

# Introductory Remarks

by Philipp Hartmann (Deputy Director General Research of the European Central Bank) to the European System of Central Banks ChaMP Network and Banco de España conference on “The Impact of Artificial Intelligence on the Macroeconomy and Monetary Policy”<sup>1</sup>

Madrid, 24 October 2024

Ladies and Gentlemen,

It is my pleasure to welcome you, also on behalf of the Bank of Spain, to this short conference on “The impact of artificial intelligence on the macroeconomy and monetary policy”. None of us has missed the “hype” around artificial intelligence (AI) that is flourishing around the globe at least since the release of ChatGPT towards the end of 2022. As just one measure, in only five months the number of Google searches for “artificial intelligence” or “AI” increased threefold after having been stable for almost 20 years. And, while a bit slower, the trend does not seem to be broken yet, having reached a peak of roughly 10 times the pre-ChatGPT level last week.

Moreover, also last week the Nobel Prize in physics was awarded to John Hopfield and Geoffrey Hinton “for foundational discoveries and inventions that enable machine learning with artificial neural networks”. Demis Hassabis and John Jumper – two of three winners of this year’s Nobel Prize in chemistry – have used the AI model AlphaFold2 to successfully predict the structure of proteins. Daron Acemoglu is one of the early authors studying the implications of AI for the macroeconomy and his book with Simon Johnson “Power and Progress – Our 1000-year Struggle over Technology and Prosperity” reviews who benefits from such innovations and how their benefits can be spread widely. None of the two got the 2024 Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel for this work, but it still illustrates how important the economic consequences of such disruptive innovations will be for all of us going forward.

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<sup>1</sup> Any views expressed are only the ones of the speaker and should not necessarily be regarded as views of the European Central Bank, the Banco de España or the European System of Central Banks. Contributions by Vida Maver (ECB) as well as comments by Galo Nuño and Jaime Martínez (both Banco de España), Luca Dedola, Luc Laeven, Ana Lamo, Paloma Lopez-Garcia, Wolfgang Modery, Myriam Moufakkir, Jirka Slacalek and Oreste Tristani (all ECB) are gratefully acknowledged.

In the remainder of my introductory remarks, first, I would like to explain the goals that the organisers – the Bank of Spain, the European Central Bank and the National Bank of Belgium – wish to achieve with today’s conference.<sup>2</sup> Second, I would like to lay out some first conceptual structure how we can think about the monetary policy implications of AI. At the end, I will link this to the programme of our conference and also announce some house-keeping arrangements.

## General impact of AI on central banks and goals of this conference

Already before all type of miraculous stories about generative AI and how it would take over many human tasks hit the media, we became convinced that recent technological advancements in computing power, big data, deep learning, generative AI etc. would herald a new era of digitalisation and automation, deeply affecting and changing not only the European and other economies – and society at large, of course – but also how we as central banks conduct our business.<sup>3</sup>

There are three ways in which this new era of digitalisation will affect central banks. First, internal business processes will change, with some tasks of human beings being fulfilled by “intelligent” computer programmes and our work force adapting accordingly. For example, our employees need to be able to operate those programmes.<sup>4</sup> Second, new methodologies from complex systems research, neural networks and large language models will enrich the analytical tools and models that we use in our economic and financial analyses and forecasts that support the fulfilment of our main tasks and functions.<sup>5</sup> Third, as said before, it is widely expected that important aspects of the economy, including financial systems, will change, with potential implications for the conduct of the policies assigned to us. This could affect all our tasks and functions, be they in the area of monetary policy, banking supervision and financial stability or payment and settlement infrastructures.<sup>6</sup>

Today’s conference is one step in assessing how we should grapple with the changes and challenges of this “AI revolution”. This time we would like to focus on monetary policy as central banks’ core function and, notably, the macroeconomic developments relevant for it. We feel that business processes and analytical methodologies are already the subject of many other conferences, discussions and trainings. Moreover, banking supervisors have moved already earlier in the area of

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<sup>2</sup> The conference is organised by our three institutions under the ChaMP research network, which the European System of Central Banks (ESCB) runs since the fall of last year. ChaMP stands for Challenges for the Transmission of Monetary Policy in a Changing World. Information about it can be found on the ECB website [here](#).

