UPDATE *the*

WHERE ARE THE GIRLS IN MATHS?

BHP & AMSI launch $22m five year national campaign Choose Maths

ACADEMY OF SCIENCE

Q&A with new Academy of Science Fellow Peter Bartlett

PROFIT TO LOSS RATIOS

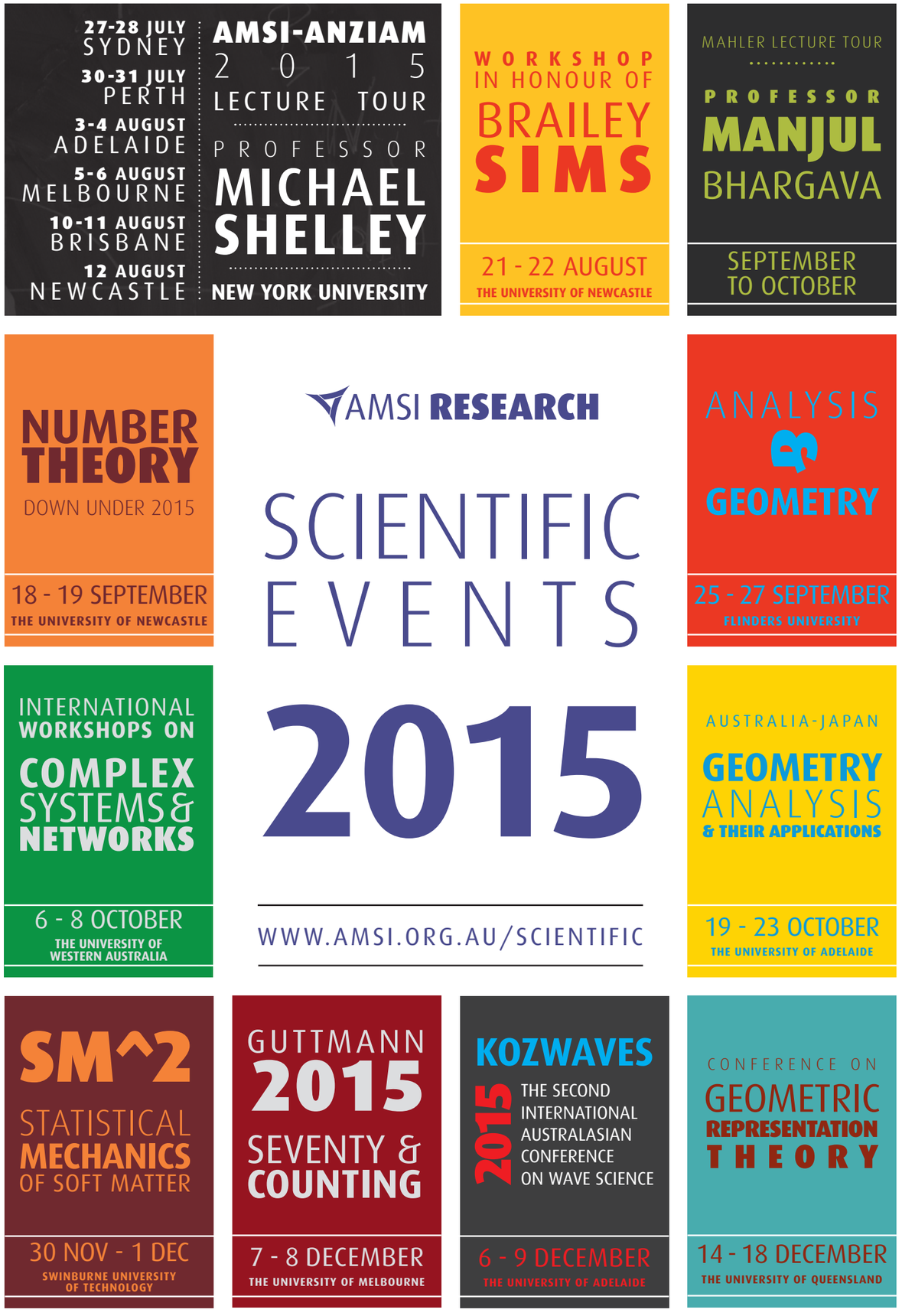
An intern's research into paraplanning for your future

