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Abstract

Conditional on the decision to enter the market for immature technology, we test for the effects that trust – as proxied by the context in which the negotiating parties met – has on the likelihood that these negotiations are successful. Using a randomised dataset of 860 university-firm and firm-firm technology transactions, we find that the depth of prior relationship and circumstantial knowledge about each other matters, and matters a lot. Parties who knew each other from a previous business are 28.2 percentage points more likely to conclude a transaction compared with cold-callers. Meeting via an industry network offers an intermediate advantage but meeting via a third party or at a conference only offers a modest advantage over cold calling.

JEL classification: O31, O34

Keywords: Markets for technology, R&D, invention, patent

1. Introduction

The importance of the size of the market in driving the division of labour – and thereby productivity – has been known since Adam Smith (1776). Since then, much progress has been made in relation to our understanding of the ways in which gains from specialisation are achieved. It is well-known, for instance, that there is a range of economic, legal, cultural and social institutions that enable firms to transact with each other (for example, see Greif 1989, 1993). More specifically, in a world of incomplete contracts and asymmetric information, firms must be able to write enforceable contracts in order for the gains from specialisation to be achieved. The ability to do so has obvious implications for the boundaries of the firm (see Grossman and Hart 1986; Alchian, Klein and Crawford 1978; Williamson 1985). In this paper, we explore one class of transactions which are seemingly mired in the full complement of market failures: technology transactions.

Although progress has been made in understanding the problems associated with contracting over technology (see Mowery 1983; Zeckhauser 1996; Arora and Gambardella 2010), there remain large gaps in our understanding of the determinants of successful technology transactions. The difficulties associated with contracting for technology might create incentives to manage the innovation process within the firm. As shown by Mowery (1983, 1995) and Lamoreaux and Sokoloff (2002), however, the organisation of innovative activity in the economy – what is done within the firm and what is done between firms – varied dramatically between the 1870s and the 1940s in the US. So, it is certainly not the case that contracting for technology is a recent phenomenon. But as international trade barriers have come down in recent years, it has become increasingly common for research to be outsourced to one company and then to pass through several other companies – often in different countries – before the product reaches the market. Given this, it is valuable to understand how the efficiency of the market for technology can be enhanced.

We examine a large sample of university-firm and firm-firm technology transactions with a view to shedding new light on this issue. Such transactions are typically one-off, involving thin markets with imperfect property rights and unobservable quality. In many ways, therefore, the market for technology incorporates all of the canonical inter-firm contractual hazards. We focus on one crucial dimension of technology transactions: the determinants of successfully concluding a deal once a decision has been made to start negotiations. That one party to the transaction – either the buyer or the seller – has decided to attempt to trade is a *prima facie* case that unexploited gains from trade exist. What we want to examine is how trust between the parties influences whether or not these potential gains from trade are realised.

One of the key features of our approach is that we draw a distinction between the market for 'mature' (ready-to-use) technologies and 'immature' technologies (which need further work in order to be useful or deliver a final product).[1] Controlling for the maturity of the technology is important since the nature and extent of potential market failures – and motives for the decision to license or sell – are quite different for mature and immature technology transactions. In the market for ready-to-use technology, the decision to transact is driven by issues associated with competition and price, especially when several complementary technologies are required for production or when the cost of inventing around is low. By contrast, in the immature technology market, the main issues driving the decision to transact are specialisation and risk sharing: how do firms collaborate in order to bring a new invention forth? Combining the two separate types of motives into a single model of behaviour will conflate and confuse the analysis.

Therefore, we eschew the decision to license ready-to-use technologies that has been much analysed.[2] Instead, we ask: conditional on the decision to enter the market for immature technology, what role does the extent of trust between the two parties have on the likelihood that the negotiations are successful? We are not focusing on how to choose the partner – which could depend on the inventor's prior experiences in technology transactions – or the nature of the technology (and expertise) they require. All we are simply doing is honing in on the role that trust plays in successfully concluding transaction negotiations. The key issue for our analysis is how we proxy trust, which is based on the way in which parties to the transaction met.[3] We argue that the differences in the social and professional ties underpinning the negotiation can play differing roles in mitigating the contractual hazards associated with the market for technology. Our contention is that the degree of trust between

[1] Giuri and Luzzi (2005) provide examples of different markets according to the maturity of the technology traded.
[2] Examples include Gallini (1984); Katz and Shapiro (1986); Rockett (1990); Gallini and Wright (1990); Arora and Fosfuri (2000); Kamien and Tauman (2002); Bessen (2005); Gallini (2011). For a review, see Arora and Gambardella (2010).
[3] They could meet via professional ties (e.g. former colleagues, professional network or association) or social ties (e.g. through a friend). This tells us something about the trust (and other social institutions) which underpins the transaction.

the parties to the (attempted) transaction affects the size of the transaction costs associated with the transaction.

Our analysis is informed by a unique dataset based on a survey of technology brokers in Australia. The list of brokers – which included in-house business development managers and independent intermediaries – was purpose built for this study. Types of transactions covered in the survey include the license or sale of IP and know-how, contract research, R&D partnerships and the sale of technology-intensive companies. To ensure random variation in the explanatory variables, each broker was asked about their 'last completed' and their 'last abandoned' technology transaction. This provides us with information about a pair of technology transactions handled by each broker. Importantly, the design of our survey ensures that the transactions in our sample are not systematically correlated with the success of the negotiations. The dataset consisted of 467 completed and 393 abandoned transactions (=860 observations) of which 68 per cent occurred between 2009 and 2011.

There are some important limitations of our analysis. First, we do not observe why firms choose to enter the market for technology. Second, our measure of 'success' relates to whether negotiations to complete the transaction were successful rather than the more complex issues surrounding whether the transaction increased profits. However, it is worth noting that successful negotiations are a necessary, but not sufficient, condition for successful commercialisation. Third, we only focus on one of many linkages in the value-added chain – there might be many other linkages that we do not observe and we therefore cannot shed any light on the relative importance of the numerous linkages. Finally, we focus on technology transfer between organisations that are based on contractual agreements. There are other important modes of transferring technology – for example, the transfer of tacit knowledge via labour movements (e.g. Arora 1995) – but these are outside the scope of this study.

To pre-empt our results, we find that the depth of prior relationship and circumstantial knowledge about each other matters, and matters a lot: parties who know each other from a previous business are 28.2 percentage points more likely to conclude a transaction compared with cold-callers. The paper is organised as follows. Section 2 provides some background while Section 3 outlines what we know about the size of the market for (immature) technology. Section 4 provides descriptive statistics on the survey data and Section 5 sets up the econometric model. Section 6 discusses the results and Section 7 concludes.

2. The Relational Context and the Market for Technology

Despite considerable reflection about the contractual hazards associated with trading in the market for technology (Arora et al. 2004; Arora, Fosfuri and Gambardella 2001; Cesaroni 2004; Pluvia Zuniga and Guellec 2009; Arora and Gambardella 2010), little empirical effort has been devoted to study the role of trust in this field. This is somewhat surprising given that trust, transaction costs and relational contracting have been examined in great detail in the literature on the boundaries of the firm more generally (see, for example, Baker, Gibbons and Murphy 2002; Lyons 1994). In this section of the paper, we provide some background to our analysis of trust, incomplete contracts and the market for technology.

In their papers on the R&D boundaries of the firm, Mowery (1983) and later Pisano (1990) have argued that there are three features of an exchange which can erode confidence to the point where market transactions collapse: uncertainty, non-codifiability and opacity. They argue that uncertainty about future cost- or demand-side conditions create an expectation that *ex post* renegotiations will be needed further down the track as unforeseeable circumstances take place. If there is a fear that the other party will behave opportunistically, parties may fail to enter an agreement (Williamson 1985). In addition, when it is difficult to accurately codify the nature of the product traded, parties may fail to exchange when there is reason to believe the other party will act on the literal terms – rather than the spirit – of the agreement. Finally, Pisano argues that when quality is unobservable – if for example, trade is infrequent or quality is only revealed through time or use – then an exchange can also fail to occur. Legal remedies (litigation) are poor substitutes for trust in this situation since their outcomes can be uncertain and their victories pyrrhic.

