The Victorian Electronics Industry Cluster

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Sections 1 to 3 lay the foundation for analysis. Readers wishing to focus on the Victorian Electronics Cluster Survey and conclusions may wish to go directly to Sections 4 and 5.

Executive Summary

This report is based on a study undertaken by the Centre for Strategic Economic Studies, Victoria University. It aims to contribute to a better understanding of the entire electronics value chain – from the design and manufacture of components and inputs to electronics manufacturing, through manufacturing and assembly, wholesale and retail distribution, installation, maintenance and repair of electrical and electronic equipment.

Electronics is a key enabling technology which underpins developments in a range of industries. In 2000-01, the electronics manufacturing industries employed around 34,750 people in Australia, realised turnover of $8.9 billion and contributed more than $2.5 billion to Gross Domestic Product (GDP).[1] Over the period 1996-97 to 2000-01, employment in the industry grew by just 0.3% per annum. Wages and salaries increased by 6.5% per annum, suggesting an increasing focus on higher-value activities.

Issues and trends

The electronics industry is being shaped by many forces. These include:

- Market trends and growth, with a return to growth in ICTs and renewed growth in automotive and consumer electronics;
- The fragmentation of the value chain, with standardisation and modularisation supporting increased outsourcing and specialisation along the value chain;
- The need to rapidly develop new business models to support increased firm and regional specialisation;
- The drive to make better use of internet-based technologies and e-business applications to support supply chain management, participation and integration;
- Environmental and regulatory demands for the removal of 'materials of concern' and increased whole-of-life 'product stewardship'; and
- The emergence and cross-fertilisation of new, converging technologies (eg. nanotechnology).

Market opportunities

Following the severe downturn of 2000-01, the worldwide electronics market now appears to be returning to annual growth rates of 5% to 7%. This is slower than the historical long-term trend,

[1] Following the Electronics Industry Action Agenda, the electronics manufacturing industry is defined as including ANZSICs: 2813 Automotive Electrical and Instrument Manufacturing; 2839 Professional and Scientific Equipment Manufacturing; 2841 Computer and Business Machine Manufacturing; 2842 Telecommunications, Broadcasting and Transceiving Equipment Manufacturing; 2849 Electronic Equipment Manufacturing n.e.c; and 2852 Electric Cable and Wire Manufacturing.

due to a combination of persistently slow market and production growth in developed countries. However, there is strong growth in developing countries, particularly China.[2]

Major world market growth areas include:

- *Automotive electronics* – with demands for increased comfort, enhanced features, engine efficiency and safety increasing the electronics content of vehicles;
- *Consumer electronics* – with the replacement of cathode ray tube displays by flat screens and new consumer products, such as DVD-writers, set-top boxes, digital TVs, home cinema, digital cameras and game consoles revitalising the sector; and
- *Power electronics* – with increasing demands for security and uninterruptability of supply, mobility and the emergence of an ever wider array of mobile devices, and the development of electric and hybrid vehicles.[3]

Structural change

Electronics industry sub-sectors vary in structure and dynamics. Whereas original equipment manufacturers (OEMs) can be vertically integrated, keeping large parts of the production and value creation process in-house, much of the electronics industry is characterised by a high degree of specialisation along the value chain, with standardisation and the modular nature of electronic products supporting high levels of specialisation and outsourcing.[4]

Increasingly, this fragmentation of the value chain is happening globally, with the formation of specialised production clusters participating in global production systems. At the same time there are cross-cutting trends, with labour-intensive, volume manufacturing shifting to contract equipment manufacturers in Asia, while Europe and the United States retain the high-end, knowledge intensive stages of the value chain, such as research and product development.[5] However, high unit volume products evolve quickly from small scale manufacturing near design centres of gravity, to large scale manufacturing near market centres of gravity, and finally to large scale manufacturing near low cost labour centres of gravity.[6] Unable to compete with Asian locations on labour costs, and remote from major markets, Australia's electronics industry must seek to maintain a position as a design and development 'centre of gravity' and/or focus on lower unit volume products.

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2 Reed Electronics Research (2004) *Yearbook of World Electronics Data: Volume 1, 2004*. Available http://www.instat.com/catalog/

3 Electronics.ca (2003) *World Electronics Industry 2002-2007*, Research Report # DE3120. Available http://www.electronics.ca/reports/industrial/electronics_industry.html

4 E-business Watch (2003) *ICT and e-business in the Electrical Machinery and Electronics Sector*, European Commission, Sector Report 11/II, p13. Available http://www.ebusiness-watch.org/marketwatch/

5 E-business Watch (2003) *ICT and e-business in the Electrical Machinery and Electronics Sector*, European Commission, Sector Report 11/II, p14. Available http://www.ebusiness-watch.org/marketwatch/

6 NEMI (2003) *Technology Roadmaps: December 2003*, NEMI, p11. Available http://www.nemi.org/

Managing the supply chain

This rapid evolution of industry structures, value chain fragmentation, the emergence of new business models and increasing firm and regional specialisation are making supply chain management increasingly important. As well as offering the potential to increase productivity, the use of internet-based technologies and e-business techniques support the increasing scope of outsourced operations, which require loosely coupled business processes spanning multiple companies.[7] The ability of Victorian Electronics Cluster firms to operate effectively and efficiently within global and highly automated supply chains will be a key determinant of their ability to access and prosper on world markets. The successful implementation of supply chain management and related e-business solutions will be crucial.

Environmental and regulatory concerns

To meet regional environmental legislative requirements, manufacturers must remove 'materials of concern'. There is increasing pressure to ensure product recyclability and even conduct recycling, and an increasing focus on lowering energy use, both in manufacturing and in product operation. There is also greater focus on 'product stewardship', with the electronics industry facing product end-of-life or producer responsibility legislation in some markets.

These demands raise two issues. First, how to manufacture in such a way as to comply *and* manufacture products that comply from a technological point of view. Second, how to establish and operate the systems to enable, support and manage conformance. Environmental legislation in various product segments will require the electronics industry to share detailed material content data on their products and components and to establish systems for product stewardship. Again, the adoption and use of sophisticated e-business applications and supply chain information systems is likely to be crucial.

Electronics futures and convergence

It has been widely noted by futurists that many of the more important technology trends of recent years have points of intersection. Indeed, convergence has been seen as a 'mega-trend', with cross-fertilisation of technology trends driving each other further and faster. Crucially, electronics is a vital enabler and key participant in many of these converging trends. It is, for example, becoming increasingly difficult to separate microelectronics, photonics and nanotechnology. As a result, future cluster strengths may require hitherto disparate skills, and the future of regional clusters may depend upon their combination and coordination, rather than the continued development of focused local strengths.

Electronics in Victoria

In 1999-2000, the electronics manufacturing industries employed 11,681 people in Victoria, realised turnover of $3.4 billion and contributed more than $920 million to Gross State Product (GSP). Victoria accounted for around 35% of national employment in the electronics manufacturing industry, 41% of industry turnover and 38% of industry value added – somewhat

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7 NEMI (2003) *Technology Roadmaps: December 2003*, NEMI, p1. Available http://www.nemi.org/

higher than Victoria's share of manufacturing overall. Moreover, Victoria accounts for 69% of national employment in automotive electronics manufacturing, and around 45% of national employment in cable and wire manufacturing.

These data reveal Victoria's relative strengths in automotive electronics and professional and scientific equipment, as well as a wealth of electronics manufacturing capabilities in other areas.

Employment and skills

Since the mid 1990s there have been mixed employment trends. The strongest employment growth in Victoria's electronics manufacturing industry has been in professional and scientific equipment. In all other areas of electronics manufacturing in Victoria employment has declined, most notably in telecommunication, broadcasting and transceiving equipment, other electronic equipment, and cable and wire manufacturing.

Because electronics is a generic technology people with electronics related skills work in a wide range of industries. At the end of June 2002, there were around 102,700 people employed in electronics occupations in Australia.[8] Employment in these occupations has declined by around 7,000 over the last three years, with a decline in communications tradespersons driving the overall trend and job growth in other areas. In Victoria there were more than 23,800 people employed in these electronics occupations – 23% of the national total and around 1% of the state's total employment.

Innovation

Across the core electronics related fields of research annual R&D expenditure in Victoria amounts to around $240 million, some 26% of total national expenditure.[9] The largest field of R&D activity in Victoria is communication technologies, which accounts for almost 70% of total electronics related expenditure in the State ($165 million).

By far the largest share of electronics R&D is conducted by the business sector, which accounts for around 93% of total R&D expenditure in these fields. By contrast, higher education accounts for just 6%, the Commonwealth Government for 1% and state and local governments for just 0.1%. The share of expenditure by the business sector is higher in Victoria than is the case nationally – emphasising the importance of policies focusing on enabling business-based R&D and forging linkages between it and R&D activity elsewhere.

The Victorian Electronics Cluster Survey

Some 2,400 electronics cluster firms were identified in Victoria, of which 23% were equipment producers, 15% components manufacturers, 10% engineers, 9% communications equipment producers, 9% were in lighting, 8% were IT producers, 6% were in security and 6% were

[8] Including: electrical and electronics engineers, electronic engineering associate professionals, electronic and office equipment tradespersons, communications tradespersons, and electrical and telecommunications trades assistants.

[9] Including: electrical and electronic engineering, computer hardware and communications technologies.

machinery producers. Some 1,788 (75%) were located in cities and 409 (17%) were in rural locations. A large proportion of the electronics firms identified in Victoria are located in the eastern suburbs of Melbourne (Monash, Kingston, Whitehorse, etc.). Outside the Greater Melbourne area, Greater Geelong, Ballarat, Greater Bendigo and Wodonga are locations of significant electronics industry activity.

A questionnaire was sent to around 1,700 firms. Of those firms responding (N=98), 77% were headquartered in Melbourne and 15% in rural Victoria – there were four firms based elsewhere in Australia and four headquartered overseas.

Cluster characteristics and capabilities

Responding firms earned a total of $1.64 billion during 2002-03 – an average revenue of $17.7 million per firm, up from $7.3 million in 1998-99 or by 23% a year. Around 80% of their revenue was derived from operations in Victoria, with a further 11% from operations elsewhere in Australia and 9% from overseas.

The majority of revenue came from manufacturing their own products (37%). Wholesale and retail distribution (27%), service delivery (16%), support and after sales services (10%) and integrated systems and solutions (8%) made up the remainder. Most firms focus on relatively High Value/Low Volume activities, with product manufacturers more likely to do so than wholesale and retail distributors.

Responding firms employed around 3,100 people in 2003, of whom 2,650 (86%) were located in Victoria. They spent an average of $1.7 million on wages and salaries – suggesting an average salary in excess of $54,000 per annum. Forty-two per cent of the firms have formal education and training policies or procedures to allow employees to further their education and develop skills.

More than 80% of respondents identified skills shortages. Twenty-nine per cent of the skills shortages identified were for technical, professional and engineering skills, and 27% were for marketing and sales skills. Relatively fewer respondents were concerned about shortages of business, project management or people management skills. Concerns about possible future shortages also focused on professional and technical skills.

Most firms are financed privately, with 69% of reported financing coming from private equity, around 12% from a parent firm, 2% from public financing and 16% from debt financing. Only 1% of financing came from venture capitalist or business angel investments. Strong competition for local customers, access to capital and skilled staff, and concerns over the costs of regulatory compliance were the main barriers to growth.

Forty-one per cent reported suppling electronics manufacturers, 56% reported undertaking electronics manufacturing activities and 49% provide electronics related services.

- *Manufacturing supplies* sourced from within the Victorian Cluster included: design services, components, sub-assemblies, R&D services, prototyping services, contract manufacturing, calibration and testing, mounting and assembly, fabrication, testing and conformance – suggesting local supply strengths in these areas.

- Among the main *manufacturing production capabilities* reported were: components, process and control equipment, power and battery, instrumentation, mobile and wireless, other telecommunication equipment, automotive, and cable, wire and optical fibre – suggesting local manufacturing strengths and capabilities in these areas.
- Major reported *services activities* included: repair and maintenance, installation, wholesale and retail, design, engineering and consulting.

Fifty-one per cent of respondents exported last year, with exports accounting for a high share of sales. The extensive use of distributors and of direct links to export customers demonstrates the importance of demand-side supply chain linkages. That almost 25% of exporting firms cited the use of internet and/or electronic delivery of their exports suggests an active adoption of new methods and a strong base capability for the development of global trading activities.

The electronics supply chain

Respondents reported on the activities of 269 suppliers and 263 customers. Fifty-six per cent of respondents' *suppliers* were located in Victoria, 26% were located overseas and 16% were located elsewhere in Australia. The supply network is relatively concentrated, with the Top 3 suppliers accounting for between 14% and 98% of total supply costs. Materials and components accounted for more than 80% of all Top 3 supplier supplies by value. Machinery and equipment came a distant second, accounting for just 6%.

Fifty-one per cent of Top 3 *customers* were located within Victoria, with 33% located elsewhere in Australia and 15% located overseas. The Top 3 customers accounted for between 8% and 98% of sales for 80% of the respondents, while 20% reported that their Top 3 customers accounted for 100% of their sales revenue. Product manufacturers were the most likely to have customers overseas (24% of their Top 3 customers). Wholesale and retail distributors were the only firms to nominate a higher numbers of customers elsewhere in Australia than within Victoria. Not surprisingly, services providers reported a strong concentration on local customers.

By value of sales, government (20% of Top 3 customers' average sales values), OEMs (16%), business and household end users (16%), and other public organizations (11%) were the major customer types reported by local firms.

Product system linkages, innovation and knowledge flows

Thirty-seven per cent of responding firms reported an involvement in some form of linkage with another company or organization (eg. a joint venture, alliance, partnering or cluster relationship). More than half the services firms reported such links, compared with just over one-third of the product manufacturers and almost one-third of the distributors.

Alliance relationships are the most common, with 41% of those firms reporting linkages involved in alliances, compared with 32% involved in partnering, 17% in joint ventures and just 10% reporting an involvement in formal cluster relationships. The primary purpose of forming these relationships was marketing and sales, which accounted for 23% of all the linkages

reported. Product development was the second most widely cited purpose, accounting for 19% of the reported linkages.

Respondents said that 20% of their products and services (by sales revenue) had been introduced within the last year, and 57% within the last 4 years. Manufacturing and services firms had the highest proportion of revenue from products and services introduced within the last year (23%), followed by integrated systems and solutions providers (19%) and support and after sales services firms (17%).

When asked where they get information about *new technical developments*, respondents reported 443 sources – an average of 4.5 sources per firm (suggesting a relatively high 'absorptive capacity'). External sources, such as professional or industry associations, professional publications and journals, trade and industry magazines, discussions at conferences and trade shows or at industry networking functions, dominated. The second most important group of sources was other firms along the supply chain (ie. suppliers and/or customers).

Respondents were also asked to rank the relative importance of the same sources of information and ideas for the introduction of *new products or services*. They reported 384 sources – an average of 3.9 per firm. Again, external and supply chain sources predominated, reflecting the importance of demanding customers and major suppliers as drivers of innovation through the supply chain and of external linkages throughout the electronics product system.

Two-thirds of respondents performed formal R&D last year, and they spent an average 14% of turnover doing so. Eighty-eight per cent of those conducting R&D did so in-house, 83% reported that it was conducted in Melbourne, 9% conducted their research elsewhere in Victoria, 5% conducted it elsewhere in Australia and just 2% conducted their R&D overseas. Firms rely primarily on internal resources to fund their R&D activities.

Mapping the Victorian Electronics Cluster

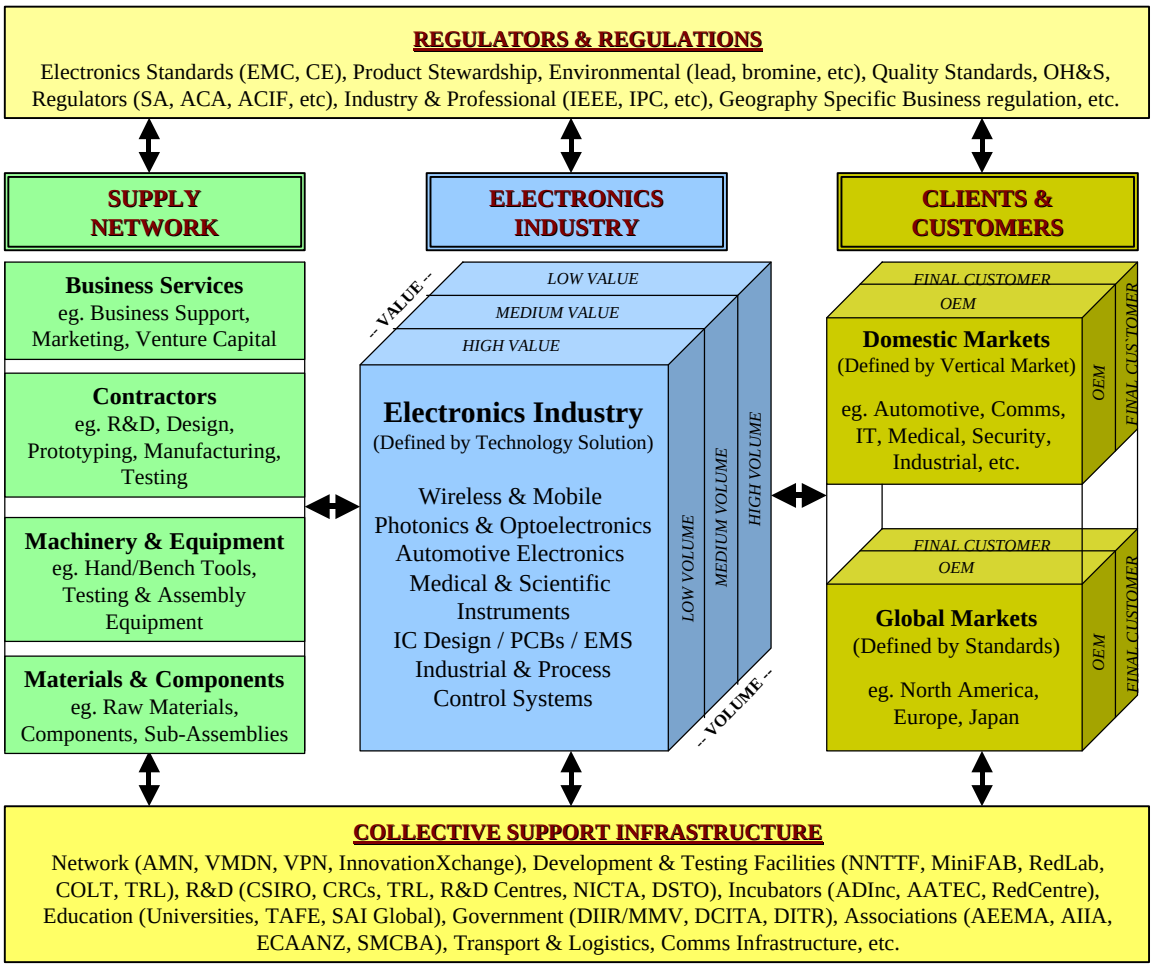
In mapping the Victorian Electronics Cluster we place electronics firms (defined by technologies, solutions and/or vertical markets) at the centre, their supply network to the left and clients, customers and markets to the right (Figure 1). These are all supported by a collective support infrastructure and operate within an overarching regulatory framework.

