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Measuring Scientific Activity in Canada and Australia before 1915: Exploring Some Possibilities

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See table of contents

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Measuring Scientific Activity in Canada and Australia before 1915: Exploring Some Possibilities

Richard Jarrell

Introduction

Let it be stated at the outset that the historian of Canadian or Australian science almost inevitably, without heroic effort, must strike a defensive pose. Because the history of science has, as a professional discipline, so long wedded itself to great men and to great ideas, any study of science in the dominions on such terms will come up short. At least before the 1950s, important research—as measured by traditional international standards—was, for both countries, the exception, not the rule. True, the award of a Nobel Prize to Banting and Macleod in 1923 was a bracing tonic for the youthful Canadian scientific community, yet it was a feat not repeated for a half-century. Is it possible, without some sense of inferiority, to construct a traditional history of science noting that William Bragg, ingenious researcher at Adelaide, had to return to England to enter the lists of physics? And to whom did he appeal from his isolated outpost but Ernest Rutherford, who had himself proceeded from McGill University to the scientific metropolis, having escaped two peripheral scientific nations, Canada and New Zealand?

Fortunately, the history of science is freeing itself, if slowly, from the thrall of a narrow vision of science that places a premium upon so-called pure science, centred upon universities. If we fix our sights upon a list of scientific 'firsts,' like latter-day Poggendorfs or Darmstädters, then we would be hard pressed to explain how both colonies emerged as sophisticated and wealthy nations. Scientific activity, of course, is a much broader, richer enterprise. We now perceive the contours of Canadian and Australian science in sufficient detail to recognise that their respective development during the last century differed in significant ways from that of European nations, though both exhibited features of American science.

There is no question that Canadian, American and Australian science were each once colonial, in the sense that their scientific priorities were dictated from beyond their own boundaries. When had Canada or Australia moved beyond this stage? There can be no doubt that this occurred for Canada in the half-century between Confederation and the first World War, and it happened on all

fronts, industrial, educational, institutional, organizational and governmental. For Australia, the transition seems to have occurred later, but was well under way before the war.[1]

For the period under consideration, we cannot deny that the hallmark of scientific activity in both dominions was practicality, though 'practicality' was a protean conception, changing in time and space.[2] The overwhelming preoccupation with the application of scientific knowledge for economic and social development did not necessarily entail a lack of interest in knowledge for its own sake. But when we measure scientific activity, we find the latter to be a small fraction of the former, even if the ratio changed over time.

Two kinds of frameworks to which we can affix our facts immediately present themselves: the developmental and the structural. The first is epitomised by Basalla's 'colonial science' model and the more sophisticated version of MacLeod.[3] This analysis sees the development of science as a passage through phases from complete dependency to eventual self-reliance. This view easily accommodates itself to a centre-periphery analysis. A structural approach focuses upon the actors, institutions and relationships with other parts of society. In their study of Australian science, Inkster and Todd[4] posit three structural elements: basal, infrastructural and superstructural. The first refers to factors supporting or constraining science such as population, urbanization, occupa-

1 Of course, depending upon how elastic our definition is of 'colonial,' we can find examples much later of 'scientific colonialism.'

2 See Ann Mozley Moyal, *Scientists in Nineteenth Century Australia. A Documentary History* (Stanmore: Cassell, 1976) and Trevor H. Levere and Richard A. Jarrell, (eds) *A Curious Field-Book: Science and Society in Canadian History* (Toronto: Oxford University Press, 1974). These documentary overviews of the nineteenth and early twentieth centuries, whilst stressing the pragmatic side of Australian and Canadian science, do not come fully to grips with the role of the state. On the Australian rhetoric of practicality, see Roy MacLeod, 'The "Practical Man": Myth and Metaphor in Anglo-Australian Science,' *Australian Cultural History* 8 (1989), 24-49.

3 George Basalla, 'The Spread of Western Science,' *Science*, 156 (5 May 1967), 611-22; Roy M. MacLeod, 'On Visiting the 'Moving Metropolis': Reflections on the Architecture of Imperial Science,' in Nathan Reingold and Marc Rothenberg (eds), *Scientific Colonialism: A Cross-Cultural Comparison* (Washington, DC: Smithsonian Institution Press, 1987), 217-49. One is easily enticed into thinking that such models are explanatory rather than descriptive; MacLeod wisely eschews the former. For an examination of this approach, see R.A. Jarrell, 'Differential National Development and Science in the Nineteenth Century: the Problems of Quebec and Ireland,' *ibid.*, 323-50.

4 Ian Inkster and Jan Todd, 'Support for the scientific enterprise, 1850-1900,' in R.W. Home (ed.), *Australian Science in the Making* (Cambridge: Cambridge University Press, 1988), 102-32. See, also, Inkster, *Science and Technology in History* (New Brunswick, NJ: Rutgers University Press, 1991), and Todd, 'Science at the Periphery: An Interpretation of Australian Scientific and Technological Dependency and Development Prior to 1914,' *Annals of Science* 50 (1993), 33-58.

tions, communications, nature of staple exploitation, in short, uniquely local conditions. The infrastructure of science refers to those institutional supports required for the growth of a scientific community, whilst the superstructure refers to the individuals and institutions who 'do' science in our conventional historical sense. These two approaches are not mutually exclusive; any reasonable account of national science would give us a 'moving picture' of the matrices of individual and institutional actors of growing complexity and shifting linkages. An important question from the developmental perspective is whether one can discern discreet points at which the picture shifts in significant ways ('phases'). If such points do exist, are they indicative of some fundamental shift in structural elements? From the structural point of view, can we be certain to have isolated the relevant factors and to have demonstrated their connexions? Clearly, we have some distance to go before offering more than generalised schemata.

In this article, I have a more limited ambition. I would like to explore a means to compare scientific activity in Canada and Australia before World War I. For the moment, I shall leave unexamined the question whether such a comparison is valuable (it is the *raison d'être* of this volume) and concentrate upon what one might compare and how. Looking to Inkster and Todd's structural elements, we may note that historians of science have a broad knowledge of the infrastructural and superstructural elements for both countries. We can juxtapose these histories and the similarities are striking and interesting if we refrain from making invidious comparisons with contemporary British or Continental science. Much less explored are the linkages between the basal elements and the other two, where the role of the state is central.