The market for technology is imbued with these three features. Upstream and immature technologies are even more uncertain than commercial-ready technologies since typically the former are technically unproven, far from the final consumer market, and are governed by weak property rights. These uncertainties make it hard to determine a price; especially when it is not easy to articulate what is being bought and sold, and parties are technologically, geographically or culturally distant. Assessing the quality of work done or knowledge provided is complicated in a technically complex area where the product is novel and incomplete. As such, we expect that the three conditions of uncertainty, non-codifiability and opacity will affect the market for immature technologies (*vis-à-vis* mature technologies) *a fortiori*.

The classic way parties try to transact under these circumstances is to seek or construct an umbrella of trust.[4] Trust – which is defined as '...confidence in an exchange partner's reliability and integrity' (Morgan and Hunt 1994, p.23)[5] – reduces complexity and improves confidence. Following Lewicki and Bunker (1996), we identify three types of trust. The first is calculus-based trust where each party knows that the counter party's behaviour is disciplined by fear of lost revenues following loss of professional reputation. The second is identification-based trust which arises from the mutual understanding and shared interests of parties belonging to a common group. Members know intuitively what other members want and know that other members understand them. The final type is knowledge-based trust which comes from direct familiarity with, and knowledge of, the other party. Whereas knowledge-based trust depends on information; calculus-based trust depends on deterrence; and identification-based trust depends on self-selection. In our empirical analysis, we draw a direct connection between these three types of trust and the way the parties to the technology transaction met.

Some studies of intermediaries, and their role in facilitating an exchange, have examined the importance of calculus-based trust. Lamoreaux and Sokoloff (2002), for example, demonstrate that the emergence of a well-developed market for technology in the late 19th century and early 20th century was underpinned by the presence of specialised intermediaries – including lawyers and patent agents.[6] Greif's (1989, 1993) classic tales of the Maghribi traders during the early mercantile period is an example of how calculus-based trust operates. Landa's (1981) study, on the other hand, of the ethically (and ethnically) homogeneous traders is a classic example of identification-based trust. Finally, documented examples of knowledge-based trust include how firms deliberately built up long-term relationships – via relationship-specific investments, for example – where there is an expectation of repeated transactions with another party (see Nunn 2007; Dass, Kale and Nanda 2011).

This does not mean that parties will automatically choose to negotiate with the opposite party with whom they have the deepest and strongest prior connections. According to Boschma (2005), if one is seeking to buy the best technology or sell their technology to the highest and

[4] It is almost a truism to say that trust is necessary for a successful transaction: as noted by Arrow (1972), every commercial transaction has some element of trust.
[5] It has also been defined as '...a state involving confident positive expectations about another's motives with respect to oneself in situations entailing risk' (Boon and Holmes 1991, p.194).
[6] Although they don't talk specifically about trade in technology, Rubinstein and Wolinsky (1987) and Biglaiser (1993) discuss the importance of middlemen in the presence of informational problems.

most valuable use, then they will not want to be limited to any subset of exchange parties. Each party has before them a menu of possible exchange parties over which exists both a defined level of confidence (based on the levels of pre-existing trust), and a defined view of their technological capabilities or needs. In deciding who to enter negotiations with, the initiating party will choose an exchange party that maximises this combination of confidence and capabilities. In a similar vein, Mansfield (1995) has argued that when firms need applied research they seek locally, but when they need basic research they search for the best in the world.

Other studies on the topic of technology exchange mainly focus on the why and wherefore of using various channels (Agrawal, 2001; Narin, Hamilton and Olivastro 1997; Agrawal and Henderson 2002; Meyer-Krahmer and Schmoch 1998; Monjon and Waelbroeck 2003; Zucker et al. 2002).[7] More relevant however are papers by Anand and Khanna (2000) and Vonortas and Kim (2004), who both analyse licensing data, found that almost 30 percent of deals are signed between parties having a prior relationship. They also found that cross-border transactions are more likely than intra-country transactions to involve parties with a prior relationship. However, to the best of our knowledge, no studies have tried to estimate the actual impact of different relational factors on the completion of a deal. Studies, such as Santoro and Gopalakrishnan (2000) and Plewa and Quester (2006), find that higher levels of trust are associated with more intense and satisfactory university-firm transactions, but their analysis does not account for endogeneity and therefore cannot identify the effect of trust on the creation of successful relationships (or vice versa).

3. The Size of the Market for (Immature) Technology

It is difficult to define the size of the market for immature technology for a number of reasons.[8] First, many analytic studies on markets for technology are (necessarily) piecemeal in that they focus on one type of activity under the rubric of the market for technology – for instance, technology transfer from universities to firms (see Bozeman 2000 for a review article). Although these studies primarily focus on immature technologies, they only tell us about one piece of the market since university-firm linkages are only one channel through

[7] As these papers recognise, there are many ways in which organisations may exchange knowledge including via meetings and conferences, consultancy and contract research, joint research, training, and employee mobility. However, it is important to note that our paper does not intend to look at the all channels of technology transfer between organisations – rather, we focus purely on formal transactions based on contractual agreements.
[8] There is much more information available on the amount of innovation done within the firm, as proxied by R&D expenditure data and the like. But our focus is on transactions between firms.

which immature technologies are transacted. Second, many studies simply do not distinguish mature from immature technologies. There are numerous studies of: research partnerships (Hagedoorn, Link and Vonortas 2000); patent licensing (Sheehan, Martinez and Guellec 2004[9]; Kamiyama, Sheehan and Martinez 2006; Motohashi 2008; Pluvia Zuniga and Guellec 2009); patent re-assignments (Serrano 2005); inter-organisation agreements (Howells 1990); and IP licensing (Anand and Khanna 2000); which are silent about the maturity of the technology being transacted.

Several studies have sought to measure the size of the market for technology by reference to aggregated accounting or administrative data. However, in these datasets it is often difficult to separate technology transactions from other forms of intangible investments. For instance, international royalty and license fee transfers have been used to infer the growth of the market for technology (Athreye and Cantwell 2005), but these include a mix of technology and non-technology transactions such as copyright, trademarks, designs, manufacturing rights right through to franchising agreements and the like. In fact, Arora and Gambardella (2010) argue that based on US data, most of the revenue associated with these transactions is from copyright, trademarks and software.[10]

In a series of papers, Mowery (1981; 1983; 1995)[11] has documented changes in the nature of the technological boundaries of US manufacturing firms through the use of historical data on the percentage of scientists in independent research laboratories relative to the total number of scientists (including those in in-house R&D laboratories).[12] Over the period 1921 to 1946, this fell from 15.2 to 6.9 percent. Another good source of data on the market for technology is from the US National Science Foundation (NSF). Since the late 1950s, the NSF has recorded the amount each consolidated domestic enterprise spent on R&D performed by parties outside the enterprise (but within the US): that is, the amount of outsourced R&D. In 2007, this amounted to 7.1 per cent of all-company R&D, but this should be regarded a lower

[9] Note that 26 percent of the 105 firms surveyed indicated that patent licensing was a substitute for internal R&D.

[10] In addition, Howells (1996) presents information on extra-mural R&D in the UK but does not clarify whether this is outside the enterprise group or not; other studies consider the percentage of start-ups intending to license (Arora and Gambardella 2010) and independent intermediaries (Arora and Gambardella 2010).

[11] He argues that shifts in the size of the market for technology are driven by changes in institutions and regulations (e.g. antitrust and IP laws).

[12] According to van Gil (2010), the modern in-house R&D laboratory started in Germany (Bayer) in 1891 followed by the US in the early 1900s (also see Mowery 1983 and Beer 1958). From World War II to the 1980s, large in-house R&D laboratories, close to head quarters, was the dominant way to source science-based ideas.