There are many forms of clusters and clustering. Clusters can be technology-based (eg. photonics), customer-based (eg. automotive), product-based (eg. smartcards), needs-based (eg. access to design skills) and/or resource-based (eg. energy or minerals resources). Clusters can also be characterised as:

- *Vertical clusters*, involving firms linked through buyer-seller relations;
- *Horizontal clusters*, involving firms that share a common end product market, use a common technology or science base, use common skills or require similar resources and conditions; or
- *Halo clusters*, involving the presence of a central actor (eg. a multinational firm) around which supply and support firms cluster.

In practice, clusters present a mixture of these things. All forms, as well as mixed forms, can be observed in the Victorian electronics industry.

Figure 1 The Victorian Electronics Cluster



Source: Centre for Strategic Economic Studies.

Capabilities and emerging opportunities

There are a number of key vertical markets into which Victorian-based electronics and related firms sell, and around which horizontal clusters form.[10] These include:

- *Automotive* – with suppliers including: Robert Bosch, Siemens VDO, Australian Arrow, Denso International/Australian Automotive Air, Air International, AME Systems, Flexdrive Cables (mechanical and electronic instrumentation), PBR (Brakes), Hella Australia, Sumitomo (Connectors and Drives), etc. Automotive electronics manufacturing is a significant activity, it is experiencing growth in world markets and is an areas that is highly prospective for further local cluster development.

[10] It should be noted that these lists are indicative and by no means exhaustive.

- *Communications and IT* – with suppliers including: Siemens, NEC, Extel, Halipex, G&D, VPI Systems, Diamond Australia, RFS, CEOS, CommTel, InterCel, Cablex, Ipex (Volante), Aegis, Alfatron, etc. While it has been severely affected by the recent downturn in telecommunication investment worldwide, communications remains a significant area of opportunity for Victorian suppliers, and increasing build-to-order is bringing new opportunities for IT related assembly activities.
- *Medical Devices* – with suppliers including: GBC, Varian, Medtron, Vision Systems (BioSystems), Compumedics, Norwood Abby, etc. While relatively small and fragmented the medical and scientific devices area has a strong local user base in Victoria.
- *Security* – with suppliers including: Interlogix (GE Security), Inner Range, Nidac, ACD Digital, Vision Systems (Fire and Security), Intelligent Fire Systems, etc. Security is an area with strong growth potential in an era of heightened domestic and international security concern and increasingly demanding regulatory oversight of fire hazards.
- *Industrial and Process Control* – with suppliers including: ANCA, Datataker, IPC Global, Innovonics, Intermoco (Australon), Moonlighting, NeoProducts, Robotron, Traffic Technologies, Atco Controls, Schneider Electric, Bytecraft Automation, etc. Both industrial process control and instrumentation are areas of local strength and opportunity.
- *Instrumentation* – with suppliers including: Agilent Technologies, Gedge, Phasefale, Datataker, Hawk Measurement, Contrec, Kingfisher, Alfa-Tek, McVan, etc. Like industrial process control, instrumentation offers opportunities to develop and market local capabilities.
- *Power Supplies* – with suppliers including: Rectifier Technologies, Setec, Selectronic, Thycon, Thytec, Arlec, etc. There is a large and growing market for a wide range of power supplies, increasing focus on mobility, security and uninterruptible power supply. There is also growing interest in electric and hybrid vehicles, for which power supply technologies are crucial.
- *Contract manufacturing and PCBs* – with suppliers including: Precision Australia, AEMS, Labtam, Duet, Millison, Clevertronics, EDPM, Unique Micro Design, etc. The emerging trend for increased customisation and build-to-order promises to provide new opportunities for contract manufacturers.

The electronics industry reveals a complex interplay between technologies, applications and markets. Particular technologies can support a range of applications and feed into a number of vertical markets. In Victoria, wireless communications and photonics are among the leading examples of this phenomenon.

There has long been a major emphasis on, and significant competence in wireless and mobile communications. This is now increasingly translating into applications in a number of vertical markets (eg. communications, automotive, health, defence, transport and logistics, etc.) for remote monitoring and telemetry, as well as the more direct wireless applications in mobile

communications. This focus feeds through the entire value system, from ASIC designs, through the fabrication and integration of DSPs, etc.

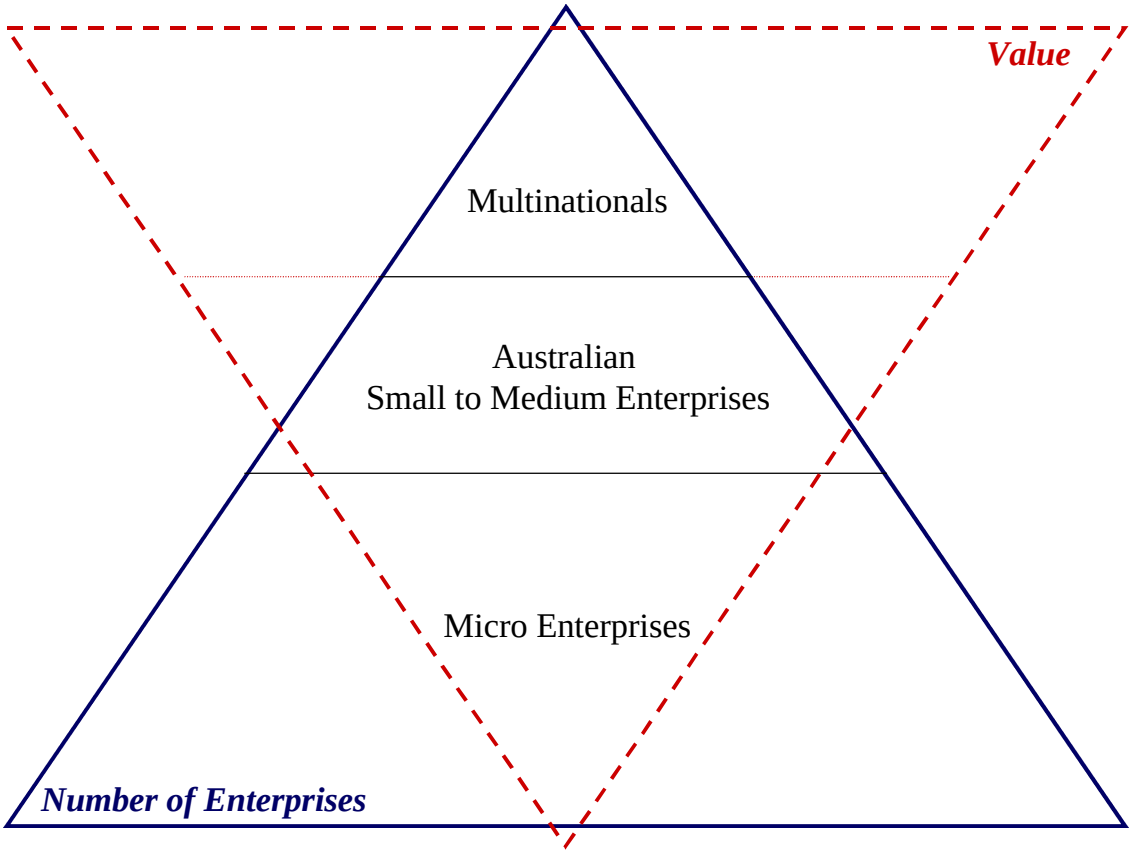
Photonics has suffered from the recent downturn in telecommunication investment. Nevertheless, it remains a strong area of focus and activity in Victoria. Victoria's photonics cluster covers a number of areas that have considerable prospects for growth, including: communications, medical, bio-photonics and micro-photonics, defence, intelligent transport systems and security.

It will also be important to exploit the synergies of convergence in photonics, microelectronics and nanotechnology, and build on local strengths by fostering linkages between players in these areas.

Structure and structural change

The Victorian electronics industry structure can be represented as a pyramid. At the top are the multinationals with a strong base in Australia and linkages into global markets. In the centre are

Figure 2 The structure of the electronics industry



Source: Centre for Strategic Economic Studies.

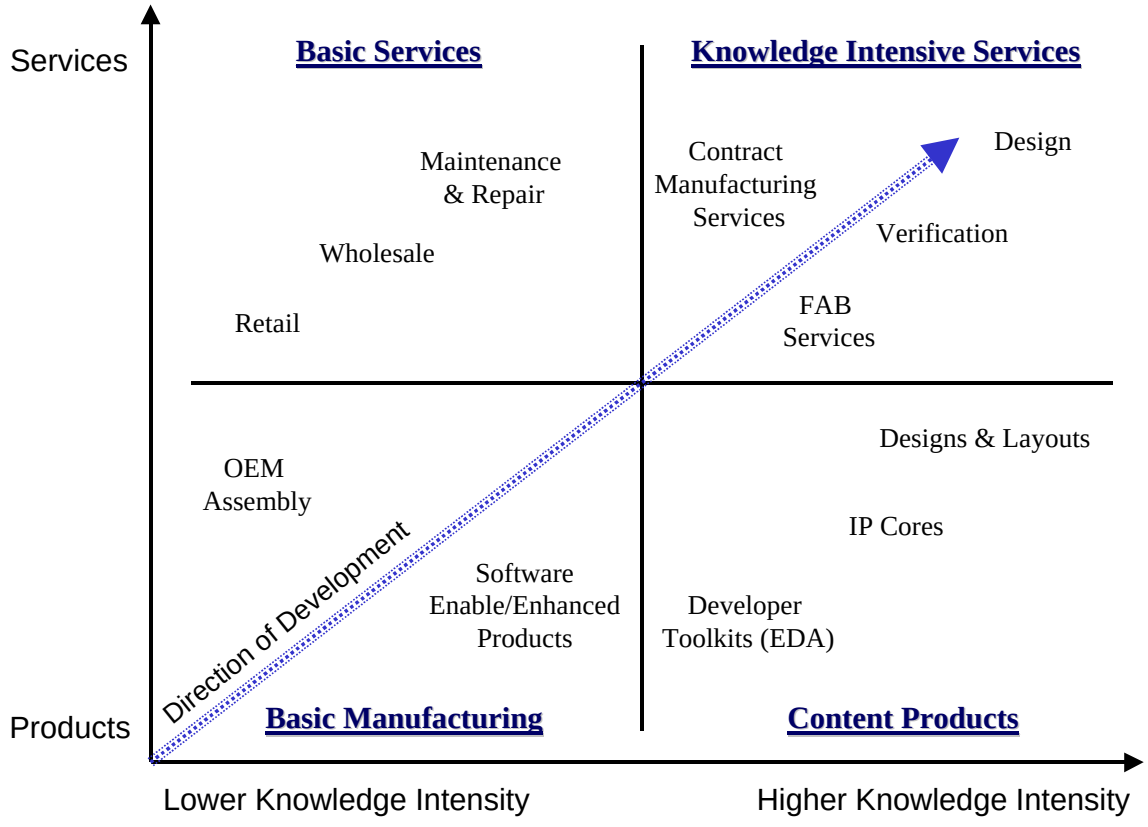
a relatively small number of Australian SMEs. The base is made up of many hundreds of micro firms. Value is the inverse, with much of the sales and export value concentrated within the

small number of multinationals and the larger indigenous firms, and relatively little realised at the micro enterprise level (Figure 2). Consequently, there is a need to focus leverage where it is likely to be most effective, while creating linkages that suit all players, or can at least accommodate them.

Networks and clusters

The evolution of the electronics industry can be seen as a fragmentation of the value chain, with separation of activities and increasing specialisation along a dimension running from basic manufacturing assembly to high-value, knowledge-intensive services (Figure 3). Integrated OEM design, verification, manufacturing, assembly, distribution, maintenance and repair is increasingly giving way to the fragmentation of these activities, and to firm and regional specialisation. Unable to compete with Asian locations on labour costs, and remote from major markets, Australia's electronics industry must seek to maintain a position as a design and development 'centre of gravity' and/or focus on areas that are lower volume. To do so, Australia

Figure 3 Dimensions of specialisation and development in electronics



Source: Centre for Strategic Economic Studies.

must develop effective linkages between global markets and emergent high value services (eg. design and verification), IP-based products (eg. IP cores, designs and layouts) and lower volume products (eg. scientific and medical equipment, instrumentation and industrial process control),

and those linkages must take account of the very different scale and capabilities of major multinationals, local SMEs and micro services and content businesses.

Sometimes products can become so commoditised that they provoke the emergence of business models based on differentiation through customisation. One example is that of desktop PCs, which are increasingly being built-to-order. Coupled with local purchasing preferences in outsourcing contracts, this has led to the development of local (final) assembly of PCs and flexible customisation. There are now a surprisingly large number of local desktop PC assemblers in Australia. Most are small shop-front operations, but there are a handful of significant players (eg. Ipex (Volante), Optima, etc.). This suggests that fragmentation of the supply chain and commoditisation of products can come full-circle, bringing new opportunities for customised and contract assembly activities linked to distribution into local and readily accessible regional markets.

The size of the Australian market and of leading customers' demand in local vertical markets acts as a limiter on the ability of local firms to specialise and achieve scale simultaneously. In most areas, demand in Australia does not support the level of capital expenditure, specialisation and scale required in order to thrive. Consolidation among the smaller players in the industry is likely to be necessary, with the formation of deep networks, clusters and alliances a partial alternative. Support for such networks, clusters and alliances is essential. Victoria's microelectronics and photonics networks are a successful model for the creation of deeper horizontal linkages within the local industry. Perhaps the only danger lies in having too many such networks, thus limiting the *de facto* scale achievable and becoming too fragmented to generate the range of vertical and horizontal linkages required.

Shared infrastructure

The viability of local electronics SMEs and of local networks and clusters will depend, in part, upon access to shared infrastructure. In electronics, unlike other areas, both the equipment and the software for design are getting more expensive, not less. As a result, it is becoming more difficult for smaller firms to afford the latest capital equipment and to keep up with developments in design, development and production technology. Limited use testing and conformance related equipment and systems are also becoming prohibitively expensive for SMEs.

Locally in Victoria, there are a number of initiatives directed to this problem, and much progress has been made. Nevertheless, these initiatives require commitment and would benefit from further support. It might also be beneficial to learn from the experience of other fields, such as that of consortial purchasing and national site licensing of scientific and professional publications by universities and the CSIRO, and apply similar approaches and solutions to such areas as the consortial licensing of design software.

Lead projects

One problem facing local electronics firms is the decline in large demanding 'informed' clients, which is exacerbated by major privatisations, risk aversion and disinvestment by some major multinationals. Consequently, while there have been many gains made in such areas as R&D

funding and there are many firms with innovative technologies and products, opportunities to participate in the development of solutions in lead projects are few and far between. Finding ways to support more lead/demonstration projects with deeper pockets and longer time horizons would be beneficial.

There are a number of areas of strength and promise that could benefit from the establishment of such projects. For example, it is apparent that remote monitoring and telemetry will be important in all sorts of applications and markets (eg. health monitoring of home-based patients). What is lacking is a lead project that facilitates the development of the devices needed and supports trials of them in the field, enabling clients, suppliers and researchers to work closely in translating technologies and supply capabilities into solutions.

There are also likely to be opportunities for the development of lead projects in e-science. The very nature of research is changing rapidly, due in part to the impacts of ICTs.[11] There are a number of major facilities (eg. Australian Synchrotron, Square Kilometre Array, etc.) and a number of network and grid initiatives (eg. AREN, GrangeNet, etc.) that could provide opportunities for the development and implementation of local electronics and related technologies.

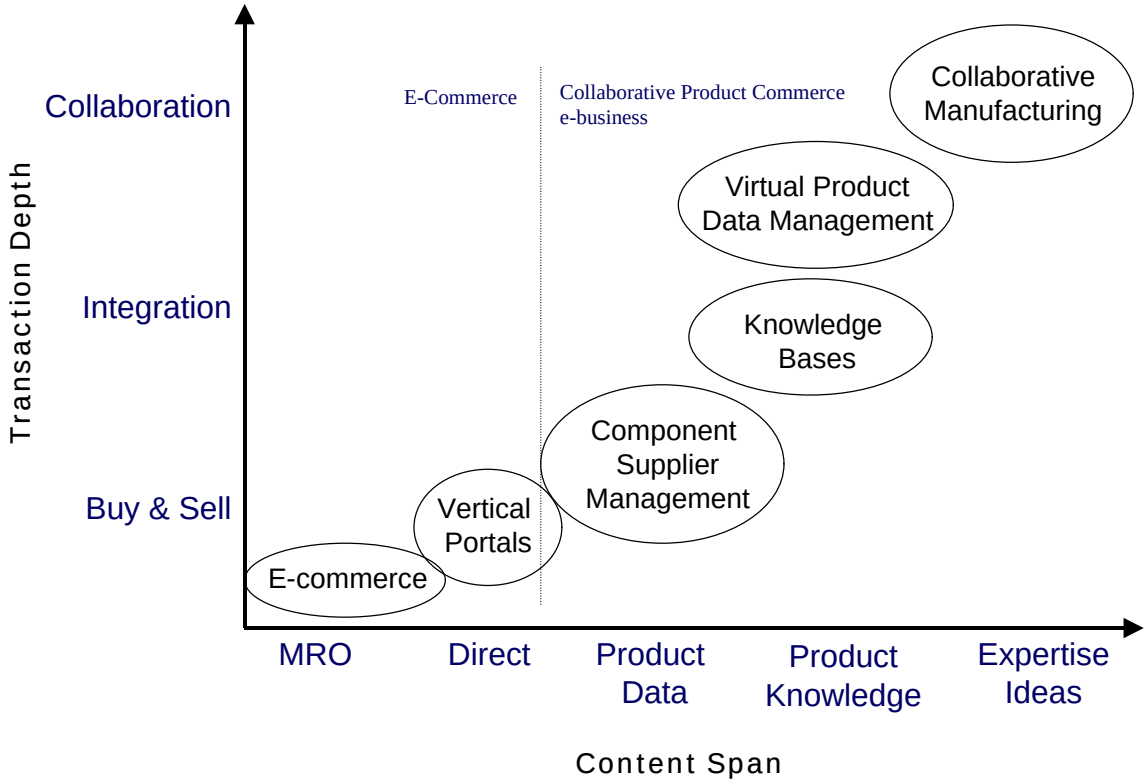
Supply chain management

A common thread throughout analyses of the electronics industry is the need for deeper linkages, both vertically throughout the supply chain and horizontally between firms in particular markets. Collaboration and supply chain management, of a kind that goes beyond management of the supply network to support deep integration and collaboration, are crucial. Local partnering and the use of B2B e-marketplaces can be developed further, but there is also an emerging need for a shift from e-commerce (ie. electronic trading) to e-business (ie. using networked systems to manage and participate in collaborative production systems) (Figure 4).

Needs-based projects are generally more successful, and one possible approach to deepening product system collaboration would be to harness the demands for information exchange and collaboration created by emerging regulatory demands for ‘product stewardship’ and control of ‘materials of concern’. A lead project in the e-business collaboration space might involve embracing compliance demands and using them as the driver for the development and deployment of an integrated, shared knowledge management system, with suitable metadata and access management standards. Such a system might provide both the foundation for an infrastructure for greater vertical and horizontal collaboration within the industry and a process for collaborative project development and management that would be more widely applicable.

