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Artificial intelligence, a fourth factor of production

As Kevin Warsh suggested at Jackson Hole, artificial intelligence has in a very short space of time become a fourth factor of production, alongside capital, labour and energy.

This raises a number of questions, in particular:

- What share of total production costs will in future go to the remuneration of artificial intelligence (the purchase of tokens for the use of language models)?
- Will artificial intelligence be complementary to or substitutable for the other factors of production?
- What will be the effect of artificial intelligence on total factor productivity and on long-term GDP growth?
- What will be the effect of artificial intelligence on the distribution of income between the producers of artificial intelligence models, their suppliers, the users of artificial intelligence models and employees?

We attempt to answer these questions.

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First question: the share of artificial intelligence in total production costs

Total production cost is the sum of the cost of capital, the cost of labour, the cost of energy and the cost of artificial intelligence consumption. Artificial intelligence consumption is **the total value of the tokens** acquired by users for the use of language models. The unit price of a token (the price of reading or writing, by a language model, a quantity of text of about four characters) has broadly stabilised (see the AI Token Price Index). The volumes used, by contrast, are growing considerably. In his address at Jackson Hole, Kevin Warsh referred to a 500% increase over one year in the value of the tokens used, which now exceeds USD 100 billion a year in the United States.

The equilibrium price of tokens will depend on the organisation of the market for producers of artificial intelligence models; if this market is competitive, the price will be close to the marginal cost of producing artificial intelligence; if this market is oligopolistic, the price will incorporate an oligopoly rent.

Overall, at equilibrium, the share of total production costs going to artificial intelligence is likely to be large.

Second question: is artificial intelligence complementary to or substitutable for the other factors of production?

It is clear that artificial intelligence:

- is **complementary to capital**;
- is **complementary to energy**.

A more difficult question is that of the **relationship between artificial intelligence and labour**.

1. The development of artificial intelligence has driven a sharp increase in investment.

The increase in investment has been observed in hardware, infrastructure, cloud and platforms. Investment in artificial intelligence amounts to USD 1 trillion worldwide, of which USD 580 billion in the United States[1]. Investment in artificial intelligence accounts in 2026 for 1.8% of US GDP and 0.9% of world GDP; it will probably be 2.5% of US GDP and 1.3% of world GDP in 2027, and 2.8% of US GDP and 1.4% of world GDP in 2028.

The scale of this investment in artificial intelligence in the United States and worldwide can be seen in the increase in investment in equipment and intellectual property products in the United States (**Chart 1**) and in the sharp rise in global semiconductor sales (**Chart 2**).

Chart 1
United States: private investment by component
(as % of GDP, chained 2017 USD)

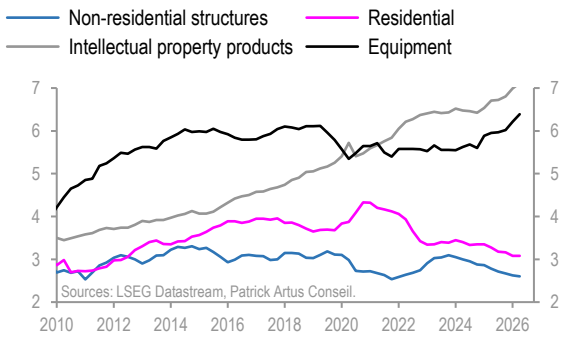
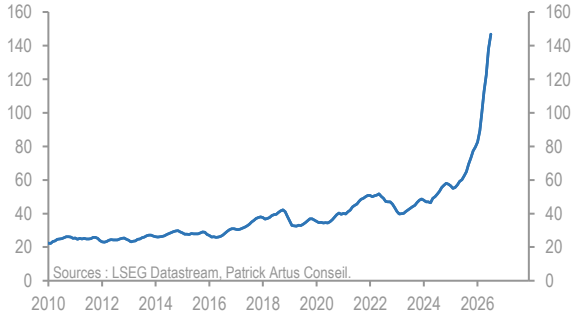


Chart 2
World: Semiconductor manufacturers'sales
(3 month average, USD bn)



This supports the hypothesis of complementarity between artificial intelligence and capital.

