

## **RSE/NSFC WORKSHOP**

**17–18 March 2008**

### ***Rare Plants and Common Interests***

Scotland and China may be thousands of miles apart, but the RSE/NSFC Joint Workshop on March 17 and 18 very clearly showed how close we are, in terms of both science and business.

Organised by the Royal Society of Edinburgh (RSE) and the National Natural Science Foundation of China (NSFC), the two-day workshop on management science at the RSE in Edinburgh brought together 22 speakers from both countries, discussing everything from wildlife, agriculture and technology to risk, innovation and trust.

RSE Vice-President Professor Tariq Durrani set the tone for the workshop, describing how the aims were to exchange ideas and knowledge, and identify areas of common interest – so researchers can collaborate and learn from each other, as well as arrange future visits. His words were echoed by Dr Zhang Wei, the Deputy Director of the Department of Management Sciences at the NSFC, who explained that his organisation played a similar role to the RSE, supporting basic research and promoting international links.

The metaphor for the event was the joint presentation by three speakers from the Royal Botanic Garden Edinburgh (Dr Mark Watson, David Long and David Paterson), describing the RBGE's involvement in China over the last 100 years, as well as contemporary projects, gathering and documenting rare specimens, to continue the tradition of research and conservation, information sharing and exchanges. This tied in neatly with a talk by Dr Cheng Guoqiang, describing China's latest agricultural policies, and efforts to address the issues raised by urbanisation, including the environment and balanced development.

On Day 2, Dr Wei Yi-Ming extended this environmental theme by focusing on China's future energy needs, discussing the problems of carbon emissions and accurate forecasts. Dr Wei was followed by Professor KL Lo, outlining Scotland's efforts to model alternative energy networks – and the parallels between the two countries.

The common thread which ran throughout the two-day event was the complexity of statistical models, and how to take account of both uncertainties and human factors when we are making predictions. Four speakers from the University of Strathclyde (Dr Tim Bedford, Dr Jiazhun Pan, Dr Xuerong Mao and Dr Lesley Walls) talked about the role of statistical models, explaining how tools such as stochastics can be used in a wide range of fields, including risk analysis for nuclear power stations and the aerospace industry to forecasting population figures, agricultural production and the stock market.

This was complemented by several speakers, including Professor Zhang Zongyi, who is studying how innovations 'spill over' from region to region, based on an analysis of patent applications in China, and Dr Tang Lixin, who explained the use of data analysis to improve production scheduling in the steel industry.

Trust was the concern of several speakers, most notably Dr Wang Dan, who described attempts to model trust between the partners in a supply chain, and Professor Umit Bititci, who asked how we can establish standards for trust in the same way as quality standards for products. On Day 1, Dr Chen Jian also shared his ideas on how to optimise supply chain performance, focusing on how to reconcile different partners' attitudes to risk.

Innovation was a major theme on both days. Professor Chen Jin started by discussing 'open innovation', and how the benefits of openness (to customers and business partners as well as internal employees) can tail off over time for certain companies, while others do better the more open they are, based on his recent research. George Boag then discussed innovation in Scotland, and the relationship between academics, government and entrepreneurs, followed by Professor Gao Xudong, who stressed the need for China's major companies to innovate and stop depending on external partners, with telecoms and petrochemical companies the most likely to succeed in the short term. Professor Jane Bower then discussed technical innovation systems in Scotland, describing the kind of environment which tends to encourage inventors and entrepreneurs, while Professor Ian Hunt focused on how to get new innovative products from concept to market.

Finally, Professor Jeff Haywood and Professor Arthur Trew provided insights into campus information systems and the use of supercomputers in simulation – ‘the next frontier’ in science.

Although most speakers focused on more esoteric aspects of business and science, there were common themes which linked their different disciplines. For example, both Scotland and China are struggling to find new solutions for power and protect the environment. They are also searching for new ways to boost innovation and the entrepreneurial spirit. Mathematicians in both countries are also concerned about how to make accurate forecasts and analyse risk, as well as understand the ‘human factors’ influencing business performance. In fact, the methods used to model more ‘technical’ subjects also have a role to play in seemingly more abstract ‘human’ dimensions, for example how to measure innovation and trust between partners in business.

Because so many speakers appear to have mutual concerns, close collaboration – as witnessed in botany over the years – is the logical next step for business and scientists in the two countries, if they learn the lessons of the RSE/NSFC Workshop.

**Peter Barr**  
**Edinburgh**

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### DAY 1

#### 1. Dr Cheng Guoqiang (Deputy Director-General and Senior Fellow, Institute of Market Economy, Development Research Center of the State Council of China)

##### *The changing face of Chinese agriculture*

To open the workshop, Dr Cheng provided some valuable insights into China's recent agricultural policies, focusing on some of the major developments in rural areas, including the migration of 200 million people to the cities over the last 30 years, drawn by higher earnings in the manufacturing, industrial and services sectors.

Dr Cheng began by putting China in perspective. It possesses about 9% of the world's arable land but has 21% of the world's population. Even though people in China are now getting richer and becoming increasingly urban, agriculture still employs 320 million workers, and still has the challenge of how to feed one billion people. China is also the world's fourth-biggest importer of agricultural products, after the US, Europe and Japan, and has one of the world's lowest tariffs on imports – and no subsidies for exports.

In 1978, said Dr Cheng, agriculture accounted for about 28% of China's economy and 70% of employment. In 2006, this had fallen to less than 12% of the economy and 42.6% of jobs.

From 1979 to 2006, agricultural production has increased by 4.6% per year, with crops down from 80 – 51% of the total and livestock more than doubling to 32% and aquatic products up from 1.6% to 10%.

