

WHY ARTIFICIAL INTELLIGENCE IS THE FUTURE OF GROWTH

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Increases in capital and labor are no longer driving the levels of economic growth the world has become accustomed to and desires. Fortunately, a new factor of production is on the horizon, and it promises to transform the basis of economic growth for countries across the world.

There has been marked decline in the ability of increases in capital investment and in labor to propel economic progress. These two levers are the traditional drivers of production, yet they are no longer able to sustain the steady march of prosperity enjoyed in previous decades in most developed economies.

But long-term pessimism is unwarranted. With the recent convergence of a transformative set of technologies, economies are entering a new era in which artificial intelligence (AI) has the potential to overcome the physical limitations of capital and labor and open up new sources of value and growth.

Indeed, Accenture analyzed 12 developed economies and found that AI has the potential to double their annual economic growth rates by 2035.

To avoid missing out on this opportunity, policy makers and business leaders must prepare for, and work toward, a future with artificial intelligence. They must do so not with the idea that AI is simply another productivity enhancer. Rather, they must see AI as the tool that can transform our thinking about how growth is created.

THE NEW FACTOR OF PRODUCTION

Across the globe, rates of gross domestic product (GDP) growth have been shrinking. Moreover, this has been true for three decades. Key measures of economic efficiency are trending sharply downward, while labor-force growth across the developed world is largely stagnant. It is even in decline in some countries (see Figures 1 to 4).

Given this poor outlook, commentators say that a stagnant economy is the “new normal.” On an even more pessimistic note, economist Robert Gordon argues that productivity growth over the next quarter century will continue at the sluggish pace we have experienced since 2004.¹ He believes that the past two centuries of “Great Inventions,” such as the steamship and telegraph, are unlikely to be repeated. And this deficit of innovation, combined with unfavorable demographic trends, flagging educational attainment and rising wealth inequality, will slow economic progress.

So, are we experiencing the end of growth and prosperity as we know it?

As grim as much of the data undoubtedly is, it misses an important part of the story.

That missing element is how new technologies affect growth in the economy.

Traditionally, capital and labor are the “factors of production” that drive growth in the economy (see Figure 5). Growth occurs when the stock of capital or labor increase, or when they are used more efficiently. The growth that comes from innovations and technological change in the economy is captured in total factor productivity (TFP).

Economists have always thought of new technologies as driving growth through their ability to enhance TFP. This made sense for the technologies that we have seen until now. The great technological breakthroughs over the last century—electricity, railways and IT—boosted productivity dramatically but did not create entirely new workforces.

Today, we are witnessing the take-off of another transformative set of technologies, commonly referred to as artificial intelligence (see “What is artificial intelligence?”). Many see AI as similar to past technological inventions. If we believe this, then we can expect some growth, but nothing transformational.

But what if AI has the potential to be not just another driver of TFP, but an entirely new factor of production? How can this be?

The key is to see AI as a capital-labor hybrid. AI can replicate labor activities at much greater scale and speed, and to even perform some tasks beyond the capabilities of humans. Not to mention that in some areas it has the ability to learn faster than humans, if not yet as deeply. For example, by using virtual assistants, 1,000 legal documents can be reviewed in a matter of days instead of taking three people six months to complete.²

Similarly, AI can take the form of physical capital such as robots and intelligent machines. And unlike conventional capital, such as machines and buildings, it can actually improve over time, thanks to its self-learning capabilities.

Based on our analysis and modeling, we can illustrate what happens when AI is seen as a new factor of production rather than just a productivity enhancer. The impact on projected growth for the United States, for example, is dramatic. As Figure 6 shows, the first scenario is business-as-usual, assuming no AI effect. The second indicates the traditional view of AI as a TFP enhancer where it has a limited impact on growth. The third scenario shows what happens when AI can act as a new factor of production—there is a transformative effect on growth. This ability of AI to complement and enhance traditional factors of production is where its true potential lies.



The advance of AI is leading us to rethink fundamental economic relationships and how value is created.



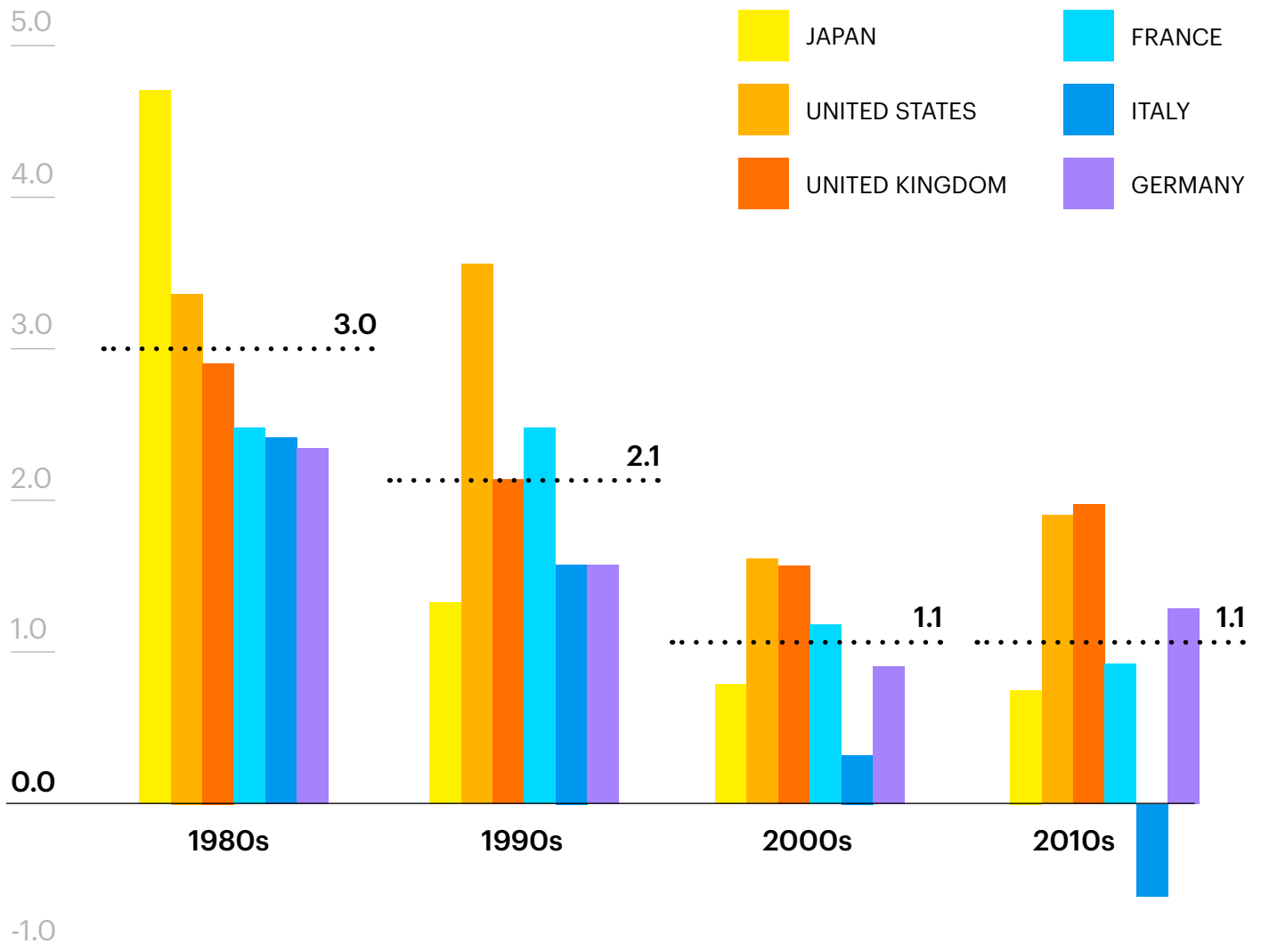
DAVID LEHRER, CEO, CONATIX

Developed economies: The end of growth?

