Driving the Hard Bargain for Australian R&D*

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ABSTRACT *This article evaluates the long-standing argument that Australian R&D levels are low because of the restrictions imposed by scale economies in production. In so doing, it is assumed that there are no intrinsic advantages or disadvantages to the integration of research and production activities within a single firm. The rents that Australian firms could accrue by selling innovations to overseas firms with production capabilities are then determined. It is demonstrated that existing overseas firms with their own in-house research units will have a greater intrinsic willingness to pay for innovations. Hence, they will spend relatively more on R&D and innovate more often than Australian research-oriented firms.*

Keywords: bargaining, economies of scale, patent licensing, research and development.

In a recent issue of *Prometheus*, Mitchell and Stonecash[1] took the position that, in understanding the process of research and development in Australia, it is useful to distinguish between the separate tasks of inventing an idea as opposed to deriving returns from that idea in production. They noted that a long standing argument as to why Australian businesses appeared to allocate a lower proportion of resources to research and development than firms in other countries was based on an assumption that the research and production tasks must be integrated within a single organisation. The traditional argument held that, as many of the most innovative industries involved production technologies with scale economies, Australian firms, facing a small domestic market for their products, could not gain as high a return from innovation than their overseas counterparts. Hence, they would engage in less research activity.[2]

Mitchell and Stonecash challenged the traditional argument on two grounds. First, there is no a priori reason to suppose that research activity must be integrated with production to yield an economic return. Indeed, many innovations, whether patentable or not, are potentially commodifiable ideas that could be sold to firms in larger markets. Those firms could then turn the innovative idea into a marketable product. So there need be no particular reason why Australian innovators could not access production facilities located in larger markets. Moreover, even if there were some reason as to why research and production were inseparable, Mitchell and Stonecash argued, secondly, that, unless there were prohibitively high transportation costs or trade barriers, Australian firms could, in principle, still realise scale economies by selling to the larger world markets.[3]

Figure 1 provides a simple taxonomy of each of these arguments regarding the

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Advantages to integration of research and production	Trade and transport barriers: Strong	Trade and transport barriers: Weak
High	Scale economies constrain domestic research	Conduct domestic research and export produced goods
Low	Conduct research and export ideas	Conduct domestic research and export ideas and produced goods

Figure 1. Taxonomy of arguments.

constraints production scale economies place on incentives to undertake research and development. Observe that the traditional argument occupies one quadrant of the diagram while in each of the rest it is possible that research incentives could be quite high despite being located in a small market. Mitchell and Stonecash supported their challenge to the traditional view by identifying examples in each of these other quadrants. For instance, the Sarich orbital engine involved an innovation in an industry with high trade and transport barriers but that did not prevent the idea itself being exported overseas to where that industry was concentrated. A similar analysis applied to Australian generated pharmaceutical innovations where this time the important barrier to production was access to overseas distribution networks. Finally, innovations in mining represented situations in which research was either integrated into an industry with scale economies but with relatively low trade barriers or, alternatively, Australian firms both produced and exported ideas elsewhere.

While Mitchell and Stonecash presented a very persuasive argument as to why the traditional argument, as to how scale economies constrain domestic research incentives, was naive, they did not offer any explanation as to why Australia did not appear to have an overall comparative advantage in research and development. In particular, they argued that the advantages to integrating research and production were likely to be industry specific, being high in some industries and low in others. However, this implies that Australian research resources would become concentrated in those industries with a relatively low advantage to such vertical integration. Indeed, one might argue that their logic leads to the thought that the mere fact that much of the world's production is concentrated away from Australia is an argument as to why Australia might research *more* rather than less intensively than other countries. When research can be easily disintegrated from production, the logic of comparative advantage going back to Ricardo states that one country will specialise in production while others will specialise in research. Indeed, such notions are present in recent growth models.[4]

