AUSTRALIAN SCIENCE AND INDUSTRY BETWEEN THE WARS*

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This paper is concerned with the early development of Australia's industrial technology infrastructure. It will attempt, in an exploratory rather than conclusive way, to establish a somewhat different perspective on the institutional development of science and technology in Australia. By drawing on a specific case study — the power struggle between the Munitions sector and CSIR — it is argued that industrial R & D became disconnected from the economic planning function of the State, and that under CSIR's aegis IR & D became an item of conspicuous consumption rather than a strategic investment for secondary industry.

Keywords: science and technology, agriculture, Australian industry, CSIR, munitions sector, R & D

The interwar years saw the formal launching of science in Australia. With the creation of a national research organisation, the nexus between science and government became tightly sealed. In order to highlight the significance of the linkages forged between science and industry in the formative interwar years, this paper covers the period and trends 1906 to 1946. It is essentially an exercise in recasting and re-mapping. The original intention was to call it 'From Imperial to National Science'. The evidence is against it. Rather my contention is that the formal institutionalisation of science in Australia, as announced by the creation of the Advisory Council of Science and Industry in 1916-17, cannot be intelligibly understood if detached from the wider context of Imperial defence priorities and the politico-economic vectors which shaped Australia's comparatively late industrialisation.

The emphasis of existing accounts of CSIR's early progress as inexorably tied to primary industry has deflected attention away from two key aspects: a) the defence concerns which provided its original political *raison d'être*; and b) the significance of CSIR's early detachment from secondary industry. The reasons for this detachment are complex. Its implications for CSIR/O as a key agency for the promotion of technological change have been poorly understood. Arguably a major segment of Australian science history has been overlooked.

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ORIGINS OF AUSTRALIA'S INDUSTRIAL TECHNOLOGY COMPLEX

The origins of Australia's industrial technology make-up can be traced back to World War I and even earlier when 'the spirit of federation' began to influence defence policy. At that time one of the tenets of federation accepted by Prime Minister Alfred Deakin, was that there should be "defence without militarism; hence the form of conception in which the Commonwealth should assist in the defence of Empire"; and that there should be "development of her country and employment of her people; hence her feeling towards protection"[1]. Deakin's ideal was to help mould an empire of equals.

In 1915, the year the Anzac mythology was born, Australia's chief export was human cannon fodder for Britain. The cost was enormous. The experience of World War I reinstated broader Imperial priorities in dominion defence policy. The extent of Australia's dependence on overseas sources for essential supplies, defence equipment, and munitions was brutally driven home.

At the time the President of the Royal Society of New South Wales was quick to note the potential role of science in reducing this dependence. Even earlier in 1904 C.O. Burge, then President of the Royal Society had ardently urged that "Australia should emulate Germany in promoting science and technical education" — suggesting that failure to do so would result in Australia being "rudely awakened from self-complacency by some crushing loss in trading or war"[2]. These proved prophetic words on both counts.

For Britain the experience of World War I had two inescapable implications: a) that the disastrous shortage of munitions Britain faced in 1915 was largely due to its failure to extend the manufacture of munitions to commercial industry; and b) the acknowledged failure of Britain to make sufficient use of science. These 'lessons' registered all the more forcibly on the Australian government after a brief visit to Britain by Prime Minister Hughes in 1917. The subsequent push for

Australian mass produced goods — Australia's path to industrialisation in effect — began not with the manufacture of motor cars, radios and refrigerators to supply a local market, but with the supply of weapons to refurbish Imperial defence commitments. While Britain got a full-fledged Department for Scientific and Industrial Research in response to deficiencies revealed by World War I, Australia got an Advisory Council which was left to its own devices after the first flush of derivative inspiration petered out.

In 1916 Hughes euphorically conveyed his views of what organised science could do for Australia:

> Science can make rural industries more commercially profitable making the desert bloom like a rose. . .It can with its magic wand turn heaps of what is termed refuse into gold . . .Science will lead the manufacturer into green pastures by solving for him problems that seemed to him insoluble. It will open up a thousand avenues for capital and labour, and lastly science, thus familiarised to the people will help them to clear thinking. . .to a saner and wider outlook on life[3].

His ambition for the Advisory Council was that it would "apply to the pastoral, agricultural, mining and manufacturing industries the resources of science in such a way as to more effectively develop our great heritage"[4]. However its subsequent financial straightjacketing confined its efforts almost entirely to primary industry. When the Advisory Council was elevated to the status of a more permanent Institute in 1921 its first Director, George Handley Knibbs, set out a general research for secondary industry. The Institute's former Chairman, David Orme Masson, a chemist, had earlier tried to find out through State Committees, whether manufacturing industry wanted government assistance in the selection of technical problems common to an industry as a whole or affecting individual firms. He was politely told that the time was not ripe to pursue the matter.

When the Institute was finally adequately endowed in 1926 and renamed CSIR, it was to concentrate on urgent national problems — the most pressing of these being Australia's balance of payments. In broad context then, the Council was essentially a "product of the idea of harnessing scientific research to the Imperial concern for men, money and markets"[5]. Even so, individual members of the Institute's Executive were aware of limitations inherent in its colonial origins. As George Knibbs pointed out in an early [1905] report into technical education in Australia:

> To understand our status as regards technical education, it is necessary to remember that in New South Wales it is but a weak reflection of that of the United Kingdom, carrying with it not only all the infirmity of the technical system of the mother country, but the added limitation of domination by persons whose practical experience was limited.