On a variety of key measures, economic data seems to support a mood of long-term pessimism.

FIGURE 1: GROSS DOMESTIC PRODUCT

Since the 1980s, GDP growth has steadily slowed in many large economies.



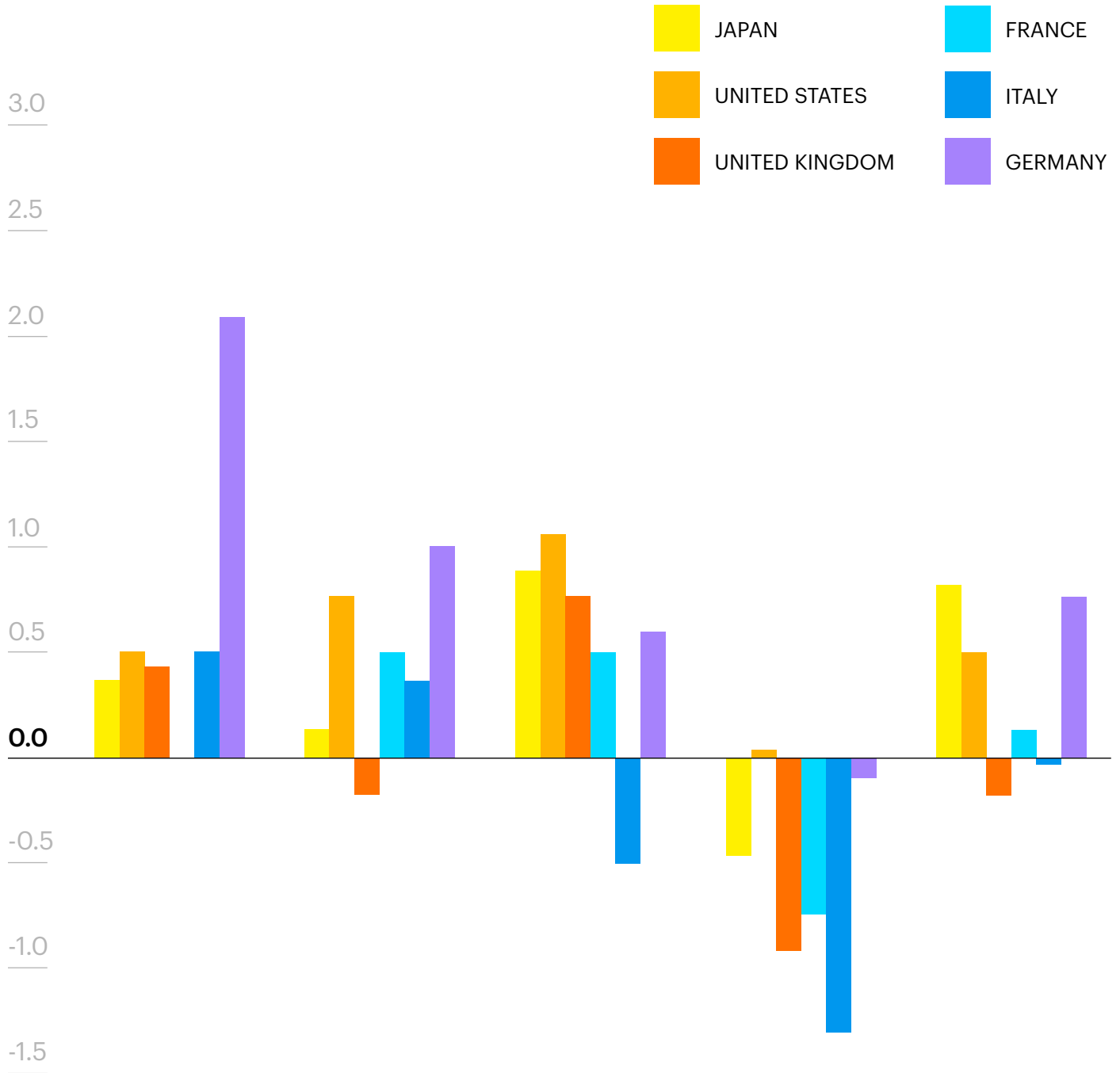
Real GDP growth (% , annual average over the period)

NB: Data points across the dashed lines indicate the average for the six countries.

Source: Oxford Economics

FIGURE 2: PRODUCTIVITY

A key measure of how well an economy uses its existing capital and people is “total factor productivity” (TFP). Data show a weakening of TFP, especially in the past 10 years.

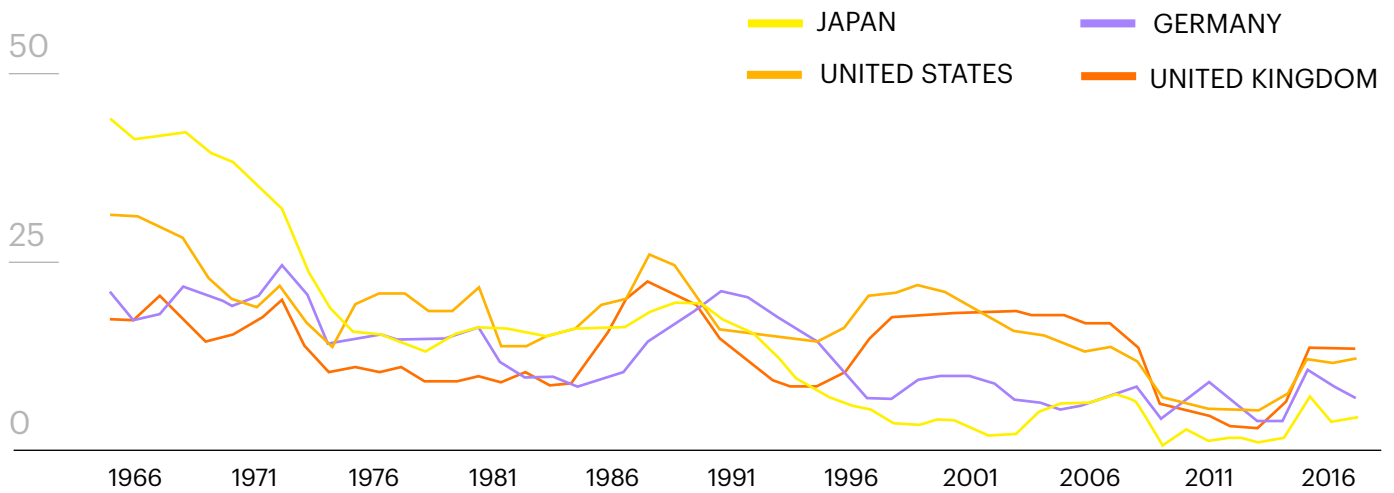


Total factor productivity (% , annual average over the period)

Source: The Conference Board, Total Economic Database

FIGURE 3: CAPITAL EFFICIENCY

The marginal capital efficiency rate, an indicator of the productivity of capital such as machines and buildings, has steadily dropped over a 50-year period.

