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TECHNOLOGISCHE ONTWIKKELING, KANS OF BEDREIGING

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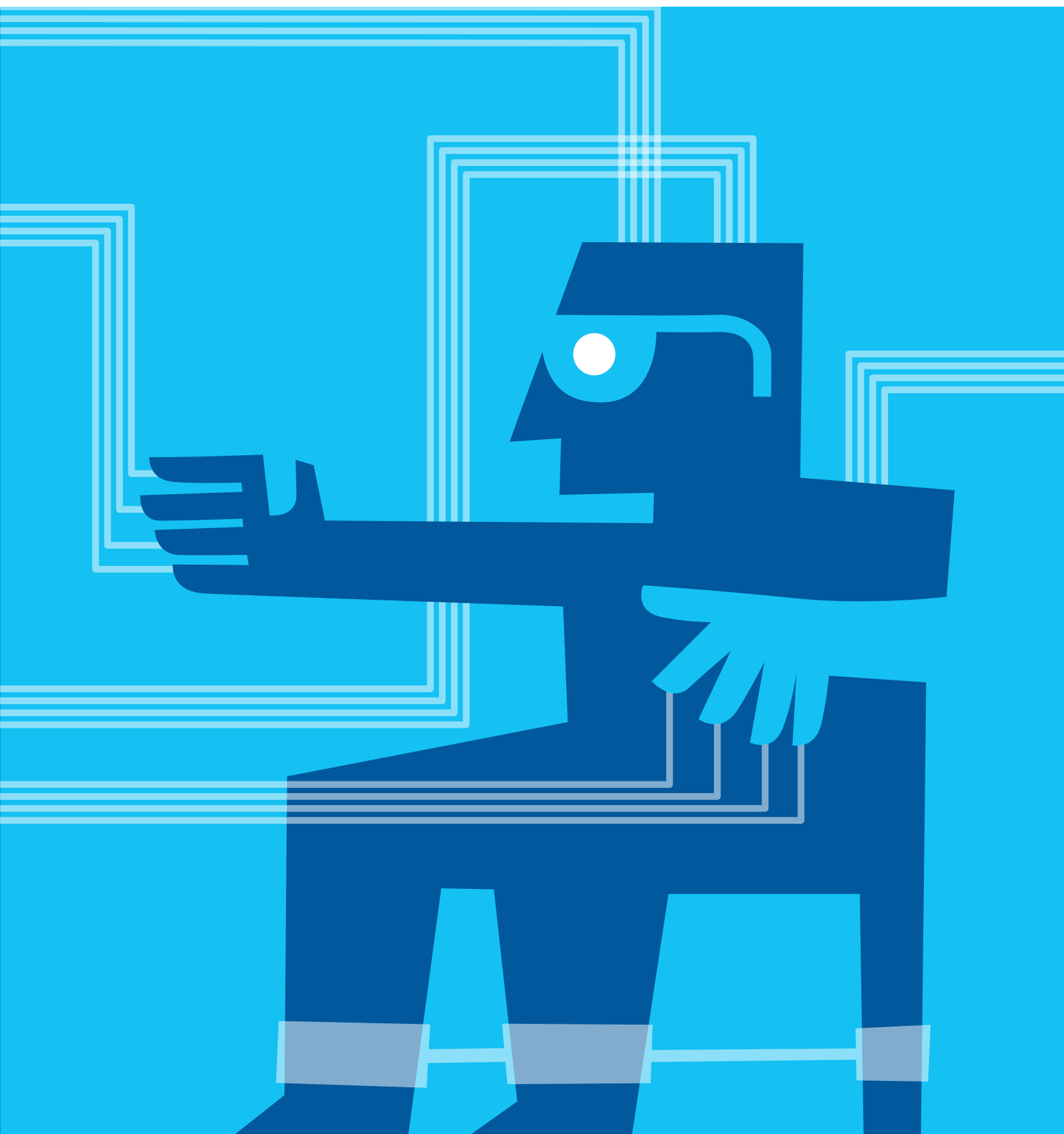

Inhoud

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Private Investeringen – Risico's, Kansen en Ontwikkelingen

Voor de wintereditie van het *VBA Journaal* nodigt de redactie auteurs uit om hun inzichten te delen over het thema "**Private Investeringen – Risico's, Kansen en Ontwikkelingen**."
Private investeringen – zoals private equity, private debt, vastgoed, infrastructuur en natural resources – nemen een prominente plaats in binnen institutionele portefeuilles. Deze niet-beursgenoteerde beleggingen bieden aantrekkelijke kansen op rendement, diversificatie en op gebied van duurzaamheid. Ze brengen echter ook specifieke uitdagingen met zich mee: beperkte liquiditeit, complexe waardering, hogere kosten, lange looptijden, informatieasymmetrie en veranderende regelgeving.
De belangstelling voor private investeringen groeit, niet alleen onder pensioenfondsen en verzekeraars, maar ook onder *family offices* en vermogende particulieren. Tegelijkertijd dwingen ontwikkelingen als de Wet Toekomst Pensioenen, hogere rente, geopolitieke spanningen, de energietransitie en technologische innovaties tot een herbezinning op allocatie, risicomanagement en selectiecriteria. In zowel de VS als het VK vinden discussies plaats om private investeringen onderdeel te laten worden van individuele DC-regelingen. De VBA-redactie is op zoek naar bijdragen die deze ontwikkelingen duiden en praktische handvatten bieden voor beleggingsprofessionals. Zowel academische analyses als praktijkgerichte inzichten zijn welkom. Onderwerpen waar de redactie aan denkt voor de lezers zijn onder meer:

- **Portefeuilleconstructie en balansbeheer:**
  Hoe verhouden private investeringen zich tot publieke? Wat zijn de implicaties voor liquiditeitsbeheer, *capital call planning* en herbalancering naar een strategische allocatie ('stuurbaarheid')?
- **Managerselectie en implementatie:**
  - Welke rol speelt historische performance nog en wat zijn de belangrijkste manager-selectiecriteria in verschillende private investeringen.
  - Welke belangentegenstelling spelen er in private investeringen tussen managers en de verschillende type beleggers? Hoe kunnen deze worden beheerst en/of gemitigeerd.
  - Wat zijn optimale feestructuren (fixed, performance) en waarom? Hoe is dit afdwingbaar?
  - Continuation funds leggen belangentegenstellingen tussen managers en opeenvolgende beleggers bloot. Hoe zijn die te beheersen en welke belangentegenstellingen spelen nog meer?
  - Wat is de balans tussen co-investments, directe investeringen, closed-end en evergreen funds? Hoe is dit anders voor verschillende type beleggers.
- **Specifieke asset classes:**
  - Wat zijn de ontwikkelingen rondom kapitaalwerving, toegang voor particulieren, regulering voor specifieke asset classes binnen private investeringen (Private equity, Private debt, Real Estate, Infrastructuur en Natural resources)
  - Hoe wordt in deze asset classes omgegaan met exogene trends en thema's, zoals: demografie, kunstmatige intelligentie, de rol van bancaire kredietverstrekkers, klimaat, veiligheid en digitalisering.

Geïnteresseerde auteurs worden verzocht uiterlijk **15 augustus 2025** een korte samenvatting van hun bijdrage te sturen naar irma.willemsen@cfasociety.nl.

Technologische ontwikkeling, kans of bedreiging?

Technologische ontwikkelingen hebben de afgelopen jaren geleid tot aanzienlijke verschuivingen. Het is een centraal thema geworden binnen geopolitieke spanningen tussen China en Amerika over halfgeleiders. Bovendien domineren technologiebedrijven de grootste aandelenbeurzen ter wereld, en spelen technologieën zoals kunstmatige intelligentie een steeds belangrijkere rol bij het structureren en beheren van het beleggingsproces. In deze editie onderzoeken we hoe technologische ontwikkelingen de toekomst zullen vormgeven. Zijn ze een kans of een bedreiging of beide?

We staan specifiek stil bij de mogelijkheden die technologieën bieden om de investment managementindustrie efficiënter te maken en meer te richten op het genereren van alpha en beheersen van risico's. Het tijdperk waarin analisten dagen doorbrachten met het doorpluizen van jaarverslagen, researchrapporten etc is voorbij. Maar hoe ziet de toekomst van de industrie eruit en waarmee moet de sector rekening houden?

Zo bespreekt Tjeerd van Capelle (aiLiftoff) quantum computing. Deze opkomende technologie kan meerdere sectoren ingrijpend veranderen doordat complexe problemen exponentieel sneller kunnen worden opgelost. Tjeerd beschrijft ook de schaduwzijde hiervan.

Dit thema komt ook aan bod in de column over tokenisatie. Deze technologie biedt volgens Keshav Bhatt de mogelijkheid om de betrouwbaarheid van de financiële infrastructuur te vergroten en daarmee weerstand te bieden tegen de potentiële negatieve impact van quantum computing.

Machiel Westerdijk, Olivera Rakic en Ashraf Mansur (Entis) betogen dat Large Language Models (LLM's) beleggers in staat stellen om systematisch eerder inzichten te ontdekken die verborgen liggen in tekstuele data. Ze verkennen concrete kansen om AI-tools te benutten in uitvoerbare beleggingsstrategieën.

Reinout van Tuyll van Serooskerken bespreekt in zijn column de impact van technologie op prijsvorming. Hoewel technologische ontwikkeling helpt bij snellere prijsvorming, lopen beleggers het risico slachtoffer te worden van desinformatie.

Voor het interview spraken we met Marcel Prins (COO van Robeco) over de recente ontwikkelingen, uitdagingen en risico's met betrekking tot technologie, data en AI in de financiële industrie en specifiek asset management. Kernpunten voor Marcel zijn onder meer het enorme belang van (eigen) data, data-governance en een adaptieve en 'learning agility' mindset van de organisatie.

Jankees Ruizeveld en Victor Verberk (Osmosis) zijn nog niet overtuigd dat organisaties deze technologieën optimaal zullen benutten, bijvoorbeeld door angst van werknemers om hun baan te verliezen. Hun artikel analyseert hoe investment managers deze barrière kunnen doorbreken. Cruciaal hierbij is dat AI wordt ingezet als ondersteunend instrument, niet als vervanger van menselijke oordeelsvorming in het beleggingsproces.

Dit klinkt als muziek in de oren van de auteurs van Power and Progress, het onderwerp van de boekrecensie. Hun stelling is dat technologie vaak niet wordt ingezet om productiviteit te verhogen, maar om arbeid te vervangen. Goed voor de elite, maar slecht voor de brede welvaartstoename. Volgens de auteurs kan dit anders.

De verschillende technologieën bieden mogelijkheden om de investment managementindustrie efficiënter te maken en nieuwe bronnen van alpha aan te boren. Dit biedt kansen, maar vereist implementatie met oog voor ethiek en controleerbaarheid. Indira van Uyten (AF advisors) bespreekt de governance bij het implementeren van nieuwe technologieën zoals LLM en AI. Zij besteden aandacht aan nieuwe EU-regelgeving en de verantwoordelijkheden van organisaties bij het gebruik van deze technologieën.

Technologische ontwikkeling is buiten de financiële industrie ook een belangrijke drijfveer achter economische welvaart en militaire macht. Hierdoor leidt het tot geopolitieke spanning. Anand Autar en Evelien van Hilten analyseren deze spanningen en bieden handvatten voor het managen van deze risico's.

Anna Dijkman neemt afscheid van het VBA journaal, maar niet voordat ze ons nog één keer meeneemt in haar afdronk van de laatste twee jaar waarin zij columnist was.

In de secties over de vereniging besteden we aandacht aan wetenschappelijk talent, ditmaal Yasmin van Straten. Zij onderzocht en bevestigde de hypothese dat bedrijven met een hogere CO_2-uitstoot op kredietmarkten te maken hebben met hogere financieringskosten. Tevens bevat het interviews met twee investment managers die onlangs de CFA Diversity, Equity & Inclusion (DEI) Code hebben ondertekend: APG en DMFCO. Zij bespreken waarom zij deze code hebben ondertekend en wat dit betekent voor hun DEI-beleid.

De redactie van het VBA Journaal wenst de lezer een fijne zomer en veel leesplezier met deze editie over het technologische veranderingen en de impact op de beleggingswereld.

Mark Geene
Evelien van Hilten
Reinout van Tuyll van Serooskerken
Gerben de Zwart

Two Perspectives on the CFA Institute DEI Code

By Anne-Marie Munnik

An increasing number of investment managers are recognizing the importance of diversity, equity, and inclusion (DEI) for their organizations. Recently, APG and DMFCO signed the CFA Institute DEI Code for Europe, joining earlier signatories PGGM and MN. The initiative is now backed in the Netherlands by over €1 trillion in assets under management. The international, voluntary Code offers concrete guidelines to promote DEI within investment organizations and their practices.

In this two-part interview with APG and DMFCO, both organizations share why they decided to sign the Code, how it aligns with their (existing) policies and organizational context, and what they expect from its implementation. They also reflect on international developments, such as the growing political backlash, and offer advice for peers who are considering signing the Code.

INTERVIEW WITH APG, MAIKEL DULLENS AND NAVDEEP SINGH

What motivated APG to sign the CFA Institute DEI Code?

Maikel Dullens (DEI Officer): "Diversity, Equity & Inclusion is not viewed as a political theme for APG, but as a core organizational value rooted in human-centered perspective. It truly reflects who we want to be as an organization. When people feel safe to be their true selves, they unlock their full potential and bring their best to the organization. DEI is really part of our strategy. Last year we renewed our own DEI-policy to ensure that we lay a foundation for our DEI approach in the organization. I was appointed as a DEI Officer two years ago and we have established an internal DEI board, of which Navdeep and myself are members. This board serves as an advisory body to the Executive Board and Committee. In addition, several employee resource network groups are actively working to raise awareness and create safe spaces for various communities within our workforce."

"Of course we also see societal and political developments regarding DEI, but at APG we truly believe that it's our responsibility as an employer to provide a safe and inclusive workplace for all. It's necessary for the well-being of our employees and equally important for the success of our organization. That doesn't mean we shut ourselves off from other perspectives. On the contrary, we actually welcome different opinions on our approach, but we will stay committed to providing an inclusive environment."

Navdeep Singh (DEI board member on behalf of APG AM NL & Senior Client Reporting Officer): "As an institutional pension fund asset manager we are not just focused on financial returns, but we also feel responsible for contributing to our society. That is also an expectation from our shareholder and pension fund clients. For us, pensions are ultimately about people, about their life and about living together in society. In order to provide the best services to our pension funds and their participants, we need to reflect the diversity amongst those participants in our workforce. But to make societal impact, we need to look further than our own organization, because what value does a great pension have, if we

Maikel Dullens
DEI Officer APG

Navdeep Singh
DEI board member on behalf of APG AM Netherlands & Senior Client Reporting Officer

live in a society where people are left behind just because of who they are?"

"For us, the signing of the DEI Code is a way to strengthen our commitment to the work we are doing. The six principles align perfectly with our internal DEI policy and give us guidance on important steps to take. When we were first approached last year to sign the Code, we decided to postpone that decision. It was important for us to make sure that we first had our own foundation embedded within the organization. In addition, we always critically assess what we commit to and we wanted to make sure that the Code adds value to the work we are already doing so as a next step, we consulted with other parties such as DUFAS and other signatories to get a better understanding on the impact of the Code. This provided us valuable insights in addition to our own analyses of the Code and eventually led to the decision to sign the Code ourselves."

What kind of impact do you expect from signing the DEI Code?

Maikel Dullens: "The principles of the DEI Code are already directly and indirectly reflected in our own DEI policy. We expect that the Code can support us in identifying concrete areas of improvement and it can help us setting priorities. Since CFA Institute is an organization valued by many colleagues, we also feel that this Code can contribute to strengthening the support base for our DEI approach within our company. In addition, as one of the world's biggest pension fund investors, we hope that our signature will inspire others to join us on this mission."

Navdeep Singh: "Indeed, our signature is also an invitation to others. How great would it be if we can build a community of signatories in the investment industry who are all committed to make sure that people feel welcome and safe in our business field. DEI is a complex topic with no final solution, it is a continuous learning journey and through this community we can join forces to inspire and learn from each other."

What would you say to other organizations considering signing the Code?

Maikel Dullens: "I can imagine that, especially when DEI is not on top of mind within your organization yet, that the Code feels extensive and as a big step. It is important to remember that as an organization, you are still in control. The Code serves as a compass, helping you craft a powerful narrative around your DEI approach. Based on the principles, it is up to you to set priorities that fit your organization in its current situation. Keep in mind that this work is related to changing the culture within the organization and that it takes time to see results, especially for larger companies."

Navdeep Singh: "As an investment industry we should not be reluctant to stand for the values we believe in. As Maikel said, it takes time to make progress and often comes in small steps. We should not close our eyes for political developments, but they also should not prevent us from reaching our goals and making progress. By joining forces and signing the Code as an investment industry we can show and make visible what actually our core values are."

Principles CFA DEI Code

AGENDA

30 september 2025
Annual Dinner
PL 1.5 CREDITS

15 oktober 2025
Vastgoed Research Seminar
PL 2 CREDITS

6 november 2025
ALM congres
PL 6 CREDITS

20 november 2025
Dutch Round Table on Investment Performance Measurement
PL 1 CREDIT

INTERVIEW WITH DMFCO, ROGIER VAN DER HIJDEN

What motivated DMFCO to sign the CFA Institute DEI Code?

Rogier van der Hijden: "At DMFCO, we've always seen DEI as more than just a policy – it's one of our five core values: being "pleasant to work with and for." We believe that fostering an inclusive environment where diverse perspectives are genuinely valued enhances decision-making and drives innovation within the mortgage industry."

"What motivated us to sign the CFA Institute DEI Code was the realisation that, even though DEI feels natural to us, we all have blind spots. Having clear frameworks and accountability mechanisms in place helps make sure we don't unintentionally overlook important aspects of inclusion. CFA Institute is a recognised leader in this field, and their Code offers practical guidelines that really complement what we're already doing."

"Some of the initiatives we already had in place include recruitment processes that actively encourage applications from diverse candidates, annual gender diversity and gender pay gap analyses, and efforts to maintain a balanced workforce. Signing the Code felt like a natural next step – to formalise our commitment and connect with a wider network of like-minded organisations."

"If anything, the political backlash against DEI in some parts of the world only made us more determined to express our commitment clearly. In the Netherlands and across Europe, we operate in a context where diversity and inclusion are deeply embedded in both legislation and broader social values. As an organisation managing €33 billion for institutional investors – including Dutch pension funds – we feel a real responsibility to reflect the diverse society we serve. And because we're a relatively small team of around 70 people, we're able to move quickly and create a culture where everyone genuinely feels they belong."

Rogier van der Hijden
CEO DMFCO Asset Management

What kind of impact do you expect from signing the DEI Code?

Rogier van der Hijden: "Signing the DEI Code helps reinforce our commitment, both within the organisation and externally. Internally, it gives structure to our ongoing efforts and ensures that DEI stays a priority as we continue to grow. Its focus on measurement and reporting fits in well with what we already do – like including DEI metrics in our annual ESG report."

"It also reaffirms something we strongly believe in: diverse teams make better decisions. For us, in mortgage lending, that means better understanding the needs of our customers and developing more inclusive financial products. With our MUNT Hypotheken brand, transparency and fairness are already key values – and strong DEI practices help support that even further."

"Externally, signing the Code sends a signal to our institutional investors – pension funds, insurers, and banks – that we're serious about responsible business practices. Many of our clients have their own ESG ambitions, and our DEI commitment helps support those broader sustainability goals. Regulators like the AFM and DNB also increasingly expect financial institutions to meet high governance standards."

"As we grow our presence in Europe and compete for top talent, being recognised as an organisation that genuinely values diversity gives us a competitive edge. When potential employees or business partners see that we've formalised our commitment by signing the CFA Institute Code, it sends a clear and credible message about who we are and what we stand for."

What would you say to other organizations considering signing the Code?

Rogier van der Hijden: "I'd say: don't think of signing the Code as the end goal – it's a helpful framework for an ongoing journey. You don't need everything to be perfect beforehand. The Code is there to help you identify where you can improve and how to go about it."

"In our experience, authenticity is key. The Code works best when it reflects your organisation's real values, not when it's treated like a box-ticking exercise. At DMFCO, DEI was already part of our identity, so signing the Code felt like a natural step, not an obligation."

"Start measuring. For us, our annual gender diversity analysis gave us a good starting point. But the Code encouraged us to take a broader, more structured approach to other aspects of diversity and inclusion as well. And while reporting might seem daunting at first, it really helps create accountability and track progress over time."

"Also, think about what your stakeholders expect. Many of our institutional investors want to see solid ESG practices, and that includes DEI. The Code gives us a credible way to show we're serious about it."

"And finally, remember – you're not doing this alone. CFA Institute developed the Code through a collaborative process with the investment industry. By signing, you're joining a wider community of organisations committed to positive change. The fact that, in the Netherlands alone, the signatories already represent more than €1 trillion in assets really shows this isn't just about individual firms – it's about moving the entire industry forward."

"Ultimately, DEI shouldn't be seen as something separate or optional – it's a core part of doing good business."

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Robert Jan van Doorn

1931– 2025

Robert Jan van Doorn (staand 10e van links) was een van de oprichters van de VBA, vereniging van beleggingsanalisten, in 1961.

We herinneren ons Robert-Jan als een beminnelijk en gewaardeerd lid van onze vereniging.
Het latere erelidmaatschap van de VBA was ten volle verdiend.
Hij was een scherpzinnig denker en goed op de hoogte van alle bijzonderheden van het moderne financieel beheer.
Tot op late leeftijd was hij actief als adviseur van vermogensbeheerders, steeds goed geïnformeerd over de wereldwijde markten door de media te volgen en Amerikaanse vakliteratuur bij te houden.

The Impact of Quantum Computing on Investment Management[1]

Tjeerd van Cappelle

Quantum computing makes more and more headlines as an emerging disruptive technology. This is not without reason. Various applications of quantum computers have been identified that cannot be achieved by classical computers. For example, quantum computers of sufficient size will be able to efficiently:

- break cryptography (encoding or hiding information) that we use in our daily lives, think of bank transactions, website identification, network access, encrypted communication, and so on
- discover catalysts and chemical processes to produce fertilizers using much less energy than is required today. Such innovation could reduce global energy use by 1 to 2 percent.
- run much more complex simulations than possible with classical computers
- solve portfolio optimization problems, with restrictions on the maximum number of different stocks in a portfolio or restrictions on the minimum trade size
- train complex machine learning models
- price complex financial products

This article discusses what quantum computing is and what its impact could be on investment management. The first two sections discuss the history and the appeal of quantum computing. The third and fourth section delve into how quantum computers work and where we stand today. Finally, the author discusses potential applications of quantum computing in the investment management industry.

HISTORY OF QUANTUM COMPUTING

Quantum computing builds on concepts from quantum mechanics. Quantum mechanics is a field in physics that describes interactions on (sub)atomic scale. Although quantum mechanics was around for decades, it was only in 1981 that the idea of quantum computing was introduced by Richard Feynman during a speech at the Massachusetts Institute of Technology (MIT) (Feynman, 1982). Feynman proposed to use quantum mechanics to simulate the evolution of a quantum nature system. By doing so, the idea is to discover new chemical processes. Feynman's speech is generally considered the starting point of quantum computing.

More than a decade later it was Peter Shor who introduced Shor's algorithm (Shor, 1994) that can be used to break all modern-day cryptography. Even though there were no quantum computers yet, the idea that all modern-day cryptography could be broken propelled the interest in quantum computing. Modern-day cryptography is based on the premise that it is very hard to factor integers of sufficiently large sizes. On classical computers to factor an integer one would try every prime number that is smaller than the square root of the number to factor. To factor 8633, one would start with prime number 2, 3, 5, 7 and so on until one divides 8633 by 89 to find that 89 and 97 are the prime factors. Shor's algorithm is a combination of steps run on a quantum computer and steps run on a classical computer to find the prime factors more efficiently.

In the 2000s the first quantum computers emerged and in 2001 Shor's algorithm was put into practice to factor 15 in 3 and 5 on a quantum computer. Even though factoring 15 might not seem that impressive, it was a milestone that proved quantum computers were indeed capable of running algorithms that have exponential advantage over algorithms that run on classical computers.

From 2000 onwards, there were many technological advancements. Big companies, like Google, IBM and Microsoft invested heavily in quantum computing. In contrast to established companies, new companies emerged like D-Wave Systems, IonQ and QuTech.

The realization that quantum computers will break all modern cryptography, inspired initiatives to come up with so-called post-quantum cryptography. Post-quantum cryptography is

Tjeerd van Cappelle
Founder & Managing Director at aiLiftoff

cryptography that is secure against attacks by quantum computers. In 2016, the National Institute of Standards and Technology (NIST), started to update their standards to include post-quantum cryptography.

Since 2019, there have been further technological advances. New quantum chips have been developed, and it is claimed that quantum supremacy has been reached (Arute, Arya, Babbush, et al., 2019). Quantum supremacy means that a problem can be solved on a quantum computer, that cannot be solved by the fastest classical computer within a feasible timeframe. To name two of the latest quantum computing chips: in December 2024 Google Quantum AI introduced Willow, a 105-qubit quantum computer which is claimed to beat all previous existing quantum chips on a variety of benchmark problems. In February 2025 Microsoft announced Majorana 1, which uses competing technology and is claimed to be much more stable than other types of quantum computers.

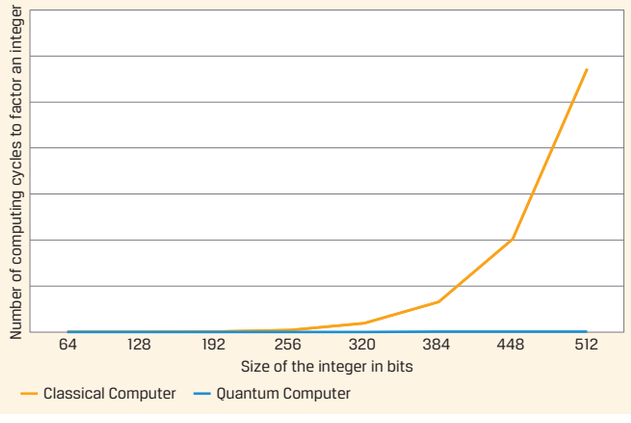
THE APPEAL OF QUANTUM COMPUTING

Classical computers can compute everything a quantum computer can compute. As quantum computers are probabilistic, they even need to repeat their calculations many times to arrive at an outcome. So, what is the appeal of quantum computers?

