Catching Up or Marking Time? Technology Transfer and Market Fragmentation in Australia*

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ABSTRACT *Australia was a latecomer to industrialisation, dependent on the importation of 'foreign' technology to help 'catch up'. While such a strategy can lead to entrenched structural dependence, a dynamic variant of product cycle theory suggests that windows of opportunity for genuine catching up are created at times of transition to new technological systems or paradigms. Such conditions arose in Australia in the 1920s with the emerging shift from natural to synthetic materials. By studying the subsequent development of a local synthetic resin industry, this article highlights the way technology transfer processes can affect market structure and behaviour, and the cumulative effect of the resulting industrial weaknesses.*

Keywords: Australian industry, fragmentation, innovation, R&D, synthetic resins, technology transfer.

Introduction

In the race to industrialisation, the transfer of 'foreign' technology has sped the passage of some countries, yet reinforced development gaps for others. Interpretations have been similarly divergent, the former tendency spawning various versions of late-starter and catch-up hypotheses,[1] the latter stimulating the development of dependency theory.[2] Where Australia fits on this spectrum of potentialities and outcomes has been a matter of some debate.[3] But at the end of the 20th century, it still struggles with stubborn structural problems and apparent dependencies which justify reflection on the Australian path to industrialisation. This article joins theory with historical data to probe the underlying processes.

The evidence of both success and failure in technology transfer suggests there may be ways out of the vicious circle of underdevelopment, but that they may be fleeting or formidable. This line of argument has been pursued by those who eschew the productivity-based discourse of catching up[4] for one which focuses upon the technologies and processes of technological change. Perez and Soete have been prominent in this latter group. They have argued[5] that specific points arise in the evolution of technology systems when developing countries might find a window of opportunity for catching up.

Typically, those countries enter new technologies and industries in their mature phase, and simply as users of the imported technology, when dynamism has dissipated

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and expertise gained in development has been locked up in proprietary products and processes. Yet genuine catching up requires participation in the generation and improvement of technologies. The real point of opportunity, it is argued, is at the transition into a new system of technologies, a new techno-economic paradigm.[6] It is then that capital and managerial requirements are at their lowest, much of the basic knowledge is still in the public domain, specific skills required for full exploitation are yet to be developed and entry costs are in fact higher for those established companies who are already committed to 'old' technologies than it is for young, unencumbered companies who can quickly and readily embrace the new. Entry, does not, of course, guarantee survival in the race.

The argument is derived from the theory of the product cycle but a new techno-economic paradigm involves much more than a new product or process. First, it implies a radical discontinuity with preceding technological development. Secondly, it involves multiple interconnected families of related technologies with supportive synergies and externalities. Thirdly, these technological systems have broad-ranging industrial scope. The micro-chip is a common example.

A phenomenon of this sort was clearly involved in the massive 20th-century shift from the use of naturally occurring materials to synthetic products. From 1913 to 1960 synthetic materials grew at 12% per year while overall industrial production in the major countries rose only 3%.[7] One of the earliest manifestations was the commercial exploitation of synthetic resins, and two of their earliest uses were for moulded plastics, like Bakelite, and for new kinds of surface coatings. The latter are the focus of this article. They involved a radical shift in the system of coating technology, and provide a case study of a resultant industry in the making—that of the resin makers which serviced the producers of coatings. Through this study we can explore the general implications of the Perez and Soete argument, and reflect upon influences on the specific pattern of Australian development.

A Shift in Technology Systems

Surface coatings of various kinds have always been used to protect and beautify, and the materials and methods of their making remained essentially unchanged for centuries.[8] Three basic components were usually involved: a pigment for covering power; a resin/oil vehicle to bind the pigment and make it adhere to the surface; and a solvent in which to disperse ingredients. The gums and resins for the basic vehicle came from the saps of living or fossilised trees. They were traditionally combined with a natural oil such as linseed after being cooked in primitive conditions in open pots, over open fires, to the appropriate degree of 'stringyness'. This was judged by experience from the length of drops on the end of a dipstick.

The resins which transformed the making and usage of paint systems were the so-called *alkyds*, long chain polymers formed by the repeated reaction of glycerol molecules with molecules of phthalic anhydride. The basic patent which made this applicable to paints was registered in 1927. It was a breakthrough for the properties of surface coatings and in the standardisation of the materials that went into them. It dramatically changed the technical requirements of paint making, and switched the source of resin supply,[9] from the forests of undeveloped areas like the Belgian Congo to the highly capitalised chemical companies in the USA, Germany and Britain.

The growth in the use of alkyd resins was dramatic, as evidenced by alkyd production in the USA[10] (Figure 1). Further innovations kept feeding the growth. The basic alkyd reaction was manipulated in an almost infinite number of ways, producing properties specific to all kinds of uses, from toys to petroleum rigs. Then came new generations of

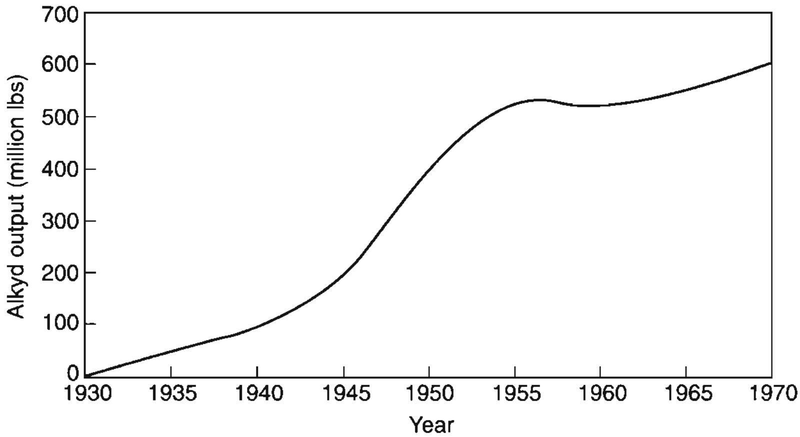

Figure 1. Alkyd production USA, 1930–1970.

resins, based on different molecular combinations, and giving more kinds of applications. Among the most significant were the resins which also turned paint from an organic solvent-based substance to one based on water. This reduced costs, inflammability and environmental hazards, improved many aspects of handling and opened up even more applications.