STATISTICS OF SPORT

Optimising the peformance of our wheelchair rugby paralympians

AMSI

AUSTRALIAN MATHEMATICAL SCIENCES INSTITUTE



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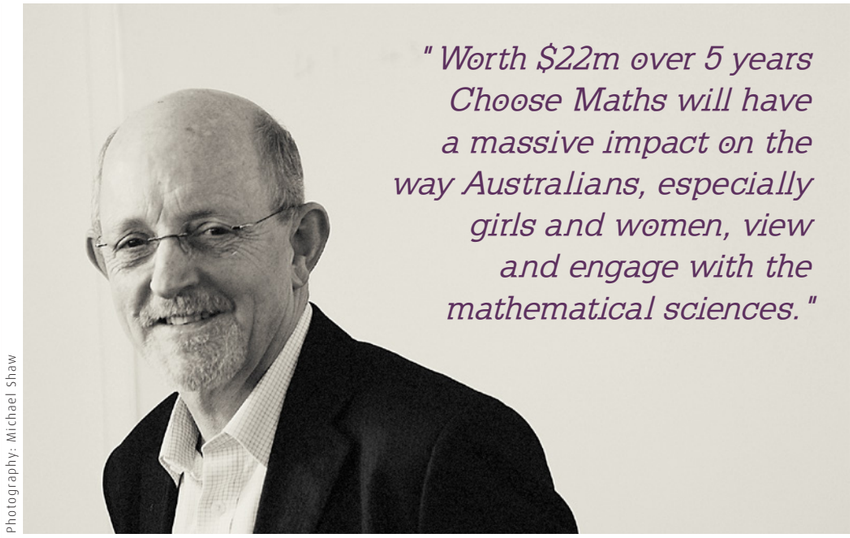

Photography: Michael Shaw

The wait is over! AMSI and the BHP Billiton Foundation have launched the Choose Maths program. Worth $22m over 5 years it will have a massive impact on the way Australians, especially girls and women, view and engage with the mathematical sciences. It will also have a significant impact on AMSI with another 12 staff joining us this year. You can find details of the program in this edition and online; I issue a warm invitation for all of you and your organisations to engage with us and grow the impact of Choose Maths.

Our other major project is the expansion of the AMSI Intern program. In collaboration with eight of our member universities we have expanded our operations in NSW and Victoria, employing a further three business development staff and two administrative staff. We are conservatively estimating more than 250 placements, across all disciplines, over the next three years with expansion to other states during that time.

This is also an exciting year for our research community with the Mahler lecture tour by Fields medallist, Manjul Bhargava. AMSI is proud to support the tour through our long-standing co-operation with the Australian Mathematical Society. And our own Terry Tao is back in Australia for the Society's annual meeting at Flinders University in September. This is also an AMSI/ANZIAM lecture tour year with renowned fluid dynamicist Michael Shelley from the Courant Institute touring in July and August.

We have had our fair share of press attention so far this year with good coverage of the Choose Maths launch. Public attention was also caught by the debate over compulsory secondary school maths. Views on this vary throughout the mathematical sciences community but there is general agreement that it is the declining number of students, especially girls, taking intermediate and advanced maths at Year 12 that really needs urgent attention. In any event the attention to our long-standing issues was welcome and AMSI's views were in heavy demand by the media.

I'm sure you'll enjoy reading about all this and more from the institute in this first issue of our new look bulletin the Update. Published twice yearly, we aim to keep our domestic and international audiences up-to-date with events, announcements and major stories relating to AMSI and Australia's mathematical sciences community.

Director

Prof. Geoff Prince FAustMS

Machine Learning

Peter Bartlett was trained as an electrical engineer and computer scientist. Now, working at the interface between statistics and computer science he aims to understand how to solve learning problems.