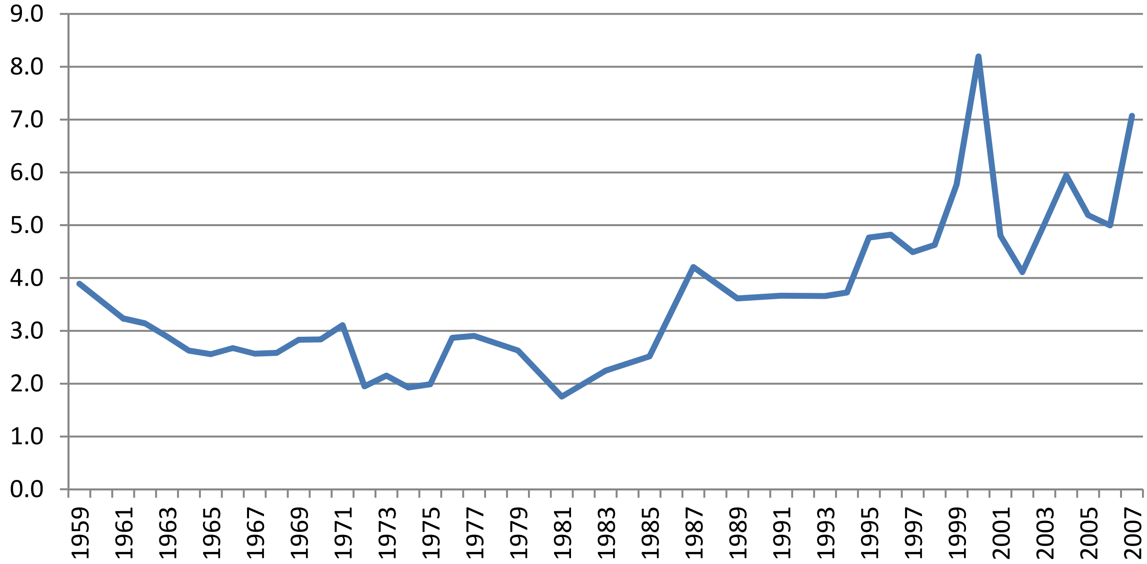
bound estimate of the total amount of outsourced R&D as it excludes R&D services contracted to organisations in other countries.[13]

The 2008 European Community Innovation Surveys also provide some indicative information on the size of the market for technology. These surveys estimate that businesses combined expenditure on extra-mural R&D[14] and 'acquisition of other forms of knowledge'[15] is equal to 16.9 per cent of their total spending on innovation.[16] However, in these statistical collections the definitions do not make it clear whether the boundary of a 'business' is the enterprise group or just the part within a group. Accordingly, an unknown proportion of this 16.9 percent will include intra-enterprise group transfers. Only the Swedish statistical office has separated intra-enterprise from inter-enterprise transactions: they estimate that about a third of the extra-mural R&D spending, as defined above, is actually spent on R&D services outside the enterprise group. Hence, the US and European data together suggest that demand by businesses for external and immature technology is in the order of 5-7 percent of their total innovation budget.

Trend data is more difficult to uncover with confidence. Again, the most solid evidence comes from R&D expenditure data. NSF data on the ratio of outsourced R&D to all R&D from 1959 to 2007, provided in Figure 1, shows a declining trend up to 1981 but a rise thereafter.[17] Between 1981 and 2007, the ratio grew by 0.15 percentage points per year (amounting to a trebling over the period). Data from the UK statistical office on business funds for extra-mural R&D as a percentage of all business funds for R&D shows that there has been a comparable increase since 1993 (see Figure 2). Both the UK and US data therefore imply that the level of externalised innovation has been rising since in recent decades.

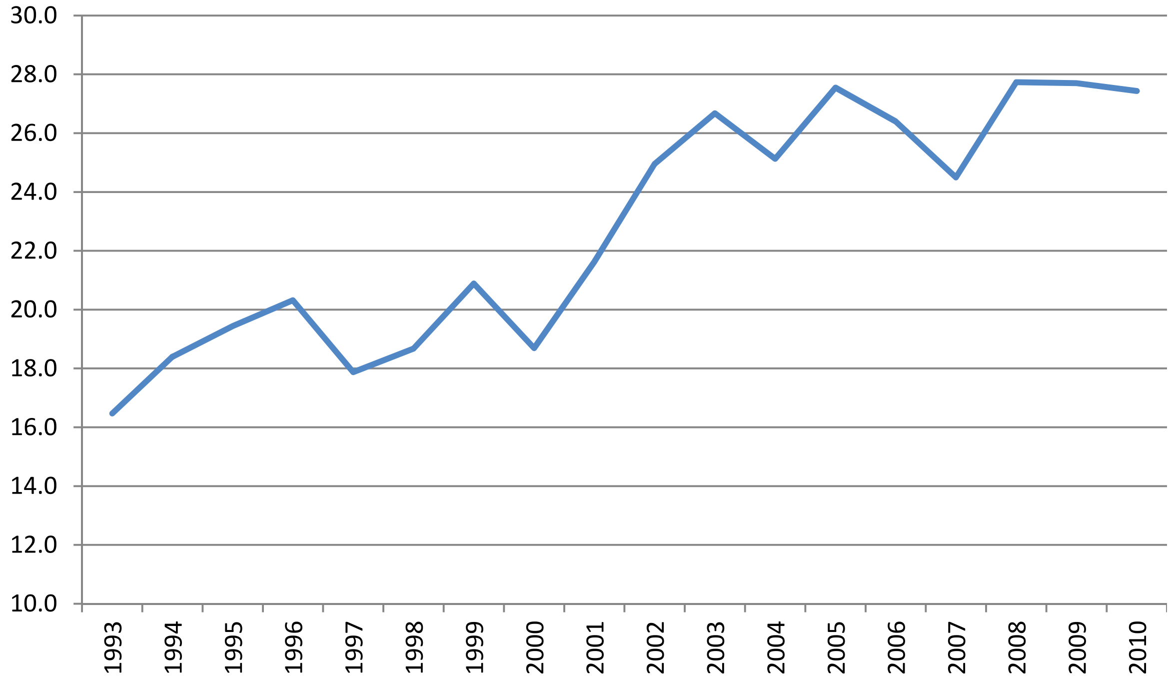
[13] Thomson (2012) shows that the US is a large gross importer as well as a net importer of R&D.
[14] Creative work performed by other enterprises (including other enterprises or subsidiaries within your group) or by research organisations and purchased by your enterprise to increase the stock of knowledge for developing new and improved products and processes (include software development in-house that meets this requirement).
[15] Purchase or licensing of patents and non-patented inventions, know-how and other types of knowledge from other enterprises or organisations for the development of new or significantly improved products and processes. We do not know how much of the patent-based expenditures were for mature technologies.
[16] Countries comprised Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Finland, France, Germany, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain and Sweden. Source: Innovation activity and expenditure in 2008 [inn_cis6_exp] http://epp.eurostat.ec.europa.eu/cache/ITY_SDDS/EN/inn_esms.htm#unit_measure, downloaded 17Apr 2012.
[17] The magnitude of the ratio (extra-mural R&D/extra-mural R&D plus intra-mural R&D) is not especially meaningful since there is a degree of overlap with one firms' extra-mural R&D being counted as another firms' intra-mural R&D. Furthermore, the market for immature technology includes more than just contracted R&D. The data are merely presented as one of the most consistent inter-temporal data series we have.

Figure 1: Company[a] funds for industrial R&D contracted to outside organizations as percentage of total company[a] funds for industrial R&D performance, USA, 1959–2007



NOTES: [a] Includes 'other' (except Federal)
SOURCE: National Science Foundation, Division of Science Resources Statistics, Survey of Industrial Research and Development (annual series). *Science and Engineering Indicators 2008.*

Figure 2: Business funds for extra-mural R&D as a percentage of all business funds for R&D, UK, 1993-2010



SOURCE: Business Enterprise Research and Development (various years) and unpublished data. Series DLDW and DLBX. Office of National Statistics, UK. The survey only includes UK businesses that conduct some intra-mural R&D and Businesses whose R&D expenditure is only extramural are excluded from the survey.