In this paper, based on the sophisticated assumptions of Mitchell and Stonecash, I wish to present a case as to why, when production facilities exist elsewhere, Australian firms might have less incentive to engage in research and development than those overseas who already own production facilities. In so doing, I will be arguing that, apart from any technological or organisational advantages to the integration of research and production,[5] there are persuasive reasons to believe that the share of the rents that

can be appropriated from an innovation are less for independent firms than those with their own internal, in-house research programs. To this end, I make the extreme assumption that there are no intrinsic advantages at all to the integration of production and research. That is, neither research nor production can be undertaken more efficiently by firms that integrate the two as opposed to a structure that has research output or ideas traded between firms. Moreover, to make the case as stark as possible I will consider a situation where the relevant production facilities must be located overseas but there are no other impediments to the flow of ideas between countries. Therefore, I concentrate my analysis in the lower left quadrant of Figure 1.

The approach here is an evolutionary one. I ask the question: in what location is research more likely to be undertaken'? The answer requires a precise understanding of the innovation incentives of independent domestic firms relative to an integrated overseas one. The analysis presented here will be relatively informal although it will be based on a more formal model.[6] In developing the intuition of that model, I will first consider what the terms of trade in ideas is likely to look like. Reflecting the title, the trade of an idea is an exercise in bargaining theory rather than traditional, neoclassical market theory. This is because an idea is a discrete indivisible good trade. Negotiations over trade in an idea will determine the share of innovation rents accruing to the Australian inventor. However, anticipation of such shares will determine relative research incentives. I will address these incentives second. A final section concludes.

Selling Ideas

Suppose that an Australian domestic firm, D, has produced a product innovation that has a positive value, V, to a foreign producer, F. In addition, suppose initially that the invention has no value to any other agent. This assumption will be relaxed later in the section. One rationale for this assumption is that F could hold key assets essential for generating economic value from the innovation. Alternatively, F could be an incumbent monopolist in the relevant world market. In this case, the maximum commercial value of the innovation is also V.

As already assumed, D has to sell to F in order to realise any returns on its innovation. Before continuing on to look at the details of that potential trade, it is worth reflecting upon here that there are generally gains to trade of innovations between an independent firm and any incumbent. Usually, the only alternative to selling an innovation—either through licensing or vertical merger—is competing with existing incumbents in the product market. However, it is almost always the case that the joint profits of an incumbent and an entrant in a product market are less than the profits of the incumbent if entry does not take place.[7] If there was only a single incumbent, this would correspond to the notion that monopoly profits exceed the sum of duopoly profits.[8] Moreover, in order to enter into the product market, an independent firm must incur some start-up costs. If, on the other hand, it were to license the innovation to an incumbent, both firms would gain. The incumbent would retain its market power while the potential entrant would save on start-up costs. Indeed, in many respects, economies of scale are constrain D's production options precisely when such start-up costs are prohibitively high. So it is generally the case that D would wish to sell its innovation to F rather than commercialise the innovation itself and become F's direct competitor.

At what price, p, will D sell the innovation to F? This price is critical in determining what share, α, of the innovation's commercial value D will appropriate. There has been much research in economics as to how parties such as F and D would bargain over the sale of something like an innovation.[9] In recent times, the bargaining process has been

viewed as a non-cooperative game in which each party has certain opportunities to make offers to the other party who can either accept or reject that offer. The problem is that, when an offer is rejected, bargaining must continue and hence, both parties, if they are impatient, suffer the costs of waiting to enjoy any share of the pie.

