The Biomedical Sectors in Australia and Canada: A Comparative Analysis

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A comparison of the size of the biomedical sectors in Australia and Canada[1][2]

As countries, Canada and Australia have much in common. There is a shared heritage as new world British colonies and accordingly a similar culture, governmental institutions, living conditions, health and educational standards. Australia is somewhat smaller than Canada - its population of about 20m is 61% of Canada's. Both have high living standards although Canada's GDP per capita is marginally higher than Australia's. The countries also share many aspirations. One is to retain their technological edge, as innovative societies, through the commercialisation of their science base.

Little could illustrate this better than the release, within the space of a few months, of innovation strategies designed to enhance the innovation process in each country. In Australia's case, its plan was set out in *Backing Australia's Ability* (DEST 2001), which followed a number of related reports and white papers, and for Canada, the more substantial document *Achieving Excellence* (Government of Canada 2002). This provided not only a detailed analysis and assessment of Canada's innovation performance, but also identified quantifiable targets to guide future action by government and industry. Both documents focussed on similar things, strengthening R&D, accelerating its commercial application and developing and retaining skills. They also emphasised the importance of broader supportive and competitive economic settings. In both cases, the governments' policy initiatives were accompanied by substantial increases in government funding for R&D and associated support programs.

Overall Canada's and Australia's R&D performance has been fairly similar. Over many years, Canada and Australia have sat within one country ranking of each other on the OECD table of R&D to GDP ratios. In 2001 Canada was ranked 14th with a GERD/GDP ratio of 1.9% compared with Australia's position of 16th with a ratio of 1.5%.

One of Canada's *Achieving Excellence* targets is to achieve a rank in the top 5 by 2010, requiring an increase in its GERD/GDP ratio of about 1% to 2.9% if other countries were to remain the same (OECDb 2002). An ambitious target, one would think, in the context of many of the higher ranked countries adopting similar, if less formally stated, innovation policies. Of course progress up the chart can be the result of low growth in GDP as well as high growth in GERD. Finland and Sweden owe their high rank to both a high rate of growth in GERD and a low rate of growth in GDP, while Korea has high rates of growth in both. (Statistics Canada 2003a) Presumably both Australia and Canada seek higher ratios while maintaining high growth rates in GDP.

While Canada and Australia occupy similar positions on the GERD/GDP ratio table, Canada's larger GDP and somewhat higher GERD/GDP ratio results in total Canadian expenditure on R&D being significantly larger than Australia's in absolute

[1] This paper is one of a series of papers comparing the performance of the Australian and Canadian biomedical industries. Over this period new data sources have emerged and where relevant have been incorporated into subsequent analysis.

[2] The enthusiastic research assistance of Alison Welsh is gratefully acknowledged.

terms, C$20.8b compared with A$10.3b respectively in 2001[3]. Moreover the much higher proportion of R&D expenditure allocated to health – 20% for Canada compared with only 15% for Australia means that in absolute terms, health R&D expenditure in Canada is substantially higher, C$4.4b compared with only A$1.6b for Australia, about one third of the level.

Sectoral measures of R&D are typically complicated by definitional issues. However measures of health related expenditure on R&D, such as those quoted above, are reasonably comparable. They are sourced from the Access Economics report on valuing investment in health R&D in Australia, (Access Economics 2003) which has adopted a definition of health R&D expenditure similar to the one used by Statistics Canada and adjusted the Australian data accordingly.

As shown in Table 1, there are very significant differences for both public and private R&D expenditure in health. The difference is most marked for private R&D expenditure, which was C$2.2b for Canada compared with A$647m for Australia in 2001. Canadian public R&D expenditure at C$2.8b was more than double Australian expenditure of A$1.3b.

Regrettably, there is much less comparability between the indicators available for the biotechnology sectors in each country. While the Canadian sector has benefited from careful measurement by Statistics Canada for a number of years, no comparable effort has been made by the ABS, so the measures available come from less well defined private surveys, or various proxies available from general collections undertaken by the ABS.

Table 1: Australia and Canada: Biomedical Sector Snapshot

	Year	Australia	Canada	Aus % of Canada
Biotechnology indicators		No.	No.	
No of biotech companies (a,b)	2001	190	375	51%
Biotech Employment				
(Human health and related biotechs) (c,d)	2001		8791	
	2003	4171		
		A$m	C$m	
R&D - Business (Biotech related) (e,f)	2001	647	2241	29%
R&D - Business (Biotech only) (g)			1337	
R&D - Business (Health) (h,i)	2000/01	426	1575	27%
R&D - Public (incl. PNP) Biotech (j)	2001	307		
R&D - Public (incl. PNP) Health (k,l)	2000/01	1284	2835	45%
Biotech Patents issued (USPTO)	2000 to 2003	305	913	33%
General Indicators				
Population (mill) (m)	2003	19.7	32.2	61%
GDP (PPP $bill) (n)	2002	525.5	934.1	56%

[3] As at 21 May 04 A$=C$0.95.

