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The Impact of Artificial Intelligence on International Trade: A Case Study of the U.S. Automotive Sector

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Abstract

This thesis explores how artificial intelligence is changing international trade by reshaping production processes, trade patterns, and value chains. Through a literature review and empirical analysis, the study first examines global trends in AI adoption and their correlation with the increase in exports of digitally deliverable services and high-tech goods. Focusing of five digitally advanced economies (United States, Germany, United Kingdom, South Korea, and Japan), the research uses AI readiness indexes, robot density data, and trade performance indicators to identify common patterns. The second part presents a case study of the U.S. automotive industry, with a focus on Tesla, Inc. to demonstrate how AI-enabled automation, supported industrial policy initiatives, is reshoring manufacturing. The findings suggest AI is altering what countries trade, how they trade, and where goods are produced. Finally, the study finds that AI is accelerating a shift towards more regional, digital, and skill-intensive trade systems.

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Introduction

Over the past decade, artificial intelligence (AI) has developed rapidly, evolving from a theoretical concept to a major source of innovation. AI is changing the way nations participate in international trade, from how goods are produced to how services are delivered across borders. This thesis aims to analyze and understand how AI is redefining trade patterns, reshaping the structure of global value chains, and increasing the competitive advantage of nations that successfully integrate it into their economic and industrial strategies.

The underlying reason behind this research is to better understand how AI-automation and digital innovation are influencing different countries in the modern economy, as some are gaining significant advantages and others risk being left behind. While it's clear that AI significantly boosts productivity, its specific trade implications (such as the growth of digitally deliverable services, the regionalization of manufacturing, and the reshoring of production) require closer examination.

This thesis is divided into three chapters to carefully investigate these trends. The first chapter offers a synthesis of the existing literature on AI's global impact across different industries and the related consequences on trade. The second chapter presents an empirical analysis of five digitally advanced economies (United States, Germany, United Kingdom, South Korea, and Japan), showing the correlation between AI adoption and trade performance in services and high-tech goods. Finally, the third chapter examines how AI is driving the reshoring of manufacturing through an analysis of the United States automotive sector. The U.S. was selected due to its leadership in AI adoption and its supportive government policies, while the automotive industry is one of the top adopters of AI in manufacturing operations. Furthermore, we focused on Tesla as it's a pioneer in AI-driven production and supply chain localization. The company is a clear example of how technological innovations and policy incentives are reshaping global trade. All in all, this thesis aims to show that AI is more than a technological shift, as it also affects the global economy and geopolitical landscape.

Chapter 1: Literature Synthesis

1.1 Understanding Artificial Intelligence: Narrow AI, General AI, and Super AI

Artificial Intelligence (AI) refers to the ability of machines to carry out tasks that normally require human intelligence. Early versions of AI relied on traditional machine learning models, requiring human intervention to process new information or perform new tasks outside their capabilities. However, AI's rapid development led to increasingly autonomous and sophisticated systems. Nowadays, AI can be divided in: Narrow AI, General AI, and Super AI (Tableau, 2023).

Narrow AI is the kind we use most commonly. It's designed to perform specific tasks such as language translation, virtual assistance, recommendation systems, or autonomous driving. These systems are quite limited and cannot perform tasks outside their programmed domain. Conversely, General AI is a type of AI that should be able to think, comprehend, learn, and solve complex problems. While it's still a theoretical concept, it should be able to mirror human intelligence. Super AI should even go further, surpassing human intelligence. Both General AI and Super AI remain theoretical as of now, but General AI has already captured the interest of top tech companies worldwide (Kanade, 2022).

Today's AI systems are almost entirely examples of Narrow AI. They rely on machine learning algorithms trained on large datasets that develop accurate predictions and perform specific tasks. So far, one of the biggest advancements in Narrow AI has been the development of Deep Natural Networks (DNNs). DNNs are machine learning models inspired by the structure of the human brain, where the output of one layer becomes the input for the next. They can process and combine different types of data, such text, images, audio, and video. DNNs mark a turning point in international trade, logistics, and manufacturing thanks to their ability to interpret complex information (Meltzer, 2018).

1.2 The Global Impact of AI Across Industries

Artificial Intelligence is rapidly changing international trade. AI technologies are altering how goods and services are produced, traded, and consumed around the world thanks to operational efficiency improvements and reduced costs. The introduction of AI impacted multiple sectors crucial to international trade, including manufacturing and industrial production, logistics and supply chains, financial services, and healthcare and pharmaceuticals.

1.2.1 Manufacturing and Industrial Production

Manufacturing is another sector experiencing transformative impacts from AI, with smart factories and data-driven processes which boost efficiency and altering global supply chain dynamics. Adopting AI-powered systems and related digital technologies in production is essential for raising industrial productivity in developed economies. Kay changes in manufacturing include the following.

Automation and Robotics: robots with integrated machine learning can handle tasks with precision and adjust in real-time, leading to automated “smart” manufacturing processes (IBM, 2023). This allows less reliance on manual labor for both routine assembly and repetitive tasks. Thanks to computer vision and AI, manufacturers achieve consistency and quality control. These improvements significantly increase output and lower error rates, increasing domestically produced goods competitiveness on a global scale.

Predictive maintenance: AI reduces downtime in production factories by predicting machine failures and scheduling maintenance accordingly (Decaix, Gentzel, Luse, Neise, and Thibert, 2021). By installing sensors that forecast when a machine is likely to need repair, companies can avoid costly breakdowns and keep production running smoothly.

Supply chain and demand optimization: AI improves manufacturers’ supply chain management and helps predict market demand. By analyzing data such as sales trends, logistics, weather conditions, and geopolitical indicators, AI systems can forecast consumer demand more accurately, allowing manufacturers to adjust production accordingly. Overall, AI allows manufacturers to be more dynamic and cost-effective, enhancing their competitiveness in international trade.

1.2.2 Logistics and Supply Chains

AI is radically changing logistics and global supply chain management by improving efficiency, speed, and reliability of cross-border trade. With increasing international parcel deliveries, AI is stepping in to make the whole process faster and more reliable by improving how each step of the supply chain. New AI powered “smart warehouses” use sensors, computer vision, and automation to streamline storage and distribution decisions, radically improving productivity and accuracy while limiting errors (Ferencz, González, and García, 2022).

Improved efficiency: AI driven systems optimize warehouse workflows by speeding up receiving, sorting, and inventory management. Essentially, AI boosted productivity by automating operations and cut down manual travel time (Ferencz, González, and García, 2022).

Better forecasting and coordination: advanced AI models predict demand and adjust logistics in real time. They help manage inventories across borders by forecasting future trends and optimizing delivery schedules (Ferencz, González, and García, 2022). Thanks to Internet of Things (IoT) sensors, AI platforms track inventories and shipments worldwide and can reroute or adjust capacity quickly to prevent delays (IBM, 2023).

Automation and Robotics: AI- powered robots are replacing manual labor by taking on the Four D’s tasks: Dirty, Dull, Distant, and Dangerous (DHL, 2022). AI powered sorting robots have dramatically increased parcel sorting capacity and speed. In ports and logistic hubs, autonomous vehicles and cranes use AI vision to load and unload containers with precision (Chen, Zhang, and Wang, 2025).

Enhanced tracking and security: AI is also used to track shipments along the supply chain. Machine learning algorithms monitor shipments in transit, flag anomalies, and predict risks (like theft or damage) so that companies can intervene proactively. Furthermore, AI can prevent accidents or routing errors, reducing human error in logistics (Ferencz, González, and García, 2022).

1.2.3 Financial Services

The finance industry was among the early adopters of AI and continues to be a leader in leveraging AI to transform services. AI provides greater efficiency and security in operations like trade finance, cross-border payments, and risk management. Some of the key impacts include

Automated credit decision and trade finance: AI systems help banks make faster and more accurate decisions on credit assessments for loans and trade finance instruments (Ferencz, González, and García, 2022). Advanced models follow a precise lending criterion, improving decisions on customer eligibility. Although algorithmic biases require careful oversight, AI ultimately contributes to a more inclusive trade finance system by expanding access for small businesses to international markets (Dash, Kremer, and Petrov, 2021).

Risk management and fraud detection: AI has significantly improved risk analytics in finance by detecting anomalies and predicting risks faster than manual methods. In banking and payment systems, AI scans large datasets (such as transaction logs, customer profiles, and sanctions lists) to identify suspicious activity and reports it to the auditors. AI also supports market risk assessment by watching for early signs of financial stress or currency volatility, allowing firms to respond proactively. Overall, AI makes digital trade more reliable by reducing losses and ensuring regulatory compliance (OECD, 2023).

