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Interdisciplinarity, Collaboration and Industry Links in Australian Discovery and Linkage Projects (2023-25)

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Abstract

Research funding schemes play an important role in shaping national research priorities and facilitating collaboration between academia and industry. This study examines collaboration patterns and interdisciplinarity in Australian Research Council (ARC) Discovery and Linkage projects funded between 2023 and 2025. Using network analysis and visualisation techniques, the study analyses data from 1,750 projects (315 Linkage and 1,435 Discovery) to investigate interstate collaboration patterns, disciplinary interactions, and industry engagement in Australian research. Interdisciplinary Distance (IDD) values were calculated using Field of Research (FoR) codes, incorporating both disciplinary disparity and balance of disciplines involved in each project to compare interdisciplinarity of the two project types. The analysis reveals distinct patterns in interstate collaboration, with eastern states demonstrating stronger collaborative ties. Engineering and Biological Sciences dominate both grant types. Linkage projects show greater interdisciplinarity than Discovery projects, with 53.7% of Linkage projects involving three distinct FoR codes compared to 48.1% of Discovery projects. IDD values of Linkage projects (mean = 0.46) were also significantly higher than Discovery projects (mean = 0.38). Analysis of industry partners in Linkage projects 2024 reveals concentration in Public Administration and Safety (21.1%) and Professional Services (19.5%) sectors, primarily in New South Wales and Victoria. The findings highlight opportunities and suggest policy implications for geographical and sectoral diversification in research collaboration, particularly in engaging underrepresented regions and industries.

Introduction

The research landscape in Australia is rich with a strong higher education sector (42 universities) that is its economy's fourth largest export sector (Spre, 2023), and high-quality research with more than 90 per cent of its university research rated as world class or higher (Universities Australia, 2019). However, there are also problems such as insufficient collaboration (Cetindamar et al., 2024), low rate of university-industry partnership (Jackson et al., 2018) and inability to translate research and innovation into innovative products (Jackson et al., 2016).

To address such challenges and direct research efforts, governments worldwide employ competitive funding schemes as key policy instruments. In Australia, this takes the form of a complex national competitive funding scheme that is managed by two research councils: The Australian Research Council (ARC) and The National Health and Medical Research Council (NHMRC). These councils operate various grant programs that each serves specific strategic objectives including supporting promising early career researchers and developing research infrastructure to fostering scientific discoveries and facilitating knowledge exchange with industry. The ARC's Discovery and Linkage schemes, in particular, have become crucial instruments for directing research efforts and stimulating collaboration, with some disciplines such as humanities showing strong reliance on these schemes for research funding (Turner and Brass, 2014).

Understanding the dynamics of collaboration, interdisciplinarity, and industry engagement within these grants is useful for evaluating their broader impact on Australia's research ecosystem. Collaboration across states and territories can reveal geographical patterns of academic networking. The co-occurrence of FoR codes provides insights into the interdisciplinary (could be also considered as multi-disciplinary) nature of funded projects. Furthermore, the connections between industry sectors and academic disciplines highlight the role of Linkage grants in bridging the gap between research and practice.

Therefore, my aim in this study is to examine these interrelated aspects using data from ARC-funded projects for funding years 2023, 2024 and 2025. By analysing inter-state collaborations, interdisciplinary patterns, and industry partnerships, this research seeks to answer the following research questions.

- What are the patterns of inter-state collaboration within Australian Discovery and Linkage projects, and how do they differ?
- What is the extent and nature of interdisciplinarity in Discovery and Linkage projects, and how do these differ?
- What are the primary industry sectors engaged in Linkage projects, and how do these sectors connect to specific Fields of Research?

About Discovery and Linkage projects

ARC Linkage projects are meant to create an alliance between industry and universities mediated by the government. They are specifically aimed at facilitating collaboration between researchers and industry, government, and community organisations, and helping with knowledge exchange between these organisations. They emphasise practical applications of research and aim to address real-world challenges, drive innovation, and create economic, social, and environmental benefits. Therefore, a condition of a Linkage project is that they must have industry partners (industry is broadly defined here) that contribute to the funding of the project. In contrast, Discovery projects focus on fundamental research and encourage the generation of new knowledge and theoretical advancements across a wide range of disciplines. Collaboration, national or international, is encouraged in all ARC projects and might increase the chance of success for grant applications.

Literature review

There have been some studies in the past on ARC-funded grants and projects. While some have focused on analysing grants awarded in specific fields, such as social work (Tilbury et al., 2020), religious studies (Possamai et al., 2021) or accounting (Clarke et al., 2011), in terms of topics investigated or the success rate of getting grants, others have used qualitative methods such as interviews to investigate other aspects such as knowledge co-production (e.g., Cherney, 2015).

A very relevant study to this one is an older study by Maldonado and Brooks (2004) who used an economic model to find out if research-intensive organisations (i.e.,

