THE INFLUENCE OF TECHNOLOGY ON REGIONAL DEVELOPMENT: CASE STUDIES FROM THE RIVERINA REGION

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ABSTRACT: Technology plays a significant role in regional development, particularly in the manufacturing sector. Technical progress, achieved through incremental change, problem solving and collaboration, enables manufacturers to achieve the economies of scale they need to become competitive in both domestic and international markets. Their growth allows them to hive off specialised divisions, leading to the formation of new regional enterprises which tend to select locations close to their 'parent' firms. This contributes to the development of clusters of linked industries, a process that stimulates regional development. Using cumulative causation as the theoretical base, this paper describes the findings of research undertaken in the Riverina Region of New South Wales to show how technology influences regional development through the above processes.

1. TECHNOLOGICAL DEVELOPMENT

Technological development or "technical progress" has been described by Pasinetti (1981, 67) as *"a very complicated process emerging from the learning activities of human beings and the application of this learning activity to production."* He argues that it involves a number of areas, including re-organising old methods of production, making better use of new materials, improving the quality of products, inventing and applying new methods of production, producing new products, finding new resources and discovering new sources of energy.

A great deal of technical progress is said to occur as a result of "learning by using and by doing" within specialised areas (Targetti 1992, 166). However, Kaldor (1972, 184) argued that advances in scientific knowledge are not enough to achieve technical progress, as they need to be followed up with repeated "application of particular engineering principles" to secure improvements in design. Rosenberg (1976, 29) argued that the optimisation of an initial invention can take many decades, as, for example, in the case of the steam engine. He commented on the significance of this, arguing that *"technology is much more a cumulative and self-generating process than the economist generally recognises"* (Rosenberg 1976, 110).

Ideas on the evolutionary nature of economic change go back more than a hundred years to the writings of Thorstein Veblen, who commented on the interdependence of supply and demand, together with the influence of technical change, as having a circular and cumulative influence on development (O'Hara 2000, 131-137). Young (1928, 533) too, drew attention to the cumulative impact of technology, pointing out that all significant developments, including inventions, change the nature of industry, causing a chain reaction in other industries; that is, "*change becomes progressive and propagates itself in a cumulative way.*"

Consequently, the development of new technology is an incremental and evolutionary process, depending on past developments (Argyrous and Sethi 1996, 487). Ricoy (1988, 732) refers to this as "the accretion of experience." Argyrous (1996, 110) describes the process as a continuous one where firms are engaged in problem solving, solutions are diffused into the economy, and new problems emerge to be solved. This view of the process has some elements in common with innovation diffusion theory as expounded by Rogers (1983) who saw the diffusion of innovation as an uncertainty-reduction process, a testing of a new idea to see if it works.

Based on her research, Rogers suggested that the rate of diffusion of innovations can vary significantly among organisations, and that it generally proceeds through a number of stages. Key stages in the diffusion process are generally described as awareness, interest, trial and adoption, with the possibility of a rejection stage occurring after any of these stages. Some stages can be skipped, a process sometimes described as "leap-frogging." Rogers felt that this could come about as a result of the work of a "change agent" providing information and advice that could speed up the diffusion of the innovation.

The cumulative character of technology is mainly based on in-house technology, together with "contributions from other firms and from public knowledge" (Dosi 1988, 1130). Collaborative relationships have been identified as playing an important role in this process, and have been observed in the industrial districts of Italy. Brusco (1989, 260) noted that "a single idea goes through all phases of its development in a continuous confrontation between clients and sub-contractors," and described this relationship as being "extraordinarily rich and complex, full of reciprocal stimulation." In other cases, problem-solving collaboration occurs between sections of a single firm, often resulting in the enterprise developing its own capital equipment. Examples of this in the machine tool industry in Australia have been described by Argyrous (1996, 104).

It is these improvements in design that enable the scale of manufacturing to be expanded, allowing for increasing returns. Cumulative causation writers have observed that the ability of manufacturing to achieve increasing returns to scale enables it to operate as the engine of growth in an economy (Kaldor 1966, 113; Targetti 1992, 170). Earlier economists such as Marshall (1920, 211-212) used the term "economies of machinery" to argue that output could be increased by supplanting manual skill with machinery, particularly for routine tasks. Other cumulative causation theorists such as Rosenstein-Rodan, Nurske and Hirschman have made similar observations on achieving economies through the use of machinery, noting that this usually occurs at the plant level (Toner 1998, 13).

Kaldor (1972, 146 and 153) argued that increasing returns to scale had never been properly explored in neoclassical economic theory, and that during the 1930s, when new economic theories on the imperfection of markets suggested that falling costs and competition could co-exist, economists failed to investigate this in sufficient detail. This view was later supported by Thirlwall (1987, 324) who argued that neoclassical economic theory neglects increasing returns. Cumulative causation theorists point to evidence showing that while agriculture and mining are characterised by decreasing returns, manufacturing is characterised by increasing returns (De Ridder 1986, 46). Hansen (1995, 99) argues that the impact of increasing returns to scale reinforces the growth of regions that are already prosperous, thus increasing the disparity between regions, while Martin (1999, 70) argues that increasing returns plays a significant role in "locking in" historical trends.