4. Data Collection and Descriptive Statistics

Given the paucity of data available on the market for technology, we collected information on the number, characteristics and success of technology transactions in Australia by surveying technology brokers – people who acted either as a go-between or on behalf of the buyer or seller. The first challenge we faced was that there is no definitive list of brokers in the market: potentially, any innovative firm might act as a technology broker. Accordingly, to scope and define our research, we conducted 66 semi-structured interviews across Australia of people in companies, public research organisations and technology transfer agencies. This enabled us to determine which organisations were potentially transacting in the market for technology, and to test pre-existing theories from the economic literature on the determinants of successful transactions. Interviewees were also asked to nominate the main deal-breakers for negotiations that had commenced but ultimately failed. Responses were wide and varied with proffered deal-breakers covering issues such as: valuation (price, equity or royalties); freedom-to-operate warrantees; the right to publish; confidentiality; exclusivity clauses; patent validity; foreground IP ownership; and ongoing rights to use IP for research.

From these interviews – augmented by on-line searches and other ad hoc contact lists – we compiled a list of contact details for 1,867 Australian technology brokers. These brokers included in-house business development managers for large organisations, independent brokers, technology transfer officers, patent attorneys, business angels and venture capitalists. Since our aim was to gather information about recent attempts to negotiate a technology transaction, we only included people who had a hands-on role in the process (rather than a managerial or supervisory role). Our final list of 1,867 brokers comprised 626 people who were in the business of assisting both buyers and sellers (mainly commercial companies); 535 who assisted the seller only (mainly business development managers for public sector or semi-public sector bodies); and 706 who acted more remotely as facilitators of the exchange (e.g. patent attorneys and public sector commercialisation advisors).

In 2011, we conducted a mail survey of a large sample of these technology brokers.[18] The overall response rate of 47 per cent is high for a company-based survey and reflects the

[18] We surveyed the population of most categories of technology brokers except in relation to patent attorneys, who we limited to 200 randomly selected people (for cost reasons).

provision of an incentive (A$50 gift voucher) in the first mail-out.[19] The response rates vary from 32 per cent (Business Angels) to 65 per cent (Public Sector Research Organisations). While in total 670 people responded to the survey, 214 indicated that they had not been involved in a technology transaction with their current employer, leaving 456 people. The Appendix A provides more information on the survey and respondents.

In our survey, we defined the scope of the transactions we are interested in by stating that:

> "A technology transaction is the buying, selling, licensing or development of a technology that needs more work before it is ready to commercialise. Such transactions cover a broad range of activities including the licensing of a new drug discovery or new mechanical component. *Please do not include technology transactions between 'parents' and their subsidiary companies.*"

The survey asked parallel questions across the different types of brokers – 'buyers', 'sellers' or 'buyers and sellers' – to enable us to collate responses with only slight wording variations according to the context. For example, the questionnaire differed slightly if we were asking a buyer about the 'last acquisition' or a seller about the 'last sale' of technology. The survey defined two different outcomes: the first was a 'completed transaction', which was one that ended in: a license, sale or cross-license of IP; another form of research contract or sale of know-how; majority purchase of a company; or an R&D partnership. The second outcome was an 'abandoned transaction', which related to negotiations over a transaction that had commenced but were not concluded within a 12 month period. In both instances, the outcomes are conditional on some negotiations having commenced. Thus, cold calls to potential buyers that ended in the response "we are not interested" are not included in our sample of transactions.

In order to collect data from a random sample of technology transactions, we asked each broker to answer a set of questions about the last completed transaction and the last abandoned transaction in which they had been involved. By doing so, we avoid any potential bias associated with the fact that – if left to select which transactions to report on – brokers might report on the most successful, the largest, or the most time-consuming transaction. Our final dataset covers 860 transactions, of 467 of which were completed and 393 which were abandoned. Of these, 258 were reported by the party representing the buyer and 579 by the party representing the seller (the remaining were reported by a go-between).

[19] 2.2 percent of contacts were not 'in scope' as their contact address had changed or the person replied that they were not involved in technology transactions. Other company surveys we undertake, which do not include incentives, typically achieve response rates of 15 percent.

Table 1 – which presents the data on the mode of meeting from the survey – shows that 37.7 per cent of buyers and sellers met through industry networks but nearly one in five (17.3 per cent) were cold calls. The remainder were split fairly evenly between conferences or professional seminars; third-party introductions; repeat business and 'Other'. Over one third nominated biotechnology as one of their fields of technology and one in five respondents nominated software. About one third of transactions were at the proof-of-concept state and just over one in five were at the prototype stage. Finally, the mean value of the technologies was estimated from a set of five interval responses and revealed that the average value of the technology was about AUD 1.3million (~USD 1.3 million). Perhaps the most notable feature of the distribution of transactions by technology area, commercial readiness and value is the small difference between the completed and abandoned groups.

Although our sample of transactions is a subset of all potentially tradeable technology, we do know something about the motives for seeking to buy/sell technologies. In the survey, we ask brokers why their organisation sought to trade the technology in question. Table 2 presents the results according to whether the respondent was replying on behalf of companies buying or selling technology.[20] If we ignore the response to 'Not part of our core business' (since this is true by definition), there are two main reasons buyers buy and sellers sell: 'It would take too long to create/develop in-house' and/or 'The required capabilities or equipment were not found in-house' (also found by Charles and Howells 1992, pp.148-50).[21] For both groups, risk and price were deemed to be only minor considerations. Appendix B provides a stylised description of the negotiation process.

[20] Note that technology transfer offices are excluded from this table since we assume they are only interested in selling.
[21] A related question put by Razgaitis (2006) to brokers in the US and Canada found that the most common reason given for licensing technologies was that they were not part of core business.

Table 1: Transaction Characteristics

	Completed	Abandoned	Total	%
Mode of meeting (Number)				
Cold called	65	82	147	17.3
Conference or professional seminar	37	50	87	10.3
Third-party introduction	37	41	78	9.2
Industry network	176	144	320	37.7
Other (ex-colleague etc)	75	31	106	12.5
Repeat Business	69	41	110	13.0
TOTAL (Number)	459	389	848	100.0
Type of transaction (Number)[a]				
License of IP	287	247	534	62.1
Sale of IP	85	75	160	18.6
Cross-license of IP	22	14	36	4.2
Contract research	78	54	132	15.3
Sale of technical know-how	63	60	123	14.3
Majority purchase of whole company	23	27	50	5.8
R&D partnership	102	71	173	20.1
Other	15	9	24	2.8
TOTAL (Number)	467	393	860	100.0
Technology (proportion)[a]				
Biotechnology	0.374	0.400	0.388	
Chemicals	0.102	0.090	0.095	
Drug & medical	0.206	0.180	0.192	
Electronic	0.102	0.113	0.108	
Mechanical	0.155	0.146	0.150	
Software	0.160	0.233	0.200	
'Other'	0.158	0.176	0.167	
Readiness (proportion)				
Basic science	0.112	0.064	0.086	
Applied science	0.191	0.173	0.181	
Proof of concept	0.341	0.310	0.324	
Prototype	0.198	0.255	0.229	
Manufacturing pilot	0.140	0.150	0.145	
'Other'	0.0407	0.073	0.058	
Estimated value (AUD '000)	1364	1333	1347	

Note: [a] multiple responses permitted.

Table 2: Reason for selling or buying (excluding public research organisations), % responding 'yes' (multiple technology responses)

Reason not to create or develop in-house	Buyer of technology (%)	Seller of technology (%)
Did not have the capabilities or equipment	52.7	58.3
Did not have complementary IP	27.6	8.5
Not part of our core business	44.3	53.3
Would take too long	53.2	29.7
Too risky	19.2	20.1
Offered a low price to buy	15.3	7.5
Total (%)	212.3	177.4

Source: Australian Markets for Technology Survey, 2011

5. Model

The unit of analysis in our model is the negotiation relating to a technology transaction: this negotiation can either succeed (i.e. a transaction occurs) or fail (i.e. no transaction occurs). For each party to the i-th technology transaction negotiation, there is a marginal value of trust which may reflect the degree of uncertainty, non-contractibility and opacity of the potential contract. In specifying our model, we assume the existence of an optimal level of trust ($Trust_i^*$) for the i-th negotiation which maximizes the expected payoffs of both parties given their choice of desired level of trust.[22] Accordingly, we have:

$$Completed_i = f(Trust_i^*, \boldsymbol{x}, \varepsilon) \qquad (1)$$

where $Completed_i$ is an indicator of whether or not the i-th negotiation is completed; $\boldsymbol{x}$ represents a vector of confounding factors that affect both the probability the negotiations will be completed and the degree of trust; and ε represent the sum of all other factors that affect $Completed$ but are independent of $Trust$.

