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YOUNG ACTUARIES AND AI

AAE ACTUARIAL ASSOCIATION OF EUROPE

BY **JENNIFER BAKER**

HARNESSING THE POWER OF AI FOR ACTUARIES

RON RICHMAN

Some insurance CEOs refer to AI as a bubble. What is your view on this? Is this something we need to be thinking about long term?

'I think this is very similar to an exponential curve. At the beginning, it moves quite slowly, but the impacts become greater and greater with time. So there's a lot of hype currently around AI, a huge amount of investment, a lot of VC money pouring in, and that can lead one to think that maybe this is overblown. But I think we cannot underestimate what this is going to do in the longer term. We're already seeing substantial impacts in actuarial work, such as reducing pricing model development time from months to days and helping write reports in a fraction of the time taken.

If you're using the best models out there, for example, if you are subscribed to chatGPT and you're working with the O1-Pro model (OpenAI's most advanced model), it's remarkable how these systems can match expert-level reasoning – you almost have a PhD-level scientific assistant in your pocket, or someone with an MBA willing to talk to you about your business. And in my experience, having worked with both of those types of people, and now having worked with the best large language models (LLM) available, we're starting to get scarily close to excellent human performance >

> ***You don't want to overregulate and stifle innovation. You don't want to overregulate and stifle innovation.***

on a wide array of advanced tasks. So while I think there is maybe too much hype right now. I think we need to be very thoughtful and introspect about what the future will look like and how we make this successful for our companies, our staff, our teams and wider society.'

How do you view the European AI Act? Do you think it's too restrictive? Does it hamper innovation? Because this is the constant refrain we sometimes hear from those who are critical of it. But the EU AI Act takes a very risk-based approach. Do you think that's the right approach?

'I think overall, the European approach is heavier on regulation. And I think if this can be implemented successfully, what the European Act will do is really ensure that you've got AI that's very well aligned with society and aligned with the sorts of goals that we expect. I think it can slow down innovation. I've seen in recent weeks some discussion of which models might be exempted. So knowing exactly where the risk lies within the various different types of models that the Act is trying to regulate is absolutely key. You don't want to overregulate and stifle innovation. I think if you look at a few of the other newsworthy items coming out of Europe in the last few weeks – for example, the significant investment in training a European LLM, or the investments into various different European AI companies – this is all positive. I think a balance needs to be found. Perhaps the European way of doing things has tended a little bit towards extra or more regulation in the past, but I think overall, the balance that we seem to be heading towards is a good thing.'

Turning specifically to the actuarial profession, what area or use purposes of AI do you think could be most transformational and most useful for actuaries?

'So I think all the hype is around the way of referencing or speaking to large language models through a chat interface. I think what we mustn't neglect is what I like to call narrow AI models, which are AI models that are specifically built for a particular purpose.

Imagine you're building a model that's excellent at actuarial pricing across a range of datasets across a range of lines of business. Those are the sorts of models I think we must focus on within the actuarial profession. For example, we've developed neural network architectures specifically for non-life pricing that maintain interpretability while increasing accuracy by 20% over traditional GLMs, particularly in areas like claims prediction and risk classification. You can ask a LLM – let's say again the top tier models, like O1-Pro or the DeepSeek model – for ideas, but it will be very difficult for the model to execute a full training run against a non-life pricing dataset or set assumptions for life insurance model.

What we need to focus on are all these advances in machine learning architecture that underlie large language models. How do we take those advances and apply them to the specific niche domains where we as actuaries need to build models? Set assumptions, quantify uncertainty and do useful things. So really, what I'm quite a proponent of is steering the actuarial profession towards using narrower models that don't approach general intelligence, but rather >

> ***I think the actuarial profession needs to have excellent ideas around how we avoid or mitigate the effects of potential proxy discrimination in these sorts of models.***

specific actuarial intelligence. That's where we've got all of the benefits that AI can bring us, which are efficiency, scale, making much better use of our data, making more accurate predictions and quantifying uncertainty around those predictions better than we've been able to.'

Well, you've explained how narrow AI compares to general AI. But what sort of concerns do actuaries need to bear in mind when it comes to using AI? Where are the potential pitfalls? Here in Europe, the General Data Protection Regulation already prohibits the use of a machine to make important decisions about individual lives. So that's something I believe actuaries have already been dealing with up to now. Is there anything new in the AI Act that they might need to worry about?

'Yes. Let's look at it from the perspective first of more narrow and specific models, and then more general models.

From the perspective of more narrow and specific models, interpretability is obviously key. I think understanding the latest advances in how you can build interpretable machine learning models is really important for actuaries, so that you can understand decisions internally and be able to explain decisions made by these models externally. I don't think the discussions around the potential for proxy discrimination in machine learning or AI models (where protected characteristics are inadvertently inferred from other variables) is going away anytime soon. I think the actuarial profession needs to have excellent ideas around how we avoid or mitigate the effects of potential proxy discrimination in these sorts of models. And I think what we need to keep doing is pushing the limits of what these models can do for us. If we don't, that's a different sort of risk. It's a strategic risk that the work we do won't be as valuable.

I think when using large language models, everyone knows about the risks of hallucination. By hallucination, I mean when these models confidently generate information that sounds plausible but is actually incorrect or fabricated. But I think there are more subtle risks. Even when it looks like a model isn't hallucinating, you have to spend a lot of time validating that any code written by these sorts of models is correct. Are there subtle bugs? Has it made a subtle mistake? And I think a more general risk is, while you can get very good answers quickly out of the top tier models, that can also limit your own creativity and the limits of your own expertise as a person, I think these are risks that we need to reckon with.

How do we make sure that we're not outsourcing all of our cognitive burden off to a chatbot and our brains aren't being used to their full potential? For instance, an actuary might become dependent on AI for tasks like model selection or assumption setting, gradually eroding their ability to perform these critical judgments independently. This is something that's worrying me and a few of the colleagues that I work with. So I think understanding the universe of risks, whether it's the direct user risks resulting from using a model or the wider implications, that's where we need to spend time and effort.' >

> ***If we want to be successful going into the future, actuaries must stop being receivers of this technology, and we must start being creators.***

Well, that leads very clearly onto my next question, which is, do you see a role for AI in education or training of actuaries?