Quantum computers can solve certain problems much more efficiently than classical computers. Typically, the type of problems that can be solved more efficiently on quantum computers, are problems where a solution is found by trying a lot of different inputs. As mentioned earlier, factoring an integer in prime numbers is such a problem.

Figure 1 shows the average amount of computing cycles that is required to find prime factors of integers as a function of the size of the integer. Looking at figure 1, it is obvious that quantum computers have an advantage over classical computers when the integers are larger. This advantage is called the quantum-advantage. For the problem of finding prime factors, the quantum advantage is exponential. This means that quantum computers can solve the problem exponentially faster than a classical computer.

Figure 1
Number of computing cycles to factor an integer as a function of the size of the integer in bits



Finding prime factors might not sound interesting. However, all modern cryptography relies on the fact that it is extremely hard for classical computers to find prime factors of large integers. A quantum computer of sufficient size could quickly get access to all our VPN's, bank accounts, encrypted communication, and a lengthy list of other things we would like to keep secure.

The quantum advantage is not exponential for all problems, sometimes it is polynomial or superpolynomial. There are also problems for which there is no quantum advantage at all. Table 1 illustrates the amount of quantum speed-up in case of exponential, superpolynomial, polynomial and no advantage.

Table 1
Illustration of the amount of speed-up for different levels of quantum advantage[2]

Quantum advantage	Computing time on		Quantum speed-up factor
	Classical Computer	Quantum Computer	
Exponential	250 years	2 minutes	66.313.952
Superpolynomial	250 years	8 hours	280.437
Polynomial	250 years	103 days	888
None	250 years	250,000 years	0,001

As can be seen the amount of speed-up is most impressive when an exponential advantage exists. It also shows that quantum computers are in fact slower than classical computers when no quantum advantage exists. For this reason, it's crucial to only run those (parts of) algorithms with quantum advantage on quantum computers.

Besides breaking cryptographic ciphers, quantum computers would also have an exponential advantage in complex portfolio optimization problems, large simulations of markets or the economy as well as in pricing complex financial products.

With currently available quantum algorithms, there would be polynomial advantage in machine learning and most portfolio optimization problems.

In short, the possibilities of quantum computing make it appealing for many different sectors, including investment management.

QUANTUM COMPUTING EXPLAINED

We have seen that quantum computers have an advantage over classical computers in many different settings. But how does it work? In classical computers there are bits that can either have values of 0 or 1. Instead of bits, quantum computers use so-called qubits. What makes qubits special is that they can be in a superposition state and that they can be entangled.

When a qubit is in a superposition state, it means that it is not certain whether the qubit is a 1 or a 0. Only when the qubit is measured, it will no longer be ambiguous. The measurement will be either 0 or 1.

Picture 1
On the left: reflections on mud flats seen through a horizontal polarizer, on the right though a vertical polarizer

To explain the superposition state, consider a photon. Photons are the particles of which light is made up of. They can be filtered using polarization. For simplicity, let's consider that photons can only be polarized horizontally, vertically, and diagonally.

For instance, light that passes a vertical polarizer will only consist of vertical polarized photons. A vertical polarized photon will pass through a vertical polarization filter all the time. A horizontal polarized photon will not pass through a vertical polarization filter. A diagonal polarized photon will pass through a vertical polarization filter with a 50% chance. A diagonal polarized photon will be vertical polarized if it passes through the filter.

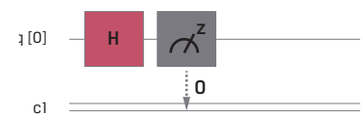
Polarized sunglasses use this property to filter light reflections (glare). Light that reflects on water mostly has a horizontal polarization. Polarized sunglasses have a vertical polarization through which horizontal polarized photons cannot pass. Picture 1 shows the effect of horizontal and vertical polarizers on reflections of sunlight.

So, if the photon is the qubit, we could consider the vertical polarization filter as the measurement of the qubit. If the photon passes, the qubit has a value of 1, if it doesn't pass it has a value of 0. A diagonal polarized photon is a qubit in superposition state, it has a 50% chance of being measured as a 1, and a 50% chance of being measured as 0.

Nowadays, you can use experimental quantum computers for free.[3] Therefore, the author shows examples of output generated with a real quantum computer.

Figure 2 shows a qubit level program which brings the qubit in superposition state and measures it. The q[0] in the diagram represents 1 qubit. C1 is a classical register of 1 bit, where the measurement of the qubit is stored. The block with the H represents a so-called Hadamard gate. The qubit is initialized at value 0. And the Hadamard gate operation brings the qubit in a superposition state. Finally, the grey block with the "z" represents the measurement operation on the qubit.

Figure 2
A one-qubit program to demonstrate the superposition state



One measurement won't tell us that a qubit is in superposition state. The measurement is either 1 or 0, each with a 50% chance. So, to obtain a result from a quantum computer, the computation needs to be repeated. In this case the computation was repeated 1000 times and the results are summarized in table 2.

Table 2
Output of superposition example code on a quantum computer

Measurement of qubit	Count	Percentage of total
1	513	51%
0	487	49%

The outcome is indeed approximately 50% of the time a 0 and 50% of the time a 1.

The superposition state is what gives quantum computers their advantage. Rather than work with one set of inputs at a time, with qubits in superposition state, all combinations of inputs can be evaluated at the same time.

Besides superposition, another important feature of qubits is that they can be entangled. Entanglement is a phenomenon where the state of one qubit is the same or the exact opposite of another qubit. Consider two diagonally polarized photons A and B. Suppose photons A and B are positively entangled. If photon A is measured with a vertical polarizer and the photon passes through the polarizer, then photon B will pass through a vertical polarizer as well, no matter where photon B and the polarizer are. Albert Einstein referred to this phenomenon as 'spooky action at a distance'.

Figure 3 shows a program that creates two entangled qubits in a quantum computer.

Figure 3
A program that entangles the qubits q[0] and q[1]

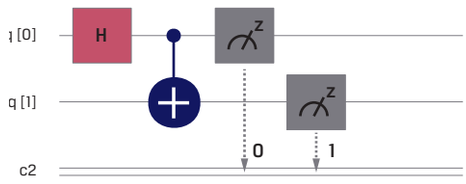


Figure 3 shows that qubit q[0] is brought into superposition state as before by applying a Hadamard gate. Qubit q[1] is initialized in state 0. The blue symbol connecting q[0] and q[1] is a so-called CNOT gate. Conditionally on the value of q[0], the value of q[1] is flipped. If q[1] is 1, q[0] will be flipped, in this case from 0 to 1. If q[1] is 0, q[0] will not be flipped and remain 0. So, after this operation, q[0] and q[1] are either both 1, or they are both 0. In other words, the qubits are entangled.

Like before, the program is run 1000 times on a Quantum Computer and the results are summarized in table 3.

Table 3
Output of entanglement example code in IBM's Quantum Environment

Measurement of qubits	Count	Percentage of total
00	473	47%
01	16	2%
10	11	1%
11	500	50%

Indeed, the outcome is 00 or 11 approximately half of the time. However, there is also a small minority of cases where the qubits have a value of 01 and 10, so where the qubits are not entangled. This happens because qubits are very fragile and can easily be disturbed by outside influences. One of the main engineering efforts to get quantum computers to work in a meaningful way, is to prevent and correct errors.

In conclusion, superposition enables quantum computers to evaluate many different combinations of inputs at the same time. Entanglement enables us to create algorithms that give the solution to a problem with a high probability.

Because of the probabilistic nature of quantum computers, the algorithm needs to be repeated many times. And through the high probability of the correct answer, the correct answer will be the most frequent outcome.

On one hand, quantum computers gain an advantage as many combinations of inputs can be evaluated at the same time. On the other hand, due to the probabilistic nature of quantum computers calculations need to be repeated. For problems where there is an algorithm with quantum advantage and that are of sufficient size, the number of different combinations that need to be evaluated on a classical computer (usually in the order of billions of billions) exceeds the number of repetitions on a quantum computer (usually in the order of thousands) by far.

CURRENT STATE OF AFFAIRS

Unfortunately, current quantum technology only works in well controlled environments. One could compare it to classical computing technology as it was in the 1940s and 1950s. Quantum Computers and their controllers occupy large rooms in laboratories.

In the previous section, photons were introduced as qubits. However, photons are not practical to use as qubits in quantum computers. Instead, most quantum computers use superconducting circuits that either have a charge or don't have a charge as qubits. The superconductors on which the qubits are created are cooled to temperatures that are cooler than outer space.

Additionally, the development of programming languages for quantum computers has only just begun. Most algorithms on quantum computers are programmed in diagrams as shown in figures 1 and 2, akin to the punched cards with which classical computers were programmed in their early days.

Like nuclear fusion reactors, quantum computers moved beyond a theoretical concept and have proven to work in practice. However, to bring them to a state where they can solve meaningful problems still requires a huge engineering effort. As mentioned, qubit reliability is a problem, which needs to be addressed by error correction algorithms. How errors will be prevented is a research effort. On one hand, qubits will need to become more reliable, lowering the physical error rate. It could be that a new type of qubit is discovered that is less prone to outside influences, or it could be that an existing type of qubit is better shielded from outside influences. On the other hand, a lot of effort is put in designing quantum error correction algorithms that can correct for the impact of outside influences. It is shown the with error correction algorithms that operate on qubits with a sufficiently low physical error rate fault-tolerant quantum computes can be created (Aharanov and ben-Or, 1997). A promising sign that fault-tolerant quantum computing is around the corner has recently been demonstrated by the Google team (Acharya, et al., 2024), where they achieved fault-tolerant quantum computing on their Willow processor for a limited amount of time.

Another task ahead is to scale quantum computers to have many more qubits. As there are more qubits, communication between qubits is over a longer distance, which has proven to be a challenge. It might very well be that the technology with which current quantum computers are built is insufficiently scalable and that other technologies need to be developed.

Finally, the way to interact with quantum computers needs further development. The algorithms for quantum computers are fundamentally different then for classical computers. Also, the amount of data that a simulation on a quantum computer can generate, is so vast, some kind of summarization needs to happen on quantum computers before outcomes are transferred to classical computers.

To summarize, quantum computing has certainly moved from a theoretical concept to a reality. Even though technological advances can sometimes go amazingly fast, practical applications of quantum computing are still years if not decades away.

APPLICATIONS IN INVESTMENT MANAGEMENT

Despite its immaturity, it makes sense to start considering whether and how quantum computers can help investment managers.

To evaluate whether a problem should be solved using quantum computers, there are three criteria:

1. Does an algorithm with quantum advantage exist to solve the problem?
2. Does the quantum algorithm bring a solution in a usable time frame? For instance, a solution time reduction from a million to twenty years is very impressive but might be insufficient for many applications.
3. Is the quantum solution better in a meaningful way than approximations of the solutions that run on classical computers? For instance, for many problems that are hard to solve exactly, there are exceptionally good approximations available on classical computers.

In case of breaking cryptographic ciphers, the answer to criteria 1 and 3 is simple. The algorithm is already there, and we know there exists no alternatives on classical computers. It is a matter of time before quantum computers of sufficient size exist that can be used to break ciphers in a meaningful time.

For Investment Management the first applications that come to mind are simulation and scenario analysis. For simulation and scenario analysis there is exponential quantum advantage. As examples, one can think of a simulation model that aims to describe or forecast the price setting process of a stock market. Or a macro-economic model that forecasts the impact of decisions made by various policy makers on the economy.

All these applications have in common that there are many different input variables with lots of different combinations that need to be evaluated to get to an outcome. On classical computers the solution is often to make simplifying assumptions in simulation models. For scenario analyses, the number of input variables to the analysis is often restricted and overly simplified. How often do we encounter analyses with only three scenarios?

With quantum computing, fewer assumptions and restrictions are necessary. Suppose we would want to model macro-economic scenario's where the input is whether forty independent events will happen or not. And the outcome that we are interested in (for instance the yield on 30-year government bonds), is a complex function of the inputs. On a classical computer we would need to evaluate 2^{40} = 1,099,511,627,776 different scenarios to arrive at an expected outcome. On a quantum computer, only one evaluation is required. The forty independent events could be represented by 40 qubits in superposition state. Still, the outcome would be probabilistic, so the computation should be repeated[4] many (for instance 1000) times. But the number of repetitions is unrelated to the number of inputs. Obviously, the amount of repetition on the quantum computer is negligible compared to the number of evaluations that is required by a classical computer. So, in case of simulation, there is the potential of exponential quantum advantage. Therefore, it is safe to say that quantum computing will lift limitations on simulations and scenario analyses.

Another area where there is potential for quantum advantage is portfolio optimization. Depending on the exact portfolio restrictions there is either exponential or polynomial quantum advantage. However, most portfolio optimization problems are insufficiently large to really gain from quantum computing. Next to that, the quantum advantage is compared to an exact solution, while most optimizers used in practice already gain speed by providing a very good approximation of the exact solution.

When optimization is part of a simulation, this could be different. For instance, in Agent Based Models of markets, one can think of interacting agents that each do a portfolio optimization before sending orders to the market (see for example research by Van Cappelle, Pokidin and Zwinkels, 2023). In such a setting by combining the portfolio optimizations done by all agents, one could get sufficient size to benefit from quantum advantage.

When training AI models, there might also be quantum advantage. With current quantum algorithms for machine learning there are a lot of caveats, and the quantum advantage is only polynomial. Like, with portfolio optimization, it is questionable whether current AI models used in finance are sufficiently large to gain from quantum advantage. Still, the situation could change if more complex AI models emerge that are trained on a lot more data than what is used today.

Like with simulation, there is exponential quantum advantage in the pricing of complex financial products (like options, swaptions or certain insurance products). On one hand, traders in these products could adopt quantum computing to gain an edge over their counterparties. On the other hand, Quantum Computing could lead to the development of even more complex financial products, that can't be priced with today's technology.

CONCLUSION

In this article the working of quantum computers has been discussed. While it is difficult to predict the evolution of quantum computers, a first milestone to look at is the development of quantum computers that are fault tolerant for a prolonged period. Once that milestone is passed, the "Chat GPT" moment for quantum computing will probably involve a breakthrough in cryptography.

Potential use of quantum computing by investment managers has been analysed. Practical applications of quantum computing in investment management may still be years or even decades

away. However, particularly for scenario analysis and simulation problems quantum computers have the potential to bring an exponential advantage over classical computers.

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Notes

1 This article discusses universal quantum computers. There are also other types of quantum computers: Quantum Simulation and Quantum Annealing. These types of quantum computers are not universal, instead they are programmed for a specific problem. In case of Quantum Annealing there is no proof (yet) that there is quantum advantage.

2 The table is for pure illustration purposes and is created by comparing exponential, polynomial and superpolynomial functions, not by actual computational experiments. It is assumed that a computing cycle takes 1/100th of a second on both the classical computer as well as on a quantum computer. Furthermore, it is assumed that the quantum calculations are repeated a 1000 times to find the most frequent outcome.

3 Programs in this article are executed on IBM Quantum (quantum.ibm.com). QuTech in Delft provides another free quantum environment: quantum-inspire.com.

4 The reptations of quantum calculations are necessary due to the probabilistic nature of quantum computing. This will still be the case when there are fault-tolerant quantum computers.

Geopolitical Shifts: How Technology Reshapes the Global Order and Investment Landscape

Anand Autar and Evelien van Hilten

INTRODUCTION

After World War II, the United States emerged as a dominant global economic force, promoting technological innovation, open markets, and economic stability. This period reinforced expectations among investors that geopolitical events would generally have limited long-term effects on market performance. However, the role of the United States in global affairs is undergoing a transformation. It is encountering challenges to its technological dominance, particularly from China, which is reshaping geopolitical dynamics. Trade wars, economic sanctions, and export restrictions have intensified competition in critical technological areas such as artificial intelligence and semiconductors. As a result, financial institutions must now regard technology in combination with geopolitical changes as a structural factor influencing long-term market stability, rather than merely temporary disruptions.

Geopolitics and technology are intricately linked, influencing each other through a dynamic and cyclical relationship. Major technological breakthroughs, such as steam power, electricity, and semiconductor technologies, have historically triggered economic transformations, societal shifts, and political realignments, redefining global power structures in the process.

This article explores the interplay between technology and geopolitics, highlighting the cyclical nature of these shifts. It also introduces a structured framework, combining short-term quantitative insights and long-term qualitative judgement, to help financial institutions navigate the growing complexity and uncertainty of today's technological development, in combination with a changing geopolitical landscape.

UNDERSTANDING THE RELATIONSHIP BETWEEN TECHNOLOGY AND GEOPOLITICS

Geopolitics examines how geographic, economic, political, cultural, and technological factors shape global power. Geopolitical risk involves potential disruptions from shifts in strategic power, national interests, territorial control, and

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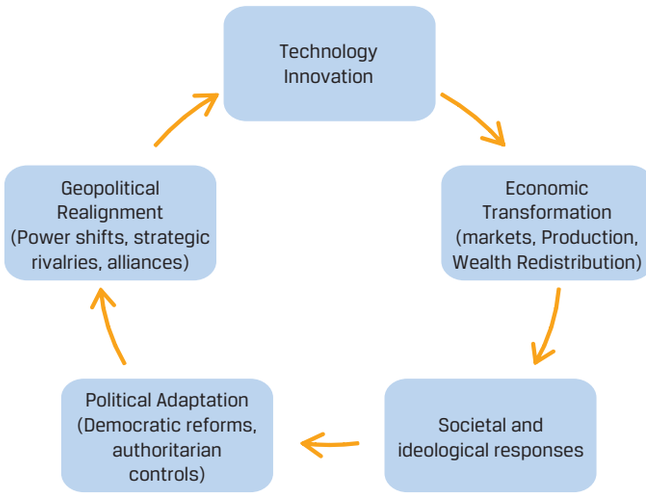
diplomacy. Early theorists emphasised territorial dominance (Heartland and Rimland), but modern geopolitics has expanded to include information control, digital networks, and global connectivity.

It is important to take a historical perspective on the relationship between technology and geopolitics since it reveals a consistent pattern across technological revolutions. Namely, technology drives economic change, prompting societal responses and political adaptations, which then reshape geopolitical structures as illustrated in Figure 1. The relationship also shows the multidisciplinary nature of geopolitics. Understanding this cyclical relationship allows financial institutions to better anticipate geopolitical risks, comprehend current strategic rivalries, and make informed decisions in a complex global landscape.

Figure 1



TECHNOLOGY AS A KEY DRIVER IN GEOPOLITICS

To comprehend the cyclical relationship, we have analysed it in the context of technological revolutions, highlighting its effect on the development of geopolitics. After all, technological innovation fundamentally creates wealth, transforming economies by enabling new industries and enhancing productivity

During the **First Industrial Revolution** (**1760–1840**), geopolitics centred predominantly around territorial expansion and resource control. The transformative technology of this era, steam power and mechanised production, reshaped economies, beginning with Britain, shifting economic power from agrarian-based societies to industrialised nations. This economic shift led to rapid urbanisation, creating entirely new social classes, such as the industrial working class and entrepreneurial capitalist elite and prompted strong societal responses, notably labour movements, public debates on inequality, and pressure for democratic reform. Technological innovation thus reinforced imperial expansion, seen in British French colonial rivalries in Africa and Asia.

In the **Second Industrial Revolution** (**1870–1914**), the geopolitical significance of technological capability became more explicit. Breakthroughs in steel, electricity, and petroleum powered large-scale corporate and military-industrial expansion. The resulting economic and resource competition intensified societal nationalism and militarism, which in turn shaped political decision-making and foreign policy. Prompting political systems to increase military spending, form strategic alliances, and embrace expansionist policies. Geopolitics thus transitioned from territorial dominance towards strategic competition driven explicitly by industrial capability, technological innovation, and critical resource control, ultimately contributing to World War I.

The **Third Industrial** (**Digital**) **Revolution** (**1960–2000**), centred on computing technology, telecommunications, and global digital networks, geopolitical competition evolved significantly. The advent of the internet transformed the world economic landscape, disrupting almost every industry in every country. The economic landscape shifted towards knowledge-driven globalised markets, creating unprecedented levels of global integration and interdependency. The United States and the Soviet Union competed in technology, but also in shaping societal models of governance, identity, and information control. This shift moved focus from territorial concerns to information dominance, digital network control, and global interconnectedness.

Post-World War II, **American global dominance** was evident as the United States promoted democracy, capitalism, and innovation. It positioned itself as the leader of the free world, especially during the Cold War. Tech giants like IBM, Microsoft, Apple, and Intel showcased liberal capitalism's edge over Soviet communism. As digital technologies reshaped the global economy, America's leadership solidified its influence on global norms, standards, and culture.

In the **Fourth Industrial Revolution** (**2000–present**), we are witnessing the rapid advancements in digital technologies such as artificial intelligence and big data enabled by semi-conductor technology. Also, significant progress is being made in other scientific areas such as biotechnology. What distinguishes this era is the scale and speed at which societal and cultural responses emerge. Social media can mobilise protests and disinformation may influence elections. Public backlash against automation and inequality is transforming political discourse. These societal shifts prompt significant political responses, where governments employ strategic regulatory frameworks, protectionist measures, and substantial investments in domestic technological capabilities.

The **U.S. global dominance** remains but is contested. Its position is now challenged by rivals, particularly China, whose authoritarian capitalist model has rapidly closed technological gaps in strategically vital sectors. All of these changes are creating a shift in the global order.

POLITICAL AND ECONOMIC SYSTEMS SHAPING TECHNOLOGICAL DIRECTION

For financial practitioners, understanding how political and economic systems shape technological direction is essential for effective risk assessments. These systems determine the pace of innovation but also how technology is governed, financed, and weaponised in global competition. As shown below they influence where regulatory fragmentation is likely to occur, how market access may be restricted, and which sectors are exposed to state intervention or protectionism.

Liberal democracies, such as the United States, prioritise private-sector innovation, entrepreneurial dynamism, and decentralised regulation. Historically, this model has driven rapid technological progress, reinforcing global influence through digital platforms, internet openness, and military innovation. However, it faces internal tensions due to rising concerns about data privacy vulnerabilities, wealth inequality, platform dominance, and the concentration of strategic technologies within few powerful companies.

Authoritarian capitalist regimes, notably China, rely on state-directed innovation and top-down planning. Massive state investments, subsidies, and tight collaboration with domestic tech giants drive rapid development in strategic sectors like artificial intelligence, semiconductors, electric vehicles, and renewable energy. While this accelerates technological advancement and geopolitical influence, it prioritises control over openness, employing technology for domestic surveillance and strategic international influence, resulting in global friction over data security, intellectual property rights, and market access.

Social democracies, exemplified by the Nordic countries and the European Union, seek a balance between innovation and public oversight. They emphasise ethical regulation, digital rights, sustainability, and technology use for societal benefit. The EU demonstrates leadership through regulatory frameworks like GDPR and initiatives around digital sovereignty, leveraging regulatory standards as geopolitical instruments. Although this approach intends to foster stability and trust by ensuring transparent data protection standards and clear compliance expectations, it may lag behind more aggressive industrial policies in global competitiveness.
Integrating these political-economic dynamics into decision making helps institutions anticipate geopolitical shifts, structural shifts in economic growth and the ESG impact of their investments.

Moreover, recognising the rising power of technology corporations, who shape global standards and public discourse, adds an important dimension to understanding market dynamics and potential regulatory backlash. For example, the Big US Tech firms, like Apple, Google and Microsoft are key drivers of technology standardisation and as such have a powerful voice in setting these standards.

Integrating these political-economic dynamics into decision making helps institutions anticipate geopolitical shifts, structural shifts in economic growth and the ESG impact of their investments.

Case Study 1: Digital Regulation and the EU's Geopolitical Influence

Rapid digitalisation has accelerated global economic integration, but it has also introduced systemic risks, such as cybersecurity threats, data misuse, digital monopolies, and regulatory fragmentation. In response, the European Union has adopted a proactive, rules-based approach to digital governance. Its flagship regulations, the General Data Protection Regulation (GDPR) and the Digital Markets Act (DMA), prioritise privacy, consumer protection, fair competition, and digital sovereignty. These policies shape the behaviour of global tech giants operating in Europe but also export EU regulatory standards worldwide, allowing the bloc to project geopolitical influence through normative power.

By contrast, China's regulatory approach is driven by state control, strategic planning, and domestic surveillance objectives. While this enables rapid technological scaling, it introduces deep policy unpredictability for investors. A stark example is the Chinese government's crackdown on the fintech sector in 2020, the halted IPO of Ant Group and the forced transition of for-profit tutoring firms into non-profit entities that led to hundreds of billions in lost market value. Chinese tech giants like Alibaba and Tencent also saw significant drawdowns, despite solid fundamentals, underscoring the risk of politically driven devaluation.

In the United States, a market-led approach grounded in private-sector dynamism and fragmented oversight has created a fertile environment for innovation, but also new forms of risk. Regulatory uncertainty around antitrust enforcement, data privacy, and platform accountability is growing. For instance, both Alphabet (Google) and Meta (Facebook) have come under antitrust scrutiny for its practices in both the U.S. and EU. These regulatory headwinds have had direct consequences for stock valuations and long-term investor confidence, when enforcement patterns shift without warning.

For investors, digital regulation is no longer just a compliance issue, it is a form of geopolitical risk. As a result, institutions must carefully assess the political logic behind each jurisdiction's regulatory regime, as these shape the operating environment of digital firms and have an impact on investment valuations. Understanding and anticipating divergent trajectories in digital governance is critical to navigating both regulatory disruption and opportunities arising from policy arbitrage.