Personalized financial services (Fintech): AI is transforming global banking by enabling more personalized and accessible services. Online and mobile platforms use AI virtual assistants, robot-advisors, and chatbots that understand and fulfill customer requests instantly. AI also makes international transactions smoother by enabling multilingual support and filling in forms automatically to simplify bureaucratic procedures (OECD, 2023). Personal finance tools track user profiles and offer tailored advice. Scalable AI systems help banks handle millions of requests while still offering a personalized experience, a very important feature in fast-growing markets. Additionally, AI-powered fintech apps are making financial services more accessible, reaching people in rural areas or without bank accounts and supporting cross-border e-commerce and payments.

1.2.4 Healthcare and Pharmaceuticals

AI is transforming the healthcare and pharmaceuticals sector by not only facilitating the trade of medical products, but also by enhancing the global exchange of medical knowledge, treatments, and access to care. Patients have now access to medical expertise and innovations developed across borders (Vora, Gholap, Jetha, 2023).

Medical diagnostics and imaging: AI is helping doctors make faster, more accurate diagnoses by analyzing medical images and lab tests. It is extremely helpful when it comes to detecting diseases based on early signs that might be missed otherwise. The widespread use of AI worldwide creates a global network where healthcare providers can access advanced diagnostic tools, improving patient outcomes globally (Vora, Gholap, Jetha, 2023).

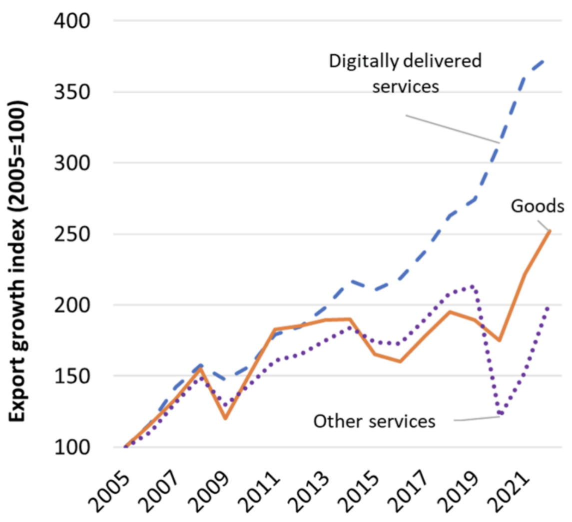
Drug discovery and telemedicine: AI is accelerating the development of new drugs and therapies thanks to its ability of analyzing large datasets (Syst, 2021). Furthermore, AI enables remote care, translation, and diagnosis, granting patients the access to expert help from other countries. By speeding up and cutting the costs of frug research and development, AI makes medication more affordable and widely available. This increase overall global health.

1.3 Main Consequences on Trade Pattern

After examining the key impacts of Artificial Intelligence across different sectors, it becomes clear that these innovations not only reshape internal business operations but also change how countries engage in international trade. From changing the types of goods and services that are traded to modifying global value chain structures and regional trade dynamics, AI is creating new global trade patterns. The following analysis outlines the main consequences of AI on international trade.

1.3.1 Shift in What is Traded

AI is causing a significant shift toward trade in services by allowing many services to be digitalized and delivered across borders. Advanced AI tools (from language translation to automated customer service) make it easier for businesses to offer professional, educational, and creative services remotely to international clients. Empirical evidence confirms that AI adoption can substantially boost cross-border services trade. For example, eBay's machine translation service increased exports to Spanish-speaking Latin America by 17.5 percent (Meltzer, 2018). As a result of such innovations, digital-deliverable services have become a dynamic component of global commerce, growing faster than goods trade. In 2023, worldwide digital services have reached roughly $4.25 trillion, reflecting 9 percent annual growth and accounting for 13.8 percent of total exports (Fasulo, 2025). This trend shows hoe AI is transforming traditionally non-tradable services, such as consulting, finance, or education, into globally traded activities, thereby increasing the share of services in international trade.



Source: IMF et al. (2023).

Figure 1: Digitally deliverable services are the fastest-growing segment of international trade

1.3.2 Regionalization of Global Value Chains

The spread of AI and automation is contributing to a regionalization of Global Value Chains (GVCs), making production networks more localized. As AI-driven automation can perform labor-intensive tasks at a lower cost, manufacturing firms are less prone to offshore for cheap labor. Many are reshoring production back to their home countries or nearshoring to neighboring economies in order to gain greater control, reduced exposure to global disruptions, and quicker response to market demand. This shift increases the importance of factors such as proximity to consumers, availability of digitally skilled labor, and infrastructure. In Europe, for example, the adoption of AI and digital technologies has boosted intra-regional trade more than extra-regional trade, reflecting a growing preference for regionally integrated supply chains (Giunta, Marvasi, Sforza, 2024).

1.3.3 Shifting Productivity and Comparative Advantage

AI adoption is relocating countries' comparative advantages by changing productivity levels across industries and countries. Countries with robust digital infrastructure and skilled labor experience improved productivity, exporting more AI-intensive goods and services. In contrast, low-income countries that rely on labor-intensive manufacturing may face competitive pressures, unless they will manage to upgrade their technological capacity. Trade patterns may shift to favor early adopters and digitally advanced economies, making AI a key driver of competitiveness.

1.4 Challenges Arising from AI Integration in International Trade

While AI offers transformative benefits for global trade, it also presents a series of complex challenges when it comes to integrating it in the production process. These challenges involve rules and regulations, economic imbalances, and social impacts. Addressing these issues is essential to ensure that the gains from trade from AI-integration are inclusive, secure, and sustainable.

1.4.1 Intellectual Property and Data Governance Issues

The rise of AI in international trade has created major gaps in current Intellectual Property (IP) frameworks and data governance standards. Existing trade agreements such as the WTO's TRIPS Agreement don't provide a clear definition of ownership or protection of AI-generated content. This raises legal uncertainty over whether outputs produced by generative AI tools (such as software code, designs, or marketing material) can be patented or copyrighted across jurisdictions (Chui, Hazan, Roberts, Singla, 2023). This regulatory vagueness complicates trade in AI-powered products and services, particularly when national laws differ on how algorithmic authorship should be handled. Furthermore, the data used to train AI systems has become an higly valuable economic resource, giving countries with access to large and diverse dataset a distinct competitive advantage in developing advanced AI models (Kesari, 2024). Countries with strong data advantages are starting to trat them like strategic assets, becoming more protective and less willing to share their datasets or allow data to flow freely across borders. Asymmetries in regulations create tension in trade negotiations and undermine efforts to establish common standards, especially as countries increase data localization laws to increase digital protectionism and national security. Without international consensus on how to handle AI-related IP and data governance, the global trade system may become even more fragmented, favoring first movers while leaving behind those economies that are less advanced digitally.

1.4.2 Changing Skill Requirements and Workforce Disruption

The integration of AI into international trade is drastically changing the skills required in the global workforce. As AI automates repetitive and rule-based tasks, the demand for low-skilled labor is declining particularly in manufacturing and administrative roles. In contrast, there is a growing need for workers with digital competences, data literacy, and the ability to understand and cooperate with AI systems. This shift has a negative impact on those countries and industries that historically relied on labor-intensive exports, as their comparative advantage diminishes along with investments in education and retraining. Many workers who lose their jobs due to automation often face difficulties in finding new roles due to skill mismatches, limited access to training programs, or the impossibility to move where new opportunities are. Without targeted initiatives for retraining and upskilling, this evolving demand for high-skill labor could increase unemployment, wage inequality, and social exclusion particularly in developing countries. Handling these labor market shifts in the right way will be essential to ensure that AI-driven trade benefits everyone (Kesari, 2024).

1.4.3 Rising Global Inequalities

AI widens global inequalities by increasing the advantage of countries that are already digitally advanced and excluding those that lack infrastructure, capital, or skilled labor. The benefits AI are far greater in knowledge-intensive sectors such as software, engineering finance, and R&D. These sectors, dominated by developed economies, are expected to gain the most from AI adoption both in terms of productivity and capacity. On the other side, low- and middle-income economies which often rely on labor-intensive manufacturing, lose competitiveness due to automation and struggle to participate in trade due to AI-enhanced services (Chui, Hazan, Roberts, 2023).

According to the International Monetary Fund (IMF), approximately 40% of jobs globally risk being replaced by AI technologies. This exposure is notably higher in advanced economies where about 60% of jobs are affected, and lower for low-income countries, where only 26% of jobs are at stake. This gap results from limited access to high-quality data, cloud computing, and digital talent. Overall, countries that can and will invest in AI gain further trade advantages, while others risk exclusion from emerging global value chains (Kesari, 2024).

The skill gap is not limited to developing countries, as automation is replacing certain categories of workers even in advanced economies. International policies must ensure equal AI diffusion in order to prevent a two-tier global economy: one where a few nations dominate high-value digital trade, while others remain stuck with declining export sectors and limited opportunities for technological upgrading (WTO, 2024).