Economies of scale are also associated with increasing urban population and associated economies in transport, labour, power supply and education facilities (Burnley 1980, 103). Epps (1999, 3) draws attention to the link with technology in his quote from Harrison et al (1996, 235) that *"a relatively densely packed community of organisations with shared interests will foster more rapid diffusion of innovations."* Storper and Scott (1992, 14) have argued that "*technical innovations are often place bound, as the stocks of human knowledge and human capital, upon which technological changes are based, tend to be concentrated in specialised labour forces, which themselves are highly localised."* In some cases, locations gain advantage from the existence of universities, corporate research laboratories and other institutions in the area (Stilwell 1992, 47). This was so in the study of information technology clusters in Silicon Valley and Route 128 by Kenny and von Burgh (1999).

Clusters have been defined as *"geographic concentrations of interconnected companies and institutions, an array of linked industries and other entities, suppliers of specialised inputs and providers of specialised infrastructure"*(Porter 1998, 13). Marceau (1999, 157) provides a similar definition, describing clusters as "*networks of strongly interdependent firms, knowledge-producing agents and customers linked to each other in a value-adding production chain."* While the concept generally refers to a group of firms in a single location producing a particular range of related products, this does not preclude linkages with firms and institutions in other places. Beer et al (2003, 138-139) list a number of clusters that have been identified in Australia, but point out that these are not the large clusters that have been identified in Europe and the United States. They argue that the reasons for this include the following:

- an incomplete industrial structure, which means that many firms are unable to find local partners with whom to collaborate;
- the small size of the economy and the lack of critical mass in many industries;
- foreign ownership, which means that a lot of R&D takes place outside Australia;
- limited interest and financial support from State and Federal governments;
- the dominance of resource-based exports, which tend to generate fewer linkages than manufacturing or advanced services;
- limited awareness by industry of the benefits of collaboration, and reliance instead on governments for assistance;
- lack of strong civic and business leadership, especially in regional areas;

- the lack of industrial specialisation in most regional towns and cities makes it difficult to identify distinctive opportunities for cluster building; and
- insufficient local integration between industries, R&D institutes, and training institutions such as universities and TAFE.

Lowe and Miller (2001, 186) also point out that other influences on the development of clusters include "chance" and "government," in their comment that *"often historical accident and/or government actions play significant roles in the early development or location decisions of local industry clusters."* Earlier writers generally referred to these centres as growth centres or growth poles, arguing that historical trends tended to generate "backwash" and "spread" effects (Myrdal 1957, 26; Hirschman 1959, 555). More recently, Hanson (2003) has pointed out that while growth centres may generate development for surrounding centres through spread effects, the main centre tends to remain dominant because of its "scale, accumulated wealth, and capacity to lead innovation." O'Connor et al (2001, 99-100) argue that recent trends in Australia have seen clusters of businesses stimulated by *"the geographic coincidence of global and national business links, reinforced by the connections between large and small firms."* They observe this occurring mainly in the larger metropolitan centres.

Castellacci (2002) used a combination of two theoretical approaches, cumulative causation and the technology gap approach, to investigate the performance of technology development and productivity growth of 26 OECD countries between 1991 and 1999. He found a range of outcomes in his comparison of the successful uptake of technology in the countries studied. In some cases, follower countries fell behind the leaders, while in others they were able to partly or totally catch up, or overtake the leaders. However, he argues that even if some follower countries are able to close the technology gap between themselves and the leaders, they may not be able to close the growth rate differential.

Wade (2005) draws attention to the significance of technology in the continuing economic disparities between the developed and developing countries, reminiscent of the "core-periphery" debate of earlier cumulative causation writers (Myrdal 1957, 26; Hirschman (1959, 557). He argues that elements of international trade and globalisation have the potential to bring about the "failure" of nation states. These elements include north-south terms of trade, including the strategies of the more economically-dominant countries and global economic multilateral organisations, the industry location decisions of multinational corporations, and the non-diffusion of modern technology to the developing countries.

Martin (1999, 79-80) has referred to the interdependence of firms in technological innovation as being "geographically constrained" in its initial stages. This results in knowledge and learning being available to the local workforce in the early stages of the diffusion of new ideas. It is the localised development of advanced technology that can give one region competitive advantage over others. Advantage also occurs where the region has educational and research institutions that help in the dissemination of new knowledge

(Martin 1999, 79). Epps (1999, 6-7) draws attention to the observation that locations need a range of established firms of varying sizes, but particularly medium-sized enterprises, to provide a learning base for employees to emerge as new entrepreneurs. Much of the incremental impact of technical change on industry occurs as a result of its diffusion through vocational training (Toner 2000, 23).

In Australia, manufacturing plays a significant role in technical progress at the regional level, as it is the source of much of the research and development for product and process innovation, import replacement and export expansion that support regional development (Bamberry 1995, 2004; Bamberry & Wickramasekera 1999; Beer et al 1994, 83). Toner (2000, 22-24) argues that it is three times more likely than other industries to engage in innovation, while Argyrous (1993, 2000) argues that it is a major contributor to the export of complex high-value goods that would put Australia on "the high road to international trade".

