Antipodean agricultural and resource economics at 60: Trends in topics, authorship and collaboration*

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This study presents results of an analysis of 1060 academic articles published in the *Australian Journal of Agricultural Economics* and the *Australian Journal of Agricultural and Resource Economics* from 1957 to 2015. Trends in research topics over time identified by the study include a decline in research on agricultural topics offset by growth in publications related to natural resources, the environment, trade, food and international development. Other trends include an increase in the average number of co-authors on each paper, a gradual increase in authorship by females, changes in the shares of top contributing institutions, increases in collaboration between institutions and a steady increase in the number of authors from outside Australia or New Zealand.

Key words: citation analysis, co-authorship, collaboration, Latent Dirichlet allocation.

1. Introduction

The *Australian Journal of Agricultural Economics* (AJAE) commenced publishing in 1957. In 1996, its name was changed to the *Australian Journal of Agricultural and Resource Economics* (AJARE) and it absorbed the *Review of Marketing and Agricultural Economics*. The 1060 publications that appeared in the Journal between 1957 and 2015 provide insights into the changing interests, priorities, specialisations, methods, affiliations, and patterns of authorship and collaboration for Australian and New Zealand (and, to some degree, international) economists working in this field. The purpose of this paper was to identify and provide a quantitative assessment of these long-term trends in agricultural, resource and environmental economics research in Australia as reflected in publications in AJAE and AJARE.

2. Methods

Tracking changes in a field of research requires classification and synthesis of the relevant body of scientific literature. Classification is commonly done using keywords or classification codes, such as JEL codes in economics. These approaches have a degree of subjectivity and do not necessary make full use of the available information about each paper. As massive amounts of textual data become available online, information science has developed a number of text mining applications to help with classification and indexing of these data (Karl *et al.* 2015). Topic models are algorithms that allow discovery of themes that prevail in large unstructured collections of documents (Blei 2012). In this study, we used Latent Dirichlet Allocation (LDA), one of the most widely used topic models (Blei *et al.* 2003). Latent Dirichlet Allocation assumes that each 'document' in a corpus of documents consists of words. A 'topic' is defined as a set of words co-occurring with a relatively high probability and can be interpreted as a meaningful combination of ideas within a corpus (Westgate *et al.* 2015). For example, the words 'fishing' and 'quota' would co-occur with a higher probability in a topic named as 'Fisheries economics' compared to other topics. Each document can include multiple topics. Latent Dirichlet Allocation uses an Expectation Maximisation algorithm to estimate the distribution of words and phrases for each topic and the probability of each identified topic in each document.

The data were collected from Wiley Online Library and Web of Science database in December 2015. We included research papers published in AJAE and AJARE from 1957 to 2015. Book reviews, editorials, comments and replies were excluded from the analysis. There were 1060 documents deemed suitable. The data for every article, including title, authors and their affiliations, year of publication, volume, issue, keywords and abstracts, were downloaded from Wiley Online Library. The data on number of times each article was cited were downloaded from the Web of Science database.

Keywords and abstracts were not available for all articles in our sample, so we used the full text. The text was extracted from articles in PDF. Errors in the extracted text were filtered using software spell checker *aspell* (Atkinson 2003). Text preprocessing was done using *tm* (Feinerer 2015), and LDA was performed using *topicmodel* (Grün and Hornik 2011) in R statistical software (R Core Team 2015). The number of topics was selected by estimating a range of LDA models with the number of predefined topics ranging from 5 to 20. In our judgement, the model with 16 topics resulted in the most meaningful grouping of words and articles, so it was chosen for further analysis. We assigned names to the topics by inspecting the words present in each topic that had the highest probabilities of occurrence and by inspecting the titles of the papers that had the highest probabilities for each topic.

The gender of each author was determined using names or by the Internet search of additional information including photographs. Out of 2115 co-authors (which includes some authors who published multiple times),

we were able to assign a gender to 1864 authors. Institution, city/town and country of each author were derived from the affiliations of article authors. Numbers of papers, weighted by inverse number of authors, were aggregated by institutions and countries. Coordinates of author locations were calculated using Google Maps Application Programming Interface (API). The spatial links between the co-authors in each paper were created in ArcGIS.