Chapter 2: Empirical Evidence of AI’s Impact on International Trade

2.1 Objective

The scope of this chapter is to analyze how the adoption of Artificial Intelligence (AI) influences trade growth in both tradable services and high-tech goods. The analysis will be conducted only on those economies that are the most digitally advanced, that is the United States, Germany, South Korea, Japan, and the United Kingdom, over the period 2015-2023. By examining these five countries, this chapter will investigate whether greater investment in AI infrastructure and skills is associated with faster growth in exports of digital services and technologically advanced manufactures. The focus is on empirically identifying patterns: do countries that exploit AI show higher growth in the trade of Information and Communication Technology (ICT) services and high-tech manufacturing exports? This period 2015-2023 coincides with the spread of AI adoption and allows us to observe its emerging impacts on trade. The objective is to spread AI preparedness with trade performance in services and goods, exposing how being at the forefront of the AI revolution may confer trade advantages. Recent studies suggest that countries investing in AI gain competitive advantage, while the ones who don’t risk being left behind in GVCs.

2.2 Key Variables and Data Sources

To understand how AI adoption influences international trade patterns it’s important to choose objective metrics that are internationally recognized. This section outlines the parameters used to measure both AI Adoption and trade performance, providing a consistent and data-driven approach in evaluating how artificial intelligence affects international trade across advance economies.

AI Adoption Indicators

IMF AI Preparedness Index (AIPI) is a composite index developed by the IMF. It measures countries' readiness for AI based on data availability, digital skills, infrastructure, and governance. It ranges from 0 to 1, with 1 indicating the best possible foundation environment to support AI adoption. The AIPI is useful for our analysis as it provides a quantitative measure to compare how prepared each country is to implement AI on a scale level (IMF, 2023).

Stanford Global AI Index (AI Vibrancy Tool) is an index and dataset provided by the Stanford AI Index reports. It measures a nation's strength of AI ecosystems across 8 pillars (talent, research, development, economy, infrastructure, governance, commercial deployment, and societal impact) using 42 indicators (Businesswire, 2025). This tool ranks countries on their "AI Vibrancy", reflecting their output of AI research, investments, and workforce, on an annual basis. The U.S., UK, and Germany score among the highest in AI Vibrancy, with South Korea also in the top ten. This metric goes beyond robotics, as it helps getting a clearer vision on how AI is being used and developed in each country.

Industrial Robot Density indicates the number of industrial robots per 10,000 manufacturing workers. The International Federation of Robotics tracks this metric to provide a clear view on how much AI automation is used in manufacturing, helping us understand to which extent AI and Robotics are integrated in the production process.

Trade Performance Indicators

Exports of Information and Communication Technology (ICT) Services. This metric captures the value of digital services that are often supported by AI. It includes computer services, software, telecommunications, and other digitally delivered services defined in the Balance of Payments statistics. Sources like The World Bank (BoP data), WTO, and UNCTAD provide useful, reliable data. For example, in 2022 the U.S. exported about $70.63 billion dollars in ICT services, the UK about $45.27 billion, and Germany about $38.94 billion (World Bank, 2023).

High-Tech Goods Exports. In our analysis we focus on key high-tech export categories for these countries, such as electronics and semiconductors, automotive vehicles (especially electric vehicles (EVs)), and precision instruments/machinery (including robotics equipment and medical or optical devices). These products are enabled by AI in their design and production, and in some cases enable AI usage (e.g. semiconductor chips). South Korea's semiconductor exports were $129.2 billion in 2022, making up for nearly 19% of its total exports (International Trade Administration, 2023). Germany's exports in automotive and machinery remain among the world's highest (€135 billion worth of cars exported in 2024) with a growing share of electric vehicles (Destatis, 2024).

Value-Added Trade in Services accounts of domestic value added in services trade, often measured through Trade in Value Added (TiVA) datasets by OECD and UNCTAD. This indicator shows how much value each country adds in the export of services. It helps understand the quality and complexity of services trade. When a country increases the value added to the services it exports, it signals a move up the value chain, offering more advanced, knowledge-intensive services.

By analysing both sets of metrics (AI adoption and trade performance) we can use the data to assess correlations. Moreover, the diverse data sources provide a comprehensive picture, ranging from macro-level indexes to specific trade values.

2.3 Country Selection Criteria

The countries selected for this case study were chosen based on their high levels of AI adoption and digital advancement. The criteria used includes top rankings in international AI readiness indices and above-average levels of automation in industry:

- AI Preparedness and Innovation Index Rankings: The IMF's AI Preparedness Index (AIPI) attributes a score from 0 to 1 based on their readiness to adopt and integrate artificial intelligence across infrastructure, labor, innovation, and regulation. All five selected countries perform above the Advanced Economies average (0.68). As of the latest data: United States (0.77), Germany (0.76), South Korea (0.74), Japan (0.72). These scores place the selected countries among the top-tier globally in AI preparedness, indicating strong institutional capacity, digital ecosystems, and policy frameworks to support AI integration. Their above average performance reflects significant investment in AI infrastructure and education, and a high degree of innovation capability (IMF, 2023). Figure 1 shows the AI Preparedness Index average for Advanced Economies, Emerging Market Economies, and Low-Income Countries.

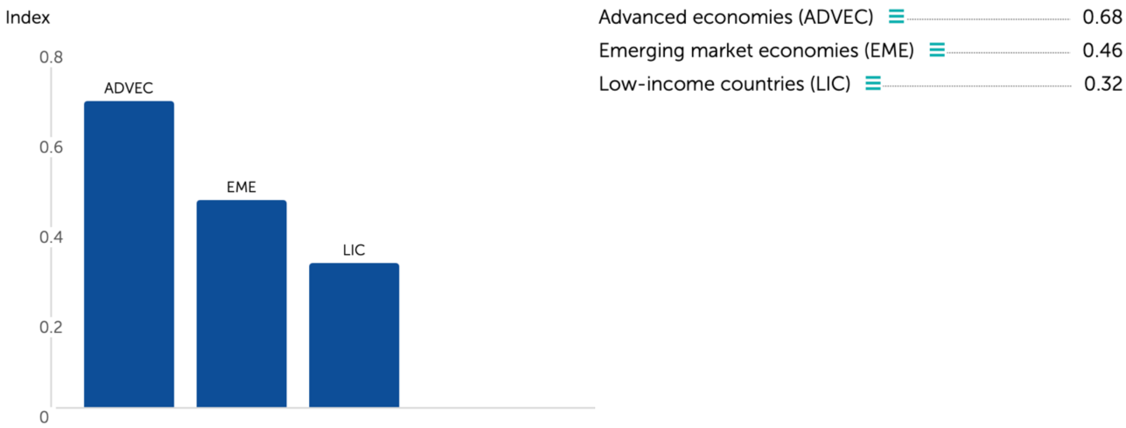


Figure 2: AI Preparedness Index

Source: IMF, 2023

- Industrial Robot Density (Automation Intensity): A key indicator of AI adoption in manufacturing is the number of industrial robots employed. High robot density in an economy proves that it is actively adopting AI and robotics in production. Based on the data collected from the International Federation of Robotics (IFR), the selected countries have some of the highest robot densities in the world. The Republic of Korea is the number one global adopter of industrial robots, with about 1,012 robots per 10,000 manufacturing workers as of 2023 (IFR, 2023). Japan and Germany are close behind, ranked 5th and 4th with 419 and 429 robots per 10,000 workers respectively. The United States also falls in the global top 10 with 295 per 10,000 workers. The United Kingdom's Industrial Robot Density is slightly lower, ranking below the top 20 globally, but the UK compensates with leadership in AI-driven services.

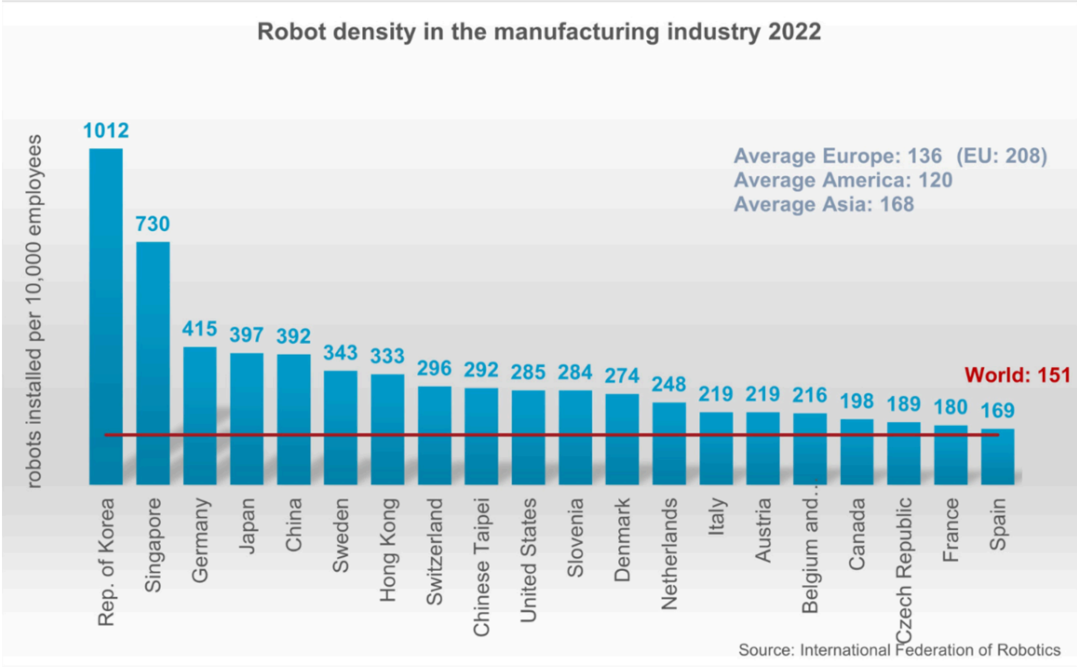


Figure 3: Industrial Robot Density in Manufacturing (2023).