[11] Houghton, J.W. Steele, C. and Henty, M. (2003) *Changing Research Practices in the Digital Information and Communication Environment*, Department of Education Science and Training, Canberra. Available http://www.dest.gov.au/highered/respubs/changing_res_prac/exec_summary.htm.

Figure 4 Collaborative product commerce



Source: Gartner Group. Cited by Waraniak, J. (2000) *Driving Web-Enabled Market Efficiency*, Federal Reserve Bank of Chicago, Detroit, MI.

Key issues

While there are many trends affecting the Victorian Electronics Cluster and many issues involved, preliminary analysis suggests a number of key points.

Structure

Firms in the local electronics industry are of three main types: multinational majors, Australian SMEs that are linked into markets and growing, and many micro businesses – some of which do not seek to grow their business, being what might be described as 'lifestyle businesses' rather than growth driven enterprises. This is not a criticism, but rather a call for recognition. Rather than lamenting a lack of hard-nosed entrepreneurialism, we should focus on adjusting policy approaches to the businesses we have.

The implications of this situation include: a need to focus on fostering SMEs and their links into global production systems; and a need for new policy approaches to the micro businesses (particularly the high knowledge–high value ones) that takes account of how they might better be mobilised and engaged in global production systems.

Structural change

There is increasing fragmentation of functions within the value chain and disbursement of production activities globally. This fragmentation is variously referred to as deverticalisation (ie. the decline of vertically integrated OEM production) and horizontal fragmentation. It is driven by outsourcing, facilitated by standardisation and is both a driver and consequence of globalisation.

The implications of this include: a greater need for supply chain management; moving e-commerce towards more deeply integrated e-business; enhanced ways of linking local producers into global production systems; and an increased focus on standards and on quality accreditation, prequalifying, etc. Enabling local electronics SMEs and micro businesses also depends, in part, upon access to shared infrastructure, such as design software, manufacturing, testing and conformance facilities, and upon enhanced IP management and access (eg. collective access to IP Cores, etc).

Innovation

A feature of fragmented supply systems is that they make innovation and learning difficult. Staying informed and in touch is vital.

The implications of this include: the need for increased attention to innovation and learning linkages around the system (eg. between R&D and educational institutions and SMEs); the importance of participating in R&D relationships, missions, etc.; the importance of value system linkages and close relations with buyers and suppliers, who are often important sources of ideas and demanding requirements that drive innovation; the importance of participation in the development of standards and standards monitoring; and the importance of quality management systems, accreditation, prequalification, etc. One widely noted ‘missing ingredient’ is a sufficient number of lead projects. The role of major local purchasers has changed, with fewer opportunities for high-profile, longer-term development projects. There is a need to find new ways to generate lead projects in areas in which there are opportunities to develop local technologies into market ready solutions.

Compliance

There are number of major compliance issues, including: materials of concern (eg. lead, bromine, etc.) and product stewardship issues, which are being pushed back up the supply chain to producers. It is not merely an add-on. Both materials of concern and product stewardship need to be designed in, making it a design and development issue too.

The implications of this include: the increased importance of testing and conformance infrastructure, to enable firms to demonstrate and meet standards (domestic, regional and global); a need to keep close contact with international standards and international developments in compliance; and the increased importance of linkages through the supply chain, supply chain management, knowledge management and the sharing of key information about products, processes and practices.

Local issues

There is also a range of more local issues, such as: skills and trade skills development, with widespread concern about shortages of trades and higher skills and the lack of training support; gaining and maintaining access to global production systems; the development of local firms within highly fragmented global production systems; a need to focus on the research, design and development end of the spectrum of industry activities; and how to effectively mobilise the many micro businesses and 'lifestyle' independents.

While all of these challenges are real and immediate, many suggest ways forward and the adoption of responses which, if not known, are at least emergent.

1 Introduction

Electronics is a key enabling technology which underpins developments in a range of industries, including: information technology, telecommunications, automotive and defence. Electronics also provides the foundation for a wide range of equipment and appliances which contribute to improvements in medical and scientific equipment, transport and logistics, measuring and mapping. In recognition of the importance of electronics to the Australian economy, the Commonwealth Government joined with the industry to launch the Electronics Industry Action Agenda in June 2003. The Australian Electrical & Electronic Manufacturers' Association (AEEMA) was given the responsibility for coordinating the implementation of the Action Agenda, as a part of which AEEMA is coordinating state-based mapping of electronics industry activities and capabilities.

This report is based on a study undertaken by the Centre for Strategic Economic Studies (Victoria University) in Victoria. It aims to contribute to a better understanding of the entire electronics value chain – from the design and manufacture of components and inputs, to electronics manufacturing, through manufacturing and assembly, wholesale, retail, installation, maintenance and repair of electrical and electronic equipment.

Following a brief look at the electronics industry in Australia, this section presents an outline of the Electronics Industry Action Agenda and the approach used to cluster mapping, before outlining the purpose and aims of this study. Section 2 looks at electronics industry trends and futures, Section 3 looks at a range of statistical sources to paint a picture of the electronics manufacturing industry in Victoria, Section 4 reports findings from the survey of the Victorian Electronics Cluster undertaken for this study, and Section 5 explores capabilities and emerging opportunities. Readers wishing to focus on the Victorian survey and conclusions may wish to skip to Section 4.

1.1 The electronics industry in Australia

This section presents a brief overview of the electronics industry in Australia. It provides a backdrop to the subsequent description and analysis of the electronics industry cluster in Victoria.

1.1.1 Australia's electronics industry employment and production

In 2000-01, the electronics manufacturing industry employed 34,745 people in Australia, realised turnover of $8.9 billion and contributed more than $2.5 billion to gross domestic product (GDP).[12] Electronics accounted for 3.7% of all manufacturing employment and 3.5% of

[12] Following the Electronics Industry Action Agenda, the electronics manufacturing industry is defined as including ANZSICs: 2813 Automotive Electrical and Instrument Manufacturing; 2839 Professional and Scientific Equipment Manufacturing; 2841 Computer and Business Machine Manufacturing;

manufacturing turnover and value added (Table 1.1). Over the period 1996-97 to 2000-01, employment in the industry grew by just 0.3% per annum, although wages and salaries increased by 6.5% per annum. Industry turnover increased by 2.0% per annum over the period, but value added declined by 1.4% per annum.

As at the end of June 2001, telecommunications, broadcasting and transceiving equipment manufacturing and electronic equipment manufacturing not elsewhere classified each accounted for around 25% of total employment – employing 9,114 and 8,928 people, respectively. Automotive electrical and instrument manufacturing employed 5,058 (15%), professional & scientific equipment manufacturing 4,548 (13%), computer and business equipment manufacturing 4,091 (12%) and electric cable and wire manufacturing 2,979 (9%) (Figure 1.1).

Table 1.1 The electronics industry in Australia, 1996-97 to 2000-01

	Employed	Wages & Salaries	Income	Value Added	Income per Person	Value Added per Person
	No.	$m	$m	$m	$'000	$'000
2000-01						
Auto electrical & instrument	5,085	248	1,612	357	317	70
Profession & scientific equipment	4,548	202	836	346	184	76
Computer and business equipment	4,091	166	1,245	230	304	56
Telecom, broadcasting & transceiving equipment	9,114	579	2,471	739	271	81
Other electronic equipment	8,928	368	1,603	589	180	66
Electric cable and wire	2,979	155	1,136	266	381	89
Total Electronics	*34,745*	*1,719*	*8,903*	*2,527*	*256*	*73*
All manufacturing	*945,882*	*38,746*	*251,759*	*71,946*	*266*	*76*
Electronics share of manufacturing (%)	*3.7%*	*4.4%*	*3.5%*	*3.5%*		
1996-97						
Auto electrical & instrument	5,225	189	924	271	177	52
Profession & scientific equipment	3,517	130	440	165	125	47
Computer and business equipment	3,059	124	1,402	260	458	85
Telecom, broadcasting & transceiving equipment	7,517	321	2,212	939	294	125
Other electronic equipment	10,553	380	1,870	678	177	64
Electric cable and wire	4,476	194	1,378	363	308	81
Total Electronics	*34,347*	*1,337*	*8,224*	*2,675*	*239*	*78*
All manufacturing	*945,298*	*32,634*	*208,348*	*63,790*	*220*	*68*
Electronics share manufacturing (%)	*3.6%*	*4.1%*	*3.9%*	*4.2%*		

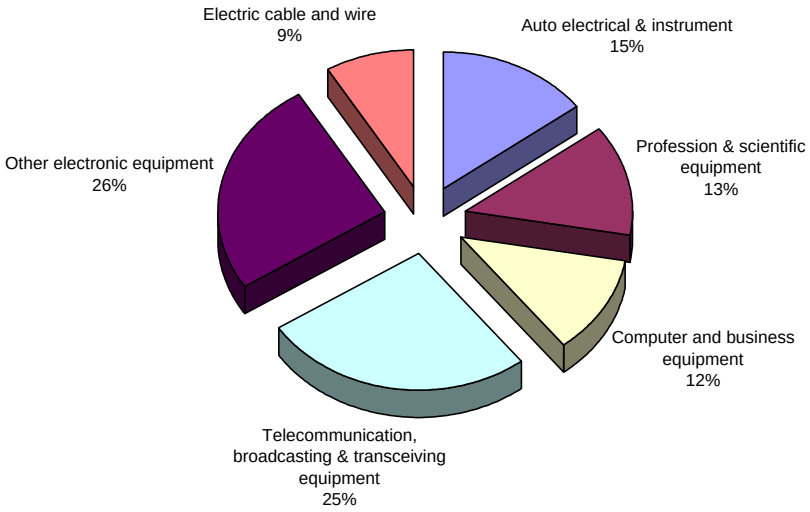
Note: All values are current prices.
Source: ABS (various years) *Manufacturing Industry: Australia*, Cat No 8221.0. CSES Analysis.

Since the mid 1990s there have been mixed employment trends among electronics industry sectors. Strong employment growth in computer and business equipment manufacturing (7.5%

2842 Telecommunications, Broadcasting and Transceiving Equipment Manufacturing; 2849 Electronic Equipment Manufacturing n.e.c; and 2852 Electric Cable and Wire Manufacturing.

pa), profession and scientific equipment manufacturing (6.6% pa) and telecommunication, broadcasting and transceiving equipment manufacturing (4.9% pa) has been balanced against falls in other areas – including an almost 10% per annum decline in employment in electric cable and wire manufacturing.

Figure 1.1 Employment in electronics manufacturing in Australia, 2000-01 (per cent share)



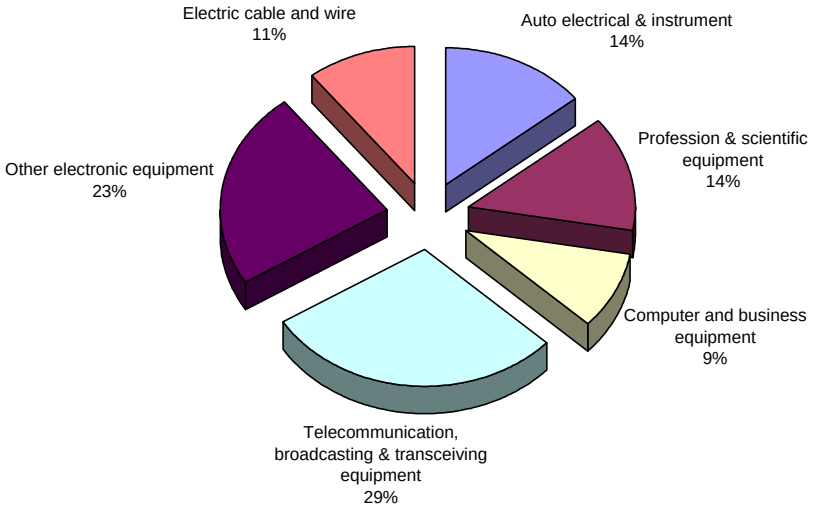
Source: ABS, CSES Analysis.

Total electronics manufacturing industry value added amounted to $2.53 billion during 2000-01, and accounted for 3.5% of total manufacturing industry value added in Australia. Telecommunications, broadcasting and transceiving equipment manufacturing accounted for 29% ($739 million), electronic equipment manufacturing not elsewhere classified accounted for 23% ($589 million), automotive electrical and instrument manufacturing and professional and scientific equipment manufacturing each accounted for around 14% ($350 million), electric cable and wire manufacturing accounted for 11% ($266 million) and computer and business equipment manufacturing accounted for 9% ($230 million) (Figure 1.2).

Over the period 1996-97 to 2000-01, electronics manufacturing industry value added declined by 1.4% per annum overall (in current prices). However, there were marked differences between sectors. Industry value added increased by 20.4% per annum in professional and scientific equipment manufacturing and 7.1% per annum in automotive electrical and instrument manufacturing, while declining 7.5% per annum in electric cable and wire manufacturing and 5.8% per annum in telecommunications, broadcasting and transceiving equipment manufacturing. Value added per person employed increased by 12.9% per annum in professional and scientific equipment manufacturing and by 7.8% per annum in automotive

electrical and instrument manufacturing, while declining 10.2% per annum in telecommunications, broadcasting and transceiving equipment manufacturing and by 9.8% per annum in computer and business equipment manufacturing.

Figure 1.2 Electronics manufacturing industry value added in Australia, 2000-01 (per cent share)



Source: ABS, CSES Analysis.

Australia accounts for around 0.3% of worldwide electronics production, with somewhat higher shares of telecommunication and radiocommunication, and control and instrument production. These higher shares of world production are reflected in overall equipment category shares and suggest local strengths in control and instrumentation equipment and communications equipment. Conversely, Australia's production of electronic components is lower than its overall average.

1.1.2 Australia's electronics equipment trade

Australia accounts for around 0.3% of world electronics exports and 1.4% of world imports. In 1997, exports of these categories of electronics equipment realised just less than USD 2 billion, while imports cost more than USD 8.8 billion, leaving a deficit on trade of almost USD 7 billion. In 1997, EDP equipment accounted for more than 50% of Australia's electronics exports and communication equipment accounted for more than 30% – compared with 37% and 14%, respectively, worldwide. Conversely, components accounted for 11% of Australia's electronics exports compared with 38% worldwide.

Looking in more detail at more recent data on trade in ICT and related equipment, we find that Australia achieved exports of $2.8 billion during 2002-03, with imports costing almost $16.6 billion leaving a deficit on trade of $13.8 billion (Table 1.2).[13] Re-exports (things brought into Australia and re-exported with little or no value added) account for a large and growing share of Australia's ICT related equipment exports – almost $1.6 billion or 56% of total equipment exports during 2002-03. Comparing locally produced exports and re-exports by category reveals

Table 1.2 ICT equipment trade 1992-93 to 2002-03 (AUD millions)

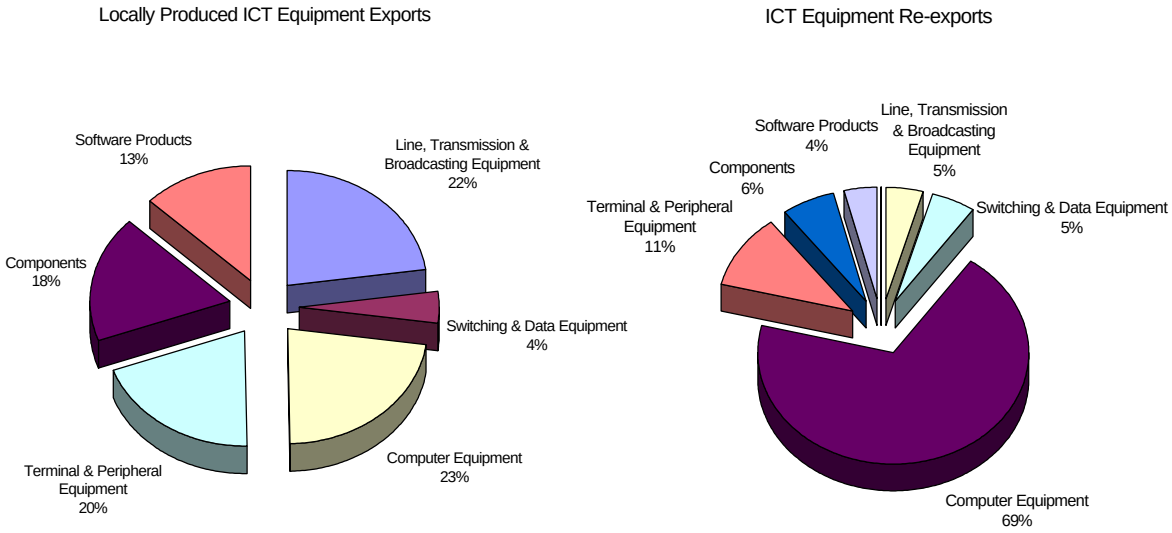
	1992-93	1994-95	1996-97	1998-99	2000-01	2002-03	CAGR
EXPORTS							
Line, Transmission & Broadcasting	184	268	474	289	560	353	6.8
Switching & Data	278	184	79	269	578	135	-7.0
Computer	810	1,357	1,471	1,281	1,360	1,357	5.3
Terminal & Peripheral	134	179	199	249	443	410	11.8
Components	120	158	140	206	294	320	10.3
Software Products	134	107	98	178	199	217	5.0
Total exports	*1,659*	*2,252*	*2,462*	*2,471*	*3,434*	*2,792*	*5.3*
Re-exports	*507*	*660*	*900*	*1,096*	*1,733*	*1,557*	*11.9*
Australian Exports	*1,152*	*1,591*	*1,562*	*1,375*	*1,701*	*1,236*	*0.7*
IMPORTS							
Line, Transmission & Broadcasting	486	1,136	1,302	1,880	3,377	2,581	18.2
Switching & Data	357	377	289	785	1,382	727	7.4
Computer	3,885	5,259	5,634	6,632	7,679	7,056	6.2
Terminal & Peripheral	1,743	2,247	2,228	2,490	3,471	3,897	8.4
Components	688	1,324	1,237	1,396	1,616	1,370	7.1
Software Products	735	894	786	1,120	967	985	3.0
Total imports	*7,893*	*11,236*	*11,476*	*14,304*	*18,492*	*16,617*	*7.7*
Re-imports	*3*	*9*	*23*	*30*	*23*	*52*	*32.2*
Foreign Imports	*7,890*	*11,227*	*11,453*	*14,274*	*18,469*	*16,564*	*7.7*
BALANCE OF TRADE							
Line, Transmission & Broadcasting	-303	-868	-828	-1,591	-2,817	-2,228	22.1
Switching & Data	-79	-194	-210	-516	-804	-592	22.3
Computer	-3,075	-3,901	-4,164	-5,352	-6,319	-5,699	6.4
Terminal & Peripheral	-1,608	-2,068	-2,028	-2,242	-3,028	-3,487	8.0
Components	-568	-1,166	-1,097	-1,191	-1,322	-1,050	6.3
Software Products	-601	-788	-688	-942	-768	-768	2.5
Total Balance on Trade	*-6,234*	*-8,984*	*-9,014*	*-11,833*	*-15,058*	*-13,824*	*8.3*
'Production Balance'	*-6,738*	*-9,636*	*-9,891*	*-12,899*	*-16,768*	*-15,329*	*8.6*

Notes: CAGR is Compund Annual Growth Rate. 'Production Balance' is the difference between domestically produced exports and foreign produced imports.
Source: TradeData (http://www.tradedata.net) and Houghton, J.W. (2003) *Australian ICT Trade Update 2003*, Australian Computer Society and Centre for Strategic Economic Studies, Sydney and Melbourne. Available http://www.cfses.com.

