Avoiding GIGO: Learnings from Data Collection in Innovation Research

Contents

1. Introduction

In the late 1950's, George Fuechsel - an early IBM programmer - was given credit for coining the term GIGO (Garbage In, Garbage Out) as a concise way of reminding users that a computer can only process what it is given (Lidwell et al., 2010, Stenson, 2016). In order to get good data, one must pay attention to the way the data is collected. However, even when intentions are good and researchers do their best to obtain the best data possible, there are still many issues that may derail the collection of quality data.

This paper describes a project that attempted to follow the path to commercialisation of the chemical platform technology known as 'Controlled Radical Polymerisation' (CRP). The project was *meant to* focus on understanding how universities and public research organisations (PRO) collaborated with firms in order to innovate and develop products or services using the same technology. We say *'meant to'* quite deliberately as this project was plagued with a range of data collection issues that we detail here, serving as a guide to researchers about considerations to be made when collecting network data. We aim to give the reader a sense of the complications our research team faced, highlight issues we did not properly consider, and detail the contingencies we put in place in the collection of the data for this project. The project did indeed have some successes, and the data we did collect was very rich indeed – it was just that it was not the data we set out to collect. However, that brings out one of the strong themes of this paper regarding network data collection – be flexible. Throughout this paper we share the lessons we learnt as a team along this journey that we wished we had more carefully considered at the outset of this project. In addition, we also share the questions we asked ourselves along the way, and for which we did not (and

in some cases, still do not) have an answer. Finally, we discuss our mistakes in the hope that we won't make all of them again in the future, and that they may serve to assist others.

2. Innovation and the Importance of Collaboration

In the early 1980's, a team at Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO) – Australia's national scientific research agency – devised a technique that gave the world significant advances in the chemistry of free radical polymerisation (CSIRO, 2018). Polymers are materials composed of large molecules used to make everyday products and they are everywhere, with examples being paint, smartphones, sunscreen and even banknotes (CSIRO, 2018). Let us be technical for a moment and say that during the next decade, the team introduced catalytic chain transfer agents, macromonomers, addition-fragmentation chemistry and pioneered a form of living radical polymerisation mediated by nitroxides (CSIRO, 2019b). This was truly ground-breaking stuff because this new way of making polymers produced a platform technology (or technology process) – that is, a technology that has multiple applications in multiple domains. The patent for this last invention, nitroxide-mediated living radical polymerisation (NMP), has been in the top 10 of the world's most cited patents since 1999 (CAS Science Spotlight). On the back of this work on NMP, a new method for the creation of polymers called 'Controlled Radical Polymerisation' (CRP) was developed. The significant advantage of this CRP technique is the ability to control the structure of polymers in very precise ways. This chemistry process has generated two highly related platform technologies, Atom Transfer Radical Polymerisation (ATRP) developed by Carnegie Mellon University, and Reversible Addition Fragmentation chain Transfer (RAFT) developed by CSIRO (Matyjaszewski and Spanswick, 2005). ATRP and RAFT are process platform technologies that allow the 'leveraging of existing technological

competencies and the application of technological know-how in different business lines' (Jolly and Nasiriyar, 2007). Platform technologies allow for innovative developments in many industries including, but not limited to, new developments in the paint, lubricant, electronics, healthcare such as drug delivery and cosmetics industries. This means that polymers can now be crafted in a huge variety of ways, and this flexibility allows different companies from different industries to create tailored materials specifically appropriate to their needs, with increased performance or new functionality being the desired outcome (CSIRO, 2019b). Notably, RAFT is listed as one of CSIRO's Top 10 inventions, with the invention of WiFi also in this list (CSIRO, 2019a).

2.1 University – Industry Collaboration

Our research project was motivated by the prospect of better understanding university-industry collaboration, an issue which is seen as fundamentally important to innovation in modern world economies. Universities perform a key role in society by providing education and generating knowledge (Perkmann et al., 2013), and as such, government support for public research is a key element of many national innovation strategies (OECD, 2017). However, in addition to teaching and research, universities are increasingly becoming engaged in technology transfer and it is not surprising that there is a strong focus from governments to introduce policies designed to encourage and guide them to play an active role in the commercialisation of academic knowledge (Siegel et al., 2003, Bercovitz and Feldman, 2006, Perkmann et al., 2013). Technology transfer, in an academic context, is the transfer of knowledge[1], in this case technologies, from universities (as suppliers) to firms (as

[1] Given this definition, we will refer to technology transfer as knowledge transfer in subsequent sections.

buyers) and is usually referred to as university-industry collaboration and is vital in fostering innovation (Hemais et al., 2005, Etzkowitz, 2004).

Given innovation is a social process, our interest in this polymerisation process was that it provided a framework for which we could investigate a range of innovation projects involving the development and application of CRP to industry problems. Importantly, collaborations can operate at multiple levels. At the individual level, collaboration has been defined as "the social processes whereby human beings pool their human capital for the objective of producing knowledge" (Bozeman et al., 2013 p3) and provides the "social infrastructure" necessary for successful innovation (Aalbers, 2015). At the organisational level, increased and effective collaboration between the public and the private sectors can increase innovation and research impact (Katz and Martin, 1997). This outcome has led governments to implement policies to develop and foster a stronger level of collaboration between these two sectors. By bringing together individuals from universities and industry (Katz and Martin, 1997), governments hope to increase collaboration, and with these collaborations, an increase in knowledge transfer leading to successful commercialisation.