There were also obvious related 'lateral' movements, into products made with similar materials or processes, such as phthalate plasticisers and polyesters for boats and surfboards. This was clearly the kind of dynamic set of interrelated technology systems on which enormous growth spurts could be made. So would it have any potential for Australia? Could it catch and ride the development wave, or simply buy in the attractive but completed end products?

Australian Conditions

Australia at this time had only a very small and limited chemical industry, basically explosives for mining and fertilisers for farming. However, an expanding system of universities and technical colleges was generating a growing supply of chemists and chemical engineers with the capacity to monitor developments in technology. By the 1920s these people were starting to find their way into local manufacturing, including the paint industry.

For decades the Australian paint industry had laboured under the preference for British products, but the First World War and then postwar tariffs changed all that. By 1927, the year of the alkyd patent, local paint manufacturers were supplying more than 80% of Australian requirements. There were 69 factories, with output worth more than £2 million. A very large part of this went to domestic uses, but an increasing amount was going to industry for cars, furniture and appliances. With growth in population and industrialisation, there was considerable scope for progress. By 1955 the value of paint production had risen to £34 million and Australians were the fourth greatest per capita consumers of paint in the world.[11]

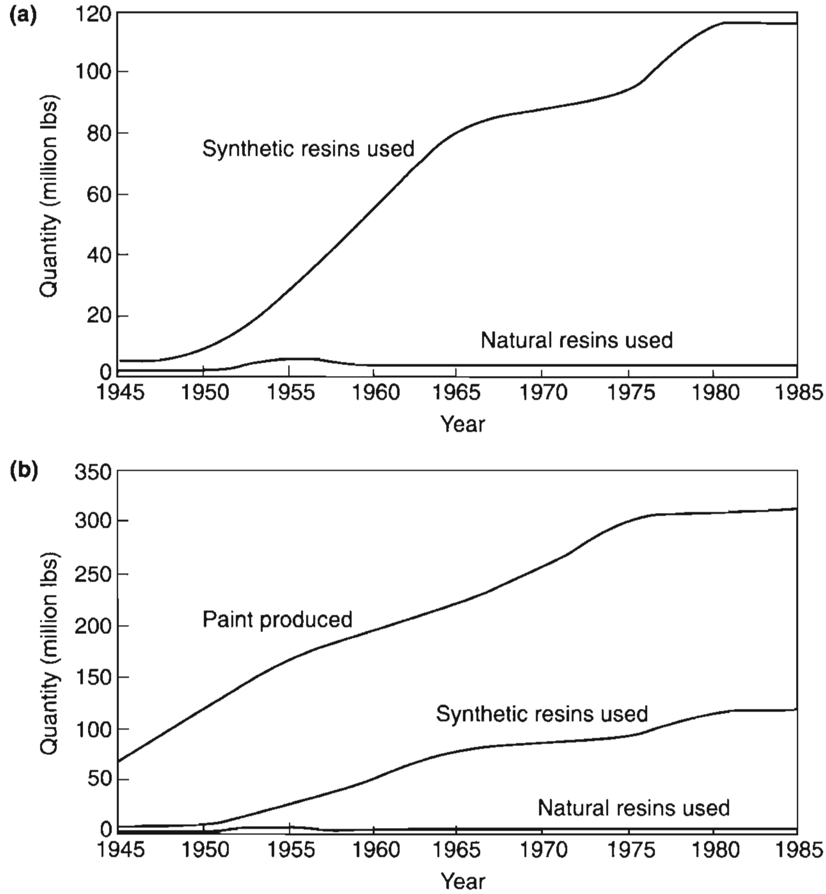

Figure 2. Postwar shift to synthetic resins in Australian paint.

Synthetic Resin Demand

With a client base for the new technology, and a local supply of chemical skill, it was a receptive environment. The shift to synthetic resins began in the late 1920s, gathered some momentum in the 1930s and accelerated rapidly in the postwar era. That postwar shift is evident in Figure 2a,b,[12] showing the relative use of synthetic and natural resins in Australian-made paint.

The Australian paint industry began the shift via a semi-synthetic called ester gum—natural rosin reacted with glycerol—but, as elsewhere, it took off on the alkyds, was fed by subsequent generations of resins, and then a second major wave of demand for acrylics and the water-based systems, called emulsions or latexes. These arrived in the 1950s. The ratio of solvent to water-based architectural paints changed from 6.14 in 1958 to 0.28 in 1992.[13]

Synthetic Resin Supply

There were two possible sources of resin supply: imports from chemical companies overseas; or local manufacture.

There is a common sequence in countries which habitually transfer technology from overseas. The first step is to import finished goods which embody the technology (such as alkyd-based paints). The second stage begins when demand permits imitative local manufacture of those finished goods, importing essential components (such as the alkyd resin). This may be followed by a third stage, of local adaptations which help expand demand. A fourth stage could also emerge, with movement backward into the manufacture of intermediate materials (such as the alkyd resins themselves), and possibly eventually into the raw materials for the resins (such as phthalic anhydride).

The process described can be long and drawn-out and, in the light of our starting proposition, could easily land new manufacturers back in the mature-phase point of entry. Timing is therefore critical. This suggests the necessity for modification or rapid compression of the transfer process if the catch-up potential of new technology is to be realised.

What happened in our Australian example? On the import side, some *finished* synthetic *coatings* appeared at the end of the 1920s (i.e. stage 1), but so did a trickle of the synthetic resins from which they could be made. In 1937, importer A.C. Hatrick had several customers in the paint and lacquer business: 16 in Sydney; 8 in Melbourne and 2 in Adelaide.[14] So in the 1930s we were moving to stage 2 in the usual transfer sequence. By 1950, however, a tariff enquiry found that virtually the total Australian demand for synthetic paint resins was being met from within Australia.[15] Clearly we had reached stage 4 of the transfer process and a new industry, of resin production, had been created.