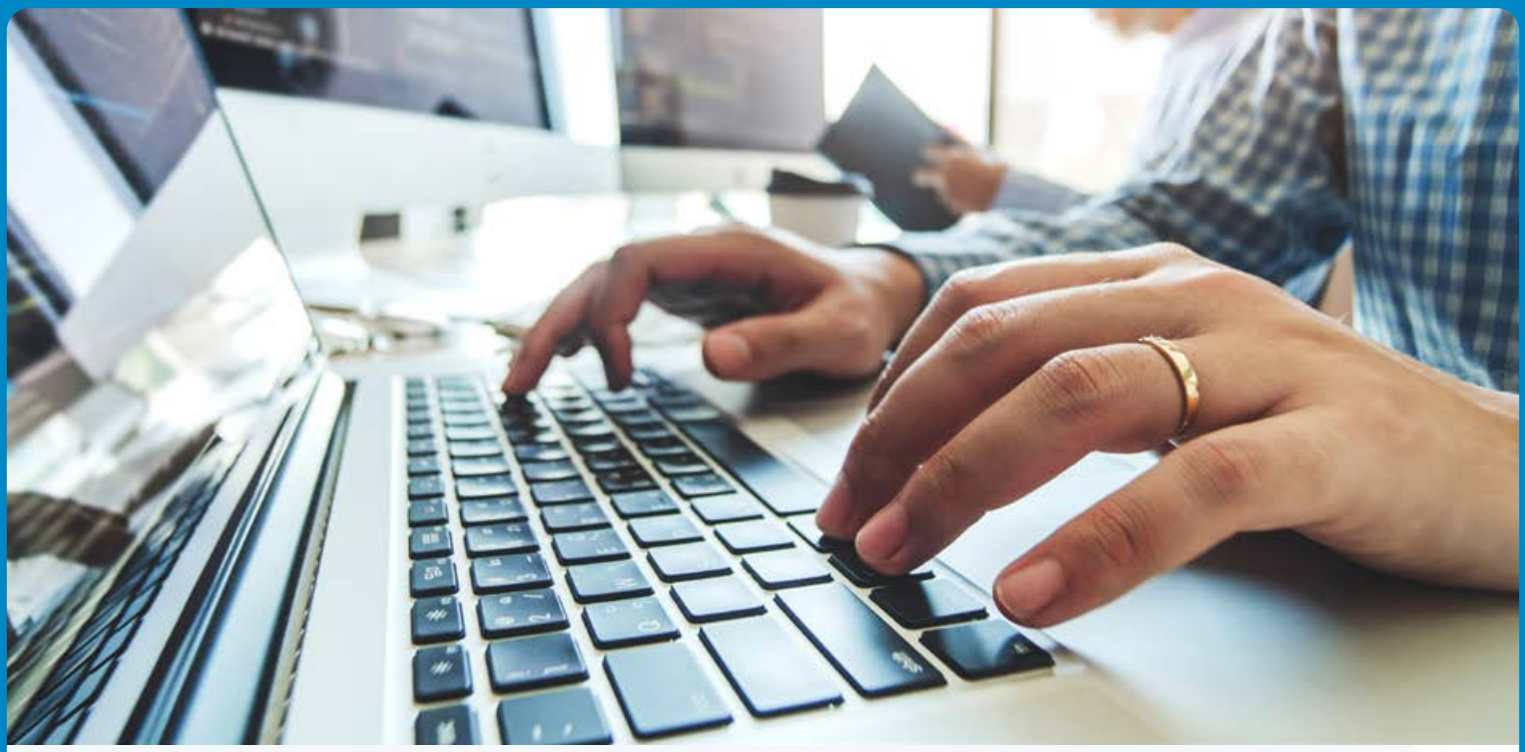
'I absolutely do. It's almost a paradox – if you feed the right context and the right background into a large language model it can give you fantastic suggestions on actuarial topics. Just yesterday, as a demonstration, I took O1-Pro, the top tier ChatGPT model, and asked it to design a new IBNR reserving method, and it did a pretty good job. An impressively good job, in fact. I think the key for me is, how do we get our actuaries up to a level of expertise as they start being educated, whether it's going through the university system in Europe, or the professional system like in the UK and South Africa.

How do we make sure that our next generation of actuaries is absorbing all of that information, becoming true experts, and not just outsourcing the cognitive burden to the machine? I think there'll be an unequal benefit of large language models in the future for people who've got their own expertise. I think there will be outsized benefits, because then you can really use these models to their full potential. And making sure that our next generation of young actuaries can experience those outsized benefits by being experts and of themselves, I think, is actually the core task of actuarial professions today.'

Finally, thinking outside of the box a little bit, what are your predictions? What should actuaries bear in mind, looking to the future and considering the use of AI?

I think that if we want to be successful going into the future, actuaries must stop being receivers of this technology, and we must start being creators. Let's take these fantastic concepts that have happened in the last, say, 10 years, from the transformer model architecture (the breakthrough neural network design powering modern AI), how to train transformers on huge amounts of data, how to make these models work across domains, and let's add our special actuarial touch to them, own the actuarial implications of these models, and not merely be end-users of a technology that's outside of the profession. I'd encourage every actuarial association to establish AI working groups focused on developing specialized tools for our profession, and for individual actuaries to invest time learning at least the fundamentals of these technologies to actively shape their implementation. <

RON RICHMAN is Founder and CEO of insureAI, a software and consulting firm bringing the power of AI to actuarial tasks. He was formerly Chief Actuary of Old Mutual Insure. He is a Fellow of the Institute and Faculty of Actuaries (IFoA) and the Actuarial Society of South Africa (ASSA), holds practicing certificates in Short Term Insurance and Life Insurance from ASSA, and a Masters of Philosophy in Actuarial Science from the University of Cape Town.



LEVERAGING LLMS FOR CODE CONVERSION IN FINANCE: BEST PRACTICES AND CHALLENGES

BY **BRAM JOCHEMS**

This article explores how LLMs can be leveraged for code conversion in finance.

BACKGROUND

In the finance sector, there is a trend to convert models and code from one language to another, amongst others due to the following reasons:

- Productivity gains: enhancing and improving current workflows with new implementations that can further automate tasks, can lead to efficiency gains.
- Improve maintainability: existing codebases can become difficult to maintain and finding developers with expertise in languages that have become less popular can be challenging.
- Performance boost: due to increasing demands on the existing systems a performance boost might be required.
- Quality boost: the quality of existing code and models might not meet modern standards.

With advancements in natural language processing (NLP), large language models (LLMs), such as GPT-4, have shown promise in aiding code conversion tasks. The LLMs perform well in the direct translation of relatively simple code (e.g. scripts). This article explores how LLMs can be leveraged for code conversion in finance, focusing on three key areas: handling non-direct translations, addressing data integration challenges, and dealing with lack of unit tests.

Throughout our discussion, we'll highlight best practices and potential limitations to consider when employing LLMs in your code conversion projects. For non-direct translations, a code example is given. More examples are given in the accompanying working paper.[1] >

[1] See Jochems (2024), Code conversion using LLMs, working paper.