MANAGING A SHIFTING TECHNOLOGICAL LANDSCAPE AMID GEOPOLITICAL RISKS

The financial landscape is becoming complex, particularly on the intersection of rapid technological advancements and the unpredictable nature of geopolitical risk. Traditional investment models and risk assessment frameworks, which are often based on historical data series, correlations and stable conditions, are no longer sufficient in navigating the evolving environment. Financial institutions and investors therefore should consider embracing a multidimensional approach to portfolio construction, integrating both quantitative and qualitative methods specifically focused on emerging risks.
Technological changes, when coupled with geopolitical uncertainty, can manifest in both short-term volatility and long-term structural shifts. Short-term risks are driven by the volatility resulting from political realignment triggered by technological shifts, while long-term risks revolve around the broader economic and societal transformations that these technologies bring. Each horizon demands a tailored response: short-term effects necessitate measures to mitigate downside risk, while long-term effects require vigilance to avoid investing in potentially stranded assets, similar to climate change-related risks.

SHORT-TERM RISK MANAGEMENT: PROTECTING AGAINST DOWNSIDE

Though long-term investment strategies are a focus for many institutions, emerging technologies may provoke significant societal shifts. This can lead to a backlash, from the public, as these technologies are seen as threatening to existing job markets and economic stability. In such times, financial institutions must be diligent in managing short-term downside risks, which could result in considerable financial losses or even broader economic dislocations.

Monitoring Short-Term Risks: Tools and Models

A variety of tools are available to assess geopolitical and technological risks in the short term. Several models rely on analysing geopolitical unrest, often utilising technology to process large volumes of data from news sources and political analysis. These models assist investors in gauging public sentiment and understanding potential shifts in political and economic stability. However, it is essential to recognise that these models are not designed to forecast political events' specific progressions, but rather to provide a snapshot of current conditions.
Forecasting geopolitical events presents significant challenges. Historical patterns may offer some insights, but predicting the course of future events with precision remains uncertain. Given this uncertainty, two widely adopted approaches for short-term risk management are stress testing and scenario analysis.

Stress Testing typically involves methods such as Monte Carlo simulations or the analysis of outliers. These tools allow financial institutions to explore potential outcomes under extreme or divergent conditions. While these techniques are valuable for gauging risk exposure, they do not attempt to predict the future but rather simulate potential scenarios based on existing data.

Scenario Analysis is a commonly adopted approach for short-term geopolitical risk management. Investment firms produce a diverse range of short-term predictive scenario sets, which are accessible online. The advantage of these short-term scenarios lies in their quantifiability, making them well-suited to the processes of most financial institutions.

Although geopolitical events are challenging to predict, short-term scenario thinking may provide valuable insights to decision-makers. It helps identify unintended concentrations within portfolios. Equally important, it instils confidence in addressing extreme scenarios arising from geopolitical risks. The goal of these discussions is to mitigate boardroom dynamics that may lead to panic-driven responses.

Additionally, it is important to note that regulatory bodies, such as the Dutch Central Bank (DNB), expect financial institutions to proactively assess the impact of geopolitical risks, including operational consequences such as shifting sanctions and escalating cyber threats. To achieve this, it is recommended to enhance above mentioned quantitative analyses with qualitative assessments. Assets like government bonds or currencies may behave differently during geopolitical tensions, making it essential for financial institutions to diversify their holdings or businesses. A focused strategy minimising sector and regional concentrations can help manage these risks. For Example, geopolitical risks may prompt a reassessment of inflation-linked products, as evidenced by the price volatility caused by sanctions on Russia during the 2022 invasion of Ukraine.

LONG-TERM RISK MANAGEMENT: NAVIGATING MEGATRENDS

Long-term financial predictions are generally based on historical data series, correlations and financial instrument behaviour. However, the combination of technological advancements and climate change is set to act as a transformative force, potentially breaking from the historical patterns on which many investment strategies are built. These changes could arrive swiftly, leaving little time to adjust portfolios, potentially leading to the accumulation of stranded assets. Financial institutions must remain aware that long-term concentration risks in certain sectors or regions can amplify the effects of technological disruption.

Incorporating Megatrends Analysis

While many financial institutions continue to rely on historical data series for decision-making due to its quantifiable nature, supplementing this analysis with megatrends (broad, long-term shifts in society, technology, and the environment) can offer a clearer view of future opportunities and risks. Megatrends analysis helps identify areas of potential exposure within portfolios as they evolve, providing a more comprehensive view.

Given that regulators are requiring financial institutions to consider long term climate change effects, enhancing this with

broader technological change is only a small step. For example, climate change and technological advancements are strongly intertwined, and integrating both into long-term portfolio strategies is essential for robust risk management.

Storytelling and Scenario Planning

A variety of methods exist for long-term scenario construction, with exploratory scenarios being the most effective for navigating uncertainty and strategic planning. This approach aligns with Shell's well-established methodology, which encourages the development of multiple scenarios to avoid the pitfalls of relying on a single prediction. By exploring diverse, plausible futures, Shell engages stakeholders in strategic discussions, fostering a deeper understanding of potential disruptions and how external forces may reshape industries. These scenarios are not intended to predict the future but to offer a framework for creating flexible strategies that can withstand various possible outcomes.

A key element of Shell's approach is storytelling, which helps decision-makers grasp the potential changes and risks in the future. This enhances alignment among stakeholders and strengthens strategic coherence within the organisation.

Shell's approach to scenario construction

1. **Identify Key Drivers**: Gather insights into the most significant forces affecting the future, including technological, political, economic, and social factors. It is important in this phase to include diverging opinions from specialists with different backgrounds and opposing research to avoid blind spots.
2. **Develop Critical Uncertainties**: Identify the uncertainties that could have the greatest impact on the future. The idea is to acknowledge that the future is uncertain, therefore these factors will be difficult to predict but highly influential.
3. **Create Plausible Scenarios**: Develop multiple scenarios (not too many) based on different combinations of key drivers and uncertainties. These scenarios should be extreme, diverse yet plausible. The intention is not to reach a consensus or to create predictions.
4. **Explore Implications**: Analyse the potential impact of each scenario on the organization. This helps in understanding how different futures could shape the business environment.
5. **Formulate Strategic Options**: Identify robust strategies that will work across a range of scenarios, enabling flexibility and improve resilience as portfolio construction and strategic thinking is approached with a broader view.
6. **Monitor and Adapt**: Regularly review and adjust strategies as the actual future unfolds.

For financial institutions, while this qualitative method does not aim to predict exact outcomes, it provides a way to develop more robust, resilient strategies. By identifying actions that remain effective across multiple scenarios, organisations can prepare for future risks without being overly dependent on predicting a specific outcome. This approach builds flexibility and adaptability in the face of long-term uncertainty.

Implications for Financial Institutions

As financial institutions engage in long-term resilience planning, they must consider how shifting technological trends, and geopolitical risks will impact their investment strategies. Does this imply that financial institutions should take active decisions based on scenario planning? This is a complex issue, as evidenced by the recent debates surrounding Dutch pension funds' investment strategies and their approach to climate change. While institutions may opt to invest in emerging markets or new technologies, particularly those focused on sustainability, the key discussion is the recognition that continuing to invest in the status quo is, in itself, also a decision. One thing is certain: the world will change. The pace and nature of these changes remain uncertain, making it essential for decision-makers to continuously monitor and engage in regular discussions regarding these evolving dynamics.

CONCLUSION

The intricate relationship between technological progress and geopolitical dynamics underscores the importance of proactively integrating these factors into strategic risk management and investment frameworks. Throughout history, technological revolutions have consistently catalysed economic, societal, and political shifts, profoundly reshaping global power balances. In our current era, the rapid advancement of artificial intelligence, biotechnology, and semiconductors highlights a geopolitical landscape marked by intense competition for technological ecosystems, digital sovereignty, and strategic supply-chain dominance.

Predicting geopolitical events, much like any human behaviour, remains challenging due to their complex and unpredictable nature. However, this is not a reason for financial practitioners to ignore this risk. Short-term scenario thinking can be a valuable tool for providing insights. It equips decision-makers to anticipate for material geopolitical events and mitigates the risk of unnecessary losses, such as those arising from unintended portfolio concentrations. This requires decision-makers to abandon their reliance on historical financial instrument behaviour, correlations and return data.

World history has shown that in the long run technological changes will create shifts in the world order. For example, the decline of American exceptionalism can have a significant impact on global trade and capital flows and as such on existing business portfolios. To prepare for such changes, it is recommended to integrate megatrend analysis and scenario planning in decision-making processes to build resilient, future-proof strategies. Taking a step back and reassessing decisions and

discussing future states of the world from different perspectives, such as the Shell scenario methodology, can be beneficial. This approach can help in minimising the risk of long-term investments in technological assets that may become obsolete. It is recommended to further embed these analysis and planning processes in core organisational decision-making processes.

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Een behouden vaart

Precies op de dag dat ik deze column tik, leverde ik twee jaar geleden mijn eerste column voor het VBA-journaal in. Het was juni 2023. Kabinet Rutte-IV zou kort daarna vallen, de laatste lockdown lag net een jaar achter ons, de enorme inflatie ging weer wat omlaag en ChatGPT was voorzichtig aan zijn opmars begonnen. Terugkijkend denk ik: was dat, op de oorlog in Oekraïne na, eigenlijk een relatief onbezorgde tijd? Vol optimisme over de toekomst en de doorstartende economie?

Of heb ik last van *rosy retrospection*? Dat is het vroeger-was-alles-beter-syndroom waardoor het verleden in je herinnering een roze gloed krijgt. Zelfs de oude Romeinen hadden hier al een uitdrukking voor: *memoria praeteritorum bonorum*, wat zoiets betekent als 'de herinnering aan het goede verleden'. Dat zou komen doordat je terugkijkend meer samenhang ziet tussen gebeurtenissen en weet hoe ze zijn afgelopen. De toekomst is echter ongewis dus vrezen mensen al snel het ergste. Dat kan zelfs tot *declinism* leiden, ofwel de neiging om te denken dat de maatschappij aan het afglijden is. Zo hoort bij 'vroeger was alles beter' ook vaak de verzuchting over 'de jeugd van tegenwoordig'.

Maar ik dwaal af.

De reden dat ik terugkijk is omdat ik nu, precies twee jaar later in juni 2025, mijn afscheidscolumn tik (helaas is mijn agenda té druk geworden). En het lijkt wel een andere wereld. Na Rutte-IV, is ook Schoof-I gevallen en moeten we voor de tweede keer in twee jaar naar de stembus. Nog afgezien van het feit dat we nu wéér in die verschrikkelijke campagnetijd terechtkomen, is het slecht nieuws dat op belangrijke dossiers als stikstof, woningbouw en migratie nog meer vertraging komt.

Waar Nederland vooral lijkt stil te staan, heeft in die twee jaar geopolitiek een aardverschuiving plaatsgevonden. Trump begon aan de wereldorde (en de Amerikaanse rechtstaat) te schudden. Zijn zero-sum-denken staat haaks op het liberale globaliseringsdenken dat de taart groter kan voor iedereen. Het is niet langer en-en, het is of-of bij Trump. Economie is een prominent geopolitiek wapen geworden.

Niet zonder gevolgen. Amerikaanse staatsobligaties en de dollar zijn niet meer de veilige havens die het altijd waren. Dankzij de handelsoorlog en Trumps *One Big Beautiful Bill* richten beleggers hun blik op Europa en opkomende landen. Op zich niet eens zo slecht, aangezien beleggers relatief overwogen in Amerikaanse aandelen zitten.

Langlopende obligaties, ooit de lieveling van institutionele beleggers, zijn uit. Sowieso is de obligatiemarkt het stralende middelpunt van de belangstelling geworden. Nou ja stralend, met wat druppeltjes angstzweet dan. De doorgaans zo saaie obligatiemarkt werd een beetje *yippie*, zoals Trump het omschreef, en liet zijn tanden zien. Trump beleefde in april bijna een Liz Truss-moment en zouden op het nippertje aan een financiële crash zijn ontsnapt. *Yippie!*

Tot slot nog één punt over kapitaal, maar dan niet van het soort waar u zich dagelijks mee bezighoudt. De Amerikaanse politicoloog Robert Putnam introduceerde begin deze eeuw de termen *bonding* en *bridging social capital*. *Bonding* gaat over de band met mensen die op je lijken. *Bridging* over verbinding met mensen die anders zijn. Trump blinkt uit in het eerste. Goed voor zijn eigen achterban, minder voor het collectief wat polarisering vergroot.

Toch hoop ik dat er meer mensen met *bridging capital* opstaan. Noem me een idealist of een dromer, maar ik zie toch echt liever iemand die groepen bij elkaar brengt dan ze verdeelt. En laten we vooral optimistisch blijven en niet ten prooi vallen aan *declinism*. Dan kijken we hopelijk ooit op deze tijd terug dat het allemaal meeviel, omdat het ondanks de hoge golven toch goed afliep. Een behouden vaart!

Data, Disruption & Drive: Marcel Prins on how Technology Reshapes the Future of Asset Management

By Gerben de Zwart, Mark Geene

For this edition we spoke with Marcel Prins, Robeco's Chief Operating Officer (COO), on technological changes in the industry. Marcel is a distinguished figure in the financial industry, providing a wealth of technological and operational experience and insights which are fundamental for understanding the current and future technology landscape of our industry.

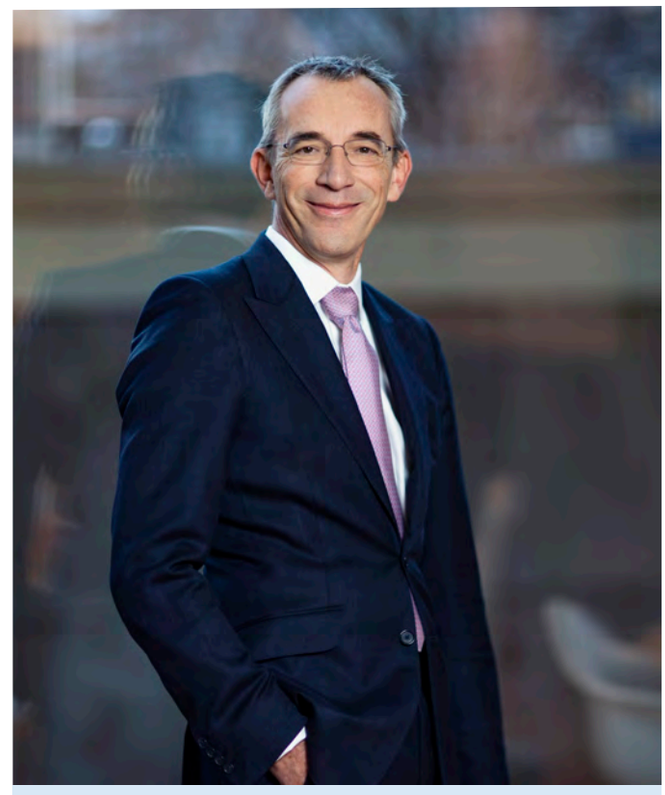
INTRODUCTION AND PERSONAL BACKGROUND

Marcel has built a career in the financial industry that represents his fascination with technology and innovation, which already began in his youth. His entrance into finance was not a deliberate choice, but rather unanticipated. A consulting firm assignment within finance was the trigger for his move into the financial industry. His academic background in Informatics led him to a technology innovation department at the GAK (nowadays UWV). At that time, he already appreciated the practical application of technology that is front and center during the remainder of the conversation.

Marcel's career trajectory took him through various roles in the industry, eventually leading him to working for Fortis, ABN AMRO, APG and Robeco and an appreciation for the industry's intricacies and its reliance on technology and data. His move from the banking part of the financial industry into asset management was credited to an opportunity offered by Angelien Kemna to join the board of APG Asset Management as COO in 2011.

With several of his secondary roles he keeps himself abreast and inspired by technological developments in adjacent financial industry (sub)-sectors. It enriches his perspective and allows him to bring outside developments into his own organization. Even though his move into finance was by coincidence, he does not see him take on a primary role in another industry. He is not yet done with technological developments and innovation in finance.

During the interview we spoke with Marcel about the technological trends within asset management, the application and disruption from technology as well as the impact and role of regulation. We concluded the interview discussing his perspectives on the future and his subsequent advice for both seasoned and young investment professionals. Based upon the interview, AI has generated a comprehensive list of 6 main points taken from



Marcel Prins: Chief Operating Officer (COO) / Statutory Director & Chairman of Diversity, Equity & Inclusion Board Robeco
Marcel is Robeco's Chief Operating Officer (COO), where he became a member of the Executive Committee on 1 June 2022. *He brings more than 25 years of experience in operations and technology in the financial services sector. Previously, he was Chief Operating Officer and Chief Digital Officer at APG Asset Management. Before that, Marcel was Managing Director for International Operations at ABN AMRO, where he was responsible for the effective operational integration of international entities following the merger with Fortis Bank Nederland. He started his career in 1991. Marcel holds a Bachelor's in Computer Science from The Hague University of Applied Sciences.*

the conversation relevant for all investment professionals with respect to technological developments.

ASSET MANAGEMENT AND TECHNOLOGY TRENDS

Global multiclient versus national asset managers: When asking Marcel about the differences in technology between his former employer APG and his current employer Robeco, he points out the difference between the number and location of their clients. Robeco has numerous international clients with localized and customized needs, that adds to the complexity of application and usage of data, technology integration and reporting requirements. International differences in regulations further add to this complexity. However, also lots of similarities exist in terms of the set-up of core business functions like investment management, risk management, finance, HR, and technology. Both firms use Bloomberg terminals, use index providers as data suppliers, but also apply AI in the main investment process. The main difference is that APG has the mid- and back office function in house, while Robeco has outsourced this to JPMorgan.

Data and data governance: In light of his background and the fact that he oversees the developments of Robeco and its global clients, we were keen to ask him about the critical trends that are reshaping the asset management industry. His immediate answer was: data and data governance. During the remainder of the interview Marcel kept emphasizing the importance of the role and proper use of data. At the forefront is the emphasis on data governance, which Marcel describes as foundational to any successful strategy. He explains: *'Five years ago, the focus was on 'know your customer.' Now it's 'know your data.' If you don't know your data, you're dead in the water. Data is the foundation for everything – from delivering better client experiences to driving investment automation and risk management. And across asset management, being able to operate effectively across multiple data channels and jurisdictions is becoming key to competitiveness. This includes the proper governance of data across the entire investment firm. And let's not forget data is a key pre-requisite for AI at scale'.*

> KNOW YOUR DATA. IF YOU DON'T, YOU'RE DEAD IN THE WATER

Marcel sees significant opportunities for data and technology to transform asset management, particularly in areas such as portfolio management, risk management and sustainability integration. He advocates for a shift towards a data-centric approach, moving away from traditional processes and system-centric models. This transition, he argues, could challenge the relevance of large software packages, as firms increasingly rely on in-house developed software components tailored to their specific needs. In this respect Marcel emphasizes the risk of data poisoning: *'As we increasingly rely on automated systems for investment decisions, we must be cautious of the risk of data poisoning. The automation of data generation can lead to a reliance on third-party data of varying quality, which poses significant risks to your internal decision making including in your investment strategies. It's crucial to maintain stringent oversight and controls over our data sources.'*

Artificial intelligence (AI): AI is another important trend that Marcel discusses. He explained that AI is already at the heart of Robeco's investment engine. He highlights the need for asset management firms to experiment with AI applications beyond the core investment processes. This means exploring how AI can be used to benefit other areas of the business to further scale it as well as shifting from focusing on AI technology to driving the AI adoption within the organization. He explains: *'At Robeco we took a conscious decision two years ago to start experimenting with GenAI tools like Copilot in a safe, exploratory way – not to rush but to learn. Now the conversation is no longer about what GenAI can do but how to ensure adoption across the organization. It's about making sure teams – whether legal, development, or operations – embrace AI to avoid leaving productivity and ultimately value on the table. The challenge has shifted from the potential of the technology to culture and leadership.'* This implies ensuring that all teams and ideally all their employees embrace working with AI to avoid productivity gaps between employees and maximize the impact for the client.
He also mentioned that as AI functionality is becoming commoditized, it is important for firms to experiment and learn in a free format way while focusing on core initiatives for general acceleration of AI. Curiosity, experimentation and learning agility is underscored by Marcel during the entire interview.

> AI ADOPTION, NOT AI ITSELF, IS NOW CENTRAL ON THE BOARD AGENDA

Blockchain: One important technological trend in the finance industry that seems less relevant for asset management and should be approached cautiously according to Marcel is blockchain. *'Blockchain could be highly disruptive to the financial system and used for smart contracts and administering real assets. But that doesn't mean it's immediately relevant for asset managers. As asset manager we are at our core users of financial markets, not providers of the underlying infrastructure. Without clear, global regulatory frameworks, I won't commit hundreds of millions to blockchain-based platforms. When our custodians and service providers adopt it at scale, we'll be ready to integrate – but being first mover as Robeco does not make sense.'*

DISRUPTION, OPPORTUNITIES, AND APPLICATIONS

Fintech: We also discussed the emergence of fintech which has been a catalyst for change within the financial industry. He explains that fintech during their first entrance in the period 2015-2018 has served as a wake-up call for, especially, traditional banks, pushing them to innovate and improve client experiences. He notes that large financial institutions started with separated innovation labs to innovate at arm's length of the main bank. However, they needed to learn how to innovate from within to truly, again he emphasizes this point, adopting new technology

effectively. This implies how to avoid the innovation lab and the legacy part of the business are not two separate worlds.

He notes that around 2017-2018, during his time at APG, they experimented with a different kind of innovation. Innovation and application of innovation was achieved more from within instead of at arms' length with business and technology closely collaborating. In addition to direct in-house (technological) innovation and adaptation, he believes that fintech can enhance various aspects of asset management, from improving operational efficiency, customized reporting to enabling more sophisticated risk management strategies.
In this respect he also emphasizes cross-industry learning, i.e. also looking beyond Fintech: *'To drive innovation, we must look beyond our own sector. Observing developments in other industries can provide valuable insights that we can apply to asset management. This cross-industry learning is crucial for identifying new opportunities and staying ahead of the curve.'*

> CROSS-INDUSTRY LEARNING IS IMPORTANT TO STAY AHEAD OF THE CURVE

On the role of fintech and new technologies he recognizes that especially for the very large financial institutions like JP Morgan, StateStreet, Bank of New York, it really took time to adopt the new technology. While fintech solutions offer exciting possibilities, it was difficult to integrate these solutions within legacy systems. However it allowed them to learn and in various cases drove re-platforming of some of their core technologies. He concludes that while some smaller fintech firms have earned their place with differentiating products, the traditional banks have survived the attacks of fintech's. Clients, and especially global clients need global servicing across multiple financial products that most fintech simply don't offer.

AI and technology trends: their critical importance for analysts and PM's: We also quizzed Marcel upon the role of AI, data and technology when portfolio managers and analysts are researching individual companies and prepare their investment thesis. He states that first and foremost he observes investment professionals use technology more and more to do their research: whether it be using alternative data sources as extra data points on a company, moving analysis from Excel to python to using GenAI to accelerate content generations. Especially young investment professionals bring many of the skills with them when joining Robeco.

Additionally, when evaluating companies the analysts have to research the risks associated with data and technology of target companies and their business models. He argues that understanding the potential disruption of data and technology is mandatory for investment decisions. '*Digital strategies and tech capabilities should absolutely be part of investment cases. Over the last ten years, data and AI have proven disruptive across sectors. If you're not asking how resilient or advanced a target company's tech strategy is, you're missing part of the risk-return profile. Stated otherwise, analysts and portfolio managers have to assess whether a target company's digital strategy is robust, or whether it's strategy and business is at risk from AI or data disruption.*'
This also requires that investment professionals keep themselves abreast on the broader set of technological developments, not just the ones that are most applicable in the financial industry.

RISK MANAGEMENT AND REGULATION

Regional differences in tech developments and regulation: We asked Marcel about his perspective on the technological differences between the US, Europe and Asia. He responded quickly that he observes an emerging differences in technological advancements and regulatory environments across the continents. '*What we're seeing is a move away from a unified global finance infrastructure. The EU, US, and China are increasingly following separate geopolitical and technological paths. The various regions have their own geopolitical ambitions which have been emerging and changed rapidly in the last 10 years. That risks fragmenting the financial fabric – systems that used to run on global standards like SWIFT could split. In addition varying regulations across spheres will arise, for example GDPR in Europe with privacy playing a different role in other jurisdictions. It's a recipe for inefficiency, higher costs, and integration risk. Finance is no longer just about economics – it's increasingly shaped by geopolitical agendas'*

We discussed how a more stringent regulatory environment has maybe put European financial institutions at a disadvantage. He notes that it is the intention of European regulators to keep Europe competitive. However, he notices some positive developments at the European level, in terms of simplification of regulation and technology adaptation. These developments and green shoots don't make him desperate about the European finance industry. While European strict regulations could hinder

Marcel Prins (COO Robeco): Key Insights from the conversation for investment professionals with respect to technological developments (prepared with the help of AI).

- **Learning Agility:** Implement a program to enhance learning agility among employees to adapt to the accelerating pace of technological changes.
- **AI Adoption:** Develop a strategy to drive AI adoption across all departments, ensuring that employees embrace working with AI tools.
- **Data Governance:** Improve data governance practices to ensure better data management and customer experience.
- **Regulatory Compliance:** Engage with Dutch and European regulators to discuss the implications of current and future regulations on the industry.
- **Technology and Data Strategy:** Ensure that portfolio managers stay updated on technological trends and incorporate digital strategies into their investment cases.
- **Secure Base Leadership:** Continue promoting secure base leadership to create an inclusive culture where employees feel safe to express their concerns and ideas, especially also on technology and risks of technology, data and AI on the firms and business models of their investments.

agility, he also recognizes that constraints are often breeding grounds for creativity.
In terms of regional technological developments, he is very interested in what is occurring in China. The Chinese are developing their own chips and operating systems and subsequently application of new technologies and data in the financial industry. From that perspective China is likely to become more decoupled from the Western Hemisphere. While they still use Bloomberg, domestic alternatives like Wind are already mainstream in China.