1. Methodology

As I have argued elsewhere,[5] we can analyse the expenditure patterns of governments over time to obtain an aerial view of the relationship between the state and scientific activity. The modern measurement of R & D expenditures is inappropriate for nineteenth-century Canada and Australia and the statistical data that we possess[6] for the period sheds no light on scientific expenditures, as these were not matters of interest to government statisticians. As a rough-and-

5 For Canadian-US comparisons, see R.A. Jarrell, 'Science and the State in Ontario: the British Connection or North American Patterns?' in R. Hall, L. MacDowell and W. Westfall (eds), *Patterns of the Past: Interpreting Ontario's History* (Toronto: Dundurn Press, 1988), 238-54; for interprovincial comparisons focusing upon agriculture, see Jarrell, 'Science and the State in Nineteenth Century Canada: Nova Scotia Discovers Agriculture,' in Paul Bogaard (ed.), *Profiles of Science and Society in the Maritimes* (Fredericton: Acadiensis Press, 1990), 221-42.

6 For Canada, see F.H. Leacy (ed.), *Canadian Historical Statistics* (Ottawa: Statistics Canada, 1983) ; for Australia, refer to N.G. Butlin, *Investment in Australian Economic Development 1861-1900* (Canberra: Australian National University, 1972).

ready measurement, I define a *Science-Related Expenditure* (SRE) as any budgetary expenditure that has an obvious scientific component, including science-based technological activities. This form of measurement recognises that state support for scientific activity was threefold: support for scientific infrastructure (universities, societies, institutions), support for science as a tool of governance (inspection, regulation) and support for science as an economic engine. Examining the changes in the types and levels of support gives us a reasonable first approximation of science's importance to government and allows for direct comparisons between jurisdictions.

Defining an SRE is not unproblematic: if 'health of animals' is a budgetary entry, what part of the expenditure is specifically scientific? Just the salaries of veterinarians and laboratory costs? It is usually impossible to define so specifically, particularly toward the end of our period when budgetary lines multiply rapidly and details vanish from annual statements. There are always overhead costs in any government operation (or in any non-governmental institution supported from the state treasury), so it is easiest to take the total figure. The same objection can be levelled at modern measurements of R & D expenditures. Put simply, if there were no scientific basis for the control of animal health, no such budgetary expenditure would appear. If we broaden our definition of 'science' in this way, it is not surprising that we would classify the vast majority of SREs as applied science, *not* the production of new science. However, in nations that are developing themselves, large expenditures of so-called pure science would be an unaffordable luxury, assuming those in power would even consider such expenditures as legitimate.[7]

The specific mechanical task required to obtain the statistics for such an analysis requires locating the most useful tabular summary of a government's annual expenditures. Fortunately, both Canadian and Australian local governments published annually their expenditures in (usually) easily read form. These might be treasury reports, auditors' reports or supply votes. Normally, Canadian jurisdictions reported final expenditure accounts, in great detail for the earlier years. Australian colonies varied. Most provided, in their parliamentary papers, detailed expenditure lists. Often, appropriations are more accessible than expenditure accounts.[8] Typically, there is sufficient detail in the expenditure lines to categorise them (Tasmania is an exception). Once one is accustomed to a

7 In fact, an examination of United Kingdom expenditures for our period reveals only a very small fraction devoted to science in the more restricted sense. Of more interest, for comparative purposes, is how little the UK spent upon applied scientific activities compared with the dominions and with the United States.

8 In a number of cases (Victoria is particularly problematic), supplementary votes appear in later volumes of the parliamentary papers, requiring some searching or revising to obtain a reasonably accurate final list. In such cases, it is easier to utilise the original appropriations; although they might not precisely match the final expenditures, they do provide us with a sense of the legislators' intentions.

particular accounting scheme, and has made decisions on what is or is not an SRE, then scanning public accounts goes quickly, if tediously. Arithmetic manipulation of the data is simpler if one employs a computer spreadsheet. Hitches in the smooth entry of data occur when one encounters changes in accounting systems, the constant shifting of agencies or lines to different ministries and the emergence of entirely new activities. For this study, I scanned all Australian colonial and state parliamentary papers between 1860 (or first account) and 1920 and the same for Canadian provinces from 1867 (or first account), along with federal accounts from 1867 to 1920.

One important SRE is almost impossible to reconstruct: the specific allocation to science in the education system. Accounts of public instruction in no jurisdiction convey more than the general expenditure on education. Even if we possessed local school board accounts, it is unlikely one could identify specific science-related costs. In a few cases, the public accounts do mention grants to school districts for apparatus or laboratories. University grants are also difficult (or impossible) to assess. Only for technical education (manual training, agricultural education, etc.) do we have access to the numbers, as it was normally considered distinct from public instruction in this period.

One further proviso: a direct comparison between Canadian and Australian expenditure patterns is not quite possible given the asymmetry of jurisdictional patterns. Before 1867, direct comparability is possible between the four existing British North American provinces and the five existing Australian colonies. After that date, Canada became a federal state, with the federal government taking on some exclusive powers, the provinces others and with some overlap of still others. By World War I, Canadian federal SREs were quite significant. The constitutional allocation of powers in the Commonwealth of Australia differed significantly from Canada. Between 1901 and 1920, the individual states maintained the lion's share of SREs. However, for this exercise, the patterns of expenditures and their relative importance are more valuable than the monetary figures.

A financial overview of science-related activities is no substitute for critical studies of the events and forces reported in the statements. What makes this approach useful at this stage of the historiography of science is its value in highlighting potentially interesting transitions, similar to the way a mineral prospector relies upon geological maps to pinpoint areas for intensive investigation. The existing literature, concentrating as it does upon individuals and scientific institutions and organisations, leaves a great void in our knowledge of science-state relationships.[9] The aerial-view approach provides a shortcut to delineate interesting

9 A scan of bibliographies will show the neglect of this side of the scientific enterprise: see Moyal, *op.cit.*; R.A. Jarrell and A.E. Roos, *A Bibliography for Courses in the History of Canadian Science, Technology and Medicine* (Thornhill: HSTC Publications, 1979); and current bibliographies in *Records of Australian Science* and *Scientia Canadensis*.

problems. It does not displace the need for 'ground-up' research on government departments and agencies, pursued with a variety of documents but primarily government reports. Anyone who has worked with parliamentary papers and departmental reports recognises the challenge of reconstructing the relationship between state agencies with society, let alone the internal development of those agencies. However, concentrating upon a single agency might, by falling into the classic trees-and-forest trap, obscure larger currents. One could write a history of a department of forestry, for example, without being sufficiently cognisant of related ministerial activities (e.g., agriculture or fisheries) to understand the place of forestry in a broader policy of economic development. The conscientious historian will object that this is unfair. A glance at the growing stack of 'official' or 'commissioned' histories of agencies will show that I am not exaggerating the importance of the synoptic view. In this brief survey, I will turn first to a comparison of the two largest jurisdictions in Canada and Australia, then to federal activities and finally to some broader statistical questions about science-related activities at the provincial/state level.