3. Results and discussion

3.1 Research topics

Figure 1 shows the topic names, the number of papers assigned to each topic and number of citations to papers assigned to each topic. Each paper was assigned to the highest-probability topic for that paper. For example, in Schilizzi and Latacz-Lohmann (2013), 'Environment' was the single dominant topic with a probability of 99%. On the other hand, some papers had several topics with nontrivial probabilities. For the purpose of Figure 1, Pannell (2001) was assigned to 'Water' (31%), but the paper also included 'Land' (27%), 'Environment' (17%) and 'Uncertainty and risk' (16%). Figure S1 in the online supplement presents the same information but as trends of smoothed proportions of topics on one graph. Figure S2 in the supplement demonstrates similarities and differences between topics and clustering of topics. Furthermore, Table S1 in the Supplement lists the top thirty most cited papers with one or two top topics assigned to each paper.
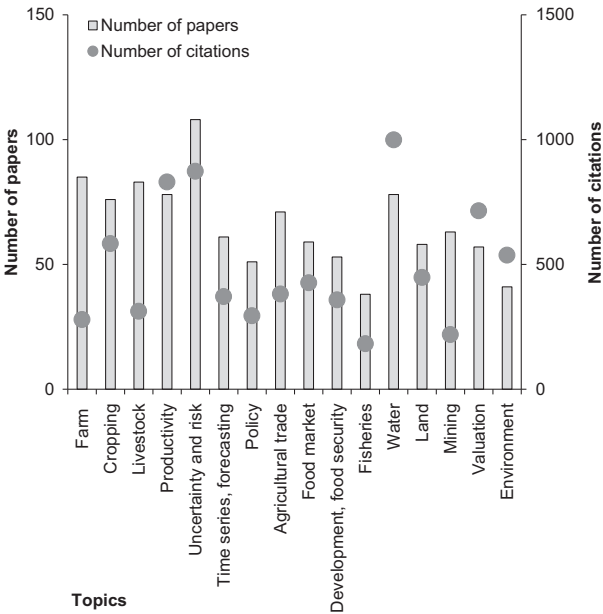

Figure 1 Distribution of papers and citations to papers by topic.

The 'Uncertainty and risk' topic had the highest number of papers (108), followed by 'Farm' (85), 'Livestock' (83), 'Productivity' (78) and 'Water' (78). 'Fisheries' (38), 'Environment' (41) and 'Policy' (51) had the least number of papers. The most citations were for papers on 'Water' (999), 'Uncertainty and risk' (873) and 'Productivity' (830). The most highly cited paper, Battese and Corra (1977), was assigned to the topic 'Productivity' (see Table S1 in the online supplement).

Figure 2 shows the number of publications each year for each of the 16 topics in AJAE and AJARE from 1957 to 2015. The dots indicate the counts of articles that have the highest probabilities for each of the 16 topics in each year. The solid lines are five-year moving averages of the number of papers for each of the topics.