Two estimation issues need consideration: first, we do not directly observe the chosen level of trust. What we do observe however is the context in which the negotiating parties met and we argue that this is the outcome of the joint decision to optimise the level of felt trust and other factors such as the understanding each party has about the other's capabilities. Thus we need some way to test that any association between the meeting context and the completion of a deal is related to trust rather than non-trust related factors. Second, while our dataset

[22] The optimal value of trust needs not to be identical between the parties. In that case, $trust_i^*$ can be thought of as a vector of $trust_{is}^*$ and $trust_{ib}^*$ corresponding to seller's and buyer's optimal level of trust respectively. However, in our empirical model, we assume that these reflect variations in the observables and unobservables that are common to both parties.

includes a number of possible confounding factors, we should allow for the possibility that unobserved confounding factors also exist. A likely candidate here is the previous history of the negotiating parties: those with deeper connections and longer histories are expected to have more relationships to choose from and could also possibly be better negotiators than parties without these connections. Hence, in our empirical model we treated *Trust* as weakly endogenous (due to omitted variable bias) and therefore instrument $Trust$ to remove any possible effects from these latent factors.

Dependent variable

In equation (1) the dependent variable is *Completed*, which is a binary variable:

$$Completed = \begin{cases} 1\ if \text{ transaction was completed} \\ 0\ if \text{ transaction not completed after 12 months} \end{cases}$$

Independent variables

$Trust$ is represented by a vector of five binary variables derived from the survey question of 'In what context did the buyer and seller meet?' The coded responses were: Cold call; Third-party introduction, conference or professional seminar; Industry network; Repeat business; and 'Other'. Based on a separate and more exhaustive survey conducted in 2010, we believe this 'Other' group refer to ex-colleagues, friends of friends and ex-collaborators. However, our estimation results are not sensitive to the whether we include or exclude this 'Other' group. These responses broadly align with the Lewicki-Bunker trust typology: calculus-based (Third-party introduction; conference or professional seminar); identification-based (Industry network) and knowledge-based (Repeat business and 'Other'). We assume Cold-call is associated with no prior trust. We model $Trust$ in two ways: as a series of unrelated binary outcomes and as a cardinal variable.

Over and above the degree of trust in the relationship, we expect that, following the literature and anecdotal evidence, there are several risk or uncertainty related factors that may be confounding factors. These comprise: market risk – the risk that, given costs of production, there will be insufficient demand to be commercial viability; appropriation risk – the risk that other parties will imitate and expropriate the original inventors returns; and people risk – the risk of misalignment between the researchers in both organisations. These three risk measures were constructed as means of the following items from the survey (each item is scaled so it has an equal weight):

Market risk – is identified as transactions that are considered specific technologies (rather than general ones); and where the respondent indicated that the existence of a market for the technology was highly uncertain and the value of the technology was highly uncertain.

Appropriation risk – is identified as technologies without patent or copyright protection; technologies which had been refused a patent; technologies that did not conform to patentable subject matter; technologies where the IP protection had been rated as highly uncertain; and where proposed or actual contracts did not include exclusivity clauses.

People risk – is identified as situations where the alignment of buyers and sellers objectives is very dissimilar; where the buyer and seller did not met early in negotiations and in fact never met; but where the prospective or actual contract required ongoing inventor participation.

While there are clear reasons why greater risk along any of these dimensions will lower the chance that negotiations will succeed, the issue for our purposes is whether the factors determining these risks also affect the chosen level of prior trust between parties. We believe that plausibly, parties who initiate negotiations over a more risky deal (either because of uncertainty about the market, appropriation or people's alignment) will chose to negotiate with a party where there is a greater level of prior trust.

Instruments

In the final set of estimations, *Trust* is instrumented by three variables which reflect the initiating party's preferences for trust (but are independent of *Completed*): the geographical distance between parties (which serves as an *ex post* indicator of a heightened preference for negotiating with a party in regular personal contact); whether the buyer initiated negotiations (we expect buyers to have a heightened preference for trust); and the number of participants in the market (trust will be deeper in smaller markets where the players know each other). Details of the survey items used for all variables in our model are included in Appendix C.

Table 3 shows the mean and standard deviation of the constructed risk variables according to whether the transaction was completed or abandoned.

Table 3: Transaction risks, mean and standard deviation by whether transaction completed

	Completed	Abandoned	Total
Market risk	0.468	0.538	0.500***
(std dev)	*0.191*	*0.169*	*0.184*
Appropriation risk	0.417	0.466	0.440***
(std dev)	*0.151*	*0.157*	*0.156*
People risk	0.314	0.376	0.342***
(std dev)	*0.229*	*0.242*	*0.237*

Note: *** difference of means significant at the 1 % level.

6. The results

Given the different estimation issues, we begin by estimation equation (1) on the basis that $Trust$ is represented by 4 dummy variables and we also ignore possible endogeneity issues. Table 4 presents this model, both with and without the three control variables. As mentioned we might want to think about meeting via a third party, conference or seminar as indicting the presence of calculus-based trust since the environment of other parties provides potential for one's reputation to be tarnished; meeting via an industry network as indicating the presence of identification-based trust; and meeting via repeat business or 'Other' reflects knowledge-based trust. Thus, the use of meeting mode allows us to infer the effects of different types of trust.

In both these estimates the ordering on the coefficients for the five types of meeting – as proxies for type of trust relationship – is consistent with our expectation.[23] Knowledge-based trust has the highest probability of completion, followed by identification-based trust and then calculus-based trust and finally 'none'. The control variables are not without interest. The greater are these risks – $Market,\ Appropriation$ and $People$ – the less likely it is that the transaction will be completed.

The simulated marginal effects presented in Table 5 show that knowledge-based trust gives an additional 20.2 to 28.2 percentage point advantage over negotiations that begin with no prior knowledge. The respective marginal advantages for calculus and identification-based trust are 2.8 and 12.5 percentage points. Including the potential confounding risk variables did not materially affect the estimated marginal effects for trust, except for that derived from repeat business. The marginal advantage for knowledge-based trust derived from repeat business fell from 28.2 to 24.6 percentage points. This indicates that negotiations involving repeat business parties tend to be lower risk than other negotiations.

[23] The estimated coefficients for the first stages are presented in the appendix.

Table 4: Determinants of a completed (versus abandoned) transaction. Trust as binary variables.

Trust type	*Variables*	*Probit*	
	MEETING (BINARY)	(1)	(2)
None	Cold called	-0.314**	-0.355**
		(0.138)	(0.138)
Calculus	Third-party introduction	-0.243**	-0.283***
	Conf. or prof. seminar	(0.0971)	(0.100)
Identification	Industry network	0	0
Knowledge	'Other' (ex-colleague etc)	0.199*	0.204*
		(0.121)	(0.123)
Knowledge	Repeat business,	0.421***	0.318**
		(0.135)	(0.144)
	CONTROL VARIABLES		
	Market risk		-1.099***
			(0.225)
	Appropriation risk		-1.346***
			(0.281)
	People risk		-0.617***
			(0.138)
	Residuals		
	Sample	848	848

Note: includes a constant. Clustering on the respondent.

Table 5: Marginal effects on the probability transaction is completed: Base case = 'Cold called'

Trust type	Meeting	Change (cf Cold called)	
		No control variables	Control variables
Calculus	Third party intro, conf. or prof. seminar	2.8	2.7
Identification	Industry network	12.5	13.3
Knowledge	'Other' (ex-colleague etc)	20.2	20.7
Knowledge	Repeat business	28.2	24.6
n		848	848

Note: Derived from the estimates in Table 4, columns (1) and (2).

