PATHWAYS TO IMPACT

Measuring the Benefits of Mathematical Research

By Professor Peter Taylor

This year the Australian Research Council (ARC) will ask Australian Universities to take part in an exercise to assess the *engagement* and *impact* of their research. The aim is to encourage universities to consider the economic and social benefits of academic research, and to ensure a return on investment for research funded by the Australian taxpayer.

In response to this foreshadowed challenge, AMSI and the Australian Research Council Centre of Excellence for Mathematical and Statistical Frontiers (ACEMS) hosted a workshop on *Measuring Research Engagement and Impact in the Mathematical Sciences*. The ideas expressed below are a direct result of discussions that occurred at, and following, that discussion.

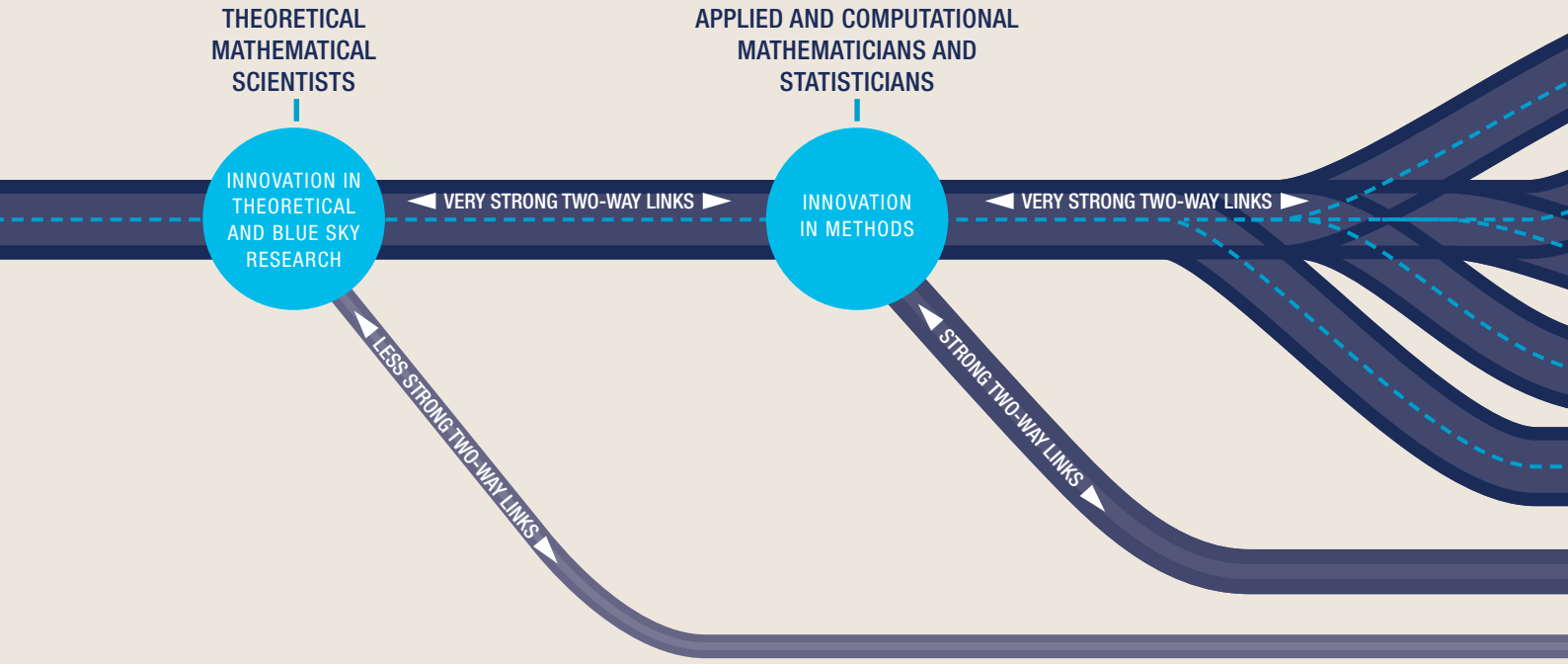
Impact for the mathematical and statistical sciences can be thought of in two high-level senses. First, mathematics and statistics are foundational sciences, and pushing the boundaries of mathematical and statistical knowledge has a flow-on effect to all fields that use quantitative methods. Second, applied to problems in the real world, mathematical and statistical expertise and research outputs can help with the design of innovative technologies and platforms, optimise systems, model future events, and help understand relationships. Such outputs are all highly-valuable to business, government and applied research communities. End-users for research in the mathematical sciences are not only industry, government or the public, but very often researchers in cognate and applied fields.

WHAT IS IMPACT?

The ARC defines research impact as "the demonstrable contribution that research makes to the economy, society, culture, national security, public policy or services, health, the environment, or quality of life, beyond contributions to academia."

While acknowledging this definition, it is important to appreciate that the impact of mathematics and statistics is much broader and more far-reaching than arises just from direct collaborations. Mathematics and statistics are enabling disciplines that support other applied research. Research outputs from mathematics and statistics continually feed into innovative methodologies used by applied researchers, which then flow onto the final end user. For example, prior, fundamental research in Hidden Markov Models played a crucial role in enabling the mapping of the human genome.

MODEL OF THE RESEARCH PROCESS



WHERE DOES IMPACT OCCUR?

It is constructive to look at impact in the context of a research pathway (see diagram below), where all but the last position of the pathway represents a specific research community. Each community accesses the output of the preceding community and influences its research agenda by posing questions of importance; in this way, the communication is very much bidirectional. All research communities engage with industry, government and other end users to different degrees. As a generalisation, the volume of that engagement with end-users increases along the pathway.

IT IS FUNDAMENTAL TO BUILD LINKS WITH THE VARIOUS DISCIPLINES WITHIN THE MATHEMATICAL SCIENCES

Within this framework, the theoretical research community outputs new fundamental mathematical and statistical results. The applied mathematics and statistics research communities translate these fundamental results into methodologies for applied problems. Applied researchers in other fields then apply these proven methodologies to gain insights about systems, relationships and other events of interest in these fields.

The diagram below is of course a simplification. Individual researchers might simultaneously be part of multiple research communities, and thus the environment is more akin to a network. In this network, researchers move between communities, and at times work on theoretical, methodological or applied problems. This serves to enhance communication in both directions between communities.

There are three main points where translation occurs within the system. They are:

1. Translation within the mathematical sciences
2. Translation to other disciplines in science, engineering, social science, economics, medical science and other 'client' disciplines
3. Translation to end-users in business, industry and government

It is thus fundamental to build bridges within the various disciplines within the mathematical sciences, to encourage collaboration across the whole spectrum from theory to methods and computing, and to applied practice. Mathematics and statistics are foundational supports for many other fields, and translation of outputs to researchers in these fields will not only grow capability and innovation in this wider community, but also reach the very wide range of end-users who engage with these fields. Finally, there is the impact of mathematical science researchers who engage directly with business, industry and government to develop new methods and insights directly influenced and fuelled by 'real-world' challenges. □

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