Throwing down the gauntlet, Knibbs went on to assert: 'We must repair the negligence of the past, or we must submit to national decay"[6].

The newly installed CSIR Executive was not unaware of the political mileage to be gained from success in primary industry research. As its Chairman, George Julius, put it in 1928: "the future of Australia was wrapped up in agriculture and the Council should do its utmost to stimulate agriculture and primary production in general. As regards secondary industry, there was a danger of overproduction". For Julius, Australia's manufacturing industry was at such a handicap, that the only sensible policy for CSIR to adopt was to maximise returns for the primary sector[7]. A curious stand for Julius as an engineer to take, but no more than an expression of the widely held view that Australia's role was to produce primary products for Britain, while Britain's role was to provide manufactured goods for the Australian market. In this scheme of things it was more likely that CSIR would become a "funnel for the transfer of British biological science to the Antipodes"[8].

Within the constraints of the 'agricultural imperative', CSIR's early program admirably met the challenge of eliminating environmental plant and livestock pests and conducted impressive fundamental research. It clearly did not warrant a deep scepticism of the possible utility of research. For instance one MP was reported to have asked during parliamentary debate on the proposed Institute "whether we could point to a single pest eradicated from Australia by means of scientific research"[9].

Few would dispute the stunning success of CSIR's early track record in rural research. The pervasive influence of successive Imperial Conferences and the specific role of the Empire Marketing Board, CSIR's guardian angel, have also been widely documented[10] and will not be detailed here. What is important is that the technology infrastructure for manufacturing concerns continued to be consolidated under the aegis of Munitions rather than CSIR. In contrast to the grudging support and hesitant beginnings of CSIR, government support for the expansion of munitions was nothing short of magnanimous.

MUNITIONS

A key figure in setting the agenda for the future role of munitions was A.E. Leighton, then in charge of the Australian Arsenal. In 1912 he had been invited by the Australian government to design and organise a cordite and small arms factory. Later, in his capacity as technical advisor to the UK Ministry of Munitions, he foreshadowed the acute shortage of chemists and skilled workers for the British war effort,

and persuaded the Australian government to send some 100 chemists to gain experience in the British munitions factories. In June 1916 the scheme was extended to include semi-skilled workers. Early in 1916, the Australian government appointed Leighton general manager of the Australian Arsenal. The arsenal office subsequently established in London became the site for technical expertise and information on munitions production and the administration of war worker schemes. The diffusion of technological know-how through the dispersal of Australian chemists, engineers and munitions workers in the munitions factories undoubtedly had a profound effect on Australian industry.

As Leighton was later to recall:

> One great fact that emerged from [World War I] . . . was the need for marshalling the resources of industry and science as part of a political and defence policy. . .It is therefore of cardinal importance to stabilize essential industries in Australia and secure a stock of trained brains and inventive resource, so that in time of need the industries can be made to function for war.

However he cautioned that "protection in itself will not stabilize industry in Australia, for it is not backed by capable and progressive scientific management.[11]

By 1918 Leighton was directed to plan the reorganisation of supply and munitions; four years later he was appointed Controller-General of Munitions. Leighton's attitude to defence was announced by his comments on disarmament in 1920.

> An industrially developed nation cannot be disarmed. Exact knowledge of munition production, a nucleus of skilled workers, supplies and then within a few months a nation is transformed. . .The power to retain a strong position in the world depends ultimately, not on the possession at any moment of ships, engines, and munitions of war, but on the extent and variety of the nation's industries and the possession of knowledge to apply the resources of the industries quickly and effectively to the problems.[12]

Leighton's subsequent proposal for the restructuring of munitions factories was to make explicit the linkages between science and industry on an institutional basis. Briefly, he proposed that: a) the government's munitions factories should meet the nation's peacetime demands with adequately equipped scientific laboratories to provide the basis for future commercial manufacture and expertise; and b) eventually the burden of mass production of munitions be transferred to the private sector as soon as it was in a position to handle these demands.

The opening of the Munitions Supply Laboratory [MSL] at Maribyrnong in 1922 marked the launching of Leighton's scheme. As Mellor notes:

> The expenditure during the early twenties of about £ 3,000,000 on the four government munitions factories and the laboratories, an amount far greater than that of all the other Dominions put together for the same period, was a concrete expression of the Government's recognition of the obligations it had assumed.[13]

By 1923 the equipment and manufacturing facilities now housed by munitions factories were unrivalled in Australia.

IMPACT OF THE DEPRESSION YEARS ON MUNITIONS

For the next ten years government munitions factories expanded slowly but surely. With the onset of the Depression , army contracts were cut back drastically. However three considerations led the munitions sector to diversify and survive the crisis. First, the government now had too great an investment tied up in the manufacturing capacity of munitions. Secondly, it could ill afford to lose the hard-won technical expertise of the MSL and the munitions factories. Finally, it could not countenance the spread of unemployment which closure of the factories would represent.

Diversification took on interesting forms. During the late 1920s and early 1930s, the Ordnance Factory and the MSL at Maribyrnong played an important role in the development of the motor industry. New tariff restrictions forced large foreign-owned concerns to find ways around the requirements for local manufacture of spare parts. General Motors, for instance, sent out its own engineers from America to assess local manufacturing capacity. They reported back that the only agency equipped to handle its manufacturing specifications was the Munitions Ordnance Factory and its supporting laboratories. For the mass production of motor axles, a further prerequisite was high grade alloy steel. In a joint venture between the Ordnance Factory and BHP, the requirements of General Motors were met. Mellor claims that with the resumption of its munitions role after the Depression, the technical know-how so acquired was passed on to commercial industry[14]. What he failed to point out is that profits, control, ownership and managerial/organisational expertise were not. In the case of the car industry, the prospects for its development as an indigenous concern became progressively circumscribed.