To account for possible endogeneity, due to unmeasured confounding factors, we converted the binary meeting variables into a cardinal measure – based on the ordering of coefficients in Table 4. We then estimate equation (1) using the IV probit; linear IV; and two-stage residual inclusion method (Hausman 1978, with an ordered probit in the first-stage). Table 6 presents the econometric results and Table 7 presents the simulated marginal effects using the two-stage residual inclusion estimation. These results clearly show that $Trust$ is significant and positive, that is, the higher the level of prior trust present between the two parties, the greater is the probability that negotiation will conclude in a deal. Compared with no trust, having knowledge-based trust increased the probability that the negotiations would be concluded by

28.2 percentage points (as shown in Table 7). The marginal increments for calculus- and identification-based trust were 7.2 and 14.4 percentage points respectively.

Based on information derived from our interviews, we conjecture that formal IP may be used to as substitutes for trust. To test this, we split the sample according to the type of IP the seller held over the technology at the time of negotiations. From our dataset, we construct four (partly overlapping) samples of technologies: possessing a granted patent; possessing a pending patent; holding copyright and not holding a granted patent. Results from the marginal effects from these four separate regressions support our prior view that a patent can be a substitute for when trust is absent. If a granted patent is present, the size of the coefficient for $\boldsymbol{Trust}$ is two-thirds the coefficient if there is no patent. Furthermore, the estimated coefficients for the copyright holder sample were not significant. It is easier to interpret our results if we consider the marginal values shown in Table 9. If we just compare the added effect knowledge-based trust has on negotiations over cold calling we can see that, if a granted patent is present, trust only increases the probability that negotiations will conclude by 20.7 percentage points. However, if there is only a pending patent or no granted patent, the addition of knowledge based trust added 33.4 or 33.7 percentage points.

We might also expect that the importance of trust would differ by stage of development given the classic contracting problems of uncertainty, non-codifiability and opacity would vary by how upstream in the value-added chain the technology was. The results in Table 9 are however somewhat at odds with this view: if the technology was at the basic or applied research stage, knowledge-based trust (over no trust) added 29.0 percentage points to the probability that negotiations would be completed. At the development stage (proof of concept or prototype), this level of prior trust added 32.0 percentage points and at the pilot manufacturing and other stages it was 26.9 percentage points.

Table 6: Determinants of a completed (versus abandoned) transaction. Trust as a cardinal variable

Variables	*Probit*	*IV Probit*	*IV Linear*	*Probit – 2SRI*
Trust	0.193***	0.813***	0.396***	0.371***
	(0.0382)	(0.0897)	(0.122)	(0.0913)
CONTROL VARIABLES				
Market risk	-1.094***	-0.586*	-0.365***	-1.220***
	(0.226)	(0.332)	(0.115)	(0.262)
Appropriation risk	-1.329***	-0.953***	-0.542***	-1.586***
	(0.279)	(0.327)	(0.129)	(0.326)
People risk	-0.614***	-0.235	-0.159**	-0.703***
	(0.137)	(0.200)	(0.0743)	(0.158)
Residuals				-0.278**
				(0.132)
F test – Trust			11.99	
Hansen J stat. P-val			0.3668	
Endogeneity test P-val			0.0007	
Sample	848	752	752	655

Note: includes a constant. Clustering on the respondent.

Table 7: Marginal effects on the probability transaction is completed: Base case = 'Cold called'

Trust type	Meeting context	Change (cf Cold called)
Calculus	3rd party intro, conf. or prof. seminar	7.2
Identification	Industry network	14.4
Knowledge	Repeat business	28.2
n		742

Note: Derived from the estimates in Table 6, column (4) .

Table 8: Determinants of a completed (versus abandoned) transaction by IP status

Variables	*Probit*						
	IP status				*Stage of development*		
	Patent[a]	*Pending patent[a]*	*Copyright[a]*	*No patent[a]*	*Research[b]*	*Develop-ment[b]*	*Pilot manuf. & other[b]*
Trust	0.140**	0.228***	0.147	0.235***	0.196**	0.228***	0.182**
	(0.0643)	(0.0639)	(0.0911)	(0.0492)	(0.0782)	(0.0547)	(0.0831)
CONTROL VARIABLES							
Market risk	-1.073**	-1.333***	-1.205**	-1.080***	-0.234	-1.672***	-1.019**
	(0.426)	(0.390)	(0.608)	(0.285)	(0.494)	(0.346)	(0.510)
Appropriation risk	-0.689	-1.708**	-0.458	-2.005***	-1.549**	-1.623***	-0.489
	(0.703)	(0.678)	(0.712)	(0.417)	(0.618)	(0.381)	(0.577)
People risk	-0.523**	-0.502**	-0.595*	-0.700***	-0.907***	-0.511**	-0.498
	(0.252)	(0.233)	(0.352)	(0.176)	(0.285)	(0.209)	(0.323)
Sample	280	330	145	568	224	462	174

Note: includes a constant.

Table 9: Marginal effects on the probability transaction is completed: Base case = 'Cold called'

Trust type	Meeting context	Change (cf Cold called)						
		IP status				*Stage of development*		
		Patent[a]	*Pending patent*[a]	*Copyright*[a]	*No patent*[a]	*Resear-ch*[b]	*Developm ent*[b]	*Pilot manuf. & other*[b]
Calculus	3rd party intro, conf. or prof. seminar	5.4	8.2	5.4	8.4	7.1	8.3	7.0
Identification	Industry network	10.7	16.7	10.5	17.1	14.5	16.6	14.0
Knowledge	Repeat business	20.7	33.4	19.8	33.7	29.0	32.0	26.9
n		280	330	145	568	224	462	174

Note: Derived from the estimates in Table 6.

Finally, we earlier canvassed the possibility that the context in which parties met may proxy not for trust but for familiarity about the other party – to the extent to which these factors are distinct. While there is no certain way in which we can separate trust and familiarity, it seems clear that if the meeting context only reflected familiarity, then we would be unlikely to observe that pattern of results found in Tables 8 and 9. That is, we would not expect that meeting context would have a differential effect depending on whether a granted or pending patent was present if it only reflected familiarity.[24]

7. Conclusions

Since the early 1980s (in the US at least) the translation of science and technology into usable products has increasingly involved more than one organisation. Contracts are typically invoked when (immature) technology is crossing distinct legal boundaries. However, contractual incompleteness can mean that attempts to transact the technology fail for reasons that have nothing to do with the underlying feasibility of the technology or the demand for the product. We argue that where the problems of uncertainty, non-codifiability and opacity are greatest, the party initiating the deal will opt to deal with more trusted counterparts, potentially at the expense of dealing with others who possess greater technical expertise.

We used data from 467 completed and 393 abandoned technology transactions to estimate the effect that prior trust has on the probability that negotiations will be completed in a deal. We find clear results that deeper prior trust, as represented by prior business dealings and, what appears to be other personal and collegiate ties, have the largest impact on negotiations. This is especially true when a granted patent is absent and for the development stage of

[24] We thank Mark Shankerman for making this point.

innovation. Audretsch (2001) has argued that the ability to translate science into a commercialisable product requires the presence of high-risk financial vehicles, an entrepreneurial culture and regulations that foster start-ups. We would add that knowledge-based trust is also a useful ingredient.

Appendix A – The survey process

A technology broker is defined in this study as a person who acts as a go-between or match-maker connecting the buyers and sellers of technologies that need further development before they can be used. Since comprehensive lists do not exist for people employed in this capacity, we undertook an extensive process to uncover the names and addresses of all relevant people in Australia. This process took over two years and involved: 66 semi-structured interviews with people who were referred to us as being in technology transaction business; extensive on-line searches; and the careful acquisition of ad hoc contact lists. The organisations covered by this search process included: business angels; Commercialisation Australia; COMET; cooperative research centres (CRCs); the Commonwealth Scientific and Industrial Research Organisation (CSIRO); state departments of primarily industry; large companies conducting significant R&D; public providers of innovation services and information; patent attorneys; public-sector research institutes; universities; R&D corporations; venture capitalists and independent firms which specifically act as technology brokers.

In all, by the beginning of 2011 we had collected 1867 names and addresses. While many of these could be described as in-house brokers – business development managers for large organisations – some were employed by stand-alone businesses whose express function was to act as a broker. We were interested only in people who had a hands-on role in technology transactions and thus did not survey managers with only supervisory or policy roles. Table A1 shows that of our final list of brokers, 626 were in the business of assisting both buyers and sellers (mainly commercial companies); 535 assisted the seller only (mainly business development managers for public sector or semi-public sector bodies); and 706 acted more remotely as facilitators of the exchange (patent attorneys and public sector advisors).