Technology and risk management: Further exploring risk management and regulation with respect to technology, he starts by noting that first and foremost you have to have intrinsic responsibility yourself to manage your business and risks properly. *'I always say, it starts with an intrinsic responsibility. Regulation raises the bar when collective behavior falls short.*

In this respect Marcel emphasizes the importance of operational resilience. He highlights a shift from strict financial regulation to operational resiliency regulation, which he believes was long overdue. He strongly advocates for proactive governance and operational resilience. He regards European regulations like DORA not as burdens, but as overdue frameworks that compel firms to address real threats like third-party risk and cloud concentration. '*With DORA and third-party risk, we're being pushed by new regulation to address real and growing operational vulnerabilities'.*

> YOU WON'T STAY RELEVANT IF YOU CAN'T KEEP UP WITH HOW DATA AND TECHNOLOGY RESHAPE YOUR JOB IN A RAPIDLY CHANGING SOCIETY

On regulation Marcel adds that consistent, long-term policy and regulation are crucial for organizations to build upon, providing a stable foundation for strategic planning and execution. '*What organizations need is consistency, not regulatory whiplash. We're happy to play by the rules, but we don't want the goalposts are moved every few years. Predictability is essential to build resilient systems and make long-term decisions. Additionally, as an industry you should have a conversation on the really key concerns and the implications of all current and new regulations on the (technological) developments and innovation of the financial industry. Regulators should be careful about overreach that slows down innovation. Additionally, regulators and government should provide the proper conditions for providing EU-based cloud infrastructure if mandating to retain data within the EU. A continuous dialogue between regulators and financial markets participants is therefore foundational.*

Concluding on the regulatory landscape, Marcel acknowledges the need for a balanced approach that considers both the benefits and risks of technological advancements. He advocates for a regulatory framework that supports innovation while ensuring the security and integrity of financial systems. He believes that such a framework is essential for fostering trust and confidence in the industry.

FUTURE PERSPECTIVES AND ADVICE

Mastering data and technology in day-to-day work: Looking ahead, Marcel predicts the continued evolution of data and technology, driven by developments in the US and increased regulations. He advises asset managers to focus on mastering data and technology usage in their day-to-day work, as it remains the core of any business and investment strategy. This again underscores Marcel main point during the interview: the application of data and technology in your day-to-day activities. He notes that while you cannot influence what is going on with technology developments in for instance China nor US politics, you should be aware of what going on and how this influences your work and investments. He emphasizes that the essence of the asset managers is that your data drives all decision making: *'The future of asset management hinges on our ability to integrate data and technology into our daily operations. As we navigate global market complexities, being strategically independent in our technology choices and being in control of data will be a 'no regret move' that enhances our resilience against external shifts." It ensures independence from technological shifts across different regions and readiness for new emerging technologies that consume the same data but in different ways. Focus on your own (technology) strategy instead of just being reactive: know what no regrets are, focus where you can make a difference but be equally clear on what you're not going to do (yet)'.*

Learning agility: For investment professionals and especially new entrants in asset management and adjacent technology fields, Marcel emphasizes the importance of learning agility. '*I think what becomes extremely relevant in society at large is what is called learning agility. It's about recognizing how incoming data and technologies are impacting your work and adapting accordingly and what it means for you as a professional in terms of skills and competencies required to remain proficient. Whether you work in education, medicine, or asset management, the rate of change is accelerating. If you can handle that, you're equipped for the future. That mindset is what we value and foster at Robeco.*'

> THE REAL RISK IS NOT THAT AI MAKES MISTAKES – IT'S THAT WE DELEGATE TOO MUCH TO SYSTEMS WITHOUT UNDERSTANDING THE DATA BEHIND THEM AND BLINDLY RELY ON THE OUTCOME

He suggests that individuals should stay informed about technological trends and develop the ability to adapt to changes in their work environment. To keep up to speed with a range of developments, including his personal interests, Marcel himself uses *Flipboard*. He stresses the importance of looking beyond one's field, as that is common knowledge, to observe what's happening elsewhere to gain a broader perspective. He believes that a proactive approach to learning and innovation is the key to success in this rapidly evolving field.

Danger: the Ouroboros Effect of AI: We also quizzed Marcel on the role academia plays or can play in the context of technological developments, AI and data for the investment industry. His response was mainly from a risk perspective. GenAI is nowadays also used to write (semi) scientific publications. Marcel stresses that one should always ask: *Are the article's conclusions real and properly investigated?*
However, a potential threat to LLM/GenAI is the so called Ouroboros Effect. That is a risk in general for AI, but especially in academia. The quality of the output of GenAI could be degraded over time. Reason being is that the set of all human written knowledge has been consumed by the AI-models and these models are now additionally trained on new material that is produced by GenAI. I.e. it is creating a self-reinforcing loop and additional hallucinations. Humanity is not attentive enough to the true source of knowledge, i.e. factual scientific research distinct and isolated from the GenAI generated research.
The same holds true for data and being in control of the data and its sources within and used by your firm as Marcel emphasizes several times during the interview. As an asset manager you have to concern yourself about the risk of data poisoning. This risk arises if there is too much automation in data-generation and investment decision making. Can you control the Ouroboros Effect if third party data is automatically consumed in your organization, while AI produces so much data nowadays?[1]

Figure 1
An AI generated image of an Ouroboros. Source: Image Generator

Robeco's Leadership program: At the end of the interview Marcel notes that: '*Amid all the talk about AI and data, we must remember it's ultimately about people. Their willingness to learn, to adapt, and to feel safe doing so. At Robeco, we introduced the 'Accelerate' leadership program across the whole firm. It has a strong link with topics we discussed today. We started the program three years ago and over a thousand employees across the firm worldwide were enrolled. The goal is to remain applauding results, but especially create a growth mindset among our people.'*
Again, he emphasizes the role of learning agility that each person at the firm must have. The three leadership principles for Robeco as part of the program are:

1. Results: which speaks for itself.
2. Growth mindset: continuously develop yourself as a person.
3. Secure Based Leadership: he explain this as follows: '*You have to make sure that as a manager you are and feel responsible for an inclusive culture in your team where everybody can bring their best personal and professional selves to the workplace. I.e. psychological safety. This is not just related to investment decision making but also important to dealing with emerging technologies like AI. You should dare to speak up if you don't believe in either a stock or in the role of a certain new technology. Culture isn't a soft layer around strategy – it's at the core of successful transformation.*'

CONCLUSION

Marcel Prins provided a comprehensive overview of the challenges and opportunities facing asset management in the context of technological advancements. He conveyed the message that technology and AI are impacting each firm and person in the asset management industry. Effectively, technology has to be integrated into the 'People model' of each organization. It is important to approach this topic proactively with a continuously learning mindset, both as a firm and an investment professional. His insights underscore the importance of data governance, AI experimentation, and regulatory consistency. Marcel's emphasis on learning agility and cross-industry inspiration offers valuable guidance for professionals navigating the evolving landscape of asset management. His advice to (young) investment professionals and his strategic vision for the industry highlights the need for innovation, adaptation and especially application of technology.

Note

1 See more on this topic on for instance: https://bmiddleton1.substack.com/p/the-ouroboros-effect-how-ai-threatens.

Change in Investment Landscape Due to Technological Developments

Mike Chen

INTRODUCTION

> *"This article is not written by a large language model (LLM) but by a real human."*

That one has to put that statement above is an astonishing fact that, even five short years ago, most people would have thought laughable. Of course, technology and its rapid advances and pervasiveness have dramatically impacted every facet of our lives and society. In one way or another, almost all industries and economic activities have been impacted by technology. Finance is no exception. In recent years, a particularly powerful form of technology, namely AI (of which LLM is the latest example), is poised to cause disruptive change on par with, if not more than, the steam engines during the industrial revolution, the computers in the information revolution, and the internet during the communication revolution.

In this article, we look at how technology has changed the institutional asset management industry in recent years. We look at this from the perspective of both fundamental and quantitative investors, in addition to non-investment functions such as marketing, operations, etc. We also offer a few hypotheses on how technology may further impact institutional investment practices in the near future. First, we briefly discuss three major technological trends driving such secular change.

THREE SECULAR TECHNOLOGICAL TRENDS DRIVING THE WORLD (INCLUDING INVESTING)

The broad trend of secular technological change can be decomposed into three major themes:

- Explosion of available data
- Exponential growth of computing power, and
- Availability and breakthrough of sophisticated algorithms (ML, NLP, Transformers/GenAI)

Data is the first theme. Since the internet came on the scene in the mid-1990s, later followed by the widespread availability of smart devices in the 2000s, the volume of captured data has grown dramatically. It has been estimated that the quantity of data created and captured by humans since the inception of time roughly doubles every two years [WEF, 2022]. This vast amount

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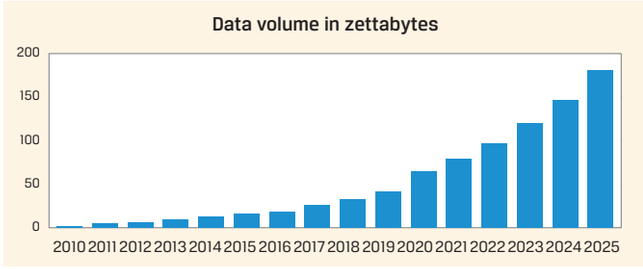
Figure 1
Global data growth



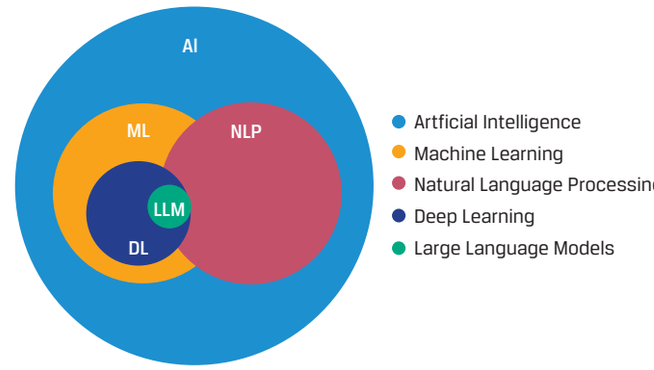
Source: [Pangarkar, 2025]

of data gives those with the ability to store, process, and analyze them an advantage on information and intelligence, leading to possibly better decisions. Figure 1 above illustrates the growth of data.

The second theme is the exponential growth of computing power. Everyone has heard of the Moore Law [Moore, 1965], which states that computing power doubles approximately every year.[1] This exponential growth in computing power, compounded over decades, resulted in everyday people owning portable devices with computing capability on par with those of supercomputers from just 15 to 20 years ago. Figure 2 illustrates this tremendous growth. The availability of computing is further supercharged by the emergence of cloud computing services, which further lowers the access barrier to essentially unlimited computation power.

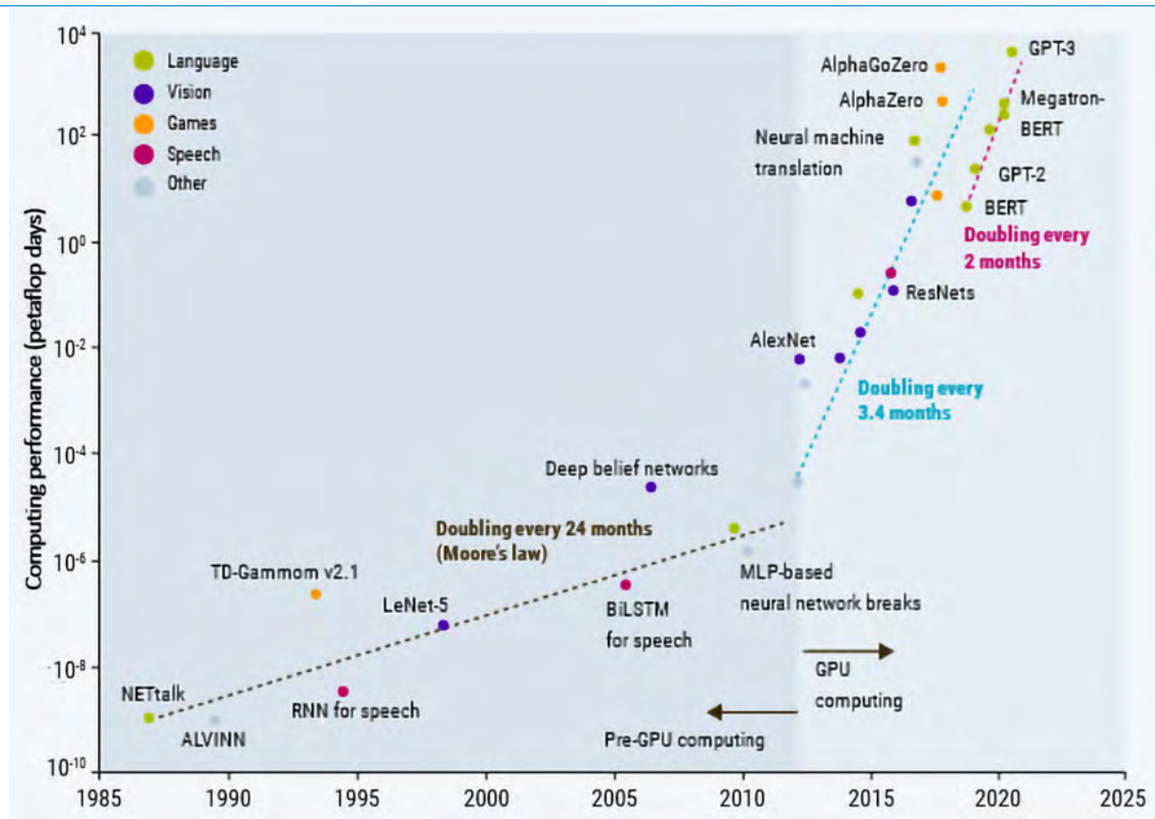
The final theme of secular technological improvement is the widespread availability and continued evolution of sophisticated algorithms, specifically AI. The simpler AI algorithms have been available for decades, but until recent growth in data and computing, they were not practically feasible. With the first two themes mentioned above, this is no longer true. Furthermore, in the past decade, we've seen tremendous innovation in these algorithms as well, such as the breakthrough invention of transformers [Vaswani et al, 2017], leading to the emergence of large language models (LLM) and the tantalizing possibility of artificial general intelligence (AGI). Figure 3 below gives the current AI algorithm's landscape, with the latest advancement, LLM, emerging in the last decade.

Figure 3
Sophisticated algorithms are now practical, and new advances are emerging rapidly



Source: Robeco

Figure 2
The exponential growth of computing power, driven in recent years by GPUs



Source [Zhu et al., 2023]

TECHNOLOGY'S IMPACT ON INVESTING: BETTER INSIGHTS AND EXECUTION

If applied correctly and artfully, the advancements described above can lead to an advantage in extracting alpha from the financial market. This advantage comes from three particular aspects: faster speed, more sources of information, and better information processing.

TECHNOLOGY'S IMPACT ON QUANT INVESTING

For quantitative investors, it is easy to see how technological advancements can improve their investment process. Certainly, quant investors have always relied on data, computing, and algorithms in their investment processes. For example, classical quant investment techniques such as factor investing applied linear or logistic regression algorithms on data from financial statements in desktop computers to derive "alpha ranks" on securities in their investment universes, and buy the best ranked securities and sell the worst ranked ones. Since Quant investors have always used computers in their investment process, the speed aspect of alpha extraction has always been there. However, recent technological improvements have broadened quants' information sources and enabled better processing of that information, thereby deriving better investment insights.

With big data, massive computing, and advanced algorithms, the realm of possibility has dramatically expanded for the savviest quant investors. Rather than being limited to financial statement data, which tends to be backward-looking and usually comes with a time lag, quant investors can now use alternative data processed by sophisticated algorithms running on large computing clusters to derive pertinent investment insights that they've always had an interest in answering, but previously didn't have means to do so. Below, we list the enabling technologies and some examples of the new investment insights they enable for quant investors:

- Alternative/big data:
  - Credit card spending: real-time B2C revenues
  - Shipping manifest: goods imported and exported, and their values
- Machine learning (ML):
  - Security return prediction: estimate of security returns based on linear, *non-linear*, and *interaction* combinations of input features. Traditionally, quant investing has been limited to linear input combinations. An example of this approach can be seen in [Gu, Kelly, and Xiu, 2020], where the authors used machine learning algorithms such as boosted trees and neural networks to combine input features to estimate securities returns. The authors noted that in addition to linear combinations, these ML algorithms were also able to deduce security return's relationship with non-linear and interactive combinations of input features.
  - Security categorization: Use unsupervised clustering algorithms to group similar securities based on various characteristics such as return, supply chain, technologies used in the production process, etc., to enhance risk management capabilities. For example, see [Dolphin, Smyth, and Dong, 2023].
- Natural Language Processing (NLP):
  - Sentiment analysis: NLP applied to appropriate textual data can reveal customer, management, or employee sentiments towards various topics. As NLP techniques have advanced from bag-of-words in the early 2000's to the latest large language models, the capability to extract textual sentiments salient and subtle has increase by leaps and bounds. For the paper that kicked off NLP in finance, see [Loughran and McDonald, 2011].
  - Entity identification: NLP can extract entities from textual information, such as suppliers, customers, or competitors, thereby enriching Quant's understanding of a company's competitive landscape.

From above, we see that technology has increased quants' capability to drive better investment decisions. However, careless application of these advanced techniques will likely not result in better *out-of-sample* performance, but rather in disappointment. One of the major concerns of quantitative investing is the problem of overfitting. Given the very high degrees of freedom inherent in these new techniques, this problem (and other such as look ahead bias, etc.) are even more exacerbated. Furthermore, finance is inherently different from other disciplines for which ML and NLP have excelled as the financial market is adaptive, non-stationary, and not always rational. All this is to say caution, common sense, domain knowledge must be exercised when applying these novel approaches to finance. For common pitfalls associated with financial ML and NLP, and practices to mitigate some of these issues, see [Chen and Zhou, 2023].

Next, we switch to see how technology changes and potentially benefits fundamental investing.

TECHNOLOGY'S IMPACT ON FUNDAMENTAL INVESTING

Although historically, fundamental investors have been less reliant on technology than their quantitative counterparts, technology's advances have been too dramatic to ignore. Fundamental investors have increasingly integrated technology into their investment process in recent years. This trend becomes increasingly prevalent with the advent and popularization of advanced AI technology, particularly NLP.

Fundamental investors can derive all three advantages from incorporating advanced technology into their investment process[2]: faster speed, broader sources of information, and better information processing. The main limitation of the fundamental investment process is that it is mainly dependent upon human investors, who get tired, have limited attention spans, have their own biases and idiosyncrasies, and cannot easily scale. Some of these limitations can be overcome by coupling human investors with technology. For example, by using LLMs, summaries of large amounts of news articles and analyst reports are now possible, allowing human investors a quick overall grasp of an investment topic, current market conversations and trends, or nuanced political developments. If the human investor finds

a particular point in the summary interesting or critical, he or she can then spend more time drilling down into the details, but now with much better direction of what to look for.

In addition to broader information sources and better information processing to help alpha idea generation, technology can also help fundamental investors scale in building various customized portfolios demanded by large institutional asset owners by leveraging optimization techniques, measuring risks associated with the various portfolios under management, or executing trades better with lower costs and market impacts. Figure 4 below gives more examples of where technology can enrich the fundamental investment process.

Similar to the quantitative investment section above, a few words of caution for technology's application to fundamental investment is warranted as well. Specifically, superficial application of advanced techniques mentioned here likely will not result in superior performance. One reason for this is that financial markets are adaptive. Much like the algorithms discussed here, markets also learn. If most fundamental investors apply these algorithms in a similar manner on the same set of securities, it is unlikely that there will be much alpha to be extracted. Even worse than not extracting alpha, superficial application of these advanced techniques could potentially get investors in trouble. Since these algorithms are trained on their input data, they also exhibit the same bias, prejudice, and blind spots their training data exhibits. To avoid potential troubles, it is essential for the fundamental investor to have a good grasp of the technology they deploy, the data based on which it is trained, its strength and weaknesses and the suitability for task upon which it is deployed.

TECHNOLOGY'S IMPACT ON NON-INVESTMENT PROCESSES: EFFICIENCY AND SCALE

Asset management is not solely comprised of investing; other functions such as sales and marketing, client servicing and reporting, risk management, operations, legal and compliance, sustainability and stewardship, etc., are all essential functions within an asset manager. When integrated thoughtfully, technology holds the promise to improve efficiency and increase scalability for all of these functions. Given the relentless margin pressure under which asset managers operate and the asset management industry is characterized by high operational leverage and economy of scale, there is a great incentive to incorporate technology to both reduce cost and increase scale. We now look at a few examples where technology can be thoughtfully incorporated to improve non-investment-related operations.

Sales and account management is the ultimate job where human-to-human relationships and connections are critical. Even in this function, technology can be incorporated to make the process better. For example, a salesperson needs to prepare insights into the client and associated talking points before each meeting. Perhaps he or she needs to anticipate where the conversation could go and prepare for potential solutions to the client's problems. Training LLMs on meeting notes from previous client interactions can surface insights into a client's needs and challenges and highlight them to the salesperson as they prepare for the meeting. AI techniques can elevate digital sales, e.g., lead generation and lead qualification, allowing more focused sales efforts towards prospects with a higher probability of converting. This is pertinent for small and mid-sized asset

Figure 4
Steps in the fundamental investment process and how technology can augment them

Security Screening (Idea generation)	Company Research	Portfolio and Risk Management	Trading and Execution
• Algorithms used to systematically screen opportunities particularly on the stort side (e.g., scanning for the use of certain words in sell-side analyst reports which data scientists have found to be correlated with good shorts) • More companies screened with more sophisticated algorithms • More data inputs including traditional (e.g., cash flows, profitabilty and alternative (e.g., satelite data, credit card data) • More internal systems to share ideas across teams	• Integrated approach across fundamental research and data science teams • Dedicated data sourcing activity covering new sources • More new data inputs to fundamental analysis • Platform and tools to run custom data analysis to support or challenge investment case • Unique information collected over many ears turned into quant data inputs (e.g., management quality) • Pure data model based valuation as a cross-check on fundamental valuation	• Complex portfolio risk attribution and scenario modelling • Fully automated position sizing and portfolio optimisation based on upside/downside, stock correlations and exposures (beta, sector, style, geography and liquidity) • More accurare measures of true idiosyncratic alpha (i.e., stripping out factor effects) • PM/Trader capital allocation models yied tot alpha size and volatility • PM performance analysis (vs. performence of all analyst recs), with compensation based on alpha (rather than pure P&L) relative systematic quantification of opportunity set and exposures	• Automated trading based on results of optimisation process • Connection to multipe platforms to ensure best execution • Short term event driven trading models to size positions (e.g., trading around corporate earnings events)

Source [Miranda, 2018]

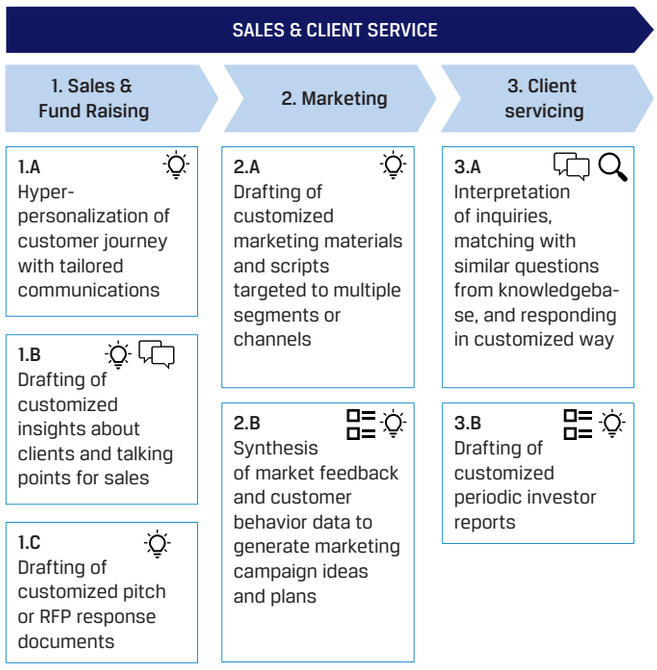
managers that do not have the salesforce of larger peers, as it allows them to punch above their weight class.

After clients are acquired, they must be serviced. For an account manager with a large and diverse client base, some accounts may need relatively routine services, while others may have more unique needs and require individualized attention. Clustering techniques from machine learning can be used to group clients by various attributes. These client groups can then be further analyzed for common investment solutions each group typically utilizes, how each group can be serviced to maximize effectiveness, etc. For clients with mostly routine requirements, technologies such as GenAI can be used to service many of their needs, freeing up account managers to focus on clients with bespoke needs.

Below, we list a few more examples of how technology can improve non-investment-related asset management operations. Additional use of technology to enhance existing sales and marketing processes can also be found in Figure 5:

- Client Q&A can be made quicker by training bots to answer commonly asked questions, taking clients' holdings and their related market developments and news into account. Reporting can also be generated similarly.
- Requests for proposals (RFPs): LLMs can be trained on previous RFPs to answer questions in the firm's unique style, discussing the firm's strengths and differentiating points, etc.
- For compliance, various detection algorithms can be run for trade surveillance (e.g., to detect suspicious trading behavior), communication monitoring (e.g., to detect policy violations or potential misconduct), etc.

Figure 5
Additional use of tech to improve sales and marketing processes within investment management



Source: Oliver Wyman
Note that no technology is 100% accurate and foolproof, and errors, omissions, or incompleteness are likely regardless of how advanced the deployed technology is. Thus, it is important to still have "human-in-the-loop" in these processes. However, when deployed correctly, technology can dramatically cut down on human time and labor, thus increasing efficiency, lowering cost, and increasing scale.

HOW TO ENSURE SUCCESSFUL TECHNOLOGY ADOPTION AND UPSKILLING?