[13] For a detailed analysis of ICT related electronics equipment trade see Houghton, J.W. (2003) *Australian ICT Trade Update 2003*, Australian Computer Society and Centre for Strategic Economic Studies, Sydney and Melbourne. Available http://www.cfses.com/.

local production strengths and possible weaknesses. Computer equipment accounted for 23% of Australia's locally produced ICT equipment exports during 2002-03, but no less than 69% of re-exports (Figure 1.3).

Figure 1.3 ICT equipment export shares, 2002-03 (%)



Source: TradeData (http://www.tradedata.net) and Houghton, J.W. (2003) *Australian ICT Trade Update 2003*, Australian Computer Society and Centre for Strategic Economic Studies, Sydney and Melbourne, p8. Available http://www.cfses.com.

Over the decade since 1992-93, Australia's ICT equipment exports have grown 5.3% per annum. However, re-exports have grown much faster than have locally produced exports – at almost 12% per annum, compared with less than 1% per annum. Over the last five years, locally produced ICT equipment exports have declined 3.8% per annum, while re-exports increased by almost 10% per annum. Of locally produced equipment exports, terminal & peripheral equipment (12% per annum) and components (11.6% per annum) have been the fasted growing over the last decade – suggesting competitive strengths in these areas.[14] Locally produced components exports have held up better than terminal & peripheral equipment exports in recent years.

1.1.3 Australia's electronics supply chain

The supply of electronics manufactures in Australia amounted to $20 billion in 1996-97, with imports accounting for $13.2 billion of that total. Domestic production amounted to $6.94 billion (Table 1.3). Some $1.5 billion worth of electronics equipment were exported.

[14] Houghton, J.W. (2003) *Australian ICT Trade Update 2003*, Australian Computer Society and Centre for Strategic Economic Studies, Sydney and Melbourne, p7. Available http://www.cfses.com/.

The supply network

Australian electronics manufacturers consumed $4.3 billion in inputs during 1996-97, of which $2.54 billion were supplied domestically and $1.74 billion were imported. Non-transport machinery and equipment was the largest individual category of domestically produced input supplies, costing $415 million in 1996-97. Other significant inputs to electronics manufacturers included: property and business services $336 million, iron and steel $307 million, electricity, gas and water $178 million and fabricated metal products $138 million.

Table 1.3 Australia's electronics manufactures supply chain, 1996-97

	Suppliers & Supplies	**Electronics Manufacturers**	**Markets & Consumers**	
Domestic %	**Supply $4,324m**	**Electronics $20,108m**	**Consumption $20,108m**	*Imported %*
59	**Domestic Supply $2,536m**	**Domestic Production $6,939m**	**Intermediate (Business) Use $9,441m**	58
24	Other Machinery & Equip $415m		Construction $2,023m	29
83	Property & Business Svs $336m		Other Machinery & Equip $1,968m	73
100	Wholesale Trade $331m		Communication Svs $989m	58
84	Iron & Steel $307m		Property & Business Svs $903m	82
100	Electricity, Gas & Water $178m		Transport Equip $615m	56
91	Fabricated Metal Products $138m		Repairs $609m	49
92	Transport & Storage $120m		Transport & Storage $452m	67
67	Rubber & Plastic Products $118m		Cultural & Recreational Svs $317m	82
46	Transport Equipment $95m		Government & Defence $279m	76
95	Accom, Cafes & Restaurant $73m		Mining $193m	29
95	Communication Svs $71m		Health & Community Svs $163m	39
71	Chemicals $68m		Education $149m	91
81	Other $286m		Other $780m	55
	Imported Inputs $1,737m	**Imports $13,169m**	**Final Demand $10,666m**	*Imported %*
			Household Consumption $2,013m	83
			Private Capital Expd $6246m	83
			Government Capital Expd $1,000m	87
			Inventories $114m	
			Exports $1,521m	
			Re-exports $1,048m	

Source: ABS. Derived from DITR/DCITA (2003) *Electronics Industry Action Agenda*, Department of Industry, Tourism and Resources & Department of Communications, Information Technology and The Arts, Canberra, p19.

Consumption and vertical markets

Consumption of electronics manufactures by businesses (ie. as intermediate inputs) amounted to $9.4 billion during 1996-97. A further $7.25 billion was spent on electronics related capital equipment. Household consumption amounted to just over $2 billion and exports were worth $1.5 billion. Major vertical markets for electronics as intermediate inputs included: the construction industry at just over $2 billion, non-transport machinery and equipment $2 billion, communications $989 million, property and business services $903 million and transport equipment $615 million. Other significant vertical markets for intermediate electronics goods included: government and defence $279 million, mining $193 million, health services $163 million, and education $149 million.

1.2 The Electronic Industry Action Agenda

Establishing an appropriate definition of the electronics industry was crucial to the development of an Action Agenda.[15] The Strategic Industry Leaders Group that developed the Electronics Industry Action Agenda suggested the following definition:

> *…the group of companies which design, produce, service, install, and distribute products and systems made from electronic and photonic components and which may contain embedded or loaded software to provide an operational device or network. It also includes companies which provide services to support the production of electronic and photonic components (including microchips and optical fibre) and products*.[16]

The Action Agenda process focussed on analysing where Australia's electronics industry is today, and where its future opportunities lie. While Australia's electronics industry may not have benefited as much as it might have from the consumer electronics and ICT revolutions, it does have some research strengths and established competitive capabilities in areas such as medical and health, automotive, defence and gaming. The electronics industry is an important contributor to the Australian economy and has a well educated, innovative and flexible workforce.

Electronics is also a key enabler that underpins growth and innovation in virtually all industries. For example, it is estimated that 90% of all future innovation in the automobile industry will be driven by electronics, with electronics representing up to 40% of a vehicle's production cost by 2010. According to the Department of Defence, the value of electronics in defence related

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[15] This summary is taken from the Electronics Industry Action Agenda report: DITR/DCITA (2003) *Electronics Industry Action Agenda*, Department of Industry, Tourism and Resources & Department of Communications, Information Technology and The Arts, Canberra.

[16] DITR/DCITA (2003) *Electronics Industry Action Agenda*, Department of Industry, Tourism and Resources & Department of Communications, Information Technology and The Arts, Canberra, p13.

This definition aligns broadly, but not perfectly, with ANZSICs: 2813 Automotive Electrical and Instrument Manufacturing; 2839 Professional and Scientific Equipment Manufacturing; 2841 Computer and Business Machine Manufacturing; 2842 Telecommunications, Broadcasting and Transceiving Equipment Manufacturing; 2849 Electronic Equipment Manufacturing n.e.c; and 2852 Electric Cable and Wire Manufacturing.

activities is even higher, with electronics representing up to 80% of the production cost of a modern war ship or a submarine. The key message arising from the Electronics Action Agenda is that without a leading-edge electronics industry the ability of other Australian industries to build and sustain global competitiveness will be constrained.

The Electronics Industry Action Agenda found that the environment in which the sector is operating is no longer domestic but one that is global, and suggested that to ensure that the Australian electronics industry is able to competitively seize the opportunities afforded by a global market, it is important that the sector addresses issues relating to sustainable skills, commercialisation of R&D, industry development and investment.

The Electronics Industry Action Agenda Strategic Industry Leaders Group identified cluster development as a key area for focus, suggesting that:

> *A fundamental problem for the Australian electronics industry is its highly fragmented nature. At this point in time there are very few strategic alliances (outside technology/vertical groups) and the importance of certain industry sectors, such as sub-contractors, is not recognised within the industry, let alone to external parties. When considered separately, these small size industries are not viewed by key decision makers within Government and industry as a major contributor to Australia's wealth and a key employer… The Strategic Industry Leaders Group recognises that through increased industry collaboration, this issue can be strategically addressed.*
>
> *There are a number of tools that support increased industry collaboration. That which the Leaders Group believes would add the most value to the future sustainability and competitiveness of the industry, domestically and globally, is through a "cluster" study approach. Through cluster mapping, pools of expertise and technologies will be identified and from this information domestic industry value-added activity in electronics can be further encouraged and promoted in high-growth areas such as photonics, wireless and micro-electronics.*
>
> *Clusters positively affect both the ability of firms to attain operational effectiveness and their ability to choose distinctive, thematic and specialised (rather than imitative) strategic positions. For example, location in a strong technological district increases the productivity of resources invested in innovation activities and the likelihood of the introduction of technological innovations that actually increase total factor productivity. Furthermore, foreign investors in technology intensive industries like ICT realise this and prefer to invest where similar firms are located and where a strong research infrastructure exists.*[17]

With this in mind, the Strategic Industry Leaders Group recommended that industry, in association with State and Territory Government agencies, should undertake cluster mapping to identify existing capabilities and gaps in the innovation and supply chain, and from the information obtained by this mapping, strategies should be developed and implemented that aim to strengthen existing clusters and improve their global outlook.

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[17] DITR/DCITA (2003) *Electronics Industry Action Agenda*, Department of Industry, Tourism and Resources & Department of Communications, Information Technology and The Arts, Canberra, p54.

1.3 Cluster studies and cluster mapping

There has been an enormous range of work done under the rubric of cluster studies. Perhaps the most widely known are the 'Porter Studies' undertaken during the late 1980s and early 1990s, and reported in *The Competitive Advantage of Nations*.[18] However, these were by no means the first such studies. As early as the 1890s Alfred Marshall commented on the development of 'industrial districts',[19] and Schumpeter noted the importance of 'innovative clusters' in 1912.[20] However, it was probably the work of Erik Dahmen on 'development blocks',[21] and Perroux and later Hirschman on 'growth poles' that first fully developed the idea of clusters of economic development during the 1950s and 1960s.[22] The common take off point for these early works, as well as those constituting the Porter Studies, was the observation that economic development is unevenly distributed and often concentrated in particular locations.

Traditionally, economists had seen a region's comparative advantage as being based on natural resource endowments and the availability of relatively low-cost inputs and low-cost labour. Porter contended that regions must develop a competitive advantage based on the ability to continually innovate. For Porter, competitive advantage is based on four key elements:

- *Factor conditions* – such as a specialized labour pool, specialized infrastructure, and sometimes selective disadvantages that drive innovation;
- *Demand conditions* – local customers who push companies to innovate, and whose demands anticipate global or local demand;
- *Related and supporting industries* – nationally competitive local supplier industries that create business infrastructure and spur innovation and spin off industries; and
- *Firm strategy, structure and rivalry* – in the form of intense rivalry among local firms and a local ‘culture’ that influences individual firms’ attitudes toward innovation and competition (Figure 1.4).

In addition to these, the Porter diamond includes the roles of the government and chance. While it is recognised that historical accident and/or government action can play significant roles in the early development of industrial clusters, they are not seen by Porter as a crucial ingredients for their maintenance.[23]

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18 Porter, M.E. (1990) *The Competitive Advantage of Nations*, The Free Press, New York.

19 Marshall, A. (1890) *Principles of Economics*, Macmillan, London.

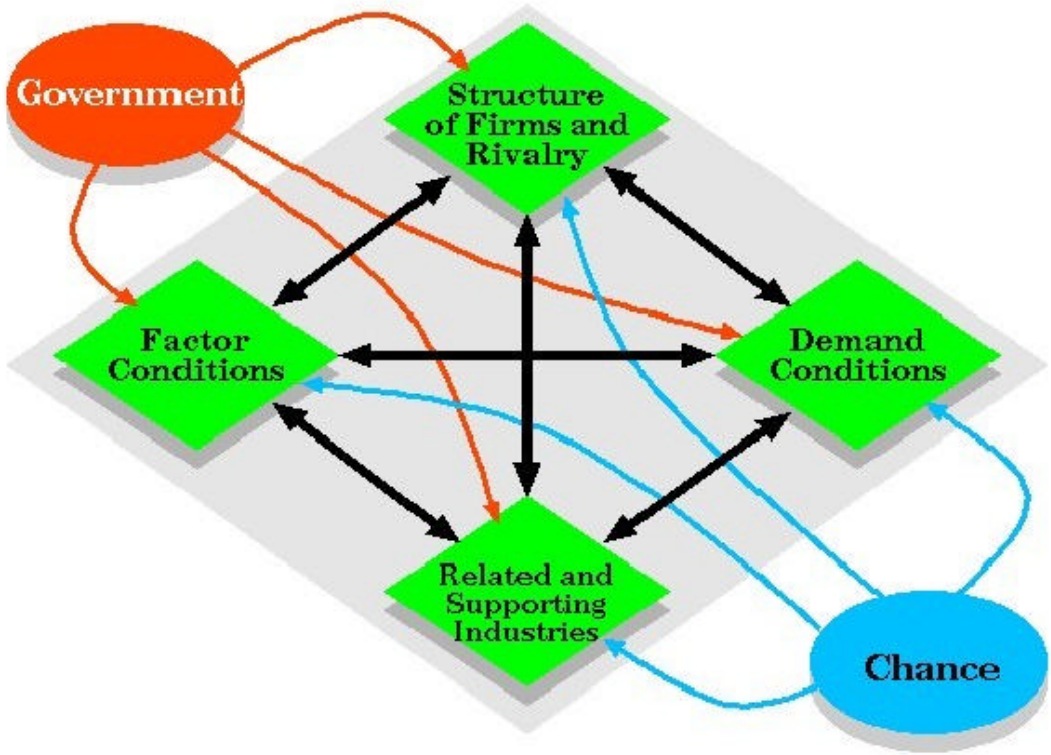
20 Noted by DeBresson, C. & Hu, X. (1999) 'Identifying Clusters and Innovative Activity: A New Approach and a Toolbox,' in OECD *Boosting Innovation: The Cluster Approach*, OECD, Paris.

21 Dahman, E. (1950) *Entrepreneurial Activity and the Development of Swedish Industry 1991-39*, American Economic Association Translation (1970), cited by DeBresson, C. & Hu, X. (1999) 'Identifying Clusters and Innovative Activity: A New Approach and a Toolbox,' in OECD *Boosting Innovation: The Cluster Approach*, OECD, Paris.

22 Noted by DeBresson, C. & Hu, X. (1999) 'Identifying Clusters and Innovative Activity: A New Approach and a Toolbox,' in OECD *Boosting Innovation: The Cluster Approach*, OECD, Paris; and elsewhere.

23 Porter, M.E. (1990) *The Competitive Advantage of Nations*, The Free Press, New York.

Figure 1.4 Porter's Diamond



Source: Porter, M.E. (1990) *The Competitive Advantage of Nations*, Free Press, New York, p72. Adapted by Werner Antweiler, University of British Columbia. (See http://pacific.commerce.ubc.ca/antweiler/).

Subsequent work on cluster development at the national level has been brought into focus by the Organisation for Economic Cooperation and Development (OECD), which under the auspices of the National Systems of Innovation Project established a focus group on Cluster Analysis and Cluster-based Policy (CACP).[24] One important point of difference is that whereas Porter's primary focus was *competitiveness*, that of the OECD group was *innovation*.

In the United Kingdom, the Department of Trade and Industry (DTI) has established several industry clusters aimed at improving the country's industrial competitiveness. According to DTI, cluster programmes are running in more than 30 countries and have been particularly successful in Poland, Colombia, Northern Ireland, New Zealand and several states in the United States. The DTI says experience shows that the most successful clusters involve the active participation of senior government, business and labour leaders in a partnership approach to sustainable development.[25] DTI efforts towards fostering cluster development in the UK have led to the

[24] See, for example, the papers collected in OECD (1999) *Boosting Innovation: The Cluster Approach*, OECD, Paris.

[25] Department of Trade and Industry (1999) *Industry's Clusters Get Their Act Together*, DTI, London. See http://www.dti.gov.uk/clusters/ accessed April 2004.

production of *A Practical Guide to Cluster Development*,[26] which draws on the lessons learned to date.

A number of US States have employed cluster-based policy approaches, including, for example: Minnesota,[27] Arizona,[28] Massachusetts,[29] Oregon,[30] California,[31] and Connecticut.[32] It has been estimated that there are 380 clusters in the United States, and that they employ 57% of the workforce and account for more than 60% of domestic output.[33] The European Commission (2002) identified more than 800 local, regional and national clusters in European member states, although methodological and definitional differences between country studies made a total count difficult.[34] For its part, the EU's Expert Group on Enterprise Clusters and Networks identified 84 clusters, of which 51 were in EU member states, 29 in candidate countries and 4 in Norway and Iceland.[35] Regional development agencies around the world are using cluster-based approaches to regional development. One leading example is that of the Scottish Enterprise Development Agency (Scottish Enterprise), where extensive and explicit use has been made of the Porter Diamond approach in the development and implementation of regional development strategies for a number of industry clusters.[36]

According to the OECD, clusters can be characterised as networks of production involving interdependent firms (including specialised suppliers), knowledge producing agents (universities, research institutes, engineering companies, etc.), bridging institutions (brokers,

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[26] Ecotec (2003) *A Practical Guide to Cluster Development*, A Report to the Department of Trade and Industry and the English RDAs by Ecotec Research & Consulting, DTI, London. Available http://www.dti.gov.uk/clusters/publications.htm accessed April 2004.

[27] See The Humphrey Institute (1999) *Industry Clusters: An Economic Development Strategy for Minnesota, Preliminary Report,* University of Minnesota; and a range of regional cluster studies in Minnesota.

[28] Where SRI developed a strategic framework for the State based on cluster analysis, see Arizona Strategic Planning for Economic Development (ASPED) (1992) *Creating a 21st Century Economy: Arizona's Strategic Plan for Economic Development.*

[29] Where Porter assisted in the development of the State's strategy, see The Commonwealth of Massachusetts (1993) *Choosing to Compete: A Statewide Strategy for Job Creation and Economic Growth*.

[30] Where the State's strategy is outlined in *Oregon Shines*. See Oregon Economic Development Department (1994) *Key Industries in Oregon*.

[31] See, for example, The California Economic Strategy Panel (1996) *Collaborating to Compete in the New Economy*. Available http://www.ca.gov/commerce.

[32] See, for example, the Governor's Council on Economic Competitiveness and Technology (1999) *Industry Cluster Progress Report*.

[33] Enright, M.J. and Ffowcs-Williams, I. (2000) Local Partnership, Clusters and SME Globalisation, paper presented at the OECD Conference *Enhancing the Competitiveness of SMEs in the Global Economy: Strategies and Policies*, OECD Paris, p9.

[34] European Commission (2002) *Regional clusters in Europe*, Observatory of European SMEs, 2002(3), Brussels, pp24-25.

[35] European Commission (2002) *Final Report of the Expert Group on Enterprise Clusters and Networks*, Brussels, p20.