The notion that negotiations can potentially take time, plays an important role in bargaining over innovations. To see this, suppose that D and F agree as to the potential expected value of the innovation, V. That is, they have no different private information. If either party has an opportunity to make an offer to the other and if they want that offer to be accepted without delay, the offer price must compensate the other for their option value of waiting until another round of negotiations. Suppose that who the offer or is each round is governed by a random event with F and D making offers with equal probability. When F makes an offer to D, it must be the case that:

$$p_F \geq D\text{'s discounted expected payoff next round} \tag{1}$$

When they get the chance, if, in the future, D expects to make an offer of p_D that is accepted and that they will accept p_F then their discounted expected payoff is simply $\delta\frac{1}{2}(p_D + p_F)$, where $\delta(<1)$ is the discount rate. Similarly, when D makes an offer to F:

$$V - p_D \geq F\text{'s discounted expected payoff next round} \tag{2}$$

Once again, the right hand side could be simply equal to

$$\delta(V - \tfrac{1}{2}(p_D + p_F)).$$

Each party is torn between making a more favourable offer and the chance that it will be rejected, agreement delayed and they lose the chance to make an offer next round.

Note that, in equilibrium, each of the above inequalities will hold with equality. This is because neither party wants to give the other party more than it has to. These equations are depicted in Figure 2. In the unique equilibrium of this bargaining game both equations are satisfied simultaneously (i.e. where the equations cross in Figure 2). That is,

$$\hat{p}_D = \tfrac{1}{2}\delta V \text{ and } \hat{p}_F = V - \tfrac{1}{2}\delta V$$

Moreover, an agreement is reached on the very first round of offers. Both F and D would

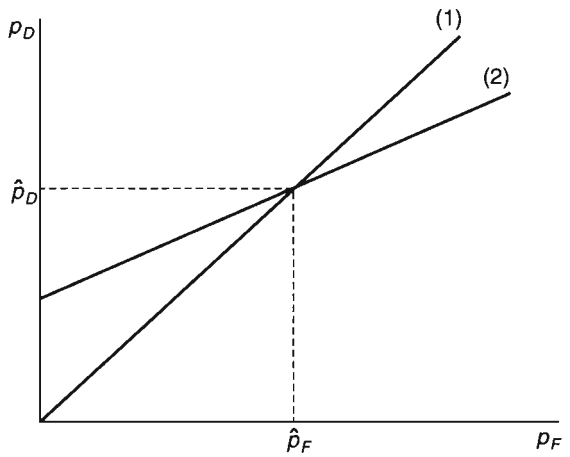

Figure 2. Bargaining equilibrium.

rather accept these offers than wait until another round. So there is no delay. The differences between the offers arise merely because of the fact that F obtains $V-p$ while D only receives p. Indeed, the expected equilibrium price is,

$$\hat{p} = \tfrac{1}{2}(\hat{p}_D + \hat{p}_F) = \tfrac{1}{2}V.$$

So for this model, because F and D are equally patient (i.e. have the same discount rate), they split the overall rents from the innovation.

The above analysis contains an implicit assumption that the intellectual property rights associated with D's innovation are very strong. This is the reason why F had to negotiate with D rather than simply continuing their own research. For many innovations, however, this will not be the case. Some innovations are not patentable as they involve tacit knowledge that its conceptual and not readily commodifiable. These innovations can be 'sold' by selling D to F, i.e. vertical integration. Other innovations, while patentable, have relatively close substitutes and can be 'worked around' to generate an innovation of comparable economic value, V.[10] The potential weaknesses of property rights mean that it could be difficult to exclude others from generating that innovation themselves. That is, so-called pre-emptive patenting might not be possible.[11] For the present analysis this means that if D has generated an innovation, this does not prevent others from continuing to research and developing an innovation of their own.

The possibility of continued research enhances F's share of the rents from innovation. On the one hand, other independent researchers around the world could potentially continue to research so long as F and D have not reached an agreement. They hope to generate an innovation and compete with D to sell it to F. From F's point of view, this is ideal and means that it will only have to pay any independent firm a small share of the rents. This possibility makes F relatively more patient than D as their expected payoff following a rejection has risen, shifting (2) to the right (see Figure 3). As a result, in equilibrium, D receives a share α of V less than one half.