companies with high R&D and IP assets) are more likely to participate in Linkage projects. They found that high R&D expenditure and revenue increased the likelihood of an organisation's participation, but the role of IP (e.g., patents, designs) was not significantly related to Linkage participation. They also looked at the rate of participation by industry sector and found that sectors where a high social impact is perceived had a greater tendency to collaborate in projects, while sectors with a trading focus had a lower tendency to collaborate. Sectors with high participation rates include libraries, museums, and the arts, community services, water supply, sewerage and drainage services, forestry and logging, oil, and gas extraction, and rail transport. Sectors with low participation include several sectors such as insurance, finance, basic material wholesale, general construction, textiles, clothing, and so on.
A few other studies have found some characteristics of different grant types and their investigators. Discovery grant recipients have significantly higher citation counts than Linkage grant recipients (Brooks and Byrne, 2006) which might be because Discovery grants emphasis academic research and discovery; and a better academic research performance is expected from investigators.
Interdisciplinarity of research has been extensively researched and there are different methods and approaches to defining it and measuring it, for instance based on journals, citations, topics and so on. Depending on these, interdisciplinarity could also be considered multi-disciplinarity or diversity. For instance, in this study I am using FoR codes, similar to Bromham et al. (2016) and if a project has multiple FoR codes, we can argue that it is both interdisciplinary and multidisciplinary. Jamali et al (2020) reviewed different ways of measuring interdisciplinarity or diversification of research. Yegros-Yegros et al. (2015) measured three dimensions of interdisciplinarity including variety, balance and disparity and found that while variety had a positive effect on citation impact, balance and disparity had a negative effect. A key study on interdisciplinarity is the study by Bromham et al. (2016) that looked at FoR codes of 18,476 ARC Discovery grant proposals, both successful and unsuccessful ones submitted over five years and found that interdisciplinary proposals had less chance of success. They used FoR codes assigned by researchers to proposals to calculate an interdisciplinary score for each proposal.
Geographical distance/proximity plays a role in collaboration and over the years there have been many studies in this area (e.g., Frenken, Hardeman, and Hoekman, 2009) that suggest an increase in collaboration (and in a way in the globalisation of research). However, many of such studies concern international collaboration whereas here my focus is collaboration within Australia. A significant study in this area is a large-scale study by Lin, Frey and Wu (2023) that analysed 20 million articles and 4 million grants and found that 'across all fields, periods and team sizes, researchers in remote teams are consistently less likely to make breakthrough discoveries relative to their on-site counterparts' (p. 987). Regarding collaboration with industry, an older study by Ponds et al (2007) analysed article co-authorship data and found that the collaboration between different kinds of organisations is more geographically localised than collaboration between organisations that are similar due to institutional proximity. A more recent study and its review of the literature

indicates that generally geographic proximity is an important factor in university-industry collaboration (Alpaydin and Fitjar, 2021).

Methods

I used publicly available data from the Australian Research Council (ARC) API to analyse patterns in Linkage and Discovery grants. I obtained the data in JSON format, converted them into an SQLite database, and managed it using DB Browser for SQLite.

For Linkage Projects, I classified 'Partner Organisations' according to the Australian and New Zealand Standard Industrial Classification (ANZSIC) 2006 version (Australian Bureau of Statistics, 2006-revision-2.0). I used the D&B Hoovers database (a business database that provides information on companies and industries) to query organisation names and obtain their respective ANZSIC classifications. ANZSIC is a hierarchical classification with four levels. The database provides classification at lower detailed levels (3rd or 4th). For instance, 'BHP Group Limited' has the class '0801 - Iron Ore Mining' which is a fourth level code (called Classes in the classification). As there are many classes, I aggregated the classes into higher levels and used the top level which are divisions. For organisations that were not present in the D&B Hoovers database, I manually classified them based on their documented activities and by comparing them with similar organisations in the same sector.

ARC funded projects use FoR codes based on the Australian and New Zealand Standard Research Classification (ANZSRC) (Australian Bureau of Statistics, 2020). Grants commencing from 2023 onwards have been classified using ANZSRC 2020, while grants from 2007 to 2022 used ANZSRC 2008. Therefore, I focused on grants with funding commencement years from 2023 to 2025. In grant applications, researchers can assign up to three FoR codes at the six-digit subdivision level to their grant, with one designated as the primary code. While the percentage allocation across these codes sums to 100% for each grant, these specific percentages are not publicly available. Hence, in this study, I used FoR codes without their weighting (percentage value). To facilitate more meaningful analysis, I aggregated the six-digit codes to their corresponding two-digit hierarchical levels.

Moreover, to better understand the connections between FoRs and industry sectors, I grouped FoR codes and industry sectors into broader, meaningful categories. FoR codes (see Table 2 for their list) were grouped as follows:

- Arts and Humanities: 36, 43, 47, 50
- Social Sciences: 33, 35, 38, 39, 44, 45, 48, 52
- Life Sciences: 30, 31, 41
- Medical Sciences: 32, 42
- Physical Sciences: 34, 37, 40, 46, 49, 51

I grouped industry divisions (see Table 4 for their list) based on typical economic models, which classify industries by their role in the production and delivery of goods and services. Primary industries, for instance, are involved in resource extraction, second industries are involved in manufacturing and infrastructure and so on.

- Primary Industries: A, B
- Secondary Industries: C, D, E
- Tertiary Industries (Services): F, G, H, I, J, K, L, M, N, O
- Social and Community Services: P, Q, R
- Other: S, NA

To assess the interdisciplinarity of the projects, I employed the Interdisciplinary Distance (IDD) metric based on the methodology developed by Bromham et al. (2016). The IDD quantifies both the disparity and balance of disciplines involved in a project by utilising a hierarchical classification of research fields similar to phylogenetic trees in evolutionary biology. I adapted this approach by applying a simplified correlation matrix. The simplified correlation included these values: Different Domain: 0.1 correlation; Same Domain, different Division: 0.3 correlation; Same Division, different Group: 0.6 correlation; Same Group, different Field: 0.8 correlation; Same Field: 1.0 correlation. This metrics allows to effectively measure and compare the degree of interdisciplinarity across ARC Discovery and Linkage projects. For a comprehensive description of the IDD calculation and its application, please see Bromham et al. (2016), which details the use of phylogenetic species evenness to standardise IDD scores between 0 (single-disciplinary) and 1 (maximum disparity with even representation). Further specifics on IDD can be found in the Supplementary Information of Bromham et al. (2016).

