability to technological change (Vilorio, 2016). Furthermore, Hanif & Arshed (2016) suggests a 1% tertiary education increase leads to 0.37% GDP growth. Brazil could benefit from the productivity gains generated by increased human capital, driving long-term economic growth.

3. *Clinical Capacity and Caregiver Efficiency:* Brazil’s public health system (SUS) faces significant understaffing and resource constraints—there are only 2.3 physicians per 1,000 inhabitants, compared to the OECD average of 3.5 (OECD, 2021). AI tools such as clinical decision support systems (CDSS) can reduce the cognitive load of clinicians, improving diagnostic confidence and efficiency (Adelusola, 2025). For example, real-world implementations of AI triage systems have demonstrated improvements in operational efficiency. In one case, an emergency department that adopted a real-time AI triage tool reported a 30% reduction in average patient wait times. (Porto, 2024). AI can streamline repetitive administrative tasks, such as billing, scheduling, and patient data management (Haberle et al., 2024; Bajwa et al., 2021; Varnosfaderani & Forouzanfar, 2024). For example, Natural Language Processing (NLP) tools like Nuance Dragon Ambient eXperience (DAX) have been shown to reduce documentation time by up to 50% while improving clinician satisfaction (Haberle et al., 2024; Bajwa et al., 2021). AI-driven solutions in Brazil could alleviate administrative and caregiver workload burdens, redirect resources to direct patient care and reduce overall costs.
4. *Secondary Impacts:* AI can potentially improve the population's health, ultimately driving economic growth. AI's integration into diagnostic processes has gained significant attention for its proven ability to improve diagnostic accuracy, often outperforming traditional methods (Siranart et al., 2024; Schukow et al., 20243). Research highlights AI's critical role in identifying complex conditions like cervical cancer, breast cancer, and left ventricular hypertrophy (LVH), where AI systems consistently deliver results that surpass those achieved through conventional diagnostic approaches (Siranart et al., 2024; Schukow et al., 2023). Healthier

workers are more likely to engage fully in economic activities, contributing to GDP growth. Ridhwan et al. (2022) synthesizes findings from 64 studies with 719 estimates and concludes improving health outcomes positively impacts economic performance. Specifically, a one-year increase in life expectancy or adult survival rate correlates with an approximate 2.4% growth in economic output (Ridhwan et al., 2022). These effects are more pronounced in less-developed countries, where health improvements spur economic-demographic transitions, longer working lifespans, and enhanced productivity (Ridhwan et al., 2022). AI-driven healthcare interventions can strengthen Brazil's economy by reducing absenteeism, improving workplace efficiency, and increasing the average working lifespan (Ridhwan et al., 2022).

Education

1. *Analysis of Cost-Savings and Implementation:* AI can reduce operational inefficiencies and save funds in higher education, particularly in administrative functions (McKinsey & Company, 2018). Automating routine tasks such as grading, scheduling, and attendance tracking could reduce administrative costs by up to 30% (McKinsey & Company, 2017). Research (2019) further suggests AI has the capability to save time and resources in administrative tasks (UNESCO, 2024). The funds and resources economized can be redistributed to other areas of education or the economy, which can create the positive changes mentioned above.
2. *Low Tertiary Education:* AI can address skill disparities and enhance productivity. Research (2023) highlights AI’s capacity to function as a “skill leveler,” particularly for less-experienced workers (Dell’Acqua, 2023). In controlled studies, less-skilled consultants using AI tools demonstrated performance improvements of 43%, significantly outpacing the 17% improvement observed among their highly skilled counterparts (Dell’Acqua, 2023). This disparity underscores AI’s potential to elevate baseline performance levels, enabling less-experienced individuals to execute tasks with precision and effectiveness comparable to seasoned professionals (Dell’Acqua, 2023). Consequently, AI can bridge skill gaps and reduce productivity disparities within the workforce, fostering greater efficiency across sectors. Brynjolfsson et al. (2023) further suggests AI’s role in