Alternatively, F could continue to conduct its own in-house research. If, during negotiations, it generates its own innovation, F appropriates all of the rents from the innovation leaving D without any options. This raises the option value of continued negotiations for F, once again pushing the rents from the innovation in its favour. With its own internal research team, F is able to credibly threaten to continue research and

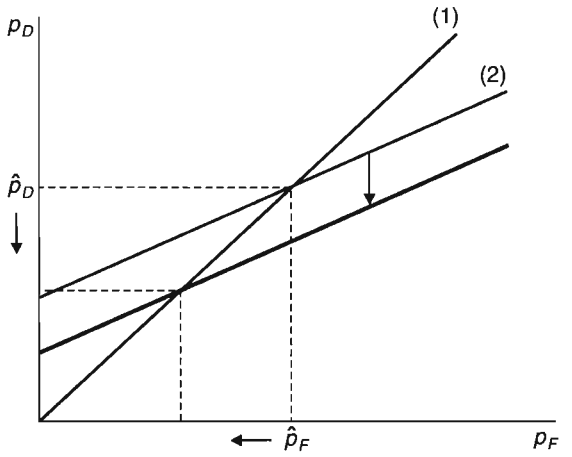

Figure 3. Bargaining equilibrium with weak property rights.

possibly exclude D entirely from economic value. The outcome is the same as when there is an alternative independent team, pushing (2) to the right and leading to an immediate agreement with D receiving less than half of V. How much less than one half it receives depends on F's efficiency in research.

Note, however, that continued research by F serves only as a threat device. There is immediate agreement so the innovative activity and the innovation are not duplicated. This does not mean that the result is socially efficient for F has a purely strategic motive to develop its own research capabilities or the capabilities of a competing independent team. The strategic advantage from having alternative researchers to D lies in its ability to give F a credible alternative during negotiations. As such, even if F's in-house research or an alternative independent team were strictly less efficient researchers than D, F's strategic incentives might cause those capabilities to be enhanced. As I will demonstrate in the next section, such possibilities diminish D's innovation incentives, further distorting the world allocation of research resources.[12]

There are two final remarks regarding this bargaining stage worth mentioning before moving on to consider the relative ex ante innovation incentives of D and F: what happens when there are alternative buyers of the innovation and when there is asymmetric information? The former possibility pushes rents in favour of D while the latter reduce overall rents. Consider the presence of an alternative buyer. Suppose that that buyer does not value the innovation as highly as F, say at $\underline{V} < V$ and that D expects to receive a share $\underline{\alpha}$ of that lower value if it were to negotiate with that alternative buyer. What this means is that D, in negotiations with F, will not make nor accept an offer that gives it less than $\underline{\alpha V}$. In this case, the bargaining equilibrium involves:

$$\hat{p} = \max[\alpha V, \underline{\alpha V}].$$

So the equilibrium price will be either unconstrained, as before, or constrained by D's outside option. Nonetheless as $\underline{\alpha V}$ must be less than V, it is still in F's interest to pay this amount (i.e. $\underline{\alpha V}$). Therefore, the strength of the outside option (i.e. how high $\underline{\alpha V}$ is), serves to shift bargaining rents in favour of D.[13]

Asymmetric information is a potential impediment to negotiations. This problem arises when D and F disagree to the value of the innovation. That is, if D believes V is relatively high. In this situation, it is possible that F's concerns that D might be overstating the value of the innovation, opportunistically, causes it to risk a breakdown in negotiations in order to achieve a lower price for the innovation. D, in turn, might hold out for a higher price and risk breakdown as it believes the innovation has higher economic value. In contrast to the complete information environment, therefore, there is a possibility that negotiations will break down and no sale will take place. This reduces the overall rents from innovation. Hence, as it is a transaction cost,[14] it means that D will expect to earn less rents from its own innovative activity. A similar effect could occur if negotiations reveal information to F about the innovation, allowing it to expropriate the idea from D. This could be because the knowledge of the innovation aids F's own internal research endeavours. Thus, the revelation of information during negotiations can also serve to reduce the rents that D appropriates.[15]

In summary, looking closely at the type of bargains that will be struck between F and D when D has generated an innovation, gives us an insight as to the rents that D can hope to appropriate. Without alternative buyers, the most D can hope to appropriate is $\frac{1}{2}V$. They could gain more with a strong credible alternative but when property rights are weak, D's share is reduced. This describes the expected payoffs D and indeed, F receives for engaging in research activity prior to successful innovation and, as will be

demonstrated in the next section, this gives us a clear insight as to who has more incentives to research.