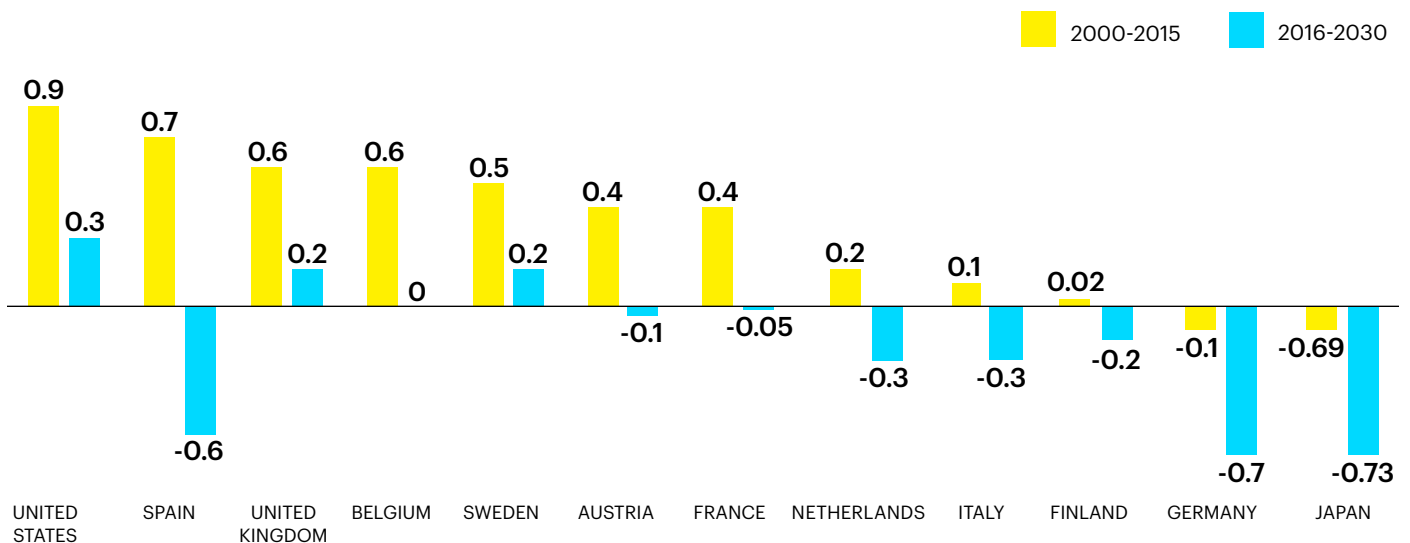


Marginal capital efficiency (% , 6-year moving average)

Source: European Commission, Annual Macroeconomic Database

FIGURE 4: LABOR

As populations age and birth rates slow, fewer people are available to pick up the slack in the workforce.

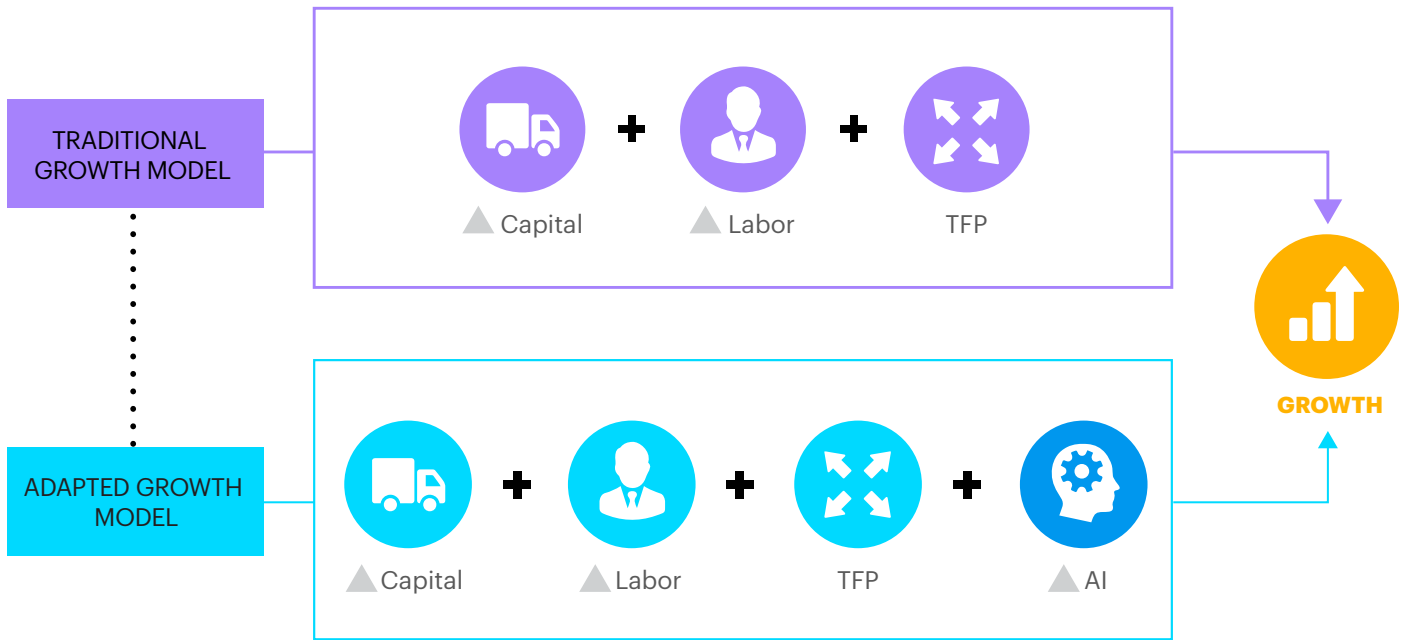


Working age population (% , annual average growth over the period)

Source: Oxford Economics

FIGURE 5: THE AI GROWTH MODEL

Our model adapts the traditional growth model by including AI as a factor of production.