[1]Source: "Global AI Investment Is Forecast to Exceed $1 Trillion in 2026", Goldman Sachs Research, 7 August 2026.

2. The development of artificial intelligence is driving an increase in energy consumption.

Data centres consumed 450 terawatt hours (TWh) of electricity in 2024 (source: International Energy Agency) and could consume 1,000 TWh in 2030 and 1,300 TWh in 2035. This is to be compared with global electricity generation (31,000 TWh). Data centre consumption would therefore rise from 1.5% of global electricity generation in 2024 to 3.2% of that generation in 2030. Other estimates put the share of global electricity consumed by data centres in 2030 at 4%. Bloomberg estimates that in the United States, which accounts for 40% of global data centre electricity consumption, data centres will consume 20% of the electricity generated in 2035, compared with 6% already in 2025.

Artificial intelligence and energy clearly appear to be complementary.

3. The relationships between artificial intelligence and employment differ across sectors.

Artificial intelligence is:

- **a substitute for employment** in sectors where it can perform more efficiently tasks previously carried out by workers. In the United States, from June to August 2026, employment declined in information (– 37,000 jobs) and in finance (– 20,000 jobs);
- **a complement to employment** in sectors where it enriches the content of tasks; from June to August 2026 in the United States, employment rose in goods production (+ 80,000 jobs) and in professional services (+ 61,000 jobs);
- finally, **without significant effect on employment** in sectors where human labour is predominant; from June to August 2026, again in the United States, employment rose rapidly in education and health (+ 91,000 jobs).

Overall, we should expect **a rise in negative employment movements in sectors where artificial intelligence and employment are substitutes** and **an increase in positive movements in sectors where they are complements**, rather than an overall destruction of jobs.

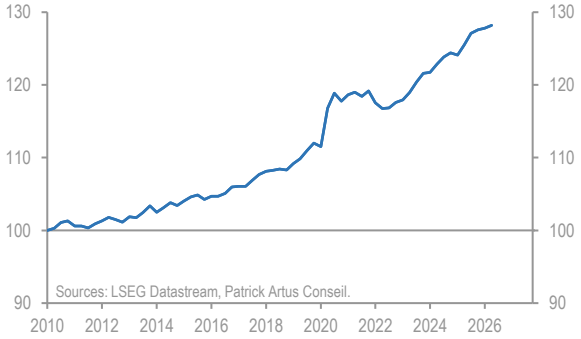
Third question: the effect of artificial intelligence on total factor productivity

Total factor productivity is the part of growth that is not explained by the growth of capital, labour, energy and the artificial intelligence used, since we treat artificial intelligence as a **fourth factor of production.** The use of artificial intelligence drives:

- very rapid growth in capital (see **Chart 1** above);
- very rapid growth in energy consumption (see above);
- very rapid growth in artificial intelligence consumption (see above);
- and it has an ambiguous effect on employment growth.

The conclusion drawn is that **artificial intelligence reduces the growth of total factor productivity**. In fact, **the additional GDP growth is explained by the additional growth of the factors of production: capital, energy, artificial intelligence and labour**. Moreover, if there is additional GDP growth, **the growth of labour productivity increases**. **Chart 3** shows that labour productivity has been accelerating in the United States since 2022.

Chart 3
United States : Productivity per hour worked in the private sector (2010.Q1 = 100)



Fourth question: the effect of artificial intelligence on income distribution

The beneficiaries of the development of artificial intelligence may be:

- the companies that produce artificial intelligence models;
- their suppliers (of semiconductors, memory and cloud services);
- the companies that use artificial intelligence models;
- employees.

What we observe, focusing on the United States, where artificial intelligence has been developing very rapidly for several years, is:

- **very strong profit growth** (**Charts 4A and 4B**);
- **stagnation in employees' purchasing power** (**Chart 5**).

