How can AI affect monetary policy?

Slide: **What drives productivity growth?**

- Put simply, we become more productive when we are able to produce more with the same amount of resources. Many factors can boost productivity.[1]
- At the aggregate level, it is about institutions that provide stability and predictable conditions for investment. At the sector level, it is about resources moving from less productive to more productive firms. At the firm level, it is about technology adoption and organisation. And at the individual level, it is about health, skills and education.[2]
- Productivity improvements are often the result of the interaction between several of these forces.
- Take AI as an example. On its own, this technology cannot substantially boost productivity unless individuals acquire the skills needed to adopt AI tools, unless firms are able to change their processes, unless resources freed up through automation are reallocated to other firms and unless regulation is in place so society can use AI in a safe and trustworthy manner.[3]

Slide: **Two common productivity measures—and a rough proxy**

- At Norges Bank, we focus on two productivity measures in particular. The measure we use the most is labour productivity per hour worked, ie gross value added per hour worked. The other is total factor productivity (TFP). The difference between the two is that TFP controls for changes in capital intensity, which measures how much capital workers have at their disposal.[4]
- Over time, the two measures normally move broadly in line—but not always. For example, the chart shows that much of the rise in labour productivity per hour worked in the 1970s was driven by higher capital intensity, while the productivity boost in the 1990s was more the result of an increase in total factor productivity—and was therefore perhaps more closely linked to technological improvements,

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[1] See Syverson (2011).
[2] See Hall and Jones (1999), Acemoglu et al. (2001), Bartelsman et al. (2013), Hsieh and Klenow (2009), Bloom and Van Reenen (2010) and Hanushek and Woessmann, (2012).
[3] See Brynjolfsson et al. (2021).
[4] See Solow (1957) and OECD (2001).

notably ICT. and was therefore perhaps more closely linked to technological improvements, notably IT.[5]

- We also see that a more summary measure like GDP per capita largely tracks the other two productivity measures over time. Differences between the growth paths of GDP per capita and labour productivity per hour worked reflect variations in the employment rate and in hours worked per employee.
- Today, I will focus on underlying productivity, or trend productivity, beginning with measured labour productivity per hour worked. I will occasionally refer to this as productivity.

Slide: **Productivity growth has slowed both in Norway and abroad**

- Underlying (trend) productivity growth has more than halved in many countries over the past 25 years. The same is true for Norway.
- To some extent, this likely reflects a normalisation after a period of time in the 1990s and early 2000s when large productivity gains were driven by ICT and increased globalisation.[6]
- In addition, there are some features that are specific to developments in Norway.

Slide: **Relatively weak productivity growth in manufacturing in Norway**

- Compared with a number of other countries, productivity growth in Norway has been particularly weak in manufacturing but has held up well in services.
- Petroleum activity was high in the decades leading up to the turn of the millennium, which likely contributed to high activity and productivity growth in the oil services industry and to restructuring in parts of traditional, trade-exposed manufacturing.[7]
- The levelling-off of petroleum activity since the early 2000s may have helped to dampen these positive spillovers.

[5] See Jorgenson et al. (2008).
[6] See Gordon (2016) and Andrews et al. (2016).
[7] See Bjørnland et al. (2019).

Slide: Offset by terms of trade gains

- However, weak productivity growth in manufacturing (in terms of volume) has been more than offset by long periods of very favourable terms of trade, not least linked to oil and gas, which have lifted manufacturing income more than suggested by productivity growth alone.
- One hypothesis is therefore that weak productivity growth in some parts of manufacturing may to some extent also reflect the fact that terms of trade gains have made the need to make productivity improvements less pressing.
- At the same time, the literature tells us that higher profitability can also ease financing of capital renewal, R&D and intangible investment, which can in turn boost productivity.[8]

Slide: Artificial intelligence and productivity

- Given that this talk is about productivity, it is difficult to avoid the topic of artificial intelligence (AI). There is strong evidence to suggest that AI is a so-called general purpose technology. this means that beyond making a broad range of tasks more efficient, it may also influence productivity growth more indirectly by enabling innovation in new technologies.[9]

Slide: **How is AI affecting firms?**

- In Norges Bank's Regional Network survey, the vast majority of firms say that they use AI and usage is widespread across industries.[10]
- Many point to the positive effects on revenue and profitability, but the contributions from AI for many firms are – for the time being - modest.
- More firms report that AI improves profitability than that AI improves turnover. They may be mainly seeing indications of lower costs.
- That corresponds well with the fact that some firms report that AI may dampen their need for labour.

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[8] See Hall and Lerner (2010).
[9] See Calvino et al. (2025).
[10] See Norges Bank (2025).