Photography: Erika Fish, QUT

Peter Bartlett is a Professor in the Faculty of Science and Technology, at Queensland University of Technology and an ARC Laureate Fellow. He became a Fellow of the Australian Academy of Science in May this year for his outstanding contributions to statistical machine learning.

AI (Artificial Intelligence) — computers doing things that are characteristically human — has been a lifelong fascination and something of a career ambition for Peter. He is a pioneer at the interface of computer science and statistics and has created the theoretical foundations for many key advances in statistical machine learning.

Peter tells us that many large-scale decision problems arise in a variety of areas – including biological science, social network analysis, speech recognition, web search, physical sciences, law-enforcement and telecommunications. These systems learn from data to improve their performance and are central to many fields across science, industry and government. Statistical learning theory is all about the science that underlies these processes.

[...Tell me, as briefly as you can, what you do?...]

I work on statistical learning theory. It's the mathematics underlying how to use large complex data streams to make effective decisions (for instance, using data to build systems that can recognise objects in images, distinguish different diseases from genetic fingerprints of cells or understand what we mean when we ask our mobile phone a question). Understanding what is possible in going from data to decisions, and how to design systems that can do this.

[...How did you get started in this area?...]

I've always been fascinated by the idea of artificial intelligence, of computers being able to do things that are characteristically human. I was attracted to the area of machine learning - a subarea of AI concerned with getting computers to learn to solve problems. And I was lucky with the timing: from around 20 years ago, there's been a growing realisation that this is a statistical problem, that it's really productive to view the world as uncertain and try to model that uncertainty. Early efforts at AI tried to use logic and deterministic approaches, but they turned out to be brittle - good in restricted domains, but introduce a slight change and these systems would fail catastrophically. Now, the statistical approach has come to dominate.

[...Why is your research important?...]

Understanding how to use large and complex data streams to make effective decisions is one of the central scientific and technological challenges of our time. It's becoming more important for industry, for science, for government. And statistical learning theory is the mathematics lying underneath this technology.

[...What do you love about what you do?...]

Understanding something that nobody understood before. I like working on things that are both mathematically elegant and relevant – things that matter, that will have an impact on our lives. That's what gets me inspired and excited.

[...How do you feel about being elected into the Academy's Fellowship?...]

It's a huge honour and I'm really delighted on many levels. I've had a lot of collaborators, including an amazing group of students and postdocs; it's a fantastic acknowledgement of their work too. And the computer and information sciences are under-represented in Australia, so it's really nice to see these areas acknowledged too.

As a Chief Investigator at ACEMS (ARC Centre of Excellence for Mathematical & Statistical Frontiers) Peter is heading a project that aims to develop design and analysis techniques for large scale decision methods, with an emphasis on data in the form of large graphs. The research project will involve probabilistic and game-theoretic formulations of decision problems, such as regression, classification and ranking problems. ■

Choose Maths

Every child starts school with the same mathematical potential; Margot is in Year 7 and she reckons there is no difference between boys and girls when it comes to mathematics: "We are all encouraged, we do the same work and our teacher sets us all the same problems. Mathematics isn't more difficult for girls." So why then, if we follow Margot's logic, does such a prominent gender gap exist in the mathematical sciences? The BHP Billiton Foundation and AMSI want to erase the gender sterotype and boost maths for girls.

Mathematics is a necessary part of life, so why then do Australian's turn their noses up at it? That's almost as ambiguous as asking how long a piece of string is, or how many bricks it takes to build a house.

If we were to think of the mathematical sciences as a country, it would be a small country, with an ageing population, falling fertility rates, rising emigration and immigration, buoyant incomes and a retirement age that keeps getting pushed up as demand for maths and stats skills grows exponentially.

Oh, and we forgot to mention, the men in this country significantly outnumber the women. What is a girl to do?

Rather than digging for answers as to why, AMSI and the BHP Billiton Foundation are acting. Over the next five years the Choose Maths initiative will turn around public perception of the mathematical sciences. While the program is aimed to address the underrepresentation of young women and girls in STEM, the $22 million investment will build self-sustaining education communities to benefit all.