Clearly, a social network approach to understanding informal collaboration and interactions for the purposes of innovation makes intuitive sense and is a well-studied topic (Aarikka-Stenroos et al., 2014). Innovation involves significant collaboration. The RAFT technology was invented by three key scientists from CSIRO – Ezio Rizzardo, Graeme Moad and San Thang who were named as contenders for the Nobel Prize for Chemistry in 2014 (Smith, 2014) – but also involved a wider group of researchers and support staff to make it happen. To then take this platform technology invention and commercialise products from it would require a range

of other industry collaborators. Even though increased collaboration is the intended outcome of diverse policies that have been introduced around the world, it is widely accepted that collaboration between public research organisations (PRO) and industry can be fraught with potential problems. These are due to the different institutional backgrounds, purposes, reward structures, cultures and norms (López-Martínez et al., 1994, Plewa, 2009, Partha and David, 1994), through which difficulties in developing links between universities and industry abound (OECD, 2014). The key differences include how achievement and reward structures are dealt with and how they can potentially inhibit the development of effective linkages between the research base and industry (ARC, 2001 p22). Conflicting institutional motives between academia and industry often means that firms will want to keep information secret in order to gain the upper hand for any patent protection, and increase potential returns of an invention, while academics are primarily interested in openness. This openness is shaped by a reputation-based scientific reward system (Merton, 1973) and is geared towards the facilitation of publication and dissemination of research results (Sauermann and Stephan, 2013). Academic researchers may worry about their freedom to have their own agenda when it comes to research (D'Este and Perkmann, 2011, Lee, 1996), while industry often wants to own intellectual property (IP) rights. In some cases, these problems are irresolvable (Hall et al., 2001) and negatively impact U-I collaborations (Ankrah and Al-Tabbaa, 2015).

3. Research Project: Collaboration Networks for Innovation Projects involving CRP

This research project sought to understand how universities and private firms worked together on 'innovation projects' involving CRP in their quest to successfully innovate in a competitive global economy. The research aimed to identify the business models applied and the activities undertaken in successful university-industry interactions in order to understand

how these enable universities and PROs to increase their ability to successfully engage with industry, and in line with government aims, to increase collaboration across this university-industry divide. The research design was a multilevel network study investigating the social interactions between individuals within and between organisations (e.g., technical advice-seeking, trust), and ties between organisations (e.g., research contracts, licences). Notably, this longitudinal project aimed to collect data on innovation projects as they unfolded, so that data was real-time rather than being historical (e.g., publication and patent data).

3.1 Original plan for data collection

CSIRO, the key partner in the project, was to provide access to a list of firms collaborating on innovation projects involving the CRP technology. CSIRO recommended a list of potential organisations that would be positively pre-disposed to collaboration in a research study of this kind, and acted as brokers by providing the research team with an introduction to these organisations. From the list, the research team would recruit ten firms. For each firm, the leader of the laboratory would be able to provide the research team with a list of all staff members from the laboratory who are engaged in any project involving the CRP technology.

In addition to the list of their industry collaborators, CSIRO was also asked to provide a list of university research laboratories (henceforth referred to as PRO research laboratories) that were rated (by CSIRO) as leading the world with their CRP research. Once again, CSIRO was to act as a broker and provided introductions to these PRO research laboratories. Our research team would then make contact with the PRO laboratories in order to recruit them into the study. Once a PRO laboratory was on board and agreed to participate in the research, the procedure would be the same as for CSIRO in terms of the procedure for recruiting firms.

The PRO laboratory would broker an introduction to at least ten firms they were collaborating with, and the research team would make contact to solicit participation. The targeted outcome was seven PRO research laboratories (including CSIRO), each recruiting ten firms they were each collaborating with. This made an expected total of 7 PRO laboratories and 70 firms working on innovation projects involving CRP, and between 250-500 individuals involved in these projects given variability in project team size (Figure 1).

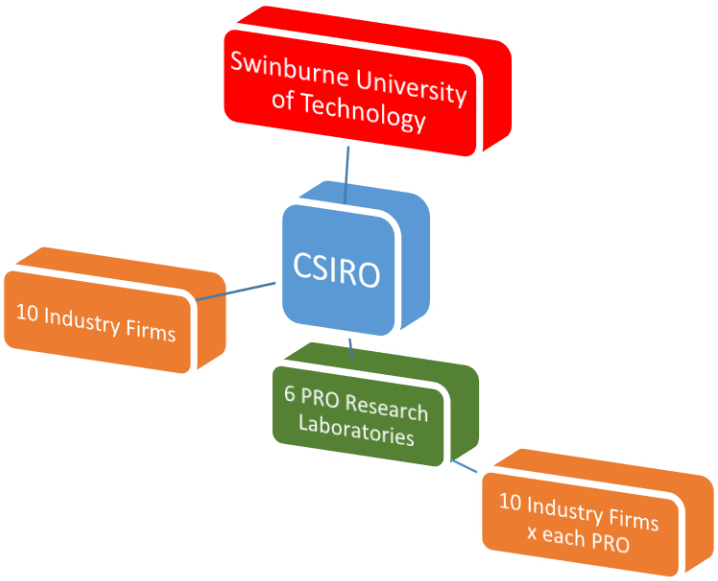

Figure 1: The Original Data Collection Plan

We note that the research team co-designed this data collection procedure with senior people from CSIRO who felt that they had enough buy-in with CSIRO staff and with associated PRO laboratories worldwide that such a procedure would be successful. Further, some of the research team were former CSIRO staff. Of course, it was anticipated that it would not all be plain sailing though, but that with significant effort we could achieve these goals.

The original study was to be longitudinal in nature with the first set of data to be collected via face-to-face individual in-depth survey-interviews with four subsequent rounds of online survey data collection at 6-month intervals using a tool developed by a research team member from the Oxford Internet Institute. While individual interviews are usually quite separate to written surveys, this study combined the two in a semi-structured interview process that was administered as a verbal interview, though at points, the written survey was handed to individuals to complete some sections that had a set of questions requiring their ratings of various statements. Further, the interviewer filled in responses to survey questions that they asked verbally of the interviewee. This type of survey-interview instrument[2] allowed interviewers to probe for details and for participants to elaborate on issues important to them. The survey-interviews also allowed the researchers to ask questions designed to capture data needed for network identification as well as general attitudinal responses to issues, checklists and other 'yes/no' responses to questions. Furthermore, the interviews also included unstructured, open-ended questioning that elicited views and opinions from the participants (Creswell, 2013). This technique falls in line with the Embedded mixed methods chosen for the research (Creswell, 2013), and enabled the quick capture of rich, contextual qualitative data. Survey-interviews were recorded and transcribed to preserve data accuracy.