<sup>3</sup> The ECB’s Chief Services Office, Myriam Moufakkir, for example, explained early applications of AI in my institution (Moufakkir, M. (2023), Careful embrace: AI and the ECB, ECB Blog, 28 September).

<sup>4</sup> See e.g., Acemoglu, D., D. Autor, D. Hazell, and P. Restrepo (2022), Artificial intelligence and jobs: evidence from online vacancies, *Journal of Labor Economics*, Vol. 40, Issue S1, pp. 293-340.

<sup>5</sup> See e.g., Freier, M. et al. (forthcoming), The transformative impact of AI for the public and private economy.

<sup>6</sup> The keynote speech by Piero Cipollone (2024), Artificial intelligence: a central bank’s view, delivered at the National Conference of Statistics, Rome, 4 July, broadly covers the three areas together.

their competence<sup>7</sup> and payments and settlements constitute a special field that has always been very much driven by technology. Given the extent of change expected in the economy, we would like to make sure that we have the right strategy to prepare for the future, both in terms of medium-term research orientations and in terms of how to modernise briefings for future policy making. And today is only a research-oriented start of our public discussions in this field. For example, on 1<sup>st</sup> and 2<sup>nd</sup> of April next year the ECB will host a larger and broader conference further deepening such discussions.

We are aware that the step to monetary policy is a daring one. The literature on macroeconomic implications of AI and related “intelligent” automation has started relatively recently. Arguably, it really took off only shortly before the COVID pandemic and references to monetary policy are still quite limited.

## **How does monetary policy come into the picture?**

So, let me try to give some structure to how we can think about the monetary policy effects of AI. I hope that this will somewhat help with the discussions we are going to have today. But I will not report about results or draw conclusions. I will leave this to the presenters in our four sessions.

One can distinguish direct from indirect effects, although the two are not entirely independent. The direct ones concern changes to the transmission of monetary policy, i.e. how policy rate changes or asset transactions transmit through the financial system and the wider economy to inflation, growth, employment etc. The indirect ones concern effects of AI on the macroeconomy, i.e. changes in macroeconomic conditions that may suggest a different monetary policy stance than without the AI effects. In going through these effects next, it should be kept in mind that some of them and the way in which they are captured in economic concepts and models could be qualitatively similar to some of the effects found in research on previous waves of automation and robotification.

### ***Potential indirect effects of AI through the macroeconomy***

Regarding indirect effects on monetary policy, a first key issue is the extent to which AI increases productivity. I am fully aware that current estimates of expected productivity effects vary widely, from very low numbers to larger ones, but let me nevertheless proceed. Higher productivity growth is associated with a higher natural rate of interest. In other words, monetary policy rates consistent with price stability would have to be higher with AI-induced productivity growth than without it. This effect

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<sup>7</sup> See e.g. the ECB Supervision Innovation Conferences [2023](#) and [2024](#), the [2024 Central Banking Digital Innovation Award](#) or the reflections by the Governor of the Bank of Spain (Escrivá, J.L. (2024), ¿Que puede hacer el Banco de España para apoyar los retos de la revolución tecnológica que afrontamos?, speech at the XV. Encuentro Financiero Expansión KPMG, Madrid, 7 October.

could be counteracted, if the “AI revolution” induced increased inequality.<sup>8</sup> If the new technology displaces existing jobs faster than it creates new ones or reinforces a “digital divide”,<sup>9</sup> then income and wealth inequality could rise,<sup>10</sup> which in turn would put downward pressure on the natural rate.<sup>11</sup>

A second key issue is whether AI has similar or different effects on aggregate supply and demand and what this implies for inflation. The larger the productivity gains from AI, the more the production potential of the economy should expand. Moreover, in times of low unemployment and aging like the present ones labour shortages could soften, if the increased automation would replace more workers than creating new jobs, and therefore reduce labour costs for firms.<sup>12</sup> Still on the supply side, the net effect on energy costs will depend on whether the electricity intensity of AI tools would be stronger than better grid management and more efficient energy consumption.<sup>13</sup> Whether all this would be disinflationary and therefore imply looser monetary policy or not will depend on what happens to aggregate demand.<sup>14</sup>