- Digital Infrastructure and Innovation Climate: Each selected country shows a robust digital infrastructure and a dynamic innovation ecosystem, as evidenced in the Stanford AI Index rankings and related benchmarks. The United States leads globally in AI development, with 61 AI models originated by US institutions in 2023. The United Kingdom ranks third thanks to its investments in AI research and initiatives like hosting the world's first AI safety summit in 2023. South Korea started focusing too on AI and Robotics, with extensive broadband networks and major investments in R&D. Japan keeps investing heavily in AI and Robotics, with advancements like the ABCI 3.0, a supercomputing platform designed to accelerate the development of AI technologies, particularly generative AI (ABCI, 2025). Germany's commitment to AI and automation adoption is highlighted by the Industry 4.0 initiative, which aims to develop manufacturing by integrating advanced digital technologies such as AI, Industrial Internet of Things, Robotics, Big Data and Analytics, and more (BFM, 2020). Altogether, these factors ensure that the selected economies are not only prepared for AI integration but are actively applying it across various sectors.

In summary, the five selected countries are not only the most prepared, but also the ones who invested the most in AI implementation, whether through human capital and resource or through tangible automation on factory floors. Focusing on economies with a high adoption of AI allows us to get a clearer view on how international trade is affected.

2.4 Trade Performance and AI Correlation

In this section we will conduct an analysis on how the five countries' trade performances from 2015 to 2023 relates to their levels of AI adoption. We will examine digitally deliverable services trade and high-tech manufactured goods separately. We will then discuss the observed associations between AI infrastructure indicators and trade outcomes.

2.4.1 ICT Services Trade in Advanced Economies

As mentioned before, the United States and United Kingdom are the two countries that experienced the greatest growth in exports of ICT and other digitally deliverable services between 2015-2023. In 2023 the United States exports of digitally delivered services reached $655.5 billion, a rough 61% increase from $406 billion in 2015. Digital services such as software, cloud computing, business and financial services delivered online represented 64% of all U.S. services exports in 2023. This data shows how heavily U.S. exports now lean toward AI-enabled, cross-border digital trade. Likewise, the United Kingdom's comparative advantage in digital services grew exponentially. With London being a global financial hub, the early adoption of AI in fintech and business services boosted UK exports of ICT from $20 billions in 2015 to over $52.9 billion by 2023, with an increase in demand for its AI-driven financial services, LegalTech, and other professional services. Additionally, many of these services rely on AI to appear more valuable to international clients, such as algorithmic trading systems, AI-powered fraud detection, and cloud-based consulting platforms (Trading Economics, 2025).

Germany, Japan, and South Korea also participate substantially in ICT services trade, although with lower levels compared to the U.S. and UK. Given the size of the country, Germany exports a significant amount of ICT and digitally enabled service, although services cover a smaller share of its total trade due to the high level of trade of manufactured goods. Japan and South Korea export a more modest amount of ICT services, ranging between $10-15 billion each. This data reflects their greater ability in exporting goods rather than services (World Bank Group, 2023). South Korea has world-class telecommunication infrastructure, along with a growing IT services sector, but it exports lie more in goods rather than in cross-border services. Overall, the data on ICT services trade shows that countries that are highly ranked in digital readiness, that is the U.S. and UK, are leveraging that capacity to achieve greater service exports, whereas the others are somewhat less dominant in this domain.

2.4.2 High-Tech Goods Export Performance

High-technology goods, such as electronics, semiconductors, precision machinery, pharmaceuticals, and advanced vehicles, require high R&D intensity. All five countries under consideration are key players, though they each specialize in different areas. Germany and South Korea world leaders in certain high-tech industries thanks to their robust manufacturing bases and adoption of automation. Germany remains one of the biggest exporters of automobiles and machinery, with rapid expansion in cutting-edge sectors like electric vehicles (EVs). Germany's exports of EVs increased by 58% in 2023 to roughly 786,000 units (valued at €36 billion), meaning EVs comprised roughly one quarter of all German car exports that year (Wehrmann, 2024). Overall, Germany's high-tech goods exports reached approximately $266 billion in 2024, one of the highest in the world thanks to its competitiveness in industries such as automotive engineering, industrial machinery, and chemicals (Grewal, Léon, Wunsch-Vincent, 2025).

South Korea's trade performance in high-tech goods is facilitated by its dominance in semiconductors. Semiconductors, such as memory chips and related components, are South Korea's single largest export category, accounting for about 19% of the country's total exports in 2022 (International Trade Administration, 2023). Firms like Samsung

Electronics and SK Hynix make South Korea the global leader in memory chip production, taking the country's semiconductor export revenues up to $120-130 billion in recent years. The country also exports advanced display panels, smartphones, batteries, and other electronics. The trade statistics underscores South Korea's strength in technology-intensive manufacturing, which is backed up by one of the highest rates of robot adoption in the industry.

Japan and the United States are both exporters of high-tech goods, though with few differences. Japan, historically an electronics and automotive powerhouse, exports large amounts of advanced goods, including automotive parts, hybrid and electric vehicles, electronics, and industrial robots. Japan is not only a heavy user of robots, but also the world's predominant manufacturer and exporter of industrial robot equipment. Its overall high-tech exports account for $100-150 billion annually in recent years, about 15-20% of its total manufactured exports (Grewal, Léon, Wunsch-Vincent, 2025). The United States has a different, broader portfolio, with its main industries being aerospace, computing, pharmaceutical, and scientific instruments. In 2024, high-tech exports in the U.S. accounted increased by 12.6%, reaching $385.3 billion, with a strong growth in sectors such as aircraft, semiconductors, and biotechnology. Being a big net importer of some high-tech products (like consumer electronics), the U.S. still outperforms other nations in terms of commercial aircraft and software exports, maintaining a leading position in many innovation-driven industries (Grewal, Léon, Wunsch-Vincent, 2025).

The United Kingdom, in contrast, has a smaller manufacturing base, but it still participates in high-tech goods trade in niche areas, such as pharmaceuticals, specialty chemicals, aerospace parts, and medical devices. UK high-technology exports were up to $70-80 billion in 2022 (Trading Economics, 2023) accounting for 25-30% of its manufactured exports. Although UK's high-tech goods output is lower compared to larger economies, the country compensates with its excellence in services (as seen in section 2.4.1). In recent years, the UK has been working to expand high-tech manufacturing, especially in sectors that could potentially increase exports in the future (for example, life sciences and clean energy). Overall, among the five countries, Germany, the US, and the Republic of Korea have the highest absolute value of high-tech goods exports (Grewal, Léon, Wunsch-Vincent, 2025), while Japan and the UK have relatively smaller high-tech export totals, but still significant compared to other countries (Figure 3). Each country's performance aligns with their level of technological industrial development and specialization.