Average income in rural areas has doubled in less than 10 years, from about RMB 2,200 to RMB 4,400, while in the cities it has climbed from about RMB 5,800 to RMB 13,800. Meanwhile, average consumption of meat has doubled from 10 to 20 kg in the cities and from 17 to 24 kg in rural areas (1983–2006), putting greater strain not just on livestock itself but also on grain production (e.g. the amount of grain fed to US livestock is enough to feed over 800 million people).

In policy terms, China is now stressing 'give more', 'take less' and 'liberalisation', focusing on income growth for farmers, strengthening production capacity and constructing the 'new countryside'. The 'give more' means setting minimum prices for rice, for example, whilst the 'take less' means reducing the level of taxes.

According to Dr Cheng, "Priorities have shifted from increasing production (e.g. grains) to rural income support as well as new environmental concerns and balanced development." He also said the government was trying to address the rural–urban divide, as well as health-care and educational and social developments.

#### 2. Dr Mark Watson (Sino-Himalayan Floristics Researcher)

##### *The 'botanical' links between China and Scotland*

Setting the tone for the rest of the workshop, Dr Watson talked about the 100-year relationship between botanists in China and the Royal Botanic Garden Edinburgh, whose mission is "to explore and explain the world of plants."

According to Dr Watson, there are more than 31,000 different plants in China, compared to only 1,500 in the UK, largely due to China's great diversity in terms of its geology and habitats – from tropical jungle to the world's highest mountains. This biodiversity is the focus of a study called *Flora of China*, which documents all the plants in China. Originally 126 volumes, written in Chinese, the work has been distilled to 25 volumes of text and 25 volumes of illustrations, and is also now available online, with the RBGE providing extensive editorial input.

Dr Watson also described a more recent RBGE study of the *taxus* genus (yew trees) which is used to produce the anti-cancer drug Taxol.

The links between the RBGE and China date back to the early 20<sup>th</sup> century, and one of its best-known collectors, George Forrest, who went there in 1904, worked very closely with the Institute of

Botany in Beijing. Some of Forrest's specimens are still being studied today. In the 1930s, several Chinese botanists came to Scotland to study, and in the 1980s these links were restored, including joint fieldwork and botanical research. In 1991, the RBGE was twinned with the Kunming Institute of Botany, to consolidate the links via joint research, sharing of knowledge and staff exchanges.

### **3. David Long (Cryptogamic Plants and Fungi Section at the Royal Botanic Garden Edinburgh)**

#### ***Gathering specimens in one of the world's most bio-diverse areas***

David described *The Biotic Survey of Gaoligong Shan* – one of the most ambitious of its kind ever undertaken in China, collecting and documenting over 25,000 plant specimens, as well as countless insects and other invertebrates.

The Gaoligong Shan is a 585km-long mountain range on the border of Yunnan Province and Myanmar which rises to heights of over 6,000 metres, including subtropical and temperate forests as well as spectacular alpine environments. The attraction of the range (declared a World Heritage Site in 2003) is its biodiversity, largely protected by the mountains' remoteness and rugged terrain, which makes exploration (and exploitation) so hard.

The five-year survey is now complete, and the team of researchers from China, the US and Scotland are now focusing on scientific description and distribution of the specimens and data to scientists worldwide. David explained that the primary aim of

the survey is to help protect the biodiversity, now under pressure from development (including new roads and energy projects).

For David, a specialist in mosses and liverworts, the project has clearly been a labour of love, including the discovery of many new species of ferns, orchids and beetles – and possibly even new genera. It also continues the tradition of the RBGE in exploration and collecting specimens in China.

### **4. David Paterson (Chartered Environmentalist, the Royal Botanic Garden Edinburgh)**

#### ***New alpine garden to protect local plant life***

Continuing the theme of collaboration between Scotland and China in horticulture, David described the work of the UK Joint Scientific Laboratory (JSL) in Yunnan Province, a joint venture between the RBGE and the Kunming Institute of Botany. The Jade Dragon Field Station in Lijiang was set up "to facilitate the conservation of plants and habitats through capacity building projects that aim to bring about more sustainable land management practices," with support from both the British (including Scottish) and Chinese governments, plus £400,000-worth of funding from sponsors such as BP, Tiso, BA and BHP Billiton.

Located on the Yulong mountain, the field station is an alpine botanic garden and nature reserve which seeks to protect and conserve the indigenous plant life and wildlife, and enable "more sustainable use of the land," including the reduction of deforestation. The local people also have their special needs, and David explained the importance of "understanding the birthright" of the people who live on the mountain, at the same time as doing their best to protect local plants – which in turn provide an economic benefit.

According to David, the project also has a role to play in traditional Chinese medicine, including the sustainable harvesting of medicinal plants, so these rare species do not disappear because of rapidly growing demand from the better-off regions of China.

Asked about how the project gets 'buy-in' from local people, David explained how his team seeks to work very closely with local people and balance the needs of different communities – for example, cultivating medicinal plants, both to generate profits and protect certain species.

## **5. Dr Chen Jian (Professor and Chairman of Management Science Department, Director of Research Center for Contemporary Management, Tsinghua University)**

### ***How to optimise supply chain performance***

Professor Chen explained how China's changing economic landscape is affecting supply chain management – and the different problems caused by decentralisation.

The major issue is how to optimise the performance of the supply chain so that everyone finds the right partners and comes out a winner, in a more decentralised business environment. When trying to identify a suitable agent, a company should ask if the potential partner is averse to risk, neutral towards risk or risk-seeking as an organisation. Different organisations have different attitudes to risk, yet the channel behaves as if everyone shares the same attitude, so greater flexibility and open-mindedness will be needed in future.