2. RESEARCH METHODOLOGY AND LOCATION

The research design for the study on which this paper is based, involved a qualitative approach incorporating the collection and analysis of data from nine in-depth case studies of small and large manufacturers located in the Riverina Region's main urban centres of Wagga Wagga, Griffith and Leeton. Brief profiles of these firms are outlined below. The qualitative nature of the research had the advantage of allowing for a closer inspection of processes of change over time, particularly those involving interactions between people (Ticehurst and Veal 2000, 95; Kerlinger and Lee 2000, 589). The case studies gave interviewees the opportunity to discuss factual information, and to express points of view and personal explanations of events, relationships and trends (Taylor and Bogdan 1998; Skinner 1999, 177). Cases were selected from key regional manufacturing sectors, including food and beverage processing, timber, textiles, and fabricated metal products.

The research was undertaken in the Riverina Region of New South Wales, a region that stretches along the Murrumbidgee River from the Snowy Mountains and Kosciusko National Park in the east to its junction with the Murray River in Hay Shire in the west, encompassing the fourteen local government areas shown in the map in Figure 1. Its total population is just over 150,000, Wagga Wagga being the largest urban centre with a population of about 56,000. The Riverina has a total area of over 63,000 square kilometres, making up approximately eight per cent of the land area of New South Wales.

The region is approximately 125 kilometres north to south, and approximately 500 kilometres east to west. It is a diverse region, ranging from the alpine forests of winter snow-capped peaks of the Kosciusko National Park, through horticultural farms, pine forests and native hardwood forests of the mountain foothills, through grain and sheep grazing farms of the slopes, through rich irrigated farm lands of the irrigation areas, to the vast open plains in the west.

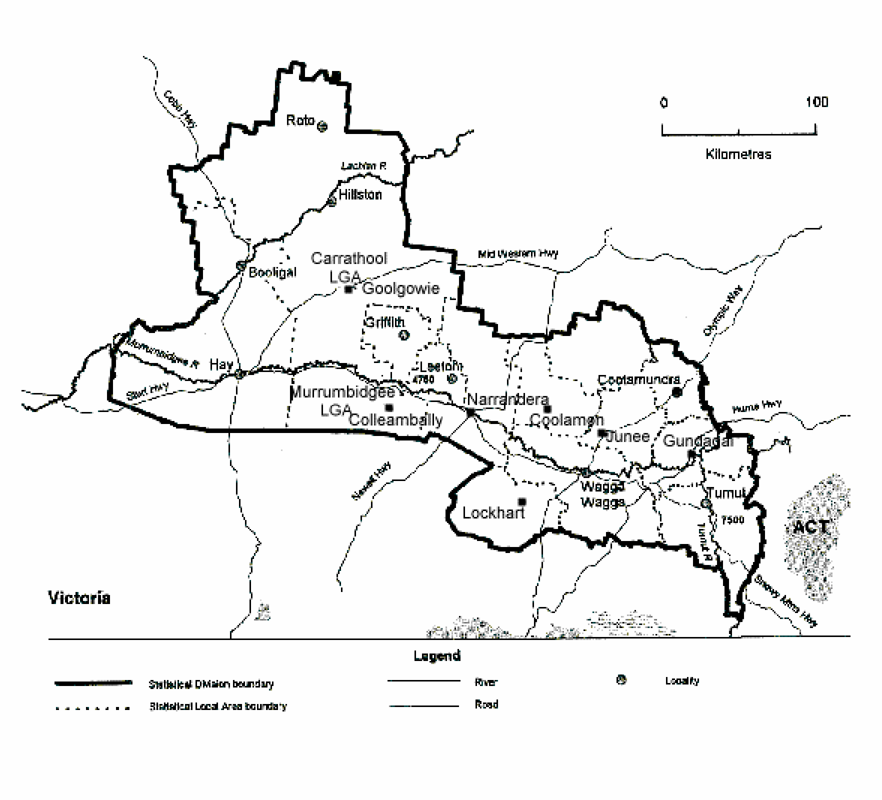

Figure 1. Map of the Riverina Region of New South Wales

A submission to the 1973-74 National Population Inquiry (the Borrie Report) noted the increasing tendency for the population of the Riverina Region to become concentrated in the four main urban centres. Census data showed that the proportion of the region's population in these centres had grown from 33 percent to 40 percent (Bamberry, Swan and O'Donnell 1973, 22). When the Riverina Regional Development Board prepared its Regional Economic Development Strategy for 1991-1996, it became apparent that in the period 1971-1991, there had been increased concentration of manufacturing in the same key centres (Riverina Regional Development Board 1991). Surveys of manufacturing undertaken by the Regional Development Board in 1992 and 1997 confirmed this trend (Bamberry 1995; Bamberry & Wickramasekera 1999).

3. PROFILES OF THE CASE STUDY FIRMS

3.1 A&G Engineering and Flavourtech

In the case of A&G Engineering (Griffith), in 1963 the founder, Ron Potter, identified opportunities for a business combining the sale of agricultural machinery and an agricultural and general engineering workshop, including the manufacture of winemaking equipment for the local industry. Potter had an agricultural science degree and a diploma of oenology, and came to the region to take up a position with the New South Wales Department of Agriculture. He later became winemaker at Miranda Wines, before moving on to establish his own business. As a result of research and development into flavour extraction, the firm has been able to hive off a separate enterprise under the name "Flavourtech."

3.2 Allgold Foods

Allgold Foods grew out of the decision by former Ricegrowers' Co-operative engineer Mike Goldring and a partner, to use their knowledge and skills to design, build and operate a plant to process grains, pulses and other local produce. They established Allgold Foods at a site in the Leeton Shire, not far from the Leeton urban area. The enterprise expanded its operations by supplying products in bulk to firms outside the region. It became a supplier to Green's Foods, later establishing a joint venture with them, and later still, merging with them.