The deployment of technology into the various asset management processes is all good and well, and most people can see the logic behind how this can benefit the clients and the business itself. The more critical and challenging question is how? Given that asset managers already have established processes in place and people in the asset management industry are already busy during the day with their assigned responsibilities, how can employees have the time and motivation[3] to learn new skills, figure out where efficiency can be gained, and re-engineer their day-to-day processes? These questions are difficult and necessary to get right if technology is to be successfully deployed and benefits from it reaped. Change management is a field in itself, and we refer the interested readers to read, for example, [Westerman and Bonnet, 2015]. Needless to say, senior management must take the lead here to drive this change. Below are some high-level suggestions on how to drive this transformation:

- Motivate why incorporating technology is necessary. Demonstrate the upside of more technological inclusion: employees can offload more repetitive work and focus more on high-value tasks.
- For each functional group, assign technology champions and create free time for people to experiment with new technology.
- Celebrate wins, disseminate lessons learned, and normalize failure as part of the process.

POTENTIAL FUTURE EVOLUTIONS: FROM EFFICIENCY TO INTELLIGENCE

In this article so far, the astute reader will have noticed that technology is used for relatively mechanical tasks to increase efficiency. Could it be possible that in the (near) future, technology evolves to a stage where it can be used for its intelligence? The concept of Artificial General Intelligence (AGI) has been a dream of technologists since the mid-20th century, and it is outside the scope of this article to discuss whether it'll happen or not, and if so, how soon. However, we postulate some investment functions that humans currently carry out, but we believe they could be possible, either augmented or replaced by technology, in the (near) future.

First, looking at quant investing. Researchers and PMs are the primary drivers of investment ideas and portfolio position adjustments. In the (near) future, it may be possible for technology, in this case LLMs or other forms of AI, to generate research ideas or recommend adjustments in portfolio positions. An AI may generate research ideas by getting an understanding of a quant strategy's alpha model, understanding where improvements in the model can be made by scanning known finance literature and market materials[4] and compare its knowledge with the current quant model to suggest new research directions based on its identified model deficiencies. Similarly, it may analyze a portfolio's holdings. Based on its understanding of

the holdings and how each has typically reacted historically under different market regimes and types of market news, combined with the latest market development, to suggest changes in the securities held. In both scenarios, human quant investors go from being direct drivers of research and portfolio positioning to becoming more akin to supervisors of AI algorithms.

Perhaps fundamental investment managers would not like to give technology such prominent and direct driving roles as in quant investing. However, for this investment style, technology could still replace or at least augment some functions currently conducted by humans. For example, fundamental investment teams typically comprise portfolio managers and analysts. Analysts would propose the bull and bear cases for each security they cover, and portfolio managers would decide to go overweight or underweight based on these analyst cases. One challenge for analysts is the number of securities they can cover. By leveraging AI, one may train it to behave like analysts and generate bullish and bearish cases for securities in an extended investment universe, thereby expanding a strategy's investment opportunity set.

CONCLUSION

This article discussed how advanced technology, driven by data, computing, and algorithms, has impacted the investment industry. Truth be told, this isn't a recent phenomenon, and the investment industry, along with all other human economic activities, has evolved and changed along with technological advancements. At the dawn of the "age of AI", technology's capability seems to become ever more powerful and its promise ever more tantalizing. For investment managers, it has the promise to expand its alpha extraction capability, increase its scale, and/or lower its cost. The use cases described here are rather general and high-level, as each investment manager's specific case for technology incorporation differs. Hopefully, this article clarifies that for those managers wanting to stay at the forefront of the investment industry, leveraging technology is not a luxury but a necessity.

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Notes

1 Specifically, the original Moore's Law, stated in 1965, states the number of transistor on a chip doubles approximately every year for the next 10 years. In recent decades the number of transistors on a chip doubles roughly every 2 years.
2 Versus the two advantages quantitative investors derived: broader information sources and better information processing.
3 The motivation piece here is critical. Most people's first reaction, upon hearing more technology is to be deployed into their daily work processes, is to fear for their job security.
4 Such as analyst reports, financial news, etc.

Technologische breinbrekers voor waardering

De versnelling in de ontwikkeling én adoptie van nieuwe technologieën stelt beleggers anno 2025 voor steeds meer uitdagingen. Niet in de laatste plaats omdat technologie steeds meer invloed heeft op het opereren van financiële markten zelf en op het type assets waarin belegd wordt. Dat stelt beleggers steeds weer voor die eeuwenoude, essentiële breinbreker: wat en wie bepaalt de waarde van beleggingen?

Snellere en meer volledige prijsvorming is een eerste effect van de nieuwe technologische ontwikkeling. Beleggers hebben minder tijd om na te denken over de betekenis van nieuwe informatie. Door de hedendaagse digitale infrastructuur vloeit informatie vrijwel continu met de snelheid van het licht naar alle uithoeken van de wereld. Kwartaalcijfers, sentimentsindicatoren en de gedachtenkronkels van menig politicus zijn wereldwijd kenbaar slechts seconden na publicatie. Dat betekent dat deze informatie ook direct kan worden meegewogen in de prijsvorming van beleggingen. En dat gebeurt ook.

Waar het gaat om macro-economische of bedrijfs-financiële data is dit onderdeel van de efficiëntie van markten. Nieuwe informatie wordt meegenomen in de financiële vooruitzichten van bedrijven en overheden en daaruit volgt een nieuwe prijs voor de beleggingen. Niets nieuws. Maar met de opkomst van sociale media is er een nieuw fenomeen ontstaan. Beleggingsinzichten worden vandaag de dag ook binnen grote groepen beleggers op sociale media gedeeld. Op basis van de beeldvorming binnen deze groepen worden op grote schaal posities ingenomen of weer verkocht. Daarbij fungeren deze groepen steeds vaker als 'echo chambers' waarin een bepaalde kijk op een belegging snel de overhand kan krijgen. Terwijl de ruimte voor onafhankelijke 'fact checkers' of andere financiële informatie beperkt lijkt. Tel daarbij op dat een groot scala aan apps dat beleggers eenvoudig laat handelen op tal van verschillende markten. De prijs van beursgenoteerde-aandelen wordt daarmee steeds nadrukkelijker ook beïnvloed door de beeldvorming op sociale media.

Dat dit voorvreemde effecten kan zorgen is duidelijk. Een in het oog springend voorbeeld is het aandeel Gamestop. Dit bedrijf richt zich op de verkoop van spelcomputers en aanverwante apparatuur en games. Door de toenemende digitalisering liep de verkoop al enige tijd terug en bevond het zich anno 2021 in zwaar weer. Het was daarom niet verwonderlijk dat een aantal hedge funds een shortpositie had ingenomen. Op sociale media kreeg men echter lucht van de grote short positie en ontstond een beweging om *en masse* het aandeel op te kopen. Een *short squeeze* was het resultaat, waardoor het aandeel in kort tijdsbestek bijna verdertigvoudigde.

Daarbij wordt nadrukkelijk een grijs gebied betreden. Een gebied waarin op korte termijn 'hype' wordt gemaakt om markten snel een kant op te laten bewegen. Traditionele economische en financiële argumenten lijken hierbij regelmatig van ondergeschikt belang. Dus hoe weeg je als belegger dergelijke informatie in de waardering? Welke rol kunnen toezichthouders vervullen in het effectief aanpakken van 'pump & dump' praktijken? En wat te doen als de 'hype' niet wordt gecreëerd door relatief obscure finfluencers, maar door de Amerikaanse president? In de aanloop naar zijn inauguratie lanceerde Donald Trump de $TRUMP cryptovaluta. Een munt die snel in waarde toenam na lancering. Goed voor een winst van tientallen miljoenen.

Het vraagstuk wordt allemaal nog ingewikkelder door de opkomst van AI-bots. Onlangs waarschuwden onderzoekers voor het risico dat AI-bots de markt (onbedoeld) manipuleren. Dit zou kunnen gebeuren door AI-bots op sociale media een bepaalde populaire *story line* over een aandeel verder verspreiden. Doordat deze bots vooral kijken naar wat het goed doet in het algoritme kunnen geruchten zich versterken en al snel opblazen tot immense proporties. AI-bots op handelsplatformen kunnen deze informatie vervolgens interpreteren als een koopsignaal om een positie in te nemen. Het gevolg is een verdere stijging die weer andere beleggers aantrekt. Gaat het in dit geval dan nog om een efficiënte markt? Of juist een die wordt verstoord door AI-ruis?

Duidelijk is dat met de huidige technologische ontwikkelingen ook de vraag wat de waardering van beleggingen drijft steeds sneller lijkt te veranderen. Steeds slimmere modellen kunnen sneller grotere hoeveelheden data analyseren om tot de 'juiste' waardering te komen. Het risico hierbij is dat dezelfde technologie ook steeds sneller op financiële markten in relatie staan tot de economische realiteit. Wat kunnen toezichthouders doen? Waarschuwen (naming & shaming), handhaven en het publiceren van nieuwsbronnen die als betrouwbaar te boek staan. En beleggers? Naast alle artificiële intelligentie zorgen dat er ook gebruik wordt gemaakt van wat ouderwetse, menselijke wijsheid.

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Unlocking Alpha from Textual Data

PRACTICAL INSIGHTS FOR INSTITUTIONAL INVESTORS USING LARGE LANGUAGE MODELS

Machiel Westerdijk, Olivera Rakic and Ashraf Mansur

INTRODUCTION: BEYOND THE AI HYPE – PRACTICAL ALPHA FROM TEXTUAL DATA

The asset manager's competitive landscape has intensified, and traditional investment factors – such as value, momentum, and quality – are increasingly well-understood, resulting in diminished returns (e.g. McLean & Pontiff, 2015; Calluzzo, Moneta, & Topaloglu S., 2019; Jacobs, Kenneth, & Lee, 2025).

One promising yet still underutilized source of alpha lies in textual data (e.g. see review by Sun et al. 2024). While traditional investment strategies rely on structured financial data, a vast amount of valuable and complementary information remains hidden within unstructured textual sources, such as annual reports, patents, earnings calls transcripts, and employee reviews.

Until recently, systematically leveraging these textual sources for investment signals remained impractical, due to technological and infrastructural limitations.

The rapid advancement of Large Language Models (LLMs) – AI systems capable of deeply understanding and interpreting human language – has changed this. LLMs now offer asset managers a powerful means of systematically extracting and quantifying insights from massive textual datasets. Leaders in the AI space, such as Open AI, Alphabet, and Anthropic, offer the most advanced models through developer-friendly interfaces, making it straight-forward to start experimenting with. While the transformative potential of LLMs is often discussed in broad terms, practical implementation in investment processes requires clear understanding, specialized expertise, and robust infrastructure.

While institutional investors must also navigate critical aspects such as ESG, sustainability, and risk management, this article focuses exclusively on identifying and capturing alpha in publicly traded equity markets using AI. We highlight academic evidence supporting alpha generation from textual data, discuss practical aspects of integrating textual signals into existing investment strategies, and address important AI-related risks and mitigation techniques. A practical case study further demonstrates how advanced peer group detection (AI-TNIC) significantly enhances traditional momentum strategies, delivering measurable alpha.

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Head of Quant Products at Entis

Crucially, we provide practical guidance for translating academic insights into actionable investment strategies, emphasizing robust infrastructure, disciplined risk management, and strategic considerations around internal versus external development of signals, to help institutional investors effectively position themselves for sustained and differentiated performance.

ALPHA POTENTIAL FROM TEXT DATA – EVIDENCE AND TYPES OF SIGNALS

Traditional quantitative strategies have historically relied primarily on structured financial data – standardized, machine-readable numbers such as financial statement line items, market prices and volumes, and accounting ratios – capturing only a small fraction of all available company information. Information about companies that is less likely to be priced in, however, is qualitative and embedded in textual data – e.g. corporate filings, patents, analyst reports, employee reviews – which had limited usage in systematic investment processes due to the high information processing and data quality management barriers. Recent advancements in LLMs have revolutionized this, enabling automated, large-scale extraction of alpha-generating signals from unstructured text data.

ACADEMIC EVIDENCE OF ALPHA FROM TEXTUAL DATA

Academic research confirms the alpha potential of signals derived from text data across several critical investment domains:

- Innovation and Patents: Patents predict long-term market leadership.
- Peer and Network Effects: A firm's strategic network positioning predicts competitive advantage and stock returns.
- Governance Quality: Consistent governance disclosures predict stock outperformance.

Table 1 summarizes key academic findings.

In addition to being used as idiosyncratic sources of alpha, the above described NLP-derived textual signals can also significantly enhance traditional factor-investing approaches by capturing insights into innovation, governance, and corporate culture. Table 2 highlights some opportunities.

Table 2

Factor	Textual Signal Enhancements
Value	Improved peer benchmarking, intangible asset valuation (patent quality)
Momentum	Narrative-driven sentiment, refined industry momentum via semantic peer identification
Quality	Governance credibility, innovation strength, corporate culture
Low Volatility	Early detection of hidden risks, crisis management clarity
Size	Enhanced small-cap coverage via niche textual sources
Investment	Capital allocation clarity, R&D direction, sustainability alignment
ESG	Real-time ESG risk detection, corporate ethics, and culture benchmarking

In summary, LLM-derived textual signals represent a transformative new source of alpha, complementing traditional factor strategies. Additionally, although annual reports and patents are public, the high information processing barrier limits adoption and slows alpha decay.

INCORPORATION IN INVESTMENT STRATEGIES

Having established the alpha potential of AI-derived textual signals, the next step is to consider their integration into existing investment processes. Practical implementation requires clearly defined selection criteria, adjustments to portfolio construction processes, and awareness of infrastructural implications. Below,

Table 1

Signal Category	Key Insight	Reported Alpha (bps/month)
Peer & Industry Similarities (e.g. Hoberg & Phillips 2016, 2018)	Highlights a company's position within its competitive landscape by analyzing similarities in business models, market focus, and risk profiles.	70–97
Governance Quality (e.g. Fee, Li, & Peng 2022, Martin, Xu, & Zhou 2021)	Assesses impact of management stability, compensation policies, and governance practices on expected returns.	30–55
Strategic Networks (e.g. Eisdorfer et al. 2022)	Identifies strategic partnerships, and competitor network connections that influence competitive advantage and market positioning.	70–90
Qualitative Disclosure Shifts (e.g. Cohen, Malloy, & Nguyen 2020)	Evaluates shifts in company disclosures, their causes, and their impact on expected returns.	48–70
Communication Discrepancies (e.g. Zhang 2024)	Examines gaps between qualitative statements and quantitative financial metrics to detect potential misalignments.	48–55
Innovation & Technology (e.g. Drechsler, Müller, Wagner 2021, Kim 2022)	Measures a company's focus on emerging technologies and its ability to innovate, indicating future growth potential and industry leadership.	20–80
Corporate Culture (e.g. Au 2019)	Analyzes employee reviews to evaluate company's culture, such as teamwork and integrity as key drivers of long-term performance.	30–76

Note: The alpha estimates listed above are based on academic studies and should be interpreted with care. These results are typically derived from idealized backtests using clean historical data, and do not account for real-world frictions such as trading costs, turnover, slippage, or capacity constraints. Furthermore, the signal categories are not mutually exclusive and often exhibit significant correlation, meaning the reported alpha values cannot be assumed to be additive in a portfolio context.

we provide a structured approach for incorporating these signals into both quantitative and fundamental investment strategies.

SIGNAL SELECTION AND VALIDATION

Given the abundance of possible signals derived using LLMs, investment teams must first prioritize signals based on robust statistical evidence, economic rationale, and incremental predictive value beyond traditional metrics. Standard quantitative validation methods such as historical backtesting, forward testing, and out-of-sample validation apply equally to these textual signals. The goal is not just statistical robustness, but also economic intuition: signals must reflect meaningful and understandable business realities.

PRACTICAL INTEGRATION INTO INVESTMENT PROCESSES

Integration into existing investment strategies varies significantly depending on whether the approach is quantitative, fundamental, or a hybrid "quantamental" method.

> NLP-DERIVED TEXTUAL SIGNALS CAN BE USED AS IDIOSYNCRATIC SOURCES OF ALPHA, BUT ALSO TO ENHANCE TRADITIONAL FACTOR-INVESTING APPROACHES

For purely quantitative strategies, the incorporation of LLM-generated textual signals is relatively straightforward once signals have been validated (see Figure 1). These signals typically come as numerical scores – such as governance quality ratings or innovation intensity metrics – similar in structure to traditional quantitative factors like value or momentum. Portfolio managers can directly integrate these scores into factor models or predictive algorithms, enhancing predictive power and portfolio diversification.

A crucial practical step is assessing interactions between new textual signals and traditional factors. Portfolio managers should explicitly test how the introduction of textual signals affects existing factor exposures, ensuring diversification benefits and avoiding unintended biases.

For fundamental or quantamental strategies, textual signals serve primarily as systematic decision-support tools. They provide structured insights into qualitative aspects such as corporate culture, strategic innovation, or peer comparability. Analysts integrate these signals into their investment analyses to sharpen conviction levels, identify hidden risks, or reassess valuations.

A clear example is the textual signal capturing digital innovation (e.g. Drechsler, Müller, Wagner 2021). Using LLMs, investment teams can systematically measure the degree of digital innovation by comparing corporate filings to a carefully constructed textual benchmark describing the concept of "digital innovation." This method yields a quantitative digital innovation score ranging from 0 to 1. Practically, such a score allows quantitative managers to construct straightforward long-short portfolios, for example, by taking long positions in companies ranked in the top 20% and short positions in those ranked in the bottom 20%. Alternatively, fundamental or quantamental analysts integrate this digital innovation score as part of a quality assessment, improving their evaluation of competitive advantages and strategic resilience.

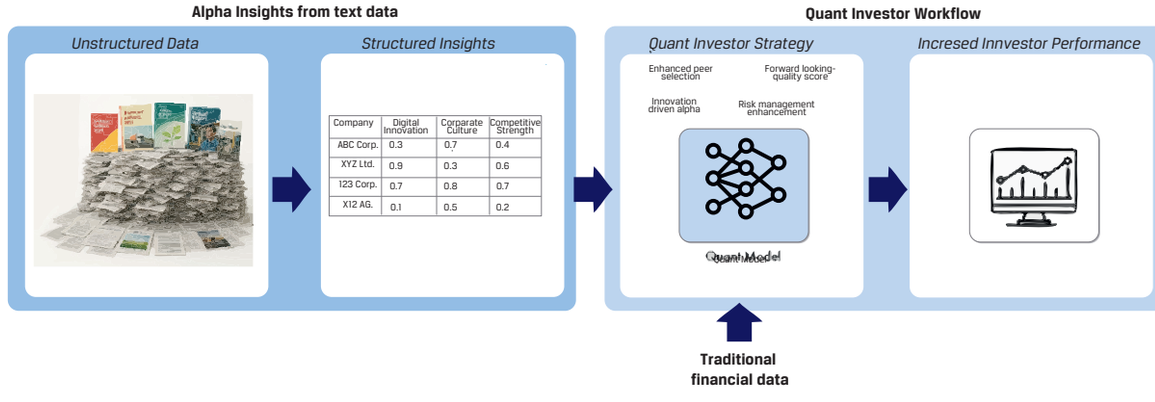
EXTERNAL PROCUREMENT VS. IN-HOUSE DEVELOPMENT OF SIGNALS

The practical considerations of incorporating textual signals depend greatly on whether these signals are externally procured or internally developed.

Procuring AI-derived textual signals from specialized external providers simplifies practical implementation considerably. Platforms like Neudata and Eagle Alpha provide overviews of data providers in this space. NLP-based quant signals can be acquired either directly from data producers such as Entis, or through data aggregators such as Quandl.

Such signals typically arrive as structured numerical data that easily integrate into existing investment workflows without major operational adjustments. Asset managers can choose between standardized 'off-the-shelf' signals or custom-developed signals tailored exclusively to their specific strategy and investment universe. Off-the-shelf signals typically offer cost efficiency, ease of integration, and rapid deployment. Tailored signals, although more expensive, provide strategic differentiation, enhanced

Figure 1
Incorporation of insights from textual information in the quant investor's workflow



alignment with investment objectives, and potentially stronger and more durable alpha due to reduced availability to competitors.

Conversely, internal development requires substantial infrastructural investment and deep technical expertise. Processing tens of thousands of corporate documents globally on a daily basis, including historical records spanning decades, demands specialized infrastructure for text extraction, automatic translations, bias corrections (e.g., correcting country-specific language nuances), and rigorous validation processes. While the technical complexity is considerable, the primary advantage is the potential for stronger alpha due to exclusive signal ownership, enhanced customization capabilities, and deeper strategic alignment.

BUILD OR BUY DECISION DEPENDS ON STRATEGIC OBJECTIVES, ALPHA EXPECTATIONS, AVAILABLE RESOURCES, AND DESIRED COMPETITIVE DIFFERENTIATION

Ultimately, the choice along this spectrum – from standardized external signals through customized outsourced solutions to fully internal development – depends critically on strategic objectives, alpha expectations, available resources, and desired competitive differentiation.

HUMAN-IN-THE-LOOP VALIDATION AND RISK MANAGEMENT

Regardless of the chosen integration route, "human-in-the-loop" validation is critical to the practical success of using AI-generated signals. While automated extraction of information continues to improve with each new generation of NLP and LLM tools, a small fraction of cases will inevitably require manual intervention to ensure the quality needed for trading models. For example, when extracting business descriptions from annual reports (needed for the computation of the AI-TNIC signal described below), in many cases filings are well structured and models can accurately extract the correct pieces of text. But in a non-negligible fraction of cases filings have a very irregular, free-format structure, and business descriptions could be mistaken with e.g. CSR disclosure, making it important to have an analyst manually review high-risk cases. Therefore, infrastructure that facilitates human oversight and allows analysts to manually correct or refine lower-quality outputs remains essential.

MANAGING AI RISKS IN PRACTICE

Generative AI models, particularly LLMs, offer powerful capabilities for interpreting textual data. Yet, institutional investors must approach their use cautiously due to inherent risks. Effective risk management practices are essential, given regulatory demands and the high standards of transparency and accountability expected from institutional investors.

KEY AI RISKS

When employing LLMs, four primary risks need explicit attention:

- **Transparency (the "black box" problem):** LLMs are inherently opaque, making it difficult to precisely trace how inputs lead to specific outputs. Unlike traditional quantitative models with clearly defined formulas, the reasoning within LLMs is challenging to interpret.
- **Biases:** Biases may originate directly from the LLM training data, causing the model to produce systemic errors. Additionally, biases can emerge from the LLM itself, through the selection of input texts provided to the model. For example, when consistently evaluating texts about digital innovation from specific countries or sectors, the resulting scores may reflect unwanted country- or sector-specific textual characteristics rather than genuine innovativeness.
- **Unintended use of prior knowledge and forward looking bias:** LLMs are trained on years of historical data, which poses a challenge for backtesting trading strategies. If an LLM model is to analyze a news item that lies inside its training window, it already "knows" what might have happened next in the real world, so any forecast it gives might be contaminated by hindsight (e.g. Glasserman & Lin 2024).
- **Hallucinations:** Hallucinations occur when LLMs produce plausible yet entirely fabricated responses. This can significantly compromise data integrity and lead to erroneous investment signals.

PRACTICAL RISK MITIGATION STRATEGIES

While a complete overview of all available methods goes beyond this article, practical risk mitigation generally revolves around two core principles: input control and output validation. Effective risk management begins with careful preparation and standardization of the input texts provided to LLMs. Treat the model as a highly intelligent analyst, explicitly instructing it to objectively interpret only the provided texts without using prior knowledge. Practical measures include:

- Removing company, product, and person names to prevent forward-looking biases, ensuring the model evaluates texts based purely on their content at a specific historical moment (time stamping).
- Providing clear, informative prompts and relevant textual sections to minimize hallucinations. Additionally, embedding-based methods (converting texts to numeric vectors) are inherently deterministic and do not lead to hallucinations.

Rigorous validation of the model's outputs is equally essential. Practical validation methods include:

- Statistical anomaly detection to identify unusual or inconsistent signals,
- Cross-validation with the same model, independent models, or simpler baseline methods to confirm the consistency and accuracy of generated scores,

- Checking the output against the ground-truth data, e.g. labeled by analysts,
- Correcting structural biases directly in numeric outputs (embeddings) to eliminate subtle but systematic distortions.

These methods can be partially automated, although human involvement and judgement is still necessary at the moment. However, one area that is gaining traction is Agentic AI, which holds promise of enabling further automation of extracting quant signals from large textual sources, by chaining specialized LLM workers into an auditable and modular full signal pipeline.

PRACTICAL RISK MITIGATION WHEN USING AI GENERALLY REVOLVES AROUND TWO CORE PRINCIPLES: INPUT CONTROL AND OUTPUT VALIDATION

It is important to note that internal biases originating from an LLM's training data typically pose fewer challenges when models are used primarily for semantic interpretation rather than factual knowledge retrieval. Regular model evaluation and periodic fine-tuning remain important, but primary bias mitigation efforts are best directed toward careful input selection, preparation, and embedding-based adjustments.

CASE STUDY – ADVANCED PEER GROUP DETECTION WITH AI (AI-TNIC)

This chapter provides a concrete illustration of how LLMs can practically generate alpha by improving peer group identification, which can be used for any application that relies on industry classifications. Specifically, we focus on enhancing a well-known factor investing strategy: peer momentum.

WHY BETTER PEER IDENTIFICATION MATTERS FOR ALPHA

Peer momentum, a proven alpha-generating factor, captures the tendency of stocks to follow trends observed in related companies. Traditional peer momentum typically relies on standard industry classifications, which are rigid and often fail to identify all genuine company peers. A more accurate method – introduced by Hoberg & Phillips (2016) through their Text-based Network Industry Classification (TNIC) – uses business descriptions from company filings to capture similarities between companies that are often missed by traditional industry classifications. However, their initial method is limited, as it simply matches words without considering their context. For example, their approach might mistakenly identify the fashion company Ralph Lauren and toy manufacturer Hasbro as close peers because they share common terms such as "brand," "design," and "marketing," despite using these terms in entirely different contexts.