As Connell and Irving point out, "The emergence of Australian-based heavy industry irreversibly changed the conditions in which fortunes could be made by other entrepreneurs"[15]. Firms dealing in

specialised materials were able to undergo unprecedented expansion. During the 1920s and 1930s, some of these gained sufficient momentum to boom and diversify after the depression. The farm machinery and car industries are good examples. American manufacturers slipped inside the Hughes tariff barrier in the 1920s. Ford set up Victorian plants in 1925 to assemble chassis and build bodies. General Motors set up its first chassis assembly plants in 1926 and in 1931 took over its local supplier of bodies, Holden. With hefty political backing, both became involved after the war in local manufacture of the complete car. The significance of this pattern, by no means peculiar to the car industry, will be drawn out later.

The diversification at many munitions centres bore little resemblance to production undertaken in more expansive times. But it greatly enhanced the industrial technology capability of munitions in the commercial sector. For instance, the Small Arms Factory at Lithgow manufactured combs and cutters for sheep-shearing machines, golf irons, refrigerator parts, gear blanks, handcuffs and sound projectors. The Footscray Ammunition Factory rolled metal strips for industry and mass-produced lipstick containers. The Explosives Factory turned out paints, lacquers and chemicals used in other commercial products.

Ironically the same considerations which safeguarded Munitions' status quo also prompted the expansion of CSIR's activities into secondary industry. Ironic since the sequel can be said to mark the beginnings of the formal separation, if not dislocation, of scientific production from industry — the very opposite of the intentions guiding the 1936-37 Report of the Secondary Industries Testing and Research Committee [SITRC]. Obvious signs of this dislocation were masked by the World War II effort when CSIR necessarily threw itself into the technological challenge that confronted it. However the advent of what has been quaintly dubbed CSIRO 'culture' emerged much earlier. As Deputy-Chairman Rivett had insisted from the outset, CSIR should become "a nursery for the scientific ethos, not merely an instrument for state policy for the promotion of economic and technological change"[16].

THE DEPRESSION YEARS — A FILLIP FOR AUSTRALIAN SCIENCE?

The timing of CSIR's expansion into secondary industry was, in one respect, fortunate for CSIR. The Depression knocked few dents in the public image of science since CSIR was one of the few agencies that was doing anything of obvious benefit for the farmers and graziers. As Schedvin notes, at a time when overseas prices for primary

products fell sharply, when banks refused to extend overdrafts and when government was unable to offer a solution, "science seemed to offer some hope"[17]. Also because of Australia's late industrialisation, the association of science with work-destroying technologies in the manufacturing sector had yet to make its presence felt. Australia was thus spared the anti-science response which occurred in Britain: "science offers the workers the split atom when what they want is bread"[18]. On the other hand by 1930, CSIR's Trust Fund was running on empty. Its survival depended on grants made to it by the Empire Marketing Board, the Rural Pastoralists Research Trust and the Rural Credits Fund of the Commonwealth Bank. Prospects for extending existing programs were bound by the same constraints.

Nevertheless the disastrous economic impact of the Depression did generate an intriguing and little-known possibility for CSIR — a new Division of Economic Research. The fate of this proposal highlights a fundamental and recurrent tension within CSIR: between CSIR's response to national economic goals and its reluctance to be drawn into or bound by the quicksand politics that defined and prioritised those goals.

A DIVISION OF ECONOMIC RESEARCH FOR CSIR?

Late in 1928, Cabinet approved the formation of a Bureau of Economics Research within CSIR — with Rivett's blessing. In the event, the proposed Bureau failed to materialise. Pertinent to this account, however, are the circumstances which stimulated CSIR to embrace the infant discipline of economics and later, to reject the notion that economics could seriously be mentioned in the same breath as 'science'.

At a time when neither Treasury nor the banks employed trained economists, proposals for such a Bureau[19] presented certain logistical difficulties. The main problem was locating the appropriate institutional niche given that the government had partly attributed the economic recession to the wastefulness of proliferating state instrumentalities. There were distinct advantages in choosing CSIR as foster parent for the proposed Bureau. Not least of these advantages was the politically neutral halo CSIR had as an independent statutory authority.

However the Interdepartmental Committee set up to investigate the proposal was polarised. W.C. Gepp, later to become influential Minister for the Department of Development and Migration and Chairman of the Committee, argued that if the Bureau was dumped on CSIR, this would inevitably politicise the Council — and with damaging effect. Curiously, Rivett disagreed. Rivett thought the gamble was worth taking since the Executive was, from CSIR's

inception, required to make economic judgments in the absence of basic information about costs, prices, and markets. Rivett's concern was that,

> Enquiry into the economic side is, or should be, always a preliminary to any scientific work of an industrial type. We have many schemes put up to us for laboratory work which, even if 100% successful as scientific investigations, would still be useless as far as their application was concerned.[20]

A second consideration was that 'basic' economic research would suffer short-term political and administrative pressures if housed in a State Department. Finally, Rivett offered the line that "economics, being a science, appears to be a matter which for research purposes might suitably be associated with other sciences"[21].