2. Science and the State: New South Wales and Ontario

Well before the rise of federal regimes, governments in the largest colonies created models that would influence other jurisdictions. I have chosen New South Wales and Ontario for comparisons because they were the most populous jurisdictions in their countries by World War I, although neither was significantly larger than its nearest competitor, Victoria and Québec, respectively. Table 1 compares the population growth of the two jurisdictions and their largest cities, Sydney and Toronto. Although total populations were similar, the metropolitan concentration was different: by 1911, Toronto accounted for 15% of the provincial population, but Sydney-siders dominated their state with 38%, reflecting the Australian pattern of city-states with sparsely-settled hinterlands.

Apart from the fact that both were the most populous and diversified political units in two 'settler' dominions (and settled almost simultaneously), do other bases for comparison exist? In both, the industrial, mining and agricultural sectors were important for development. In both Canada and Australia, the role of the state for development was significant from the outset. However, the 'interventionist state' took on different forms in the two countries, so that comparability is a higher-level generalisation.[10] In the realm of development,

10 A dated, but still useful overview of the differences can be found in Noel G. Butlin, 'Colonial Socialism in Australia, 1860-1900,' 26-78, and Hugh G.J. Aitken, 'Defensive Expansionism: The State and Economic Growth in Canada,' 79-114, in Hugh G.J. Aitken (ed.), *The State and Economic Growth* (New York: Social Science Research Council, 1959). For more detailed accounts of Australian economic development before and after

TABLE 1.
POPULATION OF ONTARIO
AND NEW SOUTH WALES, 1871-1911*

CENSUS YEAR	ONTARIO	TORONTO	NEW SOUTH WALES	SYDNEY
1871	1,621,000	59,000	503,000	135,000
1881	1,927,000	96,000	750,000	221,000
1891	2,114,000	181,000	1,124,000	383,000
1901	2,183,000	208,000	1,355,000	482,000
1911	2,523,000	377,000	1,647,000	630,000

* Ontario population figures are drawn from Dominion Bureau of Statistics, *Canada Year Book 1911* (Ottawa, 1912); New South Wales figures are those reported in Wray Vanplew, ed., *Australians. Historical Statistics* (Broadway, NSW: Fairfax, Syme and Weldon, 1987), 26 and 41.

for example, Ontario was more directly interventionist than contemporary governments in New South Wales, although Painter's claim that for the latter, 'state involvement was applauded as a sign of the application of "science" to national development, and the "cult of the expert" was a strong influence on the administrative style and political attitudes alike' could easily be applied to Ontario, but for an earlier period.[11] The asymmetry of the two federal systems (and their timing) also complicates the comparison. Nevertheless, the SREs are sufficiently similar for us to try.

1900, see Butlin, *Investment in Australian Economic Development 1861-1900* (Canberra: Australian National University, 1972) and Butlin, A. Barnard and J.J. Pincus, *Government and Capitalism: Public and Private Choice in Twentieth Century Australia* (Sydney: George Allen and Unwin, 1982); for Ontario, see I.M. Drummond, *Progress without Planning: the Economic History of Ontario from Confederation to the Second World War* (Toronto: University of Toronto Press, 1987) and Douglas McCalla, *Planting the Province: The Economic History of Upper Canada 1784-1870* (Toronto: University of Toronto Press, 1993).

11 Martin Painter, *Steering the Modern State* (Sydney: Sydney University Press, 1987), 20. For a broader outline of the political question of 'big government' in Australia, see Don Aitkin, 'Big Government: the Australian Experience,' *Australian Quarterly,* 55 (winter 1983), 168-83. A valuable study of the Ontario experience is H.V. Nelles, *The Politics of Development: Forests, Mines and Hydro-electric Power in Ontario, 1840-1941* (Toronto: Macmillan, 1974).

First, let us examine the expenditure patterns of both at two points: at the end of the 1860s, before the impact of industrialization and urban growth was substantial, and at the turn of the century. Ontario was not a separate jurisdiction until mid-1867, so I have chosen the 1868 financial report to compare with the 1869 New South Wales report.[12] Despite different portfolio arrangements, we can combine most expenditures into three broad categories:

1. *Development.* This category includes agriculture, mining and geology. Developmental expenditures were investments in industries and other economic activities.
2. *Institutions.* This includes support for societies, technical education and parks and deals with discrete organisations having a scientific thrust.
3. *Control.* This class of expenditures, first represented by surveys and statistics, concerns the state's interest in its geographic space and knowledge about its citizenry and their activities

A fourth area for NSW is *Public Health,* an area divided between federal and provincial authorities in Canada at the time.

Before examining the categories and amounts, we should note the evolutionary patterns of state science-related expenditure in the 'settler colonies.' In both Canada and Australia, during the decades before responsible government, had extremely limited need for scientific expertise, with most expenses being incurred in the civil list and justice. Legislative votes for local societies, museums or exploration tended to be sporadic and ad hoc. Britain could supply, through the Royal Navy or the Royal Engineers, the requisite knowledge for hydrographic surveys or public works. Land surveys were the single most important science-related function of the state. Thus, the surveyors-general of the British American and Australian colonies were the first permanent scientific civil servants. Only in the 1840s (in Canada) and 1850s (in Australia) did geologists become—relatively—permanent government fixtures. More general bodies, such as the Boards of Arts and Manufactures in Canada and the Board of Science in Victoria followed, alongside rudimentary bureaucracies for agricultural development. This development was little different from that of the United States. Most of the individual state governments sanctioned (usually short-lived) geological surveys from the 1830s onwards,[13] whilst land survey was a natural result of the relentless westward migration of population. The technical needs of new forms of transportation (railways, steamships) and communications (telegraphy), along with needs of commerce and agriculture

12 Sources of data are the Ontario *Sessional Papers* and the New South Wales, *Votes and Procedures of the Legislative Assembly.*

13 On the relationship of state to federal geological surveys in the United States, see Stephen P. Turner, 'The Survey in Nineteenth-Century American Geology: the Evolution of a Form of Patronage,' *Minerva* 25 (1987), 282-330.