I used Python scripts to transform the grant data into network files suitable for visualisation and analysis. These network files were used to examine various relationships, including interstate collaborations, the co-occurrence of FoR codes across projects, and links between various industry sectors and FoR codes. I used ChatGPT to assist with writing the Python codes; however, I checked the accuracy of the codes and their outputs. For visualisation purposes, I used VOSviewer and SankeyMATIC.

Findings

I analysed the data of 1,435 Discovery and 315 Linkage projects, a total 1,750 grants awarded for funding commencement years 2023 to 2025. It is important to note that while there is only one round of applications for Discovery grants annually, there are two rounds of applications each year for Linkage grants. The number of 2025 Linkage grants is lower (56) because the outcome of the second round was not yet available at the time of data collection (December 2024). Table 1 shows the number of grants by type and year with some of their characteristics.

Table 1. Number of ARC-funded projects per year, and average number of investigator and organisation per project.

Year	*Project type*	*Number of grants*	*Ave number of investigators*	*Ave number of organisations*
2023	Discovery	478	3.47	2.36
2023	Linkage	137	5.61	4.38
2024	Discovery	421	3.39	2.24
2024	Linkage	122	5.83	4.47
2025	Discovery	536	3.40	2.18
2025	Linkage	56	6.25	4.55

When examining the average number of investigators and organisations involved in each project type, it becomes evident that Linkage projects exhibit higher participation in both aspects. This is unsurprising, as Linkage projects necessitate the inclusion of industry partners, who are designated as Partner Organisations within the grant applications. Furthermore, these partnerships often involve investigators from the partner organisations, who are then classified as Partner Investigators within the project.

Distribution of projects by Field of Research

Table 2 shows the distribution of projects by Field of Research divisions (two-digit FoR codes) for Discovery and Linkage projects from 2023 to 2025. Linkage projects for 2024 are also presented separately in a column, as industry analysis was done only on those projects.

Table 2. Number of projects (2023-2025) by Field of Research divisions based on primary FoR codes.

Field of Research Divisions (2-digit FoR)	*Discovery 2023-25*		*Linkage 2023-25*		*Linkage 2024 only*		*All*
	N	%	N	%	N	%	N
30 - Agricultural, Veterinary and Food Sciences	10	0.7	16	5.1	5	4.1	26
31 - Biological Sciences	259	18.0	20	6.3	8	6.6	279
32 - Biomedical and Clinical Sciences	54	3.8	4	1.3	2	1.6	58
33 - Built Environment and Design	18	1.3	7	2.2	2	1.6	25
34 - Chemical Sciences	87	6.1	18	5.7	9	7.4	105
35 - Commerce, Management, Tourism and Services	31	2.2	7	2.2	4	3.3	38
36 - Creative Arts and Writing	6	0.4	3	1.0	1	0.8	9
37 - Earth Sciences	44	3.1	10	3.2	3	2.5	54
38 - Economics	29	2.0	4	1.3	1	0.8	33
39 - Education	23	1.6	7	2.2	4	3.3	30
40 - Engineering	297	20.7	105	33.3	39	32.0	402

41 - Environmental Sciences	34	2.4	21	6.7	14	11.5	55
42 - Health Sciences	10	0.7	7	2.2	0	0	17
43 - History, Heritage and Archaeology	37	2.6	6	1.9	2	1.6	43
44 - Human Society	89	6.2	15	4.8	7	5.7	104
45 - Indigenous Studies	11	0.8	4	1.3	2	1.6	15
46 - Information and Computing Sciences	83	5.8	29	9.2	9	7.4	112
47 - Language, Communication and Culture	42	2.9	11	3.5	1	0.8	53
48 - Law and Legal Studies	20	1.4	3	1.0	2	1.6	23
49 - Mathematical Sciences	76	5.3	1	0.3	0	0	77
50 - Philosophy and Religious Studies	17	1.2	0	0	0	0	17
51 - Physical Sciences	87	6.1	5	1.6	3	2.5	92
52 - Psychology	71	4.9	12	3.8	4	3.3	83
Total	1,435	100	315	100	122	100	1,750

The distribution of grants across different FoRs is uneven. Engineering (FoR 40) and Biological Sciences (FoR 31) received disproportionately larger numbers of Discovery grants. Although Biological Sciences received more Linkage grants than many other fields, their number (N = 20) is far fewer than that of Engineering (N = 105), which received almost three times the number of grants as the second-largest Linkage receiver, FoR 46 (Information and Computer Sciences) (N = 29).

In 2024, there were 122 Linkage projects, with the largest number (N = 39) going to Engineering (FoR 40), followed by Environmental Sciences (N = 14). All FoR divisions received some Discovery grants, including Creative Arts and Writing, which had the smallest number (N = 6). However, this is not the case for Linkage projects, as Philosophy and Religious Studies (FoR 50) received no Linkage grants at all. Mathematical Sciences (FoR 49) had only one Linkage project.

Inter-state collaboration

Australia is a vast country, and its population (about 26 million) and universities (42 universities) are not evenly distributed geographically or across its eight states and territories. The east coast of Australia, which includes the three major states of New South Wales, Victoria, and Queensland, hosts most of its population and universities. By examining interstate collaboration, we can identify how different states and territories are connected and whether there are any notable differences between Linkage and Discovery projects. It should be noted that the names of states for each participating organisation are provided in ARC data only for Australian institutions in Discovery projects. For Linkage projects, such data is not provided for industry partners, even if they are Australian. Therefore, the first two visualisations below only include collaborations between Australian institutions (usually higher education institutions) and exclude industry partners for Linkage projects.