This new resin industry had a large indigenous component. The two major players were two Sydney firms who saw the potential for making synthetic resins specifically targeted for use in paint. Their entry costs were low since they could start with a single small kettle, quarters no bigger than a garage, and minimal labour.[16]

One of the new resin firms was created by the importer, A.C. Hatrick, who in 1939 acquired a resin manufacturing licence from his former American supplier, Reichhold Chemicals. Here was the usual model of technology transfer as product import, followed by imitative manufacture. In a joint venture company, Reichhold initially provided 50.6% of the capital, although in the 1950s the company went to Hatrick control and Australian ownership on the Sydney Stock Exchange. In the meantime, Hatrick provided all the management while Reichhold provided a resin kettle, two Reichhold personnel and the rights to all current and future Reichhold technology. Reichhold was by now one of the fastest developing resin specialists in the USA.

The other Australian resin producer was W. Hermon Slade, a closer approximation to the Perez and Soete model of the infant innovator picking up technical knowledge in the public domain. Young Hermon Slade was a science graduate of Sydney University, and well versed in synthetic organic chemistry and its international developments. He was not dependent on overseas licences. This scientific capital was combined with his brother's marketing acumen, and his father's commercial guidance.

Alkyds were (poly)esters, and the Slade manufacturing knowledge of ester reactions had been building during the 1930s. The ester chemistry of university lectures acquired more practical form with the Slade company's manufacture of hand lotions, and more technical sophistication from Hermon's visit to Germany in 1937. In 1938 the Slade brothers established their own company to make glycerol monostearate. From this it was just a short step to the synthetic ester gum used in paint. With two bread-and-butter lines to generate cash flow, in 1939 Hermon Slade began his own experiments on alkyds and defined the company policy of relying on their own research. By 1944 they were using the company name Polymer to denote the nature of their business; making polymers for paint.

For both Hatricks and Slades war disrupted everything, but by the end of the 1940s their combined resin production had reached 7 million lb. But herein lay a puzzle. They were essentially the only suppliers of resin to the paint industry, yet the total Australian production of synthetic paint resins was estimated at 12 million lbs.[17] Where was the rest? The answer lay in the fact that the larger paint makers were making resins for their own use. By 1954, four resin producers were making 19.5 million lbs of resin for paints, out of an estimated total output of 35–40 million lbs.[18] In 1968, only 45% of output came from the resin companies, and in 1975 a similar situation still applied.[19]

With half of the paint resin market consistently cut off from the resin producers, the bulk of their business lay with the small paint companies who had not the wherewithall to follow the pattern set by the large firms. Those small companies were numerous, but held only a minor part of the paint market. In 1975, for instance, there were nearly 150 paint companies in Australia, but the seven major producers accounted for about 75% of aggregate turnover, and at least five of those companies still made their own resins.[20] There was thus a two-tiered structure to the resin market: big volume users who serviced the biggest industrial markets but who catered largely for their own resin needs, and a multitude of small users who all wanted particular properties in the resins they bought.

How did this situation come about and what were the consequences? To understand the how, we must examine the process of technology transfer to Australia. This is turn will help us unravel and assess the effects.

Transfer of Synthetic Resin Technology to Australia

The technology of synthetic resin manufacture was the product of chemical companies. Yet it was not transferred in the first instance to chemical companies in Australia. Instead it went directly into the three major paint companies. With regard to the Perez and Soete proposition, and the importance of timing, this was significant, as it did indeed result in the modification and compression of the usual transfer process.

The pioneer

The pioneer in production of these new resins was BALM—British Australian Lead Manufacturers. It is now the leading paint company in Australia operating under the name of Dulux. In the 1920s it was number two. It was formed in 1918 to produce white lead, then a major constituent of paint, by an Anglo-Australian combination consisting of three Broken Hill lead mining companies, controlled by the so-called 'Collins House' group, and seven British lead corroders-cum-paint suppliers. In the 1920s BALM moved into full paint production and in 1928 acquired new international affiliations when a joint company owned by ICI and Du Pont (Nobel Chemical Finishes Ltd) acquired a 40% shareholding in BALM in exchange for the Du Pont technology of Duco—the new nitrocellulose lacquers for painting cars, which were taking the automotive market by storm. This arrangement gave BALM free and continuing access to *all* Du Pont and ICI technology which was in any way related to the manufacture of these lacquers.[21]

This was a most significant agreement, not only because it put BALM in the box seat for the Duco business of General Motors (GM) in Australia, but because it was out of the further refining of Duco finishes, and the development of suitable undercoats, that the synthetic paint revolution emerged. And BALM had a direct line to the source. It was 1927 when the alkyd patent was registered, and 1928 when Du Pont released the first alkyd-containing auto products, its chief customer initially being GM. BALM had early knowledge of these developments through Du Pont reports, and it also experienced the very earliest market demand for these new products when, in May 1929, GM in Australia requested local supply.

BALM went to Du Pont for the technology in 1930 and began supplying GM with these new lacquers and undercoats later that year. The BALM chemist was still with Du Pont when they extended the use of alkyds to house and building paints and launched the new Dulux range. In December 1931, BALM too launched its own Dulux products on the Australian market. Within months it was making for itself the alkyd resins that gave Dulux paints their unique and remarkable properties. The transfer of technology had indeed been swift.

But why did BALM not simply import its resins from Du Pont, or ICI? ICI had also acquired Duco and resin technology from Du Pont and was now set on its own course of resin manufacture and development. It was certainly eager to supply BALM's needs. Indeed, the ICI–Du Pont joint shareholding in BALM was predicated on the assumption that the Australian market belonged to ICI.

There were, however, several reasons why BALM chose to produce its own alkyds. The first was a cost factor. Because of a complicated patent situation, both Du Pont and ICI would have to pay a substantial royalty for any alkyd exported. However, because the patent was not covered in Australia, BALM could produce it without royalty payment.

This open patent situation added urgency to the matter. If BALM could produce without royalty so could one of Du Pont's American competitors, who could start up Australian production, then gain tariff protection, thereby cutting off import from Du Pont or ICI, and holding BALM to ransom for technology for which they already had right of access. This would then also give the other Australian paint makers ready access to the new technology.