“Usually, companies are risk-neutral when it comes to contracts, but globalisation makes this harder to manage,” said Professor Chen. Therefore, he asked, how do you change the contract to take account of greater risk-seeking?

The objective of Dr Chen's research project is to help supply chain partners draw up the right kind of revenue-sharing contract by understanding the risk preferences of different partners, to increase profit margins and balance supply and demand. He also said that this would have an impact on the companies' ability to innovate. Ultimately, this 'marriage' of different risk attitudes will optimise the profitability of the whole supply chain, achieving the same results for decentralisation that used to be achieved with more centralised management.

## **6. Dr Tim Bedford (Professor of Decision and Risk Analysis, University of Strathclyde)**

### ***Intelligent risk analysis***

The title of Dr Bedford's talk was *Partial specification of risk models*, and he explained how his methods can be used across a range of different disciplines, from nuclear power stations to agricultural planning.

According to Dr Bedford, risk models require the specification of many parameters, including – in principle – joint probability distributions. Unfortunately data – even from experts – is only available in limited form, so methods are used “to extend partial specifications of joint probability distributions, and show how the entropy principle can be used to help specify such joint uncertainties in complex models.”

For those in the audience who struggled to grasp this, he also talked about how there are “lots of uncertainties in every decision,” and how we have to take account of these uncertainties to develop new methods of rational decision-making, especially when only part of the data is available. He also said that one of the most difficult problems in statistical modelling is how to “elicit subjective probabilities,” and how to develop an empirical basis to account for experts' personal bias. Also, how do we extract consistent data from experts so the experts do not contradict themselves?

Dr Bedford then discussed the use of ‘cupolas’ in statistical modelling, and the need to find a practical and interactive way to get data from experts so that the model does not constrain the experts.

## **7. Dr Jiazhun Pan (Department of Statistics and Modelling Science, University of Strathclyde)**

### ***New research in econometrics***

Like his colleagues at Strathclyde, Dr Pan was concerned with the problems as well as the benefits of statistical modelling – for example, the difficulties of dealing with low-frequency and high-frequency data. His talk focused on his recent research in financial econometrics, including factor analysis and heavy-tailed time series models, statistical analysis of panel data and how to “reduce dimensionality.”

## **8. Dr Xuerong Mao (Department of Statistics and Modelling Science, University of Strathclyde)**

### ***Stochastic vs deterministic statistics***

Dr Mao described the evolution from deterministic statistical modelling methods to more modern stochastic techniques, over the last 50 years. The basic idea is that when we try to forecast what will happen in the future, we have to take random change into account, rather than depend on inflexible models, rigidly based on historical data and obvious trends. For example, he said: “Classical financial models don’t work in current conditions,” because human behaviour and extraordinary or unexpected events can make any prediction redundant.

“If you don’t take stochastics into account,” he added, “you end up with inadequate models,” which fail to account for the “noise” in the real world. “But if you take uncertainty into account, then you can avoid errors.” A simple example of the benefits – and the complexity – of stochastic techniques is how it helps to model population growth. If we look at population statistics and we notice an increase in recent years, then as soon as we try to predict population, we forecast continuous growth – theoretically, all the way to infinity. Similarly, a decrease would suggest eventual extinction.

In the real world, however, we know this is not very likely to happen – just because Scotland’s population doubled in the last 100 years, does not mean it will double again in the next 100 years. Catastrophic events such as a plague or an earthquake can make any forecasts redundant, and nature also has a way of correcting the problems caused by over-population, since there may not be enough resources to support large populations in particular places at particular times.

Therefore, when we look at any economic or business issue, stochastic techniques will enable much better predictions, because they will take random change and uncertainty into account.

## **9. Professor Chen Jin (Professor of Management at College of Public Administration, Zhejiang University)**

### ***Open innovation***

How much does openness affect the innovation performance of Chinese companies, and how do we measure how open these companies are? Can too much openness be counter-productive or simply too costly? These were the key questions posed by Professor Chen, who started off by saying that companies who don’t innovate will fail – before cautioning that most innovations are failures.

Open innovation, according to Professor Chen, means using external as well as internal ideas to come up with new ideas. It can speed up innovation and improve creativity, as well as target markets more precisely and reduce uncertainty. It also means R&D working more closely with other departments as well as “innovative users,” to increase the number of new ideas bouncing around. All employees, including the sales team and customer service, can be “inno-creative,” and this is a strategy used by Chinese companies like Haier (now the world’s 4th largest white goods manufacturer) and Boasteel, who regard every member of the team as strategic business units (SBUs) and innovators, as they strive to develop new products and/or services.

But open innovation can also have a negative impact, he added, depending on the nature of the business. Every activity involves an opportunity cost as well as an actual financial cost, and sometimes there can be too much information to process – leading to a lack of focus, indecision and delays. Openness also varies from company to company, as Professor Chen discovered in a survey of over 200 Chinese organisations, looking at the ratio of new to old products and the frequency of new product introductions.

Dividing companies into two categories – science & technology driven companies (STIs) and “doing, using & interacting” companies (DUIs) – Professor Chen’s research showed that for STIs, the benefits of openness were “curvilinear” or tended to tail off over time, while for DUIs, the more open they were, the better they performed. Chinese companies may not have been open enough in the past, he concluded, but they are already beginning to progress from closed innovation to R&D-based innovation, and the next step will be open innovation networks.