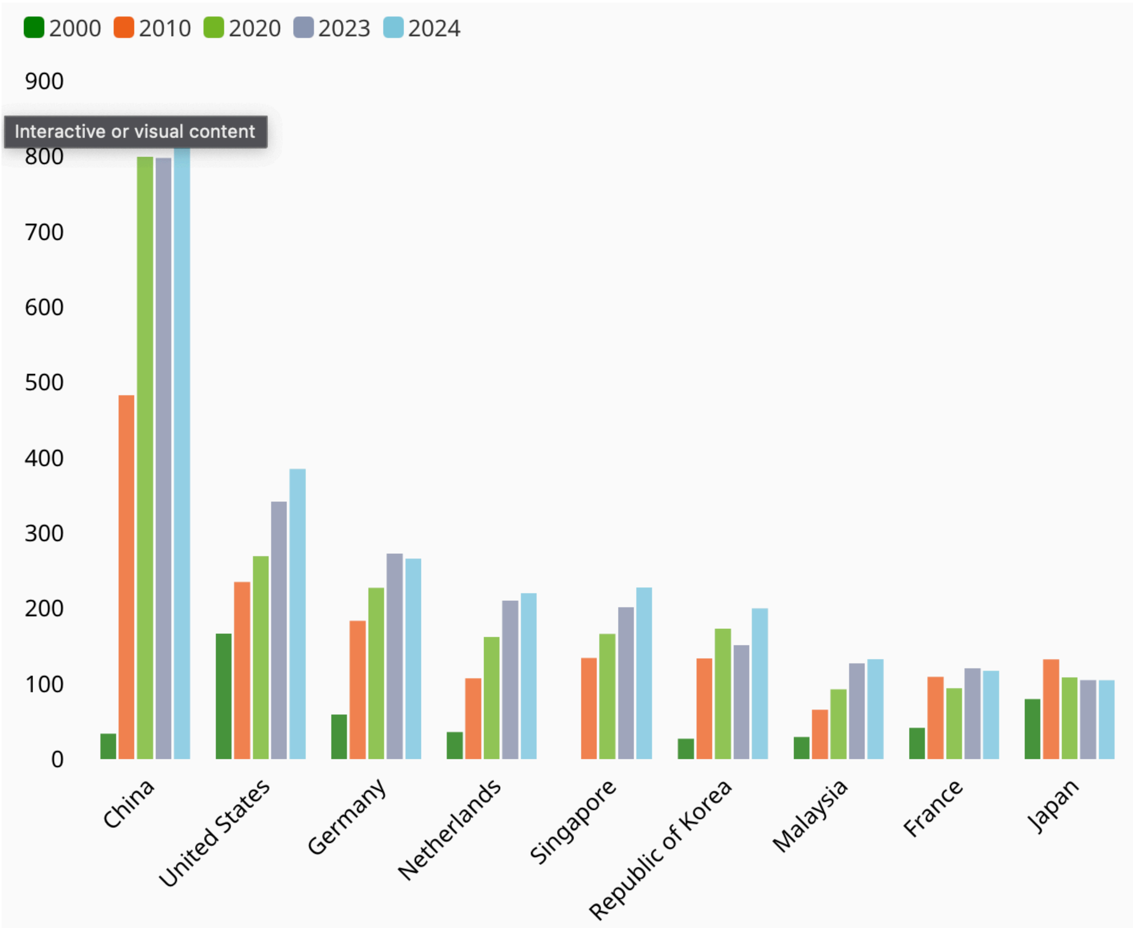


Figure 4: Top High-Tech Exporters (USD billions)

2.4.3 AI Adoption Indicators and Readiness

To better understand the correlation between AI and trade, we will consider two key indicators: industrial robot density and AI readiness index scores. Industrial robot density measures the level of automation and AI in manufacturing, while the AI readiness index scores reflect a country's overall capacity to implement and benefit from AI, including aspects such as governance, infrastructure, and business. Table 2.4.1 summarizes these indicators along with the earlier trade metrics for the five countries:

Country	ICT Services Exports ($ billion)	Industrial Robots per 10k workers	AI Readiness Index (Score, 2022)
United States	72.2	285	85.7
United Kingdom	49.7	110	78.5
Germany	48.3	415	72.6
South Korea	14.0	1012	76.8
Japan	11.7	397	75.3

Table 2.4.1: Trade performance and AI adoption for selected countries. Higher values in ICT service exports and AI readiness scores (out of 100) tend to be related with strong digital services trade, whereas high industrial robot density correlates with robust high-tech manufacturing exports. Sources: World Bank, IMF, Oxford.

With regards to robot density, the International Federation of Robotics (IFR) reports that global automation levels are at an all-time high, with the analyzed countries among the leaders. The Republic of Korea is the world's most automated country, with 1,012 industrial robots per 10,000 manufacturing workers (IFR, 2023). Given the world's average (151) South Korea's robot density truly reflects its heavy automation in electronics and automotive factories. Germany likewise has a very high robot density of about 415 robots per 10,000 workers, which is the highest in Europe. Japan ranks right behind Germany with 397 robots per 10,000 workers, making it the fourth most automated nation. (IFR, 2023). The US rates 10th globally with 285 robots per 10,000 workers. The United Kingdom is currently lacking in robot density, falling in the range of 100-110 robots per 10,000 workers. This data can be attributed to the fact that the UK's manufacturing sector is significantly smaller than other nations', though a record increase in robots' installations was registered in 2023 due to policy incentives (IFR, 2023).

National AI Readiness Indexes provide a broader view of each country's ability to capitalize on AI. According to the Oxford Insights Government AI Readiness Index 2022, all five countries rank in the global top 15 in AI readiness (UNIDO, 2022), with the United States being at the top with an overall score of 85.7/100. This result is attributable to the US's strength in technology infrastructure, talent, and innovation ecosystems for AI. The UK ranks 3rd globally (78.5), thanks to its strong tech sector, supportive policies, and R&D investment. South Korea (6th) and Japan (9th) also demonstrate high AI readiness (around 75-77), fueled by R&D investment, skilled workforce, and effective government strategies. Germany is ranked 15th (72.6). Although it's lower than the other countries considered, it's still above world average. With very high robotics usage but lower AI-readiness, there is certainly room for improvement. This data is useful to understand how each country's approach to AI might relate with trade outcomes, whether service-focused or manufacturing-focused.

2.4.4 Linking AI Adoption to Trade Outcomes

The evidence collected reveals a strong positive correlation between AI adoption and trade performance in technology-intensive sectors. There's a strong relationship between a country's AI capabilities and its volume of exports of high-technology goods and services. Countries that fully exploit AI-driven automation in manufacturing are among the most competitive exporters, as highlighted by the data provided for high robot densities. Empirical research supports this connection: firm-level studies and cross-country analyses have found that adopting industrial robots tends to increase export volumes and export competitiveness by raising productivity and product quality. Germany's exports of automobiles and machinery have significantly increased thanks to advanced automation. AI-enhanced manufacturing systems and robotics-intensive assembly lines eased its recent expansion in EV exports. Japan, as a top robot user and manufacturer, leverages AI and robotics in its factories to maintain its edge in high-value manufacturing exports, from cars to electronics and even the actual robots. These cases all prove that AI technologies boost a nation's capacity to produce goods for export, improving its trade performance in high-tech sectors.

On the other hand, countries that exceed in AI readiness and digital technologies export a greater amount ICT and digitally deliverable services. Proof can be found by analyzing the data gathered from the United States and United Kingdom. Both countries invest heavily in AI R&D and ecosystem development, which provides in return a large, innovative services industry (finance, software, business services) that succeeds in global markets. The US is world leader in AI private investment (over $100 billion annually in recent years), and this technological leadership further expands its competitiveness in digital services and intellectual property exports. The UK's high AI readiness fully reflects its status of top exporter of digital services, from fintech to IT consulting, proving that a strong national AI capacity facilitates the growth of services exports. In short, the readiness to adopt and implement AI correlates with a country's ability to export cutting-edge services, as AI-ready environments foster innovation, efficiency, and new business models in the services sector (Stanford, 2024).

It is worth mentioning that all five countries, despite their different characteristics, prove that AI and robotics adoption is associated with better trade outcomes in relevant sectors. The correlation found does not fully account for the improvements made, as trade performance is also influenced by other factors such as education, industrial policy, supply chain networks, etc. However, the consistent alignment between AI adoption and improvements in trade performance across these advanced economies suggest that AI does boost competitiveness. This relationship is bi-directional: AI adoption boosts productivity and quality, thus enhancing export performance, and in turn, engagement in high-tech trade provides feedback that further drives AI development. This insight, observed by the OECD, pointed out that international trade can provide the inputs needed for AI, such as data, software, and talent, even as AI transforms trade practices and outputs (Ferencz, González, Oliván García, 2022). This section proves that there is a cycle in which AI technologies and trade in high-tech industries mutually reinforce each other's growth.

2.5 Summary and Conclusion

In summary, the comparative analysis of the United States, United Kingdom, Germany, South Korea, and Japan, reveals a correlation between high trade performances in tech-intensive sectors with high levels of AI adoption and readiness. The US and UK show higher AI readiness, making them leaders in digital and ICT services exports; Germany, South Korea, and Japan dominate exports of high-tech manufactured goods due to their highly automated industries. Quantitatively, the countries investing more heavily in robotics and AI infrastructure are the ones that report higher exports of software, electronics, vehicles, and other advanced products. These findings prove that countries that have the possibility to exploit AI benefits experience a boost in domestic productivity and international trade.

Chapter 3: Case Study – The U.S. Automotive Sector and AI-Driven Reshoring

3.1 Trade Impacts: AI, Reshoring, and Shifts in Global Value Chains

For many years, the United States automotive industry has been part of complex global value chains, importing critical components (like semiconductors and battery cells) and exporting finished vehicles. These trade patterns are now radically changing thanks to Artificial Intelligence and automation, encouraging a trend towards "reshoring" manufacturing. Industry surveys show that nearly 85% of automotive executives plan to rely more on North American suppliers, with 41% expecting to reshore parts of their supply chains (Nasdaq, 2025). This means that, due to advances in AI and automation, production processes that were previously offshored to low-cost countries are now being reevaluated for domestic or regional manufacturing, as increased efficiency and reduced costs make local production more convenient.