3.3 Celair-Malmet

Celair-Malmet grew out of Ted Celi's decision in 1972 to establish a business making evaporative air conditioners. Prior to this he had worked as an electrician for the Ricegrowers' Co-operative. Because of the seasonal demand for air conditioners, the firm started producing heaters in winter to increase output. The firm also bought out the Gosford-based company Malmet, which produced hospital equipment, and transferred its operations to Leeton. Further expansion occurred by producing products for other companies. One of those firms was Adelaide-based Bonair-Vulcan, which Celair-Malmet was able to buy out in 1999.

3.4 De Bortoli Wines

The De Bortoli family began winemaking in 1928, four years after Vittorio De Bortoli and his wife Guiseppina emigrated to Australia from Northern Italy, and established a 55 acre vineyard at Bilbul, near Griffith. By 1936, the winery had grown to 20 vats with a capacity of 550,000 litres. The family business grew over time, with the second and third generations moving into management positions. A major development for the company was the production of their Botrytis Semillon, which was first released in 1982. It has become one of the world's most highly awarded wines, winning a large number of trophies and medals.

3.5 Parle Foods

Parle Foods had its beginnings in a family farm which expanded when the family decided to shift into growing higher-value crops, particularly gherkins. The enterprise reached a position where it was growing 70 percent of the Australian gherkin crop, and it used that position to gain the Heinz endorsement to become a processor, and to obtain a contract to supply McDonalds. The firm later diversified into processing other fruit and vegetables that were counter-seasonal to gherkins, allowing for the better utilisation of the company's resources, and reducing the risks associated with dependence on a single product (Riverina Regional Development Board 2000, 1).

3.6 Precision Parts

Ken Reynolds, the founder of Precision Parts, was formerly an engineer at the RAAF Base near Wagga Wagga, and set up an engineering partnership in Wagga Wagga after retiring from the RAAF in 1976. The business initially produced a small range of automotive parts, specialising in harmonic balancers. The firm was able to move into mass production by establishing a close relationship with Repco to produce parts for the Australian market, allowing it to expand its product range. It later began exporting auto parts to America, resulting in further expansion.

3.7 The Ricegrowers' Co-operative

Leeton's early involvement in the rice industry resulted in it becoming the headquarters of the Ricegrowers' Co-operative when it became established in 1950. The co-operative undertook a major expansion in the following years, including the building of rice mills at Leeton, Griffith, Yenda, Coleambally, Deniliquin and Echuca, as well as visitor centres at Leeton and Deniliquin. As a result of research and development, the Co-operative has been able to establish two semi-autonomous enterprises to process by-products of the industry, Biocon operating a bio-mass converter at Griffith, and Coprice producing stockfeed at Leeton and Tongala.

3.8 Riverina Woolcombers

A subsidiary of the French-based international company Chargeurs, Riverina Woolcombers cleans and processes wool, producing "wooltops' ready for the next stage of processing. The first section of its plant commenced operations in Wagga Wagga in 1981 with 118 staff, section two opening in 1987. The latter included a superwash section, a warehouse and a production line. In 1994, a new section was opened, comprising a scour line, a production line, three warehouses, training and engineering facilities, as well as new administration offices. Wagga Wagga was selected as the location for the plant as it was seen as being central to a large wool-producing area with good transport links to other wool sources.

3.9 Yoogali Engineering

Yoogali Engineering was founded by an Italian migrant who had initially worked for an engineering firm in Griffith before establishing his own business in 1974. The firm has been mainly engaged in engineering work for the agricultural sector in the surrounding Murrumbidgee Irrigation Area. As well as undertaking repairs and maintenance, the firm, in close collaboration with its clients, has engaged in the design and fabrication of capital goods for the agricultural sector.

4. FINDINGS

A number of findings emerging from the cases reflected Pasinetti's (1981, 67) observation that technical progress encompasses a range of activities, some of which include re-organising old methods of production, making better use of new materials, improving the quality of products, inventing and applying new methods of production, and producing new products. They also reflected observations in the cumulative causation literature about the incremental nature of technological change through the influence of problem solving, collaboration with clients, collaboration between workers from different sections within the firm, and learning from experience. Each of these categories is discussed below, but as there is considerable overlap across the categories, they are combined in some cases.

The Ricegrowers' Co-operative is an example of an enterprise that has achieved technological development through an incremental process involving learning by doing on the shop floor. This approach was essential in the early days of rice milling, as this was a new industry for Australia, with no other firms to emulate, and no staff with experience in the industry. Consequently, developments occurred through the process described by cumulative causation writers where a series of emerging problems are solved through the "accretion of experience." The Co-operative recognised the need to continue this incremental approach to development and later established a research and development division. This helped the co-operative to establish new operations to make use of the industry's by-products, resulting in the development of the semi-autonomous enterprises, Coprice and Biocon.

Celair-Malmet and Allgold Foods followed similar patterns of incremental technological development based on learning from experience. This is not surprising, as the founders of both firms had previously worked for some years with the Ricegrowers' Co-operative, the founder of Celair as an electrician, and the founders of Allgold Foods as engineers. They drew upon their experience in this environment of learning by doing, and incremental improvements to existing approaches, when they set up their own businesses.