Cabinet endorsed the proposal and invited CSIR to establish a Division of Economic Research. But shortly after a visit of the British Economic Mission to Australia, the Government changed its mind. The Mission advised against the association of economic work with CSIR and suggested a separate Bureau. The Bruce-Page government was defeated by the Scullin government before a director could be appointed.

And there the story should end. Except that a similar proposal was again touted a decade later. This time Rivett adamantly resisted the proposal. Partly because the disastrous impact of the Depression was widely blamed on the incompetence of the government's economic advisors, economics as a discipline underwent premature mid-life crisis and fell into disrepute. But for Rivett the gravity of making CSIR vulnerable to the vagaries of political determinaiton was now a dangerous option. Since then, there has been no serious attempt to associate CSIR with economic research nor — until the 1980s — to insert other accountability and rationalising mechanisms into its structure.

THE SECONDARY INDUSTRIES TESTING AND RESEARCH COMMISSION [SITRC]

The SITRC Report was prompted by a government proposal to establish an engines research laboratory to carry out research for aero and automobile engines. The proposal itself stemmed from the experience of the Depression years when it became clear that expansion of rural industry could no longer compensate for growing unemployment in the cities.

The question how to expand Australia's manufacturing base without offending the terms of the 1932 Ottawa Agreements was a vexed one. Under those Agreements, dominion countries became

locked into preferential trade for British manufactured goods. These agreements greatly impaired prospects for smooth industrialisation and favourable trade balance as the purchasing power of primary produce plummeted. The Ottawa deal came in for caustic criticism from Profeessor E. Shann at the 1932 ANZAAS Congress. Shann described the impact of the Ottawa Agreements as "cracking up" the world economy of the nineteenth century. He argued that the Agreements effectively created a multi-headed "autarchy" through government regulation and Britain's "virtual monopoly of demand".[22]

Certainly the Ottawa Agreements increased rather than reduced dependence on the British market and inflated the demand for local tariffs: no fewer than 430 items of manufactured goods in Australia were affected. According to the Associated Chambers of Manufacturers, the Tariff Board overnight acquired an "entirely new status with new functions" which, together with binding guidelines for monetary policy, effectively "crippled" the Australian economy. Whatever the original motives for the "complementary industrial production" which replaced the "imperial vision of the twenties"[23], few could have expected that the Agreements would be binding some twenty-four years later and in vastly different economic circumstances.

By 1935-36 it was recognised that the continued crisis in Australia's balance of trade could only be rectified by more rapid industrialisation. Later on in 1936, the notion that manufacturing self-sufficiency would be essential in the event of war, began to gain political currency. This then, was the backdrop that prompted the SITRC. On 7 July Prime Minister Lyons announced that CSIR's activities would be extended to secondary industry[24]. The SITRC Report was presented in 1937 (but not published until 1938).

With the strong backing of the CSIR Executive and some deft diplomatic manoeuvres on Julius' part, a Secondary Industries Testing and Research Committee (under Julius' chairmanship) was quickly approved by Cabinet. Serviced by numerous subcommittees which conducted a comprehensive survey of secondary industry and evidence taken from university engineers, chemists, physicists and leading industrialists, the Committee's Report was farsighted and difficult to flaw. That, and the availability of strategic advice from renowned British scientists, made acceptance of the Report's recommendations a foregone conclusion. To shorten a long story, what CSIR got was a National Standards Laboratory, and the former Radio Research Board became a full-fledged Radiophysics Laboratory.

Space does not permit a detailed account of telling differences between Rivett and Julius on the question of tactics for handling this

windfall. But one of Julius' statements clearly defines the role of the state as infinite provider:

> After ten years of experience with C.S.I.R. I am convinced that under existing Australian political conditions the wisest move is to put up such a case in connection with any proposal as will persuade Cabinet and Parliament to vote money for the *initiation* of the work and then by research results and by further argument, and by popular clamour, to persuade Parliament from year to year to give us funds to develop and carry on this work.[25]

The official rationales were, of course, somewhat different. Essentially the Report offered two sets of justifications: a) that CSIR's expansion into secondary industry would make Australian industries more competitive; and b) left to itself, the private sector, ever slow on the uptake to do its own IR & D, would not be able to manufacture essential supplies, and "in the event of isolation, [Australia] would not be able to carry on".

But it would be mistaken to assume from this that CSIR's intentions were to foster technological capability as a resource for manufacturers. As the Report comments:

> It is perhaps natural to ask why private enterprise does not initiate. . .new industries without governmental stimulation. The answer is probably to be found in the lack of knowledge available. . .[to judge]. . .prospects of an adequate financial return on the capital invested. Either of these deterrents may possibly be removed by a scientific study of the problems involved. Briefly it may be regarded as a function of government to make available such data as may be needed and procurable by science and it is the responsibility of private enterprise to use the data in the development of industries.

In the next breath, the Report admits that "few staffs in industry could cope with such problems", but that "in the national interest such problems (requiring scientific treatment) should be investigated by an independent organisation with facilities and staffs at its command".[26]

These contradictory positions betray a fundamental confusion between scientific production *and* the use of the scientific method to rationalise production. This confusion occurs with monotonous regularity throughout CSIR's history. More pertinent here is that these rationales clearly define CSIR's role in secondary industry as providing a fallback resource rather than a strategic resource for technological development.

By 1936, in view of the critical defence role now attached to expanding commercial industry, the question of how and when to mobilise the private sector became a burning issue. Leighton's

preference was to bring the munitions factories up to peak capacity. He therefore resisted any attempt to divert funds away from the government factories. On this he set himself on a collison course with CSIR's Chairman Julius. The subsequent power struggle between CSIR and Munitions marked the end of Munitions' virtual monopoly of IR & D and the beginnings of CSIR's monopoly of the R in R & D.