NON-DIRECT TRANSLATIONS

A challenge in code conversion is translating code that has no direct equivalent in the target language. This often occurs when dealing with language-specific features or specialized libraries. Consider this SAS code that performs linear regression with forward selection of explanatory variables:

```
Proc Reg data=CleanedData outest=ADJRSQ_summary;
    Title 'Adjusted R-Squared - Training data';
    model TARGET_AMT=
            log_INCOME
            No_Income
            [Some variables omitted for brevity]
            URBANCITY_HU /selection = FORWARD AIC VIF BIC MSE groupnames= 'EDUCATION' 'JOB' 'CAR_TYPE';

    output out=ADJRSQ_out pred=yhat residual=resid ucl=ucl lcl=lcl cookd=cook
    covratio=cov dffits=dfits press=prss;
run;
```

EXHIBIT 1: SAS CODE FOR LINEAR REGRESSION WITH FORWARD VARIABLE SELECTION

Translating this to Python requires implementing the forward selection algorithm and handling the various output statistics. Here's how an LLM might approach this translation:

When considering the quality of the translation, some observations can be made:

```python
def forward_selection_custom(X, y) -> list[str]:
    initial_features = []
    remaining_features = list(X.columns)
    best_features = []

    while remaining_features:
        criterion_candidates = []
        for feature in remaining_features:
            X_selected = X[initial_features + [feature]]
            model = sm.OLS(y, X_selected).fit()
            criterion_candidates.append((feature, model.aic))

        best_candidate = sorted(criterion_candidates, key=lambda x: x[1])[0]

        if best_candidate[1] < model.aic:
            # Code omitted for brevity
            ...
        else:
            break

    return best_features

def run_regression(X, y):
    selected_features = forward_selection_custom(X, y)
    X_selected = X[selected_features]
    model = sm.OLS(y, X_selected).fit()
    return model, selected_features
```

EXHIBIT 2: LLM TRANSLATED PYTHON CODE FOR REGRESSION WITH FORWARD VARIABLE SELECTION

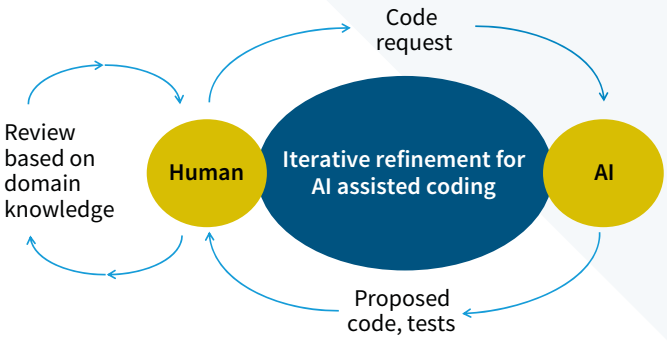
1. **The good**: the LLM has done a decent job of implementing its own forward selection regression algorithm, without the input prompt specifying that this was required.
2. **The bad:** There is no guarantee that the regression and forward selection algorithm that are being used will lead to the same outcome. For the regression algorithm, there >

might be implementation differences that cause (numerical) difference. Similarly, there could be differences in the implementation of optimization measures that could cause different variables to enter. Both are issues that could or could not really matter, depending on the specific application.

3. **The ugly:** the SAS code has a particularity that isn't included in the translation. This is the part that specifies 'groupnames ….'. This essentially tells SAS that these are categorical variables (meaning that they have values in a few categories instead of numerical values) and how the model should deal with those. This feature is completely missing in the Python code.

Best Practice: Iterative Refinement

When dealing with non-direct translations like this SAS to Python conversion, it is best practice to use the LLM-generated code as a starting point. Then, iteratively refine the code with domain expertise. In this case, you might need to adjust the forward selection algorithm to more closely match SAS's implementation, deal with categorical variables or add additional diagnostic statistics that are important for your specific use case.



In addition, LLMs can also generate tests using so-called mocks. What this does is essentially replacing part of the code with pre-generated outcomes. This is for example especially useful for testing if the regression model implementation differs between SAS and Python, without the results being influenced by the outcomes of the variable selection.

Limitation: Domain-Specific Knowledge and Edge Cases

LLMs may struggle with highly specialized financial models or proprietary libraries. In our SAS example, the LLM didn't fully implement all the options specified in the original code. With further iterative refinement, this can be improved.

Moreover, even though it may seem that LLMs generate good test cases, they could also be subtly wrong, even when the code looks good at first glance. It's important to review and supplement the generated tests with domain-specific test cases that reflect real-world usage of your models.

By combining LLM-generated code with rigorous testing and domain expertise, you can ensure that your converted code not only replicates the functionality of the original but also keeps the robustness required for financial applications.

CHALLENGES OF INTEGRATING CODE INTO EXISTING SYSTEMS

Beyond function conversions, integrating new code into pre-existing architectures presents additional challenges, especially in finance where systems often use specialized frameworks like Object-Relational Mappers (ORMs).

A common challenge arises when moving from systems that handle data with tables or dataframes (such as R or SQL) to those using ORMs (e.g., SQLAlchemy for Python or Entity Framework for C#). LLMs may convert the logic but might not account for database schema details or query optimizations crucial for performance.

Best Practice: Context Awareness

To improve the translation, we can provide the LLM with context about our ORM setup, model relationships, and project conventions. With this context, the LLM could produce a more appropriate translation.

Limitation: Performance Considerations

While the context-aware translation is more >

aligned with the project's structure, it's crucial to note that ORMs can sometimes generate suboptimal SQL, especially for complex queries. For instance, if this query is performance-critical, one might need to add indexing hints or partitioning strategies that are specific to your database system.

UNIT TESTING

Unit testing, i.e., the act of testing small components of functionality in isolation, is fundamental to ensuring high-quality implementations, helping to pinpoint functionality issues and document expected behaviour. However, in practice, many financial models brought to production often lack comprehensive unit tests. LLMs can play a crucial role in addressing this gap.

LLMs can assist in generating unit tests for both the original code and the target language implementation. This capability is particularly valuable when dealing with models developed in Excel, SAS, R, or Python that lack existing unit tests.

When converting code, LLMs can not only translate the logic but also generate corresponding unit tests to ensure the results remain consistent across both languages. By auto-generating these functional tests, LLMs reduce the manual overhead needed for verifying that the converted code remains consistent with the original version.

Best Practice: Comprehensive Testing

When using LLMs for code conversion, it's crucial to generate unit tests for both the original and converted code. This approach helps to ensure that the functionality stays consistent across languages. Tolerance-based testing can be used to account for minor discrepancies in floating-point arithmetic between languages.

Limitation: Test Coverage

While LLMs can generate basic test cases, they may not cover all edge cases or complex scenarios specific to your financial models. It's important to review and supplement the generated tests with domain-specific test cases that reflect real-world usage of your models. These tests can be generated manually, or be generated through additional prompting.

CONCLUSION

LLMs present a powerful tool for accelerating code conversion in finance, offering solutions for common problems in practice, such as unit testing, non-direct translations, and data integration challenges. However, their effective use requires a balanced approach that combines automated conversion with human expertise. By following best practices such as iterative refinement, comprehensive testing and providing context to LLMs, financial institutions can leverage these tools to modernize their technology stack more efficiently. At the same time, it's crucial to be aware of limitations around test coverage, domain-specific knowledge, and performance optimization.