The numbers of papers related to farms in general or livestock were high in early years but show noticeable declines over time. This likely reflected the declining relative importance of agriculture in the economy (Productivity Commission 2006) and declines in the importance of agriculture as a policy issue. Papers on livestock were noticeably less numerous following the collapse of the Reserve Price Scheme for wool in 1991 (Curtis 2009). On the other hand, papers focusing on cropping were relatively stable in number until the 2000s, when there is an apparently temporary increase. Examining
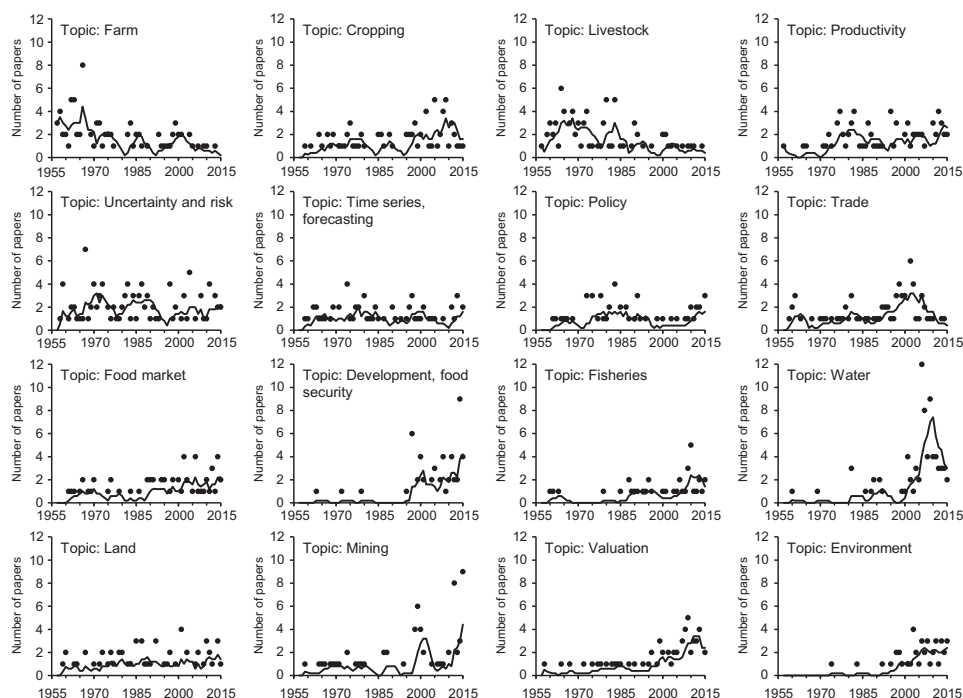

Figure 2 Trend in topics. The dots represent the counts of articles that have highest probabilities for each of the 16 topics. The solid lines are the five-year moving averages of counts of articles for each topic.

the specific topics of the relevant papers, much of the increase was due to papers related to the 'bio-revolution' (Bates and Edwards 2016), including genetically modified crops.

Published research on agricultural productivity commenced in earnest in the 1970s making substantial contributions to the field, including to productivity measurement beyond agriculture (Alston and Pardey 2016). Several papers on agricultural productivity are among the most cited publications of AJAE and AJARE (see Table S1 in online supplement). Publications on this topic have remained reasonably stable in quantity since then. Similarly, uncertainty and risk have been of high interest to agricultural, resource and environmental economists throughout the period (Quiggin and Anderson 2016), producing a number of highly cited papers (see Table S1). 'Time series, forecasting' and 'Policy' are relatively generic topics, including studies of many different commodities, products and resources, so it is perhaps unsurprising that there was no marked trend in publication numbers for either.

'Trade' and 'Food market' both showed notable increases in paper numbers from about 2000 on. These reflected the increasing research attention given to off-farm issues in agriculture in recent years. Publications on trade peaked in around 2002 and had fallen away by 2015, but the increased interest in food has been sustained.

There has long been an active research community focused on the economics of international development and food security. However, it made little use of AJAE or AJARE as a publication outlet until the late 1990s. The growth in papers on development since then perhaps reflects a growing engagement of the Australian discipline with issues in East Asia and South-East Asia, including increasing numbers of postgraduate students from the region studying in Australia.

The remaining six topics all relate to natural resources and/or the environment. Reflecting the changed names of the Journal and its parent Society, five of these six topics showed marked increases in paper numbers after the mid-1990s. The most dramatic increase was for water, reflecting the high levels of attention given initially to river salinity and subsequently to water availability and water markets by policymakers and the broader public (Pannell *et al.* 2016). The Millennium Drought (Van Dijk *et al.* 2013) was an important influence on this policy and research attention, and it is notable that, since the end of the drought, research publications on water have decreased in number.

There was almost no published research on fisheries economics prior to 1985, but from that point there was innovation in fisheries policy and more active fisheries management, resulting in a steady stream of research papers in the Journals. There have been two spikes in publications related to mining and energy, lagged relative to the investment surge in the minerals sector in the late 1990s and mining boom in the late 2010s. The high publication numbers in 2013 and 2015 were due to special issues on mining-related issues.