POWER STRUGGLE BETWEEN CSIR AND MUNITIONS

Before forwarding CSIR's shortlist of members for the SITRC to the Prime Minister, Julius met with Leighton whose cooperation would seem to have been a prerequisite for its successful endeavours. The meeting was evidently explosive with Leighton immovable in his conviction that there "was no need for any committee to enquire [about]. . .the efficiency of the secondary producer and his capacity to meet the requirements of the Defence Department, as he Leighton and his Department had done that already, and that everything was now in an entirely satisfactory condition". Julius was equally adamant that this complacency was absurd and "it would take four or five years before the secondary producer could begin to produce material satisfactorily to meet the Defence Department's needs"[27].

Leighton, evidently a quick-tempered person, ill-inclined to mince words or action, had had an earlier run-in with Julius when, as a member of the Council of CSIR he had opposed the development of a Division of Forest Products in 1928-30[28]. On that occasion too Leighton had insisted that his Department could more than adequately deal with timber-testing and forest products. Overruled by the CSIR Executive, Leighton promptly resigned from the Council. The significance of the long-standing friction between the CSIR Executive and Leighton will be amplified later.

Oppositon from the Defence Department was not removed overnight. At a preliminary meeting of the Committee, the Defence Department representative made it "abundantly clear that Maribyrnong are going to do everything possible to ensure that the whole of the work and equipment in connection with fundamental standards is kept at Maribyrnong and controlled by them, not only with reference to primary standards but also in connection with the preparation and testing of all secondary standards used by the manufacturer". Meanwhile the Minister for Defence, Sir Archdale Parkhill, approached the Prime Minister to have Leighton either coopted to the Council or to have the Government revise CSIR's Act to enable the Director-General of Munitions to be made an automatic member of the CSIR Executive and an active participant in its deliberations. Again Julius' connections and the Government's

deference to the advice of British scientific 'heavies' proved immeasurably helpful to the CSIR Executive. In the event Hebblewhite, Secretary of the SITRC, managed to persuade the Minister for Defence that without the changes recommended by the Committee "it would be impossible to organize secondary producers in Australia for the efficient production of defence machinery".

While various historians have congratulated CSIR on the timeliness of its expansion into secondary industry, or offer varying explanations as to why CSIR's gain should have been Munitions' loss, the significance of this politically motivated transfer has largely been overlooked. Mellor's explanation raises more questions than it answers:

> The resources of science were now required by industry on a much wider field than could be catered for by these laboratories without encroachment upon their essential purpose of serving the production of munitions and defence requirements generally.[29]

It is difficult to reconcile this with the admission by CSIR's first Executive in 1926 — ten years earlier — that the Defence Laboratories be regarded as the authoritative standards agency for Australia[30].

Clearly there is more to this story than official accounts have unturfed. The details of the wheeling and dealing behind the scenes of the 1937 Report are not as important as the substance of the Committee's recommendations. On paper, at least, these enshrine the terms of CSIR's commitment to the manufacturing sector.

PRELUDE TO WAR

The tempo of industrial reorganisation was spurred on by the Imperial Conference of 1937 which alerted Australian authorities to the rapidly deteriorating situation in Europe and galvanised the government into action. Significantly, by 1939, although the recommendations of the Secondary Industries Research and Testing Committee had now been implemented and the Aeronautics Division and Radiophysics laboratory were quickly pressed into service, CSIR itself was not strategically admitted into the planning phase of all-out mobilisation of industry for the war effort. One could infer from this that CSIR was itself seen as a non-essential industry.

The implications of this separation of civil science from key industrial development goals was not apparent during the aberration that was World War II. That CSIR was marginalised from the decision-making process in what was an unprecedented piece of industrial restructuring in Australia's history put it at a serious disadvantage — arguably with permanent and irreversible effect.

Mobilising Industry for the War Effort

In March 1938 Menzies appointed Essington Lewis, General Manager BHP, Chairman of the Advisory Panel on Industrial Organisation. In June 1939 a Supply and Development Act was passed. Departmental responsibilities were far more explicitly defined than those of the Munitions Supply Board had been. The National Security Act, put through soon after official declaration of war, greatly extended state powers to control industrial resources. Emergency measures were cogently described by Menzies:

> We must take every power so to order, so to command and direct the factories of Australia, those who operate and those who work in the factories in Australia that we may in the shortest possible time produce the greatest possible supplies of armaments, ammunition, mechanical transport and all those things wich the modern army requires if it is to fight with success.[31].

These words gave the green light to the ruthless appropriation of all resources on the industrial front — on a scale unparalleled in other dominion countries. In May 1940 Essington Lewis was made Director-General of Munitions. Lewis was given extraordinary powers of discretion — the post was accurately described as that of industrial dictator. Lewis proved well-matched for the job. He was one of a new breed of technocrats epitomised by a plaque hanging from his office wall, I AM WORK[32]. In June 1940 Lewis adopted a strategy for the new munitions organisation that was to endure almost unaltered for the duration of World War II. The subsequent structure of the largest manufacturing organisation ever established in Australia and the appointment of leading industrialists and public servants for its direction and control was completed within six days. Soon after MSB was hived off from the Department of Supply and Development. The Department of War Organisation of Industry [WOI] was established in June 1941. According to Mellor, by 1942 the whole of commercial industry was pressed into service. What was now needed "was the will of the community to produce its utmost effort: manufacturers with their organisations and machinery, employees with their skill and enthusiasm"[33]. By contrast the mobilisation of science and scientists was still labouring with what was called "the frustration of science"[34].