augmenting productivity among low-skill workers. Generative AI-based conversational assistants boosted worker productivity by an average of 14%, as measured by issues resolved per hour (Brynjolfsson et al., 2023). The AI had an even greater effect on novice and less-skilled workers, increasing their productivity by 34%, while experienced workers showed minimal gains (Brynjolfsson et al., 2023). Dell'Acqua et al. (2023) and Brynjolfsson et al. (2023) indicate how AI can compensate for skill deficits. This compensation is especially positive in nations where low-skilled workers are the majority since it benefits a greater proportion of the population (Dell'acqua et al., 2023; Brynjolfsson et al., 2023). In Brazil, where tertiary education attainment is limited to 15% of the workforce, AI-driven educational tools could revolutionize industry productivity (OECD, 2017). AI could increase long-term economic growth by enabling less-educated workers to achieve productivity levels comparable to their more skilled counterparts—increasing productivity

Energy Sector

1. *Electricity Generation and Grid Optimization:* In 2024, 88.2% of Brazil's electricity came from renewable sources (BEN, 2025). With wind and solar supplying 23.7% of national demand, AI-driven forecasting models allow grid operators to better predict weather-driven fluctuations and manage dispatch accordingly (BEN, 2025). This reduces reliance on costly backup plants. The International Energy Agency (IEA) estimates AI-enabled optimization in global power generation could save up to $110 billion annually by 2035—Brazil, ranked 10th in primary energy production, will likely benefit from a large share (IEA, 2025; Statista Research Department, 2025). Brazil currently loses 18% of electricity to transmission and distribution inefficiencies, more than double the OECD average (Aude et al., 2021). A study by ABRADEE suggests 14% of the electricity distributed in Brazil was stolen or illegally diverted in 2022, resulting in an estimated loss of approximately R$ 7.7 billion (ABRADEE, 2022). AI systems using smart meter data can flag anomalies in real time, enabling faster inspections and reducing illegal diversions (Jaiswal et al., 2021; Dai et al., 2022). If AI cuts even half of these non-technical losses, utilities could save billions of reais annually. Research (2024; 2025) indicates AI-driven predictive maintenance

improves operating efficiency, reduces downtime, and optimizes resource use in multiple industries (e.g autonomous vehicles) (Patil, 2025; Aeddula et al., 2024; Ünlü & Söylemez, 2024). These results can likely be replicated in the energy industry.

2. *Oil and Gas:* Petrobras, a Brazilian majority state-owned multinational corporation in the petroleum industry, deployed AI solutions across exploration, production, and maintenance operations to optimize processes and lower costs. For instance, Petrobras's generative AI assistant for offshore platform maintenance ("Petronemo") is projected to save R$20 million by 2029 through faster, predictive maintenance workflows (Braum, 2025). AI-driven analytics also enhance upstream success: machine learning algorithms analyze seismic and geological data to identify oil reservoirs with greater precision, reducing dry wells and optimizing drilling decisions (Li et al., 2024; Hanif, 2024). Such innovations boost operational efficiency and safety while lowering per-barrel costs, strengthening the industry's competitiveness. Oil now ranks as Brazil's largest export and raised $44.84 billion USD in 2024 (Estadão, 2025). Accordingly, AI-driven productivity gains in oil and gas directly translate into higher output, export earnings, and GDP growth.

Discussion

The findings of this study underscore AI's potential to enhance Brazil's economic productivity, though its benefits are unevenly distributed across sectors and regions. These results are consistent with previous research highlighting the importance of infrastructure and skilled labor for maximizing the benefits of AI integration (e.g., Wei et al., 2024; Figueiredo, 2023). This study extends these findings by emphasizing Brazil's unique challenges, including its reliance on labor-intensive industries and the uneven distribution of technological resources.

AI offers opportunities to modernize Brazil's economy, particularly by addressing inefficiencies in agriculture and healthcare. However, AI may exacerbate existing inequalities, reinforcing regional and socio-economic disparities. Future policies must prioritize digital infrastructure expansion, workforce upskilling, and R&D investment to bridge these gaps and ensure equitable AI adoption.