Racing and the Incentives to Innovate

This article is ultimately concerned with explaining why D, with no product market capabilities due to scale economies and trade barriers, might have lower incentives to generate innovations than F, an overseas firm with access to production capabilities. The previous section made precise what D could expect to earn if it innovates prior to F. However, if it loses the innovation race, F will not purchase anything for it would have its own substitute innovation.

What determines D and F's incentives to innovate in this environment? Note that it is assumed that each is equally efficient in innovation. That is, given any allocation of effort towards research, each has the same probability of generating an innovation. A common way to view the research technology is a dynamic one.[16] Imagine that firms choose how many resources to allocate to research activity in any given period. These allocations, in turn, define the hazard rate or probability that D and F will generate an innovation in that period. If F generates an innovation, the race ends with F receiving V and D without anything. If D generates an innovation first, the race ends and the bargaining game as described in the previous section begins. In this case, D expects to receive $\hat{p}$ and F, $V-\hat{p}$.

There are forces pulling and pushing firms towards researching more intensively at any given moment. Pulling against concentrated research activity are diminishing returns to research effort. That is, while increased effort raises the likelihood of generating an innovation at a particular moment, the marginal rate of increase diminishes at higher effort levels. Therefore, without an offsetting effect, firms will wish to smooth their research effort over time.

Pushing them towards more intense research activity are two distinct motives. The first is an intrinsic motive. Impatient firms will prefer to obtains the rents from innovation sooner rather than later. The strength of this effect depends upon the maximum willingness to pay that a firm has for an innovation. That is, in the absence of strategic effects, what would be the maximum amount a firm would expend to generate the innovation for itself, immediately. For D this is simply the return it would get from selling the innovation, $\hat{p}$, while for F, this is V. Note that it is always the case that $\hat{p} < V$, regardless of whether there are alternative buyers or not. Therefore, F's *willingness to pay* motive always exceeds that of D.

The second motive for greater research is a strategic one. By innovating before the other firm, there is a net benefit. The *pre-emption* motive for innovation is the difference between payoffs if the firm wins as opposed to losing an innovation race. D receives $\hat{p}$ if it innovates prior to F and nothing otherwise. So its pre-emption incentive is $\hat{p}$. On the other hand, F receives V by innovating first and $V-\hat{p}$ otherwise. As such, its pre-emption incentive is also $\hat{p}$. The pre-emption incentives of F and D are identical with D motivated by a desire to sell to F and F motivated by a desire to avoid buying from D.

Overall, given that D and F have the same research technology and face the same pre-emption incentives, the only thing that separates their net incentives to research is on the basis of willingness to pay. But here F's incentives always dominate D. Therefore, in equilibrium, F will also research more intensively than D and hence, will be more likely to generate an innovation. Because of its superior position in bargaining, by holding critical production capabilities and also conducting its own research, even when D has strong property rights (in which case $\hat{p} = \frac{1}{2}V$) and strong alternative buyers (where at best

$\hat{p} = \underline{V} < V$), it cannot hope to appropriate more than V in negotiations with F. Hence, the intrinsic returns to its own research are less than those for F. Research is more likely to take place and innovations are more likely to be observed by firms who own critical production facilities.[17]

Stripped to its fundamental essence, firms that are not integrated with production facilities are at a strategic disadvantage in innovation. In the absence of offsetting effects, such as greater efficiency in research itself, this analysis suggests that access to production facilities with economies of scale could be critical to innovative incentives and hence, success. When placed in an environment favourable to the case of Mitchell and Stonecash, we are left to conclude that there is substance to the point of view that economies of scale could limit research incentives.