As LLM technology continues to evolve, its role in code conversion and software development is likely to expand, offering even greater possibilities for streamlining financial technology operations. However, the key to success will always lie in combining the power of AI with human expertise and domain knowledge. <

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RE-CAP OF THE
‘EMPOWERING TOMORROW: YOUNG ACTUARIES LEADERSHIP AND CAREER DEVELOPMENT SEMINAR’
BY THE YOUNG ACTUARIES INITIATIVE

BY **SAMUEL CYWIE AND DANIEL JUNG**

The ‘*Empowering Tomorrow: Young Actuaries Leadership and Career Development Seminar*’, held from 28-29 November 2024 at the Le Bischenberg Conference Center in Strasbourg, marked the first in-person project of the Young Actuaries Initiative (YAI). This European initiative was jointly launched by the German Association of Actuaries (DAV) and the French Institut des actuaires (IA).

The YAI focuses on fostering the next generation of actuarial professionals through career development, mentoring, and networking opportunities. By equipping young professionals with the skills to meet the evolving demands of the European insurance and financial sectors, it aims to ensure the future resilience and relevance of the actuarial profession.

This event offered participants a unique professional opportunity as well as an exceptional personal and cultural experience. The program was >

'Leadership experiences' roundtable with Inga Helmane (AAE President), Matthias Pillaudin (AAE Vice President), Susanna Adelhardt (DAV President-elect) and Frédérique Henge (Credit Mutuelle)

specifically designed to address the diverse needs and interests of young actuaries across Europe.

During the two-day seminar, 30 young actuaries who are actively engaged in youth and technical work within their respective associations gathered from all corners of Europe — representing 12 actuarial associations from 11 countries!

This multinational gathering was more than just a traditional seminar — it provided a unique chance for young actuaries to exchange ideas, network, enhance their skills, and actively shape the future and evolution of the actuarial profession.

The program began with insightful presentations on current topics. Johanna Borsch-Schämann from DAV presented on '*Impact Underwriting and Sustainable Insurance Products*', while Antoine Heranval from IA shared insights into the use of artificial intelligence in predicting natural disasters. These inspiring talks highlighted the pivotal role actuaries can play in addressing global challenges that transcend borders.

The seminar continued with interactive workshops titled '*Connected Minds. Stronger Impact*', led by communication experts Caroline Grégoire and Stéphane Deslauriers. Through dynamic breakout sessions, participants developed practical communication strategies to enhance their professional impact.

The second day focused on career success and leadership skills. AAE President Inga Helmane, DAV Vice Chair Susanna Adelhardt, AAE Vice President Matthias Pillaudin, and Frédérique Henge who is holding the Actuarial Function at Crédit Mutuel Assurances shared valuable insights on leadership and career development, drawing from their personal journeys and lessons learned. These practical sessions encouraged participants to reflect on their own career ambitions and goals.

Overall, the seminar stood out not only for its content depth but also for the lived intercultural exchange. Reflecting on the event, it was impressive to see how this inaugural gathering became a melting pot of ideas, cultures, and ambitions from the outset. The diversity of participants created fertile ground for mutual understanding — an increasingly vital skill in a globalized world. The personal stories, experiences, and goals shared over the two days underscored each individual's unique contribution to the emerging community of young actuaries.

Looking back at this milestone event, the sense of momentum and anticipation for what lies ahead is palpable. Building on the foundation laid during these two extraordinary days is now crucial. It is essential for young professionals to bring the insights, expertise, and determination gained in Strasbourg back to their respective associations and contribute to the establishment of local YAI communities or chapters. While some actuarial associations are already further along in this journey than others, sharing best practices and learning from one another will be key. >

In conclusion, a heartfelt thank you to all participants, coaches, and speakers who made this event possible. But this is just the beginning:

Join us on 25 March 2025 for the YAI Young Actuaries Career Day!
This upcoming online-event is dedicated to personal and professional growth of young actuarial professionals – and it is free of charge. Discover topics like ownership mentality, problem-solving or international career opportunities, and connect with peers and experts to elevate your actuarial journey. The complete program will be released soon and a registration can be proceeded under www.young-actuaries.eu.

YOUNG ACTUARIES INITIATIVE

VISION AND MISSION OF THE YAI:
Almost all actuarial associations share a common objective: the need to involve young actuaries in their associations and to identify and motivate aspiring candidates to choose an actuarial career path.

Consequently, most associations provide national activities and programs to engage with those communities and target groups. Additionally, there is a need to share individual expertise and best practices within the international partner network and join forces on a transnational scale where valuable.

To serve this goal, the Young Actuaries Initiative (YAI) has been started by France and Germany.
As an access platform to facilitate exchange with peers from different countries, it aims at fostering a broad exchange of actuarial associations committed to intensifying their interaction with young professionals and creating offerings together that go beyond the national horizon. It is designed along three dimensions:

1. Personal level
Comprehensive individual career development and cross-border networking opportunities.

2. Professional level
Contribute constructively to the shaping and development of tomorrow's actuarial profession by attending or organising both physical and virtual events.

3. Intercultural level
Enabling transnational community-building among young actuaries and embracing diversity through various unifying social activities.

SAMUEL CYWIE is Head of International Affairs and Actuarial Studies at Institut des actuaires.

DR. DANIEL JUNG is Manager International Affairs and Relationship Management at Deutsche Aktuarvereinigung.

Event impressions >

EVENT IMPRESSIONS

Agata from Poland:
'In November, I had the pleasure to participate in the first YAI seminar as one of the representatives of the Polish Actuarial Society. Networking, in particular, stood out as a key takeaway from the event. During the seminar, I had a chance to connect with fellow young actuaries from various backgrounds and regions, which definitely broadened my perspective on the global actuarial landscape.'

Melissa from the Netherlands:
'The Young Actuaries Seminar was truly inspiring, connecting with peers from across Europe to share ideas and grow together. What resonated with me the most was meeting so many driven bright minds discovering who they aspire to be and creating initiatives to support each other along that way. I am grateful for this inspiration and excited to keep empowering each other.'

Lilian from Germany:
'Our actuarial profession thrives from sharing ideas and experiences with one another, looking at the past and making the future brighter. It needs highly motivated individuals who are proud to share what they do and who inspire others to do the same. Why start before retirement, when you can start earlier in your career, making a longer lasting impact?'

Alexandra from France:
'Above all, the seminar facilitated networking opportunities! We had the chance to exchange with colleagues from different countries, backgrounds and cultures. As young actuaries we tend to underestimate the importance of networking and soft skills development. If at the beginning these are 'nice-to-have', as we progress in our careers these become crucial, especially in a fast-changing world.'