International comparisons show that Australia has a lower number of highly performing students than some Asian countries. In maths, the top 10 per cent of Australian Year 4 students are at the same level as the top 40 per cent in Singapore, South Korea and Hong Kong, and in Year 8, the top 10 per cent of Australian students perform equivalently to the top 50 per cent in Taiwan, Singapore and South Korea.

The 2012 Programme for International Student Assessment (PISA), which measures the mathematics, reading and science skills of half a million 15-year-olds from around the world, found that Australian teens placed equal 17th in maths. The results show Australian students are slipping in maths performance by about half a year of schooling compared to 10 years ago; this decline was stronger in girls than boys, with Australian girls dropping to the OECD average.

Around 14,500 Australian students from 775 schools were measured in the PISA assessment, conducted by the Australian Council for Educational Research (ACER) for the OECD. The questionnaire responses also found that girls hold a much more negative view about maths.

When the results came out ACER's director of educational monitoring and research, Dr Sue Thomson, told the ABC: "Australia has slipped backwards to the type of gender disparity that was seen decades ago, and the performance scores of girls coupled with a number of particularly negative motivational attitudes puts Australia further away from providing all students with the same educational opportunities." Dr Thomson also raised concerns that more than two-fifths of students failed to reach base proficiency levels in maths.

Another ACER study found that a third of mathematics teachers lack a solid mathematics background themselves. So how can our teachers inspire our kids, if they themselves do not have a firm grip on the material they are teaching?

> In the year 2000, Australian teenagers were second only to Japan in their mathematical prowess. Now, twelve other countries are outperforming us in this age group. :(

Enrolments in intermediate and advanced mathematics classes continue to decline. In fact, the proportion of Year 12 students enrolling in advanced mathematics dropped to below 10 per cent in 2014. In 1995 that figure was 15 per cent.

And, in the year 2000 Australian teenagers were second only to Japan in their mathematical performance, however now, teenagers from twelve other countries outperform us in this age group.

In an effort to combat these falling numbers AMSI will work on the ground in 120 Australian schools throughout the five years of the program. Based on AMSI's existing model, secondary schools and their feeder primary schools will be clustered together into professional development groups. These teachers will focus on enhancing and cementing their content knowledge guided by an AMSI specialist. Without our teachers having solid foundations and engaging ways to deliver the mathematics curriculum we risk further declines in Australia's mathematical literacy.

A role model network will be established to encourage schoolgirls and young women to pursue the rich life experiences and rewarding careers mathematics can offer. This network will foster a community of high achieving mathematics professionals to act as mentors; to guide and connect women in STEM; to nurture ambitious women to succeed in STEM.

Coupled with a national mathematics careers awareness campaign and excellence awards for teachers, students and schools Choose Maths will: increase engagement, enthusiasm and confidence in mathematics; enhance teacher knowledge and confidence in mathematics; assist teachers to implement strategies known to engage and inspire girls; grow how the public holds the importance of mathematics in their minds; reverse the tightly held gender stereotypes in the STEM fields.

Summing up, the program will provide teachers with professional development in maths education, help girls at school become more aware of careers which use maths, offer role-models and networking to young women, and establish the BHP Billiton awards to recognise teachers for their excellence in maths education.

When any student sets out to study maths seriously, a weird thing happens – suddenly they notice that maths is everywhere. The trouble is, people don't realise the maths is there – in a conversation about a horse race, how to finance their home or why a statistician sees a difference between weather and climate.

Things would be much easier if more people could see the numbers and mathematical concepts hidden behind what they're saying.

At the launch of this program in April, BHP chief executive, Andrew McKenzie said: "We hope the Choose Maths program will help secure the pipeline of highly-qualified, female STEM professionals and open the door to the rewarding careers and cultural pursuits that maths offers."

So let's get the message out there: "If we're going to be smarter, better, richer and happier, we need to choose maths!"

Cognitive Prowess

With An Attitudinal Handicap

The Graduate

I never felt like a minority in school and at university for a long time I ignored the fact that I was. I suppose when I'm thinking about maths I'm not thinking about the fact that I'm female. I'm just a person with a brain who enjoys using it to learn and think.