As at 21 May 04 A$=C$0.95.
Sources:

(a) Ernst and Young 2001.
(b) Statistics Canada 2003b.
(c) Statistics Canada 2003b.
(d) Hopper and Thornburn 2003.
(e) ABS 2002e.
(f) Statistics Canada 2003b.
(g) Statistics Canada 2003b.
(h) Access Economics 2003.
(i) Access Economics 2003.
(j) Ernst and Young 2001.
(k) Access Economics 2003.
(l) Access Economics 2003.
(m) CIA 2003.
(n) CIA 2003.

Table 1 shows those indicators available for the biotechnology sector thought to be most comparable. The crux of the difficulty is that 'biotechnology' is not an industry within the industrial classification framework adopted by national statistics bureaux, but rather a set of technologies applied and developed by research institutions and companies. In its survey of biotechnology firms, Statistics Canada deals with this problem firstly by defining biotechnology as particular set of technologies and then by adopting a two-stage survey methodology. This firstly identifies organisations involved in biotechnology, while the second stage collects detailed information about their activities. From its surveys it is possible to identify those firms largely involved in biotechnology, those employed in biotechnology activities and R&D expenditure on biotechnology. Data is also available for non-biotechnology activities of these firms (Statistics Canada 2003b, 2003c).

On the other hand, the indicators of Australian activity levels in biotechnology are at best biotechnology-related because no precise definition of biotechnology is employed and no official targeted survey undertaken. The indicators most comparable are the number of biotechnology companies and biotech related business R&D. This shows that in 2001 there were 190 companies in Australia compared with 375 in Canada. The difference is more marked for business R&D. There was A$647m spent in Australia on biotech related R&D compared with C$2241m in Canada. Total Canadian business expenditure, on biotech only R&D, was C$1337m.

Employment in biotechnology firms for Australia is available from the survey conducted by Hopper and Thornburn (2003) that targets 'core biotechs'. Although few details are provided of how this is defined, it is likely to be broadly comparable to the number reported for Canadian biotechnology firms. Both sources provide details of employment in human health related biotechs and certain related sectors such as bioinformatics. This enables some comparison of employment in human health related biotechnology to be made. The Canadian number for 2001, 8791 and that for Australia in 2003 is 4171.

In the absence of other output measures, such as value added or turnover, the number of patents issued is at least an indicator of relative research outputs. In the period 2000 to 2003, there were 305 biotechnology patents issued by the USPTO to Australian inventors while Canadian inventors achieved 913 – almost exactly 3 times the number.

These indicators suggest that the Canadian biomedical industry is substantially larger than Australia's. While the indicators as discussed have their limitations, an overall pattern emerges of an industry of about 3-4 times the size of Australia's. The more favourable comparisons are for numbers of companies and public R&D expenditure while those indicating a wider disparity are for business R&D. In each case the indicators suggest that Australia's industry is small relative to the size (GDP or population) of the two countries.

Public sector investment in R&D is sometimes suggested as being relatively strong for Australia (see for instance, ABS 2002d) in contrast to business R&D, which is further down the league table. In the case of the biomedical sector, neither indicator is relatively strong when compared with Canada. For instance, Australian public R&D on health, where comparable measures are available, would need to increase by $450m or 35% to match Canada's per capita expenditure. On the other hand, business R&D expenditure on health would need to more than double, an increase of $540m. R&D expenditure on biotech related R&D would need to increase by a similar factor (about $700m).

One explanation for the more marked difference in private sector investment in the biomedical sector between the two countries, could be the close proximity of the United States and the shorter travel times to Europe compared with those to Australia. Certainly the data on alliances suggest very substantial differences in the number and size of alliances with US and European organisations and Canada compared with those for Australia.

Biomedical Alliances: Australia and Canada Compared

Neither Canada nor Australia has large domestic pharmaceutical companies that can play an anchoring and supportive role to assist the development of local biotechnology companies. While both countries have active and quite significant capital markets neither seems likely to be able finance the full development of a major drug or indeed a major technology product. Accordingly international alliances are likely to be critical in completing the testing and marketing of biomedical products.

Previous papers (Rasmussen 2004a and Rasmussen 2004b) have explored some of the dimensions of this international exchange and touched on the respective positions of Canada and Australia. In particular the evidence provided in these earlier papers suggested that Canada was undertaking an important role as a 'developer' in alliances with 'clients' in the United States and Europe. Although Australia did not have such a significant role, the number of alliances indicated that it was in the top 10 of countries ranked by the number of their biomedical alliances.