## **10. George Boag (CEO of Targeting Innovation Limited – TIL)**

### ***How to measure innovation***

Innovation in Scotland – how do we support it through government policy and how do we measure it? In his professional life, George Boag lives and breathes innovation and his talk also touched upon similar issues in China, and how far it has come in a short space of time in terms of innovation performance.

For Mr Boag, innovation is not just concerned with new products, but how to “make money from new ideas, new partnerships, new services, new forms of communication and new ways to market.” He also stressed the fact that innovation isn’t easy, and suggested that in Scotland, we need to do more to encourage new ideas, and provide tools which enable new ideas to flourish.

According to Mr Boag, “only 10 per cent of our most innovative businesses have any interaction with research institutions.” Out of 197 spin-outs from universities, 26 per cent have closed, 56 have fewer than 10 employees and only one per cent employ over 100 people. Even though Scotland has more mathematics and computer science graduates per million people than the US, Japan, Germany or Sweden, we have a lot of work to do to realise our national potential.

“We need a step change,” said Mr Boag, in our attitudes to innovation, and that is what he and his organisation are attempting to drive with his “innovation dashboard” – a tool which measures Scotland’s performance in areas such as research and development, academia, finance, industry, skills and economic growth, comparing Scotland with the rest of the UK and Europe.

Scotland’s USP (unique selling point) has always been its human capital, said Mr Boag, who has been involved in over 100 initiatives in Scotland, bidding to get new ideas to market – not just looking at the role of academia and government and how to commercialise research, but also how to inject more confidence into new business ventures.

## **11. Professor Gao Xudong (School of Economics and Management, Tsinghua University)**

### ***The innovators most likely to succeed***

China is about to enter a new stage of technological development, with indigenous innovators leading the way, and companies becoming developers rather than buyers of new technology. China has a huge trade surplus at present, and relatively low interest rates, but Professor Gao wondered if strong economic growth could continue, without a radical change in attitudes to innovation, and greater internationalisation of business to promote China’s brand names. It is no longer enough to buy new products, absorb new technologies and then try to add on innovation. Companies will need to be much more original.

Professor Gao identified five types of innovators in China:

1. Companies who import or buy innovations
2. Joint-venture innovators (e.g. car manufacturers)
3. Companies who make products based on dominant standards (e.g. laptop computers)
4. Integrators (e.g. DVD manufacturers who license technologies)
5. Developers of proprietary products.

Of all these groups, the Chinese companies most likely to succeed are those who develop proprietary technologies, including telecoms and oil & gas companies. In the highly competitive, globalised market we live in today, profit margins will shrink even more unless companies become more innovative. For example, manufacturers of TV sets in China are finding it hard to compete with their rivals in Korea and Japan (e.g. Samsung and Sony), and either can’t afford to licence the technology or can’t reach agreement to do so. In the automobile industry, China has learned a lot from its foreign partners in terms of manufacturing capabilities, but learned almost nothing about design. “Some Chinese companies have made zero contribution to their MNC partners,” Professor Gao added.

According to Professor Gao, the companies who innovate and use their own technology are doing better and competing globally. Examples: ZTE in telecoms (40,000 employees including 10,000

graduates), and CPNC in petrochemicals. In many cases, success has come because the companies have been forced to innovate, and this should be a lesson for the future, said Professor Gao.

There are many opportunities for Chinese companies in emerging technologies, or in reinventing mature technologies. The challenges are not money or technical capabilities but in developing a sense of urgency, providing the right kind of incentives and instilling confidence.

## **12. Professor Jane Bower (Visiting Fellow at Edinburgh University's ESRC INNOGEN Centre)**

### ***Technical innovation systems***

Scotland used to be a leader in technical innovation, but towards the end of the 20<sup>th</sup> century, there was increasing concern we were falling behind, so academics, government and business decided it was time to do something about it. This was the background to Professor Bower's talk about *Universities and the technical innovation system in Scotland*, and how the system has evolved over the last 15 years, leading to successful 'spin-outs' from academia into the business world.

According to Professor Bower, for technical innovation to flourish, we need key ingredients working together, including knowledge creators, demanding clients, specialist finance suppliers, complementary expertise (e.g. in law and IP) and "status for entrepreneurs." In modern times, Silicon Valley has been a good model, with a geographical clustering of academic researchers, large companies and venture capitalists, plus legal and other professionals used to dealing with start-ups and access to major industrial buyers. "These innovative networks didn't happen overnight but have built up over 50 years," explained Professor Bower, adding that entrepreneurs are also accorded more status in that part of the world.

Academic-industrial links are essential, she said, and sometimes this can happen quite informally, with 'conversations' that may lead to future new products or business relationships – simply because people are living and working in the same place. In the 1990s, Scotland had lots of knowledge creators but there wasn't much other support. Since then, we have gained much more experience (including

returning expatriates) and developed new ideas such as 'angel finance' and entrepreneurial mentors for start-ups, gradually changing not just the image but the culture of Scottish business. The RSE has also played a major role, awarding research grants and encouraging new ventures via Fellowship programmes and other initiatives.

Professor Bower said that there were ongoing problems in Scotland, such as a lack of industrial buyers and limited status for entrepreneurs, but with support from government including R&D finance, spin-out firms (growing out of large firms or universities) continue to notch up a string of successes.

## DAY 2

### **13. Dr Wang Dan (Associate Professor of the School of Management at Harbin Institute of Technology)**

#### ***Can you measure trust in business?***

There is a “trust crisis” in the supply chain today, said Dr Wang, and her job is to diagnose the factors involved, to enable different partners to establish trust and thus gain mutual advantage. Trust is a critical factor in business, but there are also many parallels in our personal lives. Diagnosing problems and building trust between business partners is like a marriage counsellor, using statistical modelling methods rather than intuition and experience, to understand each partner’s strengths and weakness, hopes and dreams, and reach agreement on the ultimate aim of the relationship.