One major driver of reshoring is supply chain resilience. During the COVID-19 pandemic, a chip shortage demonstrated how vulnerable supply networks are. For instance, the U.S. accounts for only 10% of global semiconductor output versus 75% in East Asia, making American automakers heavily dependent on foreign chip supplies (Azzoni, 2025). Nowadays cars require thousands of microchips (up to 3,000 for modern cars), and when Asian factories shut down in 2020, U.S. car production struggled. As mentioned in Chapter 1, AI technologies are helping address such vulnerabilities by optimizing supply chains in real-time. Production lines and inventories can be monitored through integrated production systems, predicting and quickly responding to disruptions. For example, AI tools provide instant alerts when a factory machine breaks down and automatically locate alternative parts or routes, minimizing delays (Azzoni, 2025). These capabilities improve supply chain transparency and agility, reducing the need for inventories or additional backup suppliers. To sum up, AI is making domestic production more feasible by smoothing logistical bottlenecks that previously favored offshoring to diversified suppliers.

Trade patterns are adjusting accordingly, as value chains become increasingly regionalized. As critical manufacturing processes such as battery assembly and electronics integration are being reshored in the U.S. or neighboring countries, more components are being sourced in North America. This trend has been made possible by shifting cost dynamics. Advanced manufacturing technologies, such as AI-guided robotics and 3D printing, can lower unit costs even in higher-wage locations, decreasing the cost advantage of importing from low-cost, distant countries. Companies are realizing that local production with AI-driven automation can be cost-competitive with imports, especially when accounting for tariffs, transport costs, and political risks (World Bank, 2023). In brief, after seeing the increased productivity in home production, AI is encouraging American firms to reshore portions of the supply chain that were moved abroad.

However, the process of reshoring is selective and strategic. Automakers are now focusing on innovative technologies, such as electric vehicles (EVs) as trade patterns change. A valid example is domestic EV battery production. Batteries constitute roughly 40% of an EV's value (OECD, 2024), and until recently, the U.S. relied heavily on imported batteries from East Asia. Thanks to AI-optimized manufacturing, dozens of new battery plants are either planned or already under construction on U.S. soil. Industry data show that the Inflation Reduction Act (IRA) of 2022 further increased this trend, as investments in U.S. EV and battery manufacturing reached nearly $200 billion in 2024. About 63% of that increase was registered after the IRA's passage. The IRA is a landmark U.S. law that provides extensive federal funding (approximately $369 billion) and tax incentives to promote clean energy production, reduce carbon emissions, and strengthen domestic manufacturing. These investments are reshaping trade flows, as the U.S. now aims to produce EV batteries and power electronics domestically or source them from allied or neighboring countries. As a matter of fact, in order to receive the full consumer tax credits offered by the IRA for EVs, the materials and components used in the vehicle's battery must come from either North America or a country with which the U.S. has a free trade agreement or strategic partnership (often referred to as "friendly nations") (Energy Innovation, 2024). Consequently, imports of auto parts from overseas are expected to decline while intra-regional trade within Nort America rises to support localized production. Overall, thanks to technological advancements and policy incentives, a partial decoupling of global supply is expected, to be replaced by an increase in regional supply.

It is worth mentioning that reshoring via AI does not imply total self-sufficiency. The U.S. automotive value chain still heavily depends on international trade, as there are certain raw materials, such as lithium, cobalt, and semiconductor wafers, and other specialized components where foreign producers remain more efficient. The only way AI will affect these areas is by improving risk management. For example, AI-driven analytics can identify alternative sourcing options and simulate the cost implications of tariffs or transport delays, allowing firms to better deal with global vs. local inputs. Wider AI adoption could further optimize manufacturing processes and supply logistics, providing even greater incentives for local production. To sum up, AI is accelerating reshoring in the U.S. by reducing the benefits of cheap foreign labor and helping domestic producers shorten and fortify their supply chains. Fewer imports and potentially more exports of American-made advanced vehicles and components may gradually reshape international trade.

3.2 Labor and Skills: Workforce Implications of AI Driven Reshoring

Reshoring automotive manufacturing in the U.S. after AI-integration in the production process implies major changes in the labor market. On one hand, AI and automation increase productivity and reduce the need for certain low-skill, repetitive jobs; on the other hand, they create demand for new skills and potentially higher value jobs. The main issue is that automation can directly replace some assembly line roles, especially given that electric vehicles engines are mechanically simpler to assemble compared to internal combustion engines. As they have fewer assembly parts, they are better suited for automated production. Studies show that EVs require roughly 30% less labor to assemble compared to internal combustion engine vehicles, and when combined with extensive automation applied in factories many conventional assembly jobs may become obsolete (OECD, 2024). For example, Tesla's new highly automated EV plant in Germany plans to produce 500,000 cars per year with only about 12,000 employees, whereas a traditional Volkswagen plant needs about 25,000 workers to produce 700,000 cars (OECD, 2024).

By analyzing the data provided it is easy to see how AI-driven automation can boost output per worker and reduce the number of workers required in manufacturing.

Such productivity advancements raise concerns about job displacement. Reshoring does not simply "bring back" all the old jobs that were offshored, as many returned operations are now performed by robots or AI systems. As pointed out by the U.S. manufacturing advisor Harry Moser, while the government may promote reshoring, those factories who bring back production in the U.S. are often highly automated and thus employ far fewer workers than in the past (Varenas, 2025). This phenomenon has been called the "automation paradox" of reshoring: while production shifts to the U.S., the intensity of labor required to produce the same amount of goods or services drops dramatically. As AI carries out repetitive and manual tasks, the jobs that remain tend to require more technical expertise, such as programming robots, maintaining AI-driven equipment, or analyzing AI-generated data. Skill requirements in the automotive workforce are changing, with a decrease in demand for assembly line operations and an increase in demand for software engineers, data analysis, robot technicians, and skilled tradespeople who can work alongside advanced machinery (OECD, 2024).

The U.S. automotive sector and policymakers are now seeking to re-skill and up-skill workers. Major U.S. automakers are now investing in education and training programs to prepare workers for AI integration. In fact, the automotive industry is one of the sectors which invests the most in workers training. Several large car manufacturers are now building in-house training centers and establishing partnerships with community colleges to teach skills in robotics, AI, and advanced manufacturing techniques (OECD, 2024). The aim of these programs is to teach displaced production workers new roles, such as robot maintenance technician or quality control analysts who supervise AI outputs. The main goal is to integrate AI-automation while maintaining or even augmenting human work. This goal is rather realistic, as even highly automated "smart factories" will still need human oversight, assistance, and innovation. Researchers observe that in AI-powered factories, humans remain essential for tasks like complex problem solving, improving AI models, and performing intricate assembly steps that are hard to fully automate (Brynjolfsson, Li, Raymond, 2023). Indeed, we already have proof that too much automation can backfire during the production of Tesla Model 3, Elon Musk acknowledged that over-automating production slowed down output and that human intervention is essential in certain roles. This reinforced the view that to reach optimal performance, AI and human labor must be combined in a complementary way.

From a broader labor economics perspective, AI-driven reshoring could ultimately shift automotive employment from quantity to quality. This means that while the total number of jobs employed in the production line may decrease, those jobs can become more skilled and better paid. Since automation boosts productivity (output per worker), if combined with the right policies, it can lead to higher wages for the technicians and engineers running advanced production systems. Evidence shows that advanced manufacturing jobs tend to pay above-average wages, and regions that attract high-tech automotive factories can see significant economic benefits (OECD, 2024). However, to fully achieve these goals, the workforce must undergo radical changes, not only through corporate training programs but also through supportive public policy measures. Such policies range from grants for technical education, apprenticeships in AI and robotics, and tailored community college subjects that focus on Industry skills. The U.S. is already taking action, for example, part of the money from the CHIPS and Science Act is being used to train people in science and tech skills. Also, local programs are helping workers get ready for jobs in electric car battery factories and other factories that use AI in manufacturing.

In summary, AI's impact on labor in the U.S. automotive sector is twofold: while it raises productivity and enables reshoring, it also displaces some traditional manufacturing roles. The sector's future workforce will likely be smaller in number but with greater skills. Monitoring this transition is crucial, as the lack of training and policy measure might lead to labor shortages in high-skilled roles and unemployment in low-skill segments. With proper investment in human capital, AI-integration and reshoring can lead to better quality jobs and maintain the U.S. auto industry competitive. Following we will see how public and private investment can support this transformation.