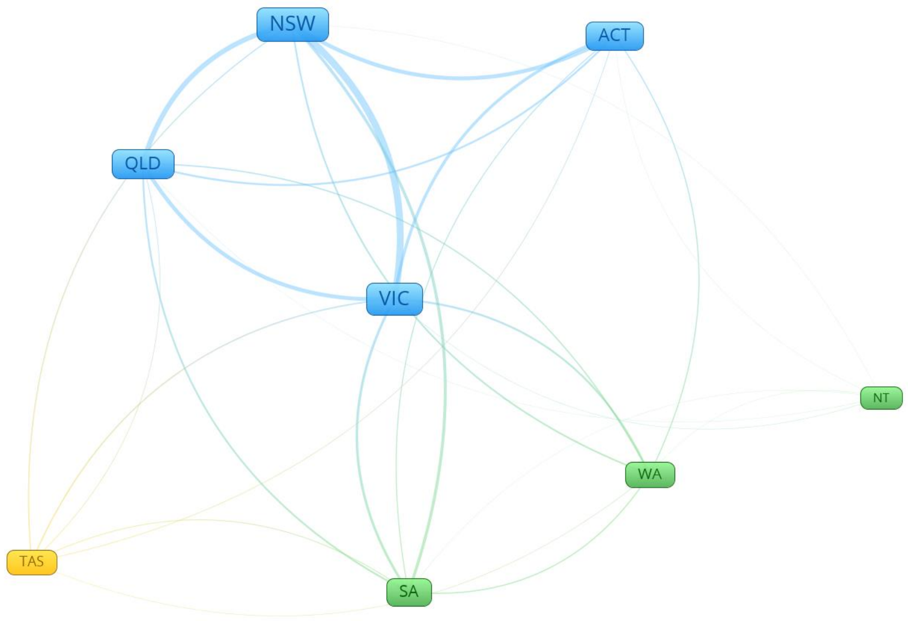

Figure 1. Inter-states collaborations in Discovery projects 2023 to 2025.

The network of interstate collaborations in Discovery projects (2023–2025) reveals three distinct clusters of research partnerships across Australia. The first cluster (Figure 1) comprises the eastern states (New South Wales, Victoria, Queensland) and the Australian Capital Territory (ACT), with NSW showing the strongest total link strength (736), followed by Victoria (644) and Queensland (430). These are major states with large metropolitan areas and several large Australian universities known as the Group of Eight. The second cluster includes Western Australia, South Australia, and the Northern Territory, with lower link strengths (164, 248, and 14, respectively). These states receive fewer grants. Northern Territory and South Australia are neighbouring states of Western Australia and this might influence their higher rate of collaboration. Tasmania forms a third cluster with the lowest connection weight (86). It has weak connections to all other states except for the Northern Territory (no link). Overall, it seems there is a trend of east coast universities mostly collaborating with one another, while universities on the west, north, and south coasts mostly collaborate within their regions.

Figure 2 shows the network of collaborations in Linkage projects (2023–2025). It depicts a more integrated collaboration pattern than Discovery projects, with seven out of eight states and territories forming a single cluster. Again, all states and territories have at least one link with one another, except that there is no link between Tasmania and the Northern Territory (similar to Discovery). New South Wales demonstrates the strongest collaborative intensity, with a total link strength of 370, followed closely by Victoria (328) and Queensland (264). The strongest link is between Victoria and NSW, with 143 connections. NT forms its own cluster due to its limited participation in cross-state collaboration and its smaller number of projects.

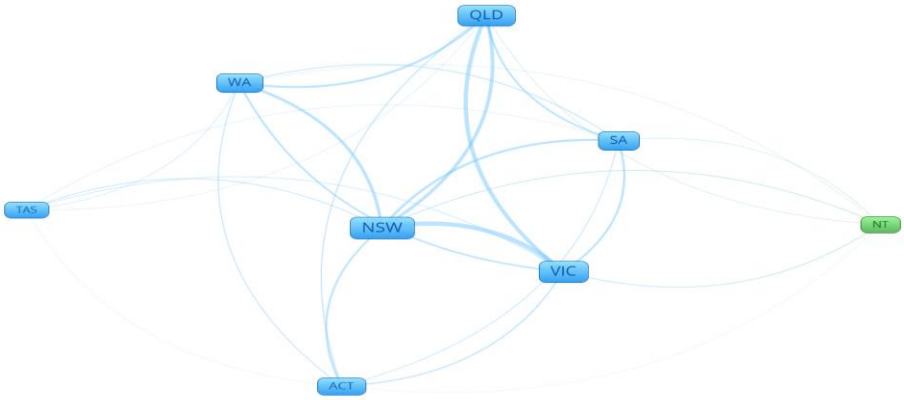

Figure 2. Inter-states collaborations in Linkage projects 2023 to 2025 (excluding industry partners).

For Linkage projects in 2024, state data were obtained from the D&B Hoovers database. Figure 3 shows the interstate collaboration only between Administering Organisations (the institution of the chief investigator) and Partner Organisations (industry partners). Most of partner organisations were concentrated in NSW (32.4%) and Victoria (18.9%). Queensland (13.2%), WA (12.8%) and SA (12.5%) had smaller number of partner organisations. ACT had 5.7% and the other two, i.e., NT and TAS each hosted less than 3% of industry partners. The network reveals two distinct clusters, with varying levels of industry engagement across states and territories. NSW demonstrates the strongest industry partnerships, with a total link strength of 238, and its strongest link is with Victoria (36). All eight states and territories have at least one link, except for Tasmania and the ACT, which have no links. South Australia and the ACT form a separate cluster, with link strengths of 96 and 74, respectively. The Northern Territory and Tasmania, despite being part of the main cluster, show the lowest intensity of interstate links (40 and 34, respectively).