Despite CSIR's officially sanctioned move into secondary industry, it was Munitions rather than CSIR which was symbiotically connected with industry and economic policy.

TRENDS IN INDUSTRIAL RESEARCH AND TECHNOLOGY TRANSFER DURING WORLD WAR II

Some reference to distinctive tendencies in Australia's technological

capability to emerge from the wartime experience are pertinent. Without this context, the consequences of the legacy set during the interwar years pale into insignificance.

Wartime emergency permitted industrial restructuring on an unprecedented scale. Neglected in generalist histories of Australian S & T (and much underrated by economic historians) has been the enormous change in the means of innovation that occurred during this ungainly acceleration of Australia's industrial base. For the purposes of this paper, the means of innovation is loosely defined as IR & D capacity, and technology transfer and skills capital. Not only was local capital used to support foreign-owned enterprises in strategic industries, but the means of innovation largely accrued to the MNC concerned rather than the State coffers which underwrote it.

At the same time, a different but complementary tendency was in the making — through CSIR and other State agencies for IR & D. Here the sort of capital being accumulated was (as it turned out) largely academic capital rather than technological capability. Both trends augured ill for the development of Australia's technological capability and for control of its means of innovation. The following material is necessarily sketchy and in no way intended to mitigate the singular contribution of individual CSIR programs for the war effort. Nevertheless, while the ethos of excellence promoted the syndrome 'publish not patent', some multinationals were doing very nicely by exploiting the industrial interstices created by wartime exigencies. International Harvester [IHC] is a case in point.

International Harvester Company

Diverted from the manufacture of agricultural machinery in order to meet large army orders for trucks and truck engines, IHC diversified on a grand scale. Its wartime brochures hailed its diversification as a masterly feat of turning ploughshares into swords. It was underwritten by cost-plus contracts, and by the boosted productivity of a ready supply of cheap labour fuelled by nationalist fervour. The pattern of IHC's diversification illustrates in microcosm,what was to become an entrenched feature of Australia's industrialisation in the war years — from import-substitution to another major phase of diversification for the war effort and further competitive advantage through monopoly of technological know-how.

Noting that a great deal of equipment had been developed by IHC engineers for the Australian forces, IHC was careful to consolidate its technical expertise and innovative capacity within the company itself. Technological know-how accrued to the parent company. Like Ford and GMH, IHC imported its own engineers to work on new designs needed for the war economy, rather than consolidate Australia's skills

bank. IHC liberally sprinkled its 'technical contactmen' throughout the country to carry out exhaustive testing of equipment and to avail itself of the home-grown expertise of the local farmers.

Some appreciation of the technological know-how so acquired may be gained from the scope of IHC's diversification during the war. IHC moved into three key areas of production with the manufacture of truck chassis; spare parts; petroleum gas units and subsitute fuels. Imported truck chassis were quickly absorbed by army quotas and IHC was proud of its innovative acumen in modifying and scaling-up chassis design to meet army specifications. Service parts production had high priority and IHC dutifully recorded that it would "continue to do its best to meet this demand so that [imported] equipment now on hand may continue in use *and thus avoid the necessity of manufacturing new machines*"[35]. Less altruistically, elimination of competition for this market also ensured handsome market advantage for IHC in the post-war period.

IHC was less coy about expected returns on its IR & D investment from the production of gas units for heavy-duty commercial motor transport. Considerable modification of imported design was necessary because the imported trucks had low pulling power due to "insufficient gas-generating capacity or engine wear". According to its own wartime brochures, Harvester engineers pulled out all stops on design and endurance tests to meet "the totally different requirements" for car and truck engines on the Australian market. Once the solution was found, IHC quickly organised facilities at Geelong Works for mass production. For the public record IHC presented a different rationale:

> Because of the wartime shortage in the normal supply of new farm machines and the scarcity of farm labour, equipment is not only precious, but also vital to the success of the National plan. . .Harvester agents and our Company's technical contactmen in agricultural centres play. . .a vital part in Australia's war effort[36].

To its locally recruited and largely unskilled workforce, IHC appealed to nationalist fervour for redoubled effort.

The postwar years saw large-scale expansion of IHC's engineering and research activities. In 1946 IHC purchased an American plant specifically to centralise its IR & D activities which had formerly been scattered at individual plants. By conflating its contribution to the war effort with its gift to Australian manufacturing, IHC was able to pass its products off as Australian. And so, like the packaging of GMH as maker of the all-Australian car, another great myth was born. What is less commonly known is the lead it cut from its chief Australian competitor, the Sunshine Harvester Works.

Hugh McKay and the Sunshine Harvester Works

The McKay Harvesting Machinery Company was established in 1890[37]. Founded by Hugh McKay, it had by 1904 surpassed itself by becoming the largest manufacturing exporter of agricultural machinery in the Commonwealth. Floated by McKay's own invention of the first successful stripper-harvester, sales expanded rapidly until production almost doubled. Sunshine Harvester became a major export concern with large markets in the Argentine and a decided threat to the North American reaper-binders. McKay moved into mechanised production and displayed the sort of innovative ingenuity that was to become the hallmark of his entrepreneurial acumen.