According to Dr Wang, surveys of large-scale enterprises in China show that there is “a lack of partnership in the real sense,” so she is now developing an intelligent theory and model to evaluate trust, diagnose problems and come up with practical business solutions.

Sometimes, lack of trust comes from informational asymmetry or lack of legal infrastructure, and Dr Wang believes there is an urgent need to monitor trust status during negotiations, to set off alarm bells and help the partners modify their behaviour, so they can collaborate better. “There are different definitions of trust,” she said, “and sometimes it is very hard to measure, but our studies are making good progress.”

The factors to consider in analysis of trust include legal, regulatory and contractual issues, technological and financial capabilities, as well as ‘human’ or subjective factors like goodwill, intentions, experience, knowledge, perception and sense of obligation. Dr Wang then adds these factors together and develops an intelligent model to help understand the processes involved. The model of ‘collaborative trust’ has not been applied in the real world to date, but Dr Wang and her colleagues are confident that it will be a highly useful tool in future, building a bridge between organisations and helping the supply chain to function more efficiently, for the benefit of all the partners involved.

### **14. Professor Umit Bititci (Director of The Strathclyde Institute for Operations Management & Professor of Technology and Enterprise Management at the University of Strathclyde)**

#### ***Raising the standards of trust***

What are the forces driving business today? How can we establish standards for trust in the same way as quality standards for products? How do we manage creativity? These were just some of the questions posed by Professor Bititci.

After reviewing some of the work done by his department, including more than 100 interventions involving companies of all shapes and sizes, he described how industry has moved from being product-driven in the early 20<sup>th</sup> century to market- and customer-driven today. Among the major factors influencing business today are openness, collaborative agreements (to create competitive advantage), mutual trust rather than using the law (to protect intellectual property), social and environmental responsibility and global networks and communities – as opposed to individual companies acting alone to pursue their self-interest. In addition, said Professor Bititci, innovation is a key strategic weapon, and value comes from personalisation of services and creative design.

Because all companies can use the same tools – such as lean manufacturing, JIT or 6-Sigma, etc. – their competitive edge can soon be eroded (or cancelled out), and this means gaining fresh advantage in other directions, from strategic excellence, innovation, learning and networking. Many companies innovate once and are very successful, he said. But that success may be a happy one-off accident. The challenge is to build the capacity for ongoing excellence, to seed new, good ideas and manage them through to commercial success.

Professor Bititci also asked: “What prevents companies adopting high-value, and what is high value? How do we manage creativity? Why do companies fail?” And his answer was to aim to for strategic, commercial, cultural and operational synergy among different partners in the supply chain – modelling aims and objectives, etc. – to ensure there are complementary capabilities and

mutual advantage. “Most companies want to do business with themselves,” he said, suggesting that they should look for difference not sameness in the search for new partners.

Finally, Professor Bititci talked about his department’s involvement in a Europe-wide project to study the future SME (small to medium-sized enterprise) – for example, looking at the opportunities for collaborative R&D.

## **15. Professor Zhang Zongyi (Vice-President of Chongqing University)**

### ***The innovation overspill***

Do innovations overflow from one place and one region to another, creating clusters of inventors who can bounce their ideas around and drive each other on to create more new products? Using data based on patent applications per 10,000 people in 29 provinces in China from 1985 (when the new patent laws were first introduced) to 2004, Professor Zhang has studied the “Spatial Overflows and Convergence of Innovation Outputs in China.” And in the process, he has reached some very interesting conclusions which may help to spread innovation around and reverse the ‘brain drain’ in less economically successful provinces.

Because he is measuring innovation in terms of new patents in specific locations, Professor Zhang also pointed out that the data can have limitations. For example, the success of Linux software has been built around a global network of inventors and developers openly sharing ideas, instead of seeking to protect their intellectual

property in order to keep all the profits. In addition, the data in China can sometimes be distorted by extraordinary local conditions – e.g. there are relatively few patents awarded in Shanghai, largely due to the large number of multinational corporations based there whose innovations are usually registered in their home countries.

From 1985 to 1996, Professor Zhang revealed, the distribution of new patents was unequal in China, and innovation depended much more on geography, focused on the major economic and industrial centres. Since then, this pattern has changed and patent growth has started to cluster. His conclusion is that before 1996, innovation tended to converge on major centres, but that since then it has been more divergent. One major factor, he revealed, is decentralisation, which has tended to encourage more widespread innovation. For example, by creating new ‘innovation centres’ in the west of the country (the Professor’s home region), he believes innovation will spread out to the provinces, and help to halt the migration of graduates to more established centres like Guangdong.

## **16. Dr Lesley Walls (Head of the Management Science Department at the University of Strathclyde)**

### ***Fear of flying (and statistics)***

The new A380 Airbus was due to land in London on its first commercial flight, that same afternoon, soon after Dr Lesley Walls delivered her talk on *Reliability informed design in aerospace product development* – a process which has also had a critical impact on the new super-jumbo.

Dr Walls explained that the focus on safety and reliability in the aerospace industry has changed in recent years, as more and more airlines lease flying hours rather than buying their aircraft outright, shifting the emphasis in manufacturing by making spares replacement more a cost than an ongoing revenue source – thus pushing manufacturers to seek new ways to improve the lifetime of various parts. To model this process and forecast probability of failure, for example, Dr Walls and her team try to learn from experience, including studying historical events, and speaking to the experts in the field as well as the engineers who design and develop components, then subjecting all the data to statistical analysis. Ultimately, this leads to safer and more profitable aircraft via better decision-making, better allocation of resources and better prioritisation, in the bid to improve the quality and reliability of the components, as well as the production process itself.