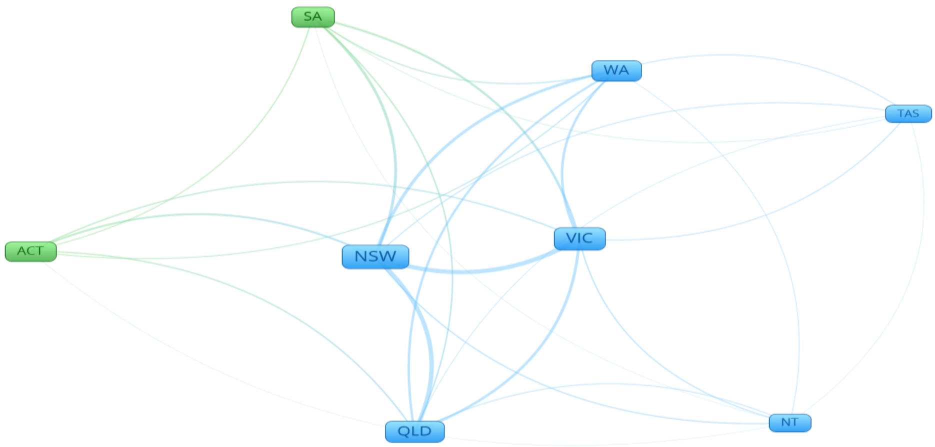

Figure 3. Inter-state collaboration between Administering Organisation and Industry Partners in Linkage 2024.

Interdisciplinarity of projects

The FoR codes (up to three) that investigators can assign to their projects at the time of grant application indicate how interdisciplinary (or multi-disciplinary) their project is and which Fields of Research are involved. Table 3 shows the number and percentage of projects in each project type that had one, two, or three distinct FoR codes at the six-digit, four-digit, and two-digit levels. It is clear that investigators of Linkage projects are slightly more likely to assign multiple FoR codes to their projects compared to Discovery projects. While 18.3% of Discovery projects had only one FoR code (six-digit), and 48.1% had three different FoR codes, in Linkage projects, 15.9% had only one FoR code, and 53.7% had three FoR codes. When aggregating the codes to higher levels of the FoR hierarchy, Linkage projects were still more likely to cover more FoR codes, with 9.8% of them having three distinct two-digit FoR codes, while this number was about half (4.7%) for Discovery projects.

The interdisciplinary distance (IDD) values shown in Figure 4 also confirm the findings above. IDD values are larger for Linkage projects which indicate Linkage projects are consistently more interdisciplinary. A Mann-Whitney U test revealed a statistically significant difference in IDD values between Discovery projects and Linkage projects ($U = 189882.0$, $Z = -4.496$, $p < 0.001$). The 95% confidence intervals for the mean of IDD were lower (0.363, 0.391) for Discovery projects compared to Linkage projects (0.425, 0.491).

Table 3. Number and % of projects with 1, 2 and 3 distinct 6-, 4- and 2-digit FoR codes.

	6-digit FoR			*4-digit FoR*			*2-digit FoR*		
Type	FoR	N	%	FoR	N	%	FoR	N	%
Discovery	1	263	18.3	1	548	38.2	1	977	68.1
	2	482	33.6	2	566	39.4	2	390	27.2
	3	690	48.1	3	321	22.4	3	68	4.7
Linkage	1	50	15.9	1	89	28.3	1	177	56.2
	2	96	30.5	2	125	39.7	2	107	34.0
	3	169	53.7	3	101	32.1	3	31	9.8

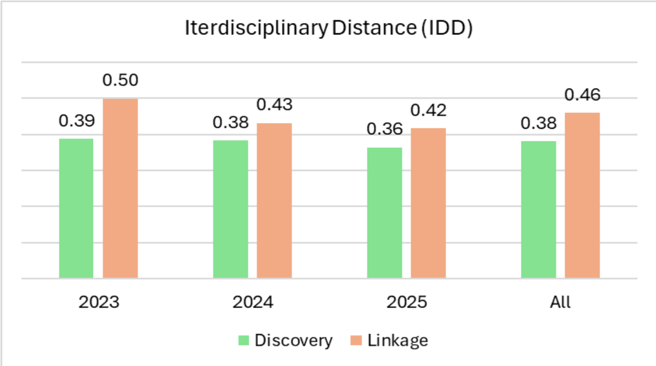

Figure 4. Interdisciplinary Distance (IDD) of Discovery and Linkage projects.

Looking at the network structure, in the case of Discovery projects (Figure 5), four clusters appear, showing clear interdisciplinary patterns. Cluster 1 in blue (on the left), with the largest number of FoR codes (13 of them), comprises mostly fields that can be considered as social sciences (e.g., 33, 35, 38) and arts and humanities (36, 43, 47, and 50), except for 42 (Health Sciences). The second cluster, in green, with five FoR codes, represents all physical sciences. Earth Sciences (FoR 37), however, forms its own cluster in the middle (Cluster 4). Cluster 3, in amber, with four FoR codes, is mostly life sciences (30, 31, and 41). FoR 32 (Biomedical and Clinical Sciences) can be considered part of Medical Sciences (together with Health Sciences 42). However, it is part of Cluster 3, which is dominated by life sciences. Although the clusters align with broad disciplinary groupings, the four clusters are well-connected. For instance, Information and Computer Sciences (46), which is part of physical sciences in Cluster 2, also has strong links with social sciences and humanities in Cluster 1, as well as life sciences in Cluster 3. This may be due to the wide application of computer science across various fields. The top three strongest links between FoRs in this network are between 31 and 32 (i.e., biological sciences, and biomedical and clinical sciences with 59 links), 34 and 40 (i.e., chemical sciences and engineering with 47 links), and 31 and 34 (i.e., biological, and chemical sciences with 36 links).