TABLE 2.
ONTARIO SREs 1868

ONTARIO EXPEDITURES 1868		
Department	**Expenditure**	**Amount ($)**
Civil List	Surveyors	8 820
	Head of Surveys	1 800
Agriculture	Societies	54 074
	Fruit Growers	350
	Agricultural Assn	10 000
Other	Mechanics'Institutes	1 610
	Institutions	3 600
	Museum & Library	2 800
Total SRE		83 054
Total Appropriation		1 182 388

(meteorology, weights and measures, agricultural training and research) required government responses in America, Canada and Australia in approximately the same order as those needs emerged. Was this the same pattern as in Europe? To take the British example, we would note a far smaller interest in land survey (for obvious reasons) but a much greater emphasis upon institutions and societies. Britain's geological survey only predated Canada's by five years. In agriculture, Britain was far more hesitant to invest in agriculture than the US or Canadian and Australian colonies. By 1860, the SRE patterns in the mother country were considerably different from those of its offspring.

Turning to our first comparison, at the beginning of our period, surveying looms larger in New South Wales (much of southern Ontario had been surveyed by Confederation), whilst agriculture was the most significant investment in Ontario. Table 2 shows the Ontario expenditure pattern, which may be compared with New South Wales in Table 3. The amounts, in local dollars and pounds, are not directly comparable; we are more interested in percentages and heads of expenses.

The SREs account for a similar level of expenditure in both jurisdictions: 7% in Ontario, 5% in New South Wales.

TABLE 3.
NEW SOUTH WALES SREs 1869

NEW SOUTH WALES EXPENDITURES 1869		
Department	**Expenditure**	**Amount (£)**
Chief Secretary	Observatory	1 650
	Medical Board	44
	Vaccine Institute	2 175
	Institutions	4 375
	Museum	500
	Msc	1 200
Treasurer	Health Officer	830
	Quarantine	900
Secretary of Lands	Surveying	67 341
	Botanical Garden	3 021
	Domain/Hyde Park	4 420
	Scab	9 595
	Inspection Cattle	333
Total SRE		97 600
Total Appropriated		2 301 887

Table 4 lists the Ontario expenditures in 1914, whilst Table 5 provides a similar listing for New South Wales for 1915-16.[14]

Again the percentage figures for SREs are similar (7% for Ontario, 4% for NSW). After the turn of the century, the broad categories remained, but with much articulation. It is striking the degree to which SREs were by then devoted to development through agencies and institutions: technical colleges and training, agricultural research and mining promotion. Such agencies and institutions emerge in Ontario about a decade earlier than in NSW. It is equally striking how little was expended upon 'pure' science. Grants to scientific societies in Ontario were minuscule, those to societies, the observatory and botanical gardens in

14 The annual financial statements for Ontario are normally final expenditures. The NSW records are not so systematic, as several supplementary votes could be listed each year. In many cases, I have found it more convenient to utilise appropriation figures, which might not match final expenditures but are reasonably close to actual figures. The expenditures have been reorganised by category and do not reflect the original distribution by department; also, minor expenditure lines have been included under broader headings.

TABLE 4.
ONTARIO SREs 1914

CATEGORY OF EXPENDITURE	AMOUNT (nearest 100 dollars)	
DEVELOPMENT	942,000	
Mining		47,800
Fisheries		2,500
Agriculture		767,000
Hydroelectric Engineering		124,700
INSTITUTIONS	499,700	
Technical Education		136,300
Schools of Mining		62,000
Royal Ontario Museum		37,000
Educational Museum/Library		18,400
Scientific Societies		3,900
Agricultural Education		242,117
CONTROL	39,700	
Bacteriology		600
Surveys		39,100
TOTAL SRE	1481400	

NSW did not surpass 2% of SREs. State-supported experimental work—in food and agriculture, forestry, fisheries and mining—was clearly applied science, as detailed in departmental annual reports.

3. Science in the Federal Government

In July 1915, the Imperial government created the Department of Scientific and Industrial Research to coordinate scientific work for the war effort. Whitehall hoped that its colonial counterparts would follow suit quickly. The Commonwealth obliged by establishing the Council on Scientific and Industrial Research.[15] The Canadian government, distracted by other matters, did not bestir itself until nearly a year later. On 6 July 1916, cabinet issued an Order-

15 On the origins of the CSIR, consult C.B. Schedvin, *Shaping Science and Industry* (Sydney: Allen and Unwin, 1987).

TABLE 5.
NEW SOUTH WALES SREs 1915-16

CATEGORY OF EXPENDITURE	AMOUNT (nearest 100 pounds)	
PUBLIC HEALTH	186,300	
Medical Board		200
Public Health		185,300
Dental Board		800
DEVELOPMENT	400,100	
Fisheries		8200
Sydney Harbour		133,300
Forestry		46,600
Western Lands Board		6000
Geological Survey		4400
Survey Laboratory		2800
Diamond Drills		1800
Mining Promotion		1000
Coal Exploration		2500
Agriculture Dept		104,200
Stocks and Brands		48,000
Irrigation		39,000
Msc Agriculture		2200
INSTITUTIONS	114,100	
Museum Endowment		1000
Museum		10,000
Zoos		2000
National Park		4000
Technical Teaching		2200
Technical Education Branch		63,000
Manual Training		5500
Observatory		4200
Scientific Societies		500
Institutions		5000
Botanical Gardens		13,200
Domain & Nursery		5800
CONTROL	23,800	
Statistics		11,000
Explosive Analyst		600
Navigation		12,200
TOTAL SRE	724,200	

in-Council authorizing the appointment of an Honorary Advisory Council on Scientific and Industrial Research, but the minister responsible, Sir George Foster, was too heavily engaged to appoint its members until November.[16] From a late twentieth century perspective, one is tempted to see these events as pivotal for direct state activity in science, given the centrality of their successors—the Commonwealth Scientific and Industrial Research Organisation and the National Research Council of Canada—in the scientific lives of the two countries. Yet, lying behind both organisations was a period of nearly seven decades of direct state support for scientific activity.

When the Canadian federal government came into operation in 1867, it gave little thought to possible future scientific operations. Much of the expenditure that had any link to science—such as funding for higher education, agricultural organizations, mechanics' institutes or scientific societies like the Natural History Society of Montreal—passed to the provinces. Naturally, the Geological Survey of Canada remained within the federal fold; as neither the provinces of Nova Scotia nor New Brunswick had created official geological surveys, the GSC, which already maintained links with local Maritime geologists, could easily expand its operations into Eastern Canada and, soon, into the vast, newly-acquired western territories. Yet, apart from the Survey's budget and small grants to observatories, the federal expenditure on science was vanishingly small. The development of the country's natural and human resources would require substantial increases in investment in scientific activities, first in surveying, then in agriculture and other economic sectors such as fisheries, mining, animal and human health. The period from 1867 until well into the 1890s was marked by episodes of economic depression, slow population growth, feeble immigration coupled with significant emigration to the United States. The country did not immediately realise the promise of the west. However, the industrialization of Canada, already well underway in the 1870s, made significant strides in the next two decades.