INTRODUCTION TO A **QUANTUM TOOLBOX**

BY **MUHAMMAD AMJAD**

Quantum computing, while seemingly complex, may be surprisingly intuitive for actuaries. Building a quantum circuit often involves capturing the essence of relationships between risks, similar to how actuaries model dependencies. For example, a quantum circuit can represent how the death of one life might impact the probability of death of another, a concept familiar to actuaries who work with joint life probabilities and correlated risk factors. This shared focus suggests that actuarial science can be readily 'quantised,' opening the door to a quantum toolbox for actuaries.

This article serves as an introduction to this emerging quantum toolbox. We will explore how quantum computing concepts such as superposition, entanglement and dense encoding, can be leveraged to represent and manipulate actuarial data and probabilistic models. We will then delve into specific quantum algorithms including Quantum Amplitude Estimation (QAE) and its potential applications in speeding up internal models. Finally, we will discuss how actuaries can proactively develop a quantum skillset.

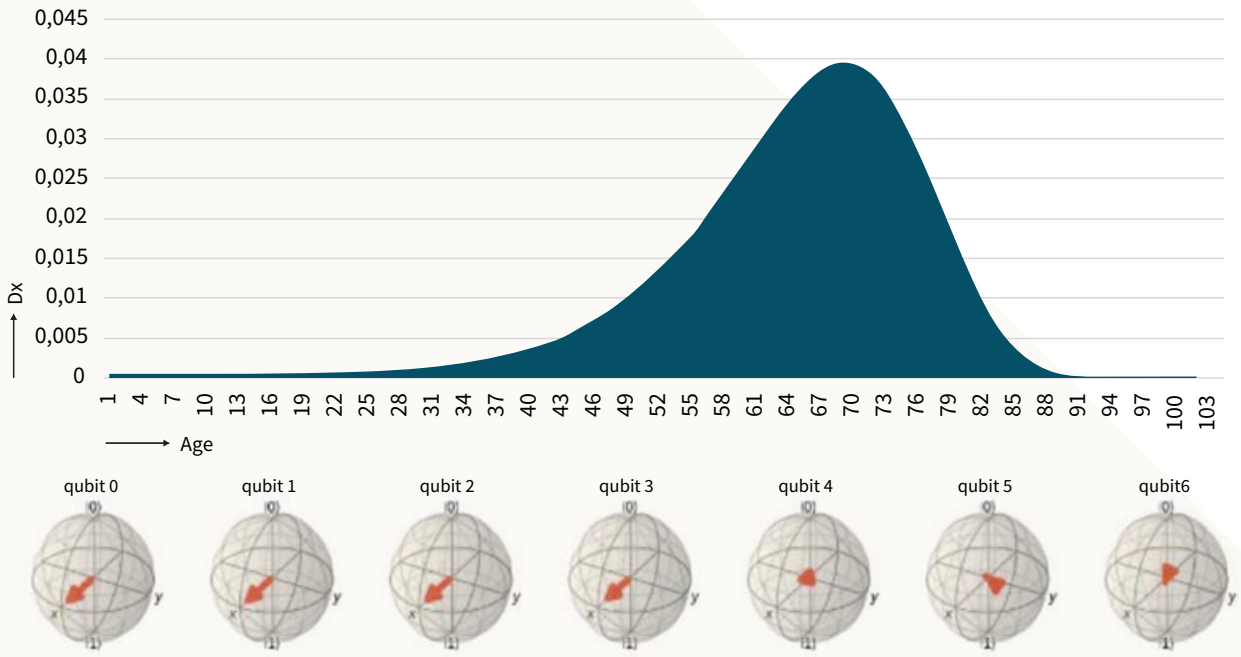
SUPERPOSITION AND ENTANGLEMENT: SCHRÖDINGER'S CATS AND SPOOKY ACTIONS

In 2025, the basics of Erwin Schrödinger's thought experiment should be common knowledge. It illustrates the counter-intuitive nature of quantum superposition. Imagine a cat in a box, its fate tied to a quantum (random) event. Before we open the box, the cat is neither alive nor dead, but rather in a superposition of both states. This concept, while perplexing, is fundamental to understanding quantum computing.

To visualise superposition, consider the surface of the Earth. Classical bits are restricted to only the North (0) and South (1) poles – binary, cold, and limited. A qubit (quantum bit), however, allows us to represent information anywhere on the Earth's surface. The warm equator represents an equal superposition of both poles, analogous to the cat being both alive and dead simultaneously.

Entanglement introduces an additional layer of richness, a phenomenon Einstein famously termed 'spooky action at a distance'. Imagine two best friends who always make independent choices but end up doing the same activities and encountering each other. If one is located at the North Pole, the other will also be found there immediately. This correlation isn't due to any classical communication; it's an intrinsic quantum property. In essence, entanglement creates a powerful connection between qubits, allowing them to act in concert and enabling complex quantum algorithms. It's this 'spooky' connection that unlocks computational possibilities far beyond the reach of classical systems. >

FIGURE 1: AMC00



DENSE ENCODING: HOW MUCH DATA DOES A QUBIT PACK, WHEN A QUBIT PACKS DATA

Consider a single entry in a spreadsheet, like Dx representing the probability of death at a specific age x (observed at birth). In classical computers, such data is commonly stored using double-precision floating-point format, requiring 64 bits. A life table with 120 D_x entries necessitates 120 * 64 = 7680 bits.

Figure 1 shows AMC00 encoded using just 7 qubits, as 7 qubits span 128 (2^7) basis states. Note that whilst the first four qubits are in an equal super position, the last three qubits are a bit ambiguous. This is because of 'entanglement' which means their combined state cannot be 'factored' into individual qubits. Each basis state is associated with an age and has a corresponding probability amplitude (written in braket[1] notation below).

The basis states like |-------> are just binary representations of age and the coefficients a_s represent the probability amplitudes.

QUANTUM ALGORITHMS: MULTIVERSE COMPUTING

David Deutsch famously described Shor's algorithm for factoring large numbers as computation in parallel universes. While not literally true, this captures the essence of how quantum algorithms can explore a vast solution space simultaneously by leveraging superposition and entanglement.

Think of the classic game '20 Questions'. You're trying to guess a number between 1 and N. Starting with no information, the best classical strategy is to ask questions that halve the possibilities with each 'yes' or 'no' answer. This leads to a logarithmic search, requiring roughly $C=\log_2(N)$ questions in the worst case.

With quantum (Grover's algorithm) we can do better. Instead of simple 'yes/no' answers, the quantum answerer provides a *probability distribution* over all possible numbers. Initially, this distribution is uniform, reflecting complete uncertainty. >

$$|\Psi\rangle = a_{0000000}|0000000\rangle + a_{0000001}|0000000\rangle + a_{0000010}|0000010\rangle + \ldots\ldots\ldots\ldots + a_{1111110}|1111110\rangle + a_{1111111}|1111111\rangle$$

[1] Also known as Dirac notation after the physicist Paul Dirac.

However, we know two things

1) Quantum answerer knows the answer, even though the probability distribution does not reveal their knowledge (the correct answer has been tagged somehow).

2) The answerer is bound by rules of quantum mechanics.