In order to generate these productivity gains, aggregate investment would have to increase, indeed. Consumption, however, constitutes the larger part of aggregate demand and is more complex to assess. The impact of AI on labour markets will be critical, i.e. whether ultimately labour demand and wages rise.<sup>15</sup> Broadly increased productivity should induce upward pressure on wages, but again the question arises as to whether the creation of new tasks and occupations exceeds the destruction of existing ones and how the balance of the two evolves over time. For example, the threat of robot adoption could reduce the bargaining power of a share of the work force, and thereby put a lid on wages.<sup>16</sup> The balance of these three forces – wages, job creation and job destruction – can be

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<sup>8</sup> See e.g., Korinek, A., and J. E. Stiglitz (2018), Artificial intelligence and its implications for income distribution and unemployment, *The Economics of Artificial Intelligence: An Agenda*, University of Chicago Press, pp. 349-390.

<sup>9</sup> See e.g., Bonfiglioli, A., R. Crinò, G. Gancia, and I. Papadakis (2023), Artificial intelligence and jobs: evidence from US commuting zones, CEPR Discussion Paper, No 18495, October, for a study that finds negative aggregate employment effects in the United States. See also Acemoglu, D (2024), The simple macroeconomics of AI, NBER Working Paper Series, No w32487, April, on implications of new advances in AI on labour income inequality.

<sup>10</sup> See e.g., Cazzaniga, M. et al. (2024), Gen-AI: artificial intelligence and the future of work, IMF Staff Discussion Notes, No 2024/001 and Gazzani, A. and F. Natoli (2024), The macroeconomic effects of AI innovation, downloaded from SSRN, August (this conference).

<sup>11</sup> See e.g., Bessen, J. (2019), Automation and jobs: when technology boosts employment, *Economic Policy*, Vol. 34, Issue 100, pp. 589-626, and Bergeaud, A. (2024), The past, present, and future of European productivity, paper presented at the ECB Forum on Central Banking, Sintra, 1-3 July.

<sup>12</sup> Cippolone (2024), op.cit.

<sup>13</sup> See Ammanath, B. (2024), How to manage AI's energy demand – today, tomorrow and in the future, *World Economic Forum*, 25 April.

<sup>14</sup> Bank for International Settlements (2024), Artificial intelligence and the economy: implications for central banks, *BIS Annual Economic Report 2024*, Chapter III, 25 June.

<sup>15</sup> For the analysis on how output and wages behave under different scenarios for AI technological progress see e.g., Korinek, A., and D. Suh (2024), Scenarios for the transition to AGI, NBER Working Paper Series, No w32255, March.

<sup>16</sup> For estimates of the effects of AI on employment in Europe, see e.g. Albanesi, S., A. Dias da Silva, J. F. Jimeno, A. Lamo, and A. Wabitsch (2023), Reports of AI ending human labour may be greatly exaggerated, *Research Bulletin*, No 113, ECB, 28 November, and the related opening paper by the same authors in this conference. On the polarisation of labour markets see e.g., Autor, D., and D. Dorn (2013), The growth of low-skill service jobs and the polarization of the US labor market, *American Economic Review*, Vol. 103, Issue 5, pp. 1553-1597. For a study on how new technologies could threaten labour, see e.g., Acemoglu, D., and P. Restrepo (2018), The race between man and machine: implications of technology for growth, factor shares, and employment, *American Economic Review*, Vol. 108, Issue 6, pp. 1488-1542.

expected to have a major influence on the strength and time profile of the response in aggregated consumption. In fact, assuming that the full benefits for consumers will materialise later than the initial investment and the expansion of supply, another key force is the expectations consumers hold about those benefits. Complete anticipation would bring stronger consumption forward in time, potentially inducing some inflation already in the short term. In contrast, partial anticipation could mean that disinflationary forces dominate in the short term.<sup>17</sup> Finally, skill mismatches and their persistence will have a reductionary effect, on both aggregate supply and aggregate demand.

Our conference today features a number of papers addressing aspects of the macroeconomic effects of AI and therefore influence monetary policy indirectly. But the literature seems to be less developed in terms of direct effects on monetary policy transmission. Let me nevertheless reflect about a few channels through which AI and related automation tendencies could induce changes to monetary transmission.