3.3 Investment and Industrial Policy: Public-Private Efforts

The U.S. government promptly recognized the strategic importance of AI and advanced manufacturing, introducing industrial policies to promote investment in domestic production. Two are the major initiatives: the CHIPS and Science Act and the Inflation Reduction Act (IRA), both established in 2022. These, together with other policies, are designed to fully exploit AI innovations to strengthen U.S. manufacturing, secure supply chains, and create high-tech jobs.

The CHIPS and Science Act addresses the semiconductor supply chain issue. Semiconductors are essential, as they are the "brains" of modern vehicles, controlling everything from engine timing to AI-powered driver assistance. As mentioned earlier, the U.S. produces only the 10% of the world's semiconductors, importing the rest from East Asia. The CHIPS Act is a $52.7 billion investment on domestic semiconductor R&D and manufacturing, including $39 billion in direct incentives for chip plant construction (Goellner, 2023). After the CHIPS Act came into effect, private investment companies such as Intel, TSMC, Micron, and GlobalFoundries started investing heavily in the construction of U.S. semiconductor fabrication plants. This implies that in the coming years a greater share of the microcontrollers, sensors, and AI chips used in cars could be made in America, protecting automakers from future global chip disruptions. Experts and policymakers think that the CHIPS Act will *"create jobs in the U.S., increase microchip manufacturing, and strengthen supply chains"* (Goellner, 2023). Although building semiconductor fabrication plants is a long-term process, these investments align with AI-driven reshoring by tackling one of the most high-tech and globally outsources inputs for car production. In addition, the CHIPS Act also funds research in AI and advanced materials, which can bring extra benefits to the car industry (for example, new chips designs specialized for AI in autonomous vehicles).

The Inflation Reduction Act (IRA) has been a transformative measure that focuses on clean energy and transportation manufacturing, particularly in EVs and batteries. It has been classified as *"the biggest reshoring and pro-manufacturing legislation in U.S. history"* for these sectors. As shown in Figure 4, the number of jobs announced through reshoring and foreign direct investment (FDI) in 2023 reached 287,299, marking the second-highest total on record after 2022. Notably, 39% of these job announcements were concentrated in key sectors supported by U.S. industrial policy, such as EV batteries, semiconductor chips, and solar (Moser, 2024).

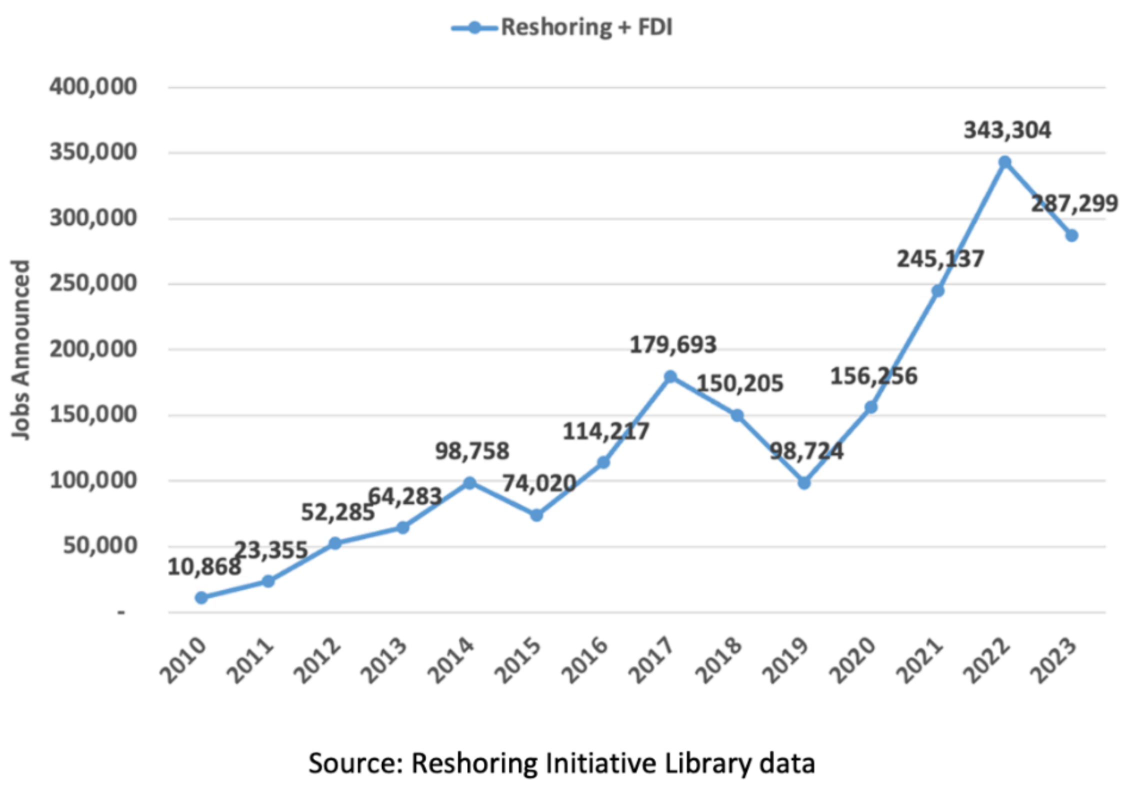


Figure 5: Reshoring + FDI Job Announcements by Year, 2010-2023

The IRA's strategy is to offer generous incentives in tax credits to customers only if the vehicle and its battery meet stringent North American assembly and content requirements. On the production side, the law provides substantial tax credits to manufacturers for making battery components in the U.S. Federal support goes beyond tax credits: the Department of Energy is also providing billions in grants to build and upgrade EV and battery factories. At the same time, the government is paying to expand charging stations across the country. Together, these policies create powerful financial incentives to produce EVs and their components in North America rather than abroad (Moser, 2024). These subsidies are compelling companies to onshore EV production if they wish to maximize their profits and qualify for the full incentives. The Inflation Reduction Act has had an immediate and massive impact: in only two years (from 2022 to 2024) over $110 billion in private investments have been announced, leading to the creation of approximately 90,000 jobs in clean energy industries (Forbes, 2024). Detroit's Big Three car manufacturers (GM, Ford, and Stellantis) are planning to either convert existing factories or build new assembly plants for EV models in the United States (Kessel, 2024). These developments show how public policy can steer private investment toward domestic manufacturing: thanks to the IRA's incentives, critical pieces of the automotive supply chain are being rebuilt in America.

AI-driven reshoring is supported by other policies, other than the CHIPS Act and the IRA. The bipartisan infrastructure law of 2021 is primarily about transport and power infrastructure, but it also mentions the allocation of funds for upgrading factories and workforce training in advanced manufacturing. "Buy American" rules have been strengthened for federal vehicles purchases, favoring domestically assembled vehicles and parts. There are also strategic considerations: for example, the Defense Production Act has been invoked to encourage domestic EV battery production in the interest of national security. AI plays an important role in many of these programs: the federal government funds AI research centers and testbeds (some focusing on manufacturing AI), and it encourages public-private partnerships where companies can cooperate with national labs on AI for automation, materials science, and supply chain management. The tactic is to keep the U.S. automotive sector at the cutting edge of technology through AI and innovation, so that it will gain competitive advantages and reduce reliance on adversaries.

Another crucial driver are private sector investments, that match these policy moves often through partnerships. Automakers and tech companies are pouring resources into AI development for both products (like self-driving software) and processes (like smart factories). For example, Ford has invested in artificial intelligence for supply chain optimization and partnered with Google to use AI cloud systems in its operations. General Motors has a stake in multiple AI startups (including autonomous drive from Cruise) and is applying machine learning to most tasks, from predictive maintenance in plants to marketing analytics. Tesla, as a new generation automaker, famously designs much of its AI hardware and software in-house (from custom AI chips to its "Dojo" supercomputer for training autonomous driving algorithms). These investments reflect a recognition that mastery of AI is now as important as mastery of mechanical engineering in the auto industry's future.