[36] See, for example, Botham, R. (1998) 'Cluster Strategies and Regional Development: Some Experience form Scotland', paper presented at Innovation and Knowledge-based Economies Conference, Sydney, November 1998. See http://www.scottish-enterprise.com/.

consultants, etc.) and customers, linked to each other in a value adding production system.[37] Rosenfield defined a business cluster as: a geographically bounded concentration of similar, related or complementary businesses, with active channels for business transactions, communication and dialogue, that share specialised infrastructure, labour markets and services, and that are faced with common opportunities and threats.[38]

Industry clusters are geographic concentrations of competing, complementary, or interdependent firms and industries that do business with each other and/or have common needs for talent, technology, and infrastructure. The firms included in the cluster may be both competitive and cooperative. They may compete directly with some members of the cluster, purchase inputs from other cluster members, and rely on the services of other cluster firms in the operation of their business. An important characteristic of clusters is that they are centred on firms that sell outside the local, state, or even national market. Such exporting firms are driving forces in a regional or State economy. They bring money into the area and support local industries.[39]

1.3.1 Why there is a growing interest in clusters?

The increased attention to cluster analysis can be linked to recent economic developments, including the major transformational forces of globalisation and increased knowledge intensity. Porter noted that:

> *In a global economy – which boasts rapid transportation, high–speed communication, and accessible markets – one would expect location to diminish in importance. But the opposite is true. The enduring competitive advantages in a global economy are often heavily local, arising from concentrations of highly specialized skills and knowledge, institutions, rivals, related businesses, and sophisticated customers. Geographic, cultural, and institutional proximity leads to special access, closer relationships, better information, powerful incentives, and other advantages in productivity and innovation that are difficult to tap from a distance. The more the world economy becomes complex, knowledge based, and dynamic, the more this is true.*[40]

In a knowledge economy, few firms can alone command the range and depth of competencies necessary to continuously innovate. As a result, they are becoming increasingly dependent on alliances with other firms and research institutions with complementary technology and knowledge assets. Hence, leading firms are increasingly involved in a network of relationships,

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[37] Definition derived from Roelandt, T. & den Hertog, P. (1998) 'Cluster analysis and Cluster-based Policy in OECD Countries,' OECD Workshop, Vienna, May 1998. See also OECD (1999) *Boosting Innovation: The Cluster Approach*, OECD, Paris.

[38] Rosenfield, S. (1995) *Overachievers: Business Clusters that Work*, Regional Technology Strategies Inc.

[39] The Humphrey Institute (1999) *Industry Clusters: An Economic Development Strategy for Minnesota, Preliminary Report*, University of Minnesota.

[40] Porter, M.E. (1998) 'Clusters and the New Economics of Competition,' *Harvard Business Review*, November-December 1998, pp77-90.

which Dunning has referred to as 'alliance capitalism'.[41] At the same time, the increasing complexity of products and the increasing drive to offer differentiated, service-enhanced products is forcing firms to integrate supply chains and changing the nature of competition in such a way as to encourage greater cooperation and collaboration. There is, in short, mounting pressure for firms to link into increasingly complex value chains or production systems and cooperate locally in order to compete globally.

1.3.2 What are the major insights from cluster studies?

Cluster analysis emphasises the dynamic interdependencies between firms or groups of firms in different industrial sectors.[42] In so doing it overcomes problems associated with, and bridges the gap between, macro studies of the economy made up of sectors and industries, on the one hand, and micro studies of firms in isolation, on the other; and provides a meso level for analysis.

The Porter and related studies have shown that, at the national level, competitive advantage is brought about by the number and size of competitive firms a nation has. Inherited endowments and factor conditions are of secondary importance in sustaining competitive strength. National prosperity has to be continuously created by developing more advanced factors of production. Thus natural resources, an unskilled labour force, and low interest or exchange rates do not have long-lasting effects on national competitiveness. In the long run, the competitiveness of a country depends on the capacity of its industry to innovate and upgrade.[43]

Cluster studies suggest that the role of government is to promote competition *and* create advanced factors of production. There is also a role as facilitator of cluster linkages and cooperative relations. As Porter pointed out:

> *While classical factors of production are more and more accessible because of globalisation, competitive advantage in advanced industries is increasingly determined by differential knowledge, skills and rates of innovation which are embodied in skilled people and organisational routines. The process of creating skills and the important influence on the rate of improvement and innovation are intensely local. Paradoxically, then, more open global competition makes the home base more, not less important.*[44]

Hence, despite globalisation, there is a increasing role for governments at the national, state and local levels.

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41 See, for example, Roelandt, T.J.A., den Hertog, P. & van Sinderen, J. (1999) 'Cluster Analysis and Cluster Policy in the Netherlands,' in OECD *Boosting Innovation: The Cluster Approach*, OECD, Paris.

42 Stenberg, L. & Strandell, A-C. (1999) 'An Overview of Cluster-related studies and policies in Sweden,' OECD Workshop, Amsterdam, October 1997.

43 Rouvinen, P. & Yla-Anttila, P. (1997) *A Few Notes on Finnish Cluster Studies*, ETLA (The Research Institute of the Finnish Economy).

44 Porter, M.E. (1990) *The Competitive Advantage of Nations*, The Free Press, New York, p58.

For its part, The Victorian Government has recently suggested that:

> *A cluster approach to economic development is well-suited to driving innovation and internationalisation – the key elements of long term competitiveness for nations and firms. Analysing, defining, accessing and using knowledge is critical to competitiveness. Clusters are a vehicle for harnessing and diffusing knowledge. By encouraging collaborative activities and networking, clusters multiply the availability of knowledge and provide firms with greater opportunities to access and use knowledge based solutions for their business operations*.[45]

It was also noted that clusters facilitate the process of internationalisation, enabling SMEs to specialise or achieve economies of scale through collaborating with other firms, and by providing a focal point for attracting and retaining foreign investment.

1.3.3 Approaches to identifying and mapping clusters

There has been a multitude of definitions and approaches to cluster studies. Nevertheless, according to Jacobs and de Man (1996) three broad definitions of clusters can be distinguished:

- *Regionally concentrated forms of economic activity* within related sectors, usually connected to the knowledge infrastructure (eg. research institutes, universities, etc.);
- *Vertical production chains*, rather narrowly defined sectors in which adjacent stages in the production process form the core of clusters (eg. the chain of supplier–assembler–distributor–customer), or networks surrounding core firms; and
- *Industrial sectors* defined at a high level of aggregation (eg. the chemical cluster), or collections of industrial sectors at an even higher level of aggregation (eg. the agri-food cluster).[46]

Regional clusters are the main focus for regional policy-makers and have been very widely discussed, with perhaps the best known example being Silicon Valley.[47] Analysts often focus on core factors underlying the regional clustering, be it natural resources (eg. the Rhur), knowledge infrastructure (eg. Stanford University), location (eg. Hong Kong port), or a central firm (eg. Nokia in Finland or Philips in the Netherlands). Value chains have also been a popular focus of cluster studies, in the form of chains of production, value systems and (complex) product systems.[48]

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[45] Ammirato, P., Kulkarni, A. and Latina, D. (2003) *Clusters: Victorian businesses working together in a global economy*, Department of Innovation, Industry and Regional Development, Melbourne, p7.

[46] Jacobs, D. & de Man, A-P. (1996) 'Clusters, Industrial Policy and Firm Strategy: A Menu Approach,' *Technology Analysis and Strategic Management, 8(4)*, 1996, pp425-437.

[47] See, for example, Saxenian, A. (1994) *Regional Advantage: Culture and Competition in Silicon Valley and Route 128*, Harvard University Press.

[48] See, for example, Piore, M.J. & Sabel, C.F. *The Second Industrial Divide: Possibilities for Prosperity*, Basic Books, New York; Porter, M.E. (1985) *Competitive Advantage*, The Free Press, New York; Kaplinsky, R. and Morris, M. (2003) A *Handbook For Value Chain Research*, Institute for Development Studies, Sussex University; and Houghton, J.W. Pappas, N. & Sheehan, P.J. (1999)

Within all these approaches there are a range of cross cutting dimensions. One basic distinction is that between those studies using clusters in a statistical sense (ie. a grouping of entities according to some specific characteristic) and those intending to imply actual relationships between the objects (ie. networks, alliances, etc.). When clustering is studied it can be in terms of any number of characteristics (eg. location, activity or product field, firm strategy, behaviour, innovative or competitive performance, size, technology or science base) and involve a range of methodological approaches (eg. factor analysis, cluster analysis, multi-dimensional scaling, etc.). When network relationships are studies it is typically in terms of linkages of various sorts (eg. value chain, supply chain, product system, user–producer relations, supplier–producer relations, innovation linkages, information and/or knowledge flows) and typically involves more qualitative methods (eg. case studies).[49] Cross cutting, or overlaying this basic distinction is that between studies having a geographic dimension and those without. Spielkamp and Vopel (1999) described this distinction as that between 'milieux or districts' and 'clusters, chains or networks', respectively.[50]

1.3.4 The Product System approach

The product system approach was pioneered by the United Kingdom's Complex Product Systems Innovation Centre.[51] It is a technique that focuses on linkages between all the actors in a complex system that affects the transformation of activities and materials into goods and services through the processes of creation, production and distribution. Its genesis was in analyses of the building and construction industry, in which innovation (learning) is especially difficult because of the one-off nature of construction projects, with different constructions being produced in different locations, with different teams of architects, engineers, building and construction firms, project managers and trades people in each case. One reason for wider adoption of the complex product system framework is that building and construction is an example of what is becoming an increasingly common phenomenon. Namely, the complexity of putting together a wide range of products and services, and integrating them into a solution for a client on a customised or project basis. New manufacturing in high-technology industries such as electronics, with flexible customisation and increasing systems complexity confronts many of the same problems.[52]

'New Manufacturing: One Approach to the Knowledge Economy', CSES Working Paper 12, Victoria University; etc.

49 Vock, P. (1997) 'Swiss Position Paper on Mapping Innovative Clusters,' OECD Workshop, Amsterdam, October 1997.

50 Spielkamp, A. & Vopel, K. (1999) 'Mapping Innovative Clusters in National Innovation Systems,' in OECD *Boosting Innovation: The Cluster Approach*, OECD, Paris.

51 See Hobday, M., Rush, H. and Tidd, J. (2000) 'Innovation in complex products and system', *Research Policy* 29(2000), pp793-804 and related papers in that special issue of *Research Policy* for an overview and introduction.

52 See, for example, Houghton, J.W., Pappas, N. and Sheehan, P. (1999) 'New Manufacturing: One Approach to the Knowledge Economy,' CSES Working Paper 12, Victoria University, Melbourne. Available http://www.cfses.com/workpaps.htm accessed April 2004.

Hobday, Rush and Tidd (2000) suggested that: because each new product tends to be different, and because development and production involves feedback loops from later to early stages and other unpredictable, 'emerging' properties, innovative organisational structures are required to coordinate production, particularly where there are uncertain and changing user requirements and technological possibilities. There is often high production and innovation complexity, not only because a wide variety of distinct components, skills and knowledge inputs are involved, but also because large numbers of firms or different organizations often have to work together in production (eg. prime contractors and systems integrators, users, buyers, other suppliers, small and medium sized enterprises, government agencies and regulators). In such systems, there tends to be two phases and forms of innovation. First, the development of a new systems architecture prior to the commercialisation of the product. In this phase, architectural designs are powerfully influenced by system suppliers, regulators, standard-making bodies and large users. Second, the phase of new product generation, where the rate of component and systemic innovation increases and successive new products and components are introduced, without fundamentally altering the established architectural design.[53] Such a characterisation fits the electronics industry.

A schematic electronics product system might include five major elements (Figure 1.5).

- At the centre are the *electronics firms* engaged in the development and production of technology-based solutions;
- The *supply network* includes all the providers of specialist machinery and equipment, materials and components, contract design and manufacturing and business services to electronics producers; and
- The *distribution network* includes all the clients of electronics firms.

These three groups form the core value chain. Their activities are supported by a collective support infrastructure, and operate within an overarching regulatory framework.

- The *collective support infrastructure* includes R&D centres, education and training institutions, professional associations, specialist consulting firms, venture capital providers, facilitators, specialist infrastructure (eg. testbeds), etc.; and
- The *regulatory framework* includes a range of industry and professional accreditation, technical standards, quality standards, conformance, intellectual property, licensing, environmental regulation, etc.

Together, these elements, and the linkages between them, form the system in which electronics-based technology solutions are created, produced and delivered to market. This framework was adopted in the Electronics Industry Action Agenda and is being used as the basis for state-based mapping.[54]

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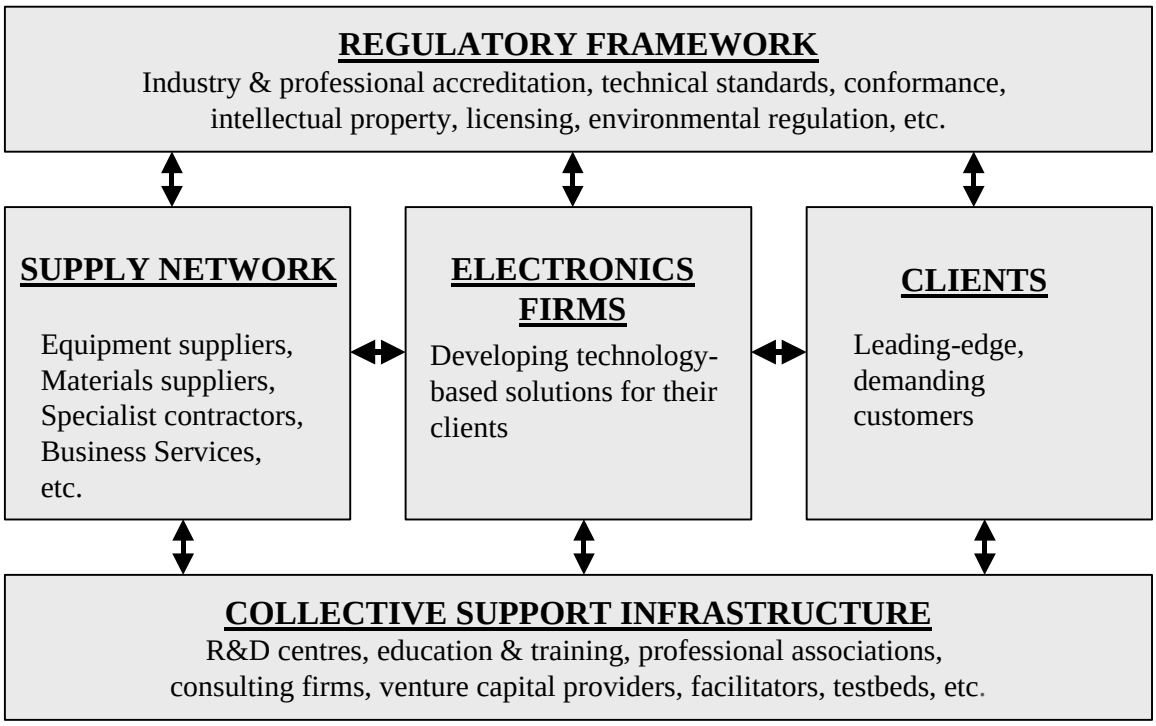
53 Hobday, M., Rush, H. and Tidd, J. (2000) 'Innovation in complex products and system', *Research Policy* 29(2000) pp793-804.

54 DITR/DCITA (2003) *Electronics Industry Action Agenda*, Department of Industry, Tourism and Resources & Department of Communications, Information Technology and The Arts, Canberra, p56.

Figure 1.5 A Schematic Electronics Product System



Source: Centre for Strategic Economic Studies.

1.4 The Victorian electronics industry cluster study

The aim of this study of the Victorian Electronics Industry Cluster is to generate a better understanding of capabilities within the industry, and identify emerging opportunities and markets. The study is a part of the Victorian Government's contribution to the national electronics industry cluster mapping program.

Clusters can be:

- *Technology based*: grouping around a product *or* process technology (eg. photonics, etc.);*Customer based*: grouping around leading edge users and/or major vertical markets (eg. automotive, medical instruments, instrumentation, etc.);
- *Product or solution based*: grouping to produce an end product, service or solution (eg. security, smartcards, wireless, etc.);
- *Needs based*: grouping to work cooperatively to overcome problems (eg. market access, supply/contract manufacturing); and/or*Resource based*: grouping around supply of skills, materials, funding, etc. (eg. underlying pre-competitive R&D).

See also Thorburn, L. (2003) *Capitalising on the Strengths of the ACT Electronics Industry*, Advance Consulting & Evaluation, Canberra.

Cluster mapping identifies key players in an industry, their suppliers, customers, clients and markets. It also identifies key elements of the collective support infrastructure (eg. research centres, education and training institutions) and regulatory framework within which they operate (eg. standards and product stewardship). Having done so it then maps the linkages between these organizations. The aim of cluster mapping is to identify and analyse core capabilities, key value chain and product system linkages, and highlight key opportunities.

The approach adopted for this study has been to combine quantitative and qualitative methods based on: a questionnaire survey of electronics products, systems and services providers in Victoria which sought the data necessary to define the cluster statistically; and in-depth interviews with key players to provide insights on the cluster's capabilities.

This study seeks to:

- *Identify leading players*: customers, electronics firms and suppliers (as well regulatory framework and collective infrastructure elements);
- *Identify leading technologies and products*: noting the sub-set of players in each case;
- *Identify leading locations*: where there are groups of electronics firms, why they are there and what they produce;
- *Trace major linkages*: intrastate, interstate and international;
- *Undertake a 'SWOT' styles analysis*: to provide a basis for understanding the cluster's strengths, weaknesses, opportunities and threats;
- *Identify emerging opportunities and markets*: which may be technology-based, customer-based or product-based (see above); and
- *Identify and analyse any gaps*: to shed light on what might be needed to fill gaps and enable the cluster to exploit emerging opportunities and markets.

This study has been designed with a specific objective of identifying one or two major project opportunities that offer the potential for seeding major new industry development opportunities. It is envisaged that the opportunities identified will be tested in cluster workshops convened by AEEMA.

2 Industry trends and futures

This section looks briefly at world market trends and the evolution of electronics production worldwide, in order to explore potential industry opportunities and threats. It provides the foundation for later analysis.

The electronics business climate is being shaped by many factors. These include:

- Market trends and growth, with a return to growth in ICTs and renewed growth in automotive and consumer electronics;
- The fragmentation of the value chain, with modularisation supporting increased outsourcing and specialisation along the value chain;
- The need to rapidly develop new business models to support increased firm and regional specialisation;
- The drive to make better used of internet-based technologies and e-business techniques to support supply chain management, participation and integration;
- Environmental and regulatory demands for the removal of 'materials of concern' (eg. lead, bromine, etc.) and increased whole-of-life 'product stewardship'; and
- The emergence and cross-fertilisation of new, converging technologies (eg. nanotechnology, micro-electronics and photonics).