- Nevertheless, the clearest message from the survey, is that AI increases the need for new skills. and will likely require more investment, particularly in intangible assets.[11]

Slide: Divergent estimates of AI-generated productivity growth

- There is already a body of recent research indicating quite sizeable micro-level gains, including in areas such as text production, customer support and programming.[12]
- But the extent and the speed AI will boost aggregate productivity is uncertain. International estimates vary widely. Some scenarios suggest a modest contribution, others suggest a much larger boost. In the chart, we show some possible productivity paths derived from a selection of international estimates of average annual growth rates over the next five to ten years (see complete list of references).
- A key source of uncertainty is the extent to which AI will accellerate innovation.
- So, to summarise: The predominant view is that AI will lift productivity growth going forward, but by how much and when is uncertain.

Slide: Productivity and monetary policy

- Let me now link this discussion on productivity more directly to monetary policy. How does productivity growth affect monetary policy?

Slide: **A permanent productivity shock**

- Let us look at two simulation exercises based on Norges Bank's main model, NEMO.[13] In the first example, we consider a permanent impulse (shock) to trend productivity that occurs in Q1. More specifically, we assume that trend productivity growth rises temporarily.
- A temporary increase in the growth rate results in a permanent increase in the level of trend productivity, and thus also contributes to potential output in the economy.
- What then happens to the key variables in the model?

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[11] See Brynjolfsson et al. (2021).
[12] See Noy and Zhang (2023) and Peng et al. (2023).
[13] See Kravik et al. (2019).

Slide: **Effects of a permanent productivity shock in NEMO**

- A period of higher underlying productivity growth will help raise consumption, private investment and GDP. At the same time, the trend paths for these same variables also shift upwards.
- Higher productivity growth and prospects for higher capital returns rapidly boost investment. This leads to a period where investment remains above its new long-run path. Consumption also rises, but by less than trend growth.
- Inertia in consumer behaviour contributes to keeping overall output below potential throughout the simulation period.

Slide: … measured as deviation from trend

- Here we show developments in the same three variables but now measured as deviations from their respective trend paths.
- We can now see more clearly that a permanent productivity shock in NEMO pushes the economy towards a negative output gap: capacity increases more than actual output in the near term, and capacity utilisation falls.
- What happens to inflation and the policy rate?

Slide: Monetary policy responds by lowering the policy rate?

- In isolation, higher productivity growth, dampens business cost inflation. Together with lower capacity utilisation, this results in lower inflation in the near term (measured as deviation from the neutral interest rate).
- In the model, weaker price inflation and a negative output gap pull the model towards a lower policy rate (measured as deviation from the neutral rate).
- At the same time, it is important to stress that different model assumptions could produce different results.

Slide: An expected future productivity shock

- So far, we have looked at how economic agents respond when trend productivity rises. But expectations of a future productivity boost may also already be affecting the economy today.[14]
- To illustrate this event, we run a simulation exercise in NEMO where we assume that productivity growth is unchanged in the near term (the first year), but that economic agents in Q1 receive information indicating a productivity boost further out (at the start of Q5).
- We also assume that the productivity boost does actually occur after one year, but what is crucial for the short-run effects is that the agents expect that this will happen.
- This exercise may be relevant in today's situation where it has so far been difficult to detect clear evidence of AI in productivity data. At the same time, many expect AI to be a general purpose technology and substantially boost productivity ahead.

Slide: **Expectations of higher productivity growth affect the economy as early as at the start of the simulation period**

- The model simulations suggest that expectations of higher underlying productivity growth further ahead will boost investment, consumption and GDP already in the near term.
- With potential output assumed to be unchanged during the first year, the output gap becomes positive in the near term.
- And here, it is tempting to speculate whether we are seeing the contours of the impact of such an expectation shock in the United States today, where growth in AI-related investment, and then also consumption, has been strong, while productivity does not appear to have risen as much.

[14] Beaudry and Portier (2006)

Slide: Monetary policy responds with a higher policy rate in the near term

- A positive output gap, and hence higher capacity utilisation, suggest stronger wage growth, and the central bank chooses to raise the policy rate to stabilise economic activity and counter a pick-up in inflation.
- In the model simulation, tighter monetary policy contributes to disinflation even in the near term. But we cannot rule out the possibility that the demand effect is strong enough to boost inflation in the near term.
- The focus here has been on what happens in the quarters before the productivity boost materialises. When the productivity boost occurs after four quarters, the subsequent path will qualitatively be similar to what we saw in the previous simulation exercise.