Biomedical alliances, recorded on the Recap database[4] by date of commencement, are classified according to three types of parties involved – pharmaceutical companies

[4] ReCap (Recombinant Capital) attempts to collect comprehensive, worldwide biomedical and related alliance information from press releases, United States Securities Exchange Commission filings and industry presentations. The information is limited to those alliances that are announced publicly. Sometimes this means that commercially sensitive information is withheld. On other occasions information is not reported until there are some positive results. For these reasons the information must be regarded as indicative and not necessarily a complete listing of all alliances. However, public disclosure rules generally require listed firms to announce information that is price

(drug), biotechs and universities, including institutes, research departments and government. It also classifies alliances as to their purpose – broadly drug development or technology transfer. Although there is some overlap between the two categories, since some alliances involve both technology transfer and drug development, most alliances are categorised as one or the other.

This section will focus firstly, on drug development alliances amongst biotechs and between biotechs and pharmaceutical companies and secondly, on technology transfer alliances between biotechs. The majority of alliances between biotechs are focussed on technology transfer while the majority of those with pharmaceutical companies involve drug development.

In most alliances there is a 'client', which directs and pays for the work done and another party, which we will call the 'developer' which undertakes the work and receives payment. Some alliances have high degrees of cooperation, where these distinctions are less clear or where payment is mostly in kind. In many alliances payment is contingent on success and made over an extended time. Some alliances bring together more than one company in the role of client or developer. Nonetheless for most alliances the distinction between the 'client' party and the 'developer' party is clear and Recap classifies the alliance parties based on this distinction.

The analysis in next section of this paper will focus on the role of the 'developer' in Australia and Canada. As suggested above our interest lies in the use of alliances as one of the development mechanisms for bringing biomedical products to market. Success by companies in both countries in attracting the necessary support from overseas partners has an important bearing on the overall development of the biomedical industry.

Drug Development Alliances

Drug development remains central to the economic significance of the biomedical industry. Most of its turnover arises from sales of drugs, even though a range of diagnostic devices and platform technologies have become increasingly important. Accordingly the formation of drug development alliances is critical to the development of the industry and is an area in which Canadian companies have had much greater success than Australian ones.

Drug development alliances are formed by biotechs, both with other biotechs and pharmaceutical companies. Worldwide the number of drug development alliances between pharmaceutical companies and biotechs is about equal to those between biotechs. Typically the higher value alliances are with pharmaceutical companies. Some of the larger biotechs Genentech, Biogen and Amgen, are beginning to behave like the large pharmaceutical companies and engaging in sizeable alliances with smaller biotechs. However in general, the financial capacity of biotechs is more constrained and the payout amounts involved generally lower than for those involving

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sensitive. In other cases firms find it in their interests to release information about alliances as independent validation of their research or a sign of progress towards their strategic goals. For these reasons it can be expected that information about most significant alliances is released, and therefore available to ReCap. See www.recap.com.

pharmaceutical companies. This is the case for both Australia and Canada as shown in Table 2 below.

Table 2: Drug Development Alliances: Australia and Canada 2000 to 2003

	Number		Total Payouts	
Alliance Parties	**Australia**	**Canada**	**Australia**	**Canada**
			US$m	US$m
Biotech - biotech	20	102	51	351
Biotech - pharma	11	70	222	1858
Total drug development	**31**	**172**	**273**	**2209**

Source: Recap.

Table 2 shows that over the four year period 2000 to 2003, there were more than 5 times the number of drug development alliances formed by Canadian companies as 'developer' compared with their Australian counterparts, 172 compared with 31 respectively. The difference in alliance payouts was even more marked with 8 times the value of payouts recorded for Canada than Australia, US$273m compared with US$2209m.

The data for payouts needs to be treated with some caution.[5] Payouts are the 'headline' amounts announced at the time of the alliance formation. The size of the alliance as reported, tends to be a total lump sum, incorporating actual upfront, as well as contingent payments dependent on milestone achievements. So it is a measure of firm intention to pay rather than the actual amount paid. It should however, be a reasonably reliable measure of relative size for inter country comparisons.

The average payout, for those alliances with a payout amount recorded, is also a useful indicator. Table 3 shows the average payout amount by parties to the alliance. It shows that the much smaller biotech biotech alliance payouts are much the same in each country ($16m Canada, $17m Australia). More importantly it shows that, for the larger pharma biotech alliances, the average payout amount for Australia is only 60% of the Canadian. Not only then, is the number of alliances heavily in favour of Canada, but also the size of the vital alliances with pharmaceutical companies is significantly larger.

Table 3: Average Size of Drug Development Alliances:
Australia and Canada 2000 to 2003

[5] The Recap database also contains information about the financial size of alliances and related transactions, including mergers and acquisitions, where this information is publicly available. The financial terms of an alliance may remain confidential so in such cases the anticipated payouts would not be recorded in Recap. The financial structure of alliances can vary widely, and may incorporate equity investments and outright product purchases, as well as the more usual licensing arrangements. The dividing line between alliance and acquisition is not always clear. Nonetheless, we have filtered the database to remove mergers and acquisitions and similar transactions.