Survey-interviews were scheduled with the participant at a time and place most convenient for them and the interviewer came prepared with a list of topics or questions (Marshall and Rossman, 2011). This involved the research team travelling to other countries to collect the data, or with international research partners conducting research in their own country, which

[2] We will refer to the survey instruments as survey-interview instrument to emphasize the concept that this is a survey carried out in the context of an in-depth interview

added significant complexity and cost to data collection. Survey-interviews were to take approximately one hour to complete. Participants were given the option of selecting the language they preferred for the interview. Interviews were conducted in four different languages, with English being the most common language. Japanese, French and German were the other three languages used. English, French and German-language interviews were carried out by members of the project team, whilst the Japanese interviews were handled by a Japanese research team member and a Japanese postgraduate student. Chinese research laboratory interviews were conducted in English. All non-English survey-interview instruments (French, German and Japanese) were translated and then verified by members of the (multi-lingual) project team[3]. Finally, a further intention of this survey-interview approach was to build rapport with the study participants to encourage follow-up online survey participation.

3.2 The reality of data collection: What happened?

In this section, we examine the issues we faced, contingencies we put in place, whether these were successful, and our learnings from them. We do so both in terms of context-specific details relating to innovation projects involving CRP across industry-academia. Every context will have its own peculiarities that need to be taken into account. Additionally, we also discuss more general issues of data collection applicable in many contexts. In presenting these, we note that there were many things we did consider but some that we did not. Further, there were problems were we able to redress or at least learn from, but other problems for which we do not have a solution.

[3] French, German and Japanese data collectors and translators were native speakers.

As mentioned, CSIRO was instrumental in providing lists of suitable industry partners and PRO research laboratories. Nominated firms and PRO research laboratories were contacted in order to recruit them for participation in the study. Participation rates for these two groups – industry and PRO – were very different. Further, industry participation also varied with regard to whether a firm was collaborating with CSIRO or not.

CSIRO nominated many more than ten industry partners. For each industry firm nominated, CSIRO maximised the likelihood of participation by getting their management team and key scientists, in this case, the inventors of the RAFT technology to introduce the research team and to confirm the purpose of the research, whilst asking for collaboration. The research team followed up with multiple attempts made via telephone and emails to make contact for a face-to-face meeting to explain about the project and to obtain commitment for participation. Unfortunately, only four firms agreed to participate in the research.

Our next significant group was the firms. However, the next step in the process, which was to recruit their collaborating firms, did not eventuate as planned. Each PRO laboratory was asked to provide a list of ten industry partners involved in research using the CRP technology. Only one research laboratory provided a list of their current collaborators. Of those firms nominated by the PRO laboratory, only two firms agreed to participate, and only did so because the head of the PRO laboratory personally endorsed the research team and solicited help from his counterpart in the firm. Other PRO research laboratories either chose not provide details of their collaborators or approached their collaborators but did not obtain agreement for participation. Of the two private firms that participated, while they provided very good general insights into their innovation project, they were unwilling to specify any

individuals in relation to network name-generator questions. Furthermore, their participation was limited to the discussion of already completed projects, not the 'live' (i.e., current) projects that the research aimed to examine.

Overall, CSIRO and the PRO research laboratories were not successful in their endeavour to recruit collaborating firms to participate in the research. The possibility of data collection failure was acknowledged before the start of the study. However, we did not expect it to go as badly as it did with firms. There were differences in terms of the types of obstacles faced when dealing with firms compared to PRO research laboratories. In addition to these differences, we learnt many things throughout this research which we would like to share, but we also recognise that there were many things for which we did not have an answer. Throughout this section of the paper, for each identified barrier, we will compare firms with PRO research laboratories in terms of our experiences, as we share with you our learnings and pose our questions.

3.2.1 Face-to-face contact

One issue that we were particularly happy with in our efforts in thinking about data collection issues up front, and which was a data collection success, was the idea of the first round data collection being an in-person experience, even though proposed participants were scattered across various countries around the world. Notably, the PRO research laboratories nominated by CSIRO were contacted, and all agreed to participate in the study. Indeed, later we were able to engage 13 PRO laboratories in the end, making them relatively easy participants in this research. The survey-interviews provided us with a consistent set of responses that you would get from a survey, but a level of detail and extra information that you only get from

interviews. The result was a very rich data set, though a somewhat different data set than anticipated.

We note that for one of the PRO laboratories we could not establish email or phone contact with the head of the lab. They were based abroad, and the research team managed to arrive in person at the lab given a visit to a neighbouring country. Turning up in person led the head of the lab not only to provide a 2-hour interview, but also walk our team down to the postdocs and PhDs, and encourage them to talk to me, saying we were 'good guys' and please help us out. After this, we managed to interview approximately 20 people in the lab – 100% of the staff.

3.2.2 Before starting

As we anticipated resistance for recruitment, several activities were put in place prior to the recruitment process starting. These included the creation of a detailed project description on the University's website of the Research Team – to show the bone fides of the research. Further, it included attendance and presentations made at a number of international polymer conferences and tradeshows. Specifically, the research team attended two and presented at one international conferences (a total of three conferences) for polymer chemistry with CSIRO staff to make contact with both laboratories leaders and firms to encourage participation. Further to this, other members of the team also attended the largest annual conference for paints manufacturers (one of the most promising industry in terms of potential innovation using the CRP platform) in order to try to canvas participation.

Learning Start building ties <u>before</u> the project is due to start

Attend conferences relevant to the industry you are targeting before you start the research, get introduced to decision makers, present your work to a wide audience to establish your credentials and the bona fide of your research (especially if you are trying to reach out to an industry you have had no connection with).