2.1 Worldwide electronics production and markets

Worldwide production of electronics grew 5.5% per annum over the decade 1990 to 2000. Components and communications were the fastest growing categories, with production increasing between 6% and 8% per annum over the period. During 2000-01 electronics production was severely affected by the 'dot com' crash and world downturn. ICTs and related components were the most affected.[55]

While sharp, the downturn appears to have been relatively short lived with a return to growth during 2002-03 and forecasts of stronger growth going forward. From a low of USD 1.2 billion during 2001, worldwide electronics markets reached USD 1.34 billion during 2003 and are forecast to reach more than USD 1.5 billion during 2005 (Figure 2.1). Hence, the worldwide electronics market appears to be returning to its 'normal' 5% to 7% per annum growth, and is forecast to continue to expand at a faster rate than the world economy as a whole,[56] suggesting a return of global market opportunities for electronics producers.

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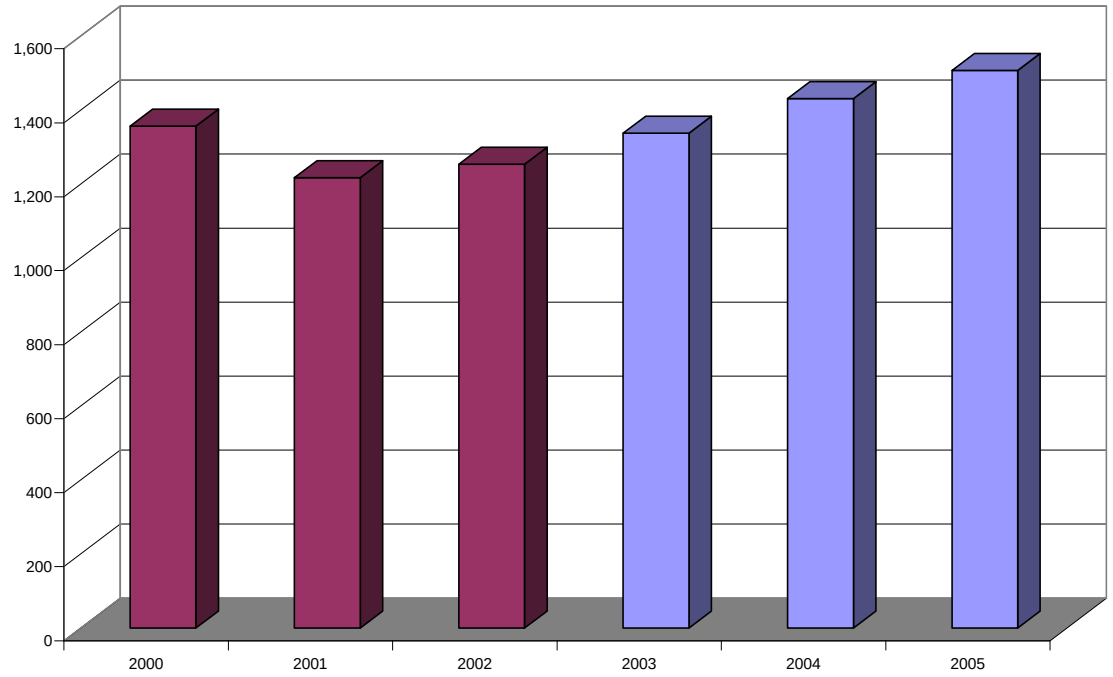
55 OECD (2004) *Information Technology Outlook 2004*, OECD, Paris.

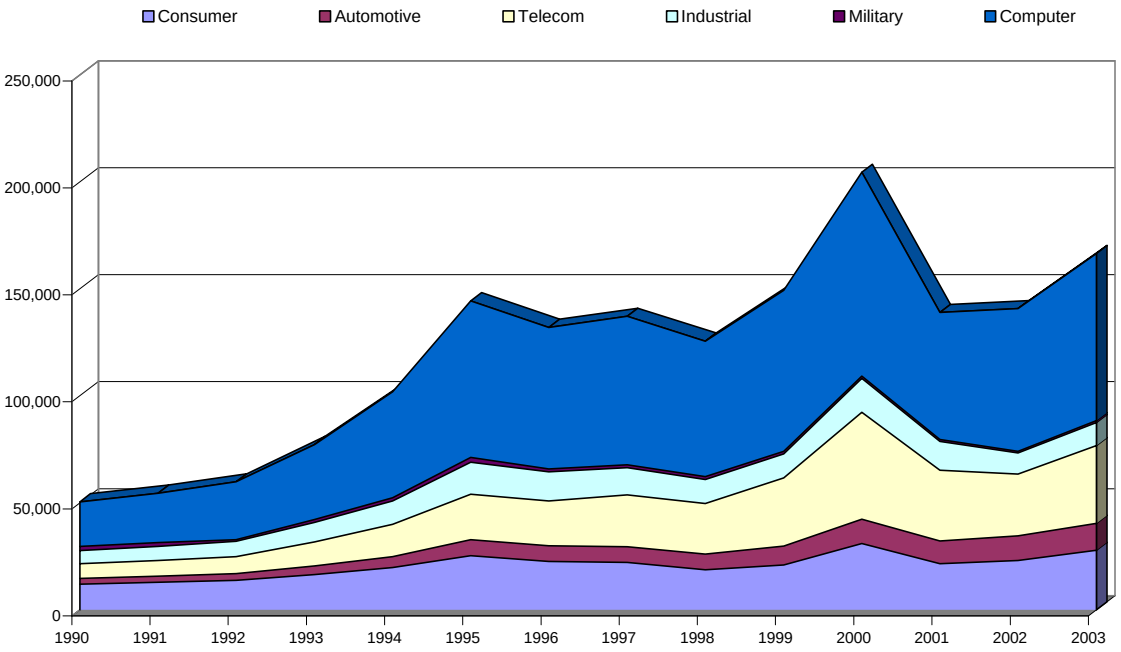
56 Reed Electronics Research (2004) *Yearbook of World Electronics Data: Volumn 1, 2004*. Available http://www.instat.com/catalog/ accessed April 2004.

Figure 2.1 World electronics markets, 2000 to 2005 (USDm current)



Source: Reed Electronics Group (2003) *Electronics Market Outlook Presentation*.

Figure 2.2 Worldwide semiconductor market by segment, 1990 to 2003 (USD millions)



Source: World Semiconductor Trade Statistics. OECD (2004) *Information Technology Outlook 2004*, OECD, Paris.

As a key input, semiconductors are a lead indicator of market trends, hit hard in a downturn and recovering early when there is an upturn. Between 1990 and 2000 the world market for semiconductors grew from USD 50 billion to more than USD 200 billion, or by 15% per annum (Figure 2.2). During the boom year of 2000 alone, worldwide semiconductor sales increased by 37%. However, 2001 brought a dramatic collapse, with sales down 32% to less than USD 140 billion. Since then there has been a rebound, with worldwide sales increasing 1.3% during 2002 and by 18.3% during 2003 to USD 166 billion. A strong return to growth in semiconductor markets in telecommunications, military and consumer applications was forecast for 2003, with annual growth in excess of 20% for all segments. All end markets except industrial were forecast to enjoy double digit growth.

The world market for non-entertainment automotive electronics, excluding sensors and commercial vehicles, was estimated at USD 26.9 billion in 2002 and forecast to reach USD 35.4 billion by 2007. Growth is forecast across all product segments and regions with the strongest demand coming from the emerging markets in Asia and East and Central Europe. Legislation, driven by environmental and safety issues and customer demand will continue to push the market, despite a slowdown in passenger car production in North America and Western Europe. The migration of electronics into the volume segments of the market will also be a driver for automotive electronics, although growth in value terms may be offset by pricing pressures.[57]

Table 2.1 World production by sectors, 2002-2007 (EUR billions and per cent growth)

Total World	2002	2007	2002-03	2003-04	2002-07
Consumer electronics	204.6	271.0	4.5%	6.3%	5.8%
Computers	370.6	492.9	7.1%	6.3%	5.9%
Telecommunications	195.4	267.2	1.4%	8.5%	6.5%
Avionics, Space, Defence	89.3	109.4	-0.9%	3.7%	4.2%
Automotive	93.4	154.5	9.9%	12.2%	10.6%
Energy, Industry and Services	188.2	246.3	1.6%	5.0%	5.5%
TOTAL	1,141.4	1,541.3	4.4%	6.8%	6.2%

Source: Electronics.ca (2003) *World Electronics Industry 2002-2007*, Research Report #DE3120. Available http://www.electronics.ca/reports/industrial/electronics_industry.html

Despite the recent downturn, long term trends reflect continued growth and opportunity in global markets for electronics producers. Electronics.ca conclude that growth in the electronics industry will be back in 2003 after the world electronics industry went through its worst crisis ever during 2001-02. Growth in 2003 will remain at 4%, but will be over 6% annually over 2002 to 2007 period. This is slower than the past long-term trend due to a combination of persistently slow market and production growth in developed countries (eg. Europe, the United

[57] Reed Electronics Research (2004) *Automotive Electronics: A profile of international markets and suppliers to 2007*. Available http://www.instat.com/catalog/ accessed April 2004.

States, Japan, Korea, etc.). However, there is strong growth in developing countries, particularly in China.[58]

The major product growth areas identified by Electronics.ca included:

- *Automotive electronics* – because increased comfort, engine efficiency and safety entail increasing the electronic content in cars;
- *Consumer electronics* – with the replacement of CRTs (cathode ray tube displays) by flat screens, first for PC monitors, but more progressively also for TVs, and with new consumer products such as DVD writers, sophisticated set-top boxes, digital TVs, home cinema sound packages, digital cameras and game consoles revitalising the consumer electronics sector; and
- *Power electronics* – reflecting progress in power technologies and new applications (eg. mobile and automotive).[59]

2.2 Electronics industry evolution

Electronics industry sub-sectors vary in structure and dynamics. Whereas original equipment manufacturers (OEMs) can be highly vertically integrated, keeping large parts of the production and value creation process in-house, much of the electronics industry is characterised by high degrees of specialisation along the value chain, with the modular nature of electronic products supporting high levels of specialisation and outsourcing.[60]

Increasingly, this fragmentation of the value chain is happening globally, with the formation of highly specialised production clusters participating in global production systems (eg. hard-disks in Singapore, LCD's in Taiwan, etc.). At the same time there are cross-cutting underlying trends, with labour-intensive, volume manufacturing shifting to Contract Equipment Manufacturers (CEMs) in Asia, while Europe and the United States retain the high-end, knowledge intensive stages of the value chain, such as product development and R&D.[61] However, high unit volume products evolve quickly from small scale manufacturing near design centres of gravity, to large scale manufacturing near market centres of gravity and finally to large scale manufacturing near low cost labour centres of gravity.[62] Unable to compete with

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58 Electronics.ca (2003) *World Electronics Industry 2002-2007*, Research Report # DE3120. Available http://www.electronics.ca/reports/industrial/electronics_industry.html

59 Electronics.ca (2003) *World Electronics Industry 2002-2007*, Research Report # DE3120. Available http://www.electronics.ca/reports/industrial/electronics_industry.html

60 E-business Watch (2003) *ICT and e-business in the Electrical Machinery and Electronics Sector*, European Commission, Sector Report 11/II, p13. Available http://www.ebusiness-watch.org/marketwatch/ accessed April 2004.

61 E-business Watch (2003) *ICT and e-business in the Electrical Machinery and Electronics Sector*, European Commission, Sector Report 11/II, p14. Available http://www.ebusiness-watch.org/marketwatch/ accessed April 2004.

62 NEMI (2003) *Technology Roadmaps: December 2003*, NEMI, p11. Available http://www.nemi.org/

Asia on labour costs and remote from major markets, Australia's electronics industry must seek to maintain a position as a design and development 'centre of gravity'.

Table 2.2 Top 50 contract manufacturers, 2002

Rank	Company	Rank	Company
1	Flextronics International: Singapore	26	Beyonics Technology: Singapore
2	Solectron: Milpitas, CA	27	VIDEOTON Holding: Szekesfehervar, Hungary
3	Sanmina-SCI: San Jose, CA	28	GES International: Singapore
4	Celestica: Toronto, Canada	29	Ionics-EMS: Cabuyao, Philippines
5	Foxconn (Hon Hai Precision Industry Co.): Tu-Cheng, Taiwan	30	Flairis Technology: Singapore
6	Jabil Circuit: St. Petersburg, FL	31	Nam Tai Electronics: Hong Kong
7	Elcoteq Network Oy: Espoo, Finland	32	Alco Electronics: Hong Kong
8	Benchmark Electronics: Angleton, TX	33	Fabrinet: Patumthanee, Thailand
9	Venture Manufacturing Singapore	34	Scanfil: Sievi, Finland
10	Universal Scientific Industrial Co., Ltd. (USI): Nan-Tou, Taiwan	35	Mid-South Industries: Gadsden, AL
11	Plexus: Neenah, WI	36	Varian Inc. Electronics Manufacturing: Tempe, AZ
12	Viasystems Group: St. Louis, MO	37	CTS Interconnect Systems: Glasgow, Scotland
13	MSL – Concord, MA	38	EPIQ: Diepenbeek, Belgium
14	Cal-Comp Electronics: Bangkok, Thailand	39	Surface Mount Technology (Holdings) Ltd.: Hong Kong
15	PEMSTAR: Rochester, MN	40	Flash Electronics: Fremont, CA
16	Finmek Group: Padova, Italy	41	Orient Semiconductor Electronics: Kaohsiung, Taiwan
17	SMTC: Markham, Canada	42	Simclar Group: Dunfermline, Scotland
18	Kimball Electronics Group: Jasper, IN	43	KeyTronic EMS: Spokane, WA
19	VOGT electronic – Obernzell, Germany	44	Reptron Manufacturing Services: Tampa,
20	SYNNEX Information Technologies: Fremont, CA	45	Sypris Solutions, Electronics Group: Louisville, KY
21	Suntron: Phoenix, AZ	46	Sparton Corp.: Jackson, MI
22	Elite Industrial Group: Hong Kong	47	Neways Electronics International: Son, The Netherlands
23	WKK Technology Ltd.: Hong Kong	48	PartnerTech: Malmo, Sweden
24	Zollner Group: Zandt, Germany	49	BreconRidge Manufacturing Solutions: Kanata, Canada
25	Teradyne Connection Systems: Nashua, NH	50	COB Technology: Singapore

Source: Manufacturing Market Insider (2003). Available http://www.mfgmkt.com/

The US-based National Electronics Manufacturing Initiative (NEMI) suggested that segments of the electronics industry are in the midst of a major re-structuring, moving the centre of manufacturing competence from the Original Equipment Manufacturers (OEMs) to the Electronics Manufacturing Services (EMS) providers and Original Design Manufacturers (ODMs). As this occurs, business models across the electronics industry are changing, leading to significant shifts in roles and responsibilities across the supply chain. The move by OEMs to outsource manufacturing has resulted in electronic manufacturing services (EMS) being one of

the fastest growing segments of the electronics industry.[63] Just as contract manufacturing gave way to electronics manufacturing services, increasingly electronics manufacturing services are facing competition from original design manufacturers (ODMs) as more and more products experience vertical disintegration and more and more functions are outsourced (Figure 2.3). During the last two decades OEMs have changed from being vertically integrated entities that managed and controlled a product through its life-cycle, to horizontally disintegrated ones, with more and more of the core electronics manufacturing processes outsourced to third-party specialist providers.[64]

Figure 2.3 Evolution of electronics manufacturing outsourcing

1985	Design: Prototype	Design: Engineering	Procurement	PCB Assembly	Box Assembly	System Testing	Sales	Repair
			Outsourced					
1993	Design: Prototype	Design: Engineering	Procurement	PCB Assembly	Box Assembly	System Testing	Sales	Repair
			Outsourced	Outsourced				
1998	Design: Prototype	Design: Engineering	Procurement	PCB Assembly	Box Assembly	System Testing	Sales	Repair
			Outsourced	Outsourced	Outsourced	Outsourced		
2000	Design: Prototype	Design: Engineering	Procurement	PCB Assembly	Box Assembly	System Testing	Sales	Repair
			Outsourced	Outsourced	Outsourced	Outsourced		Outsourced
2002	Design: Prototype	Design: Engineering	Procurement	PCB Assembly	Box Assembly	System Testing	Sales	Repair
	Outsourced	Outsourced	Outsourced	Outsourced	Outsourced	Outsourced		Outsourced

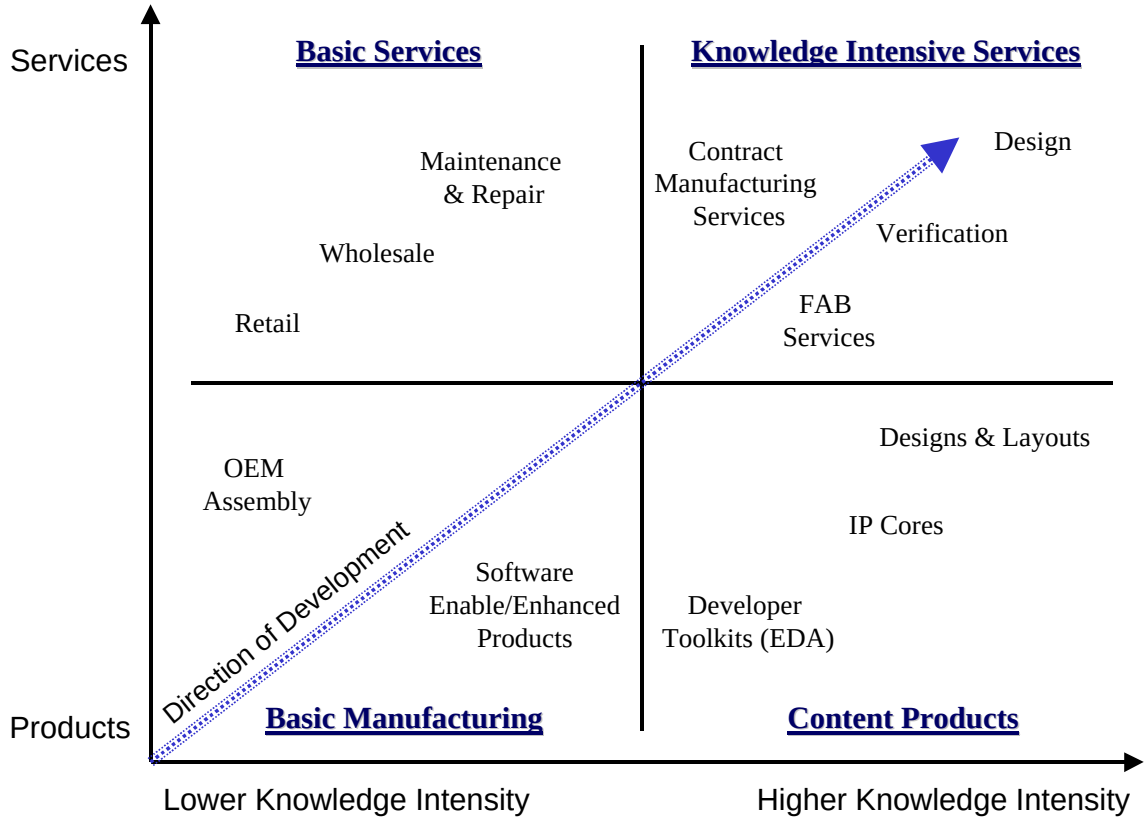
Source: PricewaterhouseCoopers (2004) *Electronics Manufacturing: EMS at a Crossroads*, PWC Global Technology Centre, p6.