In the late 1890s, just after the Liberal party came to power under Wilfrid Laurier, the tide turned for Canada. The economic sun began to shine, immigration grew apace and the Wheat Boom began. The growth of federal scientific agencies reflected all these factors. Table 6 is a listing of the federal science-related expenditure categories in 1914. Many of these categories made their debuts after 1885; expenditures grew only slowly until after the turn of the century but, as Chart 1 shows, the amounts rose rapidly once development

16 Foster raised the issue in cabinet on 23 May, but found no particular support amongst his colleagues. For details, see Wilfrid Eggleston, *National Research in Canada: the NRC, 1916-1966* (Toronto: Clarke, Irwin, 1978), chap. 1, and Mel Thistle, *The Inner Ring: The Early History of the National Research Council of Canada* (Toronto: University of Toronto Press, 1966), 3-15. An overview of the importance of the NRC to Canadian science may be found in R.A. Jarrell and Y. Gingras (eds.), *Building Canadian Science: The Role of the National Research Council* (Toronto: CSTHA, 1992).

TABLE 6.
CATEGORIES OF CANADIAN FEDERAL SREs, 1914

EXPENDITURE	Amount (nearest 100 dollars)	
Public Health	442,900	
Health		442,900
Development	3,016,000	
Mines		245,800
Exhibitions		374,700
Tobacco		24,300
Dairy/Fruit		225,200
Experimental Farms		808,600
Livestock		174,600
Meat/Canned Food		222,200
Insect/Pest Control		40,600
Fisheries		363,900
Oysters		4400
Experiments		41,200
Mines/Geological Survey		470,500
Institutions	1,267,300	
Technical Education		15,000
Marine Stations		17,000
Observatory		711,800
Museum		16,000
Tidal Survey		20,000
Institutions		490,500
Control	30,000	
Patent Office		30,000
TOTAL SRE	4,756,200	

burgeoned.[17] Whether there was a causal link between scientific expansion and development in general is a question that needs pursuing.

17 Science-related expenditures are recorded only from 1890, when SREs had become significant in the federal service, to 1914, the last full year before wartime expenditures changed the pattern of spending on science.

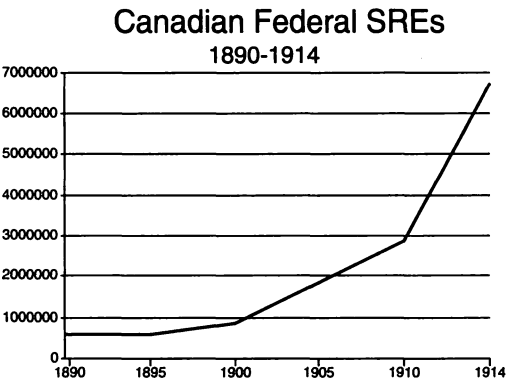

Chart 1

In 1914 SREs amounted to almost 4% of federal expenditure. Developmental areas—agriculture, mining and fisheries—as explicit categories predominate and lurk beneath other category heads. The large expense of land surveying (which by then had become institutionalised and divided amongst several bureaux) directly related to immigration and farm settlement in the west, whilst several 'scientific agencies' (observatories, geodetic, hydrographic and boundary surveys, the meteorological service, the National Museum, etc.) had a developmental role.

Direct comparison of the Canadian and Australian federal scientific presence in this period is impossible because the Australian federal-state power-sharing relationships were significantly different. We can characterise Canadian federalism in our period as much more centralised (though increasingly losing its grip to regional interests), whereas Australian federalism reflects a stronger initial emphasis upon state power (though eventually seeing a greater central presence).[18] Apart from modest amounts for quarantine, tropical medicine, defence and meteorology, one can scarcely speak of Commonwealth scientific endeavours before the creation of the CSIR. An obvious explanation is that the emergence of many government science-related activities occurred in both countries during the forty years between Canadian confederation and the formation of the Australian Commonwealth. By the time Australians agreed upon a federal scheme, the states were not inclined to transfer them to a central authority. Only later innovations—such as the CSIR—could be adopted by the central government, and even then with a struggle

18 See the essays in Bruce W. Hodgins, Don Wright and W.H. Heick (eds.), *Federalism in Canada and Australia: The Early Years* (Waterloo: Wilfrid Laurier University Press, 1978).

A reasonable question to ask at this point is: did not all governments have similar SREs during this period? And should we not expect that pattern of expenditure to be similar in most jurisdictions? We do possess limited comparative statistics on science-related expenditures for the United States, Britain and Germany to 1900 to which we can compare Canadian and Australian patterns.[19] These figures are organised differently from my own categories, but a synopsis for 1900, given in Table 7, provides a sense of the relative importance of different areas of expenditure. Such comparison is highly problematical: German figures can be divided into appropriations by the Reich government and those of the constitutent *Länder* of the empire, which in larger *Länder* (Prussia, Bavaria, Württemberg) loomed large. The United Kingdom was not, of course, a federal state at all, whilst the American figures, being only for the federal government, ignore the individual state expenditures which, given the great deal of overlap and duplication of state institutions (equally true of Canada), were not insignificant. Still, we do obtain us a rough sense of national scientific priorities at the turn of the century.

In the table, the German figures combine the Reich and *Länder* expenditures. The Reich spent the most on its exclusive areas (military, patents), leaving most other categories to the latter. Canada and the United States appear to be quite similar with three significant differences: Canada spent nothing on museums (nothing like the Smithsonian Institution existed), nothing on higher education (a strictly provincial area) and nothing on military science and technology. The last category is easily explained given that Canada was not an imperial power and maintained a very small military establishment. Germany and Britain have certain similarities, especially institutional and organisational support, but Britain was clearly behind in its investment in agriculture and development and in health. If we now take into account the population differences, we can work out a per capita expense for SREs: United States ($ .13), Britain ($ .10), Germany ($ .21) and Canada ($ .43). Even if the Canadian figures are inflated—due to the lack of financial reporting detail in the public accounts—its expenditure is clearly much larger than the more economically developed countries. That Britain brought up the rear is no surprise: as late as 1939, J.D. Bernal complained that Britain still lagged seriously behind other developed nations, especially the United States.[20] The percentage values give a better indication of the relative

19 These data have been gathered by Joel N. Bodansky, who drew figures for Britain and Germany from R.M. MacLeod and E.K. Andrews, 'Selected Science Statistics Relating to Research Endowment and Higher Education 1850-1914' (Brighton: University of Sussex, 1967) and Frank R. Pfetsch, *Zur Entwicklung der Wissenschaftspolitik in Deutschland 1750-1914* (Berlin, 1974) and, for the United States, from his own analysis of Treasury Department publications. The figures are given at ten-year intervals (1850-1900) and standardised in German marks. I have reconverted to US dollars for easier comparison with Canadian figures.