LEVERAGING LLMS FOR CONTEXTUAL UNDERSTANDING

To address this limitation, Entis developed AI-TNIC, an advanced approach leveraging LLMs to capture deeper semantic context and meaning within business descriptions. By transforming texts into numerical embeddings, AI-TNIC accurately identifies truly relevant peers across the global company landscape.

However, applying general-purpose LLMs effectively to financial texts requires specialized pre- and post-processing methods. Table 3 briefly summarizes our practical solutions.

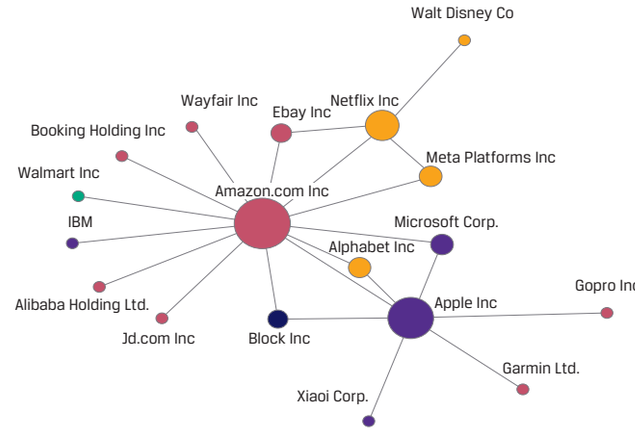
Table 3

Limitation of standard LLMs	Our Solution
Text documents too long	Split text into smaller chunks to preserve meaningful context
Broad general context of embeddings	Emphasize specific business content through embedding adjustments
Geographical bias in embeddings	Remove geographic references and correct country-specific biases
Uninformative or overly formatted texts	Identify and filter out irrelevant text through pre-defined rules

PRACTICAL ALPHA GENERATION: PEER MOMENTUM WITH AI-TNIC

Using AI-TNIC, we constructed an improved peer momentum factor based on the insight that market-relevant information about similar companies moves more slowly across less obvious peer relationships (Hoberg & Phillips 2018). This improved identification of peers results in stronger and more consistent alpha generation compared to traditional industry momentum strategies. For example, traditional industry classifications do not consider Amazon and Netflix as direct peers, despite both competing directly in the video streaming market. Figure 2 illustrates how the AI-TNIC approach correctly identifies this competitive relationship.

Figure 2
According to traditional industry classifications, Amazon and Netflix are not peers, but they compete in the video streaming space – TNIC captures this



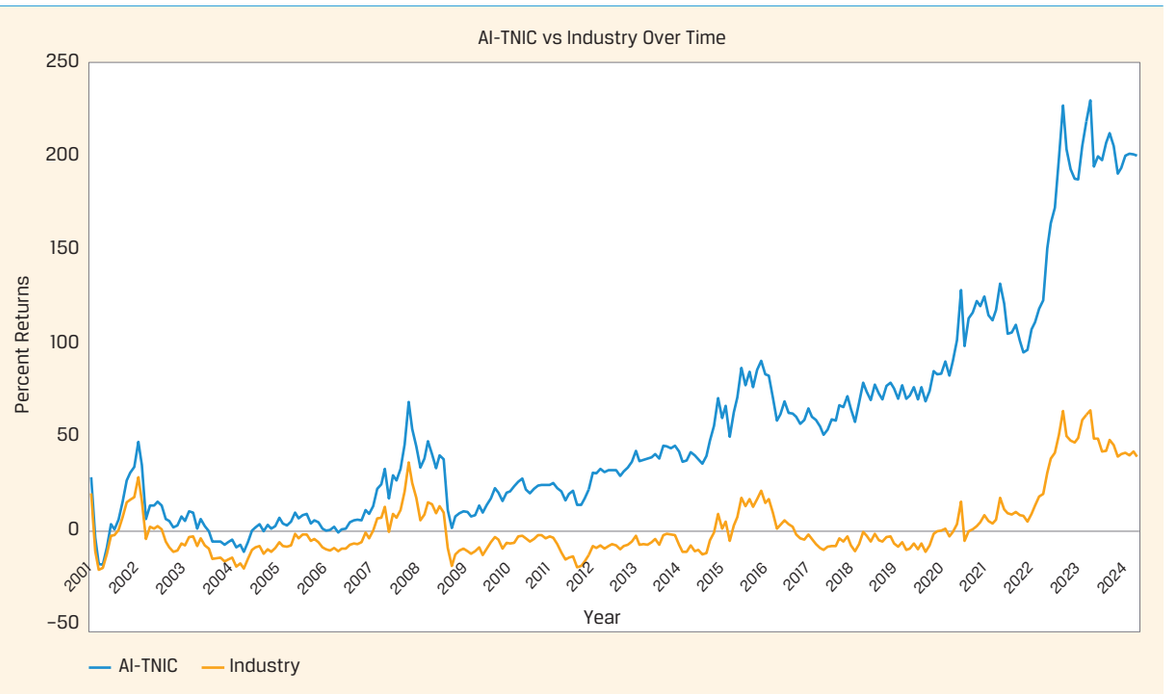


Figure 3
Cumulative Long-Short Performance of AI-TNIC Industry Peer Momentum compared to standard industry classification momentum (2001-2024)

BACKTESTING RESULTS

We applied AI-TNIC peer momentum to a universe of approximately 2,500 U.S. equities (equal-weighted), achieving robust and consistent outperformance. The figure below illustrates the long-term performance of this factor from 2001 to 2024, with cumulative returns exceeding 200% (approximately 5% annualized). Moreover, the AI-TNIC factor experiences similar but less severe drawdowns compared to using standard industry classifications, making it a stable alpha source in volatile markets.

Quantitative analysis in Hoberg & Phillips 2018 using the Fama-French three-factor model indicates a statistically significant monthly alpha of 88 basis points (t-statistic = 2.78) based on a data sample from 1997-2012. The figure above covers a longer time period, through 2024, demonstrating that TNIC-based signals have not yet been arbitraged away. Additionally, TNIC-based signals have high information processing and data quality management barriers so that limits adoption and slows alpha decay. Regarding signal turnover, it is on average 150% annually (two-way), which is comparable to the turnover of traditional momentum strategies. Please note that this analysis does not account for trading costs, slippage, or capacity constraints.

CONCLUSION: AI INSIGHTS BEYOND HUMAN CAPABILITIES

AI-TNIC demonstrates that LLM-driven alpha generation is feasible, and that it provides insights beyond human capability. While analysts traditionally relied on broad industry classifications, LLMs allow precise, dynamic, and global comparisons of companies. This reveals previously hidden patterns of emerging global businesses, capturing subtle similarities and differences far beyond human analytical capacity. Thus, advanced LLM-driven methods like AI-TNIC represent more than a productivity improvement – they offer entirely new ways of understanding market dynamics and generating sustainable alpha.

CONCLUSION: PRACTICAL RECOMMENDATIONS FOR INSTITUTIONAL INVESTORS

This article has explored the potential and challenges of using Large Language Models (LLMs) to systematically extract alpha signals from textual data, for investors looking to uncover new, differentiated sources of alpha.

Achieving robust alpha from text-based signals requires more than simply deploying advanced AI models. It demands disciplined implementation, specialized infrastructure, and rigorous risk management. Based on the insights shared in this article, we offer institutional asset managers the following practical recommendations:

1. **Prioritize Robust Infrastructure with Human Oversight:** Combine automated text processing pipelines with structured human validation processes. This ensures efficiency while maintaining transparency and compliance, and allows for manual data corrections where needed.
2. **Start Small, Then Scale:** Begin with carefully controlled proof-of-concept implementations that allow you to test signal validity, infrastructure robustness, and risk management procedures in a manageable setting before scaling up.
3. **Explicitly Address AI-Specific Risks Early:** Proactively manage key AI risks, including model transparency, biases, forward-looking biases, and hallucinations. Clear input preparation, embedding-based methods, and systematic output validation processes are critical for ensuring reliable, compliant outcomes.

4. **Make Strategic Choices on Outsourcing vs. In-House Development:** Carefully consider your strategic priorities, internal capabilities, and available budgets when deciding whether to develop LLM-driven signals internally or procure externally. Off-the-shelf datasets are quick and cost-effective but may offer limited differentiation. In contrast, fully internal development is resource-intensive but can yield significant alpha advantages. Intermediate approaches – such as collaborative research and co-development with specialized external providers – often offer a balance between cost efficiency and strategic differentiation.
5. **Leverage First-Mover Advantage:** Given that systematic text-based alpha signals remain underexploited, early adopters have a meaningful competitive advantage.

Sustainable alpha generation through AI and textual data is not a one-time effort but an ongoing strategic capability. Successful deployment involves methodical implementation, continuous validation, and systematic improvements to keep pace with technological advancements and changing market dynamics. Ultimately, disciplined, structured AI implementation can empower institutional investors to consistently generate differentiated, high-quality alpha well into the future.

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Ex Machina, Ex Regulatio: AI-geletterdheid bij financiële instellingen

Indira van Uyten

INLEIDING

We gebruiken het allemaal: artificiële intelligentie, oftewel AI, wordt steeds vaker in het bedrijfsleven ingezet om werkzaamheden te versnellen en te automatiseren. AI wordt gebruikt voor het schrijven van analyses, het genereren van beelden, het opstellen van artikelen en zelfs voor het screenen van sollicitaties. Deze technologie belooft efficiëntie, maar roept ook vragen op over betrouwbaarheid, eerlijkheid en verantwoordelijkheid.

Wat als de technologie die bedoeld is om te helpen, onbedoeld discrimineert? In 2014 ontwikkelde Amazon een geautomatiseerd systeem om sollicitaties te beoordelen. Het doel was om het wervingsproces efficiënter te maken door cv's automatisch te scoren. Echter, het systeem leerde zichzelf om vrouwelijke kandidaten te benadelen. Dit kwam doordat het algoritme was getraind op historische data, waarin vrouwen ondervertegenwoordigd waren in technische functies. Uiteindelijk werd het in 2018 stopgezet toen bleek dat het systeem niet genderneutraal functioneerde.

In Nederland ontwikkelde de Belastingdienst een zelflerend algoritme om fraude met kinderopvangtoeslagen op te sporen. Dit systeem gebruikte risicoprofielen gebaseerd op kenmerken zoals dubbele nationaliteit en laag inkomen. Zonder concreet bewijs werden tienduizenden ouders, vaak met een migratieachtergrond, ten onrechte als fraudeurs bestempeld. Het schandaal, bekend als de "toeslagenaffaire", bracht institutionele vooroordelen en een gebrek aan transparantie aan het licht binnen de overheid.

Deze voorbeelden onderstrepen het belang van AI-geletterdheid: het begrijpen van hoe AI werkt, welke vooroordelen erin kunnen sluipen en hoe dit invloed heeft op besluitvorming. Met de opkomst van AI in diverse sectoren is het essentieel dat organisaties niet alleen de technologie begrijpen, maar ook de ethische en juridische implicaties ervan. De incidenten met Amazon en de Belastingdienst dienen als een waarschuwing voor bedrijven om zorgvuldig om te gaan met AI-toepassingen en de data waarop deze systemen worden getraind.

Het is van toenemend belang dat organisaties ervoor zorgen dat AI op een betrouwbare, transparante en (ethisch) verantwoorde manier wordt toegepast.

Op 12 juli 2024 is de Verordening (EU) 2024/1689 betreffende artificiële intelligentie (AI Verordening) officieel gepubliceerd en in augustus 2024 in werking getreden. De AI-verordening kent een gefaseerde implementatie, waardoor er verschillende onderdelen van de verordening niet direct geïmplementeerd worden maar op een latere datum. Deze verordening markeert een belangrijk keerpunt in de omgang met AI binnen de EU. Het doel van deze verordening is het bevorderen van veilige, betrouwbare en ethisch verantwoorde toepassing van AI, zonder innovatie te belemmeren. Een belangrijk element binnen deze nieuwe regelgeving is de expliciete nadruk op AI-geletterdheid, oftewel het bewustzijn en begrip van AI bij zowel gebruikers als aanbieders.

Vanaf 2 februari 2025 gelden er nieuwe verplichtingen inzake AI-geletterdheid voor organisaties, waaronder financiële instellingen zoals pensioenfondsen en vermogensbeheerders. De AI-Verordening schrijft expliciet voor dat organisaties passende maatregelen moeten treffen om AI-geletterdheid binnen hun organisatie te bevorderen. Dit raakt niet alleen de IT-afdeling, maar alle lagen van de organisatie. In dit artikel bespreken we wat AI-geletterdheid precies inhoudt, hoe deze binnen het wettelijk kader van de AI-verordening is ingebed, en hoe financiële instellingen hier concreet invulling aan kunnen geven.

TOEPASSINGSGEBIED VAN DE AI-VERORDENING

Het toepassingsgebied van de AI-Verordening heeft betrekking op een brede definitie van een AI-systeem. De regelgeving ziet

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niet alleen op de AI-systemen zelf, maar ook op aanbieders en gebruikers ervan. Het gaat om de volgende categorieën:

- Aanbieders die AI-systemen in de EU in de handel brengen of in gebruik stellen, ongeacht waar de aanbieder gevestigd is.
- Gebruiksverantwoordelijken (gebruikers) van AI-systemen die in de EU gevestigd zijn.
- Aanbieders en gebruiksverantwoordelijken van AI-systemen die in een derde land zijn gevestigd, indien de output van het AI-systeem in de EU wordt gebruikt.

Daarnaast zijn bepaalde activiteiten en systemen uitgesloten van het toepassingsgebied. Dit betreft:

- Activiteiten op het gebied van onderzoek.
- Ontwikkeling en prototyping die plaatsvinden voordat AI-systeem in handel wordt gebracht.
- AI-systemen uitsluitend voor militaire doeleinden.

In Artikel 4 lid 5 van de AI-Verordening is opgenomen dat aanbieders en gebruikers van AI-systemen passende maatregelen moeten treffen om het niveau van AI-geletterdheid onder het personeel dat met AI-systemen werkt te verhogen. Dit vormt een duidelijke oproep aan organisaties om structurele kennisontwikkeling inzake AI intern te faciliteren.

WAT WORDT VERSTAAN ONDER AI EN WAT IS AI-GELETTERDHEID?

Voordat we ingaan op het begrip AI-geletterdheid is het belangrijk om eerst stil te staan bij wat onder AI en AI-systemen wordt verstaan. Volgens het Europees Parlement wordt AI gedefinieerd als *"de mogelijkheid van een machine om mensachtige vaardigheden te vertonen – zoals redeneren, leren, plannen en creativiteit."*

Een AI-systeem is *"een op een machine gebaseerd systeem dat is ontworpen om met verschillende niveaus van autonomie te werken en dat na het inzetten ervan aanpassingsvermogen kan vertonen, en dat, voor expliciete of impliciete doelstellingen, uit de ontvangen input afleidt hoe output te genereren zoals voorspellingen, inhoud, aanbevelingen of beslissingen die van invloed kunnen zijn op fysieke of virtuele omgevingen."*

Hierbij kan je denken aan AI dat wordt gebruikt voor analyse van ongestructureerde data, scenario analyse, portfolio monitoring, proces automatisering en compliance. Concrete voorbeelden zijn chatbots die klanten te woord staan op een website, algoritmes die voorspellen welke aandelen zullen stijgen, of tools die documenten samenvatten en analyseren.

AI-geletterdheid wordt in de AI Verordening gedefinieerd als *"vaardigheden, kennis en begrip die aanbieders, gebruiksverantwoordelijken en betrokken personen, rekening houdend met hun respectieve rechten en plichten in het kader van deze verordening, in staat stellen geïnformeerd AI-systemen in te zetten en zich bewuster te worden van de kansen en risico's van AI en de mogelijke schade die zij kan veroorzaken."*

AI-geletterdheid gaat dus veel verder dan hoe AI technisch werkt. Aanbieders en gebruikers van AI systemen moeten deze systemen kunnen begrijpen, kritisch beoordelen, op een-verantwoorde manier toepassen én ethische implicaties overzien. Organisaties moeten de volgende vragen kunnen antwoorden: *Wanneer mogen we AI inzetten? Wat zijn de risico's? Hoe zorgen we voor transparantie en uitlegbaarheid? Wie is verantwoordelijk voor de output?*

BELANG VAN AI-GELETTERDHEID

In moderne organisaties zijn AI-toepassingen steeds vaker verweven met kernprocessen: van strategische besluitvorming tot dagelijkse klantinteractie. Adequate kennis over AI stelt medewerkers op alle niveaus in staat om effectiever en efficiënter samen te werken met AI-systemen, kritisch te blijven nadenken over de gegenereerde output van deze systemen en uiteindelijk ook betere beslissingen te nemen.

DEZE TECHNOLOGIE BELOOFT EFFICIËNTIE, MAAR ROEPT OOK VRAGEN OP OVER BETROUWBAARHEID, EERLIJKHEID EN VERANTWOORDELIJKHEID

Ethiek speelt hierbij ook een grote rol. Neem bijvoorbeeld het gebruik van AI in HR-processen, zoals bij de selectie van nieuwe medewerkers. Wat als een systeem discrimineert? Hoe ga je om met een aanbeveling die niet uitlegbaar is? Wie is er uiteindelijk verantwoordelijk voor de uitkomst? Dit soort vragen raken niet alleen ontwikkelaars en aanbieders van AI-systemen, maar ook bestuurders, risk managers, compliance officers, juridische afdelingen en klantcommunicatiemedewerkers.

Kennis van AI en hoe om te gaan met de resultaten ervan, is essentieel. Dit betekent dat organisaties structureel moeten investeren in training en educatie over AI-risico's en -mogelijkheden, bewustwording creëren binnen de gehele organisatie en passend beleid moeten ontwikkelen. Alleen zo kunnen organisaties AI op een betrouwbare, transparante en ethisch verantwoorde manier inzetten.

RELEVANTIE VOOR FINANCIËLE INSTELLINGEN

Digitalisering is de afgelopen jaren een belangrijk thema geworden binnen de financiële sector. Zo was de sector de afgelopen maanden druk bezig met de implementatie van de Verordening betreffende digitale operationele weerbaarheid (DORA). Het voornaamste doel van DORA is om risico's bij het gebruik van ICT-diensten beter te beheersen waarmee de sector weerbaarder kan worden tegen cyberdreigingen.

In het verlengde van de toegenomen aandacht voor het beheren van IT risico's en verdere digitalisering van de financiële sector speelt ook AI een steeds grotere rol. AI is here to stay. Het is bij financiële instellingen inmiddels in meerdere processen in de bedrijfsvoering geïntegreerd. Enkele concrete toepassingen zijn:

- Risicomodellen: AI helpt bij het voorspellen van marktschommelingen, het inschatten van renterisico's en het modelleren van economische scenario's.

- Klantcommunicatie: chatbots en virtuele assistenten beantwoorden vragen van deelnemers, voeren gesprekken via video of chat en maken automatische samenvattingen van klantgesprekken.
- Compliance en monitoring: AI wordt ingezet voor het detecteren van ongebruikelijke transacties, het bewaken van naleving van wet- en regelgeving en het analyseren van grote hoeveelheden documentatie.

Deze toepassingen bieden aanzienlijke efficiëntiewinst en versnellen processen, maar komt ook met een duidelijke verantwoordelijkheid om zorgvuldig, transparant en ethisch met AI om te gaan.

RISICO'S VOOR DE SECTOR

Het gebruik van AI door financiële instellingen kent verschillende unieke risico's mede door hun maatschappelijke verantwoordelijkheid. Zij moeten voortdurend rekening houden met de belangen van deelnemers en klanten, wat extra zorgvuldigheid eist.
Een aantal belangrijke aandachtspunten zijn:

- Bias en discriminatie: Wanneer AI-systemen worden gevoed met historische data, bestaat het risico dat bestaande vooroordelen onbedoeld worden versterkt. Bijvoorbeeld bij klantsegmentatie of fraudedetectie. Denk hier aan het geval bij Amazon of de Belastingdienst.
- Transparantie en uitlegbaarheid: AI-modellen op basis van deep learning zijn vaak moeilijk te doorgronden doordat ze werken met complexe neurale netwerken die leren op basis van voorbeelden. Als binnen de organisatie onvoldoende kennis aanwezig is, kan dit leiden tot situaties waarin uitleg aan deelnemers, klanten of toezichthouders tekortschiet.
- Privacy en datagebruik: AI-modellen hebben vaak veel data nodig om goed te functioneren. Binnen bijvoorbeeld de pensioensector gaat het daarbij vaak om gevoelig persoonsgegevens. Het is daarom essentieel dat AI-systemen voldoen aan de vereisten van de Algemene Verordening Gegevensbescherming (AVG).
- Verantwoordelijkheid en aansprakelijkheid: Wat gebeurt als een AI-systeem een fout maakt? Wie is er dan verantwoordelijk? Het bestuur, de IT-afdeling, of de externe leverancier? Het ontbreken van duidelijke afspraken over verantwoordelijkheid kan leiden tot juridische en ethische dilemma's.

IMPACT OP DE ORGANISATIE

Het integreren van AI binnen de organisatie is niet alleen een technische uitdaging. Het raakt ook de governance en vereist betrokkenheid van meerdere onderdelen van de organisatie. Verschillende afdelingen spelen hierin een belangrijke rol:

- Bestuurders moeten in staat zijn om AI-ontwikkelingen en de bijbehorende risico's die hiermee zijn gepaard op hoofdlijnen te begrijpen om weloverwogen strategische keuzes te maken over de implementatie van AI.
- Compliance officers toetsen of AI-toepassingen voldoen aan wet- en regelgeving, zoals de AI-verordening en de AVG.
- De juridische afdeling ziet toe op de juiste contractuele waarborgen, bijvoorbeeld op het gebied van gegevensbescherming, het gebruik van data en aansprakelijkheid.
- De IT-afdeling is verantwoordelijk voor het ontwikkelen, onderhouden en monitoren van de modellen.
- Communicatie en klantenservice werken met AI-ondersteunde klantinteractie, waarbij menselijke nuance en ethisch bewustzijn van groot belang blijven.

Omdat AI meerdere lagen van de organisatie raakt, ontstaan er ook verschillende perspectieven op het gebruik ervan. Elk van deze perspectieven beïnvloedt het benodigde kennisniveau. Dit maakt het des te belangrijker om te werken met een gedeeld begrippenkader, en daar komt het belang van AI-geletterdheid het meest naar voren.

AI-geletterdheid zorgt voor een gezamenlijke taal, vergroot de kritische houding ten opzichte van AI-systemen en bevordert een effectieve samenwerking tussen de verschillende afdelingen. Het helpt organisaties om AI niet alleen technisch goed, maar ook strategisch en verantwoord te integreren.

AAN DE SLAG MET AI-GELETTERDHEID

De AI-Verordening maakt duidelijk dat AI-geletterdheid geen vrijblijvende aanbeveling is, maar een expliciete verplichting. Vanaf februari 2025 moeten organisaties maatregelen nemen om het bewustzijn en begrip van AI(-systemen) binnen hun organisatie structureel te vergroten.

Veel organisaties starten met AI-geletterdheid omdat het 'moet' van de wetgever. Maar wie verder kijkt, ziet ook de strategische waarde ervan. Een AI-geletterde organisatie maakt betere beslissingen, met meer oog voor risico's én kansen. Het voorkomt incidenten die reputatieschade opleveren, verhoogt het vertrouwen van klanten en deelnemers en stimuleert samenwerking tussen afdelingen en functies.

AI-geletterdheid is dus niet alleen een compliance-verplichting, maar ook een kans om slimmer, ethischer en innovatiever te werken.

HOE PAK JE DIT AAN IN EEN GEREGULEERDE SECTOR?

In complexe organisaties zoals financiele instellingen, bestaat geen one-size-fits-all aanpak. Elke organisatie kent zijn eigen uitdagingen. AI-geletterdheid moet daarom aansluiten bij de cultuur van de organisatie, de bestaande organisatiestructuur (governance, risk en compliance)-en de aard van de AI-toepassingen die binnen de organisatie worden ingezet. Toch zijn er duidelijke stappen en best practices te benoemen, die als stevige basis kunnen dienen voor het ontwikkelen van AI-geletterdheid.

De Autoriteit Persoonsgegevens (AP) heeft in februari 2025 een document gepubliceerd die als doel heeft om organisaties te helpen bij het ontwikkelen van een plan om aan de slag te gaan met AI-geletterdheid. Als coördinerend toezichthouder voor algoritmes en AI levert de AP hiermee een bijdrage aan (de voorbereiding op) het toezicht op de AI-verordening.

In dit document stelt de AP voor dat organisaties rekening moeten houden met factoren zoals de (mate van) risico's, de betrokken

personen en de context waarin AI-systemen worden ingezet. Ook de beschikbare middelen spelen een rol bij het bevorderen van AI-geletterdheid. Hoe hoger de risico's van AI-systemen, hoe hoger het benodigde niveau van AI-geletterdheid van de gebruikers.

Daarnaast adviseert de AP dat organisaties een meerjarig actieplan voor AI-geletterdheid opstellen die gericht is op het ontwikkelen van een volwassen niveau van AI-geletterdheid. Voor de uitvoering hiervan is het belangrijk dat het bestuur (i) een actieplan op bestuurlijk niveau vaststelt, (ii) voldoende budget beschikbaar stelt, (iii) organisatorische verantwoordelijkheid en regie belegt en (iv) periodieke voortgangs- en verantwoordingsmomenten inbouwt.

STAPPENPLAN VAN DE AP

Daarnaast stelt de AP het volgende stappenplan voor:

1) IDENTIFICEREN EN INVENTARISEREN

Inventarisatie van alle AI-systemen binnen de organisatie: de organisatie moet weten welke AI-systemen worden gebruikt en welke risico's en kansen daarbij behoren. Vervolgens moet de organisatie in kaart brengen welke beleidsdocumenten en maatregelen er al zijn met betrekking tot AI-geletterdheid en welke nog ontwikkeld moeten worden.