Further research should explore long-term strategies for integrating AI into underdeveloped regions and sectors, focusing on the role of public-private partnerships and international collaboration in building the necessary infrastructure. Additionally, longitudinal studies could examine the socio-economic impacts of AI over time, providing insights into its potential in Brazil's diverse economic landscape.

References

ABRADEE. (2022, September 30). Perdas de energia: Guerra sem fim? ABRADEE - Associação Brasileira de Distribuidores de Energia Elétrica. https://abradee.org.br/perdas-de-energia-guerra-sem-fim/.

Acemoglu, D., & Restrepo, P. (2022). Tasks, automation, and the rise in U.S. wage inequality. Econometrica, 90(5), 1973–2016. https://doi.org/10.3982/ecta19815.

Aeddula, O., Frank, M., Ruvald, R., Askling, C. J., Wall, J., & Larsson, T. (2024). AI-Driven Predictive Maintenance for Autonomous Vehicles for Product-Service System Development. Procedia CIRP, 128, 84–89. https://doi.org/10.1016/j.procir.2024.06.008.

Agência Gov. (2024a). Indústria, construção e serviços lideram criação de empregos no melhor trimestre em 12 anos. Agência Gov. https://agenciagov.ebc.com.br/noticias/202411/trimestre-encerrado-em-outubro-tem-a-me nor-taxa-de-desocupacao-em-13-anos-6-2.

Agência Gov. (2024b). Internet avança mais rápido em áreas rurais do Brasil e chega a 81% dos domicílios. Agência Gov. https://agenciagov.ebc.com.br/noticias/202408/internet-foi-acessada-em-72-5-milhoes-de -domicilios-do-pais-em-2023.

Arena, F., Collotta, M., Luca, L., Ruggieri, M., & Termine, F. G. (2022). Predictive maintenance in the automotive sector: A literature review. Mathematical and Computational Applications, 27(1), 2. https://doi.org/10.3390/mca27010002.

Arias, D., Vieira, P., Contini, E., Farinelli, B., & Morris, M. (2017). Agriculture productivity growth in brazil recent trends and future prospects. https://documents1.worldbank.org/curated/es/268351520343354377/pdf/123948-WP-6-3 -2018-8-39-22-AriasetalAgriculturalgrowthinBrazil.pdf.

Aude, M., Decaix, G., Nobels, K., & Pinto, J. (2021). How Brazil can optimize its cost of energy . McKinsey & Company. https://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/how-br azil-can-optimize-its-cost-of-energy.

Badet, J. (2021). AI, automation and new jobs. Open Journal of Business and Management, 9(5), 2452–2463. https://doi.org/10.4236/ojbm.2021.95132.

Bajwa, J., Munir, U., Nori, A., & Williams, B. (2021). Artificial intelligence in healthcare: Transforming the practice of medicine. Future Healthcare Journal, 8(2), 188–194. NCBI. https://doi.org/10.7861/fhj.2021-0095.

Banerjee, A., Kabadi, S., & Karimov, D. (2023). The Transformative Power of AI: Projected Impacts on the Global Economy by 2030. Review of Artificial Intelligence in Education, 4, e20–e20. https://doi.org/10.37497/rev.artif.intell.educ.v4i00.20.

BEN. (2025). Relatório Síntese BEN 2025 — Ministério de Minas e Energia. Www.gov.br. https://www.gov.br/mme/pt-br/assuntos/secretarias/sntep/publicacoes/balanco-energeticonacional/ben-2025/relatorio-sintese/Sintese_BEN2025/view.

Bredt, S. (2019). Artificial intelligence (AI) in the financial sector—potential and public strategies. Frontiers in Artificial Intelligence, 2(16). https://doi.org/10.3389/frai.2019.00016.