In both firms, but especially in Allgold Foods, the founders built much of the equipment needed to establish their operations. One of the reasons for taking this approach was to keep capital costs and the level of debt as low as possible in the early stages of development. Other reasons were more technical in nature. As well as being able to call upon skills gained from previous work experience, both enterprises were venturing into new territories, where a level of experimentation and learning by doing was necessary. Later, both firms sought to achieve economies of scale by buying in machinery appropriate to their higher levels of output.

In the early years of Celair-Malmet, each new model of air conditioner incorporated new ideas in content and manufacturing processes, as staff learnt from their experience with previous models. Later, following the purchase of the hospital equipment manufacturer, Malmet, the same approach was used to upgrade appliances to meet new health standards. To ensure it maintained its own standards, Celair-Malmet undertook to obtain ISO 9002 accreditation for its operations in 1993, and successfully obtained this. The firm has also encouraged the sub-contractors it has helped establish to engage in innovative approaches to problem solving. The manager gave an example of this process:

> *One of the good contractors I mentioned previously comes back to us with ideas of how to do things. If we want a job done, we don't invent it ourselves now. We just ask him how he would do it, and ask him to come back to us with a quote. He's quite skilled in that way.*

At Allgold Foods, much of the technical progress was built on the incremental experience gained by the founders in working as engineers at the Ricegrowers' Co-operative. They were able to adapt the processes of rice milling to the milling of other grains, as well as pulses. Technical progress was achieved through incremental modifications to machinery as staff gained experience operating the plant, and as they sought to improve the quality of outputs to meet clients' specifications.

The Precision Parts case study revealed an example of both incremental change and the process Kaldor (1972, 184) referred to as "repeated application of particular engineering principles to secure improvements in design." The manager of Precision Parts described this process:

> *You start developing your own product, and there is a progression as the business grows. First, you have to start drawing things, and then you have to follow through with proper drawings and proper computer-based programs. Then all of a sudden, the fitter and turner turns into an engineer.*

It was through incremental changes such as this that Precision Parts was able to gradually increase its output, achieve economies of scale, and become competitive enough to enter the export market. The resulting increase in demand for its products in overseas markets has allowed the firm to further expand its operations.

Several of the cases provided examples of technological change resulting from problem solving that led to increased output and improved economies of scale. One of the cases showing evidence of this was A&G Engineering at Griffith. Over a number of years from the 1970s, A&G developed the highly specialised spinning cone technology, which grew out of seeking a solution to a particular problem in the wine industry. In this case, seeking to solve the problem of removing sulphur dioxide from bulk-stored wine resulted in the discovery of the process of flavour extraction from foods and beverages. A great deal of the flavour is often lost in the processing of primary products, particularly in processes involving heating. The spinning cone technology developed by A&G Engineering enables flavours to be extracted in the early stage of food and beverage processing, and held apart while other processing, often involving heating, is undertaken. The flavour previously extracted is then returned to the product without the flavour loss normally associated with processing.

Following extensive research and development, including collaboration with local winemakers and with researchers at Charles Sturt University, A&G developed the spinning cone technology for use in the manufacture of complex food and beverage processing equipment. This activity was later hived off as a separate enterprise, Flavourtech, which was able to expand its output and become a significant regional exporter of capital equipment. Another example of problem solving was outlined in the following comment from a director of A&G Engineering:

> *When A&G started producing stainless steel tanks, we had a problem with them overheating in this hot climate. Discussion with the winemakers resulted in the dimple plate concept, which has enabled us to get far better temperature control. This involves putting a jacket on the outside of the tank by dimpling the plate, welding the jacket on and circulating cool brine around the tank.*

De Bortoli Wines had also developed new technology in response to dealing with a problem they faced. The head winemaker described how wineries had traditionally pre-gassed bottles with carbon dioxide because they needed an inert filling operation to prevent oxygen coming into contact with the wine. An additional requirement was to be able to fill bottles to different heights. This was because bottles going straight to the marketplace needed to be filled at a lower height than bottles being prepared for binning or aging. The latter needed to be filled higher to allow for a certain amount of evaporation and absorption by the cork over time.

However, they faced the problem that modifying the fill height in the bottle caused a break in the hygiene when filler tubes were replaced, resulting in the need for a re-sterilisation cycle. To overcome this problem they designed a machine that would evacuate the bottle similar to the process used in the brewing industry, then fill the bottle with an inert carbon dioxide or nitrogen mix, and then fill the bottle with wine. They found by experimentation that they could then adjust the fill height "by winding the machine up or down." This reflects the incremental character of technical progress described by Dosi (1988, 1130) who argued that innovations are mainly based on in-house technology, together with "contributions from other firms and from public knowledge."

Riverina Woolcombers faced the problem of the need to expand output to meet an increased demand for its wool tops, as well as improving economies of scale while not interrupting current production schedules and output. The firm did this by building a completely new wool processing plant in a separate building. The initial plant had commenced operations in 1981 with 118 staff, while section two of the plant commenced operation in 1987. This included a superwash section, a warehouse and a production line. The new, more modern plant was opened in 1994, comprising a scour line, a production line, three warehouses, training and engineering facilities, as well as new administration offices. The advanced technology of the new plant resulted in greater output and higher labour productivity than that achieved in the old plant, which was still being used. Later, when demand dropped, the firm closed down the old plant and concentrated all production in the more efficient new plant.