Conclusions

In many ways, the analysis here is only a first step towards understanding the incentives of Australian firms to conduct research and development. It has looked only at the case in which access to production facilities with scale economies and barriers to trade are important limitations. As Mitchell and Stonecash demonstrate, there are many situations in which Australian firms operate in an environment where trade barriers are low. In this circumstance, they might be credible competitors with overseas firms and hence, may be able to threaten to alter the structure of final product markets.[18] This might mean that their relative research incentives could exceed that of existing overseas firms.

Future research might employ the model of the paper to analyse policy issues. While the present paper does not suggest any specific policy alternatives it does suggest that policies directed at enhancing commercialisation possibilities for Australian innovation should be examined closely. These policies need to be aimed at maximising the returns from research. To this end, helping finance integration into manufacturing and hence, head-to-head competition with larger overseas firms is potentially fraught with difficulties.[19] The same is true of policies that prevent licensing to such firms. For given the gains to trade in ideas, especially when production involves scale economies, such integration is not only privately but socially suboptimal. Integration has direct costs and also dissipates the rents through competition with overseas firms. Thus, it reduces the overall gains that Australian researchers could achieve by innovating.

However, this is a worst case scenario. Such policies could themselves provide Australian researchers with a lucrative outside option in negotiations with overseas firms. This will help shift rents back towards Australian firms even if self-commercialisation never eventuates. It is important that commercialisation schemes such as the concessional loans be evaluated in this light. Their benefit may be in their lack of use. These are issues that definitely merit further attention.

Notes and References

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3. As Mitchell and Stonecash, *op.cit.*, Ref. 1, acknowledge, this latter argument rests on Australian firms being a least as efficient in production as their overseas counterparts.
4. For example, G. Grossman and E. Helpman, *Innovation and Growth in the Global Economy*, MIT Press, Cambridge, MA, 1991. Mitchell and Stonecash did not make this latter argument and, using a

general equilibrium model, disaggregated into a greater variety of sectors than simply research and production, the Ricardian logic is not compelling in this case.

5. See H.W. Chesbrough and D.J. Teece, 'When is the virtual virtuous?' *Harvard Business Review*, Jan–Feb, 1996, pp. 65–73, for a very clear discussion of these.
6. For formal details, I refer readers to J.S. Gans and S. Stern, 'Incumbency and R&D Incentives: licensing the gale of creative destruction', *mimeo.*, MIT, 1997.
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13. If D were able to auction the invention off to the highest bidder, the winner of that auction would be the buyer with the highest V and they would pay price equal to the second highest bidder, say $\underline{V}$. Note that it is only in the special case where more than one firm has the maximum value, V, that D can appropriate all of the rents from innovation.
14. P. Milgrom and J. Roberts, *Economics, Organizations and Management*, Prentice-Hall, Englewood Cliffs, 1992.
15. For a discussion of information revelation and bargaining for the sale of an innovation see J.J. Anton and D.A. Yao, 'Expropriation and inventions: appropriable rents in the absence of property rights', *American Economic Review*, 84(1), pp. 190–209.
16. See J.F. Reinganum, 'Uncertain innovation and the persistence of monopoly', *American Economic Review*, 73(4), 1983, pp. 741–748.
17. In Gans and Stern., *op.cit.*, 1997, it is possible that product market entry is a credible alternative for independent research firms. In this case, the incumbent might be so concerned about such competition as to give the independent firm more than the simple economic value of the innovation. Therefore, it is possible that when entry is a credible alternative, independent researchers may have superior willingness to pay incentives to the incumbents.
18. See Gans and Stern, *op.cit.*, for a complete analysis of this case.
19. For more on this see J.S. Gans, 'The inventive alternative', *Australian Financial Review*, 12th June, 1997, p. 19.