This is easier said than done though when your potential participants are located in seven different countries around the world. Travel requires funding so in all likelihood this can only start when the project starts. However, start as soon as you can.

Learning Find out what makes your target participant tick and give them what they want!

While engaging with potential participants, it is a good opportunity to do some research in order to find out what it is that they are interested in, what information would be useful for their organisation; information that would help them to do their job. These are potential trigger points to maximise participation. This will help you "sell your wares" in a more targeted manner.

Learning Build trust with your participants

If you are doing research at a school, or a single organisation, you can spend time there, get to know people, talk informally about your research. The sheer scale of this project meant that we were aiming for 70+ organisations to participate from around the world. Getting to all organisations was never going to be feasible, and getting a foot in the door to industry was even more of an issue, particularly because we were not even sure up front which organisations were engaged in innovation projects using CRP.

When we physically went overseas to specific PRO laboratories and spent time there, we built rapport and trust and collected great quality data. But in the absence of such engagement, it was all too easy to ignore our research team. Further, going overseas and getting access into firms was incredibly difficult.

3.2.3 Secrecy

Much has been written about the potential problems that may impact on collaboration between university and industry. However, the extant literature does not address in any level of detail what impact secrecy has on the collection of the data before there can be an outcome to analyse and discuss. As part of an academic team of researchers who want to create 'leaky' knowledge in order to have their ideas acknowledged by their peers (Brown et al., 2000), our motivations were in sharp contrast to industry participants who we sought to

engage in this research. As we operate under the same institutional framework (Boschma, 2005) as the laboratories we were engaging, in other words, under the same "sets of common habits, routines, established practices, rules, or laws that regulate the relations and interactions between individuals and groups" (Edquist and Johnson, 1997p. 46) , we spoke the same language and shared the same values. Homophily (McPherson et al., 2001) played out in our favour when reaching out to PRO research laboratories embedded within universities and public research organisations. We had a 100% success rate. In contrast, the original target of seventy firms was not reached. As mentioned earlier, six firms agreed to participate in the research. The primary motivations of firms' knowledge creation activities are for private gain, and openness to external actors (or lack thereof) is used as a strategic mechanism to gain advantage over competitors (Chesbrough, 2006), which means that by definition, knowledge is in need of protection from the world at large, especially competitors. This situation introduces an environment where secrecy is the norm. As an example, one organisation we spoke with were extremely excited about the project, with one senior manager telling the research team that this sort of project is exactly what his role is all about – making sure people collaborate well to achieve the best outcomes for the organisation. However, he could not speak to us about anything he was doing 'at this time' (or probably any time). This is not a surprising situation. Firms actively restrict information flows both within and outside their boundaries with the objective of limiting unintended information spillovers (James et al., 2013). Many firms counter this possibility by keeping their R&D activities secret (Sofka et al., 2018). In fact, extant literature indicates that secrecy has increased over the years. Research in 1966 by Hagstrom (1974) indicated that 50% of 1,042 respondents reported feeling safe in talking with all others about their current research, but by 1998, when Walsh and Hong (2003) surveyed 202 scientists from the same three fields,

this number had decreased to 26%. What are the key take home messages for the research team?

Learning Organisational differences lead to different needs

Even though all effort was made to tell people that the research team was not interested in the specifics of their research, firms were still very reluctant to discuss it and even if they did, they more often than not, would have to get permission from a superior. The strategies we came up with to mitigate the impact of secrecy did not ameliorate the situation. These included explaining about the Ethics of the university and of CSIRO and how these would preclude us from discussing any aspect of the research…

Question What else could have been done to improve the situation?

The question to ask here is "did the research team, or indeed the broker from the research laboratory make it clear enough that the innovation and the products that were being researched were of no interest to the researchers? Could we have clarified this more so that the impact of secrecy could be moderated?"

3.2.4 The 'local champion'

The research team advocated for CSIRO to appoint one champion within their organisation senior enough to drive the project. This was achieved, and we had in fact two champions, one more senior, with decision-making capability, and one who got things done for us at a practical level. However, changes within the organisation meant than the project lost its appointed champion; a champion who was not replaced. This halted the recruitment process for a period of time, and the research team had to rethink its recruitment strategy.

Learning A local champion is vital

Having a local champion who is senior enough to be able to influence industry partners by making personal contact with the appropriate people in these organisations. This does not always assure success but it will maximise your chances.

Buy in at the top, and at the bottom are both needed. Someone in authority needs to give approval, but that someone is usually too busy to do the work. You need someone on the ground to do the work.

Question What do you do when you lose your champion?

An issue which can arise though when a local champion leaves, and organisational priorities change.

3.2.5 The failure of cold calling

Given recruitment difficulties, the research team also tried independently to make contact with organisations that had been classified by CSIRO as using the CRP technology in innovation projects. These organisations had been identified as using the CRP technology to innovate but were not on the list of companies that CSIRO brokered an introduction. The thought behind this set of activities was to try and maximise the level of participation. As we did not have a point of entry into these organisations, and therefore no name to address correspondence to, we resorted to a number of strategies. We Googled organisations and searched their organisational structures, we used lists publicly available online of people who were employed at organisations that had been mentioned and tracked them via LinkedIn. We sent emails containing information about the project to those we managed to get details for, but, not unexpectedly, we did not get any response.

When we embarked on this task, one of the things we underestimated was the fact that in an organisation, particularly a large multinational one, there are multiple areas/departments within an organisation could be using CRP but did not talk to each other. As an outside group, unless there is a specific name and department, knowing that an organisation is involved in CRP research does not help to track down a specific department or project, let alone a specific individual. However, in some cases we were able to track down some individuals in the right area, and in this case, a letter from a senior staff member of the university who is a well-respected polymer chemist, along with a description of the research was dispatched to said people. This did help. However, instead of silence, we simply got a 'no thank you'.