Slide: Covariation between the neutral rate and productivity growth over time

- Productivity growth not only affects assessments related to capacity utilisation, it also affects the neutral real interest rate, the rate that, in the long term, neither stimulates nor restrains the economy. Both theory and empirical evidence suggest a positive relationship between trend productivity growth and the neutral real rate.[15]
- The chart shows that the decline in underlying productivity growth over the past 20 years has broadly coincided with a fall in the neutral real rate, based on an average of model estimates. This illustration is not intended to suggest causality in either direction. The neutral real rate is influenced by many factors that drive global investment and saving decisions.[16]
- Our estimates of these variables are uncertain. It is difficult to distinguish between temporary fluctuations and more persistent trends, especially in real time! We therefore have to accept that we have to make decisions without subsequently knowing if they were the right ones.[17]

[15] See Laubach and Williams (2003).
[16] See Obstfeld and Zhou (2023).
[17] See Orphanides and van Norden (2002).

Slide: Policy rate projections and the actual policy rate

- Our published policy rate paths provide an illustration of sorts. The chart shows policy rate projections together with actual outcomes.
- Some call this chart a bad hair day. You could also call it a bad hair decade.
- For a given inflation target, the projections at the end of each projection period provide a rough indication of our real-time assessment of the neutral rate.

Slide: "Real-time" estimates and model estimates of the neutral real rate

- Here we show, using a fairly broad brush, annual averages of our real-time assessments of the neutral real interest rate, based on the end points of the policy rate paths.
- We also show again the average estimate of the neutral real rate from a larger set of models.[18] These are by no means real-time estimates. They answer a different question: Given everything we know today, what is our best assessment of the neutral real rate between 2005 and 2025?
- It is therefore not surprising that our real-time assessments, in the clear light of hindsight, sometimes appear too high and sometimes appear too low.
- And so here we are today, in real time, wondering how AI will affect the neutral rate and therefore our assessment of interest rate levels in the slightly longer term. To the extent that AI boosts productivity ahead or economic agents believe strongly enough that this will happen, AI could contribute to an increase in the neutral rate.

Slide: **AI may change how the policy rate affects the economy**

- So far, I have observed AI and monetary policy through a lens of productivity, and I also believe that the effect via productivity will be the most important channel. However, AI may also affect monetary policy in other ways. The literature refers to several channels.
- AI is likely to reinforce the need for intangible investment (software, data and skills). Several studies find that intangible investment responds less to monetary tightening than other forms of investment because it is harder to finance with debt (absence of

[18] See Almlid and Asshoff (2025).

suitable collateral). This would make overall activity less interest-rate sensitive (ie monetary policy less effective; affecting the IS curve and resulting in lower σ).[19]

- At the same time, AI may affect the relationship between activity and inflation(the Phillips curve). AI may make it easier to adjust prices faster, more frequently and more precisely.[20] This could result in prices responding more quickly to cost shocks and shifts in demand than before (higher γ). On the other hand, prices could become stickier if AI leads to market concentration and more monopoly pricing (lower γ).[21]

Slide: … and therefore how monetary policy should respond

- Changes in the transmission mechanism would in turn affect how the policy rate should respond to changes in both inflation and capacity utilisation.
- Our reaction function may need updating. But perhaps AI and new technology can help.

Slide: **Harnessing new technology can improve monetary policy**

- At Norges Bank, we are increasing our use of AI.
- We can test and develop models faster, which means we can likely tailor models to specific questions to a much greater extent.
- We are also working to use AI and machine-learning techniques to clean and analyse large datasets and to develop nowcasting models that give us a better view of current conditions and better short-term forecasts.
- We are also exploring the use of AI to communicate the same monetary policy messages but tailored to different audiences.
- AI will also help us increase the precision of our communication.
- All of this will, of course, be done in a safe and responsible manner.

Slide: **What is normal productivity growth?**

- Let me conclude.

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[19] See Döttling and Ratnovski (2023).
[20] Bank for International Settlements (2024) and Cipollone (2024)
[21] See De Loecker et al. (2020).

- Productivity growth is clearly important for welfare over time, but it also significant for the monetary policy stance.
- The predominant view is that AI will lift productivity growth going forward, and AI may also influence monetary policy in other ways.
- I firmly believe that we can use new technology to improve both our analyses and how we communicate.
- But to avoid sounding overly optimistic, let us lift our gaze and look back 200 years in time. That period was marked by major technological advances without productivity going off the charts. Perhaps AI is simply one more general purpose innovation among many other innovations that are needed to lift productivity growth back towards more normal levels.

References

Acemoglu, D., Johnson, S., & Robinson, J. A. (2001). The Colonial Origins of Comparative Development: An Empirical Investigation. American Economic Review, 91(5), 1369–1401.

Almlid, E., & Asshoff, S. (2025). Estimating the Neutral Real Rate of Interest in Norway. Norges Bank Staff Memo, 8/2025. https://www.norges-bank.no/en/news-events/publications/Staff-Memo/2025/staff-memo-8-2025/

Andrews, D., Criscuolo, C., & Gal, P. N. (2016). The Best versus the Rest: The Global Productivity Slowdown, Divergence across Firms and the Role of Public Policy. OECD Productivity Working Papers, No. 5. OECD Publishing, Paris.

