



UNIVERSITY OF
LIVERPOOL

IFAM

**THE INSTITUTE FOR FINANCIAL
AND ACTUARIAL MATHEMATICS**

liverpool.ac.uk/ifam



Welcome to the Institute for Financial and Actuarial Mathematics (IFAM)



**Professor
Corina Constantinescu**
Director of IFAM,
University of Liverpool



Established in 2011, the Institute for Financial and Actuarial Mathematics (IFAM) provides research and training in actuarial and financial mathematics, partnering with world-leading academics, industrial partners, NGOs and 3rd sector organisations around the world.

At IFAM, we are passionate about collaboration and conducting interdisciplinary research within an inclusive and diverse environment. We are home to a wide range of research expertise in the field of financial and actuarial mathematics, with a global focus.

Our international academic team bring a wealth of perspectives and expertise, supporting our work championing actuarial and financial mathematics as a discipline and profession around the world.

We are an international hub for actuarial and financial maths collaborations. Through our research, we contribute to society by creating solutions to financial problems and influencing governments and policymakers around the world.

We also provide teaching and support for hundreds of students each year at undergraduate, master's and PhD levels, training and developing the next generation of actuarial and financial mathematicians. Our teaching programmes are accredited by the Institute and Faculty of Actuaries.

Our research

IFAM conducts interdisciplinary research in financial and actuarial mathematics at an internationally recognised level.

We collaborate on our research with a range of companies and organisations in the UK and around the world, including the financial services industry, academic institutions, NGOs and the 3rd sector. We work across a diverse set of research areas, including:

Financial inclusion

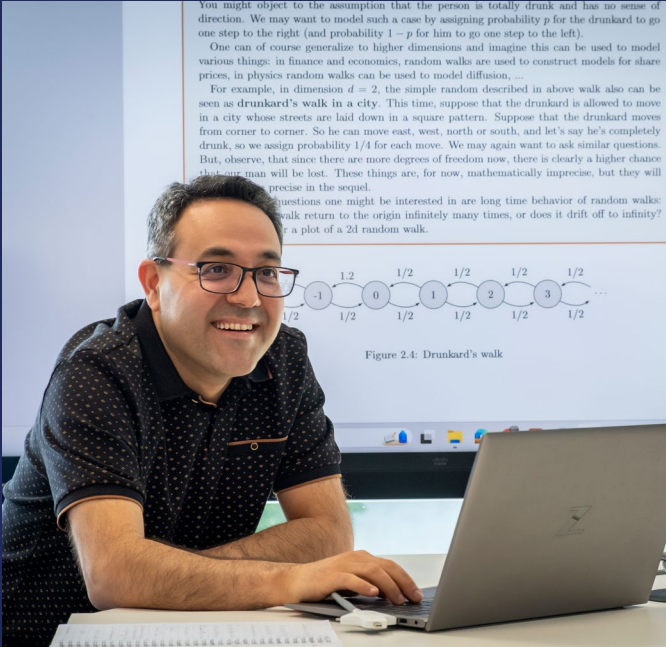
Our financial inclusion research focusses on microinsurance and microfinance in low-income countries, with the aim of using the mathematical models we develop to help alleviate poverty around the world.

Extreme events

Our research in the area of extreme events focusses on how society can financially protect and recover from extreme events such as earthquakes and pandemics, and specifically how financial services can aid faster recovery.

Mortality and longevity modelling

Our research on mortality and longevity modelling supports and informs policy details for insurance companies and pensions.



Machine learning in finance

We harness machine learning technologies to both calibrate traditional financial stochastic models and to transition towards data-centric approaches. Using these techniques, we aim to tackle classically complex financial decision-making challenges such as analysing large financial datasets, pricing, and hedging complex financial instruments, mitigating operational risk, and forecasting price trends.

Pension mathematics

Our research in pension mathematics involves product design, modelling, and valuing pension savings in public and individual pension systems. We focus on a number of areas including mortality and interest rate modelling, analysing funding and investment strategies, regulatory compliance, and risk management.



Stochastic processes, stochastic analysis, and applications

We have global research expertise in topics such as stochastic analysis, backward-forward stochastic differential equations (FBSDEs), stochastic control, numerical stochastic differential equations, Malliavin calculus, Malliavin-Stein approach, rough path theory, regularisation by noise, pathwise methods in stochastic analysis, fractional Brownian motion, and Markov processes, particularly in their applications to stochastic finance and insurance.