His meteoric rise to fame and acclaim depended as much on his flair for high-risk financial management as that for manufacturing and supply. Branded as a "free trader in humans" for his evasion of the wages board, McKay lost no time in launching a campaign for higher tariffs against the "American Octopus Trust", the International Harvester Company of Chicago.

World War I trade pumped fresh blood into McKay's domestic market and provided a launching pad for unparalleled expansion. In the post-war years Harvester, reconstituted as H.V. McKay Pty Ltd in 1921, diversified into the manufacture of engine-propelled harvesters (1916), combined seed and fertiliser drills and cultivators (1917), reapers and binders (1921) and self-propelled auto-headers (1925).

McKay's prosperity relied heavily on mobilising the inventiveness of practical farmers and specialist engineers, especially those with patents to sell. But McKay's preference for absolute control of his enterprise left his empire floundering when he died in 1926. Four years later McKay's Australian interests merged with its Canadian competitor Massey Harris. The timing was critical since the Australian subsidiary of IHC was able to move inside the tariff wall and corner the domestic market for farm machinery while it was still reeling from the aftermath of the 1930 Depression. By World War II Sunshine Harvester housed a considerable engineering and metallurgical capability. Its wartime effort, while not insignificant, did not seed bedrock industries in the postwar period — as it did for IHC.

Although entirely new industries were created by World War II, the underlying technological know-how did not necessarily feed into indigenous IR & D capacity. Nor did local IR & D necessarily fuel economic growth through technical change. The fate of the Commonwealth Aircraft Corporation, the optical munitions industry and the Hartnett car are prime examples.[38]. In these instances the loss to Australia's skills capital is unquantifiable. But the case of the aluminium industry puts a telling price tag on the cumulative cost of forfeited know-how.

The Bayer-Hall Alumina Process

Plans for an aluminium industry were first touted after World War I but hit the stumbling block of international cartels[39]. The idea again found favour following the world-wide drought of aluminium in the 1930s. Wartime shortages made further prevarication critical. In 1942 CSIR's Division of Industrial Chemistry was drawn into the government's deliberations. The Commonwealth Oil Refinery was finally established in Tasmania in 1955 after heart-breaking delays in construction as Alcoa held out on providing the requisite know-how.

After only a few years in operation, the plant was sold to Kaiser Aluminium & Chemical Corporation and Consolidated Zinc Corportation (which formed Comalco). According to Grant, when Western Mining later negotiated with Alcoa for another Bayer-process, it tried to retain control in Australian hands but had to concede defeat because of Alcoa's technological monopoly[40]. This scenario was repeated in the Bayer-process alumina refinery at Gove where Swiss Aluminium Ltd transferred the technology and gained a majority equity. The upshot was that the know-how so acquired was later bought in three separate transactions, thus giving the Australian government the dubious distinction of paying three times over for the same technology. The exquisite irony is that the original Bayer-Hall process was developed by CSIR during World War II (with a little help from the British). Worse still, the technical base in each case is now outside Australian control. The result is that significant process development no longer occurs in Australia. Nor is it possible for Australian firms to transfer the technology to any other country[41].

But IR & D capacity alone is no guarantee of commercial return without technology transfer bargaining power. Skills capital accumulation thus becomes a critical underpinning of both.

SCIENCE AS SHOWCASE RESOURCE

The force of the 'excellence' ethos is well illustrated by Wark's characterisation of his early years as Chief of the Division of Industrial Chemistry [DIC]:

> [W]e were referred to as the pride of the prima donnas. . .if you were to tell Wark in the morning that you have discoverd how to annihilate gravitational forces, he'll want to know what you are doing in the afternoon''[42].

Apocryphal story or not, it does state underlying penchants.

Like a proverbial mandala, the justification for DIC's entire research program is based on the economic pay-off of one outstanding

contribution[43]. In this instance it was cement research methods using sophisticated geological and chemical techniques. DIC researchers found that the underlying cause of deterioration of concrete structures was the use of high-alkali cements and unsuitable aggregate materials.

However, the fate of other programs was less fortunate. During the war Munitions requested DIC to develop an alternative process for alkali fusion. "This method was developed to pilot plant stage and was equally applicable to high grade ores. However it was *CSIR policy at the time to publish rather than to patent,* and no company could be found to spend £300,000 on development without patent protection"[44]. Later on a separation process for zircon was discovered and patented but since its use in Australia was extremely limited, it was sold for £300,000.

THE ALIENATION OF ACADEMIC RESEARCHERS FROM SCIENTISTS AND ENGINEERS IN INDUSTRY

The importance of a 'suitable environment' for research had been recognised as far back as the 1920s when Sir Herbert Gepp,then Manager of the Electrolytic Zinc Company, made arrangements for a newly appointed research metallurgist to work in the University of Melbourne instead of at the company's research department at Risdon, Tasmania — and thus avoid the constant distraction of attending to technical troubles arising at the plant[45]. By the early 1920s other government agencies also started up fledgling research laboratories. Foremost among these was the PMG's research laboratory initiated by its Director, Harry Brown.

Briefed to keep up with latest developments in 'electrical communication', and to undertake experimental work to be adapted by engineers, Brown soon faced the pressing problem of shortfalls in skilled engineers and technicians. The PMG's interest in radio research was further stimulated by the creation of the Radio Research Board [RRB] at CSIR in 1926. Brown played an active role in its progress. Chaired by J.P. Madsen, Australia's first Professor of Electrical Engineering (Sydney University), the RRB's brief was to carry out fundamental research to ensure against "a slavish application of experience" from radio research overseas[46]. Without the PMG's vote of £8000 to RRB in 1928 to tide it through the Depression years, it is unlikely that Madsen's ambition for an original research program could have been realised.