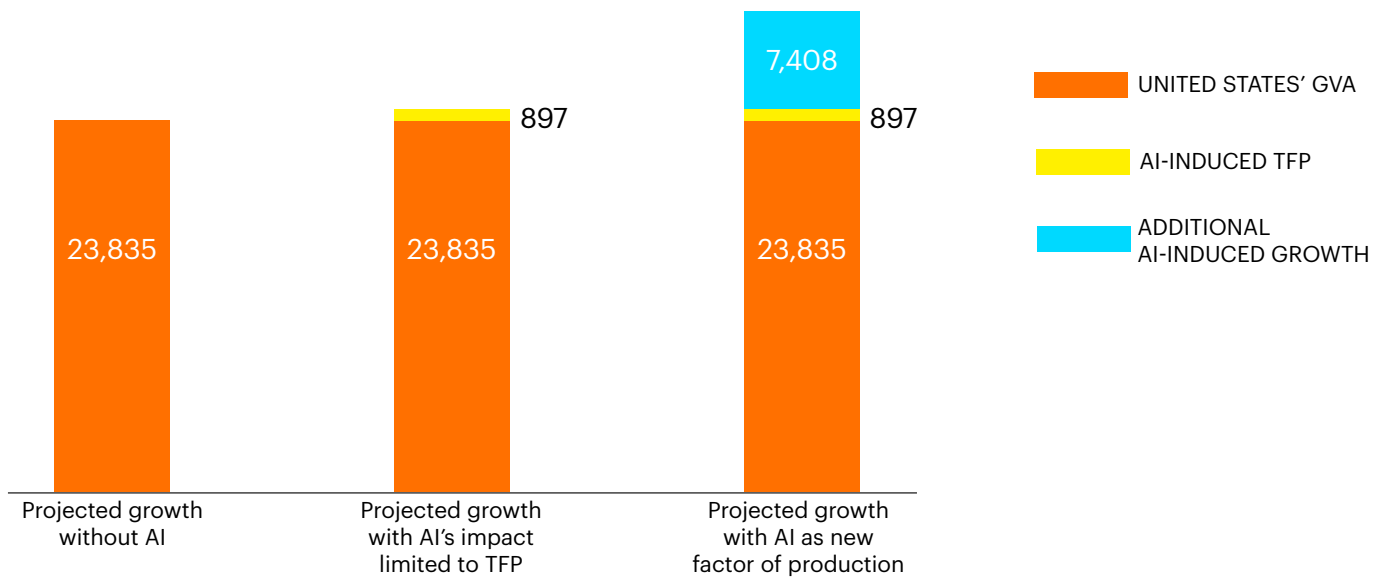


NB: ▲ indicates the change in that factor.

Source: Accenture analysis

FIGURE 6: THREE GROWTH SCENARIOS FOR THE UNITED STATES' ECONOMY

AI as a new factor of production can lead to significant growth opportunities for the United States' economy.



United States' gross value added (GVA) in 2035 (US\$ billion)

Source: Accenture and Frontier Economics

WHAT IS ARTIFICIAL INTELLIGENCE?

AI is not a new field; much of its theoretical and technological underpinning was developed over the past 70 years by computer scientists such as Alan Turing, Marvin Minsky and John McCarthy. Today, the term refers to multiple technologies that can be combined in different ways to:



Sense

Computer vision and audio processing, for example, are able to actively perceive the world around them by acquiring and processing images, sounds and speech. The use of facial recognition at border control kiosks is one practical example of how it can improve productivity.



Comprehend

Natural language processing and inference engines can enable AI systems to analyze and understand the information collected. This technology is used to power the language translation feature of search engine results.



Act

An AI system can take action through technologies such as expert systems and inference engines, or undertake actions in the physical world. Auto-pilot features and assisted-braking capabilities in cars are examples of this.

All three capabilities are underpinned by the ability to learn from experience and adapt over time. AI already exists to some degree in many industries but the extent to which it is becoming part of our daily lives is set to grow fast.

Two key factors are enabling AI growth:

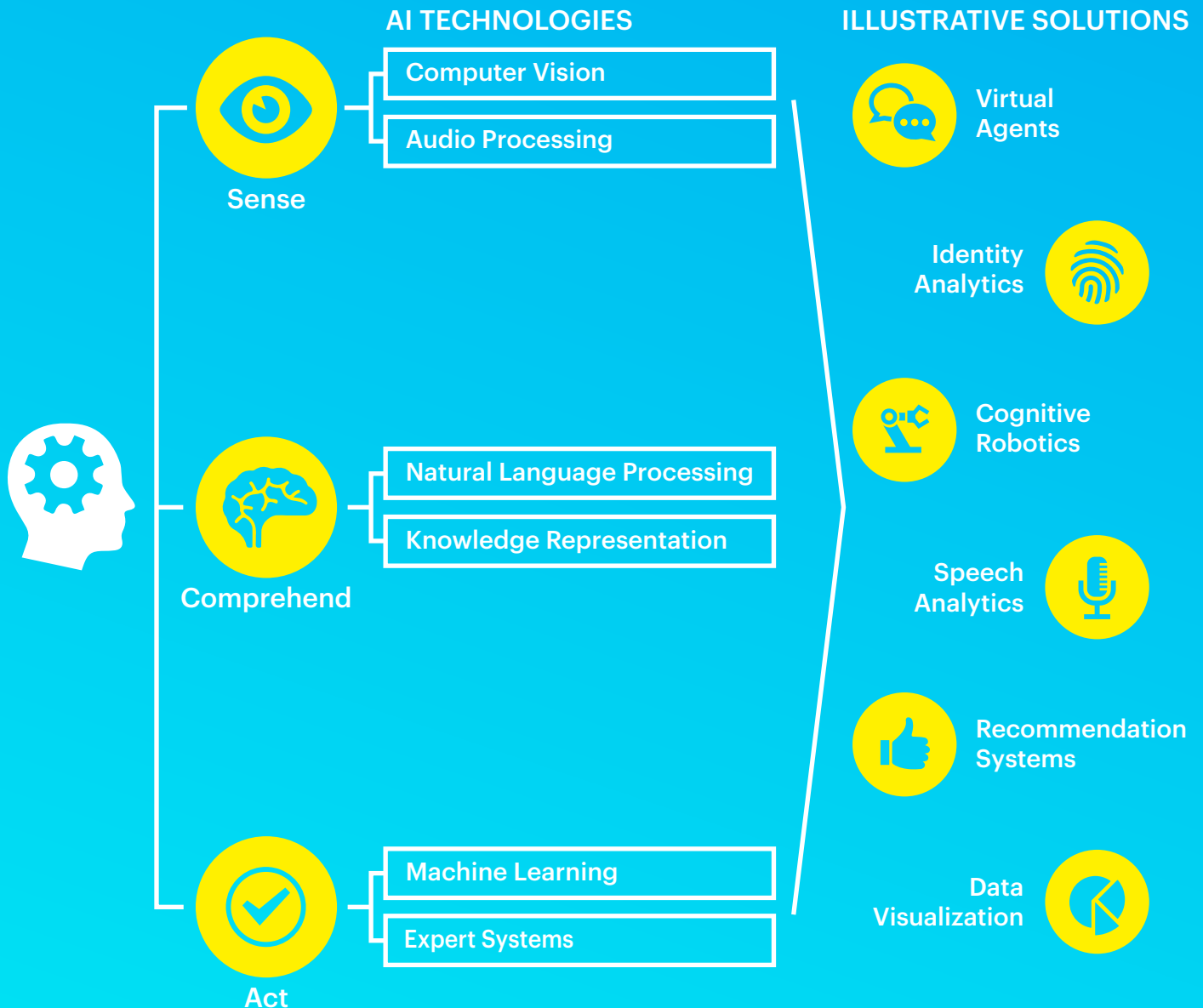
1. Unlimited access to computing power.

Public cloud computing was estimated to reach almost US\$70 billion in 2015 worldwide. Data storage has also become abundant.

2. Growth in big data.

Global data has seen a compound annual growth rate (CAGR) of more than 50 percent since 2010 as more of the devices around us have become connected. As Barry Smyth, professor of computer science at University College Dublin, told us: "Data is to AI what food is to humans." So in a more digital world, the exponential growth of data is constantly feeding AI improvements.