#### ***Potential direct effects of AI on monetary policy transmission***

Perhaps one of the most obvious candidates is the formation of prices. Companies that are more digitalised and use algorithmic pricing methods may adjust their prices more often in response to shocks than other companies. And through competition this may affect also less digitalised companies and make their prices more flexible and uniform across different locations of customers.<sup>18</sup> Higher price flexibility would induce – everything else equal – a steepening of the Phillips curve and should accelerate and strengthen monetary policy transmission to inflation. At the same time, companies operating through the internet can also use machine learning techniques for differentiating prices across customers, depending on their online search behaviour and purchase history.<sup>19</sup> Moreover, this raises the issue of market power and whether the algorithms of different companies would compete or learn to collude, all the more as concentration tendencies for online platforms seem to be strong. Such discriminatory tendencies could make the link between monetary policy and the prices that customers see less direct.<sup>20</sup>

While it seems likely that the complex labour reallocations induced by AI-driven technological change and the related distributional effects change also monetary transmission through the labour market, it

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<sup>17</sup> Aldasoro, I., S. Doerr, L. Gambacorta, and D. Rees (2024), The impact of artificial intelligence on output and inflation, BIS Working Papers, No 1179, April (this conference).

<sup>18</sup> See e.g., Cavallo, A. (2018), More Amazon effects: online competition and pricing behaviours, NBER Working Paper Series, No w25138, October, Aparicio, D., and K. Misra (2023), Artificial intelligence and pricing, *Artificial Intelligence in Marketing*, pp. 103-124, March, and Aparicio, D., D. Eckles, and M. Kumar (2023), Algorithmic pricing and consumer sensitivity to price variability, IESE Business School Working Paper No 4435831, May.

<sup>19</sup> See e.g., Strasser, G, E Wieland, P Macias, A Blazejowska, K Szafranek, D Wittekopf, J Franke, L Henkel, and C Osbat (2023), E-commerce and price setting: evidence from Europe, Occasional Paper Series, No 320, ECB.

<sup>20</sup> See e.g., Calvano, E., G. Calzolari, V. Denicolo, and S. Pastorello (2020), Artificial intelligence, algorithmic pricing, and collusion, *American Economic Review*, Vol. 110, Issue 10, pp. 3267-3297, and Rigbi, O. (2017), The effects of mandatory disclosure of supermarket prices, CEPR Discussion Paper, No 12381, October.

seems hard to derive general predictions at present. While households with lower incomes and less wealth will have a higher marginal propensity to consume and less access to credit and therefore respond more to monetary policy, the reaction of aggregate consumption to monetary policy shocks will depend on the precise nature of the distributional effects induced by AI. For example, if an increase in these poorer households dominates, then monetary transmission to consumption would strengthen. But if the distributional effects would make the income growth of richer and more skilled households dominate – who already constitute a larger share in total consumption and tend to be little responsive to interest rate changes –, then monetary transmission could weaken.

Second, if the threat of AI-led robot adoption reduces the bargaining power of workers, then the Phillips curve should flatten – as wages become less responsive to unemployment changes – and therefore the impact of monetary policy on inflation soften.<sup>21</sup> Third, AI may further stimulate the so-called gig economy, as it is at the basis of the platforms that allocate tasks to the gig workers. One issue is whether the higher income volatility of gig workers will also lead to a more volatile consumption response to monetary policy impulses. Another issue is whether further growth of the gig economy would weaken the impact of monetary policy on employment and wages, as gig work is task-based and shocks could lead to less hiring and firing of full-time positions and less reactive wages.

Another part of the monetary policy transmission chain that could be particularly affected is through the financial sector. Let me also say a few words about this part, although we do not have papers on this aspect in our conference today. First, the bank lending channel (and the interest rate channel) could accelerate and strengthen to the extent that banks' investment in AI-related technology makes their internal processes for responding to shocks faster and more efficient, improves their ability to assess the riskiness of borrowers and enhances their internet presence and operations.<sup>22</sup> Related increases of leverage by firms and households could contribute to this as well.