Brynjolfsson, E., Li, D., Raymond, L., Acemoglu, D., Autor, D., Axelrod, A., Dillon, E., Enam, Z., Garicano, L., Frankel, A., Manning, S., Mullainathan, S., Pierson, E., Stern, S., Rambachan, A., Reenen, J., Sadun, R., Shaw, K., & Stanton, C. (2023). Generative AI at work. https://www.nber.org/system/files/working_papers/w31161/w31161.pdf.

Cavalcante, L. R., & De Negri, F. (2014). Produtividade no Brazil: Uma análise do período recente. Ipea. https://repositorio.ipea.gov.br/bitstream/11058/3016/1/TD_1955.pdf.

Cazzaniga, M., Jaumotte, F., Li, L., Melina, G., Panton, A. J., Pizzinelli, C., Rockall, E. J., & Mendes, M. (2024). Gen-AI artificial intelligence and the future of work. International Monetary Fund.

Chernew, M., & Mintz, H. (2021). Administrative expenses in the US health care system: Why so high? JAMA, 326(17), 1679–1680. https://doi.org/10.1001/jama.2021.17318.

Cortez, M., Maurício, R., & Reis, C. (2023). RENDIMENTOS EM RELAÇÃO RENDIMENTOS EM RELAÇÃO AOS TRABALHADORES AOS TRABALHADORES COM ENSINO MÉDIO COM ENSINO MÉDIO.

https://repositorio.ipea.gov.br/bitstream/11058/11822/1/TD_2861_Web.pdf.

Dai, W., Liu, X., Heller, A., & Nielsen, P. S. (2022). Smart meter data anomaly detection using variational recurrent autoencoders with attention. ArXiv.org; Cornell University. https://arxiv.org/abs/2206.07519.

De Maria, M., Zanello, G., Nakagawa, L., Robert^, J., Visentin, J., Pavani ¤, B., Branco, P., Fendrich, A., Giaroli, A., Pereira Barretto, O., Rocha Junior, A., & Lima Ranieri, S. (2022). Moving towards a sustainable soybean supply chain – A sustainable policy toolbox for brazilian stakeholders and other global actors. UK research and innovation global challenges research fund (UKRI GCRF) trade, development and the environment hub. https://www.iis-rio.org/wp-content/uploads/2022/09/MOVING-TOWARDS-A-SUSTAIN ABLE-SOYBEAN-SUPPLY-CHAIN.pdf.

Delivorias, A. (2022). Brazil's economy challenges for the new president. https://www.europarl.europa.eu/RegData/etudes/BRIE/2022/738196/EPRS_BRI(2022)73 8196_EN.pdf.

Dell'Acqua, F., McFowland, E., Mollick, E., Lifshitz-Assaf, H., Kellogg, K. C., Rajendran, S., Krayer, L. J., Candelon, F., & Lakhani, K. R. (2023). Navigating the jagged technological frontier: Field experimental evidence of the effects of AI on knowledge worker productivity and quality. Social Science Research Network. https://doi.org/10.2139/ssrn.4573321.

Estadão. (2025). Quais são os 10 produtos que o Brasil mais exporta? Veja o ranking. Estadão. https://www.estadao.com.br/economia/produtos-que-o-brasil-mais-exporta-para-o-mundo -nprei/?srsltid=AfmBOoqOnRQkTAa_HCR6dC36S7n2Xa0fy_5a6kwzupUnlCSdnXecIc ak.

Figueiredo, P. N. (2023). Capacidade tecnológica e inovação: Desafios para a transição industrial e econômica do Brasil. Editora FGV.

Gov.br. (2024). Despesa pública - portal da transparência. Portaldatransparencia.gov.br. https://portaldatransparencia.gov.br/despesas.

Hanif, N., & Arshed, N. (2016). International journal of economics and financial issues relationship between school education and economic growth: SAARC countries. International Journal of Economics and Financial Issues, 6(1), 294–300. https://dergipark.org.tr/en/download/article-file/364734.