According to Dr Walls, all innovations introduce new analytical problems (because they create new conditions), but using stochastic modelling methods, which take randomness into account, they can more accurately predict the performance of any component at any given time in the future, by interrogating the available data in different departments, including repair shops and the experts

themselves – who are interviewed individually as well as in groups. There are five key principles in the research, said Dr Walls: reproducibility, accountability, neutrality, fairness and empirical control.

“Engineers can be sceptical about expert judgement,” she said, “but the results prove it works – our modelling techniques do help to manage reliability of innovations in product design and development.” The next step, she said, was to validate the modelling methods through studies of historical data, checked against the forecasts – including the performance of the A380, in the real world.

### **17. Dr Wei Yi-Ming (Deputy Director-General of the CAS Institute of Policy and Management, Director of IPM-CAS and RIET-CNPC Joint Center for Energy and Environmental Policy Research)**

#### ***Modelling future energy needs***

Dr Wei’s talk spelled out the key challenges for China’s energy policy makers and how new modelling techniques could help them make better decisions.

First, he described China’s huge appetite for energy, and the relationship between energy consumption and GDP, highlighting top-down factors (driven by the economy) and bottom-up factors (driven by technology). He also pointed out that growth in energy consumption has overtaken economic growth, and explained that sustainability was becoming a much bigger issue in China, adding to other issues such as security, the need to increase production to balance supply and demand, the need to improve efficiency and lower emissions, the impact of price fluctuations and the need to reduce dependence on imports of oil.

Dr Wei then described how all these factors have to be taken into account in his model of China’s energy needs – looking at the relationships between Society, Energy, Environment, Economy and Technology (SE3T), and asking questions such as how much energy will be needed in future, how to balance regional supply and demand, the need to manage coal supplies, oil price mechanisms, control of CO<sub>2</sub> emissions, the impact on society and industry, etc. Ultimately, Dr Wei added, looking forward to the year 2020, the big issue is how to manage China’s energy consumption at the same time as achieving sustainable economic growth, in a multi-regional nation where local conditions can vary dramatically.

The SE3T model looks at five basic scenarios in eight different regions, across four different sectors, to see what pressures there would be with different rates of economic growth and changes in power production – as well as changes caused by global warming.

### **18. Professor K L Lo (Head of power system analysis research at the Department of Electronic and Electrical Engineering at the University of Strathclyde)**

#### ***Modelling alternative energy networks***

Wind and other alternative sources of power (e.g. wave & tidal) promise to solve many problems, but how do we connect renewable energy sources to the national network, and how do we model the process to work out the best way to do it? That was the chief question posed by Professor Lo, who also asked what China and Europe have in common, and what they can learn from each other, when it comes to renewable energy.

In Europe, he said, the target is to grow from 34GW in 2004 to 180GW by 2020. The UK aims to increase its wind power from 10% of installed capacity in 2010 to 20% by 2020, with Scotland today contributing just over 50% of the total from wind, or 1.1GW. Germany is the most advanced wind generator in Europe, contributing over 40% of the total, or 28.5GW.

China added 3GW of wind power to its national network in 2007 alone, Professor Lo continued – making it the fastest-growing market for wind power in the world. China also plans to add 1,300 GW of power by 2020, with 25–30% coming from clean and renewable sources. This compares to the 1,000 GW produced by the US today, and means that China will – in effect – build more capacity over the next 12 years than the US has built since the dawn of electricity.

As well as facing difficult choices regarding the ideal design for wind turbines, trading costs against efficiency and using different types of turbines in different locations, power companies also face a number of economic and technical problems when it comes to connecting their turbines to the

national grid – with some problems common to Scotland and China. The key issue is to reduce fluctuations in voltage due to the nature of wind power, forcing generators to keep alternative sources such as coal in reserve, to maintain 500MW at all times in the network, thus increasing emissions and reducing overall efficiency. The lower the reserve, the more you save, and this is a key aim of energy planning.

By dispersing wind farms throughout the network, fluctuations can be greatly reduced, Lo explained – optimising the efficiency of wind power as a whole, at the same time as having a significant impact on prices. To achieve this aim, we therefore have to analyse (and model) the tolerable limits of the network, taking risks and probability into account – e.g. forecasting weather conditions, and how often turbines are forced to shut down, as well as wear and tear. When problems occur, it is also important to isolate parts of the network, to stop problems spreading. And Professor Lo explained that his research models take into account all of these complex economic and technical factors.

## **19. Dr Tang Lixin (Chair Professor and Director of the Logistics Institute at Northeastern University)**

### ***Improving steel production scheduling***

Production scheduling in the iron and steel industry was the focus of Dr Tang's presentation. Steel plays a critical role in China's economy, and the national steel industry has been the Number One producer in the world since 1996, feeding other sectors such as construction, automobile manufacturing and machinery.

The major characteristics of the steel industry are a long and complex production schedule, combined with high energy and capital consumption, plus the need to optimise capacity and minimise downtime (delays between orders) and materials wastage. The questions facing Dr Tang and his team are therefore how to reduce energy consumption, how to cut production costs and how to keep the furnaces burning – in other words, optimisation of production scheduling and logistics, for different production stages and processes.