Given this urgency, BALM was also frustrated with two years of delays caused by ICI, its formal channel of access to Du Pont technology. Instead BALM went direct to Du Pont. There, the BALM chemist satisfied himself that BALM could make the alkyds successfully in their existing varnish plant, with only minor modifications. In other words, the 'new' technology could be grafted onto the 'old', minimising capital outlay and plant disruption. This they did in 1932.

A Limited Mandate

Given this pioneering spirit, we might wonder whether BALM might not have developed a resin-producing offshoot as market demand allowed. After all, Du Pont and ICI were both chemical companies with a paint offshoot. However, BALM was solely a paint company, and ICI was intent on keeping it that way.

Behind much of the ICI delay was an internal debate about just how the patents and technology rights for Australia should be handled. This impinged on an agenda much broader than BALM or synthetic resins. ICI had been deeply involved in establishing an ICI counterpart in Australia, to be positioned for a monopoly ranging across the existing and future development of the Australian chemical industry. ICI in the UK wanted to ensure that BALM, which it did not (yet) control, did not gain any technological territory that should reside with the Australian ICI, which it did control.

It had been the original intention of ICI to use its own Australian company as the direct recipient of Du Pont's Duco technology. For several reasons this plan was modified during 1927, but at the time the decision was made to deliver *Duco* to BALM, ICI did not fully realise the scope and future potential of what was implied in the agreement. At the time the *alkyd* technology was delivered to BALM, by virtue of this same agreement, ICI was still working out its own position and strategy in this field. But it knew it wanted to be in it.

BALM was thus to be limited to making synthetic resins for its own use in paints, varnishes and lacquers, even while marking out and holding the Australian territory until ICI could develop its own foothold as a synthetic resin supplier. By 1933 ICIANZ was importing its own brand of synthetic resins into Australia. Any branching out by BALM into production of resins for sale would have been a severe encroachment on ICI territory and plans.

Meanwhile, Du Pont was extremely anxious that there be no leakage of technology to its competitors. But the number one paint company, Berger (Aust), although a subsidiary of Berger in the UK, received its paint technology from Sherwin Williams, the major paint company in America, and a major competitor of Du Pont. Such was Du Pont's determination to quarantine its own technology, that in 1930 it soundly squashed a proposed merger between BALM and Berger (Aust). Such were the conditions of swift access to the latest technology.

Close Followers

Overseas affiliations similarly affected the policies of the other leading paint companies. Berger (Aust) had received Sherwin Williams' duco equivalent in 1926. In the mid-1930s came Sherwin Williams' alkyd technology, and similar strictures on secrecy.[22]

Taubmans developed similar technological channels. Having reached number three position, behind BALM, this all-Australian company observed the technological advantages gained by Berger and BALM through overseas affiliations, and in 1930 traded 51% of their equity for the promise of technology from Britain's major paint company, Pinchin Johnson. Seeking to emulate the success of BALM's alkyd-based Dulux, Taubmans acquired via Pinchin Johnson the alkyd technology of the great German combine, IG Farben, with its own unique set of processes and requirements. In 1936 Taubmans started a research department and by 1939 their alkyd plant was in full swing.[23] Four years later a separate chemical division was spawned by services to war. However, this venture was always frowned upon by Pinchin Johnson, who eventually forced its sale to ICIANZ.

So the three paint majors were producing alkyd resins before the war, and before there was any local resin producer to supply them. But instead of subsequently casting off outdated plants and switching to the resins now available from specialist suppliers, the paint company policies of the 1950s entrenched the prewar pattern with a new wave of investment in specialised, closed resin kettles and expanding resin staff. What were their reasons?

Paint Company Logic

Technological 'pipelines' and secrecy obligations. The technology transfer process had institutionalised a 'pipeline' structure of technical relationships, practices and obligations. Each paint company was committed to a different version of the resin technology, channelled through an ongoing relationship with an overseas technology supplier. They followed the practices of overseas affiliates, assimilated a continuing flow of improvements from the same source, and in return complied with strict codes of secrecy which prohibited the passing of formulations, data and techniques onto any external resin producer.

Table 1. Alkyd production, 1963

Resin companies	**Output (tons)**	**Paint companies**	**Output (tons)**
Hatrick	3588 (67% cap)	BALM	5864 (82% cap)
Polymer	2000 est.	Taubmans	3378
Jordan	1842	Berger	3000 est.
		British	2097
Total	7430	Total	14339

Technological/market factors. Secrecy was also related to product differentiation. The ability to manipulate the properties of synthetic resins was a major source of product innovation, and also enabled tailoring to very specific market requirements and industrial user idiosyncracies. Paint companies believed their own resin departments could give them a technological edge over competitors in a way that no resin producer could do.

Independence from suppliers. Both the above factors led the major paint companies to value independence from suppliers and the full control of their own formulations. Even after formal secrecy obligations had been superseded, the paint companies were reluctant to trust to outside production, even under their own secrecy agreements. By contrast, small paint companies worked with the resin producers to develop products specifically directed to their needs. The company that became Wattyl found this a most rewarding interaction.

Economic factors. The paint companies themselves all said it was cheaper to make their own resins than to buy it from the local producers, who added a sizeable profit margin. Economic evaluations were never spelled out, but at the end of the 1950s British Paints said it was compelled to build its own resin plant in order to compete on paint.[24]

There is some substance to this economic claim for the simple reason that the paint companies were often individually producing in a volume which exceeded that of the specialist resins producers[25] (Table 1). In fact, British Paints also wanted independence from resin suppliers and their protected pricing. British Paints then decided to join the resin-selling club, undercutting other producers, and slicing away not only their own contribution to the available market but also another 1000 tons per year.[26]

Political factors. Political factors could also intrude into the logic and location of resin manufacture. State government contracts for paint were lucrative but gave preference to product made in the same state, encouraging interstate plants. Then the expense of interstate resin transport from Sydney-based suppliers in turn encouraged the installation of a resin plant at each paint mill.