Hatzius, J., Briggs, J., Kodnani, D., & Pierdomenico, G. (2023). The recent emergence of generative artificial intelligence (AI) raises whether we. Goldman Sachs. https://www.key4biz.it/wp-content/uploads/2023/03/Global-Economics-Analyst_-The-Po tentially-Large-Effects-of-Artificial-Intelligence-on-Economic-Growth-Briggs_Kodnani. pdf.

IBGE. (2021). Produto Interno Bruto - PIB | IBGE. Ibge.gov.br. https://www.ibge.gov.br/explica/pib.php.

IBGE. (2024a, August 16). Internet foi acessada em 72,5 milhões de domicílios do país em 2023 | agência de notícias. Agência de Notícias - IBGE. https://agenciadenoticias.ibge.gov.br/agencia-noticias/2012-agencia-de-noticias/noticias/4 1024-internet-foi-acessada-em-72-5-milhoes-de-domicilios-do-pais-em-2023.

IBGE. (2024b, September 3). GDP grows by 1.4% in Q2 2024 | news agency. Agência de Notícias - IBGE. https://agenciadenoticias.ibge.gov.br/en/agencia-press-room/2185-news-agency/releasesen/41166-gdp-grows-by-1-4-in-q2-2024.

IBRAM. (2023). Brazil country mining guide 2023. https://ibram.org.br/wp-content/uploads/2023/03/1677590829_dead89_14141_kpmg_bra zil_country_mining_web_digital_v2-1.pdf.

IEA. (2025). AI for energy optimisation and innovation . IEA. https://www.iea.org/reports/energy-and-ai/ai-for-energy-optimisation-and-innovation.

IEDI. (2023). Letter IEDI n. 1199—the industrial slowdown in Brazil and in the world. Iedi.org.br. https://www.iedi.org.br/artigos/textos/english/letter_iedi_n_1199.html.

IMF. (2022). Government expenditure, percent of GDP. Imf.org. https://www.imf.org/external/datamapper/exp@FPP/USA/FRA/JPN/GBR/SWE/ESP/ITA /ZAF/IND?year=2022.

IMF. (2023a). AI preparedness index. Imf.org. https://www.imf.org/external/datamapper/AI_PI@AIPI/ADVEC/EME/LIC.

IMF. (2023b). AI preparedness index (AIPI).

IMF. (2024a). Statistical appendix | world economic outlook.

IMF. (2024b). World economic outlook | Brazil. Www.imf.org. https://www.imf.org/external/datamapper/profile/BRA.

International Labour Office. (2023). Trends 2023 ILO flagship report. https://www.ilo.org/sites/default/files/wcmsp5/groups/public/@dgreports/@inst/documen ts/publication/wcms_865332.pdf.

Jaiswal, R., Fadwa Maatug, Davidrajuh, R., & Rong, C. (2021). Anomaly detection in smart meter data for preventing potential smart grid imbalance. https://doi.org/10.1145/3508259.3508281.

Jung, J. (2015). Regional inequalities in the impact of broadband on productivity. Evidence from Brazil. IBEI. https://www.ibei.org/regional-inequalities-in-the-impact-of-broadband-on-productivity-ev idence-from-brazil_82139.pdf.

Lara, C., & Prado, S. (2023). From boom to gloom: Brazilian labour productivity in manufacturing relative to the United States, 1912–2019. The Economic History Review, 76. https://doi.org/10.1111/ehr.13228.

Laricchia, F. (2022). Brazil: Position in the digital competitiveness ranking 2022 . Statista. https://www.statista.com/statistics/1180289/brazil-digital-competitiveness-ranking-positi on-factor/?utm_source=chatgpt.com.

Li, D., Wang, H., & Wang, J. (2024). Artificial intelligence and technological innovation: Evidence from china's strategic emerging industries. Sustainability, 16(16), 7226. https://doi.org/10.3390/su16167226.