New problems emerging from the above developments involved the need to contain and, where possible, to reduce costs associated with 'non-core' activities such as electrical and mechanical engineering, logistics and maintenance. Riverina Woolcombers solved these problems by hiving off the functions to new enterprises, Beam and KPL (Key Performance Logistics), managed and staffed by former employees, and by contracting out the maintenance function to an existing firm, Fluor Daniel. Celair-Malmet solved a similar problem by contracting out the production of components and the powder-coating of appliances to new and existing small local enterprises.

The Ricegrowers'Co-operative faced the problem of cost-effective disposal of waste products from rice processing without generating environmental problems. Research into new technology resulted in finding ways of converting the waste material into saleable products, including stockfeed and material for the nursery industry. These activities were eventually hived off as separate enterprises owned by the Co-operative, Coprice and Biocon.

Collaboration with clients or between sections of a single firm emerged from the cases as a significant influence on technological development. A case where collaboration, both external and internal to the firm, had a major influence on the development of new technology was Yoogali Engineering at Griffith. Through collaboration with a client, the firm recognised the need for a better way to make pallets for the local horticultural industry, resulting in the development of a pallet-making machine. Other examples of technological inventions resulting from collaboration with clients include the development of an orange grader, an onion washer and a lettuce harvester. In the latter case, the client "had a rough idea in his head," and after explaining this to staff, the design work was undertaken by the firm. This was followed up by the production of the equipment by the manufacturing section. Collaboration with the client ensured the equipment met his needs, as well as meeting requirements associated with engineering design, manufacturing practicalities and cost considerations.

The findings from Parle Foods at Griffith showed an example of internal collaboration between engineering and production staff. Parle Foods indicated that they produced much of their equipment in-house, and had established a large engineering workshop for this purpose. The firm bought machinery and equipment from factories that were closing down, then re-located and re-built it to meet their particular needs. Anthony Parle described the process as follows:

> *Most of our machinery has been modified. You wouldn't find it to be the same as anyone else's. If other firms' can cookers do 200 cans a minute, we'd modify ours to do 250 or 300, and that's where we would make our money – through that extra bit. It's not that complex technology, it just means that if we can do it more cheaply we will have an advantage over our competitors.*

An example of collaboration with local industry, combined with incremental change in production methods, was the introduction of stainless steel equipment in the wine industry in the Riverina. This was described by Lionel Irving of A&G Engineering:

> *We were really encouraged into the wine-making equipment area by Ben Sutcliffe, the engineer at Penfold's Wines. At that time stainless steel started to make inroads into the industry, replacing concrete and wax finishes. It was recognised that the concrete tanks needed to be replaced as they were labour intensive and dangerous. On the other hand, stainless steel is easier and safer to work with, has a long life and is easier to clean and maintain.*

The manager of Allgold Foods also described how technical progress occurred through collaboration with external contactors:

> *It's much easier to get someone to come in and to show them what you need and explain what you want to achieve. They'll often come up with a lot more ideas than you had in the first place. If they come up with a better idea it would be silly not to change. They deal with a lot more customers using similar machinery. The people we deal with also deal with Uncle Toby's and others, and they pick up ideas from the other factories. As long as you're not cutting in on something that they've developed and branded, they're quite willing to share it with you.*

The findings show that the above technological developments, combined with locational factors, influence the region's economic development. These developments enabled firms to achieve economies of scale which allow them to expand in the domestic market as well as enter export markets. For example, Celair-Malmet was able to expand its domestic market to a level where it was able to take over Adelaide-based Bonair-Vulcan, as well as move into export markets such as South Africa. Other firms that expanded markets included A&G Engineering, Flavourtech, Parle Foods (Japan), the Ricegrowers' Co-operative and Precision Parts (USA).

The locational impact of technological development is also evident in the formation of new firms, where specialised activities had been hived off as new enterprises, and where some functions had been contracted out to new or existing businesses. In all of the cases, the new and existing enterprises established their operations close to the 'parent' firms, supplying goods and services to these as well as other regional firms. This process has had a cumulative impact on regional development by increasing output, and by creating additional job opportunities in the region.

5. CONCLUSION

The case studies revealed that in a number of cases, incremental improvements in the design of processing equipment enabled the firms to increase their output substantially, enabling them to achieve economies of scale . For firms such as Celair-Malmet, Allgold Foods and Parle Foods, the impetus for technical progress was the development of equipment that would give them a competitive advantage in the marketplace. In other firms, it was the combination of technical progress and the need to increase output that led to the hiving off and contracting out of certain functions to new and existing enterprises. There were also examples of more formal research and development activities in R&D departments, or through the use of engineering divisions for this purpose, as in the case of the Ricegrowers' Co-operative.

These findings reflect the observation made by cumulative causation writers that technological development involves a sequence of problem identification, finding solutions to the problems, and identifying further problems (Argyrous and Sethi 1996, 487), or what Ricoy (1988, 782) refers to as "the accretion of experience." This is similar to Rosenberg's (1976, 29) earlier observation on problem solving, and Kaldor's (1972, 184) argument that repeated application of technical processes is a necessary part of learning by using and by doing.