Emerging AI technologies



Source: Accenture analysis

THREE CHANNELS OF AI-LED GROWTH

With AI as the new factor of production, it can drive growth in at least three important ways. First, it can create a new virtual workforce—what we call “intelligent automation.” Second, AI can complement and enhance the skills and ability of existing workforces and physical capital. Third, like other previous technologies, AI can drive innovations in the economy. Over time, this becomes a catalyst for broad structural transformation as economies using AI not only do things differently, they will also do different things.

Intelligent automation

The new AI-powered wave of intelligent automation is already creating growth through a set of features unlike those of traditional automation solutions.

The first feature is its ability to automate complex physical world tasks that require adaptability and agility. Consider the work of retrieving items in a warehouse, where companies have relied on people’s ability to navigate crowded spaces and avoid moving obstacles. Now, robots from Fetch Robotics use lasers and 3D depth-sensors to navigate safely and work alongside warehouse workers. Used in tandem with people, the robots can handle the vast majority of items in a typical warehouse.³

Whereas traditional automation technology is task specific, the second distinct feature of AI-powered intelligent automation is its ability to solve problems across industries and job titles. For instance, Amelia—an AI platform by IPsoft with natural language processing capabilities—has supported maintenance engineers in remote locations. Having read all the manuals, Amelia can diagnose a problem and suggest a solution.⁴ This platform has also learned the answers to the 120 questions most frequently asked by mortgage brokers and has been used in a bank to handle such financial queries, traditionally a labor-intensive task.⁵

The third and most powerful feature of intelligent automation is self-learning, enabled by repeatability at scale. Amelia, like a conscientious employee, recognizes the gaps in her own knowledge and takes steps to close them. If Amelia is presented with a question that she cannot answer, she escalates it to a human colleague, then observes how the person solves the problem. The self-learning aspect of AI is a fundamental change. Whereas traditional automation capital degrades over time, intelligent automation assets constantly improve.

Labor and capital augmentation

A significant part of the economic growth from AI will come not from replacing existing labor and capital, but in enabling them to be used much more effectively.

For example, AI can enable humans to focus on parts of their role that add the most value. Hotel staff spend a lot of their time making routine room deliveries. Why not assign the task to Relay, an autonomous service industry robot developed by Savioke, instead? Last year, the Relay fleet made more than 11,000 guest deliveries in the five large hotel chains where it is deployed. As Steve Cousins, CEO of Savioke, told us: “Relay enables staff to redirect their time toward increasing customer satisfaction.”

Also, AI augments labor by complementing human capabilities, offering employees new tools to enhance their natural intelligence. For example, Praedicat, a company providing risk modeling services to property and casualty insurers, is improving underwriters’ risk-pricing abilities. Using machine learning and big data processing technologies, its AI platform reads more than 22 million peer-reviewed scientific papers to identify serious emerging risks. As a result, underwriters can not only price risk more accurately, but also create new insurance products.⁶

AI can also improve capital efficiency—a crucial factor in industries where it represents a large sunk cost. For instance, in manufacturing, industrial robotics company Fanuc has teamed up with Cisco and other firms to create a platform to reduce factory downtime—estimated at one major automotive manufacturer to cost US\$20,000 per minute.⁷ The Fanuc Intelligent Edge Link and Drive (FIELD) system is an analytics platform powered by advanced machine learning. It captures and analyzes data from disparate parts of the manufacturing process to improve manufacturing production. Already FIELD has been deployed in an 18-month “zero downtime” trial at one manufacturer, where it realized significant cost savings.⁸

“Often people only think of AI boosting growth by substituting humans, but actually huge value is going to come from the new goods, services and innovations AI will enable.”

DAVID AUTOR, PROFESSOR OF ECONOMICS, MIT

Innovation diffusion

One of the least-discussed benefits of artificial intelligence is its ability to propel innovations as it diffuses through the economy.

Take driverless vehicles. Using a combination of lasers, global positioning systems, radar, cameras, computer vision and machine learning algorithms, driverless vehicles can enable a machine to sense its surroundings and act accordingly. Not only are Silicon Valley technology companies entering the market, but traditional companies are building new partnerships to stay relevant.

For instance, BMW is collaborating with Chinese Internet search giant Baidu⁹; Ford is working with Massachusetts Institute of Technology (MIT) and Stanford University.¹⁰

As innovation begets innovation, the potential impact of driverless vehicles on economies could eventually extend well beyond the automotive industry. Mobile service providers could see even more demand from subscribers as drivers, now free to enjoy leisure activities while traveling, spend more time on the Internet, which, in turn, could create new advertising opportunities for the service providers and selling opportunities for their retailer partners.

The insurance industry could create new revenue streams from the masses of data that self-driving vehicles generate. By combining vehicle data with other streams such as smart phones and public transport systems, they could not only build up a more complete picture of their customers, but also they could create new policies that insure total customer mobility, not just driving.

Real-time, accurate road and traffic data generated by driverless vehicles could supplement other sources of information to enable local authorities to change the way they charge for road usage. Standard vehicle registration could be replaced with more equitable and convenient pay-per-use road tolls, with instantly updated prices to help reduce congestion.

There could even be significant social benefits. Driverless vehicles are expected to reduce the number of road accidents and traffic fatalities dramatically, making the technology potentially one of the most transformative public health initiatives in human history. They could also give back independence to people who cannot drive due to disability, enabling them to take up jobs from which they were previously excluded. And, even among those who can drive, driverless cars will make traveling far more convenient, freeing up time that people can dedicate to work or leisure.

FACTORING IN AI

To understand the value of AI as a new factor of production, Accenture, in association with Frontier Economics, modeled the potential impact of AI for 12 developed economies that together generate more than 50 percent of the world's economic output.¹¹

Our results reveal unprecedented opportunities for value creation. We find that AI has the potential to double annual economic growth rates across these countries—a powerful remedy for slowing rates in recent years.

Boosting national economic growth

To estimate the economic potential of AI we compared two scenarios for each country. The first is the baseline, which shows the expected annual economic growth rate under current assumptions about the future. The second is the AI scenario, which shows expected economic growth once the impact of AI has been absorbed into the economy. As it takes time for the impact of a new technology to feed through, we used 2035 as the year of comparison. (see “Appendix: Modeling the GVA impact of AI”).