Finally, there was substantial growth in papers on 'Valuation' and 'Environment' commencing in the late 1990s, reflecting growth in policy interest and the availability of research funding. These increases in research on the economics of resource and environmental issues reinforce the wisdom of the Journal and Society name changes referred to earlier.

3.2 Collaboration

Trends in types of collaboration and numbers of co-authors by decade are presented in Figure 3. The number of single-author papers in the Journals has fallen dramatically over time, from almost 80 per cent in the first period to a little over 20 per cent in the final period. The number of papers with four or more co-authors has increased substantially, from close to zero to around 20 per cent. The proportion of papers with at least one author resident outside Australia or New Zealand has grown consistently over time, reaching 25 per cent in the last decade.

Figure 4 shows the composition of authorship by gender. There were almost no female authors until 1980. By 2015, the fraction of females among authors and co-authors had risen to 20 per cent, which is still lower than proportion of female authors in the *Journal of Environmental Economics and Management* (zero to 30 per cent from 1974 to 2010 (Schymura and Löschel 2014).

Figure 5 shows the trends in authors' affiliations by institution and region. The seven Australian institutions with the most AJAE and AJARE
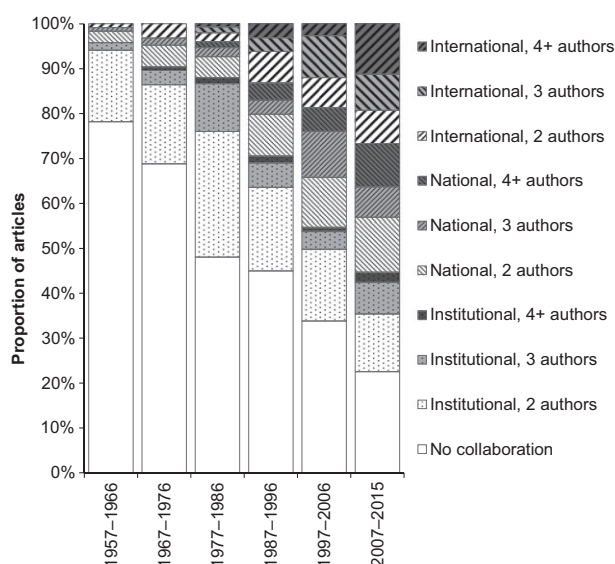

Figure 3 Trends in types of collaboration and number of authors per paper. Institutional: co-authors are from same institution; national: co-authors are from different institutions in one country; international: co-authors are from different countries.
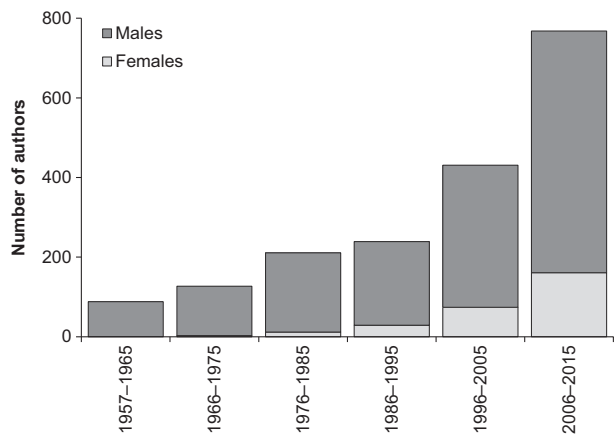
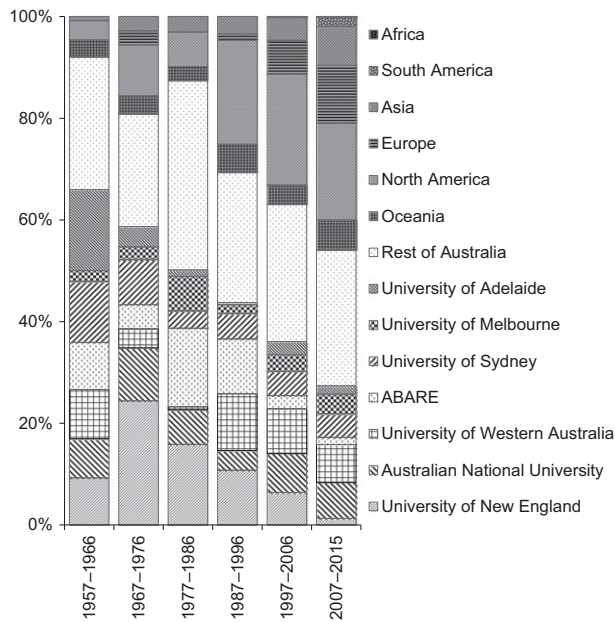**Figure 4** Trend in publication co-authorship by gender.