Therefore several factors drove on the practice of large paint companies making most of their own resins. On the other hand, the local resin producers were making the new synthetic resin technology accessible to the numerous small paint companies, and on this demand they were growing rapidly in the post-war boom. Moreover, new entrants came in, obviously reading this as a growth industry. So did it matter that the large paint companies made their own? After all, it is not unusual for manufacturers to integrate vertically into production of raw materials.

Table 2. Comparative unit operating costs, USA *vs* Australia, 1950

	Batch size (lb)	Total unit cost (d/lb)	Selling price (d/lb)	Margin (%)	Material cost (d/lb)	Factory cost (d/lb)	Labour cost (d/lb)	Admin. cost (d/lb)
USA	37,334	15.14	18.58	18.5%	11.17	0.87	0.52	2.57
AUS	15,951	20.71	25.25	17.98%	14.31	2.00	0.87	3.53

Note: American costs are converted into Australian currency equivalents.

The Significance of Market Fragmentation

The answer is yes, it did matter for several related reasons, which together show that practices which were perhaps unproblematic in other countries could set up problems in the Australian setting.

Limits to Economies of Scale

The manufacture of chemicals is highly capital-intensive and scale-sensitive. Lack of scale has been a general problem for the Australian chemical industry, manifest in high unit operating costs, high unit capital charges, and exacerbation of both these tendencies by the under-utilisation of capacity and the usual necessity for stepwise addition to plant.[27]

If we assume that market fragmentation effectively halved the potential scale of resin operations, a consideration of capital charges alone indicates one kind of cost disability which might occur. The 'power rule'[28] suggests that unit capital charges would thereby have been increased by a third. This effect is compounded by the characteristic stepwise addition of capacity: capital charges of 0.5 units per ton on a 5000 gallon kettle would rise to 0.8 units for that capacity reached by steps of 1000 gallons, then 2000 and 2000.

For resin manufacture, this and other scale effects turn out to be relevant, though modified by three basic factors:

(1) Raw material cost has been overwhelming, at 50–80% of production cost,[29] and imposing an Australian cost disadvantage quoted as high as 33%;[30]
(2) With batch-style production, capacity anywhere was increased by adding *more* reaction kettles as well as installing larger ones. Against the Australian producer's two or three kettles of 1000–2000 gallon capacity, overseas plants might have rows and rows of 5000 gallon kettles, but not one vast vessel.
(3) Inherent fragmentation was induced by the enormous scope to manipulate polymer molecules to specific criteria.

These three factors moderated the scale disadvantage of small producers. But they did not eliminate it. As late as the 1970s, Parry's survey of scale and efficiency in the Australian chemical industry found a synthetic resin manufacturer whose plant capacity was only half the accepted optimum size, and whose unit costs were some 45% higher than those overseas.[31] This echoes a 1950 comparison of the batch costs of a resin made identically in Australia and America[32] (Table 2): both producers took an 18% profit margin but the American producer could sell 25% lower. 56% of this difference was attributable to raw materials, but 44% came from the general overheads which are all affected by scale.

So there was significant potential to gain scale economies, but market fragmentation reduced that potential in two important ways. First, it affected the batch and plant size for all resin products. But secondly, because of the way the market was divided, the problems arising from the multiplicity of resins was compounded; the big volume lines where some economies might be gained were the ones retained by the paint companies, leaving the myriad small volume lines to the resin companies.

Delayed Entry into Commercial Resin Production

Timing is critical in realising the growth potential of new technology, and in catching the early opportunities before world prices are hit by more numerous competitors, improving technology and the increasing size of plants. Australia is typically prone to *two* different kinds of technology delays: the lag before any viable scale of production can begin; and the pace of the usual sequence of technology transfer to a technology importer. In this case, the usual sequence was reversed when leading resin *users* pre-empted potential *suppliers*. This dramatically compressed the lag to Australian production.

Unfortunately, this modified pattern of transfer came with a serious side-effect. In the resulting 'pipeline' structure described earlier, each paint company was committed to a different version of the new technology, reducing the commonality of technology and hence the commonality of demand which would provide much-needed volume and economies of scale. None had the authority nor the incentive for diversifying into resin selling themselves. At the same time, the resin demand represented by their own needs was cut off from the market and from any aspiring resin producers, who awaited demand from the small paint makers.

Arch Hatrick was certainly waiting in the wings. As early as 1934 he invited Reichhold to join him in Australian manufacture, but a Reichhold survey concluded that the available market was too small.[33] This delayed any action until the end of the 1930s. With the subsequent disruptions of war, it was not until the late 1940s that the Hatrick, and Slade, resin manufacture 'took off'. This put them 10–15 years behind the 'transition point' into this new system of technology.

Need for Tariff

By then the world resin industry was entering a new phase and the infant Australian industry would increasingly rely on tariff protection. From 1950 to the mid-1960s, the tariff on resins rose from zero to 40% for the general rate and 30% British Preference. The cycle of justification through several tariff enquiries reflected the maturing and increasingly strident competition of the resin industry overseas.

Paint Company Price Leverage

At home, the leading paint companies exerted the market muscle afforded by overseas affiliations plus independent resin supply. Business given to resin makers was usually at lower margins.[34]

Reinforcement of Small Company Industry Structure

The major client base for the local resin industry nevertheless remained with the numerous small paint companies who were thereby kept in the technological race. If they could grow at the *expense* of the majors, the resin companies could thereby expand their market access. In fact, the stronger tendency was to encourage and reinforce the small

Table 3. R&D contributions to resin unit cost, Beetle Elliot, 1954

Resin type	Unit cost (d/lb)	R&D contribution	Royalty
Phenolic	35.38	0.4%	–
Urea	33.34	0.4%	1.25%
Melamine	46.14	0.26%	5.7%
Vinyl	27.41	0.46%	1.4%

Source: Australian Archives, Series B1/1, Item 1298, data to Tariff Board Enquiry on Synthetic Paint Resins, 1954.

company structure in the local end of the paint industry. For decades, the proportion of paint factories with 10 or less people remained stubbornly at around two-thirds.[35]

Limits on Turnover and Reinvestment

Limited markets mean limited turnover. This was *not* moderated by those factors which limited the impact of lost economies of scale. Yet it is on adequate turnover that companies rely for funds for reinvestment in up-to-date plant, for technical service, and for the research and development which leads to future innovation.