The evolution of the electronics industry can be seen as a fragmentation of the value chain, with separation of activities and increasing specialisation along a dimension running from basic manufacturing assembly to high-value, knowledge-intensive services (Figure 2.4). Integrated OEM design, verification, manufacturing, assembly, distribution, maintenance and repair is increasingly giving way to the fragmentation of those activities, and to firm and regional specialisation.

[63] Reed Electronics Research (2004) *The European Contract Electronics Assembly Industry 2002-2007*. Available http://www.instat.com/catalog/ accessed April 2004.

[64] PricewaterhouseCoopers (2004) *Electronics Manufacturing: EMS at a Crossroads*, PWC Global Technology Centre, p6. Available http://www.pwcglobal.com/ accessed May 2004.

Figure 2.4 Dimensions of specialisation and development in electronics



Source: Centre for Strategic Economic Studies.

2.3 Managing the electronics supply chain

This rapid evolution of industry structures, value chain fragmentation, the emergence of new business models and increasing firm and regional specialisation are making supply chain management increasingly important. As well as offering the potential to increase productivity, the use of internet-based technologies and e-business techniques support the increasing scope of outsourced operations, which require loosely coupled business processes spanning multiple companies.[65]

It is somewhat beyond the scope of this study, but there is evidence to suggest that electronics manufacturers are relatively advanced in their adoption and use of ICT, the internet and e-business solutions. E-business Watch (2003), found that the electronics and electrical machinery industry was already advanced in e-business usage, with large firms leading in some e-business applications and SMEs not far behind. The electronics industry was found to be more advanced than the electrical machinery sector. E-business drivers in the electronics industry include: short product life cycles, standardised components and products, a complex value chain that exhibits

65 NEMI (2003) *Technology Roadmaps: December 2003*, NEMI, p1. Available http://www.nemi.org/

an extremely high degree of outsourcing, IT-competence of firms in the electronics sector, and a truly globalised industry.[66]

Across the EU5 countries (ie. France, Germany, Italy, Spain and the United Kingdom) 10% of electronics firms were using EDI in March 2003, 9% were selling online and more than 55% were using online procurement. Larger firms were more active, with 34% of firms with more than 250 employees using EDI, 17% selling online and 64% using online procurement. Of all firms selling online, online sales accounted for more than 50% of sales for almost 13%, although for almost 50% online sales accounted for less that 5% of sales. Thirty per cent of firms selling online linked online payments with those sales, and 70% provided after-sales service online. Of the 55% of European electronics firms using online procurement, 65% did so for MRO goods and 68% did so for the purchase of direct production goods. Eighty-six per cent of firms were procuring through the company website and 29% were using electronic marketplaces. Only 9% of those firms using online procurement did so for more than 50% of their procurement inputs. Thirty per cent of European electronics firms reported using online technologies to share documents and/or perform collaborative work (Table 2.3).[67]

Table 2.3 Use of online collaboration by European electronics firms, 2003 (per cent of enterprises)

	Product design	Forecast demand	Manage capacity	EDI suppliers	EDI customers	Negotiate contracts
Total	*18.9*	*11.7*	*10.9*	*47.3*	*47.3*	*18.6*
0-49 employees	19.1	11.7	10.5	47.8	47.7	19.0
50-249 employees	13.3	6.7	15.3	36.4	42.2	15.3
250+ employees	22.9	20.8	24.5	48.1	39.9	6.4

Note: EU5 countries include: France, Germany, Italy, Spain and the United Kingdom.
Source: E-Business Watch (2003) *ICT & e-business in the Electrical Machinery and Electronics Sector*, Sector Report 11/II, July 2003, European Commission, Brussels.

Of those European electronics firms selling online, 67% reported that it had a positive effect on the volume of sales, 43% reported a positive effect on the number of customers, 66% reported a positive effect on sales area, 66% reported a positive effect on the quality of customer service, and 49% reported a positive effect on internal business processes. The European study concluded that:

> *the internet is speeding up the process of globalisation and specialisation. The trend towards specialisation (both of firms and of regions) is being supported and enabled by the widespread implementation of e-business solutions. This should lead to an exploitation of comparative advantages and thus improve overall sector productivity*

[66] E-Business Watch (2003) *ICT & e-business in the Electrical Machinery and Electronics Sector*, Sector Report 11/II, July 2003, European Commission, Brussels, p15. Available http://www.ebusiness-watch.org/marketwatch/ accessed April 2004.

[67] E-Business Watch (2003) *ICT & e-business in the Electrical Machinery and Electronics Sector*, Sector Report 11/II, July 2003, European Commission, Brussels, p15. Available http://www.ebusiness-watch.org/marketwatch/ accessed April 2004.

and economic growth… Further specialisation and outsourcing (especially within the electronics industry) could eventually contribute to a further disintegration of individual firms, strengthening the position of highly specialised firms, service providers and contract manufacturers.[68]

Box 2.1 Impacts of e-commerce in the UK electronics design and manufacturing industries

Large OEMs are driving e-commerce developments with their suppliers. Benefits are realised from increased information transfer and awareness, improved forecasting ability, streamlined efficient procurement operation resulting in reduced costs, global control of suppliers. Many SMEs are still operating at the Website/e-mail level. Orders are taken and placed through e-mail, fax or telephone.

Large CEMs have fully integrated intranets and are realising benefits of e-commerce. While proximity to customer is clearly best in reducing delivery times, the intranet enables contract jobs to be allocated to whichever site has appropriate capacity at the time. Small and medium CEMs use e-mail and non-interactive websites. As the smaller companies are swallowed by the larger then e-commerce is implemented within that site as it becomes incorporated within the larger company's intranet.

Large components manufacturers are international companies operating intranets and extranet throughout a global corporation. Small and medium sized companies like their OEM counterparts are still operating at email, fax and telephone level. Particularly in the area of specifically engineered product, companies do not see that there is a need for e-commerce.

E-commerce is essential to survival of large distributors where a few large companies account for a significant level of business. All are looking to trade more through the internet to gain the cost saving benefits of doing so. Large distributor companies are international and run global operations and all are now set up with intranet, extranet and interactive websites. Small/medium sized companies are moving more slowly to e-commerce and the majority recognise the benefits for their larger customers. All have websites and are looking to move to interactive sites through which orders can be placed. Smaller distributors are targeting SMEs as customers, as large distributors are already tied in through e-commerce to the larger OEMs and CEMs. The expectation from smaller distributors is that e-commerce will enable them to increase their customer base.

Large PCB manufacturers are forced to adopt e-commerce systems in order to maintain contracts with customers. Smaller companies are moving towards e-commerce as their customers call for it.

Source: BPA (2001) *E-commerce Sectoral Impact Assessment for the Electronics Design and Manufacturing Industries*, Department of Trade and Industry, London.

In Australia, 73% of manufacturing firms used internet during 2002-03, 30% placed orders online and 24% received orders. Of all Australian businesses using internet, 39% placed orders

[68] E-Business Watch (2003) *ICT & E-Business in the Electrical Machinery and Electronics Sector*, Sector Report 11/II, July 2003, European Commission, Brussels, p15. Available http://www.ebusiness-watch.org/marketwatch/ accessed April 2004.

online and 31% made online payments, while 19% received orders online and 3% received online payments. Of those firms earning income online, online income accounted 50% of their income or more for around 7% of firms. Most of the online orders received were received via email. Sixteen per cent of firms receiving online orders had automated links with other business processes. Speed of processing and improved quality of services were the most widely cited benefits of e-commerce.[69]

Table 2.4 Electronics B2B e-marketplaces

allocation.net	newtronCompoNET
Asia-Links	nexMart
Asia-Tech	PartMiner freetradezone
AsianProducts	PCB-Broker
BidVantage	Photonics Online
Bizipoint	PST Inventory Online
click2procure	RF Globalnet
Com2B	Semiconductor Online
Converge	SMT/SEMICONDUCTOR/FPD
DRAMeXchange	Sonegocios.com
E2open	The Broker Forum
EEchain	Tooling Online
eeParts.com	Tradeplace
elcina	TraderFirst
ElectronicsWeb	United Raw Materials Solutions Inc.
ElectroSupport Online	USBid.com
EUDAR.com	Vendorbase.com
eXcessportal.com	VertMarket: Test and Measurement.com
eXcesstrade.com	VertMarkets: Hospital Network.com
GlobalSpec.com	VertMarkets: Premises networks.com
GovSupport Online	VertMarkets:ElectricNet
materialboerse.de	VertMarkets:Fiber Optics Online
Mectronic.net	Virtual Chip Exchange
netCOMPONENTS	Virtual Component Exchange
newtronAutomotive	

Source: Berlecon Research (2004) *E-market directory/Electronics & Electrical products,* EMarket Services Database. Available http://www.berlecon.de/output/b2bdb/en/index.php accessed May 2004.

According to a recent PricewaterhouseCoopers study, the electronics industry is also a leading user of e-marketplaces. A number of factors contribute to this, including high levels of modularity and standardisation, wide geographic dispersion of manufacturers, high volatility of prices in some components (eg. processor and memory chips), etc. In 2002, PricewaterhouseCoopers identified and evaluated more than 100 marketplaces for the electronics industry, and found that: the number of marketplaces in the electronics industry is higher than in other industries; most marketplaces offered more than a simple trading platform;

[69] Australian Bureau of Statistics (2004) *Business use of Information Technology, Australia 2002-03*, Cat No 8129.0, Canberra.

and integration of back-end-systems, such as inventory control systems, and of elements of users' supply chains, such as logistics, finance, insurance etc., was a weakness of most marketplaces, with users often having to adapt their systems to the marketplace, which is costly and time-consuming.[70] Berelcon Research's *eMarket Services Database* listed 49 B2B electronics marketplaces in April 2004 (Table 2.4).[71] Electronics-ee lists 72 electronics and semiconductors B2B markets.[72]

Box 2.2 The supply chain and supply chain management

The concept of the supply chain is used to describe the integrated process of producing value for the end user. In general terms, the supply chain covers the planning, sourcing, making and delivery of products and services to final customers.

Supply chain management can be broadly defined as 'the management of up stream and down stream relationships with suppliers and customers to deliver superior customer value at less cost to the supply chain as a whole'. Whilst the concept of supply chain management is relatively new, it is essentially the logical extension of logistics management. Management of the supply chain is of strategic importance to any organization delivering a product or service to a consumer.

There have been 3 phases of development:

- Phase 1 - Physical Distribution Stage: Integration of Warehousing and Transportation
- Phase 2 - Enhanced Logistics Management: Extending the Integration
- Phase 3 - Integrated Supply Chain Management: Including the Suppliers and Customers

While most firms remain in phase three, there are a number of companies who have developed the idea of integrated supply chain management and extended it to include more functions such as marketing, customer service and product development.

There is now an increasing realisation that in most markets there are in fact supply webs or networks, rather than chains, with multiple customers and multiple suppliers. More and more firms are moving away from the traditional linear supply chain and starting to design and leverage supply chain networks.

The truly leading edge companies realise that the future does not belong to any single firm, no matter how large or how long they have been established. Instead it will be controlled by a network of inter-linked firms with their joint resources focused on meeting the specific needs of consumers. It is an age where supply network will compete against supply network.

Source: Wright, C. (2000) *Foresight: Manufacturing 2020 – Supply Chain Issues*, Department of Engineering, University of Cambridge.

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70 PricewaterhouseCoopers (2002) *Electronic market places: Chances and risks for Operators and Participant*s. Available www.pcw.com accessed April 2004.

71 Berlecon Research (2004) *E-market directory/Electronics & Electrical products*, EMarket Services Database. Available http://www.berlecon.de/output/b2bdb/en/index.php accessed May 2004.

72 Electronics-ee (2004) *Electronics and semiconductor B2B markets*. Available http://www.electronics-ee.com/Electronics_and_semiconductors/B2b_markets.htm accessed May 2004.

Despite the high level of sophistication of e-marketplaces in the sector, the number of firms using B2B e-marketplaces is still limited. Less than 5% of all enterprises in the electronics sector in Europe reported participating in an online marketplace in 2003, although a further 5% of all enterprises said that they planned to trade on an e-marketplace by March 2004.[73] Nevertheless, eMarketer estimated that Internet-based e-commerce (excluding EDI) between computer and electronics manufacturers and their trading partners would grow from USD 48 billion in 2001 to USD 214 billion by 2005. As a portion of total industry sales, internet-based trade accounted for just over 3.4% of total industry trade in 2001, and was projected to grow to 10% in the next four years.[74]

The ability of Victorian electronics cluster firms to operate effectively and efficiently within global and highly automated supply chains will be a key determinant of their ability to access and prosper on world markets.

2.4 Environmental and regulatory developments

There are emerging demands to meet environmental criteria as a condition of market access. To meet regional environmental legislative requirements, manufacturers must remove environmental 'materials of concern' (eg. moving to lead free soldering, bromine free flame retardants, etc.). There is increasing pressure for electronics manufacturers to ensure product recyclability and even conduct recycling, and increasing focus on lowering energy use, both in manufacturing and product operation. There is also greater focus on 'product stewardship', with the electronics industry facing product end-of-life or producer responsibility legislation in some markets.

These demands raise two issues. First, how to comply by manufacturing in such a way as to comply, and to manufacture products that comply, from a technological point of view. Second, how to establish and operate the systems to enable, support and manage conformance. Environmental legislation in various product segments will require the electronics industry to share detailed material content data for their products and components and to establish systems for product stewardship. Again, the adoption and use of sophisticated e-business applications will be crucial.

2.5 Emerging technologies, opportunities and markets

It has been widely noted by futurists that many of the more obvious technology trends of recent years have points of intersection. Indeed, convergence has been seen as the mega-trend, with cross-fertilisation of technology trends driving each further and faster. Crucially, electronics is a vital enabler and key participant in many of these converging trends.

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[73] E-Business Watch (2003) *ICT & E-business in the Electrical Machinery and Electronics Sector*, Sector Report 11/II, July 2003, European Commission, Brussels, p27. Available http://www.ebusiness-watch.org/marketwatch/ accessed April 2004.

[74] eMarketer (2002) *Consumer Electronics Online*, eMarketer. Available http://www.emarketer.com/ accessed May 2002.

In the late 1990s the Rand Corporation produced a list of 'emerging technologies' that has been widely cited. It included: software, microelectronic and communications technologies, advanced manufacturing technologies, materials and sensor and imaging technologies. On the horizon in the late 1990s the RAND group identified the following major emerging technology classes: software, computer hardware (including data storage, displays, etc.), manufacturing equipment used to make computer components (eg. lithography), communications technologies, biotechnology (relating to medicine, agriculture, the environment, communications), new materials (making old materials new ways; environmentally friendly materials), and energy.[75] The Department of Education, Science and Training recently nominated: quantum computing, complex systems, photonics, nanotechnology, bioinformatics, photovoltaics, aquaculture and ICTs as priority emerging areas in Australia.[76]

An extended quotation from one recent futures report demonstrates just how central is electronics to emerging technology trends.

> *Medicine and biotechnology are being transformed by numerous simultaneous revolutions. Bioinformatics uses mathematical techniques to uncover information in several areas including the gene sequences studied in genomics and the newer field of proteomics which reveals the structure and function of proteins. DNA chips can be used to quickly identify genetic differences between people. Rational drug design uses bioinformatics to more precisely identify drug targets, while directed evolution methods generate numerous potential substances from which the most promising can be culled and recombined leading to better drugs. Both supercomputers (IBM's Blue Gene) and distributed computers (folding@home) are being brought to bear in protein folding computation, which attempts to model the massive complexity of protein structure to precisely design effective treatments. These trends are moving us towards in silico biology-thorough computer modeling of biological processes that obviate the need for slow biological trials and tests…*
>
> *In the core area of computing technology, most of the emerging trends will be relatively well known. Distributed computation (including grid computing, instant messaging, and distributed information architectures) is a catch-all term for numerous technical innovations in search of profitable applications. Rapidly advancing data storage capacity is far from a new trend, but within this long-term exponential growth are some new emerging technologies that promise to keep alive the explosive growth in data storage. New materials for hard discs, optical storage, and now molecular-scale memory are drawing plenty of research funding. Microprocessors companies continue to develop new processor architectures, often using computer-aided design to handle otherwise intractable difficulties in optimizing data flows. As we rush towards the limits of traditional chip manufacturing technologies, entirely new approaches are beginning to bear fruit in the laboratories. 3D chip arrays will bring another dimension to circuit*

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75 Porter, A.L., Roessner, J.D., Jin, X-Y and Newman, N.C. (2002) 'Emerging technology: Measuring national emerging technology Capabilities, *Science and Public Policy* 29(3), June 2002, p3.

76 DEST (2004) *Mapping Australian Science and Innovations: Main Report*, DEST, Canberra, pp287-325. Available www.dest.gov.au accessed April 2004.

layout. DNA computing could be an immensely powerful form of parallel processing, though it may have a limited range of applications. Quantum computing, until recently dismissed by many scientists as science fiction, is showing real results and could eventually lead to computers many orders of magnitude more powerful than today's supercomputers. These and other emerging computing technologies suggest that the exponential growth in computer power could continue for decades to come.

Also in the general area of "hard technologies" we are seeing the development and proliferation of MEMS or microelectrical mechanical systems, which include sensors, actuators, and monitors. MEMS form just part of the large field of micromachines which includes all devices operating on a microscopic level such as micromirrors used in optical switches and tiny accelerometers which deploy airbags. At a level one thousand times smaller than that of micromachines, we are beginning to see the field of molecular nanotechnology move from pure theory to practical applications… Eventually we may achieve molecular-scale nanobots working with nanocomputers (with the power of today's supercomputers packed into a device small enough to move easily inside a human cell). Carefully programmed nanobots, multiplying themselves into numbers sufficient to reach every cell in the human body, could lead to a mature nanomedicine capable of eliminating all disease and augmenting the immune system (among the more modest possibilities).

Materials science, while less glamorous than the latest and coolest information technologies, is feeding many of the other emerging trends. New battery technologies (including fuel cells), new polymers, and more precise ways of arranging matter are allowing the fabrication of previously impossible products: Inexpensive, high resolution flat-screen displays, foldable computer screens, and high contrast monitors for e-books and portable devices. Materials science is combining with other advances such as in optics to produce other innovations in display technology. The popularity of cellphones, PDAs, and other portable computing devices is driving improvements in microdisplays. After years of development, it appears that virtual retinal displays (VRDs) are moving from the labs into initial industrial applications. VRDs use low-power lasers to "paint" information directly on the retina, allowing a virtual overlay giving the appearance of a full-size monitor that could be used with tiny portable devices. With the move from research to early uses in medical and engineering applications, VRDs could become a powerful trend in the consumer arena in the next decade.

Among other hardware innovations, particularly intriguing is 3D printing. 3D printing allows users to construct physical objects on the spot simply by running a program on a machine with the necessary ingredients. While this technology is already being used for rapid prototyping and limited uses, if the range of materials usable in 3D printers can be expanded, we should expect a massive new market to develop and the distributed production of more goods to occur. Many products may be built to individual specifications at home or local outlets, completely transforming manufacturing.