McKinsey & Company. (2017). JOBS LOST, JOBS GAINED: WORKFORCE TRANSITIONS IN A TIME OF AUTOMATION. https://www.mckinsey.com/~/media/McKinsey/Industries/Public%20and%20Social%20S ector/Our%20Insights/What%20the%20future%20of%20work%20will%20mean%20for %20jobs%20skills%20and%20wages/MGI-Jobs-Lost-Jobs-Gained-Executive-summaryDecember-6-2017.pdf.

Ministry of Science, Technology and Innovations. (2021). Summary of the brazilian artificial intelligence strategy -EBIA- 2021 brazilian artificial intelligence strategy. https://www.gov.br/mcti/pt-br/acompanhe-o-mcti/transformacaodigital/arquivosinteligenc iaartificial/ebia-summary_brazilian_4-979_2021.pdf.

Morceiro, P. C., & Guilhoto, J. J. M. (2023). Sectoral deindustrialization and long-run stagnation of Brazilian manufacturing. Brazilian Journal of Political Economy, 43(2), 418–441. https://doi.org/10.1590/0101-31572023-3340.

OECD. (2017). Education at a glance. Inep.gov. https://download.inep.gov.br/acoes_internacionais/estatisticas_educacionais/ocde/education_at_a_glance/CN_Brazil_OECD_2017.pdf.

OECD. (2020a). Education at a glance 2020.

OECD. (2020b). OECD observer roundtable on local firms and automation written by: OECD. https://www.oecd.org/content/dam/oecd/en/publications/reports/2018/09/oecd-observer-roundtable-on-local-firms-and-automation_0683c155/edb193aa-en.pdf.

OECD. (2021). Gross domestic spending on R&D. OECD. https://www.oecd.org/en/data/indicators/gross-domestic-spending-on-r-d.html.

OECD. (2021). Primary Health Care in Brazil. In OECD Reviews of Health Systems. OECD. https://doi.org/10.1787/120e170e-en.

Olaseni, P., & Familoni, N. B. T. (2024). Transforming fintech fraud detection with advanced artificial intelligence algorithms. Finance & Accounting Research Journal, 6(4), 602–625. https://doi.org/10.51594/farj.v6i4.1036.

Ottoni, B., Oliveira, P. R. e, Estrela, L., Santos, A. T., & Barreira, T. (2022). Automation and job loss: The Brazilian case. Nova Economia, 32(1), 157–180. https://doi.org/10.1590/0103-6351/6367.

Padhiary, M., Saha, D., Kumar, R., Sethi, L. N., & Kumar, A. (2024). Enhancing precision agriculture: A comprehensive review of machine learning and AI vision applications in all-terrain vehicle for farm automation. Smart Agricultural Technology, 8, 100483. https://doi.org/10.1016/j.atech.2024.100483.

Patil, D. (2025). Artificial intelligence-driven predictive maintenance in manufacturing: Enhancing operational efficiency, minimizing downtime, and optimizing resource utilization. SSRN. https://doi.org/10.2139/ssrn.5057406.

Pinheiro, A. C., Giambiagi, F., & Moreira, M. M. (2001). O Brasil na década de 90: Uma transição bem-sucedida? https://web.bndes.gov.br/bib/jspui/bitstream/1408/13894/1/O%20Brasil%20na%20d%c3%a9cada%20de%2090%20uma%20transi%c3%a7%c3%a3o%20bem-sucedida.%20td-9 1_P_BD.pdf.

Porto, B. M. (2024). Improving triage performance in emergency departments using machine learning and natural language processing: a systematic review. BMC Emergency Medicine, 24(1). https://doi.org/10.1186/s12873-024-01135-2.

PricewaterhouseCoopers. (2018). Beyond the hype: PdM 4.0 delivers results. https://www.pwc.de/de/industrielle-produktion/pwc-predictive-maintenance-4-0.pdf.

Ramos, L., Rivas-Echeverría, F., Pérez, A. G., & Casas, E. (2023). Artificial intelligence and sustainability in the fashion industry: a review from 2010 to 2022. SN Applied Sciences, 5(12). https://doi.org/10.1007/s42452-023-05587-2.