Financial mathematics

Our financial mathematics research focuses on financial derivatives – contracts based on an underlying asset, group of assets, or benchmark, agreed upon by two or more parties. Our research encompasses pricing, hedging, risk management, optimal investment strategies, implied volatility modelling, and rough volatility models.



CASE STUDY

Promoting social justice and advancing decent work worldwide with the ILO

The International Labour Organization (ILO) is a United Nations agency whose mandate is to advance social justice and promote internationally recognised human and labour rights. The ILO’s Social Finance Programme seeks to find ways in which the financial sector can contribute to its decent work agenda by creating jobs, improving working conditions and enhancing resilience for workers worldwide.

The ILO’s Social Finance Programme does this through three work streams. The first deals with financial inclusion, looking at how under-served market segments can be integrated into the financial sector so that they have access to the same services as everyone else. The second stream involves promoting impact insurance as a tool for managing risks for governments, financial institutions, small enterprises and low-income households.

Finally, the ILO works with investors to help them consider what impact they are having on the world of work when making investment decisions, looking beyond basic compliance rules to explore how their investments can help create jobs and improve working conditions.

The ILO and IFAM are jointly working on two aspects. The first is a meta-analysis of the behavioural impact of inclusive insurance products, including their benefits on health, wealth and wellbeing. The team gathered qualitative data from over 750 academic papers to identify examples of behavioural change resulting from people taking out insurance.



The inclusive insurance meta-analysis project is demonstrating to companies that inclusive insurance products are not only socially responsible, but they are both financially viable and make good business sense. This aims to encourage them to operate within this growing market segment. Working in partnership with ILO, the team are developing a detailed business case on the value of inclusive insurance products to demonstrate the effectiveness of their approach on alleviating poverty, promoting decent work and reducing global inequality.

Another collaborative project is analysing the feasibility and effectiveness of the implementation of digital wage payments across countries in Asia and Africa. Supported by the Bill & Melinda Gates Foundation, the ILO brings together unions, governments and employers to encourage them to move from cash payments for workers to digital systems. Utilising the World Bank’s Global Findex Database and harnessing machine learning techniques, the project is predicting the evolution and effectiveness of rolling out digital payment methods to communities across the world.

This digital payment project is being harnessed by ILO’s Global Centre on Digital Wages for Decent Work to influence public policy around the world, encouraging governments and regulators worldwide to promote awareness of and implement digital wage payments for workers.



“IFAM is helping us to drive impact in the real world through its pioneering financial and actuarial mathematics research, enabling us to promote social justice and advance decent work for people around the globe.”

CRAIG CHURCHILL,
CHIEF OF THE SOCIAL FINANCE
PROGRAMME AT THE INTERNATIONAL
LABOUR ORGANIZATION (ILO)

CASE STUDY

Reducing financial exclusion across Merseyside with Enterprise Credit Union

Financial exclusion is a major challenge in many areas of the world, including in Merseyside where IFAM is based. In the city of Liverpool, around 63% of the local population reside in areas that are classified as being located within the top 20% most deprived communities in England, with three in every 10 children under the age of 16 living in poverty in Liverpool.

As a result, many people across Liverpool are ‘financially excluded’ – meaning that they are unable to access financial credit or loans. According to PwC, more than 20 million adults in the UK in 2022 were defined as being ‘financially under-served’, leading to one in three adults having difficulty to access credit from mainstream lenders such as high-street banks and building societies.

Credit unions are often one of the only places that people who are financially excluded can turn to when they require a loan. Today, over two million people across the UK are members of credit unions, helping them to access credit when they need it most. Credit unions also play a critical role in providing and delivering financial education to help people move towards being ‘financially included’ through various approaches, including by building up their levels of personal savings over time.



To help tackle the major issue of financial exclusion, IFAM is working with Enterprise Credit Union, a financial co-operative that is owned and controlled by its members across Merseyside.

IFAM and Enterprise Credit Union are collaborating on a pilot scheme to look at how mathematics can be used to help improve financial inclusion across Liverpool and the Merseyside area for a potential customer base of around 800,000 people.

Financial and insurance mathematics are traditionally taught and studied through the lens of the behaviour of financially included people and customers. When addressing financial exclusion related challenges, the assumptions in these models need to be changed.