But one day I caught myself having less respect for the female speakers at a conference than for their male counterparts, and I spent a long time trying to work out why it was. I think it was partly due to my having internalised mild sexist attitudes in the community, from not having seen many high-level female mathematicians and partly due to the fact that these women actually seemed more self-conscious and less sure of themselves than the men, perhaps because they'd internalised the attitudes as well. After that I became more aware that it was likely I wouldn't be taken as seriously as a man would, which began to partly undermine my confidence when speaking!

We need more visible female mathematicians. I think it's probably better to treat mathematics as a human endeavour, one that requires thinking, which everyone can do – rather than to advertise with statements like "girls can do maths too".

Anita Ponsaing *is a lecturer at the University of Melbourne. Her research interests lie in the integrability of lattice models in statistical mechanics and she spent 12 months as a post doc at the University Pierre et Marie Curie in the Laboratoire de Physique Théorique et Hautes Energies.*

The Maths Teacher

Beginning my tertiary studies in mathematics from within the Computer Science Faculty, I was acutely aware that I was part of a minority. Although I was comfortable that both my class-groups and friendship-groups largely consisted of males, the occasional appearance of another girl in a tutor group or social room would always relieve me. Unfortunately, as the years progressed, the balance of sexes did not change for me. This became even more obvious when I was studying to be a mathematics teacher: my colleagues were vastly male.

I never felt that I was discriminated against while studying mathematics. I did feel, however, that social environments for mathematics students were not always conducive to female participation; this may work as a deterrent for females considering their options for their careers or further studies.

I feel the BHP program is important because the teaching profession is dominated by women and yet the STEM disciplines are predominantly staffed by men. Although the gender does not affect the teaching standard, it is an unfortunate truth that certain young and impressionable minds may feel this is a learning area that is "for" men. And this idea perpetuates the problem.

Francesca Dias *is a teaching mentor at Caulfield Grammar. She completed her bachelor's degree and teaching qualifications at the University of Melbourne and has taught mathematics, English and science internationally. Having taught across all age groups/levels and various curriculum, Francesca is an all round educator.*

The Professional

In high school I heard a talk that compared the skill of a mathematician to the skill of a musician; they described how learning concepts in mathematics to apply to problems is very similar to learning about crotchets and quavers in music and applying them to different pieces of music. Being able to look at mathematics in that way has always stuck with me.

I don't think I suffered any discrimination because I did a mathematics degree, I was definitely in the minority though. There is, however, a general level of surprise when I mention I have a mathematics degree and the comments always go: "that's an unusual choice for a woman." I work in a male dominated industry (mining), so certainly feel like I am in a minority, still. Being able to get more women in this industry or in any STEM field would certainly break down barriers.

The breadth of careers available for women with mathematics degrees are endless, but this is not clear when students are making university choices. It is so important that young women know the opportunities are varied, not limited. To get girls interested in mathematics they simply need to be shown how interesting mathematics is and they must be exposed to both men and women who do it for a living.

Jessica Pritchard *works at the Hunter Valley Coal Chain Coordinator in Operations Planning. She completed a Bachelor of Arts (majoring in politics) and a Bachelor of Mathematics (majoring in statistics) at the University of Newcastle; since then Jessica has held positions across the manufacturing and mining industries.*

The Academic

Back in the day, in my third year honours in mathematics at the University of Sydney I was one of three girls in a class with 50 boys. I certainly faced a great deal of difficulty at every stage of my career, I would hope that young women these days will not be faced with the same problems I was.

Diversity is strength. Diversity not just in gender, but also in mathematical ways of being, the topics being researched, where you do your research (which is more important than what you might think) and what you care about. One of the problems I see at the moment is the propensity of the media to admire what I call "smartypants" mathematics (Olympiads and the like), which for gifted girls especially, is existentially pointless.