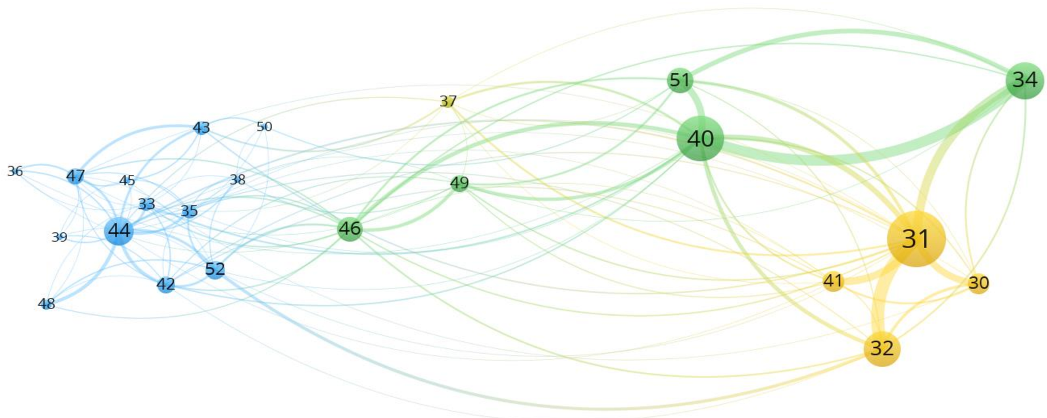

Figure 5. Co-occurrence of 2-digit FoR codes in Discovery projects 2023 to 2025.

The interdisciplinarity network for Linkage projects, illustrated in Figure 6, differs from that of Discovery projects. First, unlike Discovery projects that cover all 23 FoR codes, the Linkage network includes only 22 of them. FoR code 50 – Philosophy and Religious Studies – is absent from the network because no Linkage projects have used this code. Second, the Linkage network consists of five clusters, and these clusters do not follow the broad subject groupings seen in the Discovery network.
Cluster 1, in blue on the left, includes eight FoR codes, three of which are arts and humanities fields (36, 43, 47) that appear close to one another on the far left. The remaining five are social sciences (39, 44, 45, 48, 52). Cluster 2, in green at the top, contains five codes and is a mix of social sciences (33, 38) and physical sciences (40, 46, 51). Cluster 3, in amber, consists of four codes and combines life sciences (30, 31), medical sciences (32), and physical sciences (34). Cluster 4, in sulphur yellow, includes three codes: 35 from social sciences, 42 from medical sciences, and 49 from physical sciences. Finally, Cluster 5, in purple, includes two codes: 37 (earth sciences) from physical sciences and 41 (environmental sciences) from life sciences. Although the clusters are interconnected, the pattern shows that the co-usage of FoR codes in projects involving industry collaboration is different from that in projects focused primarily on scientific discovery. The three strongest links between FoRs in this network are between 31 and 41 (i.e., biological, and environmental sciences with 16 links), 40 and 41 (i.e., engineering and environmental sciences with 14 links), and 34 and 40 (i.e., chemical sciences and engineering with 10 links).

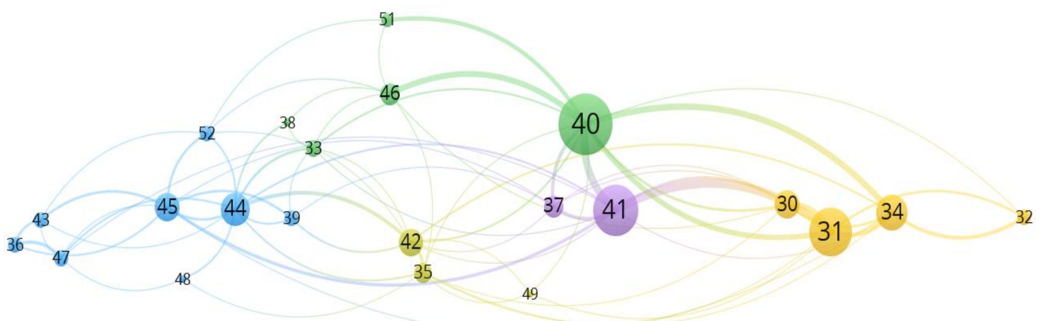

Figure 6. Co-occurrence of 2-digit FoR codes in Linkage projects 2023 to 2025.

Industry sectors

The analysis of partner organisations by industry sector, presented in Table 4, reveals that Public Administration and Safety (67 partners) and Professional, Scientific and Technical Services (62 partners) are the dominant sectors engaging in Linkage projects. Health Care and Social Assistance (37 partners) and Manufacturing (31 partners) also show strong representation. These are the industries that benefit more from Australian higher education as universities seem to focus more on solving the challenges of these sectors. Some sectors, such as Accommodation and Food Services and Rental, Hiring and Real Estate Services, show no participation.

Table 4. Number of Partner Organisation in Linkage projects 2024 from each industry sector.

ANZSIC Industry Divisions	*N*	*%*
A - Agriculture, Forestry and Fishing	5	1.6
B - Mining	11	3.5
C - Manufacturing	31	9.7
D - Electricity, Gas, Water and Waste Services	8	2.5
E - Construction	5	1.6
F - Wholesale Trade	4	1.3
G - Retail Trade	2	0.6
H - Accommodation and Food Services	0	0.0
I - Transport, Postal and Warehousing	1	0.3
J - Information Media and Telecommunications	3	0.9
K - Financial and Insurance Services	6	1.9
L - Rental, Hiring and Real Estate Services	0	0.0
M - Professional, Scientific and Technical Services	62	19.5
N - Administrative and Support Services	4	1.3
O - Public Administration and Safety	67	21.1
P - Education and Training	20	6.3
Q - Health Care and Social Assistance	37	11.6
R - Arts and Recreation Services	10	3.1
S - Other Services	29	9.1
NA - Non-classifiable Establishments	13	4.1
Total	318	100

The Sankey (alluvial) diagram (Figure 7) illustrates the connections between primary 2-digit FoR codes and industry sectors in 2024 Linkage projects. The diagram depicts 105 flows between 38 nodes, with a total of 318 links. The numbers next to FoR codes represent the sum of links or partner organisations associated with each code, while the numbers next to industry codes indicate the number of partner organisations in each industry.