The IFAM team has extensive experience of adapting and adjusting conventional financial and actuarial mathematics tools to create fairer credit systems for people which also produce better risk management solutions for the financial organisations providing them with credit.

IFAM is applying their data science and financial mathematics research expertise to help Enterprise Credit Union to further grow their customer base within the large community of people across Liverpool who could meet the criteria of obtaining a loan from a credit union due to their personal circumstances.

The IFAM team is analysing anonymised data sets taken from Enterprise Credit Union’s financially excluded customer base to try to understand the fundamental factors and trends that underpin relationships and behaviours connected to social and financial history for financially excluded people and communities, as well as to help predict future outcomes.



“The pilot project that IFAM and Enterprise Credit Union are collaborating on aims to study the causes and trends that will effectively reduce financial exclusion, thereby making a positive impact on the lives of real people across the Merseyside area and beyond.”

KAREN BENNETT CBE,
CEO OF ENTERPRISE CREDIT UNION

CASE STUDY

Developing the next generation of African mathematical scientists with AIMS

Established in 2003, the African Institute for Mathematics Sciences (AIMS) is a pan-African network of centres of excellence that is enabling Africa’s talented students to become innovators to drive the continent’s scientific, educational and economic self-sufficiency.

AIMS is Africa’s first and largest network of centres of excellence for innovative post-graduate training in mathematical sciences. With five centres located across South Africa, Senegal, Ghana, Cameroon and Rwanda, as well as a research and innovation centre in Rwanda, AIMS is leading Africa’s socio-economic transformation through innovative scientific training, cutting-edge research, and public engagement.

Mathematics underpins most of modern life. To create technology, you need mathematics and mathematicians. Africa’s excellent resource is its people. There can be no more effective investment in Africa’s future than in education, which empowers talented young people to contribute to their country’s development and be better equipped to fight the multidimensional causes of poverty.

To go “beyond potential”, Africa needs a trans-disciplinary STEM workforce, that works across Africa’s key sectors of agriculture and food production, resource development and clean energy, precision health, finance, information technology and telecommunications.



Recognising the critical importance of improving African mathematics education, AIMS and IFAM began working together in 2017 to foster new collaborations to train and develop the next generation of scientists across the continent. The partnership was first established by IFAM’s Professor Olivier Menoukeu Pamen, who was appointed as the Alexander von Humboldt Chair in Mathematics and its Applications at AIMS Ghana in 2016, and the two organisations signed an MoU in 2021 to further cement their partnership.

Together, AIMS and IFAM are facilitating the emergence of new applied and theoretical mathematical science research collaborations between IFAM academics and leading African scientists to tackle challenges applicable to the African social and economic context within which they are located, supporting the development of the next generation of scientists in Africa, and facilitating knowledge exchange through enabling IFAM academics to spend time working at AIMS centres.

Students who have been trained and mentored through the partnership between IFAM and AIMS have gone on to work on important projects that are raising the standards within their countries and beyond. Whilst on sabbatical with the International Labour Organization’s Social Finance Programme, IFAM Director Professor Constantinescu designed a number of MSc projects that aligned with the ILO’s research themes in social finance. Eight students from AIMS Rwanda undertook these MSc projects under Professor Constantinescu’s supervision and were able to apply their mathematical skills to complex, real-world problems in the field of social finance.

This experience advanced the ILO’s research objectives and provided an exciting academic opportunity for the students at AIMS Rwanda, which is likely to have a lasting influence on their future careers. This work is already informing the policy direction of the ILO’s Social Finance Programme and is a truly fantastic example of the potential that can be unleashed when education and social finance come together to drive positive change in the world.



“Our partnership with IFAM is driving forward positive change across the continent of Africa through cutting-edge research collaborations, the development of the next generation of scientists in Africa, and knowledge exchange between IFAM and AIMS academics.”

WILFRED NDIKON,
RESEARCH AND INNOVATION CENTRE PRESIDENT AND THE CHIEF SCIENTIFIC OFFICER OF THE AFRICAN INSTITUTE FOR MATHEMATICAL SCIENCES (AIMS) – GLOBAL NETWORK

CASE STUDY

Developing equitable car insurance for women in Saudi Arabia with Allied Cooperative Insurance Group

Allied Cooperative Insurance Group (ACIG) is a major insurance company in the Kingdom of Saudi Arabia which provides insurance products across a wide range of sectors, including motor, medical, travel, personal accident, home, workers' compensation, public liability, marine, and medical malpractice.