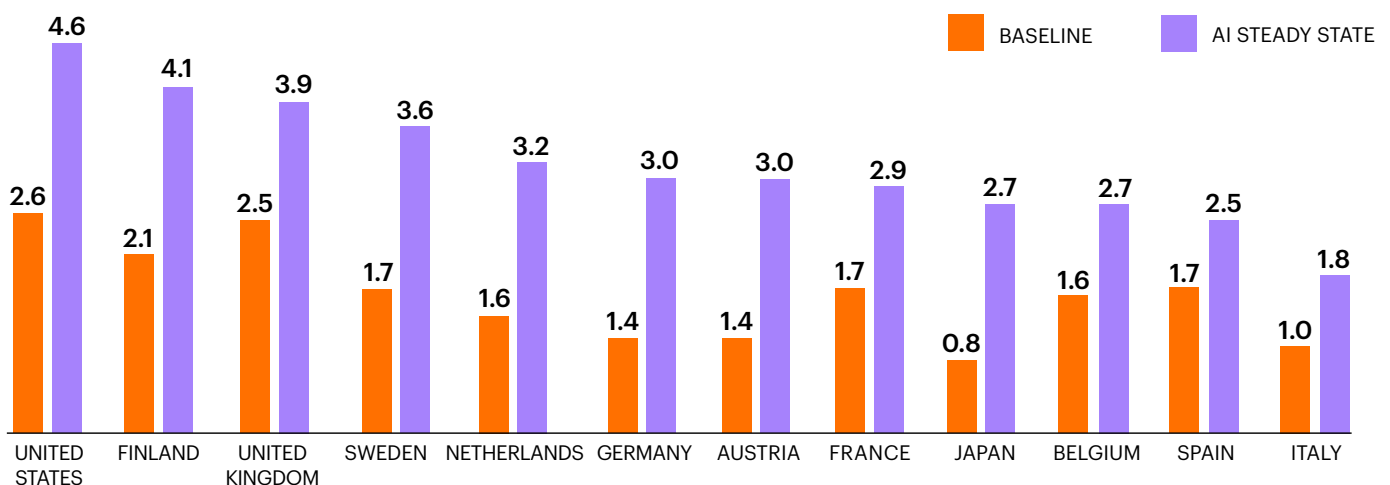
According to our research, AI yields the highest economic benefits for the United States in absolute terms, culminating in a 4.6 percent growth rate by 2035 (see Figure 7). Japan could more than triple its gross value added (GVA) growth during the same period,

raising it from 0.8 percent to 2.7 percent. Germany, Austria, Sweden and the Netherlands could see their annual economic growth rates double (see “AI’s potential impact on national growth”).

Cross-country comparisons mask the significant impact that AI could have on seemingly lagging economies, such as Italy, Spain and Belgium. While the level of technological maturity and public investment does not yet match that of their leading peers, these countries are also set to benefit from AI. For instance, AI is expected to raise Italy’s growth rate to 1.8 percent by 2035—the lowest GVA rate increase in the countries analyzed—but this is still a sizeable amount (nearly US\$230 billion or 15 percent of the country’s current GVA).

FIGURE 7: THE ECONOMIC IMPACT OF AI

AI has the potential to double annual economic growth rates in the countries that we analyzed in terms of gross value added (a close approximation of GDP).

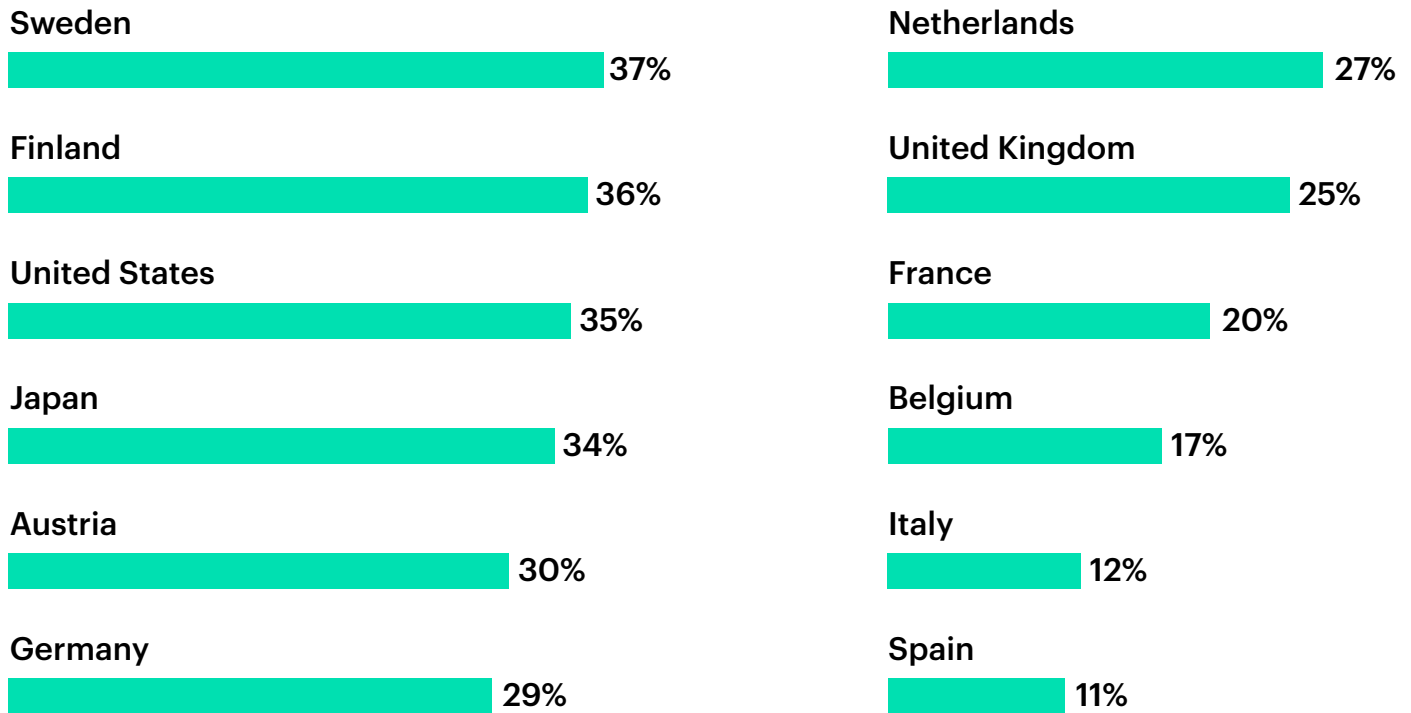


Real gross value added (GVA) (% growth)

Source: Accenture and Frontier Economics

FIGURE 8: INCREASE IN LABOR PRODUCTIVITY IN AN AI WORLD

Artificial intelligence promises to significantly boost the productivity of labor in developed economies.