Using these insights, we ask questions ('Grover iteration') that manipulate the answerer in skewing the probability distribution in favour of the correct answer, which is revealed in fewer steps, roughly $Q=\sqrt{C}$ where C represents the steps it takes the logarithmic search algorithm outlined above. In computer science, such a gain in efficiency is called a 'quadratic speedup'.

Figure 2 illustrates the quantum answerer's 'internal' representation (probability amplitudes) in the top pane, and the answers it gives (probability distribution) in the bottom pane. At the start of the game, neither participant has any information. The answerer needs to read the right answer (apply Oracle) to be able to respond to the questioner but cannot respond directly (probabilities remained unchanged). Note the probabilities are calculated by squaring the amplitudes. The Grover iteration flips all amplitudes around the mean, revealing the correct answer in one step, compared to the three steps needed classically.

QUANTUM VAR: QUANTUM LEAP PAST BUFFON'S NEEDLES WITH QAE

Monte Carlo methods can be traced back to 1777 with Georges-Louis Leclerc, Comte de Buffon, and his experiment to estimate π by randomly dropping needles onto a grid of parallel lines. The probability of a needle crossing a line is mathematically related to π, allowing for its estimation through repeated trials.

However, the Monte Carlo methods we know today had to wait for the advent of computers. Stanislaw Ulam and John von Neumann recognized the power of random sampling to simulate complex physical processes, such as neutron diffusion in atomic bombs. The name 'Monte Carlo,' inspired by the famous casino, reflects the method's reliance on chance. >

FIGURE 2

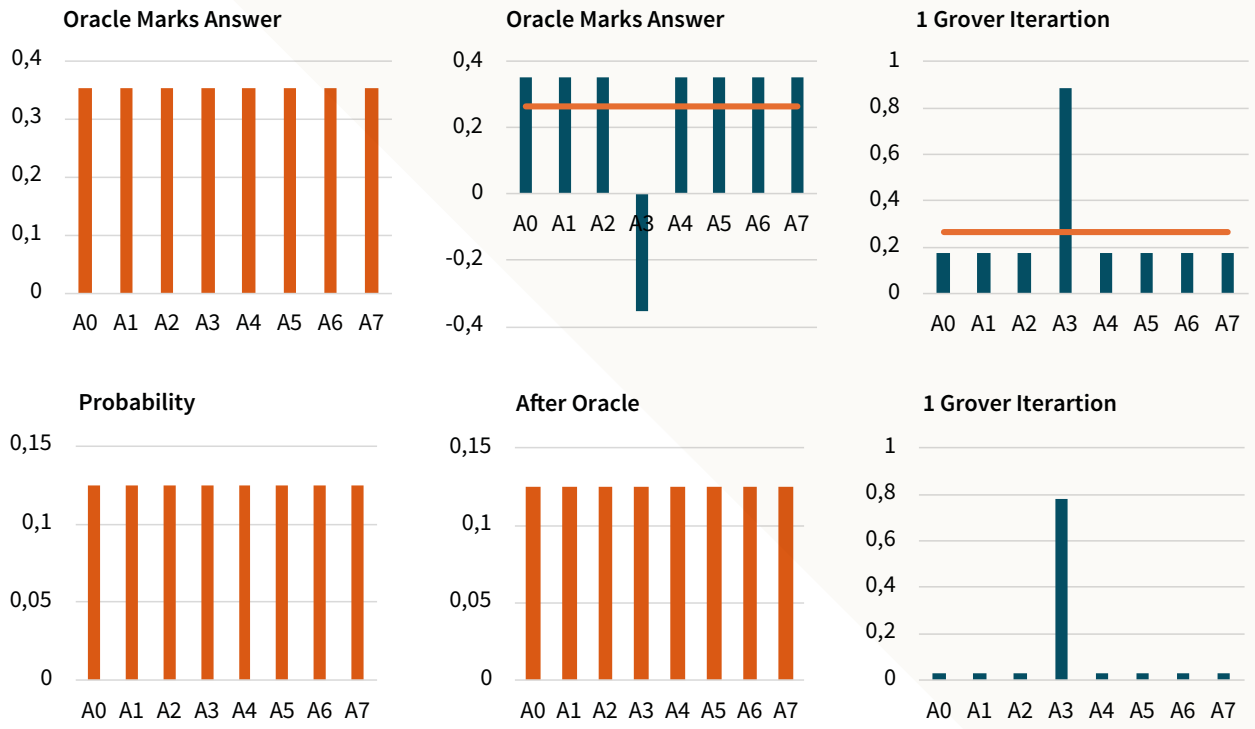
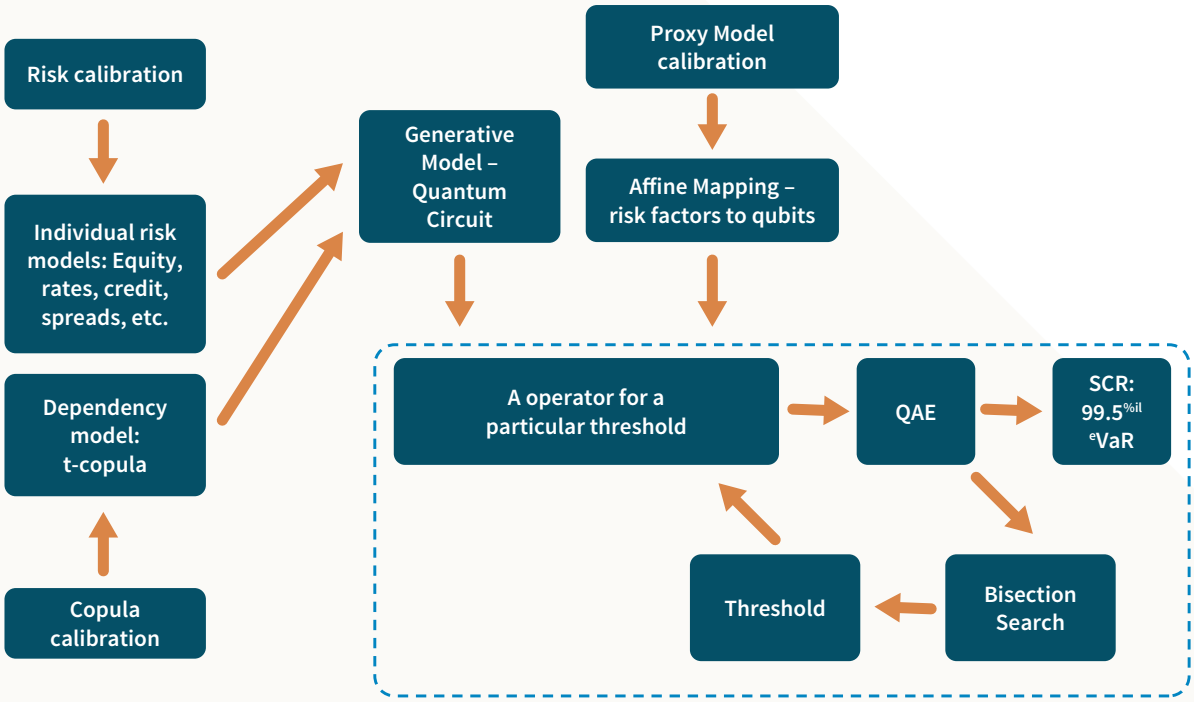