Naast de toezichthouders zijn ook marktpartijen bezig met het opstellen van richtlijnen over hoe de sector kan omgaan met de risico's en kansen van het toepassen van AI. De Pensioenfederatie heeft in december 2024 de *Gedragslijn AI en Ethiek voor de Pensioensector* gepubliceerd, waarin 21 principes zijn opgenomen voor het ethisch en verantwoord inzetten van kunstmatige intelligentie binnen de sector. Deze gedragslijn biedt pensioenfondsen concrete handvatten om beleid en processen te ontwikkelen die zowel de kansen van AI benutten als de bijbehorende risico's beheersen. De principes zijn gebaseerd op Europese richtlijnen en best practices, en richten zich onder andere op transparantie, uitlegbaarheid, datakwaliteit, non-discriminatie en menselijk toezicht.

Inventarisatie kennisniveau AI: Organisaties moeten nagaan wie de betrokken personen en rollen binnen de organisatie zijn. Dit kan door een interne enquête om het huidige kennisniveau van de medewerkers binnen de organisatie vast te leggen. Met deze resultaten heeft men inzicht in het kennisniveau bij aanvang en kan de ontwikkeling van AI-geletterdheid worden geëvalueerd.

2) DOEL BEPALEN

De organisatie moet duidelijk vaststellen welke doelen en prioriteiten centraal staan. Niet elke medewerker heeft immers dezelfde kennisbehoefte. Medewerkers die werken met AI-systemen moeten voldoende inzicht hebben in de risico's en weten hoe ze de gegenereerde resultaten kritisch kunnen beoordelen. De benodigde kennis en vaardigheden verschillen per functie, waarbij zowel de context van het gebruik als het risicoprofiel van het systeem bepalend zijn.

Organisaties moeten rekening houden met wie gebruikers zijn en wat van belang is voor zijn of haar functie. Onderstaande lijst geeft een korte overzicht (niet limitatief) over wat de behoefte aan AI-geletterdheid kan zijn afhankelijk van de functie:

- Bestuurders: Strategisch inzicht in kansen, risico's en governance rond AI.
- Compliance/Juridisch: Begrip van wettelijke kaders, risico's, audit en rapportage.
- IT: Technische verdieping en kennis van ethische kaders.
- HR: Inzicht in leerbehoeften en competenties met betrekking tot AI.
- Klantcontact: Bewustzijn van AI in klantinteractie en datagebruik.

Een goede aanpak houdt dus rekening met het verschil tussen de behoeftes van elke functie.

3) UITVOEREN

Organisaties moeten acties ondernemen om AI-geletterdheid te integreren in de organisatie. Als duidelijk is wat de behoefte is van elke functie, is de volgende stap hoe men deze behoeftes gaat vervullen. AI-geletterdheid is geen eenmalige training of een afvink-oefening. AI-geletterdheid is een doorlopend proces dat vraagt om periodieke actualisatie. Zeker als men rekening houdt met hoe snel AI zich in de laatste jaren heeft ontwikkeld. Net zoals compliance met financiële wetgeving continu aandacht vereist, geldt dat ook voor AI.

> WAAR AI VOORHEEN VOORAL EEN ONDERWERP WAS VOOR DE IT-AFDELING, INNOVATIEVE ONTWIKKELAARS EN DATASPECIALISTEN, WORDT HET NU EEN STRATEGISCH, RISK, COMPLIANCE EN JURIDISCH THEMA VOOR ALLE ORGANISATIES DIE GEBRUIKMAKEN VAN AI-SYSTEMEN

Een succesvolle aanpak vraagt om een cultuurverandering, waarin medewerkers zich verantwoordelijk voelen om actueel te blijven, vragen te stellen en hun eigen kennis te vergroten. AI-geletterdheid, net als andere processen, moet verankerd worden in de cultuur van de organisatie.

Onderstaand zijn enkele voorbeelden gegeven hoe organisaties aan de slag kunnen gaan met AI-geletterdheid en het structureel integreren hiervan:

- Periodieke kennissessies: De afdeling Risk & Compliance kan in samenwerking met de IT-afdeling periodieke, interactieve kennissessies organiseren. Deze sessies creëren bewustzijn wordt rondom AI-gebruik door middel van trainingen die zich verdiepen in ethische, technische en juridische aspecten van AI-systemen. Denk hierbij aan een verplichte algemene

introductiesessie, gevolgd door verdiepende modules gericht op specifieke afdelingen functie (specialisatietrainingen). Daarnaast kunnen ook casussen worden besproken die betrekking hebben op een incident binnen de organisatie of een incident extern.
Op deze manier wordt geborgd dat de gebruikte AI-systemen het due diligence proces van de organisatie hebben doorlopen en dat de IT-afdeling zorgvuldig de bijbehorende risico's en kansen heeft geëvalueerd.

- Digitaal bulletinboard of interactieve dashboards: Organisaties kunnen een intern platform opzetten waar actuele AI-ontwikkelingen worden gedeeld. Medewerkers kunnen ervaring en kennis met elkaar delen en vragen stellen op een digitaal bulletinboard. Via interactieve dashboards kan de IT-afdeling medewerkers informeren over welke AI-systemen worden toegepast binnen de organisatie en met welke risico's ze te maken hebben.
- Microlearning of korte e-learnings: De afdeling Risk & Compliance in samenwerking met de IT-afdeling kunnen korte modules over onderwerpen ontwikkelen als 'Wat is bias in AI?' of 'Hoe weet je of een AI-systeem veilig is?'
- Simulaties of serious games: Medewerkers kunnen via simulaties geconfronteerd worden met ethische dilemma's waarin ze zelf keuzes moeten maken over AI-toepassingen.

De organisatie hoeft dit niet volledig zelfstandig te ontwikkelen. Er zijn steeds meer gespecialiseerde opleiders, adviesbureaus en overheidsbronnen. Ook de AP en Europese instellingen bieden trainingsmateriaal, handreikingen en bewustwordingsmodules. Op deze manier blijft AI-geletterdheid niet beperkt tot abstracte kennis, maar wordt het concreet, toepasbaar en relevant in de dagelijkse praktijk.

> AANBIEDERS EN GEBRUIKERS VAN AI SYSTEMEN MOETEN DEZE SYSTEMEN KUNNEN BEGRIJPEN, KRITISCH BEOORDELEN, OP EEN VERANTWOORDE MANIER TOEPASSEN ÉN ETHISCHE IMPLICATIES OVERZIEN

Naast bewustwording moet AI-geletterdheid ook onderdeel worden van het bredere risk en compliance-framework. Door AI ontwikkelingen actief te monitoren, kunnen organisaties zicht houden op de leercurve binnen de organisatie en inzicht krijgen in de voortgang van verantwoord AI-gebruik.

Verantwoordelijkheden rondom AI kunnen worden geborgd door deze expliciet toe te wijzen aan specifieke rollen binnen de organisatie, zoals compliance, risicobeheer of de IT-afdeling. Beleid dient vervolgens zodanig ingericht of bijgesteld te worden dat het duidelijke richtlijnen biedt voor het gebruik van AI-systemen.

Er kunnen bijvoorbeeld restricties worden ingesteld voor het gebruik van publieke AI-diensten of het zelfstandig downloaden van gratis AI-tools. Waarbij dergelijke toepassingen alleen mogen worden ingezet na toetsing door, en afstemming met, de IT-afdeling of een daarvoor aangewezen beoordelingscommissie, om de veiligheid, ethiek en databescherming te waarborgen.

4) EVALUEREN

Organisaties moeten regelmatig evalueren of de doelstellingen zoals hierboven benoemd (stap 2) worden gehaald. Dit kan worden gedaan door periodieke rapportages en interne of externe audits. Door de resultaten te evalueren kunnen nieuwe doelen worden gesteld en maatregelen bepaald om AI-geletterdheid op niveau te brengen en houden. Op die manier wordt AI-geletterdheid een levend onderdeel van de cultuur en compliance-structuur.

AFSLUITING

De komst van de AI-Verordening markeert een belangrijk moment voor het gebruik van AI in Europa door financiële instellingen. Waar AI voorheen vooral een onderwerp was voor de IT-afdeling, innovatieve ontwikkelaars en data specialisten, wordt het nu een strategisch, risk, compliance en juridisch thema voor alle organisaties die gebruikmaken van AI-systemen. Vanaf 2 februari 2025 geldt ook een expliciete verplichting voor organisaties om AI-geletterdheid structureel te bevorderen, niet als optionele training, maar als integraal onderdeel van verantwoord AI-gebruik.

Voor pensioenfondsen en vermogensbeheerders is dit bijzonder relevant omdat in deze sector juist vertrouwen, transparantie en zorgvuldigheid centraal staan. AI kan daarin een waardevolle bijdrage leveren, mits het op de juiste manier wordt ingezet. AI-geletterdheid zorgt ervoor dat medewerkers op alle niveaus, met verschillende functies en verantwoordelijkheden, begrijpen wat AI is, wat het doet, en wat de ethische en juridische implicaties er verbonden zijn aan het gebruik ervan.

Aan de hand van dit artikel en met behulp van het stappenplan dat de AP voorstelt, kunnen organisaties bewust worden van het feit dat AI-geletterdheid breder is dan alleen technische kennis. Ook al is AI-geletterdheid verplicht onder de AI-Verordening, de integratie heeft ook strategische waarde. Het stelt organisaties in staat om risico's beter in te schatten en draagt bij aan een betere samenwerking, besluitvorming en innovatie.

Misschien is het belangrijkste inzicht dat AI-geletterdheid geen einddoel is, maar een doorlopend proces. Een proces dat vraagt om investering, tijd en aandacht, maar wat ook veel kan opleveren voor de organisatie. AI-geletterde organisaties maken zichzelf toekomstbestendig. Ze versterken het vertrouwen van deelnemers, verbeteren hun interne governance en benutten de kracht van technologie op een verantwoorde manier.

AI-geletterdheid is niet alleen een verplichting.

Het is een kans.
Laten we die kans grijpen.

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De AI Productiviteitsparadox

Jankees Ruizeveld en Victor Verberk

INLEIDING

In veel ondernemingen, waaronder financiële instellingen, doet zich momenteel een opvallende paradox voor. Het overgrote deel van de medewerkers gebruikt Artificiële Intelligentie (AI) bij het schrijven van e-mails, het vertalen van teksten of het samenvatten van documenten. Tegelijkertijd blijft er in professionele omgevingen vaak terughoudendheid bestaan om AI-tools bedrijfsbreed te omarmen. Er bestaat een discrepantie tussen individueel gebruik en de mate waarin dit als waardevol instrument wordt gezien voor de gehele organisatie (Humlum & Vestergaard, 2025; Rosenbush, 2025).

Deze paradox heeft twee kanten. Enerzijds gebruiken medewerkers voor persoonlijke taken graag AI-tools, maar zodra het gaat om afdelingsbrede invoering ontstaat er bij werknemers onzekerheid over veranderingen in hun stabiele werkomgeving of zelfs over baanzekerheid – dan neemt hun enthousiasme snel af. Anderzijds leeft bij werkgevers het gevoel dat AI voor individuele toepassingen wel werkt, maar voor organisatiebrede processen nog niet, omdat bijvoorbeeld structuren en kennis onvoldoende lijken om complexe werkstromen door AI te laten vervangen. Beide kanten van deze paradox vragen om een oplossing door het senior management (Lovich et al., 2025).

Dit artikel analyseert hoe vermogensbeheerders deze paradox in de praktijk doorbreken en welke concrete voordelen dit oplevert. De praktijkervaring toont aan dat vooral researchafdelingen aanzienlijk kunnen profiteren van AI-ondersteuning. Cruciaal hierbij is dat AI wordt ingezet als ondersteunend instrument, niet als vervanger van menselijke oordeelsvorming in het beleggingsproces. Door routinematige taken te automatiseren, kunnen analisten zich meer richten op hun kernexpertise en -competenties, waardoor de kwaliteit van analyses juist toeneemt. Dit leidt tot efficiëntiewinsten die zich kunnen vertalen in kostenvoordelen voor cliënten en nieuwe mogelijkheden voor dienstverlening.

Deze praktische toepassing wordt geïllustreerd aan de hand van de implementatie bij Osmosis NL, een boutique fixed income vermogensbeheerder. Dit praktijkvoorbeeld laat zien hoe organisaties de theorie succesvol omzetten in concrete resultaten.

DREMPELS VANUIT WERKNEMERSPERSPECTIEF

Onderzoek toont aan dat een op de drie werknemers hun AI-gebruik verbergt voor hun baas (Ivanti, 2025). Bijna een derde doet dit uit vrees voor baanverlies – een begrijpelijke reactie gezien het feit dat 52% van kantoormedewerkers bevestigt dat

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efficiënter werken alleen maar resulteert in meer taken van hun werkgever.

Een tweede factor is sectorspecifiek: de vrees dat compliance-afdelingen beperkingen zullen opleggen aan het gebruik van AI-tools. Financiële professionals opereren immers in een streng gereguleerde omgeving waar data-integriteit, privacy en auditeerbare besluitvormingsprocessen van cruciaal belang zijn. Dit leidt ertoe dat AI-gebruik veelal 'onder de radar' blijft.

Een derde factor die de adoptie van AI-systemen belemmert, is veranderingsaversie: onzekerheid over veranderingen in een stabiele werkomgeving. Beleggers en financiële professionals staan traditioneel bekend om hun loyaliteit aan beproefde methodologieën en werkwijzen. Veel analisten werken met spreadsheetmodellen die de tand des tijds hebben doorstaan, en Bloomberg-terminals worden gebruikt met schermen die soms decennialang onveranderd zijn gebleven Deze professionele inertie, die vaak wordt versterkt door een relatief hoge gemiddelde leeftijd in de sector, vertraagt de integratie van nieuwe AI-capaciteiten in de dagelijkse werkpraktijk. Deze voorkeur wordt versterkt door een fundamentele menselijke bias: bouwen op het bekende in plaats van experimenteren met het onbekende.

DREMPELS VANUIT WERKGEVERSPERSPECTIEF

Asset managers opereren in een omgeving waar cliënten en consultants stabiliteit en consistentie verwachten. Deze externe partijen reageren vaak terughoudend op veranderingen in werkwijzen, zelfs wanneer deze de dienstverlening potentieel verbeteren. Werkgevers anticiperen op deze conservatieve houding door voorzichtig te zijn met het doorvoeren van innovaties.

Daarnaast uiten risico- en compliance-afdelingen legitieme zorgen over databeveiliging, privacy en de traceerbaarheid van beslissingen die door AI worden ondersteund. Zonder helder inzicht in hoe AI-tools specifiek worden toegepast binnen beleggingsprocessen, neigen compliance-teams naar een restrictieve houding. Deze interne controlefuncties streven naar beheerste bedrijfsvoering, wat kan botsen met de 'creative destruction' (Schumpeter, 1942) die AI-innovatie met zich meebrengt.

Een derde uitdaging betreft de transformatie van individueel AI-gebruik naar grootschalige systemen, wat een substantiële technische horde vormt. Waar individuele analisten relatief eenvoudig publieke AI-tools kunnen inzetten, vereist organisatie-brede invoering beveiligde infrastructuur die naadloos integreert met bedrijfsdata en bestaande systemen. Hoewel financiële instellingen vaak wel over de afzonderlijke expertise beschikken, vereist het samenbrengen hiervan tot een coherent geheel de juiste strategische keuzes van het senior management (E. Gavrikova, Volkova & Burda, 2020).

Ten slotte vormt de strategische onderwaardering van IT-investeringen binnen veel financiële instellingen een fundamentele barrière. Ondanks het potentieel van technologie – en AI in het bijzonder – als strategische groeiversneller, wordt de IT-afdeling vaak primair behandeld als kostenpost waarop bezuinigd kan worden. Dit wordt versterkt doordat IT-kosten binnen een asset management begroting doorgaans de hoogste inflatie vertonen, wat een natuurlijke reactie oproept om af te schalen. Het gevolg hiervan is dat er veelal minder ruimte bestaat voor innovatieve projecten die op lange termijn juist significante waarde kunnen toevoegen. Dit creëert, alweer, een paradoxale situatie: terwijl budgetten krap zijn door dalende fees, kan AI juist de productiviteitswinst opleveren die de sector zoekt. Echter, dit vereist visie en moed om te investeren in organisatieverandering. Management teams die technologie omarmen naast hun traditionele beleggingsexpertise, positioneren zich hiermee waarschijnlijk als de winnaars van morgen.

CONCURRENTIEVOORDELEN DOOR AI-IMPLEMENTATIE

Praktijkervaring toont aan dat het overbruggen van de kloof tussen individuele adoptie en afdelingsbrede implementatie van AI een van de grootste kansen biedt in asset management.

Ten eerste bevat het analyseren van ondernemingen talrijke manuele en routinematige werkzaamheden, variërend van het verzamelen van relevante informatie uit jaar- en kwartaal-rapportages tot het extraheren van financiële data uit verslag-legging. Hoewel dit hooggeschoold werk is dat verstand van accounting vereist, zijn deze taken vaak zeer tijdrovend en daardoor bij uitstek geschikt voor automatisering. Praktische implementatie vereist wel nauwe samenwerking tussen IT en beleggers om tot de juiste uitkomsten te komen.

> IN DE PROFESSIONELE OMGEVINGEN BLIJFT VAAK TERUGHOUDENDHEID BESTAAN OM AI-TOOLS BEDRIJFSBREED TE OMARMEN

Bovendien kunnen AI-systemen moeiteloos cruciale informatie detecteren die strategisch in voetnoten of bijlagen verborgen is. In minuten tijd kunnen duizenden pagina's worden geraadpleegd om een specifieke vraag te beantwoorden. Doordat bij elke analyse gebruikgemaakt wordt van een vaste systematiek, wordt de consistentie en volledigheid van het onderzoeksproces aan-zienlijk verhoogd. Het resultaat: onvermoeibare precisie waar menselijke analisten onvermijdelijk tekortschieten.

Bij succesvolle implementatie leidt de verhoogde efficiëntie tot aanzienlijke voordelen op meerdere vlakken. Analisten kunnen meer tijd besteden aan hun kernactiviteiten – diepgaande analyse en oordeelsvorming – in plaats van aan het invullen van modellen en het lezen van documenten. Meer tijd komt beschikbaar voor strategische activiteiten zoals het ontwikkelen van goed onder-bouwde en onderscheidende marktopinies en het nemen van weloverwogen investeringsbeslissingen. Dit verhoogt de research-kwaliteit, de basis voor superieure alpha-generatie.

Daarnaast zorgt deze efficiëntie ervoor dat analisten meer en sneller relevante analyses kunnen maken, databases kunnen opbouwen van eerdere analyses en sneller tot vergelijkingen en conclusies komen. Deze efficiëntieslag stelt vermogensbeheerders in staat om een tweeledig concurrentievoordeel te realiseren: zowel een aantrekkelijkere prijsstelling als een kwalitatief hoogwaardigere dienstverlening voor hun klanten. Hierdoor ontstaan nieuwe mogelijkheden om het *know-your-assets* principe verder te ontwikkelen, cliëntrapportage te verrijken, uitgebreidere coverage te bieden en nieuwe diensten zoals second opinions aan te bieden over ondernemingen die voorheen buiten bereik lagen. Ons praktijkvoorbeeld illustreert de omvang van de transformatie: waar een analist traditioneel meerdere dagen nodig had voor het raamwerk van een rapport, kan de basis voor een analyse nu binnen enkele minuten worden opgesteld. Deze kostenrevolutie transformeert de fundamentele economie van investeringsresearch en maakt diepgaande analyse economisch haalbaar op voorheen ondenkbare schaal.

Een goed geïmplementeerd systeem slaat alle data en verwerkingsstappen op, waardoor traceerbaarheid wordt gewaarborgd en de kwaliteit van analyses continu kan worden verfijnd.
Dit vergroot de transparantie van het gehele beleggingsproces.

Het realiseren van deze voordelen vereist echter doordachte besluitvorming door het senior management over de organisatorische voorwaarden voor succesvolle AI-implementatie.

ORGANISATORISCHE VOORWAARDEN VOOR AI-SUCCES

Uit ons praktijkonderzoek en de daaruit voortgekomen inzichten blijkt dat voor een succesvolle AI-implementatie het essentieel is dat deze technologie door senior management wordt beschouwd als een versterking van menselijke capaciteiten. Deze zogeheten '*augmented intelligence*'-benadering reduceert niet alleen organisatorische weerstand, maar weerspiegelt ook realistischer de huidige mogelijkheden van AI-systemen. De symbiose tussen menselijke expertise en technologische ondersteuning leidt tot betere resultaten dan beide componenten afzonderlijk zouden kunnen bereiken: AI biedt snelheid en consistentie, terwijl mensen creativiteit en strategisch inzicht inbrengen.

De werkwijze van analisten evolueert fundamenteel door het gebruik van AI-systemen. Waar zij voorheen dagen besteedden aan het doornemen van jaarverslagen en andere relevante documenten, wordt dit tijdrovende leeswerk nu overgenomen door AI. De focus van analisten verschuift naar het strategisch denken welke informatie precies nodig is om tot goede beleggingsconclusies te komen. Deze transitie vereist nog steeds dat analisten beschikken over diepgaande fundamentele kennis om de juiste vragen te definiëren. Senior management moet verwachtingen over deze verandering van focus actief managen en consequent benadrukken dat oordeelsvorming het exclusieve domein van analisten blijft.

Een succesvolle AI-implementatie is uitsluitend mogelijk binnen een goed gestructureerd beleggingsproces. Deze structuur zorgt voor een duidelijke ordening van gegevens, logica en werkstromen die schaalbare, herhaalbare en transparante financiële analyse mogelijk maakt. Voor een effectief proces is het essentieel dat alle analisten volgens consistente methodologieën werken, met gestandaardiseerde procedures die naadloos aansluiten bij de ondersteunende systemen. Management moet daarom, voor zover dat al niet het geval is, het beleggingsproces zoveel mogelijk standaardiseren en toezien op consequente toepassing.

Een niet te onderschatten voordeel van gestructureerde AI-implementatie is de versterkte controlecapaciteit. Doordat alle gegevens in een beveiligde omgeving volgens vooraf bepaalde structuren kunnen worden opgeslagen, faciliteert dit op termijn retroactieve analyses om *behavioural biases* binnen de beleggingsafdeling te onderzoeken, waarmee het beleggingsproces verder kan worden geoptimaliseerd. Denk hierbij aan het opsporen van systematische voorzichtigheid bij kredietanalisten, het herkennen van *confirmation bias* waarbij analisten onbewust informatie selecteren die hun vooroordelen bevestigt, of het identificeren van ankereffecten waarbij te sterk wordt vastgehouden aan eerdere conclusies. Bovendien kunnen alle processtappen worden geaudit, waarbij het onderscheid tussen machine- en mensgestuurde componenten volledig transparant wordt gemaakt. Leidinggevenden moeten de juiste infrastructuur en processen opzetten om deze versterkte controle- en auditmogelijkheden daadwerkelijk te benutten.

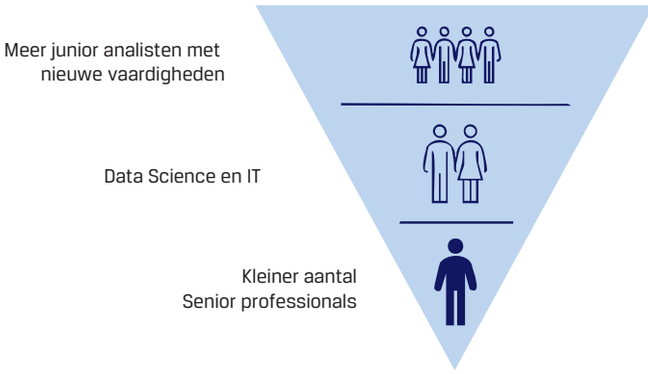
> DEZE PRODUCTIVITEITSPARADOX VORMT EEN STRATEGISCHE KANS VOOR ORGANISATIES DIE HUN BEDRIJFSMODEL DURVEN TE HERZIEN

Naast technische aspecten vereist succesvolle implementatie ook organisatorische aanpassingen. Cruciale samenwerking moet ontstaan tussen beleggers, data scientists en softwareontwikkelaars. Deze professionals met affiniteit voor AI en programmeervaardigheden moeten aan de desk samenwerken om effectieve kruisbestuiving mogelijk te maken. Dit vraagt van de leiding dat traditionele organisatorische grenzen worden doorbroken en multidisciplinaire teams actief gefaciliteerd worden.

Het cumulatieve effect van deze veranderingen is aanzienlijk verbeterde schaalbaarheid van de research-afdeling. Senior beleggers blijven cruciaal omdat zij de projecten aansturen, maar krijgen ondersteuning van meer IT-professionals en talent met technische vaardigheden zoals Python-programmering en AI-expertise). Hierdoor kunnen veel meer researchprojecten gelijktijdig worden uitgevoerd, wat de totale capaciteit en efficiëntie van de afdeling dramatisch verhoogt. Het management dient deze fundamentele omwenteling van de traditionele hiërarchie te leiden en de organisatie te transformeren van een klassieke piramide naar een technologie-gedreven, schaalbare structuur. Dit betekent een verschuiving naar meer jonge

analisten met data science-begrip en op termijn een verminderde afhankelijkheid van kostbare senior beleggers, zonder hun strategische rol te ondermijnen. Deze fundamentele omwenteling van de traditionele hiërarchie wordt geïllustreerd in Figuur 1. De verandering in personeelssamenstelling kan organisch plaatsvinden door in de tijd jonge nieuwe talenten met andere vaardigheden toe te voegen, waardoor bestaande teams geleidelijk worden versterkt zonder abrupte reorganisaties.

Figuur 1
Professionele piramide op zijn kop



Bron: Osmosis IM NL

PRAKTIJKVOORBEELD: AI-IMPLEMENTATIE IN DE BELEGGINGSSECTOR

De hierboven beschreven AI-integratieprincipes zijn concreet toegepast bij Osmosis NL, een zusterbedrijf van Osmosis UK. Osmosis UK bestaat al 20 jaar en is gefocust op sustainable equity. Osmosis NL richt zich op fixed income en heeft een ervaren team van beleggers dat de ambitie had om voor zichzelf te beginnen en daarbij moderne technologie te omarmen. Deze aanpak heeft geleid tot zowel technologische als organisatorische verbeteringen, waarbij hetzelfde beleggingsproces een veel hogere output oplevert.