	Av. Payouts Amt	
Alliance Parties	**Australia**	**Canada**
	US$m	US$m
Biotech - biotech	17	16
Pharma - biotech -	44	74

Source: Recap.

The reason for this difference is the higher proportion of much higher value, later stage alliances in Canada than in Australia, as shown in Table 4. Later stage alliances are those either in clinical trial or at the approval phase. The starkest contrast between the two countries is for payouts. While Canada has attracted later stage alliances with US$1889m in payouts, Australia has just $51m. Most of this difference arises from payouts from pharmaceutical companies, which total over US$1.6b for Canada compared with zero for Australia.

The difference between the two countries is less marked when measured by number of later stage alliances, but the majority of Australia's alliances are with biotechs and therefore relatively low value. Further examination of the data indicates that all of these alliances are either phase 1 or 2. Alliances formed at phase 3 attract higher payout levels, partly because the cost of phase 3 trials is the most expensive but also because the likelihood of success is more assured.

Table 4: Later Stage Drug Development Alliances: Australia and Canada 2000 to 2003

	Number		Total Payouts	
Alliance Parties	**Australia**	**Canada**	**Australia**	**Canada**
			US$m	US$m
Biotech - biotech	7	36	51	268
Biotech - pharma	2	42	0	1621
Total Later Stage	**9**	**78**	**51**	**1889**
% of total Drug Development	**29%**	**44%**	**19%**	**86%**

Source: Recap.

Moreover, alliances at phase 3 and approval stage have a greater focus on distribution. It is noteworthy that while about one third of Canadian alliances involve marketing and distribution only one Australian alliance is in this category. At this later stage the value of the drug can be more accurately forecast and incorporated into the payout value.

International links

One of the reasons for Canada's relative success in establishing high value alliances may be its proximity to the United States. It is doubtless more convenient to establish partnering relationships with Canadian companies, than Australian. However while Table 5 below illustrates the strength of partner relations with the United States, with 31 out of 70 pharma biotech alliances and $585m in payouts, and a further 50 biotech biotech alliances, the engagement with Europe is at least as strong. There are a total of 60 alliances with European companies with total payouts of US$1200m, US$1101m of which is for pharma biotech alliances.

In contrast, Australia's small number of pharma biotech alliances is relatively concentrated in the United States (7 out of 11). On the other hand there are 8 out of 20 biotech biotech alliances with European companies.

Canada also has a relatively large number of internal biotech biotech alliances (15 out of 102) with payouts totalling US$193m.

Table 5: Client Country: Drug Development Alliances: Australia and Canada 2000 to 2003

Client Country	Pharma Biotech Alliances				Biotech biotech alliances			
	Number		Payouts US$m		Number		Payouts US$m	
	Australia	Canada	Australia	Canada	Australia	Canada	Australia	Canada
Australia		3			5	1	23	
Canada		1				15		193
Asia	2	4	0	163	1	7	0	0
Europe (incl. UK)	2	31	3.5	1101	8	29	28	109
United States	7	31	218	595	6	50		49
Total	11	70	222	1858	20	102	51	351

This analysis serves to illustrate the relative integration of the Canadian biomedical sector into the global drug development network, through high value alliances with pharmaceutical companies located in the US and leading European countries. Compared with Australia, Canadian companies have a number of large alliances with major pharmaceutical companies. There are six such alliances in Canada with payout values over US$100m compared with the single alliance in Australia between Merck and Amrad of over US$100m.

Technology Alliances

Previous analysis of Australian biomedical alliances has indicated that Australia is relatively active in biotech biotech technology alliances. (Rasmussen Dev Paths). This section provides some comparisons of the types of alliances formed by Canadian and Australian biotechs, both in the role of developer and client. It also compares for Australia and Canada, the countries involved in the technology transfer, either as client or developer. It focuses on biotech biotech alliances. Most technology transfer alliances (over 80%) are between biotechs.

Recap classifies certain alliances by technology. These include both general platform technologies applied to the general discovery and development of drugs such as screening, recombinant chemistry, genomics etc as well as 'other technologies' targeted on various drug classes such as monoclonal antibodies. It also identifies those involved in diagnostics and devices. Some alliances are classified as belonging to more than one technology type. On average there are about one and a half technologies per alliance.

There is also some overlap between alliances involving drug development and those classified according to a particular technology. Based on sampling, some 25-30% of alliances are categorised according to both a stage in the drug development process and a particular technology. The data on technology alliances presented in this section includes this proportion of drug development alliances.

Table 6 presents the number of technologies involved in alliances (called 'alliance technologies' since there may be more than one technology for each alliance, rather than alliances) formed by Australian and Canadian biotechs, both in their role as developer and as client, over the period 2000-03, by broad type of technology.