In another case, the research team contacted a firm who we later found out had asked their PRO research laboratory not to be named to anyone. Unfortunately the PRO had provided us with an old contact list on which the organization remained listed. The research team received stern warnings from the organisation, and the PRO was similarly castigated as they came across as breaching their collaborator's trust. The PRO was not happy about this, even though it was not the research team's fault.

Learning **Have a contingency plan in place if you are expecting some difficulties to develop**

The literature on secrecy did suggest that firms were very secretive, but as a research team, we did not anticipate that the recruitment of potential participants would prove to be this difficult. After all, we had introductions from CSIRO and other PROs, and we were not interested in the outcomes of the research. And yet, the wall was up and would not be breached.

Question **If you can see early enough in the study that your recruitment design is not working, when should you make a decision to stop or change tactics?**

A lot of time was taken up trying to recruit firms with little success. Once the decision was made to concentrate on PRO research laboratories only, the data collection was undertaken quite quickly and without problems. When should the decision have been made?

3.2.6 Ethics requirements

Once an organisation agreed to participate in the study, the process was identical for all. Each leader was sent information about the project, the research methodology, and details on the ethics, confidentiality and rights of participants prior to the interview. This was a Swinburne University Human Research Ethics Committee requirement. This information was written by the research team in plain language. The documents were also used by CSIRO to explain the project to potential participants. Two consent forms were required to be signed by leaders prior to their interview with a research team member. One form was required for the leader

as an individual participating in the research project and the other was required as a person authorised to speak on behalf of their organisation. Two issues emerged from the need to have these forms signed. Firstly, feedback and behaviour of the participants during the interviews indicated that these were rarely read. Most stated that they had not read the information that they had received, and would appreciate a quick overview of what the research was about. Secondly, feedback from participants who did take the time to peruse the kit also indicated it was overwhelming. The amount of information provided and, most importantly the fact that participants had to sign on behalf of their organisations was something that became a barrier. For some, this was beyond their jurisdiction and this meant that either their line manager or lawyers needed to be involved. This feedback from both firms and PRO research laboratories enabled the research team to go back to the University Ethics committee for an amendment and the requirement for a form to be signed on behalf of their organisation was overturned.

Learning **Push back against ethics requirements if they are not working**

It is possible to push back on ethics requirements. While the intent of that consent form was to protect people, it ended up making them feel more vulnerable, and it was a major hurdle to firm participation in the study.

Learning **Do not make the task of participation too onerous**

Ethics required participants to sign a personal consent form and for those representing their organisation, a second form on behalf of their organisation as well. For some of those in industry, this second form caused some concern and quickly became something that needed to be taken further, either to internal lawyers or up the management chain.

In short, our ethics form rang alarm bells regarding responsibility that individuals were not keen to take on, and so it was easier to say 'no'.

Question **Is there a better way to handle University Ethics requirements when dealing with firms?**

3.2.7 Operational Matters

A large scale, multinational and multisite project requires much more planning and operationalising than anyone ever anticipates. Good project management may not have alleviated organisational secrecy and the associated refusals, but it would have made the introduction phase of the study a more structured and streamlined process with procedures in place for allocation of tasks and responsibilities well.

However, although at the start of the process, procedures were put in place to commence recruitment of potential firms, an event which was out of the research team's control occurred to the detriment of the project. A few months into the study, the key research partner, CSIRO, underwent a major re-structure and was in a state of constant flux for quite a period of time, with multiple changes of staff occurring during the set-up and data collection period. The changes in staff directly affected the project as it meant that there was no 'local champion' to push the project through. Many of those who originally were involved in the organisation of the project and were to introduce and solicit help were moved on and replaced by new staff who were not au fait with the project and were just not interested or invested. This was extremely important as the partner was going to act as a broker and provide the research team with access to other public research organisations as well as private firms. Additionally, support staff within the research team who were working on project planning and organisation moved to another project and were not able to be directly replaced. This meant there was no project manager for the project.

Research team meetings were inclusive by nature, which meant that everyone who was involved with the project was invited, and although many things were discussed, specific

operational tasks were often not discussed due to time constraints. These small operational tasks did not need to be discussed during these meetings, but they did indeed need to be addressed and dialogue about the specifics of these tasks needed to be entered into. Smaller teams at the operational levels were needed to map out the time lines, the requirements and the responsibilities with specific tasks to be achieved by the next meeting. Such a team was necessary to take charge of the recruitment process which was recognised as being a key aspect of the whole research. This team could report their progress to the management team without waiting for each meeting. In hindsight, having separate meetings for the intellectual side and the administrative side of the project was required. But instead, the two were put together, with the latter not given as much attention as it required. Loss of staff within the research team and at CSIRO compounded these issues.

Learning **Have regular meetings and follow up on any decisions or tasks that have to be finalised**

Regular administrative meetings to assess the progress while still in the planning stage are vital to keep abreast of the status of the project. Meetings need to be attended by your client/research partner also in order to obtain their buy-in and keep the project on track.

These meetings need to be followed by action so that everything is in place before the research starts, and progress needs to be communicated to the management team and ultimately at the planning meeting.

Learning **Ensure that there are clear, defined roles and structure for all involved in the project as well as clear distinction for responsibility**

Include a plan B in the event of changes in the current situation.

This will make sure that all involved know what their role and responsibility are, and in the event of changes in personnel, there are clear instructions as to the tasks that need to be done and getting up to speed is not reliant on only a verbal debrief. For example, an internal staff member dedicated to this project and specifically to the role of data collection, left the project and took a long time to be replaced, meaning there was a long period of inactivity as the research team was not able to move forward with the data collection.

Learning Accountability

Managing the recruitment needed to be managed collaboratively. We needed to have a specific research team member accountable for this part of the study working closely with a CSIRO staff member to engage with potential firms who are CSIRO's collaborators. This team needed to work closely together and report back to the management team of the project on a regular basis and not wait for the management meetings which were held regularly but quite far apart in terms of time frame. This would mean that problems could be picked up early and dealt with promptly.