20 J.D. Bernal, *The Social Function of Science* (Cambridge, MA: MIT Press, 1967), 62ff.

TABLE 7.
NATIONAL SREs, USA, BRITAIN, GERMANY AND CANADA 1900

EXPENDITURE CATEGORY	UNITED STATES	UNITED KINGDOM	GERMANY	CANADA
	$US %	$US %	$US %	$US %
Agriculture/ Forestry/ Fisheries (1)	3210000 33	504000 11	715000 6	895000 39
General Science & Technology (2)	3330000 35	1784000 39	1476000 13	1024000 45
Medicine & Health Health	446000 5	472000 10	850000 7	195000 9
Academies & Societies	—	36000 1	99000 1	8000 1
Other Activities (3)	578000 6	58000 1	842000 7	167000 7
Museums	224000 2	702000 16	271000 2	—
Higher Education	1220000 13	498000 11	6777000 58	—
Military Science	627000 7	475000 10	663000 6	—
TOTAL	9636000	4528000	11694000	2289000

Notes: All figures rounded to nearest $1000 (percentages may add to more than 100% due to rounding).

(1) Includes botanical gardens;

(2) Includes surveys, geology, meteorology, standards and patents;

(3) Includes boundary surveys, grants for exhibitions, special grants.

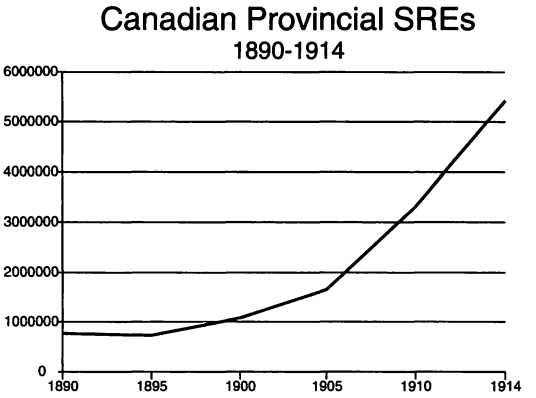

Chart 2

spending patterns. The Australian Commonwealth did not exist in 1900, so no direct comparison can be made, but the similarity to Canadian patterns has already been noted. A comparison of Canadian and American federal government science expenditures for 1914-15 also shows the convergence of spending patterns: Canada spent 46% of its SREs on food/agriculture, 19% on development and 35% of 'other', and the US government spent 43%, 28% and 28%, respectively.[21] The American total was approximately $51.3 million, compared with Canada's $6.7 million. Allowing for dollar differences and given a nearly 10:1 population difference, Canadians were spending more of their tax dollars on scientific activity than the Americans.

4. Science at the Provincial/State Level

The British North America Act specified the division of authority between federal and provincial jurisdictions, such as relegating education to the provinces, but many grey areas existed. Both levels of government could, and did, involve themselves in agriculture, industry, mining, forestry, fisheries, navigation, geology, surveying and other activities. An analysis of provincial science-related expenditures shows a striking similarity amongst provincial jurisdictions—which suggests a strong imitative drive. Canadian activities mirrored American endeavours, which is not surprising given that both societies were undergoing expansion and development under similar conditions. By 1916, nine of the eventual ten provinces (save Newfoundland) and the northern territories were in operation. Chart 2 shows the aggregate provincial science-related expenditures at five-year intervals from 1890 to 1915. This period begins

21 American federal figures were reconstructed from reports of the Secretary in the *United States Treasury Reports.*

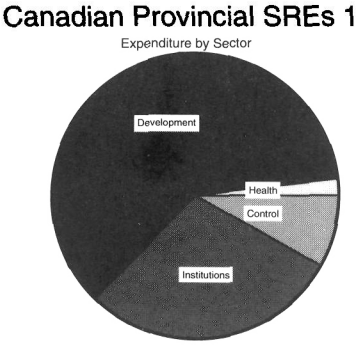

Chart 3a

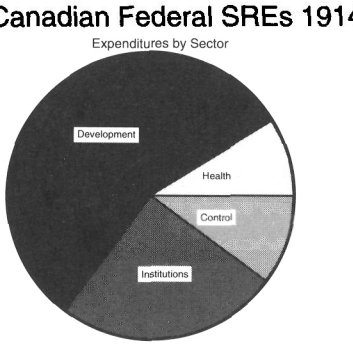

Chart 3b

with the stagnation of the depression of the 1890s and ends with the ebullient decade bracketing 1910. As expenditures tended to reflect populations (and thus revenue), we would expect Ontario and Québec to lead the group.[22] Chart 3 shows the total science-related expenditures of the federal and the provincial governments in 1914 by sectors, indicating the relative interests of the two levels of government.[23] I have omitted provincial educational expenditures related to science. The broad areas shown are the same used above (public health, development, institutions and control).

The expenditures upon each sector reflect the nation's stage of economic development. A closer view of individual provincial budgets would show differences: Alberta, Saskatchewan and Manitoba naturally expended a far larger proportion of SREs upon agriculture than British Columbia, where forestry, mining and fisheries were the dominant economic activities. The central provinces, with more mature industrial sectors, exhibit more balanced expenditure patterns. A noteworthy feature of the post-1900 expenditures is the appearance of entirely new categories of state science-oriented activities such as bacteriological laboratories, machinery and electrical inspections, game protection, conservation, forestry research, boards of health and technical assistance to developing industries such as dairying. Many of these activities were already underway in neighbouring American states at the turn of the century.[24]

22 I have excluded Prince Edward Island (too small) and Saskatchewan and Alberta (too new, being organised as provinces out of the old Northwest Territories only in 1905). Sources of data are the provincial sessional papers.

23 Not all of these figures cover coincident periods, given varying fiscal periods of the federal and provincial governments. All of them overlap some part of 1914 and the figures listed should be taken only as indicative of the scale of expenditure.