As developer, Australia has a relatively high proportion of GPT alliance technologies (about half of its total) compared with Canada which has about 37%. Other technologies, which are mainly technologies directly related to drug discovery and development, are high for Canada, 82 or about half of its total alliance technologies. This suggests a different emphasis in the two sectors. Canada has been much more successful in attracting drug development alliances and this is reflected in the higher 'other technologies' component. Australia has had more relative success in platform technologies and devices. Platform companies such as Proteome Systems and Eiffel Technologies have each formed several alliances over the period.

As a client, each country has formed a similar proportion of GPT alliance technologies, about half, while Australia has a higher proportion of device and diagnostic technologies. Canada on the other hand has a higher proportion in 'other (drug related) technologies'. The pattern that emerges from this data is that Australia has a relative focus, both as a developer and client, on platform technologies, diagnostics and devices while the larger number of 'other technologies' reflects Canada's much greater involvement in drug development.

Table 6: Biotech Biotech Alliance Technologies s by Type: Australia and Canada 2000-03

	Developer		Client	
Broad Technology	Canada	Australia	Canada	Australia
Device	10	6	4	2
Diagnostics	15	6	5	12
GPT	64	32	74	25
Other Technology	82	25	51	13
Grand Total	171	69	134	52

Table 7 sets out the countries of domicile for companies partnering Australian and Canadian companies. It shows the number of alliances (not 'alliance technologies') for each country involved in a technology alliance with Canada and Australia, both in the role of developer and client.

Table 7: Biotech Biotech Technology Alliances by Country: Australia and Canada 2000-03

	Developer		Client	
	Canada	Australia	Canada	Australia
Australia	1	7		7
Canada	10		10	1
Europe	29	11	21	4

United States	66	18	55	23
Other	12	3	3	
Total	118	39	89	35
Aus % Canada		33%		39%

In its role as developer, Canada formed 118 technology alliances, 56% of them with the United States and 25% with Europe, over the period 2000-03. Australia formed 39 technology alliances, 46% of them with the United States and 28% with Europe. As client, Australian and Canada companies had 66% and 62% respectively of their alliances with the US, indicating its importance as a source of leading edge technology.

It is noteworthy that both countries have an almost equal number of alliances in which it acts as ‘client’ and as ‘developer’ – Australia, 35 and 39 respectively and Canada, 89 and 118 respectively. It is typical of those companies involved in technology alliances that the trade is two-way. Proteome Systems formed three alliances over the period as developer and four alliances as the client. Agen Biomedical (Agenix) has several alliances of each kind. Such companies require leading edge technologies as inputs to the development of their own products, as much as they require support from companies interested in helping them in the development of their products.

Table 7 also enables a comparison of Australian and Canadian biotech alliance formation. This shows that Australia’s relative position with respect to Canada, is somewhat better for technology alliances than for drug development alliances. As developer, the ratio of Australian alliances to Canada is 33% compared to less than 20% for drug development alliances. However, this is still significantly less than what might be expected on a population or GDP basis (61% or 56% respectively)

The significance of payout values may be less for technology alliances, where the in-kind values may be relatively more important. Certainly average payout values for technology alliances are a fraction of those pertaining to drug development alliances. Nonetheless the differences between Australia and Canada for technology alliance payouts is very significant $275m over the period for Canada compared with $34m for Australia. In part this reflects Canada’s greater focus on higher value drug development technologies.

Possible Explanations

This brief analysis of the biomedical industries in Canada and Australia suggests that the industry in Canada is much larger and more substantially integrated into the global biomedical industry than is simply explained by the relative size of the two countries. While there are significant issues of data definition in comparing the size of the industries in the two countries, the differences across the range of indicators are sufficient to suggest that the industry in Canada is 3 to 4 times the size of its Australian counterpart. This is supported by the data on alliances discussed above, which indicates that the degree of global integration of Canadian companies is substantially greater than is reflected in the differences of size between the two national industries.

The growth of the biotechnology industry is typically ascribed to five broad factors. (see for instance Zucker et al. 1998, Hall et al. 2002, Government of Canada 2001). These are:

- Excellence of the life science base
- Generous government funding of health and biotech related R&D
- Availability of finance - government start up grants, venture capital or other risk capital
- Strategic alliances that provide technology access and product development support
- Favourable regulatory regime (or absence of an unfavourable one)

For each of these factors, there are many subsidiary factors and issues of measurement and emphasis. For instance what makes for an excellent science base and how is it measured. Zucker et al. (1998), for instance, suggests that it is the location of star scientists, which is critical. Others use more general indicators such as number of papers, patents and citations (see for instance CHI report for ARC and CSIRO (ARC 2000)). Some of the factors are closely interrelated and have high levels of dependency. For instance the level of government funding has a considerable bearing on the quality of the science base.

It is beyond the scope of this paper to provide a detailed evaluation of each of these for Australia and Canada. Clearly the earlier part of the paper provides a strong basis for consideration of the influence of strategic alliances, but the other factors can at best be sketched out at this stage.