Percentage difference between baseline in 2035 and AI steady state in 2035

Source: Accenture and Frontier Economics

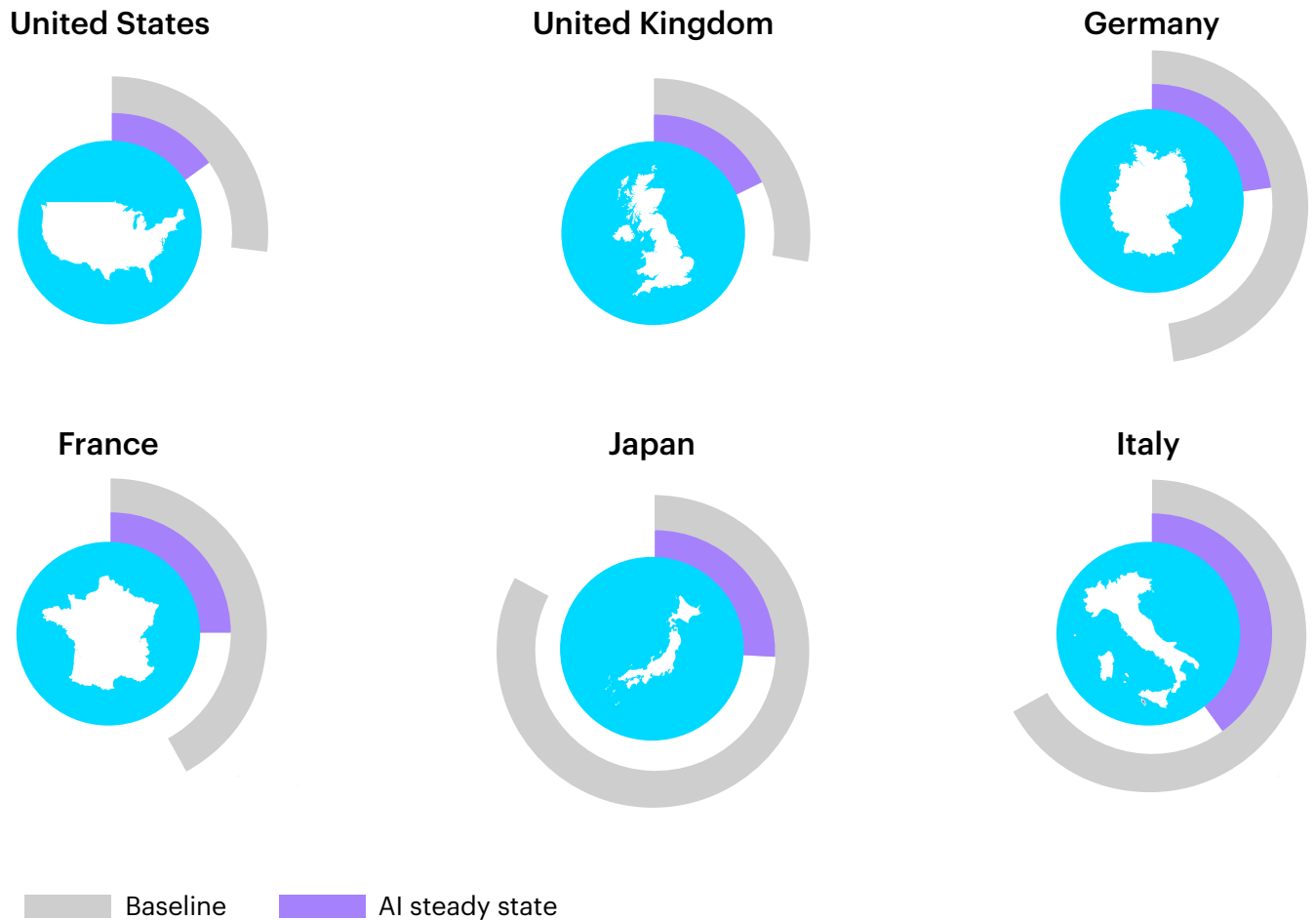
Labor productivity revival

AI has the potential to boost labor productivity by up to 40 percent in 2035 in the countries we studied (see Figure 8). This rise in labor productivity will not be driven by longer hours but by innovative technologies enabling people to make more efficient use of their time.

This labor productivity increase dramatically reduces the number of years required for our analyzed countries' economies to double in size (see Figure 9). The results are primarily driven by a country's ability to diffuse technological innovations into its wider economic infrastructure. While the gains vary from country to country, our results are indicative of AI's ability to transcend regional and structural disparities, enabling huge, rapid leaps in labor productivity.

FIGURE 9: TIME FOR ECONOMIES TO DOUBLE IN SIZE

AI paves the way to faster economic growth.



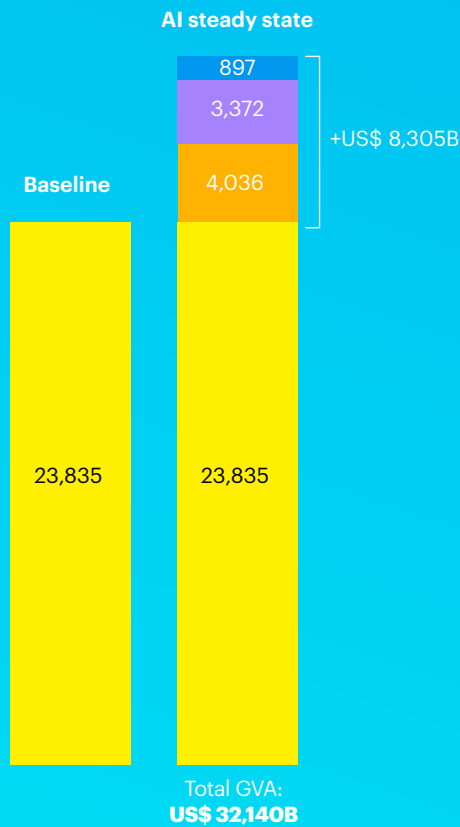
Number of years for the economy to double in size (a full circle represents 100 years)

Source: Accenture and Frontier Economics

Overall, AI is expected to unleash remarkable benefits across countries, countering dismal economic growth prospects and redefining “the new normal” as a period of high and long-lasting economic growth.

AI'S POTENTIAL IMPACT ON NATIONAL ECONOMIC GROWTH

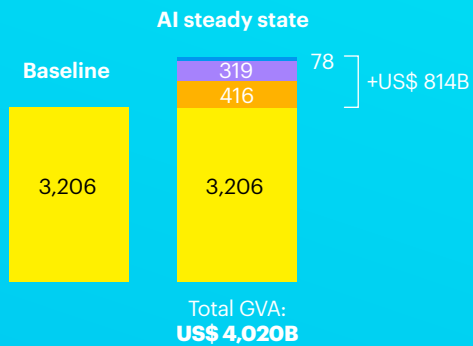
By focusing on individual countries, we can analyze the impact of AI in more detail. We compare the size of each economy in 2035 in a baseline scenario with the AI scenario, where AI has been absorbed into the economy. We can also see the relative importance of the three channels through which AI has an effect.



United States

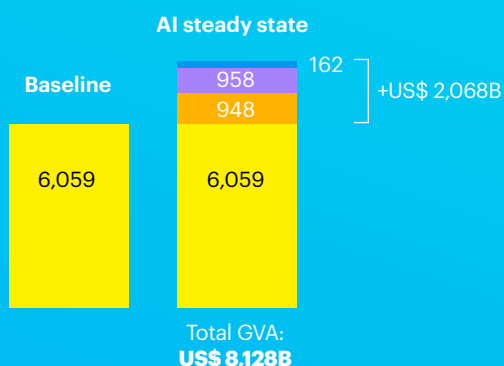
A strong entrepreneurial business climate and advanced infrastructure position the United States to benefit from the economic potential of AI. Accenture research forecasts a significant increase in United States' GVA growth, from 2.6 percent to 4.6 percent in 2035—a level not seen since the economic peak in the 1980s. This translates to an additional US\$8.3 trillion GVA in 2035—equivalent to today's combined GVA of Japan, Germany and Sweden.

- Intelligent Automation
- Augmentation
- Total factor productivity (TFP)



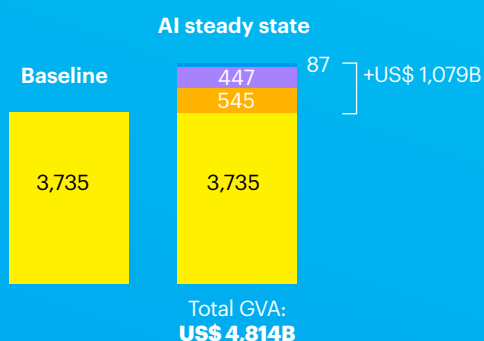
United Kingdom

AI could add an additional US\$814 billion in 2035 to the UK's economy—with growth rates increasing from 2.5 percent to 3.9 percent in 2035. The growth boost will result in approximately equal parts from the augmentation and intelligent automation channels. While the UK's dominant service sector can adopt AI to fuel the productivity of knowledge workers, Britain's strong pharmaceutical and aerospace industry could also capitalize on intelligent systems to optimize production.