This would also allow the research team to be on top of how the recruitment process is going and may help with a question posed earlier, 'when should you pull the pin when you can see that it is not working out the way you planned?'

3.2.8 Relevance and Investment

This research was an Australian government-funded project, to which CSIRO also contributed cash and in-kind support. No other funding was received from any of the participating PRO research laboratories or firms, and this may be one of the reasons for the lack of firm participation. It is important to understand who stands to gain from the research. In this instance, CSIRO put time, effort and money into the project. They had a clear objective of understanding the social processes of collaboration that are effective in facilitating industry engagement and commercialisation of products/services using their process platform technology – RAFT. In contrast, firms had no financial stake in the research, and most likely questioned its value as not being of practical importance to them. In addition, the research team believes that we were not able to sell the 'what's in it for me' benefits of the outcomes of the research to potential firm participants. Lack of investment and lack of relevance combined led to lack of interest.

As noted, other PRO laboratories were very supportive of the project, and were willing participants. It seem the PRO laboratories realised there was something to be gained by being involved in the research. While they did not invest money, perhaps because of their

understanding and valuing of university research, perhaps because they realised the importance of collaborating with industry, these PRO laboratories participated. Boschma's idea of institutional proximity resonates here (Boschma, 2005). Firms, on the other hand, could not see the benefits or value for their organisation. In addition, this project was very much an Australian project even though partner investigators were internationally diverse, and this factor may have reinforced this sentiment. This has been mooted by the research team as four of the six firms who participated in the research were Australian organisations. In addition, it should be noted that many of the firms did not know Swinburne by reputation; and in this case, coming from a lesser known university may have been a hindrance.

Learning **Ensure relevance and interest to potential participants by offering something that they would find of value to their organisation**

The research team has speculated that a more concerted effort into providing information about the expected outcome of the study that would be perceived to be of value to firms might have triggered more attention and perhaps piqued their attention enough to be convinced to participate.

Question **What sort of information could we have provided to increase participation rates?**

Would anything the research team could provide have helped?

Would an example of what could be done with the data, using the pilot study, be a useful tool to take into meetings with potential firms to show what outcomes they could expect, and how these would benefit their organisation? Social network analysis is a new technique for research scientists in this industry – did we let ourselves down by not explaining it well enough?

Question **Was coming from a lesser known university a barrier to successful recruitment of firms?**

3.2.9 Understanding referral pathways: 2-path vs 3-path closure

Finally, our understanding of social networks and 2-paths and 3-paths provides a final lesson for us. All PRO research laboratories that the research team reached out to agreed to

participate in the research. In addition to the institutional proximity factor discussed earlier, there was a strong connection between the laboratories as all PRO research laboratories contacted were involved in using CRP technology to innovate. As such, CSIRO had very good relationships with PRO research laboratories. These ties between laboratories contributed to the success in the recruitment process, and in the successful closure of the 2-paths connections in this case (Figure 2).

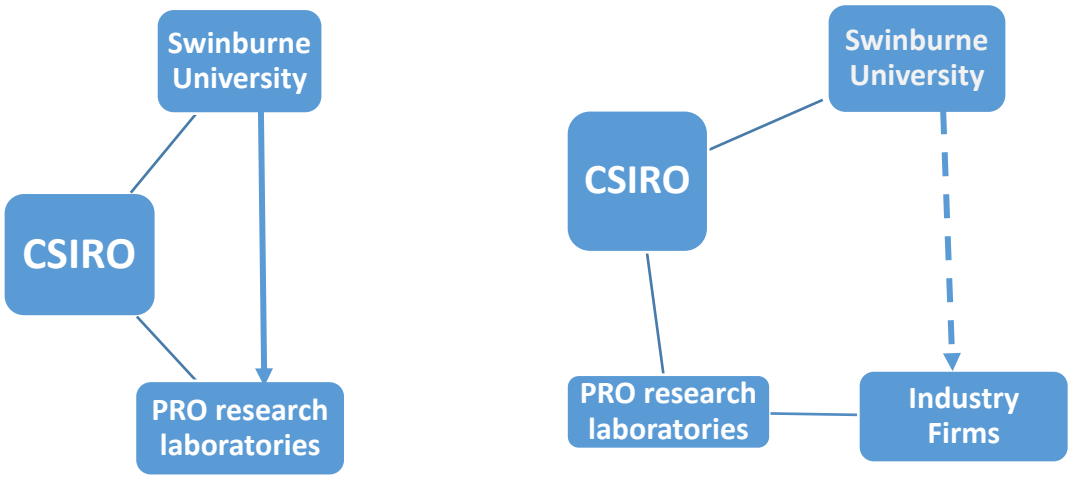

Figure 2*:* 2-path and 3-path closure with PRO research laboratories

University-Industry collaboration has been shown to be fraught with barriers and difficulties. These collaborations are rarely strong ties, and we were most successful in closing a 2-path connection especially if the tie between the two nodes involved was a strong tie. For example, four of the firms that agreed to participate in the research had a strong relationship with CSIRO and in addition, the leaders of the research group had a previous relationship with a member of the research team. However, without these strong ties, as proposed by Granovetter's weak tie hypothesis (1973), closing the two path was not possible. Given these

difficulties with 2-paths, the process of trying to close a three-path (Figure 2) was even more difficult to achieve.

Learning Consider how many paths you need to recruit participants

The shorter the distance between the research team and the potential participant, the higher the likelihood of participation. However, if the bond between the research participant and the research team is through a third party, the likelihood of recruitment significantly diminishes.

3.2.10 Having a Plan B

Once the realisation that the research team would not be able to collect the data as planned, the research team needed to re-group and assess how best to move forward given the situation. We needed to be flexible and "agile" in order to ensure a good outcome given the difficulties that presented themselves during the course of the data collection process. The decision was made to concentrate on the PRO research laboratories and to gain a deeper understanding of how collaboration and knowledge transfer occurred within and between laboratories. This decision was made for two key reasons: 1) all PRO research laboratories were situated in universities and public research organisations and all agreed to participate in the study, and 2) the multilevel aspect of the research, one of the key intended outcomes, would be retained as the research would look at relationships within and between PRO research laboratories.