24 For example, many of the expenditure categories in Ontario mirrored those of its most

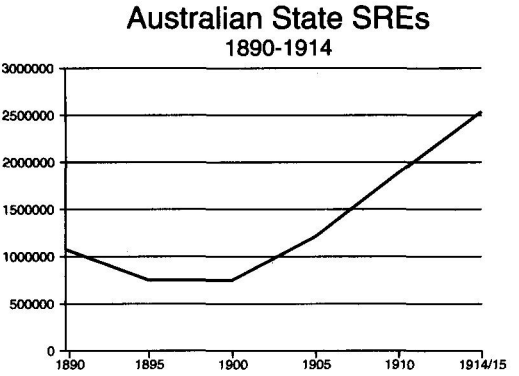

Chart 4

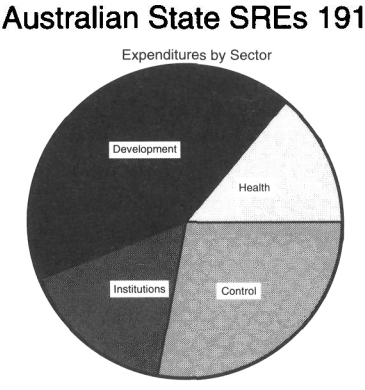

Chart 5

Yet, during 1914, Ontario expended more than three times as much as neighbouring Michigan, with the same population and a similar economy.

An analysis of the science-related expenditure patterns of the Australian colonies and states, also measured as expenditures from 1890 to 1915 by five-year intervals (Chart 4), exhibits a similar pattern to Canada's.[25] A closer look at the actual expenditure lines shows a tendency of states to mimic the agencies and categories of expenditure of its neighbours. As one would expect, SREs are more diversified in larger states such as NSW and Victoria in comparison with smaller or less developed states (Tasmania and Western Australia). This is a pattern one

similar American neighbour, Michigan. See R. A. Jarrell, 'Science and the State in Ontario.'

25 Sources of data are the parliamentary papers of each state.

TABLE 8.
BRITISH COLUMBIA AND SOUTH AUSTRALIA
POPULATION, 1881-1911*

CENSUS YEAR	BRITISH COLUMBIA	VANCOUVER	SOUTH AUSTRALIA	ADELAIDE
1881	49,000	N/A	276,414	38,000
1891	98,000	14,000	315,533	39,000
1901	179,000	27,000	358,346	39,000
1911	392,000	100,000	408,558	190,000

* British Columbia population figures drawn from the *Canada Year Book 1911* (Ottawa, 1912), South Australian figures from Vanplew, *Australians. Historical Statistics.*

finds in analysing all the expenditure accounts; one would surmise that this was a function of both population and level of development. Taking a global view (Chart 5), we can compare the percentage distribution of SREs for the Australian states in 1914 with Canada.

Just as one may argue a basis of comparison between Ontario and New South Wales, one might find parallels between less populous jurisdictions: British Columbia and South Australia. Settlement occurred earlier in South Australia (from the late 1830s) and agriculture was a far more significant economic activity before the turn of the century.[26] Population growth reached a plateau in South Australia during the depression of the 1890s. The population of British Columbia doubled every decade from the 1880s. After the turn of the century, population in both concentrated in the major cities. (See Table 8)

The SREs in both were small until after the turn of the century, when the interest in state support of development became an important factor in both jurisdictions. In Table 9, we see the SREs for British Columbia for 1914-15.

In British Columbia, this amounted to 5% of provincial expenditure. The South Australian expenditures for 1914-15 are tabulated in Table 10. The outlay represented 5.5% of the total state appropriations for that year.

Both jurisdictions (see Chart 6) devoted over half their SREs to development. Agriculture (including the support of education, associations, stockbreeding, fruitgrowing, exports and irrigation) and forestry consumed the most funds in both instances, though for geographical reasons, the emphasis is reversed.[27]

26 From an agricultural perspective, both were relative 'wastelands' with mountains in British Columbia and vast arid areas in South Australia.

27 See Michael Williams, *The Making of the South Australian Landscape* (London:

TABLE 9.
BRITISH COLUMBIA SREs 1914-15

CATEGORY OF EXPENDITURE	AMOUNT (nearest 100 dollars)	
PUBLIC HEALTH	29,500	
Board of Health		29,500
DEVELOPMENT	595,400	
Mines		25,800
Irrigation		13,600
Forestry		318,800
Fisheries		39,400
Fruit Growing		46,300
Agricultural Branch		84,200
Agricultural Societies		67,300
INSTITUTIONS	25,100	
Museum		16,500
Botanical Office		2500
Grants to Societies		6100
CONTROL	219,400	
Surveys		138,600
Electrical/boiler Inspection		6700
Fruit Inspection		41,200
Game Protection		32,900
TOTAL SRE	869,400	

* Source: British Columbia, *Journal of the Legislative Assembly 1914-15.*

Despite substantial differences in the political economies of South Australia and British Columbia (to say nothing of their geographies), the patterns of their science-related expenditures clearly converge by the time of World War I.

Whilst industry grew in Australian states and Canadian provinces (again, especially the larger jurisdictions) around the turn of the century, state investment in agriculture also increased significantly. After a gradual rise in agriculture and food-related SREs before 1900, the amounts jump rapidly. Chart 7

Academic, 1974) and R.A. Shearer, ed., *Exploiting our Economic Potential: Public Policy and the British Columbia Economy* (Toronto: Holt, Rinehart and Winston, 1968).

TABLE 10.
SOUTH AUSTRALIA SREs 1914-15*

CATEGORY OF EXPENDITURE	AMOUNT (nearest 100 pounds)	
PUBLIC HEALTH	5500	
Board of Health/Medical Officers		5500
DEVELOPMENT	142,400	
Mining and Prospecting		12,000
Exhibitions		800
Forestry		25,000
Exploration		200
Hydroelectric		800
Fisheries		1500
Irrigation		23,500
Agriculture Dept		25,900
Produce Export		45,500
Stocks and Brands		5600
Agricultural Societies		1600
INSTITUTIONS	42,400	
Botanical Garden		7600
Zoo		3800
National Park		500
Domain		1800
Museum		9200
Agricultural Education		200
Institutions		10,500
Societies		7100
Observatory		1700
CONTROL	52,100	
Statistics		2600
Surveys		44,800
Marine Engineering/Surveys		4700
TOTAL APPROPRIATION	242,400	