I am currently engaged in kick starting a project highlighting socially conscious mathematics to help students become more aware citizens through mathematics. This, I believe, will be more attractive. To me, it is not a question of are girls good enough for the mathematical sciences, but rather, are the mathematical sciences good enough for girls? ■

Elizabeth Mansfield *is a professor of mathematics at the University of Kent, UK. She has recently joined AMSI's Scientific Advisory Committee, is the current Vice President (Learned Societies) of the Institute of Mathematics and its Applications, she also sits on the Council of the London Mathematical Society and the Society of Mathematics and Computation in Music.*

Photography: Michael Shaw

Risky Business

Adverse? Neutral? Loving?

AMSI INTERN WEI WU MODELS RISK TAKING HABITS TO INCREASE PROFIT TO LOSS RATIOS

Budgeting, it's a cringe worthy word. Optimisation, that sounds more like it! But have you the faintest idea of what it is? And did you know that mathematicians use it to help financial planners increase the expected size of their client's financial nest egg with risks that are acceptable to them and their stage in life?

AMSI Intern, Wei Wu, is well versed in the mathematical technique of optimisation used in finance. In fact, he recently completed an internship at Optimo Financial.

Hugh Bannister, Principal, Optimo Financial, has been building energy and financial models using optimisation techniques for over 25 years. He believes the work completed during Wei's internship will allow Optimo to improve its offerings to the market.

"Optimo's existing tools greatly improve financial planners ability to offer good, robust financial advice to clients, Wei's input and work strengthens these tools. We plan to implement it initially as a web-based demonstration of the methodology," Hugh says.

Multi-period portfolio selection problems (MPPSP) are of great interest to academics and financial planners. Wei formulated the problem as a Markowitz mean–variance optimisation problem in terms of time-varying means, covariances and higher-order and intertemporal moments of the asset prices.

An important decision when constructing an MPPSP is the choice of objectives. In his seminal work, Markowitz illustrated how the mean–variance principle can be used to generate the admissible subset of investments for risk-averse individuals by eliminating any investment that has a lower mean and higher variance than a member of the given set of investment alternatives.

One of the challenges in providing good advice is to take careful account of risk. Depending on the client's attitude and stage in life, a conservative or somewhat more aggressive investment strategy may be appropriate. However, it is very difficult to balance all the factors that would deliver a satisfactory strategy for each client's needs. Standard portfolio theory is more designed for institutional investors than individuals.

According to Wei the mean–variance approach has maintained its popularity because it is typically more economical to trace out a mean–variance efficient set than to maximise the expected utility of terminal wealth. Wei undertook a deep analysis on the multi-period portfolio selection problem with mean-standard-deviation as the objective. He formulated the problem as an optimal control problem and reviewed the difficulty in solving these problems.

The project also outlined the pre-commitment approach — Duan Li and Wan-Lung Ng, 'Optimal dynamic portfolio selection: Multiperiod mean-variance formulation', Mathematical Finance', 2000 — and dealt with the time inconsistency issue (chosen optimal strategy valid at time A no longer optimal at later time B) with the game theory argument of Tomas Björk and Agatha Murgoci, in 'A general theory of Markovian time inconsistent stochastic control problems', Technical report, 2010.

"People have different investment needs, some invest for the short-term, saving for a house deposit, or long term, saving for their retirement. I was able to apply my mathematical skills to help financial planners find the best investment strategies for their clients by looking at, and taking into account, numerous factors," Wei says.

The MPPSP model was extended by Wei and his academic mentors — Professor Ben Goldys, University of Sydney and Assocociate Professor Spiridon Penev, University of New South Wales — to fit into the required context, and an algorithm was written to find the optimal control in both the original case and the log-transformed case. Risk analysis of the optimised portfolio and a lower bound of the estimated cash off-take were also provided.

Optimo Financial can customise reports that detail a series of recommendations, each having been made after consideration of a particular client's present financial position, their objectives and the current conditions of the financial market. All this allows their clients to achieve their goals and objectives previously discussed.

"Optimo had developed a conceptual approach to solving this problem, but sought academic input through AMSI Intern to ensure the state-of-the-art in the field was recognised," Hugh says.

"The academic mentors and Wei were able to make certain the proposed approach was theoretically and practically sound and were also able to explore possible improvements." ■

Photography: Istock. PonyWang

STATISTICS OF SPORT!