The Life Science Base

Both countries would claim that their science base is a competitive advantage in establishing a biomedical industry. A recent analysis of the comparative positions of the two countries appears in the Third European Report on S&T Indicators (European Commission 2003) for the period 1995-99. This suggests that both countries have a relatively powerful life science base. Canada is ranked 6th in the world with 25,039 publications while Australia is ranked 11th with 13,200 (about equal on a population adjusted basis). However Canadian research is cited more frequently, 8.9 times compared with 6.9 for Australia. This puts Canada up to 3rd in the world, while Australia remains 11th ranked. The mean field citation score in basic life sciences, considered the most accurate in levelling out various country size distortions, still has Canada ranked ahead of Australia, 6th vs 14th. A number of smaller European countries improve their positions, as does Singapore, based on this measure.

Table 1 showed that the number of biotech patents issued by the US Patent Office over the period 2000-03 totalled 305 for Australia compared with 913 for Canada. An analysis of patents prepared by CHI (ARC 2000) shows, for the period 1994-98, a similar pattern to that of scientific papers. Canadian patents in the pharmaceutical and biotechnology sectors tend to be cited more frequently than Australian ones. It is this citation by subsequent patents that has been found to correlate closely to the value of the technological advance made by that prior patent (ARC 2000, p. 24). To measure this, CHI constructed a ‘current impact index’. For the biotechnology sector it was 1.02 for Canada and 0.88 for Australia. For the pharmaceutical sector it was 1.12 and 0.84 for Canada and Australia respectively. Each of these indices was relatively high in terms of country rankings – Canada was second, behind the US, in both the biotechnology and pharmaceutical sectors, amongst a group of 10 selected competitor countries listed in the report. Australia ranked 5th and 4th in the biotechnology and pharmaceutical sectors respectively.

This analysis suggests that while Australian science is certainly world class, it does not have the equivalent impact of the Canadian life sciences.

Public Spending on Life Sciences R&D

Table 1 provides a number of indicators of public expenditure on life sciences related R&D. The most comparable measure between the two countries is public expenditure on health R&D. This showed for 2001, that Canada's expenditure was substantially higher, C$2.8b compared with Australia's of A$1.3b. It is of course expenditure over many years, which establishes the value of the science base. Unfortunately comparable time series data is not readily available so it is not possible to assess whether this relativity has persisted over say the previous decade. However as calculated earlier in this paper, Australia's public R&D expenditure on health would require a lift by about A$450m, a reasonably hefty increase to achieve comparability on a population basis.

Availability of Finance

Comparative measures of sources of finance for the biomedical sector are at best patchy. For instance a survey of Australian venture capitalists (AVCAL) indicates that venture capital investment in Australian biotechs was A$257m in 2001, while the Canada Statistics survey of Canadian biotechs suggested that the Canadian figure was C$363m. Such figures are however subject to considerable year-by-year variation. The Australian figures for 2000 and 2002 are A$41m and A$53m. Comparable data are not available since the Canadian survey was not conducted for those years.

An alternative view of private sector funding is provided by business expenditure on R&D. While this will include some expenditure provided by government sources, at least for Canada, this appears to be less than 3% of the total (Statistics Canada 2003d). Again comparability of coverage is an issue, however as shown on Table 1, biotech-related business R&D expenditure was $C2241m for Canada compared with A$647m for Australia in 2001. Similarly business R&D expenditure on health was $C1575m for Canada compared with A$426m for Australia in 2001. If these figures are at all indicative, then the availability of private sector funds for Canadian biomedical and other biotech companies is almost four times that available to (or required by) their Australian counterparts.

Strategic Alliances

The analysis of strategic alliances presented in this paper indicates a considerable gap between Canada and Australia. This is particularly the case for drug development alliances, but also applies to technology alliances. Canada's close proximity to the United States might be expected to give it a particular advantage. Certainly Canada represents a close-by, lower cost source of biomedical research expertise, than many companies in the United States (KPMG 2002). However it is only a partial explanation. Canadian alliances with European companies seem to be of at least equal breadth and depth.

One particular advantage apparent from the analysis is that there is a greater number of later stage drug development alliances formed by Canadian companies. Presumably this reflects a more advanced drug development pipeline than Australia's. However whether the existence of high value, later stage alliances is a cause or effect is more difficult to judge. The broad based participation by both European and US large pharma, capable of large investments, is certainly a feature of the Canadian alliances.

Relatively speaking, Australia's strength is in platform technologies, diagnostics and devices, but even in these, compared with Canada, Australia 'punches well below its weight'.