There is evidence that Australian producers felt constrained in all these ways. Certainly, it was admitted that the additional capital outlay required for the superior solvent process of alkyd manufacture prolonged commitment to the older fusion process.[36] But the most important consequence of restricted turnovers may have been in the effect on R&D.

Limited and Fragmented R&D

R&D figures are scarce and those shown in Tables 3 and 4 are merely indicative.[37] Despite limitations, they do suggest two things overall. First, the R&D component of unit cost is generally low compared with levels in other countries,[38] and the actual sums available for resin research look paltry. (Monsanto USA spent about $58 million in 1963.) But secondly, the BALM figures suggest that the Australian resin R&D may in fact have become more concentrated in the large paint companies than in the resin companies themselves.[39]

Certainly BALM was spending big, at 30% of sales by the late 1950s,[40] with resin work featuring prominently. Taubmans and Berger were also committing a sizeable amount of their research to resins.[41] At the same time, the local resin makers were mostly struggling to reach any kind of critical mass in research. Polymer alone built up a serious research establishment, reaching 30 technical staff, including several PhDs, by 1958. But it was competing against the research of potential clients.

The overall picture is limited funds spread over disconnected and small pockets of resin research, often well under the threshold needed for effective advance.[42] The funds were limited by the size of the Australian market. But the fragmented structure of that market led to fragmentation of the total research effort as well, a result that could ill be afforded when the amount of research obtained per unit of funding was already extremely low compared with countries who subsidised their industrial research in many ways.[43]

Table 4. R&D expenditures, 1963

Resin type	**Company**	**R&D weighting (%)**	**R&D expenditure* (£)**
Alkyds	BALM	2.2%	24,355
	Hatrick	1.3%	7,633
Polyesters	Monsanto	3.6%	10,335
	Hatrick	1.7%	4,118
	Polymer	1.6%	823
PVA	Monsanto	2.9–3.2%	12,178
	Hatrick	1.2–1.4%	3,970
Acrylics	BALM	28.1%	93,437
	Rohm & Haas	12.7%	42,897 (incl admin/sales)

*Calculated from R&D component of unit cost, together with sales and output figures.
Source: Australian Archives, Series B1/1, Item 1769, Box 14, data to Tariff Board Enquiry into Industrial Chemicals and Synthetic Resins, 1964–66.

Maintenance of Technology Import Bias

Catching up in technology and development implies developing the capacity to close the gap. Learning was undoubtedly occurring through making and adapting overseas products.[44] But were Australian companies moving closer to the 'leading technological edge'?

Table 5[45] charts the changing technology gap by comparing the date of the world's first commercial production of various resins with their commercial production in Australia. On this 'catch up' test there were mixed results. In introducing the new products of overseas affiliates, Beetle Elliott and Hatrick with straight PVAs, Monsanto with its styrene-acrylic tetrapolymer, were among the best examples. In independently copying and modifying overseas products and trends, Polymer picked up earliest on polyesters and nylon line, being first onto the Australian market. Such activities were important in servicing the domestic-user markets more effectively, but usually left intact the standard gap of a decade or so.

By contrast, escape from small, protected markets requires innovations not available elsewhere. Polymer was the prototype of the kind of company that might do it, and started to close the gap with emulsion research begun in 1952,[46] the year after Rohm and Haas had made acrylics suitable for water-based paint systems.[47] By the beginning of 1957 Polymer had a world first, with a self-plasticising acrylic copolymer. This was licensed to at least two companies overseas, and became a subsequent standard in the coating industry. However, the basic acrylic monomer, produced in the USA, was soon available to all imitators. Then, success with the superior but more expensive pure acrylics remained elusively beyond their resources.[48]

In general, then, with new generations of resin technology, the Australian resin industry continued to take its cue from overseas innovators. Despite exceptions, the perception prevailed that the local resin companies were not 'inventors' of resins and would not be a source of significant innovation.[49] The large paint companies thus found little to divert them from their policy of maintaining and seeking out overseas technology links, in their own efforts to keep abreast of world trends.

Vulnerability in Crowded Markets

In 1955, four alkyd resin producers comprised a largely indigenous industry. Hatricks

Table 5. The Australian resin technology gap

Resin	World commercial exploitation	Earliest commercial production in Australia	
Alkyds	1929	Hatrick	1940
		Polymer	1946
Urea formaldehydes	1929	Hatrick	1944
		Polymer	1945
		Beetle Elliot	1946
Polystyrene	1937	Monsanto	1953
Melamine formaldehydes	1939	Beetle Elliott	1946
Nylon	1940	Polymer	1953
Polyesters	1941	Polymer	1952
		Hatrick	1954
		Monsanto	1955
Epoxies	1950	Shell (Aust)	1960
		Hatrick	1961
PVA	1930s (Germany)	Beetle Elliott	1949
	late 1940s (Europe)	Hatrick	1954
		Polymer	1956
PVA/acrylic copolymers	1930s (Germany)	Polymer	1956
	1950 (USA)	Hatrick	1960
		Gardinol	1961
		Jordan	1961
Acrylic emulsions	1951 (Rohm & Haas, USA)	Polymer	1961
		Monsanto	1961
		Gardinol	1961
		Rohm & Haas	1962
Styrene/acrylic tetrapolymer	1956 (Monsanto USA)	Monsanto	1959
Self-plasticising PVA/acrylic copolymers	1957	Polymer	1957
		Hatrick	1965

was now public; Polymer, Jordan and Keemar were all family firms. Beetle Elliott, part-owned by Beetle UK, was also a minor supplier.

By 1960 the indicators of imminent change were already there, with two new overseas producers on the scene—Monsanto and British Paints. Both had already taken over a local company: in 1958 British absorbed Keemar and Monsanto took over Beetle Elliott. In the early 1960s competition in the alkyd market intensified with the entry of another local company, Kemrez, the result of an employee defection from Hatricks. There were now six commercial alkyd producers, and resin prices were on a definite downward trend.