In June 2018, women in Saudi Arabia were granted the right to drive motor vehicles for the first when a long-standing ban was lifted by royal decree by King Salman.

This was a significant social change in Saudi Arabia and created a major challenge for the national motor insurance sector, which now needed to incorporate a significant number of new female drivers who had no claims history and hence were classified as first-time drivers with high insurance premium rates.

To tackle this challenge, ACIG partnered with IFAM researchers to analyse motor insurance data in Saudi Arabia since women first began to receive licenses in 2018, with a view to creating a system for fair car insurance pricing.

Within the global car insurance market, it is well established that the frequency of claims is similar for both men and women, with the severity of claims being lower for female drivers.



“ACIG benefited a lot from working with the IFAM team. Our collaborative work is already making a real difference for women drivers in Saudi Arabia and the impact of our partnership is set to help transform the sector in the future.”

MOHAMMED AL GADHI,
CEO OF ALLIED COOPERATIVE
INSURANCE GROUP (ACIG)

ACIG and IFAM worked together on collaborative research that compared first time male and female drivers, which was the point when the discrepancy in the insurance rates being offered to each gender in Saudi Arabia was most notable.

Their work looked at how to make the system fairer and more equitable over time for both male and female drivers, creating a merit-based system that would reward or penalise drivers in a fair way based on driving performance, as well as advising that the severity of insurance claims be factored into existing methodologies.

ACIG have already begun to implement changes to its policies based on the work by the IFAM team and the impacts of fair and equitable insurance premiums stemming from these changes are expected to spread across the insurance industry in Saudi Arabia over the coming years.



CASE STUDY

Creating a lasting impact across Central Africa through mathematical modelling and expert training with BEAC

The Bank of Central African States (BEAC) serves the six African countries which form the Economic and Monetary Community of Central Africa: Cameroon, Central African Republic, Chad, Equatorial Guinea, Gabon, and the Congo.

Founded in 1973, BEAC manages currency, controls the supply of money, and implements monetary policy for its member states. Through its work, BEAC aims to achieve economic stability within its member states by ensuring that the economy grows whilst inflation is kept low and prices remain stable.

BEAC first began collaborating with Professor Olivier Menoukeu Pamen and the IFAM team on applied mathematical research which used predictive models and stochastic analysis to investigate whether BEAC’s main policy rates – the interest rate set by a central bank – are being set at the appropriate level to strike a balance between price stability and economic activity through the control of money supply and inflation.



“Our partnership with IFAM will make a lasting impact across central Africa and beyond through the implementation of the mathematical models we are creating, as well as the education of young people across our sub-region who will go on to work in this industry for years to come.”

DR EVRARD MOUNKALA,
CENTRAL DIRECTOR OF RESEARCH
STUDIES AND STATISTICS AT THE BANK OF
CENTRAL AFRICAN STATES (BEAC)

A major strand of BEAC’s partnership centres around researchers from IFAM delivering training to equip current and new BEAC staff members with cutting-edge knowledge and skills. This will create long-term benefits for the BEAC team, enabling BEAC staff to make robust and informed financial and economic decisions whilst helping BEAC create a critical mass of expertise within their organization through capacity building.

In the future, the IFAM team will use their research to investigate how actuarial science models can be used to help improve the performance of pension funds, as well as develop new models that can be used across the sub-region to rate commercial banks, thereby providing BEAC with the ability to better identify which are thriving and which are struggling. Once implemented, this work will have a lasting impact on how BEAC interacts with commercial banks across central Africa and will help improve credit rating at national and sub-regional levels.

IFAM and BEAC are also planning to work together on the implementation of novel sustainability stress tests to measure how banks can recover from a crisis using new mathematical tools that have been previously successfully applied by the IFAM team in other contexts.

CASE STUDY

Pioneering new approaches for more inclusive earthquake insurance for people and communities in Japan

Whilst earthquakes are not rare events in Japan, for cultural reasons only a small number of homeowners in Japan have the appropriate level of insurance cover.

In the event of an earthquake, uninsured or under-insured homeowners – who represent around 70% of the market – are forced to continue paying off the mortgage on their home which has been partially or completely demolished, and is therefore uninhabitable.