Steel-making continuous casting (SCC) has relied upon Just-In-Time (JIT) methods to optimise production scheduling, and Dr Tang's work focuses on using new modelling methods (including Lagrangian relaxation algorithms) to understand what's happening at any stage during production and thus make better decisions. Unlike the machinery industry, production and logistics scheduling in the iron and steel industry involves extra complications like job grouping and precedence constraints, as well as high waiting costs. Working with major producers in China such as Boasteel and Tian Steelpipe, Dr Tang's modelling techniques have led to significant improvements in productivity and reduced bottlenecks, taking advantage of advanced mathematical and heuristic algorithms.

## **20. Professor Ian Hunt (Head of School of Engineering and Built Environment, Napier University)**

### ***Mind to market***

Professor Hunt focused on the work of his department in helping new products from concept to market, using recent examples including a device for measuring vibration in construction tools and a meter to monitor power consumption, designed for the home. His chief concern was taking the leap from design to production, and how this often means Scottish companies looking abroad to identify new manufacturing partners, particularly in Eastern Europe and the Asia Pacific. He also talked about the challenges which face designers and developers, including the critical role of the entrepreneur, innovation, the importance of fast and flexible response to market demand, and how to "pull information back from customers" in the modern global market.

At Napier, Professor Hunt's team engages in a diverse range of activities, including manufacturing planning and control, preparing and assessing prototypes, and advanced materials research, as well as simulation and seismic studies.

Among the school's recent successes are the new HAV (Hand Arm Vibration) meter invented by REACTEC in Edinburgh, which is now being manufactured and distributed worldwide, and the

award-winning Ewgeco energy management system, another new device prototyped at Napier, invented by Perth-based Tanya Ewing.

## **21. Professor Jeff Haywood (Vice-Principal for Knowledge Management, Chief Information Officer and Librarian at the University of Edinburgh)**

### ***IT at university***

Professor Haywood provided the workshop with a number of insights into the computing environment at the University of Edinburgh, focusing on the acquisition and integration of new information systems, and how to optimise performance – something which depends on many different individual criteria, particularly the different perceptions of users and service providers. He also talked about the cultural tensions which can sometimes arise between academic and ‘corporate’ stakeholders.

The university’s network consists of research systems, learning and teaching systems, and corporate systems, and Professor Haywood noted that “whatever we design must take account of what will change.” For example, many systems (e-portfolio and online learning) which were considered highly innovative a short time ago are now essential systems which are taken for granted. Also, as the network evolves, there are fewer and fewer standalone systems (excluding supercomputers).

It would be easy, said Professor Haywood, to start from scratch when you build a new campus network, but in reality the network usually has many legacy systems which must be connected and talk with each other. Increasingly, he added, the university must also “reach agreement with the community of users” when it introduces new systems, and comply with legal and procurement constraints. Some users need and demand different tools, but unless they can justify their individual requests, they must comply with university-wide standards. On the one hand, this can inhibit purchasing methods, but Haywood also believes it forces people to ask the right questions about their requirements and reach a compromise which in the end benefits everyone to some degree – by making the right decisions from the start. There is always a trade-off, he explained, between security and connectivity, for example, or cost of ownership versus ‘agility’.

Professor Haywood also talked about the ‘roller-coaster’ of user expectations when new systems go live – how people often ‘mourn’ the old system, as they struggle to come to terms with a new system, before they finally acknowledge the benefits. According to Haywood, this presents a challenge to service providers, who must ensure that users don’t expect too much initially, to soften the blow of the inevitable disappointments and frustrations of using new systems. “It’s all about people and managing change,” he said, as well as having very clear objectives, aligning expectations, listening to users and communicating clearly with stakeholders. Finally, he said, “it’s not technology management but people management” which matters the most.

## **22. Professor Arthur Trew (Director of the EPCC – Edinburgh Parallel Computing Centre)**

### ***Simulation in the real world***

Professor Trew kicked off by describing the evolution of scientific research from theory to experiment and more recently to simulation – a methodology pioneered in Edinburgh since the early 1980s. He said that the EPCC (founded in 1990) is now the “major centre for computational research in Europe,” and aims to rival similar facilities in the US. Although the centre emphasises academic research and technology transfer, and has worked with 75 major industry clients over the last three years, he also said, “It’s no good doing research if you don’t train the next generation,” adding that the university also provided a better environment for certain kinds of research than commercial facilities, by providing easy access to diverse academic resources.

Even though Professor Trew said that people were the most important asset of the centre, he is also very proud of its computers, especially HECToR (High End Computing Terascale Resources), which is one of the most powerful computers in the world, capable of 60 Tflop/s. In fact, it is so powerful that it uses more power than 10,000 households, and its power plant is three times the size of the actual computer. To appreciate the progress made in computing over the years, Trew said that the university’s first “supercomputer,” purchased in 1982, was built around processors the

equivalent of today's more advanced mobile phones – and yet it was still smart enough to enable researchers to produce over 180 ground-breaking papers.

With £100 million-worth of computer, the EPCC is capable of doing some challenging work, including computational fluid dynamics, which helps researchers improve the efficiency of the new generation of wind turbines, as well as research into nuclear fusion and production scheduling. One of the future challenges for the EPCC will be its work in what Trew described as the “circle of life,” doing research into biological systems, including molecular dynamics and population (e.g. looking at avian flu), as well as some mind-boggling problems in physics.

Professor Trew concluded by saying that the key to success for the EPCC is the continuing links between academia and its hardware suppliers and industry partners.

**Peter Barr**  
**Edinburgh**

## **RSE/NSFC WORKSHOP**

**17 March 2008**

**Visit by Ms Fiona Hyslop**

**Cabinet Secretary for Education and Lifelong Learning**

### **Introduction**

Ms Hyslop, Cabinet Secretary for Education and Lifelong Learning welcomed the delegation to Scotland and to Edinburgh. She reminded the meeting that the Deputy Director of the NSFC, Professor Zuoyan Zhu, had visited Scotland in 2007 to receive an honorary degree from the University of Aberdeen – the first to be awarded to a scholar from mainland China. During the same visit he signed the bilateral agreement with the Royal Society of Edinburgh, which directly resulted in this workshop, which the Scottish Government was pleased to support.