At the same time, the “AI revolution” could also give another boost to FinTech firms and bank disintermediation.<sup>23</sup> To the extent that a greater share of monetary policy shocks is transmitted through tech-prone non-banks or even BigTech firms entering credit markets, interest rate pass-through and lending could accelerate and strengthen further.<sup>24</sup> On top of this, however, there could also be an asymmetric effect through the reduction of the relevance of the bank capital channel of monetary policy. Both the lower lending growth of less well capitalised banks in a monetary loosening and the greater cutting of credit of less well capitalised banks in a monetary tightening would be

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<sup>21</sup> Basso, H.S., and O. Rachedi (2024), Robot adoption and inflation dynamics, mimeo., Banco de España, July (this conference).

<sup>22</sup> Leitner, G., J. Singh, A. van der Kraaij, and B. Zsamboki (2024), The rise of artificial intelligence: benefits and risks for financial stability, Financial Stability Review, ECB, May.

<sup>23</sup> Boot, A., P. Hoffmann, L. Laeven, and L. Ratnovski (2021), Fintech: what's old, what's new?, Journal of Financial Stability, Vol. 53, Issue 100836.

<sup>24</sup> Holm-Hadulla, F., F. Mazelis, and S. Rast (2023), Bank and non-bank balance sheet responses to monetary policy shocks, Economics Letters, Vol. 222, Issue 110918.

softened. In this sense, the acceleration and strengthening of monetary transmission through financial intermediaries could be weaker for tightening phases. Last, to the extent that most dynamic non-bank intermediary type – investment funds – would gain a further edge from AI and has a longer portfolio duration than banks’ loan portfolios, (non-conventional) monetary policy measures (such as Quantitative Easing) that operate through longer rather than short rates can be expected to have stronger transmission effects than without the further boost to investment funds.

Before I conclude, some words of caution are in order as well. There are also measurable risks associated with the “AI revolution”, beyond potential adverse distributional effects, whose materialisation can also interfere with macroeconomic developments and monetary transmission. They range from geopolitical ones, to financial stability risks and to privacy considerations. They may feature only tangentially in this conference. But these risks exist and need to be managed carefully.

## **Concluding remarks**

So, let me conclude by turning to the conference programme and some house-keeping arrangements.

Most of our programme will be on the indirect effects via the macroeconomy, in line with how the literature is evolving at present. But we asked presenting authors and discussants not to miss drawing implications for monetary policy, where possible. The first session focuses on European and US labour markets, as the labour market seems to be the linchpin of the macroeconomic implications of AI. It features recent research on the effects on employment, productivity, wages and inequality. Research session 2 goes from the employment reallocation issues to central banks’ core interest in inflation. It considers the role of cross-sector linkages, the role of expectations for investment and consumption as well as changes in wage bargaining power and the slope of the Phillips curve. Research session 3 returns to some of the issues of the first two sessions, suggesting that the aggregate implications of AI very much depend on cross-sector linkages and general equilibrium effects.

Given the focus of the papers on macroeconomic effects, the panel discussion at noon has an important role. We asked the panellists to express their views on implications for the conduct of monetary policy. Undoubtedly, this will not be possible without a good dose of speculation at the present juncture. But some speculation is probably necessary to reach the goals for today that I mentioned at the start.

It is precisely during moments of rapid shifts – like the “AI revolution” – that knowledge gaps emerge. This is the time for cutting-edge research helping to bridge these gaps. In my view, it is one of the strengths of central banks, such as the Banco de España, the ECB and many others, that we made

strong research teams part of our culture and ensure solid scientific foundations for our policies. Conferences like the present one, featuring ground-breaking research, should be of invaluable help for policy makers to navigate a complex future economic landscape. At the same time, we need to stay humble and acknowledge that the “AI revolution” is ongoing, uncertainty is high and it is still early for finding all the necessary answers.

Before we start with the first session, some house-keeping announcements need to be made:

- 1) Let me remind you that media have been invited and may report about what is said during the conference;
- 2) Participants that are not employed by the Bank of Spain should stay in the conference area here and not go to other parts of the Banco de España premises;
- 3) During the breaks coffee will be served in the foyer Lucernario, next to Sala Europa here;
- 4) Lunch will be served at Hall Marqués de Cubas down the stairs or elevators from here; Banco de España staff will be available to guide you there;
- 5) Galo Nuño from the Bank of Spain, who will chair the final session and close the conference this afternoon, will make an announcement then how those of you who have been invited can find their way to dinner.

I now wish you a productive day on “The impact of artificial intelligence on the macroeconomy and monetary policy”.