Australia is a sporting nation and Norah Finn is a sports fanatic. When she realised sports and the mathematical sciences could mix, she had to get in for a try—Norah spent her summer on the job with our paralympians.

Discovering that her love of numbers was as strong as her love of sports happened in Year 12: "I had a fantastic teacher in Year 12 who was extremely passionate about mathematics. She motivated me to work hard and I realised how much I enjoyed the challenge of mathematics."

Norah attended AMSI's 2015 Summer School at the University of Newcastle. She says residential schools offer fantastic opportunities to be immersed in mathematics and statistics. "We bonded like a sports team; made good friends; and were able to teach and learn from each other."

Summer 2014/15 was pretty hectic; not only did Norah attend SS, but she was also awarded a Vacation Research Scholarship. Over six weeks Norah worked with our wheelchair rugby team and members of the Australian Paralympic Committee to investigate workload training. The research aimed to determine how players perform in competition in comparison to when they train. At the time, the plan was to continue this as an honours project at RMIT throughout 2015.

"I didn't come to any major conclusions in my report. I have, however, set myself up very well for my honours year by getting a majority of the groundwork and coding done. I also have a well-defined set of goals."

Things didn't quite go as planned. Norah's honours project is now on Bayesian spatial analysis for the evaluation of breast cancer detection methods. Statistics provides a mathematical way of describing occurrences in life and can act as a predictive tool to maximise quality of life. "My new research topic is very different to sports statistics! But has always been a path I considered taking. It's great to have gained training in stats research in both fields.

"The most time-consuming task of my VRS project was the creation of the code window. There weren't many mathematical calculations but, creating the links between opening and closing different code buttons was a laborious logical problem! Also, ensuring all codes were labelled coherently and consistently was very tricky – it's one of those things that until you've attempted it yourself you cannot understand how complex it is!"

> *"Doing both SS and VRS, at the same time, taught me how to handle high intensity projects while still working to my full potential."*

Once all this was sorted Norah started sifting through the enormous data set to collect several descriptive statistics, which were dependent upon other variables. Her main forms of analysis were fairly standard hypothesis tests and chi-square tests. "I attempted more complex procedures, but the short time frame of the VRS meant I was only able to code two games, and so, I didn't have a big enough sample size."

Norah confesses that while her curiosities lie in sports statistics, on a day-to-day basis, statistics are crucial. "Stats can help answer questions about where to build a new school or hospital or what the pros and cons are of building a train line, as opposed to a road. Stats is used in many aspects of finance, can assess the performance of new drugs, model the spread of viruses and help uncover ways to contain outbreaks. Or, you can use it to see exactly how your sporting team is performing."

Even though there was no break between finishing her undergraduate degree and officially starting honours, the work was gratifying.

"Doing SS and VRS, at the same time, taught me how to handle high intensity projects while still working to my full potential."

It isn't just the programs Norah believes are of value; she reckons AMSI's work hits it for six too. "The institute encourages and promotes the study of mathematics in society, which is important in a society where the importance of studying mathematics receives not even a fraction of the air-time given to the importance of studying subjects such as English, law and medicine."

Norah definitely recommends both events: "They offer great complimentary opportunities. SS allows you to study with a new group of students, with fantastic lecturers from across Australia and the world, studying subjects that may not be available at your home institution. And the VRS allows you to experience life as a researcher; you gain a feel for what honours will be like. VRS also exposes you to presenting your research to your peers with similar interests – an opportunity not readily available to an undergraduate."

Norah Finn's enthusiasm and expertise will see her shepherding her way past other statisticians to a sporting club, or beating all the other researchers to the scrubs in a medical research facility... very soon. ■

Norah Finn is one of AMSI's favourite ambassadors, tackling both a VRS project and graduate school over summer. She is now applying her statistical skills at RMIT University to breast cancer detection methods.

Photography: Australian Paralympic Committee

2015 MAHLER LECTURE TOUR

2014 Fields Medalist

Professor Manjul Bhargava

Princeton University

Touring Australia September—October

Photo courtesy of Infosys Science Foundation

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