Learning Be Flexible and agile

This message is perhaps the most important one that our research team could share with others about to embark on any large scale research project. Be prepared as much as possible by planning for all possible contingencies, but allow yourself to be flexible and adapt to the difficulties that may present themselves and to make the most of what is achievable at the time.

The final sample included thirteen PRO research laboratories and six firms based in Australia, the United Kingdom, the United States, France, Germany, Japan and China, with a total of 196 individuals participating in the study. Of these 196 participants, 170 were public research organisation employees and only 26 participants from firms. This low number of participants from industry meant that the original research question could not be addressed, so the decision was made to exclude firms from the main analysis. Although not what we set out to capture, the information we collected is a significant dataset in its own right. The research question has changed, but the analysis technique did not. The data collected has yielded invaluable information about collaboration and trust between and within PRO research laboratories involved in the commercialisation of the same polymerisation process. We had collected quality data, but data with a slightly different focus.

4. Discussion

The process of data collection is one which researchers are familiar with. Researchers are also very much aware of the potential difficulties that they face in the course of obtaining data to inform their research. Our experience studying innovation with collaborators from industry has been particularly fraught with problems, especially in the area of eliciting participation from firms. This area was a wasteland of non-response from potential participants. This level of non-response was so high that that project direction and research questions needed to be changed on the run during the course of the project. On the other hand, our involvement with PRO research laboratories was extremely positive. The concept of institutional proximity seems appropriate here, and more than the original plan of recruiting seven laboratories (including CSIRO) we actually recruited thirteen laboratories for our research.

A large scale, longitudinal, multisite, multi country project potentially involving up to 80 organisations requires much planning. We might say that in such complex research scenarios, a lead researcher who has himself/herself as a project manager has a fool for a client. Along with putting in place operational measures to maximise the likelihood of successfully completing a project on such a large scale, potential problems need to be anticipated. Our research project has shown that anticipating potential difficulties that may come up during the course of the project enables the research team to be prepared. We were not completely successful in achieving this level of preparedness and have shared with you some of our key take-outs during the course of this research. Our key message to colleagues who are about to embark in such a project is to "*be flexible, be prepared and be agile*". We also shared with you a number of questions we have asked ourselves throughout the course of our data collection, questions we don't yet have answers to.

There are many barriers that impact collaboration between the public and the private sectors. These barriers exist largely due to different institutional motives between academia and industry and give rise to a number of differences in the way each party perceives the outcomes from the innovation process should be handled. From an academic's point of view, openness and dissemination of research results are the outcomes of choice whilst firms are more interested in keeping information secret in order to retain or gain any advantage over their competitors to increase potential returns from these results. Given these known barriers, perhaps it was no surprise in many ways that we could not recruit participants from industry. We were in a sense a victim of the very thing we wished to research – the university-industry divide.

There is a clear opportunity to understand how to conduct research in the innovation space effectively, with particular attention paid to understanding why participants from firms find it difficult to participate in research. What, specifically are the issues that researchers need to address to enable potential participants to move beyond their concern that secrecy and confidentiality regarding their research will not be honoured? In other words, how do we convince them that we are not interested in their research, but we are interested in the networks and relationships they form in the course of their collaboration journey?

To this end, our research team's upcoming work with a global aerospace company on an Australian Research Council grant has proven that it is possible to engage with industry. We can do network research on innovation within large multinational organisations with their blessing. But this relationship has been built slowly over a number of years into a trusted collaboration. It is with an Australian-based local subsidiary of a global aerospace company, so it is geographically proximate to the research team. Importantly, we have senior management buy-in due to a strong relationship of trust built over time. When the rubber hits the road for the project, the firm has also committed an 'on the ground' person who is invested in making the project work, and who assists with the day-to-day running of the research. Finally, this firm has contributed significant funding to the project, demonstrating they see value in the project and they wish to see some return on their investment. Of course, other problems may arise, and already have. The recent General Data Protection Regulation (GDPR) laws make collecting network data in Europe somewhat problematic at present. But we have learned some lessons from our study of CRP polymer technology which is helping us

in our current work, and which does show that industry can indeed be very interested in social network research.

Acknowledgements

We acknowledge that this publication and its underpinning research were supported by an Australian Research Council Future Fellowship Grant to Dr Dean Lusher (FT130101201).

References

Aalbers, R. a. 2015. *Innovation Networks : Managing the networked organization*, London : Taylor & Francis Group.

Aarikka-Stenroos, L., Sandberg, B. & Lehtimäki, T. 2014. Networks for the commercialization of innovations: A review of how divergent network actors contribute. *Industrial Marketing Management,* 43**,** 365-381.

Ankrah, S. & Al-Tabbaa, O. 2015. Universities–industry collaboration: A systematic review. *Scandinavian Journal of Management,* 31**,** 387-408.

ARC 2001. Mapping the nature and extent of business-university interaction in australia. Canberra: Australian Government Publishing.

Bercovitz, J. & Feldman, M. 2006. Entpreprenerial Universities and Technology Transfer: A Conceptual Framework for Understanding Knowledge-Based Economic Development. *Journal of Technology Transfer,* 31**,** 175-188.

Boschma, R. 2005. Proximity and Innovation: A Critical Assessment. *Regional Studies,* 39**,** 61-74.

Bozeman, B., Fay, D. & Slade, C. P. 2013. Research collaboration in universities and academic entrepreneurship: the-state-of-the-art. *The Journal of Technology Transfer,* 38**,** 1-67.

Brown, K., Ryan, N. & Parker, R. 2000. New modes of service delivery in the public sector–Commercialising government services. *International Journal of Public Sector Management,* 13**,** 206-221.