Regulatory Environment

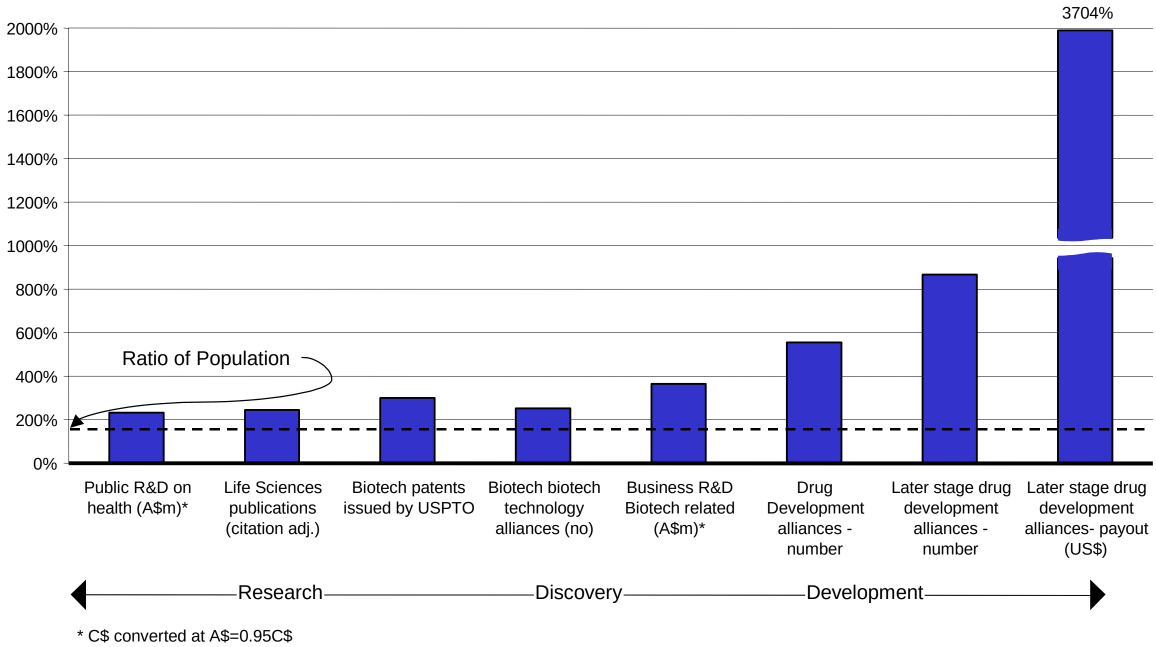
As is widely recognised the regulatory environment for the biomedical sector is fundamental to the conduct of the industry. This covers patent protection, product approval and sales approval by national and provincial agencies. Both Canada and Australia offer similar levels of IP protection and this should be competitively neutral between the two countries. The key regulatory authority for product approval is the US FDA, which stands guard over the world's largest market. Companies in both countries therefore, seek approval through much the same process.

The sale of drugs is controlled, in both Canada and Australia, by governmental bodies and the key issues are delays in the approval of drugs available for sale and the price of those drugs. The price of drugs for the Australian market is set under the Pharmaceutical Benefits Scheme and Canadian prices are set by the Patented Medicine Prices Review Board. Sweeny (2003**)** shows that Australian prices are 30-40 %, and Canadian prices are some 50-60%, respectively of US levels. Canadian prices are however above those generally prevailing in Europe. It has been suggested that the low level of Australian prices acts as a disincentive for pharmaceutical companies to support Australian biomedical research and product development. Certainly the higher relative prices in Canada may act to its advantage.

Policy Implications

Canada appears to be ahead of Australia across a broad range of measures from public support for health R&D to the number and value of drug development alliances. The relatively high drug prices also helps to support an industry, which is significantly larger than Australia's. Chart 1 draws together the key indicators used through the course of this paper to measure the relative size of particular aspects of the sector in the two countries.

Chart 1: Ratio of Key Canadian to Australian Indicators for the Biomedical Sectors



See Appendix A for details of measures used.

The indicators are presented according to their approximate position in the value chain, from the level of public investment in health sciences, to measures of research outputs and business inputs and finally, the value of alliances, at the later stages of the drug development pipeline. The reservations and qualifications that pertain to each of the indicators have been discussed through the course of the paper.

However what is striking about the ratio of Canada to Australia for each indicator is how a relatively modest difference between the two at the beginning of the pipeline, develops to be of such a magnitude towards the end. The benchmark could be considered to be the difference in population between the two countries(163%). The additional investment made by Canadian government agencies is reasonably significant at 232%, but the indicators of research output is higher, 245% for publications and 299% for patents issued. Technology alliances typically focus on the discovery or early development stage of the drug pipeline and is area where Australia is not so weak, with the ratio of the number of alliances being 252%. The majority of business R&D, which in Australia and Canada tends to be invested early in the development stage, has a ratio of 365%. Drug development alliances provide support for biotechs over each of stage of the pipeline, but most of the differences emerge in the later stages (phase 3 and approved) when the ratio in the number of alliances increases to over 8 times and that for total payout value to 37 times.