Our intention with the survey was two-fold: first, to scope the characteristics of the market for technology in Australia; and second, to analyse the determinants of a successful technology transaction. As mentioned, in order to collect a random sample of data on transactions that succeeded and those that did not, we asked each person to answer a set of questions about the <u>last</u> completed (successful) transaction and the <u>last</u> abandoned (unsuccessful) transaction in which they had been involved. Asking about the last transaction is a well-known technique for reducing sample selection. For example, we did not want people to report on the most successful, or the largest, or the most time-consuming transaction. With respect to our meaning of success: we sought only to record whether or not the deal was done since we did not believe this was the appropriate type of survey to record what happened to the technology after the transaction was completed (or not). As such we do not report on any standard measure of success such as whether or not the technology was used.

The first mail-out for the survey took place in June 2011, with 99 per cent of responses returned by December 2011. We surveyed the whole population except in relation to patent attorneys, who we limited to 200 randomly selected people (for cost reasons). Table A1 presents the response rates across different types of broker. The overall response rate was 47.0 per cent, which is high for a company-based survey and reflects the provision of an incentive (A$50 gift voucher) in the first mail-out.[25] The response rates vary from 31.6 per cent (Business Angels) to 65.0 per cent (Public Sector Research Organisations). While in total 670 people responded to the survey, 214 indicated that they had not been involved in a technology transaction with their current employer, leaving 456 people.

Table A1: Population and survey sample of technology brokers

	Population	Surveyed	Responded	Response rate (%)	Involved in transaction
Buyer and seller	**626**	**626**	**271**	**31.6**	**198**
Business Angels	19	19	6	46.2	
Venture Capitalists	39	39	18	43.5	
Industry (independent brokers; large R&D companies; contract research organisations)	568	568	247	43.3	
Seller only	**535**	**535**	**285**	**49.6**	**200**
Public Sector Research Organisations (other than universities)	252	252	125	65.0	
Research & Development Corporations	20	20	13	58.3	
Technology Transfer Offices (universities)	216	216	126	44.7	
Cooperative Research Centres	47	47	21	53.3	
Facilitator	**706**	**266**	**114**	**35.3**	**58**
Information providers	51	51	18	44.7	
Patent Attorneys	637	197	88	44.4	
Commercialisation Australia/Comet case managers	18	18	8	42.9	
TOTAL	1867	1427	670	47.0	456

Note: these classifications are more indicative that precise as some organisations can belong to more than one category.

[25] 2.2 per cent of contacts were not ‘in scope’ as their contact address had changed or the person replied that they were not involved in technology transactions. Other company surveys we undertake, which do not include in the hand incentives, typically achieve response rates of 15 per cent.

As shown in Table A2, about one-third of survey respondents described themselves as a business development professional, with the other main nominated roles being manager, CEO or scientist/engineer (people could nominate more than one role). According to the data presented in Table A3, over 40 per cent of people had been working in the technology transaction business for over ten years. Only 5.8 per cent had been in the business for less than a year, which is comparable to the 4.5–9.5 per cent range for the US and Canada, as found by Razgaitis (2006).

Bio-technology was the most common technological area (nominated by two-thirds of respondents), followed by drugs and medical technology (47.1 per cent). This probably reflects the particular business model in the bio-technology/bio-pharmaceutical industries rather than a bias in Australian R&D. Most Australian R&D is in xx – the 'bios' are a mere xx. Anecdotally, the bio-technology and pharmaceutical areas are less likely to complete an R&D cycle wholly in-house but, rather, tend to follow a pattern whereby a problem or opportunity is identified by a research organisation which then sells or licenses the findings to subsequent organisations with complementary specialist capabilities. Under this innovation process, ideas are owned by a series of parties who share in the risk of the whole process.

Table A2: Respondent's role in organisation

Role	Buyer/seller	Seller only	Facilitator	TOTAL
Business development professional	23.5	53.6	12.5	34.4
CEO	34.3	11.1	14.3	21.1
Chief Technology Officer	16.4	3.2	0.9	8.2
Lawyer	1.9	3.6	8	3.6
Manager	32.1	38.6	13.4	31.7
Patent attorney	1.9	3.6	66.1	13.5
Scientist/engineer	29.9	13.6	8.9	19.4
Other	9.3	11.4	8	10
Total %	149.3	138.6	132.1	141.8
Total people responding	268	280	112	660

Table A3: Years respondent has worked in technology transactions field

Years	Buyer/seller	Seller only	Facilitator	TOTAL
<1	5.3	5	9.1	5.8
2 to 5	18.4	32.7	17.3	24.3
6 to 10	23.7	30.6	22.7	26.5
11 to 15	19.9	14.7	16.4	17.1
> 15	32.7	17.3	34.5	26.5
Total %	100	100	100	100
Total people responding	266	278	110	654

Table A4: Organisation's main technology areas in Australia

Technology area	Buyer/seller	Seller only	Facilitator	TOTAL
Automobile	6.2	12.8	36.2	14
Mechanical (not auto)	18.9	33.7	66.7	33.1
Biotechnology	49	76.6	70.5	64.4
Chemicals	12.4	40.3	58.1	31.9
Communications	10.4	36.6	58.1	29.5
Drug & medical	27.4	59.7	62.9	47.1
Electronic	22.4	39.9	69.5	37.7
Hardware	14.7	25.6	54.3	25.9
Software	26.3	46.9	61	40.8
Total %	187.6	372.2	537.1	324.3
Total people responding	259	273	105	637

As shown in Table A5, our respondents were spread quite evenly across organisations classified by size. About four in ten were employed in organisations with at least 200 employees. Very few were from organisations with any foreign ownership. According to Table A6, only one in ten people were from organisations that would be classified as foreign-owned – that is, with over 50 per cent foreign ownership – and these were almost all in the buyer/seller group.

Table A5: Approximate number of people employed in the organisation?

Employment size	Buyer/seller	Seller only	Facilitator	TOTAL
1 to 10	28.0	13.3	28.9	22.0
11 to 20	14.5	9.5	7.8	11.2
21 to 200	23.2	30.3	37.8	28.7
201 +	34.3	46.9	25.6	38.0
Total %	100.0	100.0	100.0	100.0
Total people responding	207	211	90	508

Table A6: Foreign ownership of organisation

	Buyer/seller	Seller only	Facilitator	TOTAL
0%	56.1	94.3	92.2	78.4
1 to 10%	8.8	1.4	2.2	4.6
11 to 50%	11.2	2.4	0.0	5.5
51 to 100%	22.9	0.5	0.0	9.5
Unsure	3.9	2.9	5.6	3.8
Total %	100.0	100.0	100.0	100.0
Total people responding	205	210	90	505

Given that many of our respondents operate as in-house brokers, we also asked about the types of research alliance their organisations had engaged in over the previous five years (since 2006). One in five people reported no such alliances and these were mainly brokers who acted solely as facilitators (although one in five from the buyer/seller group also reported no alliances). The most common form of alliance, involving half of respondents, was a private research joint venture; this was followed by Cooperative Research Centres and then ARC Linkages. Finally, Table A8 indicates that about one in ten organisations received over half of their sales revenue from new products in the previous year.