Chesbrough, H. W. 2006. *Open business models : how to thrive in the new innovation landscape,* Boston, Mass., Boston, Mass. : Harvard Business School Press.

Creswell, J. W. 2013. *Research design : qualitative, quantitative, and mixed method approaches,* Thousand Oaks Calif., SAGE.

CSIRO. 2018. *RAFT: Making better polymers* [Online]. CSIRO. Available: https://www.csiro.au/en/Research/MF/Areas/Chemicals-and-fibres/Chemistry-and-biotechnology/RAFT [Accessed 5 November 2018].

CSIRO. 2019a. *Our top 10 inventions* [Online]. CSIRO Publishing. Available: https://www.csiro.au/en/About/History-achievements/Top-10-inventions [Accessed 10 July 2019 2019].

CSIRO. 2019b. *RAFT (Reversible Addition-Fragmentation chain Transfer) polymerisation* [Online]. Melbourne: CSIRO Publishing. Available: https://csiropedia.csiro.au/raft-polymerisation/ [Accessed 24 June 2019].

D'Este, P. & Perkmann, M. 2011. Why do academics engage with industry? The entrepreneurial university and individual motivations. *The Journal of Technology Transfer,* 36**,** 316-339.

Edquist, C. & Johnson, B. 1997. Institutions and organizations in systems of innovation. *In:* EDQUIST, C. & MCKELVEY, M. (eds.) *Systems of Innovation: Growth, Competitiveness and Employmen.* Edward Elgar.

Etzkowitz, H. 2004. The evolution of the entrepreneurial university. *International Journal of Technology and Globalisation,* 1**,** 64-77.

Granovetter, M. S. 1973. The Strength of Weak Ties. *American Journal of Sociology,* 78**,** 1360-1380.

Hagstrom, W. O. 1974. Competition in science. *American sociological review***,** 1-18.

Hall, B., Link, A. & Scott, J. 2001. Barriers Inhibiting Industry from Partnering with Universities: Evidence from the Advanced Technology Program. *The Journal of Technology Transfer,* 26**,** 87-98.

Hemais, C. A., Barros, H. M. & Rosa, E. O. R. 2005. Technology Competitiveness in Emerging Markets: The Case of the Brazilian Polymer Industry. *The Journal of Technology Transfer,* 30**,** 303-314.

James, S. D., Leiblein, M. J. & Lu, S. 2013. How firms capture value from their innovations. *Journal of management,* 39**,** 1123-1155.

Jolly, D. & Nasiriyar, M. Technology platform exploitation: definition and research boundaries. 16th International Conference on Management of Technology, Miami Beach, FL, 2007.

Katz, J. S. & Martin, B. R. 1997. What is research collaboration? *Research Policy,* 26**,** 1-18.

Lee, Y. S. 1996. 'Technology transfer' and the research university: a search for the boundaries of university-industry collaboration. *Research Policy,* 25**,** 843-863.

Lidwell, W., Holden, K. & Butler, J. 2010. *Universal principles of design, revised and updated: 125 ways to enhance usability, influence perception, increase appeal, make better design decisions, and teach through design*, Rockport Pub.

López-Martínez, R. E., Medellín, E., Scanlon, A. P. & Solleiro, J. L. 1994. Motivations and obstacles to university industry cooperation (UIC): a Mexican case. *R&D Management,* 24**,** 017-030.

Marshall, C. & Rossman, G. B. 2011. *Designing qualitative research,* Los Angeles, Calif., Los Angeles, Calif. : SAGE.

Matyjaszewski, K. & Spanswick, J. 2005. Controlled/living radical polymerization. *Materials Today,* 8**,** 26-33.

McPherson, M., Smith-Lovin, L. & Cook, J. M. 2001. Birds of a feather: Homophily in social networks. *Annual Review of Sociology,* 27**,** 415.

Merton, R. K. 1973. *The Sociology of Science : Theoretical and Empirical Investigations,* Chic., Chic. : U. Of Chicago.

OECD 2017. *OECD Science, Technology and Industry Scoreboard 2017*, OECD Publishing.

Partha, D. & David, P. A. 1994. Toward a new economics of science. *Research Policy,* 23**,** 487-521.

Perkmann, M., Tartari, V., McKelvey, M., Autio, E., Broström, A., D'Este, P., Fini, R., Geuna, A., Grimaldi, R., Hughes, A., Krabel, S., Kitson, M., Llerena, P., Lissoni, F., Salter, A. & Sobrero, M. 2013. Academic engagement and commercialisation: A review of the literature on university–industry relations. *Research Policy,* 42**,** 423-442.

Plewa, C. 2009. Exploring organizational culture differences in relationship dyads. *Australasian Marketing Journal,* 17**,** 46-57.

Sauermann, H. & Stephan, P. 2013. Conflicting logics? A multidimensional view of industrial and academic science. *Organization Science,* 24**,** 889-909.

Siegel, D. S., Waldman, D. A., Atwater, L. E. & Link, A. N. 2003. Commercial knowledge transfers from universities to firms: improving the effectiveness of university–industry collaboration. *The Journal of High Technology Management Research,* 14**,** 111-133.

Smith, B. 2014. CSIRO scientists Graeme Moad, San Thang and Ezio Rizzardo named as Nobel prize contenders. *The Sydney Morning Herald*, 25 September.

Sofka, W., de Faria, P. & Shehu, E. 2018. Protecting knowledge: How legal requirements to reveal information affect the importance of secrecy. *Research Policy,* 47**,** 558-572.

Stenson, R. 2016. Is this the first time anyone printed 'Garbage In, Garbage Out'? *Atlas Obscura* [Online]. Available: https://www.atlasobscura.com/articles/is-this-the-first-time-anyone-printed-garbage-in-garbage-out [Accessed 11 April 2019].

Walsh, J. P. & Hong, W. 2003. Secrecy is increasing in step with competition. *Nature,* 422**,** 801.