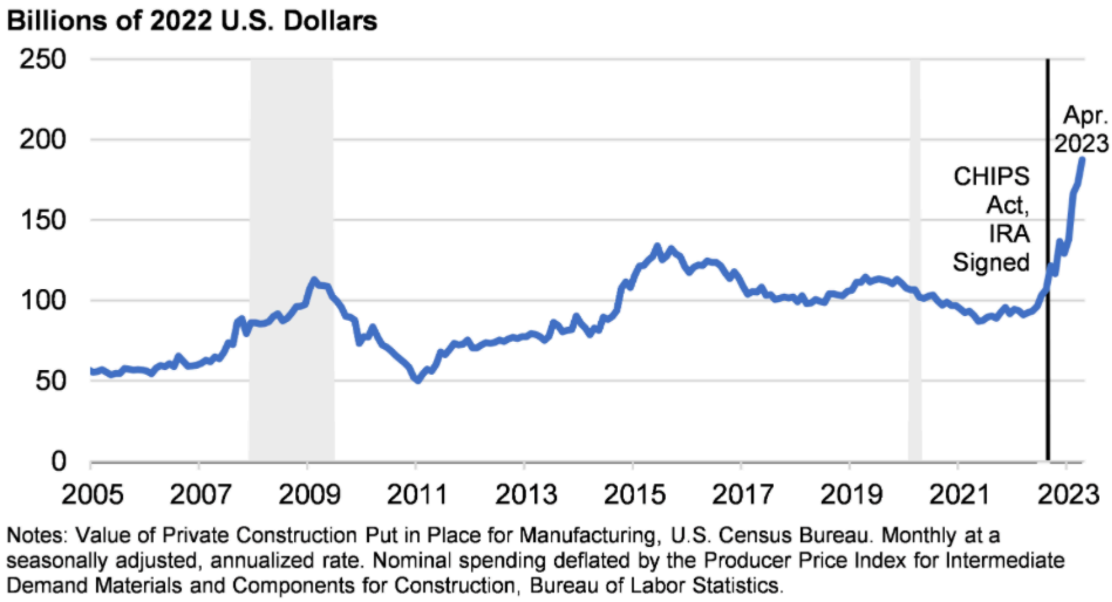


Figure 6: Real Total Manufacturing Construction Spending

Source: U.S. Department of the Treasury

In summary, U.S. industrial policy is actively aligning with AI-driven reshoring in the automotive sector. The CHIPS Act strengthens the semiconductor foundation needed for AI-enabled cars; the IRA supercharges domestic production of EVs and components; and complementary measures address infrastructure and skills. Together, these create an ecosystem where public and private investment reinforce each other, ensuring for the United States a future in a globally competitive industry while also creating jobs and innovation domestically. The success of these policies depends on implementation and global market responses, but early indicators (tens of billions in new investments and thousands of jobs announced) are promising. The next section will consist of an analysis on company level, examining how one U.S. automaker demonstrates the impact of AI adoption of reshoring and industry dynamics.

3.4 Firm-Level Case Study: Tesla's AI-Driven Transformation of Automotive Manufacturing

When it comes to integrating AI in the automotive sector, Tesla, Inc. stands out as a pioneer. As an electric vehicle manufacturer born in the Silicon Valley tech culture, tesla has from the start integrated AI and automation deeply into both its products and production. This makes Tesla a clear example of how AI is changing the industry, influencing trade patterns, labor, and competitive strategy.

Manufacturing and Reshoring: Tesla's manufacturing process in U.S. plants is heavily automated. Most of Tesla's vehicle production for the North American market takes place in its California factory and the newer Gigafactory in Austin, Texas. These factories are designed as high-tech hubs: they use robotic arms for assembly, AI-driven vision systems for quality control, and advanced software to orchestrate the entire production line in real time (Varenas, 2025). By doing so, Tesla achieves efficiency levels that help offset U.S. labor and operating costs. At first, the Gigafactory (which produces batteries and cars in the U.S. at bigger scale) was seen as risky and overly ambitious, but Tesla's success demonstrated that mass production can be competitive on U.S. soil when cutting-edge automation is applied. In fact, Tesla's growth in the U.S. (including its battery factory in Nevada and upcoming facilities) shows how AI and automation are helping the process of reshoring. Instead of sending parts overseas like many traditional carmakers, Tesla kept key production steps local. For example, by making its own battery packs in the Nevada Gigafactory with Panasonic, Tesla reduced its dependence on imported batteries early on. This approach gave the company more control over its supply chain and helped avoid some global disruptions. It also influenced other carmakers, who are now building battery plants in the U.S. as well thanks to the government incentives support (Naor, Coman, Wiznizer, 2021).

However, Tesla faced challenges and setbacks too in its journey. In 2018 Tesla attempted to operate an "Alien Dreadnought" factory to increase the production of their Model 3. This type of factory consists in a fully automated production line with minimal human labor, but it instantly showed its limitations: the highly complex robotic system was producing around 2,000 cars per week vs. a planned 5,000 (Wilson, Daugherty, 2018).

Musk admitted that *excessive automation was a mistake, and some tasks were better left to human hands.* The company had to reintroduce more manual operations in certain areas to reach full production capacity. This case proves what was stated in paragraph 3.2: for a factory to be optimal, it must blend automation with human flexibility. Now the company focuses AI where it's most effective, such as vision systems for inspection, and machine learning algorithms for supply chain. By mid-2020s, Tesla's factories became some of the most productive in the world in terms of output per worker, validating that with the right approach, AI-driven reshoring can deliver world-class manufacturing performance on U.S. soil (Randall, Pogkas, 2022).

Product and Technology Leadership: Tesla's investment in AI goes beyond manufacturing. It's central to the product itself, especially in autonomous driving. Tesla cars include AI-powered "autopilot" system, with an optional Full Self-Driving (FSD) upgrade. These features use neutral networks that process data from cameras and sensors. Since 2016 Tesla has already collected over 1.3 billion miles of Autopilot driving data (Bloomberg, 2016). This gave it an early lead over traditional carmakers in developing self-driving technology. The large amount of real-word data helps train its AI systems and keeps tesla ahead in the industry. This leadership has two main effects on the industry: (1) it shifts the focus from hardware to software and data. Companies that already use AI are setting the standard for new car features. Others must now invest in AI or partner with tech firms; (2) it's changing demand for high-tech components. To support Autopilot, Tesla developed its own AI chip but also uses chips from U.S. firms like Nvidia. The system needs advanced sensors and computing parts, increasing demand for these technologies. As a result, Tesla's AI-first approach is helping shift supply chains towards more domestic, tech-heavy productions that align with policies such as the CHIPS Act.

Labor and Skills at Tesla: Tesla's workforce reflects the labor trends discussed earlier. Because of its reliance on automation, Tesla's factories employ fewer assembly workers per vehicle produced than older automakers (OECD, 2024). Yet Tesla has thousands of employees in software engineering, data analysis, and equipment maintenance. The company annually hosts AI recruitment events to hire AI specialists and invests in training technicians for its production lines. In California and Nevada, Tesla has worked with local colleges to create training programs for advanced manufacturing. Even though Tesla's

U.S. production workforce is modest compared to other companies, it created new up-skilled jobs that blend manufacturing and tech.

Finally, it's important to mention Tesla's impact the U.S. automotive industry. Tesla proved that EVs production at scale in the U.S. is possible and profitable. This encouraged both federal and state governments to provide support through programs such as the CHIPS Act and the IRA. Tesla's Gigafactory model is now being replicated in public-private projects, often backed by government funding. In many ways, Tesla initiated the shift of the auto industry towards electric vehicles and automation, giving the possibility to companies and policymakers to learn from its wins and its mistakes. For example, Ford and GM have launched major EV projects in Michigan, Ohio, and Tennessee. They've publicly said they're taking advantage of market trends and policy incentives, both resulting from Tesla's production. This proves that AI-driven reshoring is a part of a broader shift in the auto industry. AI and electric vehicles are the driving force for the future of cars in America.

In conclusion, Tesla's cause illustrates the opportunities and challenges of AI in reshaping the auto industry. It shows that AI can increase domestic manufacturing's efficiency and drive innovation, but it also highlights the need for iterative learning and human oversight. Tesla has influenced trade by keeping key production steps in the U.S., changed labor needs by shifting the kinds of skills required, and blurred the line between car companies and tech firms. Tesla's case is a key example of AI-driven reshoring. Like others, the company has benefited from U.S. policies like EV tax credits, but it also helped shape those policies by showing that reshoring production at reasonable costs is possible. As more automakers are now changing their production processes, Tesla's journey offers valuable insights on how AI can help increase domestic production in a fast-changing global market.

Conclusion

The key question that this thesis explores is: how is artificial intelligence transforming international trade? The analysis conducted on both empirical data and real-world case studies revealed that AI is not only changing what countries trade, but also how, where, and with whom.

AI is enabling new patterns of specialization and competitiveness, ranging from the rise of digital services to the resurgence of domestic manufacturing. Countries that fully exploit AI and invest in digital infrastructure, automation, and skilled labor, are set to be leaders in global trade. This applies whether in software and cloud services or in the production of high-tech goods like semiconductors and electric vehicles.

The U.S. automotive industry is a perfect example. In this case, AI plays a central role in reshoring production, optimizing supply chains, and reshaping labor skill requirements. Thanks to the support offered by the government through policies such as the CHIPS Act and the Inflation Reduction Act, firms like Tesla are demonstrating that smart factories and AI-driven operations can make American manufacturing competitive again. However, this shift won't happen without challenges: it requires a new king of workforce, heavy public and private investment, and careful attention to equity and global cooperation.

Moreover, AI is accelerating a transition toward a more regional, skill-intensive, and digitally enabled global trade system. Whether this will lead to greater inclusion or deeper divides depends on how governments, firms, and societies will handle this transition.

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