Also, the findings showed that much of the technical progress came about through firms engaging in collaboration with customers to meet their specific needs. Other examples of collaboration were observed in the workplace where it occurred informally between staff in different sections of the enterprise. The findings on collaboration are similar to those observed by Brusco (1989, 260) in relation to the "reciprocol stimulation" between clients and firms in Italy. They also reflect Dosi's (1988, 1130) view that cumulative change based on technology mainly comes about as a result of in-house experimentation and discovery, supported by contributions from other firms and from public knowledge. As well as collaboration occurring between clients and firms, it also occurred between firms and their capital-goods suppliers. There was also localised collaboration with enterprises established by former employees (e.g. Celair-Malmet and Allgold Foods) and where firms had hived off specialised activities to new enterprises or to subcontractors (e.g. Flavourtec, Beam, and KPL).

The findings showed that technological changes have contributed to the economic development of the Riverina Region because of their significant locational character. This was particularly noticeable in developments in the wine industry in the Griffith area, and in the food processing industry around Leeton, where incremental change, problem solving and collaboration grew out of interaction between clients and firms at the local level. The findings reflect the links in cumulative causation theory between technical progress and location, summed up in the observations of Storper and Scott (1992, 14) that "technical innovations are often place bound." They argue that one of the reasons for this is that technological changes depend on human knowledge and human capital, and that these tend to be concentrated in pools of specialised labour that are also closely tied to place. The findings reflect Martin's (1999, 79) comments that the interdependence of firms in technical innovation is "geographically constrained."

Locational elements are also significant in the link between technological development, economies of scale and the clustering of manufacturing. Kaldor (1972, 146) observed that manufacturing was able to reduce its costs per unit of output as the scale of operations increased. When this happens, firms prefer to be in large centres in order to be able to tap into large pools of specialised labour, large sources of inputs and, in some cases, large local markets (Krugman 1993, 73). This was reflected in the trend in the Riverina for manufacturers, who have used technology to increase their scale of operations, to cluster in the main urban centres of the region. Technological progress therefore appears to support regional development through these processes at the local and regional level.

The findings of this study have implications for policy. They show the importance of government support for technological development in manufacturing, as firms in this sector "are three times more likely than other industries to engage in technical innovation" (Toner 2000, 24). The findings suggest the need for policies to consolidate the development of technologies linked to industries in particular locations through programs supporting research and development organisations for these industries. Additional support could be provided to encourage collaborative research between regional manufacturers and universities. Policies could also be implemented to provide funds for in-house research, where manufacturers seek solutions to specific industry problems in collaboration with their clients. Both the Commonwealth and New South Wales governments have programs in these areas that could be expanded.

Policymakers need to look for opportunities to enable increasing returns to operate to the benefit of regional development. For example, they could encourage regional firms to incorporate new technologies through programs of assistance for upgrading plant and equipment that increase economies of scale and improve productivity and competitiveness. These could include the provision of loans to regional SMEs for new equipment, as well as incentives such as taxation and depreciation benefits. Policymakers also need to be aware of the significance of the links between technological developments and particular locations, and to build on the opportunities arising from this (Argyrous and Sethi 1996, 487). The cumulative growth implications of technological advances for regional development suggest that policies to stimulate and support these advances have long term benefits for regional economic growth.

REFERENCES

Argyrous, G. (1996) Cumulative causation and industrial evolution: Kaldor's four stages of industrialisation as an evolutionary model. *Journal of Economic Issues*, 30(1), pp. 1-23.

Argyrous, G. (1993) Emerging exporters: an evaluation. *Journal of Australian Political Economy*, 32, pp. 106-126.

Argyrous, G. (2000) The high road and the low road to international trade: emerging exporters re-visited. *Journal of Australian Political Economy*, 45, pp. 46-67.

Argyrous, G. and Sethi, R. (1996) The theory of evolution and the evolution of theory: Veblen's methodology in contemporary perspective. *Cambridge Journal of Economics*, 20, pp. 475-495.

Bamberry, G. (1995) *The nature of manufacturing in the Riverina region and its potential for further development: key findings and recommendations.* Charles Sturt University: Wagga Wagga, NSW.

Bamberry, G. (2004) Internationalisation and regional development. In *Proceedings of the Annual Conference of ANZRSAI.* Wollongong, NSW.

Bamberry, G., O'Donnell, B. and Swan, K. (1973) *A submission to the National Population Inquiry on behalf of the Regional Advisory Council for Region Six in New South Wales.* Regional Advisory Council: Wagga Wagga.

Bamberry, G. and Wickramasekera, R. (1999) *Manufacturing in the Riverina: a report for the Riverina Regional Development Board.* Charles Sturt University: Wagga Wagga, NSW.

Beer, A., Bolam, A. and Maud, A. (1994) *Beyond the capitals: urban growth in regional Australia.* Commonwealth Department of Housing and Regional Development: Canberra.

Beer, A., Maud, A. and Pritchard, W. (2003) *Developing Australia's regions: theory and practice*. University of New South Wales Press: Sydney.

Brusco, S. (1989) A policy for industrial districts. In Goodman. E. and Bamford, J. (eds) *Small firms and industrial districts in Italy.* Routledge: London.

Burnley, I.H. (1980) *The Australian urban system: growth, change and differentiation*. Longman Cheshire: Melbourne.

Castellacci, F. (2002) Technology gap and cumulative growth: models and outcomes. *International Review of Applied Economics,* 16(3), p. 333.