This suggests that compared with Australia, Canada's biomedical sector enjoys a virtuous circle in which a relatively small but significant difference in public sector investment appears to produce a very substantial difference in industry performance in the later stages of the drug development pipeline. At each stage the differences between the two countries are magnified.

If Australia's biomedical sector was to match the performance Canada's, this analysis suggests that industry policy could usefully focus on three aspects of the drug development pipeline:

- Public expenditure on health and biotech related R&D
- Funding to complement private financing of commercial development
- Policies designed to attract large pharmaceutical companies to partner biotechs

Australia's pride in its small number of successful life science developments, perhaps diverts attention from its relative position overall, behind Canada and some of the smaller European countries. Much follows, in terms of private investment, from the potential commercial value of the outputs of the life science research base. Given the importance of strategic alliances and therefore the need to attract the attention of overseas pharma and biotechs, Australia's relative, as well absolute output, is important. Australia's public expenditure appears to be low relative to Canada and its effectiveness, as measured by citation adjusted publications and patents, is further shaded by Canada.

Both countries share similar industry objectives in this area, as demonstrated by their parallel innovation policy announcements. Canada has restructured in research funding institutions establishing the Canadian Institutes for Health Research and a well funded Genome Canada to focus research in that area. (Industry Canada 2001). Likewise Australia is increasing its efforts in similar areas through additional funding of research infrastructure, the CRC program and the ARC (DEST 2001). More recent comparative data would be useful in identifying any changes in relative position, but if this has occurred it is yet to feed through into number of patents issued or the number and value of later stage alliances for which recent data is available. Higher levels, of more commercially focussed public research funding, seem to be necessary for Australia to close the competitive gap.

Canadian business biotech and health related R&D appears to be significantly higher than Australia's. In Australia there is a range of policies designed to increase business investment in innovative industries. Funding for the R&D Start program has been increased and jointly funded venture capital funds have been promoted. Tax incentives have however been the largest of these, in terms revenue foregone, in recent years but have recently been wound back. Canada claims to have one of the most generous R&D incentives in the world. Its 35% tax credit for Canadian controlled private companies is refunded to firms as cash.(Industry Canada 2001)

Strategic alliances are extremely important at all stages of product development, but this is particularly the case in the later stage. The recently announced P3 program focuses 'on the develop[ment] of medicines for global markets and [to] encourage multinational firms to foster partnerships with local players' (DITR 2004). It has available $150m over 5years to support expenditure on R&D. First round offers have been made, to both large pharma and Australian biotech, for amounts up to $10m. Its objective is to encourage the formation of partnerships, but whether its scale is of sufficient size too to have a serious impact remains to be seen.

Canada has established Technology Partnerships Canada, which invests a range of ‘high tech’ projects that include biomedical projects. However the fostering of partnerships intent on commercialisation seems to be only part of its brief.

More work is required on the policy initiatives announced by the two national governments, and the complementary policies of the state and provincial governments, to assess their likely impact on the biomedical sector of the two countries. Each government has advanced policies to address the key policy levers – R&D, risk finance and strategic alliances but an assessment of their effectiveness requires more serious analysis.

Conclusion

This paper has compared the size of activities conducted by the biomedical sectors in Canada and Australia using a range of indicators. It has paid particular attention to differences in alliance formation. It has found that the Canadian industry is significantly larger than Australia’s across many facets of the value chain. From the indicators available, it appears that these differences become more marked towards later stages of the value chain.

Compared with the relative size of the two populations, there appears to be no area where Australia could claim to be ahead. While there are issues of comparability in each of the indicators available, the marked differences suggest that it is reasonable to conclude that in relative terms, Australia appears to be behind in public expenditure on R&D, as well as in the effectiveness of its research output. Similarly business R&D is significantly lower, as is the level of alliance formation.

More work is required on the policy implications of this analysis. Both countries have announced remarkably similar innovation strategies. An analysis is required of their implementation in order provide a basis for valuing their effectiveness and to identify where they might be strengthened.

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Appendix A

Table A1: Key Indicators for the Canadian and Australian Biomedical Sectors

Indicator	Year	Australia	Canada	Canada % Aus
Population	2003	19.7	32.2	163%
Public R&D on health (A$m)*	2000/01	1284	2984	232%
Life Sciences publications (citation adj.)	1995-99	91080	222847	245%
Biotech patents issued by USPTO	2000-03	305	913	299%
Biotech biotech technology alliances (no)	2000-03	121	305	252%
Business R&D biotech related (A$m)*	2001	647	2359	365%
Drug development alliances				
- number	2000-03	31	172	555%
- payout (US$)	2000-03	273	2209	809%
Later stage drug development alliances				
- number	2000-03	9	78	867%
- payout (US$)	2000-03	51	1889	3704%