Chart 4A
United States: Profits after tax and interest, before depreciation, of non-financial corporations (as % of GDP)

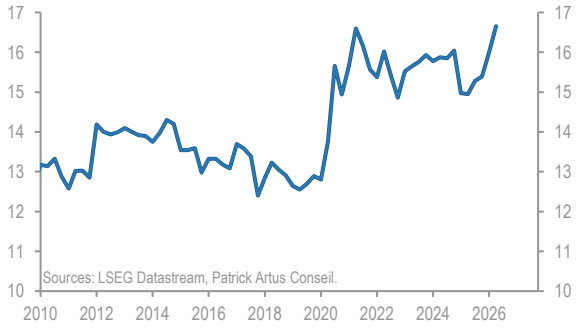
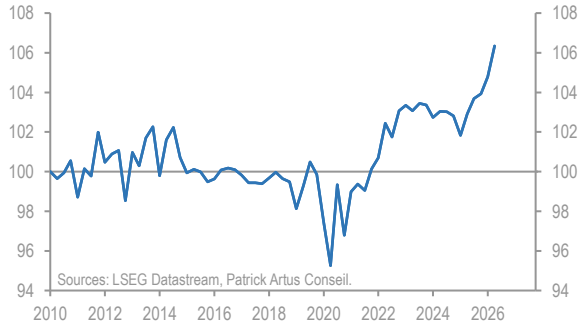
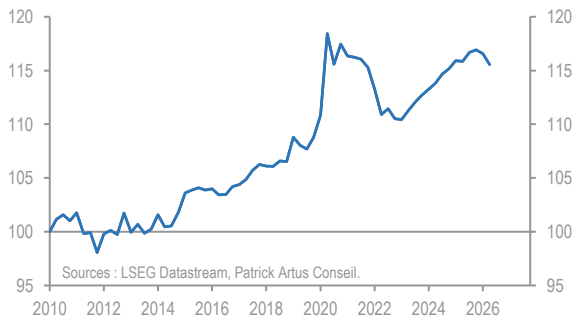


Chart 4B
United States: Business sector profit margin* (2010 Q1 = 100)



* Ratio of the value-added price deflator to unit labour costs, business sector.

Chart 5
United States : Hourly compensation of a private sector employee, deflated by the CPI (2010.Q1 = 100)



Looking at the situation at company level, we observe:

- low profitability, or losses, for the companies that develop artificial intelligence models (Anthropic, OpenAI);
- very high profits for the companies that supply cloud services (Alphabet, Amazon) and for those that sell the hardware needed for artificial intelligence (Nvidia, Micron);
- high profits too for companies in traditional sectors, in healthcare in particular, which suggests that artificial intelligence benefits its users.

Overall, the shift in income distribution in favour of companies is clear. Earnings per share for the S&P 500 index rose by 10.7% in 2024 and by 10.5% in 2025, are projected to rise by 24% in 2026 and, according to the consensus, are expected to increase by 13% in 2027.

Summary: what macroeconomic effects follow from the emergence of artificial intelligence as a fourth factor of production?

Artificial intelligence is becoming a fourth factor of production, alongside capital, labour and energy. The probable macroeconomic effects of the emergence of this fourth factor of production are the following:

- the share of total production costs that will in future remunerate artificial intelligence consumption will be very high;
- artificial intelligence is complementary to capital and to energy; depending on the sector, it is a substitute for or a complement to labour;
- artificial intelligence reduces total factor productivity measured using four factors of production, but raises labour productivity and potential growth;
- artificial intelligence leads to a marked shift in income distribution in favour of companies and to the detriment of employees. This shift in income distribution supports the return on equity despite the increase in capital intensity resulting from investment in artificial intelligence.

The main difficulty is that, given the very large scale of investment in artificial intelligence, companies have to shift income distribution in their favour if they are to maintain their level of profitability (on capital or on equity).

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