FIGURE 3



Despite their power, Monte Carlo methods can struggle with extremely complex problems where exploring the entire state space is computationally prohibitive. With Quantum Amplitude Estimation (QAE), we can do better. The basic idea is very simple, QAE is similar to playing 20 questions with our quantum answerer. They can't tell us the SCR directly, but if we specify a loss, they can tell us the probability amplitude associated with that loss. Readers might recognise an opportunity to employ the logarithmic search algorithm to zero in on the SCR. In fact, QAE is another quantum algorithm that promises a near quadratic speedup compared to classical Monte Carlo. The detailed implementation is more complex, but the high-level process is illustrated in *Figure 3.*

THE FUTURE: QUANTUM ENABLED ACTUARY (QEA)

Actuaries can prepare for the future by proactively developing a quantum skillset. This involves

1) Familiarising themselves quantum mathematics (linear algebra) and fundamental quantum concepts
2) and gaining hands-on experience with quantum programming tools like Qiskit (IBM)

Starting with smaller, well-defined problems can be a valuable way to hone these quantum skills. Problems involving optimisation or probability estimation, where quantum algorithms may offer advantages, are good candidates. As quantum technology matures, actuaries can increasingly tackle more complex challenges, including those currently intractable for classical computers.

By embracing quantum capabilities, the quantum-enabled actuary (QEA) can unlock new insights, enhance their analytical toolkits, and contribute to developing innovative solutions in the quantum age. <

MUHAMMAD AMJAD is currently a Director at Willis Towers Watson focusing on Private Assets, Capital Management and Capital Modelling. With a strong background in quantitative finance, data science and quantum computing, he is passionate about harnessing emerging technologies to transform actuarial practice and advance the insurance sector.

THE IMPACT OF THE EUROPEAN ARTIFICIAL INTELLIGENCE ACT ON ACTUARIES: BETWEEN CHALLENGES AND OPPORTUNITIES

BY **CLARA SIKORSKI**

The European Artificial Intelligence Act 2024/1689 ('AI Act') came into effect on August 1, 2024, with a phased implementation from 2025 to 2027. For actuaries, specialists in statistical analysis and risk modelling, this regulation introduces new obligations primarily concerning data governance, model fairness, and algorithmic transparency.

ACTUARIAL MODELS AND RISK CLASSIFICATION

The AI Act classifies AI systems into four risk levels. Systems deemed unacceptable, such as social scoring, are strictly prohibited. High-risk systems are subject to stringent rules aimed at ensuring safety and transparency. Limited-risk systems, such as chatbots, must comply with specific information and transparency obligations. Finally, minimal-risk systems are not subject to specific obligations. >

Actuaries working in the life and health insurance or banking sector are impacted by the provisions regarding high-risk AI systems ('HRAIS'). Indeed, AI systems used to evaluate the creditworthiness of individuals, or for risk assessment and pricing in life and health insurance, may fall under this category. This classification entails numerous compliance obligations.

A key point to note is that any AI system used for profiling, within the meaning of the General Data Protection Regulation (GDPR), is automatically considered high-risk. The GDPR defines profiling as an automated processing of personal data to analyse or predict personal characteristics, such as an individual's economic situation or health.

RISK ASSESSMENT: A DELICATE BALANCE FOR ACTUARIES

An actuarial model will not fall into the 'high-risk' category if it does not pose a 'significant risk of harm to the health, safety, or fundamental rights' of individuals, including by not materially influencing the outcome of decision making.

Thus, models that merely detect decision-making patterns or deviations from such prior patterns and are not intended to replace previously completed human assessments, are exempt from the provisions regarding high-risk systems.

Furthermore, regulatory requirements are applicable exclusively to models that are categorised as AI systems. The AI Act defines an AI system as a 'machine-based system that is designed to operate with varying levels of autonomy and that may exhibit adaptiveness after deployment, and that, for explicit or implicit objectives, infers, from the input it receives, how to generate outputs such as predictions, content, recommendations, or decisions that can influence physical or virtual environments'.

The central element of an AI system is its capacity to infer. This inference capability, distinguishing an AI system from a traditional software system, includes both the process of obtaining outputs and the ability to derive models or algorithms from inputs or data. This distinction justifies regulatory oversight of machine learning techniques, which are widely used in actuarial models.

Therefore, actuaries face a threefold challenge: mapping their tools against the definition of an AI system, assigning a risk level to them, and anticipating the resulting obligations. Navigating these complexities is essential for ensuring proper classification of the models and compliance with the AI Act.

GENERAL OBLIGATIONS OF THE AI ACT AND IMPACT ON ACTUARIES

The AI Act imposes a set of precise administrative obligations on providers of HRAIS, starting with a statement of conformity, CE marking, and registration in an EU database. These requirements must be supported by internal control measures and the implementation of a quality management system that spans the entire lifecycle of the AI system.

For their part, the deployers (users) of these systems must conduct a Fundamental Rights Impact Assessment and, in cases where personal data is processed, perform a Data Protection Impact Assessment.

All this regulatory documentation will need to detail the measures taken to ensure the fairness and transparency of the HRAIS results, which are two major requirements of the European regulator. >

DATA GOVERNANCE AND FAIRNESS OBLIGATIONS

The AI Act significantly strengthens data governance obligations for HRAIS by imposing rigorous controls on training, validation, and test datasets, and requiring a thorough assessment of their availability, quantity, and suitability.

The objective is to ensure algorithmic fairness by identifying and correcting potential biases that could lead to prohibited discrimination. This involves a detailed review of the models, along with appropriate measures to detect, prevent, and mitigate biases. The previously mentioned Fundamental Rights Impact Assessment will need to formalise these controls and demonstrate the effectiveness of the tools used to limit algorithmic distortions.

Meeting these obligations may necessitate significant investments in data governance tools and rigorous validation processes. Additionally, actuaries will have to be trained in bias detection tools and methodologies, which are crucial for conducting the Fundamental Rights Impact Assessment and ensuring model compliance.

Foto S. Morsli

CLARA SIKORSKI serves as the Global Data Privacy Director at Milliman. Formerly Attorney-at-Law with the Luxembourg Bar specialising in data protection, her current professional focus is on global data privacy and data ethics.

TRANSPARENCY OBLIGATION

For actuarial models classified as HRAIS, the transparency obligation requires documenting the underlying logic of their outputs to facilitate interpretation. When these results lead to decisions with legal effects or significantly impact individuals, this requirement extends to providing an explanation to those affected.