* Source: South Australia, *Parliamentary Papers, 1914-15.*

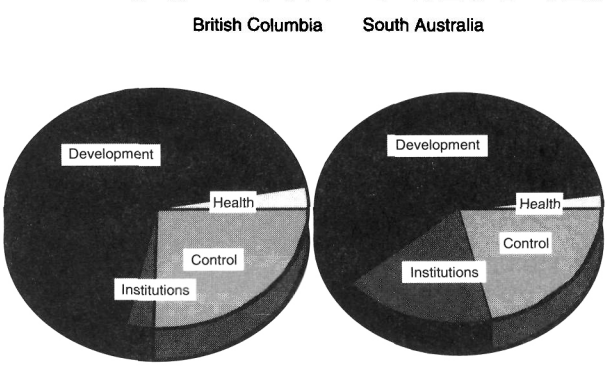

Chart 6

provides the agricultural SREs for the individual Australian states and totals at five-year intervals (1880-1915); Chart 8 shows Canadian provincial outlays for the same period. Total Australian investment in agricultural infrastructure reached £600,000, whilst total Canadian investment (including approximately $500,000 by the federal government) reached $3 million. The growth rate and the timing of the rapid investment increase in both countries is clearly visible.[28] The convergence noted above is also evident in the analysis of specific agricultural expenditures—again keeping in mind different local conditions. Agricultural education became important, and institutionalised, in Ontario in the 1870s and in South Australia in the 1880s. Other states and provinces quickly followed. We see the same pattern in support of the dairy industry (a worldwide phenomenon), cold storage experiments, experimental farms, inspection and stockbreeding amongst others.

Conclusions

It was probably the case—although we lack the data—that the distinguished British, French or German scientists with international reputations at the turn of the century represented only a tiny élite within a larger mass of scientific workers. Those workers, like their Canadian, American or Australian counter-

28 There is no satisfactory general account of Canadian or Australian (or particularly New South Wales) agricultural history. General studies include R.L. Jones, *A History of Agriculture in Ontario 1613-1880* (Toronto: University of Toronto Press, 1946), B.R. Davidson, *European Farming in Australia* (Amsterdam: Elsevier, 1981) and Samuel Wadham, *Australian Farming 1788-1965* (Melbourne: F.W. Cheshire, 1967). On the relationship of the AAAS and agricultural research, see Davidson, 'Developing Nature's Treasures: Agriculture and Mining in Australasia,' in Roy MacLeod (ed.), *The Commonwealth of Science: ANZAAS and the Scientific Enterprise in Australasia 1888-1988* (Melbourne: Oxford University Press, 1988), 272-91.

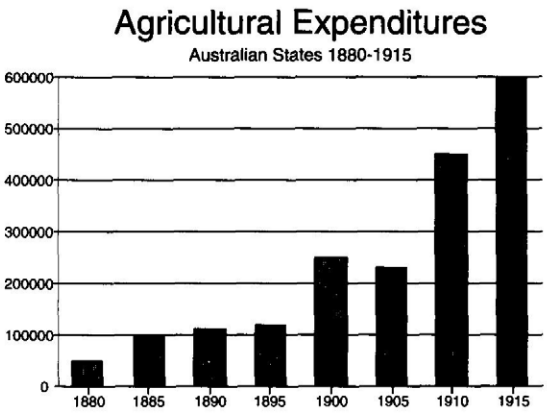

Chart 7

parts, were engaged in practical scientific labours to solve economic and social problems for their corporate or government employers, be they manufacturers, schools, hospitals or government bureaux. North American and Australian governments took up with alacrity science as a tool of state. Not surprisingly, they shared much the same outlook, utilising and organising science in similar ways. Because we are dealing with developing societies, this is no surprise. One might object to the characterisation of science in the dominions as 'practical,' and its measurement with SREs as, if not illegitimate, at least a misrepresentation of our common notion of science. I am unapologetic. We assume that 'advanced' societies are economically superior, with a citizenry blessed with a comfortable standard of living, because of their utilisation of science. Thus, if science is a factor in an advanced society, which both Canada and Australian arguably were after the turn of the century, and if neither produced much 'pure' science, then they must have imported this scientific knowledge and applied it.[29] This made them no less 'scientific,' than Britain, for example—just different. That the dominions could be prosperous societies on this basis, compared with the mother country, should make us suspicious, at least, of the modern conviction that those nations that most support pure scientific research are invariably those most economically advanced.

29 Comparative work on academic physics, for example, does not show any clear-cut distinctions between European patterns and those in Canada and Australia. Each had, by 1900, two important universities (Toronto and McGill, Sydney and Melbourne) with significant research effort and staff, comparable to good provincial universities in Germany, Britain or France. In sheer numbers the Americans surpassed everyone. See Paul Forman, John L. Heilbron and Spencer Weart, 'Physics *circa* 1900: Personnel, Funding, and Productivity of the Academic Establishments,' *Historical Studies in the Physical Sciences* 5 (1975), 3-185.

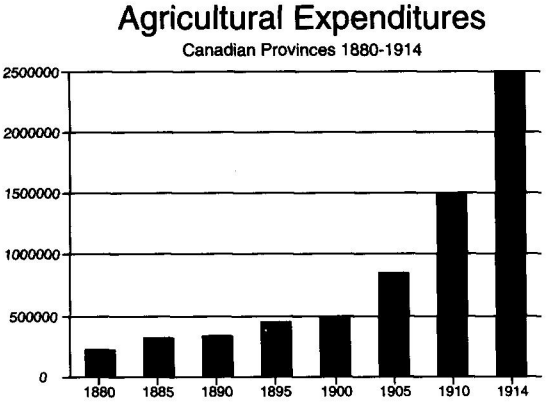

Chart 8

This aerial view, incomplete and flawed though it may be, does provide us with some further questions to pursue:

- On what basis did those in government, who advocated the use of science, assume that an economic 'payoff' would ensue?
- How were priorities set for scientific investment in the developmental arena (e.g., agriculture, manufactures, forestry, mining, fishing, etc.)?
- What were the 'vectors' of new models of state agencies and types of investment? Were they simply imitative?
- Did anyone know how to measure the 'success' of such investments? Were attempts made to assess the outcomes?

An attempt to answer these questions requires three kinds of analysis. First, one needs to undertake fine-grained studies of the state agencies and the political circumstances leading to their creation or, in Inkster and Todd's language, the infrastructural elements. Second, we need to have a much better understanding of how the evolution of those institutions relates to the contemporary political economies of each country (the basal elements). Third, we need further comparative studies of science-related activities, in the wider sense argued here, for relevant countries (e.g., the United States and the United Kingdom), for if we want to argue the case for science as means of development, then we need to understand the context of that development.