The major changes were, however, advancing on another front—the resin emulsions or latexes which would form the basis of the new generation of water-based paint, and the acrylics which could serve both emulsion and solvent systems. In the late 1950s it was clear around the world that the polyvinyl acetates (PVAs), the acrylics and their various copolymers were the materials of the future and their market in Australia suddenly gathered pace. Five trends accompanied this shift:[50]

(1) Imports again became an issue as overseas producers targeted this new growth area,

Table 6. Acrylic/latex producers in Australia, 1965

Foreign	Local
Monsanto	Hatrick
Rohm & Haas	Polymer
Hoechst	Gardinol
Borden	Jordan
British Paints	Kemrez
	Frankston

which also extended the pattern of industrial use well beyond paint and into adhesives, polish and textile and paper coatings. In the late 1950s, the main attacks came from BASF in Germany and Rohm and Haas in the USA and Canada, with Union Chimique in Belgium and Dow USA also active.

(2) New resin producers from overseas started to enter Australian production as local resin companies also shifted resources into the new field. In 1955 there had been three producers of latexes for water-based paints. By 1960 it was four; by 1965 it was 11-six locals and five from overseas[51] (Table 6).

Local technology lags left open territory for overseas companies to stake a claim as competition in the international chemical industry intensified. Rohm and Haas, a world technology leader in acrylic emulsions, jumped the tariff wall in 1962. It was soon followed by Hoechst and Borden, later by Dow and BASF, and then a stream of others. Other foreigners used the locals to achieve the same thing. Gardinol made emulsions under licence to Union Chimique, and Jordan joined a 50/50 venture with National Starch & Chemical Corp, USA.

(3) The big paint companies also moved into the acrylics and emulsion fields, again constricting the available market. BALM started into solvent acrylics in 1958. In PVAs, Taubmans was first, in 1963. In 1964, Berger entered a joint venture with Rivertex UK with latex manufacture at the Berger plant.

(4) Where paint companies were discouraged by the greater complexity and capital requirements of emulsion technology, they mainly looked to the new overseas entrants for supply. BALM, for instance, made solvent acrylics but felt its run on emulsions was too late. It bought some latex from Polymer but by 1963 was already purchasing 25% of the output of the new Rohm and Haas factory at Geelong.[52] BALM's subsequent innovations for enhancing acrylic emulsions were licensed to other users through Rohm and Haas.

(5) Finally, in the shake-out which eventually followed the resultant overcrowding, it was the local companies which were either partially or totally absorbed. While there had been some specialisation into niche areas, as the 1960s progressed everyone knew there were too many companies vying for too small a market. Utilisation rates were down and profits were shaky. In 1965, Hercules USA beat stalking corporate raiders when it acquired a 60% holding in the Hatrick company, now called Australian Chemical Holdings (ACH). In 1967 Polymer was completely bought out by General Mills, USA. In 1969 the two were merged under Hercules control when ACH took over Polymer from General Mills. Kemrez was bought by ICI. Jordan went, via Emery, to Croda and then Ashland, USA. Gardinol went to Albright and Wilson. By

the time of the 1985 IAC enquiry, the level of foreign ownership in the industry was 80% on turnover, more than double that of manufacturing as a whole.[53]

Conclusion

The phenomenon of fragmentation of production in a crowded supply industry is well enough known, as is the exacerbation of this effect by tariff-induced entry of foreign firms.[54] What we have drawn attention to here is the other side of the fragmentation coin—the splintering of client industry demand.

It has been argued that this market fragmentation arose from the way technology was transferred from overseas. The consequent resin policies of the large paint companies in turn affected the scope, outlook, and long-term viability of the local resin industry. While paint makers in large overseas markets might integrate backwards with little undue damage, similar practices transferred to the small Australian market were more troublesome. Synthetic technology was delivered quickly to Australian users, but the local resin market was restricted and fragmented, delaying resin industry formation, and limiting turnover and economies of scale. This in turn constrained the funds available for the continuing innovation needed to close the technology gap.

So what have we learned? At the general level, we find that the Perez and Soete proposition is based on early learning with new technologies and is thus predicated on the fundamental importance of timing in realising the potential of development opportunities. Factors which delay entry into new technologies and industries thus become critical, and the process by which the new technology is transferred is a factor of powerful influence. An issue of particular importance is whether the transfer process aggregates and optimises domestic demand or whether it fragments and dissipates it. The latter can cause serious delays and impediments.

From the Australian perspective, we gain insights into the specific stresses and strains this can set into the development pattern. Swift introduction to new technology can go hand in hand with delayed entry into local production and squeezed windows of opportunity. This interacts with and exacerbates small country disabilities. The cumulative effect is familiar—a local industry locked into the domestic market, reliant on protection, but without the policy supports to foster innovation and vigour: hence ultimately vulnerable to subsequent external onslaughts as the world and its technology moved on.

Both the Vernon Committee and the Tariff Board recognised the perils of fragmentation due to excess suppliers, but did not register the fragmentation induced by the structure and market behaviour of the client industry. The Tariff Board regularly interrogated the resin suppliers about the parameters and scale of their production but did not investigate the phenomenon or factors involved in resin manufacture of paint makers. The process of separate industry enquiries restricted the analytical view.

The policy of protecting local products, not local companies, also had its effects. There were no instruments which might inhibit those overseas competitors who would simply jump the barriers to an expanding market, as evidenced with acrylic and emulsion technology. In that field, the Polymer company seemed to be narrowing the technology gap, but always within the constraints of a small and fragmented market, and then in the environment of ever-encroaching chemical giants and escalating capital requirements. The Polymer operation was innovative and reasonably profitable. But its horizon and fate was too closely linked to the small paint companies. It simply did not grow enough and did not have enough fellow innovators in the industry. When overseas companies moved in from the heat of the international market, Polymer, like other local companies, was vulnerable.