Figure 5 Publications by institutions and regions. Seven most productive Australian institutions are shown separately, and the rest are grouped into regions.

publications are named, and the remaining institutions are aggregated by region. In the first half of the period, the dominant institution was the University of New England. However, its output had fallen to a very low level by the latest decade. ABARES[1] also fell markedly in published output after

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[1] The Australian Bureau of Agricultural and Resource Economics and Sciences, earlier the Australian Bureau of Agricultural and Resource Economics or the Bureau of Agricultural Economics.
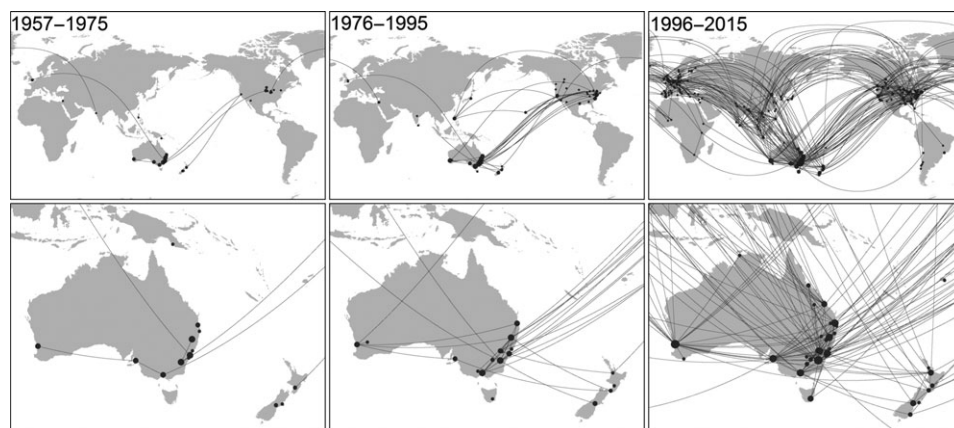
Figure 6 Spatiotemporal patterns of authorship and collaboration. Size of the dots represents number of authors and papers in each location. Lines represent collaboration connections.

its peak in the middle two periods. In the second half of the time period, the most productive institution was the University of Western Australia (with emphases on agricultural, resource and environmental economics), followed by the Australian National University (with emphases on resource and environmental economics).

The spatial patterns of national and international co-authorship are shown in Figure 6. The sizes of the dots indicate the number of papers published by authors in each location, and the lines represent co-authorship links between different locations. In 1957–1976, authors were mainly Australian with a few collaborations between Australia and the USA as well as between New Zealand and the USA, although there were no collaborations between Australia and New Zealand. Co-authorship, including with international authors, grew in the second period (1976–1995) and exploded in the third period (1996–2016), corresponding with the change of journal name and the shift from in-house publishing to use of an international publisher (Blackwell and later Wiley-Blackwell). While AJAE was largely local in its focus, AJARE is much more international, with authors from every continent, but particularly from North America, Europe and Asia.

4. Conclusion

Overall, in the course of six decades there have been major changes in various aspects of the research articles published in AJAE and AJARE. Key changes include a declining emphasis on agriculture, accompanied by increasing emphases on natural resources, the environment and development; growing internationalisation; an increase in multiple authorship of articles; and an increase in collaboration, reflected in co-authorship between researchers from different institutions and different countries.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Table S1 Thirty articles published in AJAE and AJARE with the highest number of citations in Web of Science database.

Figure S1 Smoothed proportion of papers by topic and year.

Figure S2 Topic similarity represented by distances between topics.