Ms Hyslop pointed out that Scotland is famous for its great thinkers and philosophers, including David Hume and Adam Smith and its great engineers, including Thomas Telford. Today it continues this tradition with a strong capability in Business and Management Sciences and also in Engineering. Another area of strength is Biological Sciences and many Chinese scientists have also participated in projects in this field through the RSE exchange programme. Energy is another key area for collaboration and partnership now, and will be in the future. Across the entire breadth of the research base, important 'pooling' of research in key disciplines is also being seen, particularly in areas such as life sciences, physics, chemistry and economics.

There has been a general increase in collaboration between scientists in Scotland and China. As a pilot, in 2008 the Scottish Government with the British Council is funding an exchange of a small number of science and technology students with Chinese institutions, through the International Association for the Exchange of Students for Technical Experience (IAESTE). In addition, it continues to support student activity through its own Scottish International Scholarship programme and individual Scottish institutions are engaged in many more programmes, both their own and UK initiatives.

Ms Hyslop explained that her main responsibilities as Cabinet Secretary for Education and Lifelong Learning are education, skills, research and innovation. It is her role to ensure that Scottish people are successful learners and effective contributors to society and she was pleased to report that the Scottish science community is a fantastic ambassador for the rest of Scotland in all these respects.

One of the areas of her portfolio, which the Scottish Government is keen to develop, is skills utilisation. School pupils are part of her responsibility and the Scottish Qualifications Authority has strong links with China. Increasing numbers of Chinese students have been coming to Scotland in recent years and bonds are being formed, not only in education but also of friendship. Ms Hyslop pointed out that the Scottish national poet, Robert Burns, with whom many Chinese are familiar, came from her birthplace.

Scotland has a long and distinguished educational heritage, a healthy curiosity for making new discoveries, and a great appetite for dialogue with others from across the globe. In terms of innovation and leadership, something important is happening in Scotland – Scottish institutions are collaborating, thus providing a single entry point for international partners.

Scotland is – and historically has been - a 'Science Nation'. Its world-class universities excel in research and innovation. It is first in the world in terms of citation rates for research papers and also has one of the world's top impact factors for research citations per paper. But science is a truly international endeavour. Ms Hyslop said that the Scottish Government recognises that driving forward competitive science requires not only the commitment of those who work within the world-class research base in Scotland, but also the building of strong international partnerships. Scottish institutions have always been outward looking and China is becoming increasingly important as a world player. Scotland takes its relationship with China very seriously and needs to do even more

to partner with China, to their mutual advantage. Ms Hyslop stated that everyone present at the meeting would play an important part in achieving the sustainable economic growth that is key to both their futures.

Scotland and China already have a history of science collaboration through long-standing links with the Royal Botanic Garden Edinburgh with its field station in Lijiang and its expertise in Chinese plants and conservation, discussed earlier in the workshop.

Links continue to be established through institutions and companies in many areas of interest. Increasing numbers of Chinese students are choosing Scottish institutions and developing long-lasting friendships with people in Scotland and the Scottish Government wishes to build on those links. The Scottish Government is currently progressing five science IAESTE scholarships, researcher exchanges through the RSE/ NSFC programme and exchanges through the SIPS exchanges, also funded by the Scottish Government

Ms Hyslop said she would be visiting China in April 2008 and intended to discuss education and science links. During the visit she will spend time in Beijing, Jinan and Shanghai and hopes to witness a signing ceremony in Beijing on a new agreement between Aberdeen University and the Chinese Academy of Sciences on a research centre for Eco-Environmental Sciences.

### **Questions and discussion**

Ms Hyslop said that she was interested to hear about the priorities of those present and invited questions or comments on the usefulness of the workshop:

The Cabinet Secretary answered a question on the gender balance within the Scottish Government, noting that two out of the six Cabinet Secretaries in Scotland are women. In addition, with females making up 40% of the whole Scottish Parliament (all parties) this is one of the most equal gender balances in the world.

When asked for more detail on the claim regarding Scotland's eminence in citation rates for research papers, Ms Hyslop referred the delegates to the Scottish Government website, which published a report in February 2008 on *Metrics for the Scottish Research base*, statistically demonstrating Scotland's prowess on citations in science and research internationally.

Ms Hyslop told the meeting that Principals of Scottish Institutions have been working on a six-month review of funding for higher education in Scotland. Funding is limited but extra money has been released.

Further discussions centered around development in Scotland of a system of greater employer engagement and the agreement that distance learning is an important learning tool.

Finally, the group discussed ways to increase the number of postgraduates and entrepreneurs and how to expose undergraduates to further research. It was agreed that there are many challenges around the interaction between Institutes of Higher Education and business and that responsibility for increasing this cannot lie entirely with Higher Education.

### **Closing remarks**

Ms Hyslop thanked delegates for their contributions. She said she was pleased with the level of interest in what is happening in Scotland, exemplified by their commitment to attend this event.

Ms Hyslop hoped that hearing about the Scottish experience would help the Chinese delegates to develop their thinking and that their trip would be both stimulating and productive. At the same time, she stated that Scotland is a learning nation and it was hoped that Scottish scientists had also been challenged by the visit. Finally she encouraged delegates to explore possible actions arising from the workshop, alongside continuing discussion with the RSE and with others.

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