While tariffs protected local markets and margins, local resin producers were able to make a profitable living out of supplying local needs, and learned a great deal about polymer technology. They could therefore arrest and stabilise the innovation lag. But they could not catch up with the leading edge. In the technological race, they were riding with the pack; marking time, not gaining time. While it would always be difficult for local producers in a small country, the delays, constraints and market fragmentation which flowed from the early transfer process were a significant factor in limiting the potential of a vibrant resin industry.

Notes and References

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10. Charles R. Martens (ed.), *Technology of Paints, Varnishes and Lacquers*, Reinhold, New York, 1968, p. 7; US Tariff Commission, *Synthetic Resins and their Raw Materials*, Report No. 131, Washington DC 1938, p. 31.
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14. Australian Archives (AA), Series B1/1, Item 847, list of Hatrick customers, in papers re Tariff Board Enquiry into Cellulose Enamels, Lacquers and Varnishes ... and Synthetic Resins Incorporated in Oil, 1937.

15. Tariff Board, *Report on Synthetic Resins*, Government Printer, Canberra, 1951, p. 5.
16. Details on the early years of the Hatrick and Slade companies come from Tariff Board, *Report on Plastics Industry*, Government Printer, Canberra, 1946, from internal notes and records held by Australian Chemical Holdings Ltd, and from interviews with personnel from both companies.
17. Tariff Board, *Report on Synthetic Resins*, Government Printer, Canberra, 1951, p. 7.
18. Tariff Board, *Report on Synthetic Paint Resins*, Government Printer, Canberra, 1955, p. 6.
19. 1968 and 1975 figures from market survey results in the private records of Australian Chemical Holdings (ACH), the parent of Hatrick Chemicals.
20. Industries Assistance Commission, *Report on Paints, Varnishes and Lacquers*, Australian Government Publishing Service, Canberra, 1976, p. 5.
21. These and subsequent details on BALM have been constructed from a variety of archival and published sources, as well as interviews with industry personnel. The major archival sources are: (1) the series of files of ICI UK, London, relating to BALM, to glyptal resins, and to Australian policy; (2) the records of the Du Pont company held by the Hagley Museum and Library, Wilmington, USA, especially those relating to relations with ICI and BALM. The major published sources include *United States* v. *Imperial Chemical Industries Ltd, 100 Federal Supplement 504*, pp. 505–94; W.J. Reader, *Imperial Chemical Industries. A History*, Oxford University Press, London, 1970, 2 vols; W.S. Robinson & G. Blainey (eds), *If I Remember Rightly*, Cheshire, Melbourne, 1967; Graham D. Taylor & Patricia Sudnik, *Du Pont and the International Chemical Industry*, Twayne, Boston, 1984; David A. Hounshell & John Kenly Smith Jr, *Science and Corporate Strategy: Du Pont R&D, 1902–1980*, Cambridge University Press, New York, 1988.
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24. AA, Series A1732, Item 1769, *Proceedings of Tariff Board Enquiry into Industrial Chemicals and Synthetic Resins*, 1965, pp. 1228–1231.
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26. Interview with former Manager of British Paints resin plant.
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28. Used in the chemical industry, the 'power rule' expresses the typical relationship between capital charges and plant size. See ACIC, *op cit.*, Ref. 27, Vol 1, pp. 31–45.
29. AA, Series B1/1, Item 1298, Comparative analyses of company data provided to Tariff Board Enquiry on Synthetic Paint Resins, 1954–5.
30. AA, Series A1732, Item 1298, *Proceedings of Tariff Board Enquiry into Synthetic Paint Resins*, 1955, p. 41.
31. Parry, Plant Size *op. cit.*, Ref. 27, p. 141.
32. From production data provided to the Tariff Board Enquiry into Synthetic Resins, 1950, in AA, Series B1/1, Item 1129.
33. Typescript notes on the Hatrick company history held by ACH.
34. Shown, for instance, in Hatrick list of customers and prices provided to the Tariff Board Enquiry into Synthetic Resins, 1954–5, in AA, B1/1, Item 1128.
35. Australian Bureau of Statistics, *Secondary Industries, 1959–60*, Government Printer, Canberra, 1960.
36. AA, Series A1732, Item 1769, *Proceedings*, pp. 878–879; AA, Series B1/1, Item 1769, Box 14, 'Alkyd Analysis', December 1964.
37. For instance, firms use different accounting procedures, and products attract different levels of research funding at different points of their life cycle. Also, the low figure for Polymer runs counter to its commitment to in-house research and may partly be due to its policy of allocating funds to projects on an as-required basis, rather than by any standard annual budget.

38. Although these figures were not low by contemporary Australian industry standards (see Peter-Stubbs, *Innovation and Research*, Cheshire, Melbourne, 1968, Ch. 4), the corresponding figures for R&D as % of sales would be lower than those cited in Tables 4 and 5, and lower than many overseas companies at this time, e.g. Hoechst at 3.6%, Monsanto (USA) at 4–5%, Du Pont 5.3% (see AA, B1/1, 1769, boxes 13, 15). For Australian R&D by American-affiliated companies see Donald T. Brash, *American Investment in Australian Industry*, Australian National University Press, Canberra, 1966, Ch. VI, especially p. 152.
39. This also fits with 1980s figures showing the paint industry with a higher R&D intensity (2.7%) than the resin industry (1.7%). See Ralph Lattimore, 'Research and development: hidden investment in Australian industry', in Clive Hamilton (ed.), *The Economic Dynamics of Australian Industry*, Allen and Unwin, Sydney, 1991, pp. 173–195, see p. 175.
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51. AA, Series B1/1, Item 1769, Box 14, 'Analysis No. 55 (Acrylics)' and 'Analysis No. 65 (PVAs)', February 1965. Table 6 includes commercial producers of PVAs, copolymers and/or acrylics. Acrylics could be used in solvent or emulsion form. At this time British Paints were making solvent-based acrylics and designing a plant for emulsion acrylics.
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54. For instance, Vernon Committee, *Report of the Committee of Economic Enquiry*, Canberra, 1965, Vol. 1, p. 213; Tariff Board, *Annual Reports*, 1963–64, p. 15; 1964–65, p. 11–12; Parry, 'Plant Size', *op. cit.*, Ref. 27, pp. 142–145.