Bank for International Settlements. (2024). III. Artificial intelligence and the economy: implications for central banks. In Annual Economic Report 2024.

Bartelsman, E., Haltiwanger, J., & Scarpetta, S. (2013). Cross-Country Differences in Productivity: The Role of Allocation and Selection. American Economic Review, 103(1), 305–334.

Beaudry, P., & Portier, F. (2006). Stock Prices, News, and Economic Fluctuations. American Economic Review, 96(4), 1293–1307.

Bjørnland, H. C., Thorsrud, L. A., & Torvik, R. (2019). Dutch Disease Dynamics Reconsidered. European Economic Review, 119, 411–433.

Bloom, N., & Van Reenen, J. (2010). Why Do Management Practices Differ across Firms and Countries? Journal of Economic Perspectives, 24(1), 203–224.

Brynjolfsson, E., Rock, D., & Syverson, C. (2021). The Productivity J-Curve: How Intangibles Complement General Purpose Technologies. American Economic Journal: Macroeconomics, 13(1), 333–372.

Calvino, F., Haerle, D., & Liu, S. (2025). Is Generative AI a General Purpose Technology?: Implications for Productivity and Policy. OECD Artificial Intelligence Papers, No. 40. OECD Publishing, Paris.

Cipollone, P. (2024, 4 July). Artificial intelligence: a central bank's view. Keynote speech by Piero Cipollone, Member of the Executive Board of the European Central Bank, at the National Conference of Statistics on official statistics at the time of artificial intelligence, Rome. European Central Bank.

De Loecker, J., Eeckhout, J., & Unger, G. (2020). The Rise of Market Power and the Macroeconomic Implications. The Quarterly Journal of Economics, 135(2), 561–644.

Döttling, R., & Ratnovski, L. (2023). Monetary Policy and Intangible Investment. Journal of Monetary Economics, 134, 53–72.

Gordon, R. J. (2016). The Rise and Fall of American Growth: The U.S. Standard of Living since the Civil War. Princeton University Press.

Hall, R. E., & Jones, C. I. (1999). Why Do Some Countries Produce So Much More Output per Worker than Others? The Quarterly Journal of Economics, 114(1), 83–116.

Hall, B. H., & Lerner, J. (2010). The Financing of R&D and Innovation. In B. H. Hall & N. Rosenberg (Eds.), Handbook of the Economics of Innovation (Vol. 1, pp. 609–639). Elsevier.

Hanushek, E. A., & Woessmann, L. (2012). Do Better Schools Lead to More Growth? Cognitive Skills, Economic Outcomes, and Causation. Journal of Economic Growth, 17(4), 267–321.

Hsieh, C.-T., & Klenow, P. J. (2009). Misallocation and Manufacturing TFP in China and India. The Quarterly Journal of Economics, 124(4), 1403–1448.

Jorgenson, D. W. (2008). A Retrospective Look at the U.S. Productivity Growth Resurgence. Journal of Economic Perspectives, 22(1), 3–24.

Kravik, E. M., Mimir, Y., & Paulsen, K. S. (2019). A Complete Documentation of Norges Bank's Policy Model NEMO. Norges Bank Staff Memo (March 22, 2019).

Laubach, T., & Williams, J. C. (2003). Measuring the Natural Rate of Interest. The Review of Economics and Statistics, 85(4), 1063–1070.

Norges Bank. (2025). Regionalt nettverk 4/2025: Spesialtema – bruk av kunstig intelligens blant bedriftene. Norges Bank.

Noy, S., & Zhang, W. (2023). Experimental Evidence on the Productivity Effects of Generative Artificial Intelligence. SSRN Working Paper.

Obstfeld, M., & Zhou, H. S. (2023). Natural and Neutral Real Interest Rates: Past and Future. NBER Working Paper No. 31949.

OECD. (2001). Measuring Productivity: OECD Manual. OECD Publishing, Paris.

Orphanides, A., & van Norden, S. (2002). The Unreliability of Output-Gap Estimates in Real Time. The Review of Economics and Statistics, 84(4), 569–583.

Peng, S., Kalliamvakou, E., Cihon, P., & Demirer, M. (2023). The Impact of AI on Developer Productivity: Evidence from GitHub Copilot

Solow, R. M. (1957). Technical Change and the Aggregate Production Function. The Review of Economics and Statistics, 39(3), 312–320.

Syverson, C. (2011). What Determines Productivity? Journal of Economic Literature, 49(2), 326–365.

Trajtenberg, M. (2018). AI as the Next GPT: A Political-Economy Perspective. NBER Working Paper No. 24245.