Ridhwan, M. M., Nijkamp, P., Ismail, A., & M.Irsyad, L. (2022). The effect of health on economic growth: A meta-regression analysis. Empirical Economics, 63. https://doi.org/10.1007/s00181-022-02226-4.

Sahni, N., Stein, G., Zemmel, R., & Cutler, D. M. (2023). The potential impact of artificial intelligence on healthcare spending. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.4334926.

Schukow, C., Smith, S. C., Landgrebe, E., Parasuraman, S., Folaranmi, O. O., Paner, G. P., & Amin, M. B. (2023). Application of chatgpt in routine diagnostic pathology: Promises, pitfalls, and potential future directions. Advances in Anatomic Pathology, 31(1). https://doi.org/10.1097/pap.0000000000000406.

Schukow, C., Smith, S. C., Landgrebe, E., Parasuraman, S., Folaranmi, O. O., Paner, G. P., & Amin, M. B. (2023). Application of chatgpt in routine diagnostic pathology: Promises, pitfalls, and potential future directions. Advances in Anatomic Pathology, 31(1). https://doi.org/10.1097/pap.0000000000000406.

Statista Research Department. (2025). Energy production globally by leading country . Statista. https://www.statista.com/statistics/1398127/global-energy-production-by-leading-country.

Statista Research Department. (2024a). Largest Brazilian listed companies 2024. Statista. https://www.statista.com/statistics/1402000/largest-listed-companies-in-brazil/.

Statista Research Department. (2024b). Number of professional, scientific & technical employees in Brazil. Statista. https://www.statista.com/statistics/763521/number-employees-professional-scientific-tec hnical-sector-brazil/.

Svanberg, M., Li, W., Fleming, M., Goehring, B., & Thompson, N. (2024, January 19). Beyond AI exposure: Which tasks are cost-effective to automate with computer vision? Social Science Research Network. https://doi.org/10.2139/ssrn.4700751.

UNESCO. (2024). Use of AI in education: Deciding on the future we want. Unesco.org. https://www.unesco.org/en/articles/use-ai-education-deciding-future-we-want.

Ünlü, R., & Söylemez, İ. (2024). AI-Driven Predictive Maintenance. Springer Tracts in Nature-Inspired Computing, 207–233. https://doi.org/10.1007/978-981-97-5979-8_10.

Urraca-Ruiz, A., Torraca, J., Britto, J., Carlos Ferraz, J., & Ferraz, J. (2024). Campinas (SP), 22, e023014. Rev. Bras. Inov, 22, 1–35. https://doi.org/10.20396/rbi.v22i00.8668448.

Van der Meulen, R., & Pettey, C. (2017). Gartner says by 2020, artificial intelligence will create more jobs than it eliminates. Gartner. https://www.gartner.com/en/newsroom/press-releases/2017-12-13-gartner-says-by-2020-a
rtificial-intelligence-will-create-more-jobs-than-it-eliminates.

Veloso, F., & Zaourak, G. (2024). A literature review on productivity and growth in brazil.

Vilorio, D. (2016, March 29). Education matters. Bureau of Labor Statistics. https://www.bls.gov/careeroutlook/2016/data-on-display/education-matters.htm?utm_sou rce=chatgpt.com.

Wei, H., Xu, W., Kang, B., Eisner, R., Muleke, A., Rodriguez, D., deVoil, P., Sadras, V., Monjardino, M., & Matthew Tom Harrison. (2024). Irrigation with Artificial Intelligence: Problems, premises, promises. Human-Centric Intelligent Systems, 4. https://doi.org/10.1007/s44230-024-00072-4.

World Bank. (2004). Inequality and economic development in Brazil. https://documents1.worldbank.org/curated/en/456611468744062519/pdf/301140PAPER0 Inequality0Brazil.pdf.

Zymek, R. (2024, September 3). Back to basics: Total factor productivity. IMF. https://www.imf.org/en/Publications/fandd/issues/2024/09/back-to-basics-total-factor-pro ductivity-robert-zyme.