Table A7: Research alliances organisation engaged in since 2006

	Buyer/seller	Seller only	Facilitator	TOTAL
None	21.7	3.8	67.4	22.4
ARC Linkage	30.5	68.4	15.7	43.7
Cooperative Research Centre	24.1	75.1	21.3	44.9
Private research Joint Venture	42.4	69.4	24.7	50.5
Other	36.5	43.1	12.4	34.9
Total %	155.2	259.8	141.6	196.4
Total people responding	203	209	89	501

Table A8: Percentage of sales derived from new products in previous year

	Buyer/seller	Seller only	Facilitator	TOTAL
0%	32.1	55	74.1	48.7
1 to 10%	33.7	33.3	12.3	29.8
11 to 50%	19.4	4.8	8.6	11.6
51 to 100%	15.8	6.9	4.9	10.3
Total %	100.0	100.0	100.0	100.0
Total people responding	196	189	81	466

In relation to each of their most recent technology transactions, respondents were asked why they believed either party had wanted to buy in or sell out. We provided respondents with a list of options and they were permitted to give as many positive responses as appropriate. Table A9 gives these percentages, again disaggregated by type of respondent. The most common given reason was ‘not part of core business’ (58.4 per cent), followed by the related response ‘did not have the capabilities or equipment’ (52.2 per cent). Few people indicated that price provided the inducement (although it may have been critical in completing the transaction) and only 15.8 per cent thought that a lack of complementary IP was an issue. A related question put by Razgaitis (2006) to brokers in the United States and Canada found that the most common reason given for why technologies would never be licensed was that they were not part of core business.

Finally, we asked people who had been brokers for at least five years to estimate the number of transactions they had been involved in since 2006. The results in Table A9 show that brokers engaged in 22.6 transactions, or about six deals per year. Even bearing in mind that some people may not work full-time in a broking capacity, the data suggest that each transaction is a time-consuming process. Further, most of the effort appears to be focussed on selling for one's organisation rather than buying (11.5 cf. 6.0 transactions).

On average about 16 of the attempted transactions were completed, three were abandoned and three were still in negotiation, giving a 'negotiation completed' total of 83 per cent (excluding incomplete negotiations). This 'completed' rate is considerably higher than the rate calculated by Razgaitis (2006) for the United States and Canada. From his sample of 588 brokers he found that only 67 per cent of attempts to license led to substantial negotiations and, of these, 53 per cent ended in a deal. Razgaitis reported that the main reasons given for why deals failed were 'financial terms of the deal' followed by 'non-financial terms'. The difficulties with financial terms included different assumptions about valuation and the amounts and structure of payments. Less important reasons included the emergence of a better alternative for one party; problems with enforcement or validity; inability to agree on the scope of IP to be included; lack of trust; ego–hubris; and too many parties and legal problems.

It would not be appropriate to simply extrapolate from these data to give an estimate of the number of technology transactions per year since we are likely to have surveyed people who are parties to the same transaction. However, a very simple calculation of six deals per year multiplied by 1194 brokers gives 7163 transactions a year. This should be regarded as an upper bound on the estimated number of such transactions taking place in Australia each year.

Table A9: Number of technology transactions per respondent, since 2006.

Status of transaction	Purchase for my organisation	Sell for my organisation	Facilitate for two external parties	Total
Completed (contract signed)	4.7	8.1	3.5	16.3
Still in negotiations	0.7	1.7	0.6	3.0
Abandoned (negotiating over 12 months)	0.7	1.8	1.0	3.4
Total	6.0	11.5	5.1	22.6

Note: only includes people employed as a broker for over 5 years.

Appendix B – Negotiating a deal

There are many and varied ways in which buyers and sellers meet for the purposes of serious negotiations: some negotiations represent repeat business, other meetings are between existing industry acquaintances or former work colleagues. Some introductions occur through third parties. When there is limited prior knowledge, the reputation of the parties is critical. Once parties have agreed to negotiate, parties typically move quickly to agree on a 'term sheet' which is a plain language document that sets out what each party wants from the deal and what limitations they will agree to. Term sheets are used to guide the drafting for the ultimate contract but they are not necessarily binding. They should define what success looks like and what failure looks like; align expectations between parties and raise the hard and significant issues up front. In so doing, term sheets should identify areas of highest risk. Business managers report that some of the most intense haggling occurs around the specification of the terms sheet, what parties will budge on and what is essential. It can take weeks or months to agree on the term sheet.

Views are mixed about how frequently contingencies, which were not specified in ex ante contracts, arise. Many people claim that these situations are ameliorated by only dealing with trusted or long-term parties so that unanticipated issues can be re-negotiated in good faith. However, some believe they avoid this problem by the use of very detailed ex ante contracts. Most interviewees however felt that opportunistic behaviour is uncommon, although this may be a result of only dealing with trusted parties. Some people noted that goodwill is eroded over time when one party feels poorly treated.

Most parties believe that it is possible to articulate the technology in a contract but contrary to popular wisdom, the use of patents depended on the technology and was not universal. Most problematic issues involved buyers understanding the perimeter of what they were buying, that is, where one idea ended and other began.

No people we interviewed for this research believed that it was difficult to assess the quality of work done and only three people responded that asymmetrical information creates markets wherein the main motive for selling is to make gains from a technology that is too inferior to develop in-house. Most people indicated that use of milestone payments and loss of reputation was enough to prevent moral hazard issues and that the considerable costs of selling, made a 'lemons' business model risky and unviable. Generally, brokers thought that people initiated transactions because they did not have the capabilities to create or develop in-house or that this activity was not part of their core business.

Appendix C - Variable definitions

Variable	*Description*	*Questions / statements*	*Mean*	*Std dev*
Technology transaction		A technology transaction is the buying, selling, licensing or development of a technology that needs more work before it is ready to commercialise. Such transactions cover a broad range of activities including the licensing of a new drug discovery or new mechanical component. *Please do not include technology transactions between 'parents' and their subsidiary companies.*		
Completed	Binary variable = 1 if negotiations were successful	We would like to ask a few questions about the last completed technology purchase you were involved in – either via a license, other contract, or the purchase of a company. What year did you sign the contract to purchase the technology?	0.543	0.498
Abandoned	Binary variable = 0 if negotiations were unsuccessful	We would like to ask a few questions about **the last abandoned** technology purchase you were involved in – either via a license, other contract, or the purchase of a company. *Assume an abandoned purchase is one that did not conclude within 12 months*	0.457	0.498
Cold called	Binary variable = 1 if cold called; =0 otherwise	In what context did the buyer and seller meet? (options given)	0.103	0.304
Third-party introduction, Conf. or prof. seminar	Binary variable = 1 if Third-party introduction, Conf. or prof. seminar; =0 otherwise	In what context did the buyer and seller meet? (options given)	0.265	0.442
Industry network	Binary variable = 1 if Industry network; =0 otherwise	In what context did the buyer and seller meet? (options given)	0.377	0.485
Other	Binary variable = 1 if cold called; =0 otherwise	In what context did the buyer and seller meet? (options given)	0.130	0.336
Repeat business	Binary variable = 1 if Repeat business; =0 otherwise	In what context did the buyer and seller meet? (options given)	0.125	0.331
Trust	Cardinal variable, 1-5	1=cold called; 2= Third-party introduction, Conf. or prof. seminar; 3= Industry network; 4= Other; 5= Repeat business.	2.909	1.140
Market risk	A 3-item, 7 point scale measuring the market risk.	(1) In terms of its specificity in application, how would you characterize the technology? General purpose=1…Specific=7. (2) How uncertain was the existence of a market for the final product? 1=very certain…7=very uncertain (3) How uncertain was the valuation of the technology? 1=very certain…7=very uncertain.	0.500	0.184
Appropriation risk	A 6-item average of 5 binary items and 1 7-point scale item measuring the risk that profits from the technology will be expropriated by 3rd parties	(1) At the time of negotiations, what type of formation intellectual property (IP) protection did the technology have? Registered patent='no' (2) At the time of negotiations, what type of formation intellectual property (IP) protection did the technology have? Copyright='no' (3) If there was no patent or patent pending, do you know why? Patent refused='yes' (4) If there was no patent or patent pending, do you know why? Subject matter not patentable='yes'	0.440	0.156

		(5) How uncertain was the validity of the IP protection? 1=very certain…7=very uncertain (6) Did the signed/proposed contract include exclusivity clauses? = 'no'		
People risk	A 4-item average of 3 binary items and 1 7-point scale item measuring the risk that people will not share the same interests in the development of the technology	(1) How different were buyers' and sellers' motivations? 1=very similar…7=very dissimilar (2) When did you/they first meet in-person with the prospective buyer/seller? Never='yes' (3) When did you/they first meet in-person with the prospective buyer/seller? Early in negotiations='no' (4) Did the signed/proposed contract include on-going inventor participation? = 'no'	0.440	0.287

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