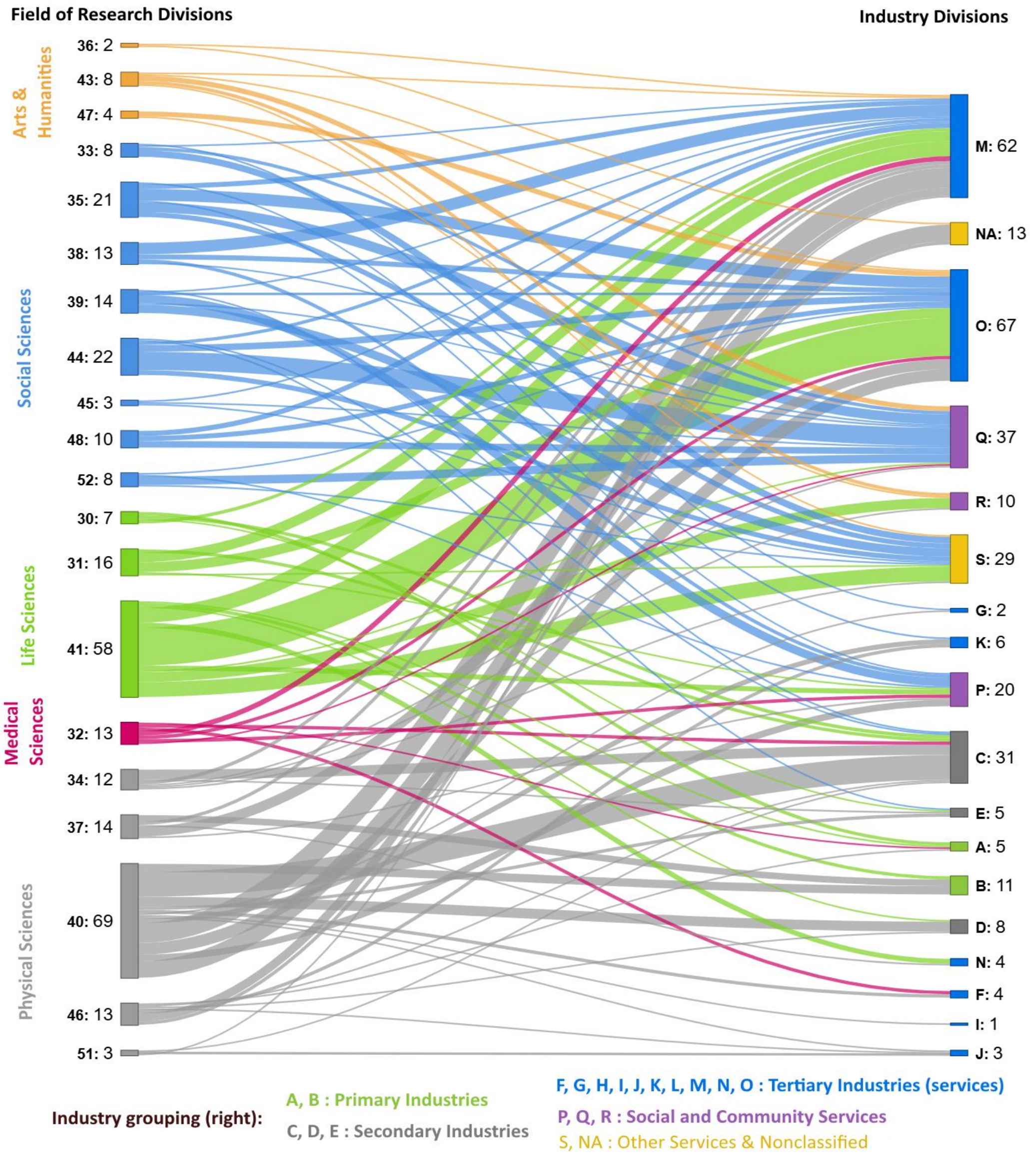

Figure 7. Sankey diagram of links between various primary FoR codes and industry sectors in Linkage projects.

The diagram reveals the patterns of research-industry engagement. Physical sciences, including engineering, demonstrate the broadest range of industry connections, linking with multiple sectors such as Manufacturing, Public Administration and Safety, and Professional Services. Life sciences, including environmental sciences, show strong connections with tertiary industries (services), including public sector organisations.

The Sankey diagram illustrates the connections between Primary FoR and industry sectors in Linkage projects. A key finding is the dominance of specific industries, such as tertiary industries (e.g., services categorised under M and O), which exhibit the highest level of engagement across multiple research fields. For instance, FoR

40 (Physical Sciences) is strongly connected to tertiary industries with 15 links to industry C and 12 links to M. Similarly, life sciences, particularly FoR 41, show substantial connections, prominently linking to industry O (23 links) and tertiary services more broadly.

The diagram also reveals the distribution of less prominent but meaningful connections, which indicate a degree of interdisciplinarity. Fields like arts and humanities (e.g., FoR 36) have limited but focused collaborations, such as their ties to industry M (professional … services). The medical sciences (e.g., FoR 32) display more diverse but smaller-scale collaborations across primary, secondary, and tertiary industries. Additionally, there are some niche yet significant links, such as FoR 40's (Engineering) connection to secondary industries like C (manufacturing) and D (electricity…).