Japan

In our model, AI will accelerate expected growth from 0.8 percent to 2.7 percent in 2035, resulting in US\$2.1 trillion of additional GVA for Japan. Among the countries we studied, Japan is expected to benefit considerably from additional innovation effects driven by its sophisticated research networks, dominance in patent applications and longstanding prowess in fields like robotics. Considering its large electronics goods industry, Japan offers a favorable context for AI to stimulate wider growth impact.



Germany

AI could contribute an additional US\$1.1 trillion GVA for Germany in 2035. The bulk of economic rewards will stem from intelligent automation. Its advanced manufacturing sector, coupled with initiatives like Industry 4.0, offer prime conditions for a seamless integration of intelligent systems into production processes.

- Intelligent Automation
- Augmentation
- Total factor productivity (TFP)

CLEARING THE PATH TO AN AI FUTURE

Entrepreneur Elon Musk has warned that artificial intelligence could become humanity's "biggest existential threat." The more optimistic view of futurist Ray Kurzweil is that AI can help us to make "major strides in addressing the [world's] grand challenges."

The truth is, it all depends on how we manage the transition to an era of AI.

To fulfil the promise of AI as a new factor of production that can reignite economic growth, relevant stakeholders must be thoroughly prepared—intellectually, technologically, politically, ethically, socially—to address the challenges that arise as artificial intelligence becomes more integrated in our lives.

The starting point is understanding the complexity of the issues.

Prepare the next generation for the AI future

Successfully integrating human intelligence with machine intelligence, so that they coexist in a two-way learning relationship, will become more critical than ever. As the division of tasks between man and machine changes, policy makers need to reevaluate the type of knowledge and skills imparted to future generations.

Currently, technological education goes in one direction: people learn how to use machines. Increasingly, this will change as machines learn from humans, and humans learn from machines.

For example, customer services representatives of the future will need to act as "role models" to their digital colleagues, and potentially vice versa.

Technical skills will also be required to design and implement AI systems, exploiting expertise in many specialties including robotics, vision, audio and pattern recognition. But interpersonal skills, creativity and emotional intelligence will also become even more important than they are today.

Encourage AI-powered regulation

As autonomous machines take over tasks that have exclusively been undertaken by humans, current laws will need to be revisited. For instance, the state of New York's 1967 law that requires drivers to keep one hand on the wheel was designed to improve safety, but may inhibit the uptake of semi-autonomous safety features, such as automatic lane centralization.¹²

In other cases, new regulation is called for. For example, though AI could be enormously beneficial in aiding medical diagnoses, physicians avoid using these technologies, fearing that they would be exposed to accusations of malpractice.¹³ This uncertainty could inhibit uptake and hinder further innovation.

AI itself can be part of the solution, creating adaptive, self-improving regulation that closes the gap between the pace of technological change and the pace of regulatory response. In the same way that intelligent solutions combined with massive data can guide decision making in areas such as urban, healthcare and social services planning, they could also be used to update regulations in light of new cost-benefit evaluations.

Advocate a code of ethics for AI

Intelligent systems are rapidly moving into social environments that were once only occupied by humans.

This is opening up ethical and societal issues that can slow down the progress of AI. These range from how to respond to racially biased algorithms to whether autonomous cars should give preference to their driver's life over others in the case of an accident. Given how prevalent intelligent systems will be in the future, policy makers need to ensure the development of a code of ethics for the AI ecosystem.

Ethical debates need to be supplemented by more tangible standards and best practices in the development of intelligent machines. As a segment of AI, the robotics industry is already ahead in setting universal standards for its operations. Business standards regarding robots produced by the British Standards Institution (BSI) are a step in the right direction.

Address the redistribution effects

Many commentators are concerned that AI will eliminate jobs, worsen inequality and erode incomes. This explains the rise in protests around the world and discussions taking place in countries, such as Switzerland, on the introduction of a universal basic income. Policy makers must recognize that these apprehensions are valid.

Their response should be twofold. First, policy makers should highlight how AI can result in tangible benefits. For instance, AI can improve job satisfaction. An Accenture survey highlighted that 84 percent of managers believe machines will make them more effective and their work more interesting.¹⁴

Beyond the workplace, AI promises to alleviate some of the world's greatest problems, such as climate change (through more efficient transportation) and poor access to healthcare (by reducing the strain on overloaded systems). Benefits like these should be clearly articulated to encourage a more positive outlook on AI's potential.

Second, policy makers need to actively address and preempt the downsides of AI. Some groups will be affected disproportionately by these changes. To prevent a backlash, policy makers should identify the groups at high risk of displacement and create strategies that focus on reintegrating them into the economy.

“

In the future AI will be diffused into every aspect of the economy.

”

**NILS J. NILSSON, PROFESSOR OF ENGINEERING
IN COMPUTER SCIENCE, STANFORD UNIVERSITY**

APPENDIX: MODELING THE GVA IMPACT OF AI

AI has the potential to have a broad-based disruptive impact on society, creating a variety of economic benefits. While some of these benefits can be measured, others, such as consumer convenience and time savings, are far more intangible in nature. Our analysis focuses on measuring the GVA impact of AI.

We began with a modified growth model developed by Robin Hanson, professor of economics at George Mason University, Virginia, United States. We looked at the additional increase in growth that would occur as a result of AI by contrasting it with the baseline growth rate.

In our model, we defined labor as a continuum of tasks that can either be performed by a human or artificial intelligence—not work solely done by humans. The intent was to introduce intelligent systems as an additional workforce capable of handling activities that require an advanced level of cognitive agility.

To estimate the shares of workers' tasks that could be performed by intelligent machines (AI absorption rates), we drew on research by Frey and Osborne who take a task-based approach to identifying roles and occupations that are affected by AI.¹⁵ The estimates are aggregated at country- and industry-level, taking into account the different mix of occupations and industries within each country. These figures were adjusted to reflect:

- **Assumption about long-run employment:** We assume that employment will be constant in the long term.
- **Differences between AI's technological potential and actual potential achieved:** We considered the uptake of AI—from zero to the maximum technological potential. We assumed that a 50 percent uptake would be reasonable in the time frame analyzed, that is, AI substitution is assumed to achieve 50 percent of its technological potential.

- **Capacity of countries to absorb AI technologies:** A key driver of the impact of AI on growth is how well each country is positioned to benefit from the emergence of new technologies and how ready it is to integrate them into its economy—measured by what we refer to as a country’s “national absorptive capacity” (NAC). This includes factors such as access to a sophisticated information and communication technology infrastructure, a reliable regulatory framework, and considerable public and private investments in the digital economy. All economies that derive a significant AI dividend rank high on this index. This is a relative measure where countries are compared to the top performer, the United States. (For further details on the importance of national absorptive capacity, see “The Growth Game-Changer: How the Industrial Internet of Things can drive progress and prosperity”¹⁶).

With these calculations and adjustments, we arrived at our final estimates of AI absorption rates used in our macro model. Along with the quantitative model, we supplemented our research by conducting interviews with experts from a range of different disciplines and secondary research to give insight into the capacity of AI to generate economic growth.

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