De Ridder, J. (1986) Cumulative causation versus comparative advantage. *Journal of Australian Political Economy,* 20, pp. 44-48.

Dosi, G. (1988) Sources, procedures and microeconomic effects of innovation. *Journal of Economic Literature,* 26, pp. 1120-1171.

Epps, R. (1999) The critical role of non-economic factors in new rural firm formation: two New South Wales case studies. In *Proceedings of the Annual Conference of ANZRSAI.* Newcastle: NSW.

Gammage, B. (1986) *Narrandera Shire.* Narrandera Shire Council, Narrandera: NSW.

Hansen, N. (1995) Addressing regional disparity and equity objectives through regional policies: a sceptical perspective. *Papers in Regional Science*, 74(2), pp. 89-104.

Hanson, L. (2003) Regions need cohesive plan to curry growth. *The Business Press*, May 12, p. 27.

Harrison, B., Kelley, M.R. and Grant, J. (1996) Innovative firm behaviour and local milieu - Exploring the intersection of agglomeration, firm effects and technological change. *Economic Geography,* 72(3), pp.233-258.

Hirschman, A. (1959) Investment policies and 'dualism' in underdeveloped countries. *American Economic Review,* 47, pp. 550-570.

Kaldor, N. (1972) Advanced technology in a strategy of development. In *Further Essays on Applied Economics.* Holmes and Meyer: New York, 1978.

Kaldor, N. (1970) The case for regional policies. In *Further Essays on Economic Theory,* Holmes and Meyer: New York, 1978.

Kaldor, N. (1966) Causes of the slow rate of economic growth in the United Kingdom. In *Further Essays on Economic Theory,* Holmes and Meyer: New York, 1978.

Kenny, M. and Burgh, U. (1999) Technology, entrepreneurship and path dependence: industrial clustering in Silicon Valley and Route 128. *Industrial and Corporate Change*, 8(3), pp. 67-103.

Kerlinger, F.N. and Lee, H.B. (2000) *Foundations of behavioral research*, 4th Ed. Wadsworth.

Lowe, J. and Miller, P. (2001) Business clustering: panacea or placebo for regional Australia? In Rodgers, M.F. and Collins, Y.M.J. (eds.) *The future of Australia's country towns.* Centre for Sustainable Regional Communities, La Trobe University: Melbourne.

Marceau, J., Manly, K. and Sicklen, D. (1997) *The high road and the low road? Alternatives for Australia's future*. Australian Business Foundation: Sydney.

Marshall, A. (1920) *Principles of economics.* Macmillan: London.

Martin, R. (1999) The new 'geographical turn' in economics: some critical reflections. *Cambridge Journal of Economics*, 23, pp. 65-91.

O'Connor, K., Stimson, R. and Daly, M. (2001) *Australia's changing economic geography: a society dividing.* Oxford University Press: Melbourne.

O'Hara, P.A. (2000) How can economics be an institutional - evolutionary science? *Journal of Economic and Social Policy*, 4(1), pp. 127-140.

Pasinetti, L. (1981) *Structural change and economic growth.* Cambridge University Press: Cambridge.

Patton, M. (1990) *Qualitative evaluation and research methods.* Sage: Newbury Park, California.

Porter, M. (1998) Clusters and the new economics of competition. *Harvard Business Review*, (Nov-Dec), pp. 77-93.

Ricoy, C. (1988) Cumulative causation. In Eatwell, J. Milgate, M and Newman, P. (eds.) *The new palgrave: a dictionary of economics.* Macmillan: London.

Riverina Regional Development Board. (2000) *News.* RRDB: Wagga Wagga.

Riverina Regional Development Board. (1991) *Riverina economic development strategy.* RRDB: Wagga Wagga.

Rogers, E.M. (1983) *Diffusion of innovation,* 3rd ed. Free Press: New York.

Rosenberg, N. (1976) *Perspectives on technology.* Cambridge University Press: Cambridge.

Stilwell, F. (1992) *Understanding cities and regions: spatial political economy.* Pluto Press: Leichhardt, NSW.

Storper, M. and Scott, A.J. (eds.) (1992) *Pathways to industrialization and regional development*. Routledge: London.

Swan, K. (1970) *A history of Wagga Wagga*. Wagga Wagga City Council: Wagga Wagga.

Targetti, F. (1992) *Nicholas Kaldor, the economics and politics of capitalism as a dynamic system*. Oxford University Press: Oxford.

Taylor, S.J. and Bogdan, R. (1984) *Introduction to qualitative research methods : the search for meanings.* Wiley: New York.

Thirlwall, A. (1987) *Nicholas Kaldor*. Wheatsheaf Books: London.

Ticehurst, G.W. and Veale, A.J. (2000) *Business research methods: a managerial approach.* Longman: Frenchs Forest, NSW.

Toner, P. (1998) *Main currents in the theory of circular and cumulative causation: the dynamics of growth and development.* St Martin's Press: New

York.
Toner, P. (2000) Manufacturing industry in the Australian economy: its roles and significance. *Journal of Australian Political Economy*, 45, pp.18-45.
Wade, R. (2005) Failing states and cumulative causation in the world system. *International Political Science Review*, 26(1), p. 17.
Young, A. (1928) Increasing returns and economic progress. *Economic Journal*, 38(152), pp. 527-542.