Discussion

The analysis of ARC Discovery and Linkage projects reveal a few patterns in Australia's research funding landscape, particularly regarding collaboration patterns, disciplinary focus, and industry engagement. These patterns have implications for research policy and practice in Australia.

Industry partners are not distributed evenly across the states with NSW hosting by far more than other states, followed by Victoria. This to some extent should be expected as these are larger states in terms of population and there are probably more business and organisations located in them. However, there might be also room for wider inter-state collaboration with industry partners. In terms of industry sector, the largest was Public Administration and Safety (with 21.1%) followed by Professional, Scientific and Technical Services (with 19.5%), and Q - Health Care and Social Assistance (with 11.6%). All other sectors had less than 10% presence. Public Administration and Safety (class O) is mostly government agencies including local government (e.g. councils). The distribution of sectors shows some room for more diversity.

The diversity of participating organisations has increased over time. While in early years of the Linkage scheme, there were a small number of firms that actively involved in Linkage projects (Maldonado and Brooks, 2004), in 2024 there were many different organisations (about 300) involved in linkage projects from different sectors, although some sectors had a bit of dominance. This might indicate a positive change in Linkage projects and possibly increased awareness among potential industry partners about the benefits of academic collaboration. This is something that requires further investigation.

Both Discovery and Linkage grants are considered a type of Category One grant in Australia, that is to say they are the most prestigious and competitive and sought after by researchers. But Linkage applicants might not need to have a strong citation and publication track record as Discovery applicants have (Brooks and Byrne, 2006). This distinction reflects the different objectives of these grant schemes. Linkage projects emphasise practical impact and industry engagement over traditional academic metrics and applicants need to have better links with industry rather than an impressive publication record.

The assignment of FoR codes to projects reveals interesting patterns that may reflect both genuine interdisciplinarity and strategic behaviour. The results indicate that Linkage projects, which involve industry collaboration, exhibit significantly higher IDD values than Discovery projects. This means that industry engagement might foster multi- or inter-disciplinarity. Assigning FoR codes to projects by researchers at the time of grant application submission is not necessarily purely driven by the fields or topics covered in an application. Politics and tactics are involved as FoR codes assigned play a key role in the success of an application because it determines which ARC Panel of Experts will make the decision about a grant's success. There can be a bit of gaming involved in this. Past research on UK Research Assessment Exercise (RAE) showed that researchers engaged in a bit game-playing to influence the outcome of the assessment (Kelly and Burrows, 2012). In Australia, also a study on religious studies showed that researchers submit applications that are about religious studies but do not use the FoR code for that field (2204), instead use different codes that they perceive will increase their chance perhaps (Possamai et al., 2021). This might be more important in Discovery projects than in Linkage projects and it might be one of the reasons why Discovery projects are less likely to have fewer FoR codes.

The analysis reveals distinct patterns in how different disciplines engage with industry and how collaboration occurs across state boundaries. The dominance of engineering and physical sciences in Linkage projects, particularly in their connections with manufacturing and professional services sectors, suggests these fields have developed stronger industry engagement mechanisms or they are perhaps more inherently suitable for industry collaboration. Past research has alluded to the positive impacts of these grants, as Linkage projects have improved industry partners engagement with academics (Cassity and Ang, 2006). However, their long-term impact has not been adequately investigated.

The study has a few limitations. It relies on ARC data that lacks some elements (e.g. percentage value of each FoR code is not publicly available). I only examined the grants from three years and trends and patterns (for instance industry collaboration) might be different in other years. I also aggregated FoR codes and industry classification to higher level for pragmatic reasons as it is very difficult to meaningfully analyse and present hundreds of different detailed codes and classes in a short paper. I also did not consider the size of grants (i.e., the amount of funding) in the analysis.

In terms of implications for policy, the findings suggest a few areas for consideration including geographic concentration in NSW and Victoria that might indicate a need for initiative to broaden. The uneven distribution of grants across disciplines also needs examination. Here, I only analysed successful grants, and we do not know if under-funded areas do not apply or they simply have lower rate of success and there could be unintended biases in the evaluation process. The strong presence of public sector and professional service partners indicates potential opportunities to diversify industry engagement into other sectors.

Although the context of this study was Australian, its findings have broader implications for research funding policies globally. Many countries employ competitive funding schemes that emphasise industry engagement, such as the Horizon Europe program or NSF Industry-University Cooperative Research Centers. The observed patterns in Australia - particularly the higher interdisciplinarity in industry-linked projects - suggest that similar schemes in other nations may also foster broader disciplinary integration. It would be useful to find out if this is the case in the USA and Europe, as it has implications for collaborative and interdisciplinary research.

Conclusion

This analysis of ARC Discovery and Linkage projects from 2023 to 2025 sheds some light on how research funding is distributed across disciplines, the extent of collaboration within and between states, and the level of industry engagement. The analysis reveals distinct patterns of interstate collaboration, with stronger connections among east coast institutions in both Linkage and Discovery projects, however, Linkage projects exhibit a more integrated collaboration pattern overall. A disproportionate number of Discovery grants are awarded to fields such as Engineering and Biological Sciences, while some fields (e.g., Creative Arts and Writing, Philosophy and Religious Studies) receive minimal funding. Linkage projects show a similar pattern but with stronger interdisciplinarity. The findings show that projects with industry linkage are more interdisciplinary, and more disciplines are involved in projects on average. The dominance of certain industry sectors, particularly in public administration and professional services, indicates potential room for diversifying industry engagement. Future research might investigate a few under-explored aspects of these projects including their long-term impact, the benefit of Linkage projects for industry partners, and factors that facilitate or hinder the participation of certain industry sectors to engage in Linkage projects.

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