What if Europe championed new AI hardware?

Europe could gain competitive edge by supporting the development of new hardware for artificial intelligence (AI). Current state-of-the-art hardware is not optimised for machine learning, and both academic and private sector research is already leading to new designs. At the same time, the need for more time- and energy-efficient machine-learning hardware is increasing as more consumers and companies want access to machine-learning applications. The European Union (EU) has the opportunity to leverage its strong regulatory framework for AI products as a mark of trust and safety, while also investing to support the next generation of hardware, opening up a new market for Europe's high tech industry. What would happen if the EU formulated a cohesive plan to support these technologies through both research and economic policy?

Artificial intelligence and machine learning require large amounts of computing power. Training a new application and using that application to generate responses to user queries are tasks that are already performed by dedicated hardware – GPUs (graphics processing units). These specialised computer chips are fast and efficient at processing and displaying images and videos, but also faster than regular processors at machine-learning tasks.

Though graphics card manufacturers have pivoted towards AI as the primary use of their devices, demand for GPUs has already caused shortages. At the same time, energy usage by GPUs used for machine learning is becoming a concern. Recently, Microsoft announced plans to restart a nuclear power plant just to power AI data centres. Industry leaders have stated that they expect a shift away from GPUs within 5 to 10 years, and major technology companies have already developed custom chips to execute some AI-related functions, citing the limitations of GPUs as reason.

The economic incentives to develop new hardware are strong, and Europe is in a unique position to take competitive advantage of the developing market. With the AI Act in place, there is a regulatory standard in the EU that would lend European AI technologies a mark of safety and privacy that is not currently perceived elsewhere. While the AI hardware sector is currently focused around non-European companies such as NVIDIA and AMD, a new market niche is opening: Europe could promote the development of new, specifically designed non-GPU hardware and gain market share through policy and investment.

Potential impacts and developments

The scientific community has taken note of the potential to improve the performance and energy efficiency of machine learning by developing new purpose-built hardware. Because machine learning usually consists of 'artificial neural networks' – code that mimics the interconnection and firing of synapses in the brain – the emerging field is called neuromorphic computing. Defined in a 2022 issue of *Nature Computational Science* as 'computers whose structure and function are inspired by brains and that are composed of neurons and synapses', research in this area includes both entirely new types of computers and direct replacements for GPUs in the form of chips dedicated to machine-learning functions. However, not all new AI hardware is necessarily called neuromorphic, and there are many routes of active inquiry.

Scientists are also developing photonic chips, which make direct use of light as an input, for their advantages in time-critical applications like autonomous driving, and in computer vision where AI is used to process visual information. Another technology being developed for machine-learning chips is the memristor, a circuit component similar to a resistor. Memristors' electrical properties could reduce the amount of computer memory needed for machine-learning programs and speed up the computations needed to train and run them.

Current research in both photonic and memristive technologies is routinely published in major peer-reviewed academic journals. The performance of existing hardware, such as Google's Tensor Processing

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Units, is likewise being studied. The consensus is that new hardware could surpass existing solutions both in terms of performance and energy efficiency, and more than one technology may succeed in doing so.

From an industrial perspective, memristor-based hardware more closely resembles the process for traditional silicon chips (though sometimes requiring slightly different materials). Photonic chips present an entirely new paradigm, though existing photolithography techniques – where Europe is already a leader – are still relevant. In either case, new industrial facilities may be necessary for full-scale commercialisation.

Multiple new companies, including Ephos, Lightmatter (photonic chips) and Graphcore (dedicated AI processors), have received funding – including from the European Innovation Council (EIC) – to develop hardware informed by new scientific research. Within the next decade, one or multiple technologies will likely become available to the market. GPUs for AI represented a US$48 billion market in 2023 that is projected to grow by roughly 25 % year on year. This creates a strong incentive for new technologies to compete. Combined with a growing awareness of the energy costs of AI, it is highly probable that new, specifically designed hardware will be sought after and implemented as it becomes available.

Anticipatory policymaking

A concerted research effort could position Europe as the leader of a new wave of machine-learning hardware developments. The European Chips Act already has objectives, including energy efficiency and innovation in semiconductor technologies, that align with supporting purpose-built AI hardware. The increased energy efficiency of this hardware would also align with European Green Deal goals.

More efficient hardware would lower the cost of generative AI applications, leading to their even greater proliferation. Generative AI is already causing concern, especially among creative and programming workers, and 'deepfake' media is troubling for both law enforcement and European citizens concerned with the integrity of elections. The risk to democracy exists regardless of whether new AI tools are actually used maliciously, since their mere presence can be enough to create distrust.

The risks of AI have been covered in other EPRS publications, discussing how those risks apply to democracy, the European economy, and healthcare, among other things. The AI Act has already set a strong regulatory standard, so far unique in the world, and the European AI safety initiative has been followed up by the creation of the Centre for Algorithmic Transparency. Building on existing regulation, information on how to use AI tools responsibly should be distributed, with special attention given to elections. The risks of AI should not discourage the promotion and development of new hardware.

European digital leadership could be improved by pairing the safety and transparency created through strong regulation with investment in new machine-learning hardware. If the best AI hardware were European, this would create an incentive to bring new AI applications to the European market. Strong regulation could be reframed as a new European brand – tied to a certification standard – for AI products. An 'EU Safe AI' label, reflecting compliance and quality, could promote European hardware and software.

There are ways to advance this strategy and strengthen the EU's competitive resilience. First, directing funds from Horizon Europe and the next framework programme for research and innovation towards new and existing machine-learning hardware research would help position AI hardware as a fundamental part of Europe's digital and industrial value chains. Second, funds such as the European Fund for Strategic Investments Equity Instrument could help companies with actionable product designs. Finally, an incentive structure could be created to encourage AI software companies to develop applications in the EU that comply with the AI Act using the new European hardware. These actions should cover the whole industrial chain, from raw materials to software, in turn generating both software- and hardware-related jobs.

European AI products would emerge with a reputation for safety, privacy, efficiency, and speed. Broad investment in multiple new machine-learning hardware technologies would increase resilience and minimise risks, and a similar research investment structure could also benefit related fields. Novel hardware could provide Europe with a unique and decisive competitive edge in technological innovation.