In this context, actuaries will need to familiarise themselves with algorithmic transparency and model explainability tools and may even prioritise more interpretable models for a non-technical audience.

Regulatory compliance will thus necessitate strengthened collaborations between actuaries, data scientists, and legal experts. However, beyond the constraint, it also opens an opportunity: by enhancing transparency and fairness, it fosters public and regulatory trust and creates increased demand for compliant actuarial models. In this context, responsible AI could become a true strategic lever for the insurance sector.

The information provided in this article is for general informational purposes only and does not constitute legal advice. <

ERM, ACTUARY AND *DOUBLE MATERIALITY*: THE NEW CHALLENGE

BY **MARIANNA DUCA**

Enterprise Risk Management (ERM) is extensively used by both financial and non-financial organizations to mitigate negative and uncertain situations that could jeopardize business strategy and operations. By minimizing the impact or likelihood of such events, ERM helps prevent reputational, financial, or other types of damage. It is recognized as an effective tool for reducing losses from unexpected risks and enhancing business performance across various industries.

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IN RECENT YEARS, three key factors have been reshaping the risk landscape:

1. Organizations are increasingly exposed to a wide range of potential negative events that are uncertain and difficult to quantify using traditional risk management practices.

2. Potential negative events are closely linked to sustainability issues (e.g., climate change), with a broad spectrum of long-term outcomes.

3. New sustainability regulations related to Environmental, Social, and Governance (ESG) risks are being implemented. ESG risks encompass:

   - Environmental: climate change, pollution, water, biodiversity, and circular economy.
   - Social: interactions with employees, communities, customers, and consumers.
   - Governance: corporate ethics and business conduct.

In this rapidly evolving context, actuaries are well-positioned to support organizations in transitioning to new enterprise risk management practices. This is due to four main reasons:

1. Actuarial approaches to risk management focus on statistical analysis to understand uncertainties.

2. Actuaries emphasize economic and financial quantifications of risks, including pricing and capital requirements.

3. Actuarial methods explore all possible implications of negative events, from short to long term, considering the evolution of risk impact over time.

4. Actuaries are familiar with social and environmental factors, incorporating them into actuarial analyses for insurance product pricing and the calibration of best estimate liabilities and solvency capital requirements. >

Given these reasons, the actuarial approach to Enterprise Risk Management can give benefits to organizations that adopt it. Despite their extensive knowledge of risk practices, actuaries must align with emerging ESG regulations. The recent EU sustainability regulations, known as the Corporate Sustainability Reporting Directive (CSRD), emphasize the identification, quantification, and disclosure of ESG risks. CSRD introduces the concept of *double materiality* assessment for both financial and non-financial sectors.

This principle requires companies to consider and report both the impact of sustainability factors on the company (financial materiality) and the impact of the company on the environment and society (impact materiality). Specifically:

- Financial Materiality (outside-in): how sustainability factors influence the company's value, performance, and financial position. For example, climate risks that could affect business operations, such as increased insurance claims due to extreme weather events.

- Impact Materiality (inside-out): how the company impacts the environment, society, and the economy. For example, the company's CO2 emissions and their effect on climate change, or the social impact of investment policies.

The principle of double materiality, a key element of the European Green Deal, requires the systematic integration of financially relevant sustainability risks and impacts into economic and financial decision-making processes.
All organizations subject to European CSRD regulations must adopt a *double materiality* approach starting from FY2024 to identify and assess sustainability risks.

To integrate the *double materiality* approach into actuarial approach to risk management, actuaries need to:

- Strengthen technical knowledge on sustainability matters.

- Gather new data on ESG factors.

- Develop new risk models by integrating ESG factors.

- Interact with new business stakeholders (e.g., sustainability departments).

- Enhance their mindset towards new enterprise risk processes.

According to the new sustainability regulatory framework and actuarial risk principles, actuaries should improve their professional approach by:

- Understanding the context and interrelation between the company's operations, products, services and ESG factors.

- Identifying and evaluating sustainability risks and opportunities over different time horizons (short-medium-long), with robust risk assessments.

- Prioritizing sustainability factors for detailed disclosure, considering the level of risk, opportunities, and impact (Double Materiality).

- Collecting data on material sustainability factors, aligned with all CSRD requirements.

- Preparing sustainability reports and plans for future improvement.

In conclusion, actuaries can significantly contribute to the evolving risk landscape, which is increasingly intertwined with sustainability. <

COLUMN

It's not AI replacing actuaries, but it's actuaries using AI replacing actuaries who don't!

This is a remarkable prediction by Charles Cowling, President of the IAA in 2024, and I could not agree more.

With the global focus on Artificial Intelligence (AI), with non-European countries investing billions to further develop AI, and with the European Union implementing strong regulation of AI, it is essential for any actuarial association to broaden its focus to include this emerging technology and how it can be applied for the benefit of society. Listening to young mathematicians and actuaries, this is what they expect us to do to shape the future and stay relevant!

While it remains crucial to be able to apply traditional methods effectively, the use of AI can bring a number of benefits. First, AI can help actuaries tackle complex problems more efficiently, allowing them to focus on high-level strategic decision-making. By incorporating AI into their work, actuaries can enhance their analytical capabilities, ultimately leading to more accurate insights and improved risk management.

Young actuaries, in particular, are increasingly tech-savvy and fascinated by these emerging technologies. By incorporating AI-related training and resources into our offerings, actuarial associations can appeal to them. Not only can this help attract new members, but it can also enable the actuarial profession to stay at the forefront of industry developments.

Some potential initiatives actuarial associations can explore include:
Training programmes: Develop comprehensive training programmes to familiarise members with AI tools, machine learning, and data visualisation.
Professional workshops: Host workshops, conferences, and seminars that bring together experts in AI and actuarial science to discuss the latest applications and best practices.
Knowledge sharing: Create online platforms where members can share their experiences, ask questions, and access AI-related resources.
Mentorship programmes: Connect young actuaries with experienced mentors who can guide them in integrating AI into their daily work and, vice versa, be inspired by the technical skills of young actuaries.
Industry partnerships: Forge alliances with organisations specializing in AI and other industries that share common interests.

By broadening our focus to include AI, we as actuarial associations can revitalise our relevance, attract new talent, and move the profession forward. As AI becomes increasingly widespread, actuaries who are proficient in these technologies will be better equipped to navigate this evolving landscape.

As the actuarial profession continues to evolve, embracing AI is not only essential, it is critical for actuarial associations to attract young talent. Those that seize this opportunity will thrive, enhancing their position as thought leaders within the industry and influencing a new generation of actuaries.

The AAE is supporting European actuarial associations in this journey and some of the above mentioned programmes are already available to European actuaries. Please support your association by becoming an active volunteer and help develop this new field also in your country and for whole Europe.

By dr. Frank Schiller
Frank Schiller is Chair of the AAE Communications Panel

COLOPHON

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