But it would be misleading to confuse the desire for an autonomous research program with that of founding a science infrastructure to promote indigenous scientific activity. Two further developments were to handicap the long-term capacity of CSIR's radiophysics research to serve the needs of an industrialising economy. The first

stemmed from the unstated, but increasingly strained division of labour between CSIR's Radiophysics Laboratory [RPL] and the PMG's Research laboratories. This was exacerbated by the tense deadlines of wartime production when hand-in-glove collaboration between CSIR and the PMG was stretched to the limit. CSIR's RPL soon became credited with being the powerhouse of innovation while the PMG research staff were relegated to the role of "breadboard cutters"[47].

Even then the efforts of both proved unable to handle the Herculean task of armed services orders and in 1942 the organisational structure for radar production was revamped. The Radiophysics Advisory Board now came under WOI instead of Defence[48]. This second development was to have a definitive impact on CSIR's subsequent program in radar research. This restructuring followed the fiasco in struggling, against odds, to mount a radio installation at Darwin soon after the attack on Pearl Harbour[49]. Stung by what was felt to be a politically expedient exercise as Munitions looked for a convenient scapegoat, Madsen resigned. RPL researchers were subsequently able to retreat into the more familiar routine of pure research (notable ionospheric and meteorological research) as the pressure of war emergency wore off.

The defensiveness was the understandable, if unfortunate, outcome of a superlative and sorely-tested contribution at a formative stage of Australia's radar development. The massive boost in status and funding of the Radiophysics Division in the postwar years, set the pace for the backing of big science projects in a country with little science resources.

CONCLUSION

This overview depicts the nature of the linkages forged between science and industry in Australia. Certain striking tendencies appear. During the interwar years the power struggle between CSIR and the munitions sector intensified and continued to undermine CSIR's capacity to serve an industrialising economy. Ironically, although World War II saw the massive expansion of Australian industry, the postwar consolidation of Australia's industrial base had the effect of pre-empting indigenous technological development and reinforced a derivative industrial structure. Munitions and Supply became more exclusively defence-oriented and much of the commercial and technical facility Munitions once provided for the private sector became obsolete.

Meanwhile the research enterprise was distracted from the commercialisation of experimental programs. The divergency between

the academic research community and their scientific and engineering peers in industry grew stronger — a trend which represented "a sundering of research from development"[50]. It also helped consolidate the hegemony of Australia's largest research organisation as a source of academic employment.

At the same time a new breed of technocrats and science-trained bureaucrats was gradually distanced from the industry policy process. This meant, *inter alia,* that the work of State-supported research agencies was progressively diverted into esoteric science areas where prestige could be sustained by the pretext of distinguished contribution to the international pool of knowledge.

The identification of technological utility with increased scope for political interference intensified the effects of CSIR/O's detachment from industrial development and economic policy. The impact of cold war invective against CSIR/O in the post-war years subverted the nationalist sentiments of attempts by a wider science community to establish science as a socially productive resource[51]. Hence the ideology of autonomy turned full cycle — from attempted independence to internationalism with no specific protfolio. As Sir Eric Ashby, one-time President of the Australian National Research Council, was moved to comment in 1942:

> We have become so anxious to prevent science from becoming a twentieth century priesthood that we have deprived the scientist of the very influence he sought to exert in his own sphere. . .He cannot take the offensive because the strategy for science is out of his hands.[52]

Over time the ethos of excellence was consolidated by an introverted science policy. The quest for autonomy ultimately took on the force of preferred *modus operandi* — that science is best left to those who know what is best for science[53]. The legacy has been as lethal as it has been enduring. It has disfigured Australia's industrial innovative performance. The consequently skewed R & D system consolidated under the aegis of CSIRO in its massive postwar expansion is now legendary.

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39. Indeed a CSIRO Executive minute much later recorded that the cartel bogey was often carted out in an attempt to stall expansion of strategic industries in Australia. The aluminium industry was cited as a case in point. (CSIRO Archives. Executive Minutes. Submission to the Economic Committee of Enquiry, October 1963).
40. Paul Grant, 'The International Transfer of Technology for Secondary Processing Projects in Australia', Paper to the *Fourth National Conference of the Australian Mining and Petroleum Law Association',* Sydney, June 1980.
41. Grant also shows that the history of titanium dioxide pigments produced from Australian beach sands followed a very similar pattern. Pre-war production and markets were dominated by cartels, but wartime shortages led to local development and the potential basis for an Australian industry. In each case control was retained by the relevant MNCs through the DFI package such that future transfers could only be made by the parent company.
42. I. Wark, *op. cit.,* p.8.
43. In Wark's view, "This one research project alone justified the Division's policy of conducting investigations on as fundamental basis as was necessary for success", *loc. cit.,* p.30.
44. My italics, *loc. cit.,* p.17. This view is corroborated by CSIR's 1945 *Annual Report* which notes the need for closer liaison with industry, claiming that "the problems of a whole industry should be preferred to those of individual companies". Interestingly it also considered that "a team of experts in the various chemical engineering unit processes should be built up" and that "in special circumstances contract work might be undertaken, but with publication of results".
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47. As Moyal points out the distinction was both inaccurate and invidious: "CSIR was quick to claim public credit for Australian radar work although the major part of the undertaking that brought radar into operation was the engineering task performed by the small, creative and persistently determined PMG Research Laboratories team", *ibid.*, p.167.
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