As a result, a significant proportion of the Japanese population are at risk of falling into “double-debt”, a situation in which they are still paying their old mortgage whilst being forced to take out an additional mortgage to buy a second property they can live in.



The 2011 Great East Japan earthquake and tsunami, the fourth most powerful earthquake ever recorded in history, brought this problem into even sharper focus. It is estimated that almost one million buildings were damaged and over 120,000 were destroyed.

Following the earthquake, a leading academic at Ritsumeikan University in Japan published research findings which identified Japan’s double-debt phenomenon for the first time.

“IFAM is globally recognised for their inclusive insurance mathematics research. Through our collaborative partnership, we are applying new and existing mathematical approaches to make insurance in Japan more inclusive for people and communities affected by extreme events such as earthquakes and pandemics.”

PROFESSOR JIRO AKAHORI,
RITSUMEIKAN UNIVERSITY

With the country at increased risk of further major earthquakes, Professor Jiro Akahori and his colleagues at Ritsumeikan University have worked with the IFAM team to mathematically model and design a new mortgage product with insurance that could improve the management of financial risk.

Crucially, the model was designed to focus on driving forward and delivering positive social outcomes, rather than simply focussing on maximising profitability for financial institutions.



The proposed solution involved introducing an insurance mechanism incorporated within mortgage repayment schemes based on methodology from mathematical risk theory.

Since their research findings were published, the model has gained significant traction within the mortgage industry in Japan. Professor Akahori has also advised Japanese investment banks on the benefits of this approach.

The underpinning mathematics model has been adopted by actuaries across Japan. Students from Japan who collaborated on the project are now working in industry, helping to spearhead the implementation of this work across the Japanese financial sector.

Internships, undergraduate degrees, master's programmes and postgraduate research



IFAM offers a variety of study options, from undergraduate degrees to taught master's programmes and postgraduate research degrees.



GOLD RATING
IN TEF 2023



TEACHING PROGRAMMES ARE
ACCREDITED BY THE **INSTITUTE**
AND FACULTY OF ACTUARIES

Summer internships

IFAM is a vibrant, engaging and stimulating environment to study. You will learn from internationally recognised experts who will encourage you to take part in research projects. We offer spring and summer schools in partnership with industry for our students to gain further skills and increase their employability.

Our actuarial and financial mathematics programmes offer a wide range of modules, providing a strong foundation for a successful career in banking, insurance, software development, research institutions or government agencies.

For more information, email:
Professor Corina Constantinescu
c.constantinescu@liverpool.ac.uk

Master's degree programmes

We offer an MSc in Applied Statistics and Data Science at the University of Liverpool which will equip you with the ability to apply methods of statistics and data science to solve complex real-world problems across a broad range of fields, from global health and epidemiology to finance and investment.

In semester two, you can choose between the:

- **'Machine Learning for Investment Science'** pathway and learn how to employ the power of machine learning to model, predict, and interpret international financial trends and economic forces
- **'Social Finance'** pathway and learn how to use mathematical and statistical concepts to price and manage financial products with positive social outcomes

For more information, visit: liverpool.ac.uk/courses/applied-statistics-and-data-science-msc



Undergraduate degree programmes

We offer a variety of undergraduate degree programmes based at the University of Liverpool, including:

- **Mathematics with Finance BSc**
- **Actuarial Mathematics BSc**
- **Mathematics and Economics BSc**

For more information, visit:
liverpool.ac.uk/courses/subjects/mathematics



Postgraduate research

Studying for a PhD at IFAM provides an opportunity to explore and enhance your understanding of financial and actuarial mathematics. Through our industry contacts, you will also be able to see how these new insights apply in the real world.

You will tackle problems which require a high level of mathematical understanding and so will require an undergraduate degree with a significant mathematical component. Candidates from the UK are expected to have at least a 2:1 degree from a leading university. International students should also be of a comparable level.

For more information, visit: liverpool.ac.uk/study/postgraduate-research/degrees/mathematical-sciences





UNIVERSITY OF
LIVERPOOL

For more information please visit:
liverpool.ac.uk/ifam

Professor Corina Constantinescu,
Director of IFAM

c.constantinescu@liverpool.ac.uk



THE ORIGINAL

REDBRICK

Printed on 100% recycled FSC® certified stock.