De organisatie heeft een geavanceerd platform ontwikkeld onder de naam 'Sequoia'. Dit systeem helpt analisten bij het efficiënt produceren van bedrijfsanalyses.

Het eerste onderdeel van Sequoia levert een solide basis voor een credit rapport. Wanneer aan een nieuwe analyse wordt begonnen, worden relevante documenten waarop een analist de analyse baseert in het systeem geladen. Dit kan openbare informatie zijn zoals jaar- en kwartaalverslagen, *transcripts* van *earnings calls*, offering memorandums en bedrijfspresentaties, maar ook betaalde research van brokers, experts-networks of rating agencies. Indien gewenst heeft het systeem ook toegang tot nieuws en documenten op het internet.

Nadat de documenten zijn ingeladen worden de misschien wel tienduizend pagina's grondig gelezen door het systeem en wordt vastgelegd welke informatie erin staat. Het Sequoia platform heeft naast een standaard zoekfunctie om benodigde informatie snel te vinden, ook de mogelijkheid om gecompliceerde vragen van analisten te beantwoorden, zoals 'Hoe heeft management de verwachtingen voor de EBITDA-marges voor het komend jaar bijgesteld na de verhoging van de importtarieven in de VS?'.

Voor elke onderneming heeft de analist honderden vragen klaarstaan die inzicht moeten geven in de belangrijkste drijfveren voor de kredietkwaliteit van de onderneming. Deze omvatten vaste vragen die door het team al jaar en dag bij elke ondernemingsanalyse worden gesteld, evenals sector en ondernemingsspecifieke vragen die analisten hebben opgesteld op basis van hun jarenlange sector- en ondernemingskennis. Het up-to-date houden en verfijnen van deze vragen op basis van de verkregen antwoorden blijft specifiek de verantwoordelijkheid van de beleggers.

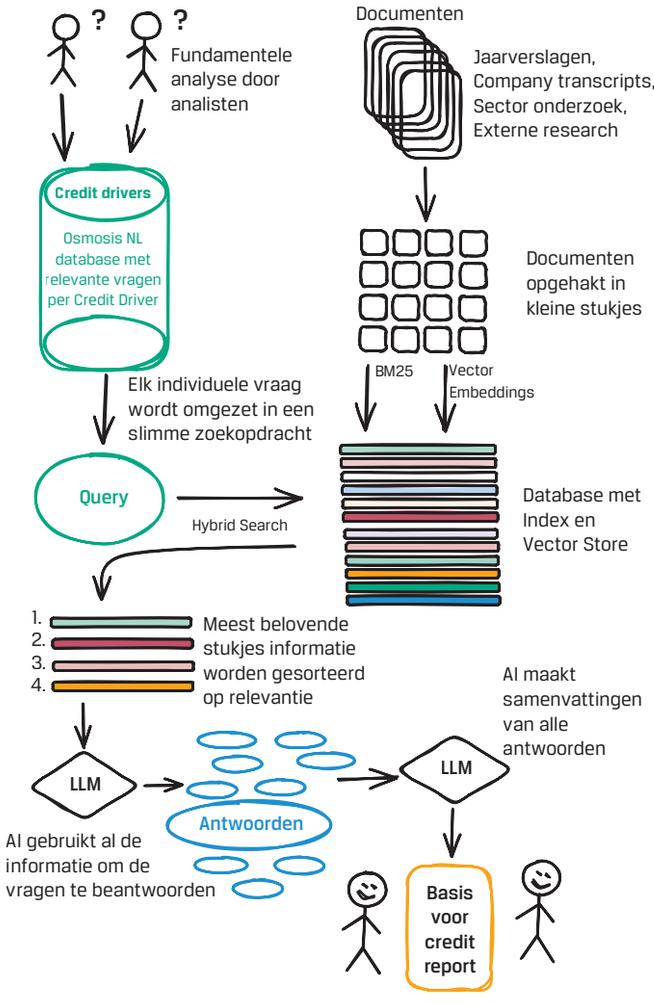
Deze systematische ondervraging levert per drijfveer een korte samenvatting op, die als bouwsteen dient voor het uiteindelijke rapport. De analist kan bij elk antwoord de bron terugzoeken ter verificatie. Dit levert een enorme tijd- en kwaliteitswinst op: rapportages zijn consistent en onderling vergelijkbaar, terwijl de analist direct kan beginnen met oordeelsvorming op basis van de gevonden antwoorden. Een simpel voorbeeld: met één vraag wordt gezocht naar het *off-balance sheet* pensioentekort van een Amerikaanse onderneming. De documentatie wordt in enkele minuten gelezen en het antwoord met de bronvermelding kan geanalyseerd worden, inclusief eventueel commentaar van *sell side research*. Figuur 2 toont hoe dit volledige proces van informatievergaring tot gestructureerde analyse verloopt.

> DE BASIS VOOR EEN ANALYSE KAN NU BINNEN ENKELE MINUTEN WORDEN OPGESTELD. DEZE KOSTENREVOLUTIE TRANSFORMEERT DE FUNDAMENTELE ECONOMIE VAN INVESTERINGSRESEARCH

Het tweede deel van Sequoia helpt bij de financiële data-extractie. De financiële bedrijfsverslagen worden ingeladen en de relevante informatie wordt automatisch gedetecteerd en verwerkt. Dit vult de *as-reported* database van het systeem nauwkeurig en efficiënt. De analist kan vervolgens alle noodzakelijke aanpassingen doen om te komen tot een gestandaardiseerd financieel model die vergelijking met andere ondernemingen mogelijk maakt. Deze financiële data en de daaruit volgende financiële ratio's worden ook direct gebruikt bij de oordeelsvorming over de kredietkwaliteit van de onderneming en zijn in tabel of grafiekvorm automatisch beschikbaar bij het schrijven van het uiteindelijke kredietrapport. Deze automatisering kan leiden tot aanzienlijke kostenbesparingen op externe data, die voor organisaties kunnen oplopen tot honderdduizenden euro's per jaar.

Het derde element van Sequoia assisteert bij het houden van het kredietcomité, zoals het team dat de afgelopen 20 jaar heeft gedaan. Dit is de vergadering waarin analisten en portefeuillemanagers hun kennis delen rond een onderneming en waarin

Figuur 2
Geautomatiseerde creditanalyse workflow



Bron: Osmosis IM NL

de analist tot een finaal oordeel komt. Het systeem biedt ondersteunende functies die vroeger onmogelijk waren, zoals inzichtelijk maken waar de data in het rapport precies vandaan komt en het ter plekke beantwoorden van nog niet volledig beantwoorde vragen op basis van de verzameling documenten of eventueel met websearch. Ook helpt het systeem de analist om het rapport systematisch door het comité te leiden en wordt automatisch alle feedback vastgelegd, waardoor de governance van het proces verbetert.

Het vierde element is een dashboard met overzichtelijke rapporten van onderzochte ondernemingen en kredietcomité-beslissingen, waarbij opnieuw elk element herleidbaar is tot de bron. Dit geeft een compleet beeld van het hele beleggingsproces.

Met dit platform bespaart een analist rond de 70% van de tijd bij het maken van een beleggingsrapport. Dit illustreert perfect het 'augmented intelligence'-principe: het systeem is expliciet ontworpen als aanvulling op – niet als vervanging van – de kredietanalist, met als resultaat hogere productiviteit en lagere research-kosten.

DE PARADOX ALS STRATEGISCHE KANS

In de praktijk heeft Osmosis NL de discrepantie tussen persoonlijk AI-gebruik en organisatiebrede implementatie succesvol doorbroken. Deze doorbraak werd mogelijk gemaakt door vier cruciale randvoorwaarden: (1) een organisatiecultuur die technologische vernieuwing omarmt, (2) een helder gedefinieerd beleggingsproces dat zich leent voor systematische ondersteuning, (3) multidisciplinaire expertise die de brug weet te slaan tussen technologie en financiële analyse, en (4) een benadering die AI positioneert als versterking van menselijke capaciteiten.

De behaalde concurrentievoordelen zijn aanzienlijk: door vrijgekomen capaciteit te benutten voor inhoudelijk betere analyses en innovatieve dienstverlening, kunnen beleggingsorganisaties hun waardepropositie voor cliënten versterken door lagere kosten, snellere second opinions, transparante beslisprocessen en inzichtelijk bias-onderzoek.

Deze ervaring toont aan dat de productiviteitsparadox een strategische kans vormt voor organisaties die hun bedrijfsmodel durven herzien – mogelijk de meest ingrijpende verandering in de beleggingssector in decennia. Het opschalen van deze aanpak vereist echter visie, budget en intensieve samenwerking tussen afdelingen. Senior management moet daarom draagvlak creëren voor een fundamentele herziening van processen die jarenlang onveranderd zijn gebleven. Voor organisaties die deze stap kunnen en durven te zetten, wacht een beslissend concurrentievoordeel.

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Tokenization: Building Financial Resilience for Tomorrow

The financial sector currently operates with a paradigm built on centralized and vertically integrated systems. While this paradigm has historically ensured robust operations, recent outages at reputable service providers demonstrate these systems are unable to keep pace with the increase in the scale of products and users thereof. Therefore, it is imperative that the financial sector embarks on the pursuit of creating future-proof solutions.

Consider the recent outage of the Bloomberg terminal on May 21, 2025, which delayed critical operations such as the UK 4% 2031 debt auction. This is especially egregious given the cost of these terminals and their pivotal role in a plethora of operations. This incident is not isolated, nor are other vendors immune to service interruptions. Platforms such as LSEG's Refinitiv and CME's BrokerTec have experienced multiple outages in recent years.

Solutions to mitigate vendor lock-in exist, with the most quixotic being the usage of telephones and fax-machines. However, the failure of a Financial Market Infrastructure (FMI) poses a structural threat to market stability. Recent major outages at Euronext, CME, FedACH, and especially the TARGET Services of the Eurosystem, which experienced a ten-hour outage in February 2025, are concerning. The incident at TARGET is particularly troubling because the backup systems did not work, despite significant investments by the ECB to improve network resilience after a similar outage in 2020.

Although, technicians have managed to contain the adverse impact of such issues within a span of a few hours, these events reveal deeper systemic risks arising from centralized systems. Beyond operational concerns, second-order risks like market risk, liquidity risk, portfolio instability, and reputational damage have also become apparent. Nevertheless, the typical attitude towards such outages – given their frequency and persistence – has been one of resigned complacency, purporting that building fail-proof systems is impractical and prohibitively expensive.

The advent of decentralized systems such as blockchain and the tokenization of assets offers ways to mitigate risks arising from centralized infrastructures. Unfortunately, this technology is a victim of confusion primarily due to the recent hype surrounding various crypto-assets. Therefore, a brief distinction between key terms is necessary. At the core of decentralization is Distributed Ledger Technology (DLT), a broad term for decentralized databases that record transactions across multiple nodes. Blockchain is a specific type of DLT that orders data chronologically and cryptographically. Secondly, tokenization involves converting assets – including traditional financial instruments like bonds and equities – into digital tokens stored on a blockchain. Lastly, crypto-assets such as Bitcoin, NFTs, and memecoins are speculative assets often likened to betting on horses.

Positive developments by major financial institutions to explore the advantages of tokenization such as enhancing liquidity, reducing transaction costs, and enabling 24/7 trading are being made. Notably, BlackRock's USD Institutional Digital Liquidity Fund and Franklin Templeton's OnChain U.S. Government Money Fund exemplify positive developments in tokenizing money market funds.

The advantages of tokenization are not exclusive to crypto-native institutions. New tokenized offerings from reputable issuers, combined with supportive EU regulations such as Markets in Crypto-Assets (MiCA) help in enhancing market integrity and ensuring financial stability. Due to this, the benefits of DLT such as transparent pricing, instant settlement, elimination of central counterparties, and automation of strategies are accessible to investors domiciled in the Netherland. While tokenization cannot fully replace systems like Euronext or Euroclear, it complements them by offering resilient trading and settlement options during outages. Finally, the ability to access data transparently without intermediaries enables institutions to reduce costs and mitigate vendor lock-in.

Notwithstanding the numerous benefits of DLT, it is important to acknowledge the associated risks. The technology's relative infancy means many tokenized markets suffer from limited depth, leading to speculative trading, reduced liquidity, and challenges in exiting positions.

Furthermore, the ever-present threat of malicious actors in cyberspace, combined with rapidly evolving technologies such as quantum computing, demands that blockchain security remain constantly ahead of emerging vulnerabilities.

Additionally, the majority of platforms hosting tokenized offerings – such as Aptos and Stellar, used by BlackRock and Franklin Templeton – are based in the USA, introducing geopolitical risks. While these risks require careful management, the potential for tokenization to reduce systemic dependencies on centralized infrastructure makes it worthy of serious institutional consideration.

On behalf of the committee
Risk Management, Keshav Bhatt

How investors value green innovation in the corporate bond market

Yasmine van der Straten is a PhD Candidate in Finance at University of Amsterdam and will join Nova SBE as Assistant Professor in September 2025. Her research focuses on the financing of adaptation and the green transition. One of her papers examines how climate transition risk affects the cost of capital and whether investors value green innovation.

While policymakers stress the importance of achieving net-zero emissions by 2050, current progress falls short of what is needed to limit global warming to 1.5-2 degrees Celsius. Delays in climate action increase the risk of a disorderly transition, leaving firms increasingly exposed to regulatory, technological, and legal risks. Forward-looking financial investors may anticipate these transition risks and adjust firms' cost of capital accordingly. We focus on the corporate bond investors, given that bond financing serves as the marginal source of capital for many firms globally, and particularly so for emission-intensive firms. In the corporate bond market, emission-intensive firms may face a higher transition risk premium – reflected in higher yield spreads – due to investors' concerns about climate-related risks. However, investments in green innovation may help reduce this premium, by signaling a company's effort to transition to greener technologies. Our research explores whether corporate bond investors recognize and reward firms' efforts to transition toward greener technologies since the adoption of the Paris Agreement in December 2015.

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Using global firm-level data on greenhouse gas emissions and data on firm financing in the corporate bond market, we find strong evidence of a positive transition risk premium. Firms with higher carbon emissions face significantly higher bond yield spreads, showing that investors factor climate transition risk into corporate debt markets. However, our results also indicate that the transition risk premium is lower for firms actively investing in green innovation – measured by their share of green patents. A one standard deviation increase in a firm's green patent ratio lowers its transition risk premium by about 20 percent.

Our findings are robust across several tests. We control for key bond characteristics to ensure that the observed carbon premium is not driven by factors like credit risk, liquidity, or maturity. We also verify that our results are not merely reflecting a rise in bond issuance due to banks reducing lending to emission-intensive firms, nor are they driven by the ECB's Corporate Sector Purchase Programme. We further account for the rise of green financing instruments, such as green bonds, to ensure that the transition risk premium we identify is distinct from the well-documented 'greenium' – the yield discount associated with green bonds. Finally, we confirm that our results hold when applying a stricter definition of green innovation. We also find that the effect is stronger for firms with more technologically successful green patents, as measured by their citation count.

Our findings suggest that while investors tend to penalize carbon-intensive firms with higher borrowing costs, they also recognize and reward those making efforts to transition to greener technologies. This indicates that corporate bond market investors differentiate based on firm's green innovation efforts. In other words, investors do not only respond to a company's current carbon footprint but also consider the extent to which they invest in green technologies to mitigate climate change.

Institutional investors play a particularly important role in this process. Using confidential holdings data, we find that European institutional investors, especially mutual funds, have a relatively higher demand for bonds from emission-intensive firms engaged in green innovation. These investors influence bond yield spreads related to climate transition risk, as the yield discount associated with green innovation is more pronounced when European mutual funds hold a larger share of the bond. Our findings point toward risk pricing as the primary channel through which environmental performance influences bond yield spreads. This suggests that investors with greater risk-bearing capacity play a crucial role in channeling capital toward firms making efforts to decarbonize.

As investors increasingly account for climate risks in capital allocation decisions, this can create stronger incentives for firms to invest in green technologies, to benefit from lower financing costs.

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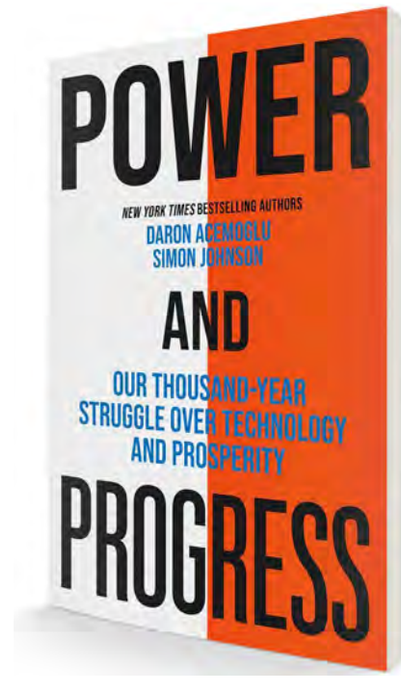
Power and Progress: Waarom technologische vooruitgang geen toeval is

Book review door Evelien van Hilten



Auteur: Daron Acemoglu, Simon Johnson
Uitgever: Basic Books
ISBN: 9781541702530

In een tijdperk waarin AI en automatisering onze economie razendsnel beïnvloeden, legt *Power and Progress* de vinger op de zere plek: technologische vooruitgang is geen garantie voor gedeelde welvaart. De bestsellerauteurs, Daron Acemoglu en Simon Johnson – beiden gelauwerde economen– nemen je mee in een scherpe analyse van macht, technologie en ongelijkheid. De hamvraag voor hen is: wie profiteert écht van innovatie?

Hoewel het boek 422 pagina's telt, leest het opvallend vlot. De schrijfstijl is toegankelijk en het werk biedt een brede historische samenvatting van technologische ontwikkelingen van de middeleeuwen tot nu. Het boek laat je na elk hoofdstuk achter met nieuwe inzichten, omdat het de economische geschiedenis bekijkt door de ogen van de arbeider in plaats van via een standaard macro-economische lens.

De auteurs laten zien hoe technologie historisch vaak werd ingezet om de factor arbeid, en daarmee arbeiders, te vervangen in plaats van de kwaliteit van de verrichte arbeid te verhogen. Denk aan de introductie van watermolens, stoommachines en het mechanische weefgetouw. Met als gevolg stijgende ongelijkheid wanneer technologie uitsluitend wordt ingezet voor automatisering in plaats van productiviteitsverhoging per werknemer.

Er zijn echter ook momenten in de geschiedenis waarop dit níét het geval was, bijvoorbeeld na de Tweede Wereldoorlog. Technologische innovatie werd toen gecombineerd met sterke instituties zoals vakbonden en publieke investeringen. Dit samenspel leidde tot een brede welvaartsdeling. Overheden stimuleerden infrastructuur en onderwijs, terwijl bedrijven werknemers lieten meeprofiteren. Deze sociaal ingebedde aanpak zorgde voor hogere productiviteit, stijgende lonen en de opbouw van een stabiele, groeiende middenklasse.

De auteurs benadrukken dat dergelijke positieve uitkomsten geen toeval zijn, maar het resultaat van bewuste beleidskeuzes. Vooruitgang vereist politieke wil, maatschappelijke druk en institutionele structuren die ervoor zorgen dat technologische baten eerlijker verdeeld worden. Zonder die fundamenten is innovatie kwetsbaar voor kaping door gevestigde belangen, vaak de factor kapitaal.

De auteurs trekken vervolgens deze historische trends door naar de toekomst en stellen dat AI op dit moment nog te veel gericht is op automatiseren. Het doel is vooral kostenreductie, denk aan chatbots en AI-agents, in plaats van het vergroten van de efficiëntie van werknemers. Hierdoor lijkt ook deze technologie opnieuw arbeid te verdringen. Tegelijkertijd wijzen de auteurs op het risico van datamonopolies zoals die van techconglomeraten als Google en Meta, die enorme invloed uitoefenen dankzij hun datadominantie.

De auteurs zijn hierbij uitgesproken dat technologie belangen weerspiegelt. Wie bepaalt er bijvoorbeeld wat er technologisch wordt ontwikkeld en met welk doel? Zolang die beslissingen ondoorzichtig zijn en gedreven door de elite van de private sector, zal vooruitgang ook asymmetrisch zijn. Technologie zal ingezet worden om winstgevendheid te vergroten van het kapitaal en de macht van de elite te verstevigen. Hun conclusie is daarom dat zonder correctie technologie ook vandaag de dag leidt tot stagnerende reële lonen en toenemende ongelijkheid.

Volgens Acemoglu en Johnson is structurele ongelijkheid geen technisch, maar een institutioneel probleem. Daarom zijn sterke, inclusieve instituties nodig om te waarborgen dat technologische innovatie niet ontspoort. Denk aan regulerende overheden, vakbonden en goed functionerend onderwijs, zodat de welvaart breed gedeeld wordt. Ook pleiten zij expliciet voor overheidsinvesteringen in publieke dataplatforms. In tegenstelling tot een laissez-faire aanpak bepleiten de auteurs een hybride model, waarin marktwerking wordt aangevuld met krachtige regulering. Mededingingstoezicht, datawetgeving en ethische AI-regels zijn volgens hen essentieel om monopolievorming te voorkomen.

Power and Progress biedt hiermee een aanvullende kijk op de ontwikkeling van technologie, omdat het oproept tot actie en handelingsperspectief biedt. Door de uitgesproken politieke invalshoek in de laatste hoofdstukken is het boek bovendien een uitstekend startpunt voor het debat over de overheidsrol in technologische ontwikkeling.

Het is een intellectueel stimulerend werk dat technologie scherp in historisch en maatschappelijk perspectief plaatst. Het nodigt uit tot reflectie: voor wie is vooruitgang eigenlijk vooruitgang? Voor lezers met belangstelling voor economie, technologie en ongelijkheid is dit een waardevolle aanrader. Wie sceptisch is over een grootschalige overheidsrol, zal bij de slothoofdstukken wellicht wat twijfels ondervinden, maar tegelijk ook veel *food for thought* hebben.

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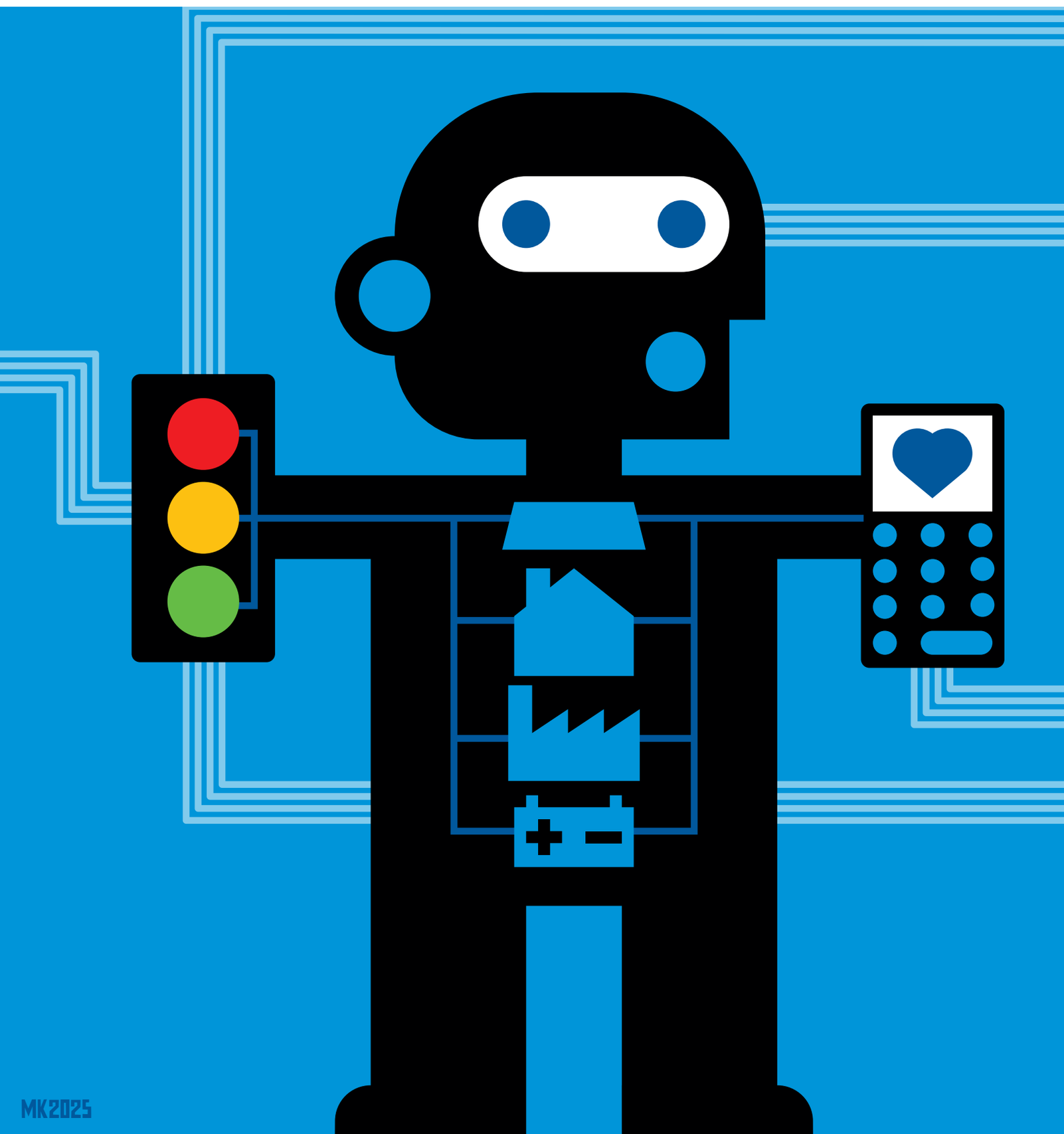
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