Robotics is another trend that has been emerging for decades, but which I mention here because new sensor technologies and the crossing of a critical threshold in computer

> *power may now push the field forward at higher speed. While industrial robots are familiar, we are now seeing sudden growth in the market for home robots of increasing sophistication. Robots capable of cleaning house remain a difficult challenge, but robots are quickly getting better at recognition and navigation…*
>
> *Some trends that are obvious but have uncertain schedules are digital television, digital radio, digital theaters, and media convergence (the possible mixtures of cable, Web, wireless, set-top box, and gaming devices), and interactive advertising…*
>
> *Wireless, networking, and other technologies will come together in various combinations to enable home networking, logistical location tracking and global position monitoring. Combined with further miniaturization of cameras and microphones, we will have to deal with the very likely scenario of ubiquitous surveillance. Advances in broadband, content management, and communication protocols will also bring next-generation teleconferencing, distance learning, e-meetings, and more advanced collaboration tools.*[77]

Electronics plays a key role in such trends and is, in turn, affected by them. For example, nanotechnology is likely to be one of the more disruptive technologies for electronics manufacturers over the coming years. Timing in adoption and use will play a major role in establishing the product leaders in key fields of electronics.

NEMI noted that the need for rapid introduction of complex, multifunctional new products to address emerging markets, has favoured the development of functional, modular component systems in portable products and some consumer and office equipment. Such a design approach increases the flexibility and shortens the product design cycle, and places the test burden on the producers of the modules. It allows for product upgrading at the modular level, reduces the barriers to market entry for start up firms and changes the dynamics of the supply chain. Contract manufacturers (manufacturing services providers) are expanding their capabilities so they can supply cradle-to-grave design, sourcing, manufacturing, fulfilment, repair, and take-back services to large and small industry members. Supply chain management is emerging as a key enabler and enhancer of productivity, with the focus moving from functional expertise to 'integrated response management' and 'build to inventory' and even 'build to forecast' moving increasingly to 'build to order' or 'configure to order'. NEMI also noted the importance of nanotechnology, MEMs and energy storage systems.[78]

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[77] Manyworlds (2001) *Taking Advantage of Technological Acceleration: Tracking Emerging Technologies and Trends*, Manyworlds, Houston, Texas, pp6-12. Available www.manyworlds.com accessed April 2004.

[78] NEMI (2003) *Technology Roadmaps: December 2003*, NEMI. Available http://www.nemi.org/ accessed April 2004.

3 The electronics industry in Victoria

This section synthesises data from a range of existing sources in order to present an overview of electronics manufacturing in Victoria and compare Victorian activities with those in Australia as a whole. It provides a backdrop to the following section, which reports findings from the survey of the Victorian Electronics Cluster undertaken for this study.

3.1 Victoria's electronics industry employment and production

In 1999-2000, the electronics manufacturing industry employed 11,681 people in Victoria, realised turnover of $3.4 billion and contributed more than $920 million to Gross State Product (GSP).[79] Electronics accounted for 4% of all manufacturing employment, 4.6% of manufacturing turnover and 4.2% of manufacturing value added in Victoria (Table 3.1). Over the period 1996-97 to 1999-2000, employment in the electronics manufacturing industry in Victoria declined by 4.8% per annum, although wages and salaries increased by 9.4% per annum. Industry turnover increased by 7.2% per annum over the period, but value added declined by 4.4% per annum. Victoria accounted for around 35% of national employment in the electronics manufacturing industry, 41% of industry turnover and 38% of industry value added – somewhat higher than Victoria's share of manufacturing overall.

As at the end of June 2000, automotive electrical and instrument manufacturing accounted for around 32% of total *employment* in the electronics industry in Victoria (3,648 people). Telecommunications, broadcasting and transceiving equipment manufacturing is the next largest, accounting for 19% (2,203), electronic equipment manufacturing not elsewhere classified accounted for 15% (1,807), professional and scientific equipment manufacturing and electric cable and wire manufacturing each accounted for 13% (around 1,525) and computer and business equipment manufacturing accounted for 8% (less than 1,000 jobs) (Figure 3.1). Notably, Victoria accounts for 69% of national employment in automotive electrical and instrument manufacturing and around 45% of national employment in electric cable and wire manufacturing.

Since the mid 1990s there have been mixed employment trends among industry sectors. The strongest employment growth in Victoria's electronics manufacturing has been in professional and scientific equipment manufacturing, which has increased jobs from 1,200 in 1996-97 to more than 1,500 in 1999-2000 or by 8.7% per annum. In other areas of electronics manufacturing in Victoria employment has declined, most notably in telecommunication,

[79] As above, the electronics manufacturing industry is defined as including ANZSICs: 2813 Automotive Electrical and Instrument Manufacturing; 2839 Professional and Scientific Equipment Manufacturing; 2841 Computer and Business Machine Manufacturing; 2842 Telecommunications, Broadcasting and Transceiving Equipment Manufacturing; 2849 Electronic Equipment Manufacturing n.e.c; and 2852 Electric Cable and Wire Manufacturing.

broadcasting and transceiving equipment manufacturing (11.7% pa) other electronic equipment manufacturing (8.9% pa) and electric cable and wire manufacturing (8.4% pa).

Table 3.1 The electronics industry in Victoria, 1996-97 to 1999-2000

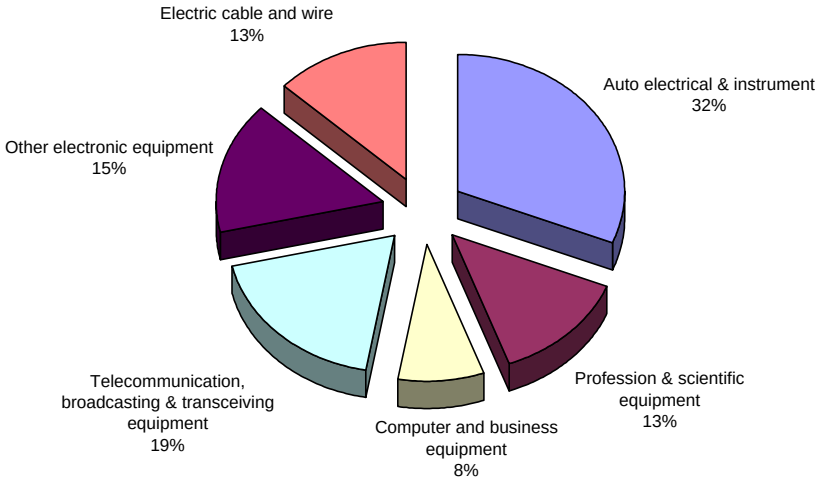
	Employed	Wages & Salaries	Income	Value Added	Income per Person	Value Added per Person
	No.	$m	$m	$m	$'000	$'000
1999-2000						
Auto electrical & instrument	3,648	175	975	258	267	71
Profession & scientific equipment	1,531	63	265	114	173	74
Computer and business equipment	971	50	586	87	603	89
Telecom, broadcasting & transceiving equipment	2,203	114	840	214	381	97
Other electronic equipment	1,807	74	303	113	167	63
Electric cable and wire	1,521	76	443	136	291	90
Total Electronics	11,681	553	3,411	921	292	79
All manufacturing	292,050	11,679	74,312	22,159	254	76
Electronics share % of manufacturing	4.0%	4.7%	4.6%	4.2%		
1996-97						
Auto electrical & instrument	3,781	145	698	195	185	52
Profession & scientific equipment	1,192	51	159	67	133	57
Computer and business equipment	993	n.p	n.p	n.p	n.p	n.p
Telecom, broadcasting & transceiving equipment	3,195	148	1,255	628	393	197
Other electronic equipment	2,388	n.p	n.p	n.p	n.p	n.p
Electric cable and wire	1,981	79	655	164	331	83
Total Electronics	13,530	422	2,766	1,055	204	78
All manufacturing	306,636	10,662	68,420	21,807	223	71
Electronics share % manufacturing	4.4%	4.0%	4.0%	4.8%		

Note: All values are current prices. n.p. is not published, for reasons of confidentiality.
Source: ABS (various years) *Manufacturing Industry: Victoria*, Cat No 8221.2. CSES Analysis.

Total electronics *industry value added* in Victoria amounted to $921 million during 1999-2000, and accounted for 4.2% of total manufacturing industry value added in Victoria. Automotive electrical and instrument manufacturing accounted for 29% of electronics industry value added in Victoria in 1999-2000 ($258 million), telecommunications, broadcasting and transceiving equipment manufacturing accounted for 23% ($214 million), electric cable and wire manufacturing accounted for 15% ($136 million), professional and scientific equipment manufacturing and electronic equipment manufacturing not elsewhere classified each accounted for 12% ($114 million), and computer and business equipment manufacturing accounted for 9% ($87 million) (Figure 3.2).

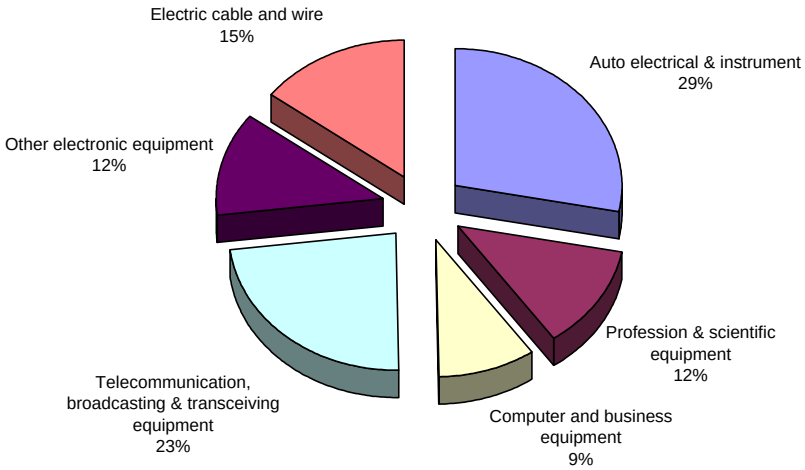
These data reveal Victoria's relative strengths in automotive electrical and instrument manufacturing and professional and scientific equipment manufacturing, as well as its wealth of electronics manufacturing overall.

Figure 3.1 Employment in electronics manufacturing in Victoria, 1999-2000



Source: ABS, CSES Analysis.

Figure 3.2 Electronics manufacturing industry value added in Victoria, 1999-2000

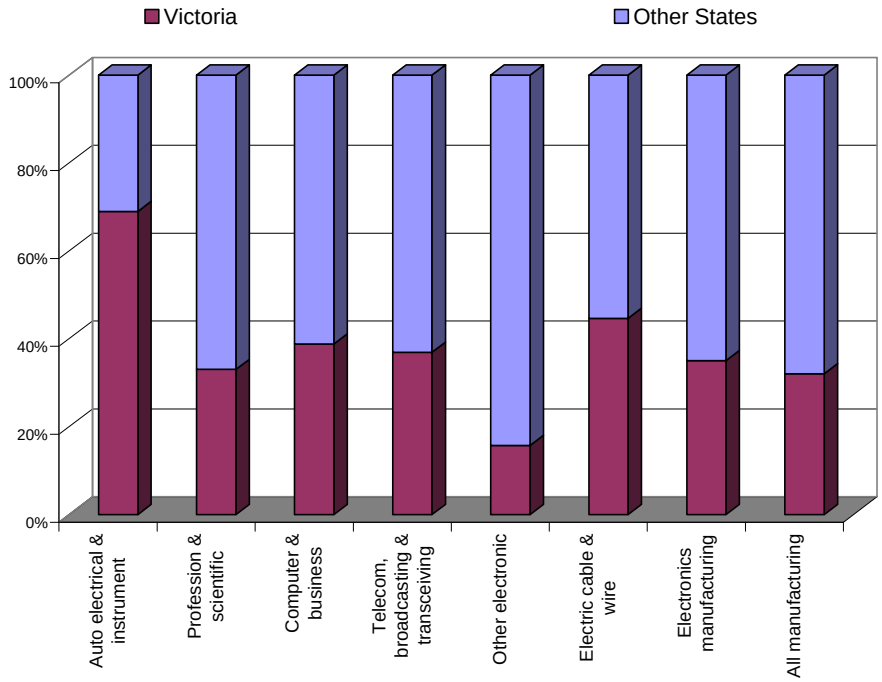


Source: ABS, CSES Analysis.

Data on enterprise size are available only at a more aggregated level (ie. machinery and equipment manufacturing). Establishment with 100 or more employees employed almost 56% of those employed by machinery and equipment manufacturers in Victoria in 2000, establishments employing 50-99 people accounted for 13% of total industry employment and those employing 49 people or less accounted for 32%. Similarly, machinery and equipment manufacturing establishments in Victoria employing 100 or more people accounted for 66% of industry value added in 1999-2000 and those with 49 or less accounted for 21%. Both show a somewhat larger share of larger enterprises in the industry in Victoria than is the case across manufacturing as a whole. Victorian machinery and equipment manufacturers were also somewhat larger than the Australian average.

Victorian machinery and equipment manufacturers employing 49 people or less exported around 9% of their sales during 1999-2000, those employing 50-99 exported 15% and those employing 100 or more exported 23%. These figures closely match national averages for machinery and equipment manufacturers. Victorian machinery and equipment manufacturers that did not export accounted for 27% of industry value added and 38% of industry employment, while those that exported more than 50% of their sales accounted for 16% of industry value added and 11% of industry employment. Both suggest a higher level of exporting from Victorian machinery and equipment manufacturers than is the case nationally.

Figure 3.3 Employment by electronics industry sector in Victoria and other states, June 2000 (percentage share)



Source: ABS, CSES Analysis.

Figure 3.3 shows the share of electronic manufacturing industry employment in Victoria and elsewhere by industry sector, all electronics manufacturing and all manufacturing industries.

The relative concentration in Victoria on automotive electrical and instrument manufacturing is clearly evident. However, in terms of the relative employment trends in Victoria and Australia as a whole (including Victoria), computer and business equipment manufacturing and electric cable and wire manufacturing are the only areas in which Victoria outperformed Australia in job retention between 1996-97 and 1999-2000. In all other areas of electronics manufacturing Victoria has under-performed Australia – most notably in electronic equipment manufacturing not elsewhere classified, in which Victorian employment declined by 9% compared to an overall employment growth in Australia of 3%. A couple of notable plant closures were significant contributors.

3.2 Victoria's electronics equipment trade

In 2002-03, Victoria's domestically produced ICT related equipment exports were worth $376 million, up from $242 million a decade earlier (Table 3.2).[80] Victoria accounted for 35% of national (State attributable) locally produced ICT equipment exports. Victorian ICT equipment exports have declined since the mid 1990s – from $584 million in 1997-98. The big fall has been in exports of computer equipment, which were worth $295 million in 1997-98, but only $61 million in 2002-03. Amongst other factors, this probably reflects the exit of Bluegum/Solectron from Wangaratta.

Overall, ICT equipment exports from Victoria increased by 4.5% per annum over the last decade, but there has been significant variation by category. For example, terminal and peripheral equipment exports increased more than 12% per annum over the decade, while switching and data communications equipment exports declined by 9% per annum.

Imports of ICT equipment destined for Victoria cost $3.2 billion in 2002-03, up from less than $1.7 billion a decade earlier. Victoria accounted for around 20% of national ICT equipment imports. Computer equipment accounted for $1.1 billion of these imports, terminal and peripheral equipment for $955 million, line, transmission and broadcasting equipment for $510 million components for $417 million, software products for $142 million and switching and data communication equipment for $85 million. Exports of ICT equipment from Victoria have grown 4.5% per annum over the last decade, while imports into Victoria have grown by almost 7% per annum.

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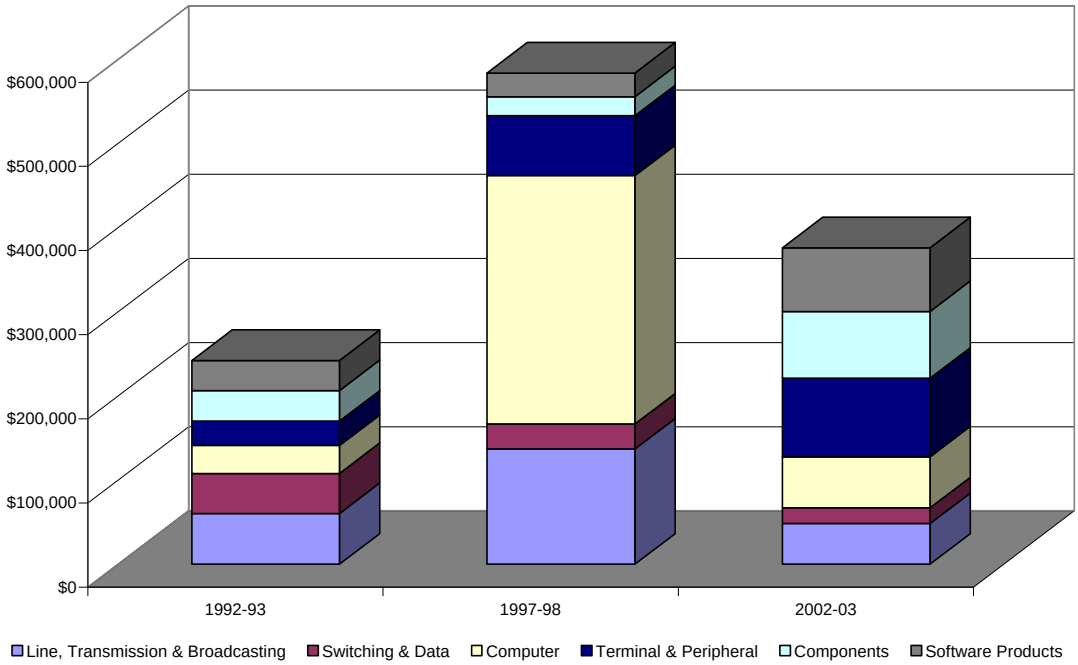
[80] ICT equipment trade data are derived from customs returns, which show the *State of Origin* for exports and the *State of Destination* for imports. Because of the way in which State of Origin and State of Destination are coded in trade data, State-based exports exclude re-exports but State-based imports included both re-imports and re-exports. Hence, the difference between State exports and imports reported here is a close approximation to the difference between the States' domestically produced exports and its foreign produced imports – which might be described as the 'deficit on production'. This is *not* the same as the State's ICT trade balance. It should also be noted that there are cases in which either the origination or destination are not known. In other cases, returns are incorrectly filed – with, for example, the head office address given as origin/destination instead of the address of the branch or office that is the ultimate origin/destination. Consequently, State-based data are subject to a degree of error and should be interpreted with caution.

Table 3.2 Victoria's ICT equipment trade, 1992-93 to 2002-03 ($ '000)

	1992-93	1997-98	2002-03	CAGR %
ICT Equipment Exports				
Line, Transmission & Broadcasting	60,220	136,952	48,234	-2.2
Switching & Data	47,594	29,675	18,663	-8.9
Computer	33,254	295,162	60,603	6.2
Terminal & Peripheral	29,015	71,330	93,605	12.4
Components	36,176	22,443	79,324	8.2
Software Products	36,079	28,214	75,582	7.7
Total	*242,339*	*583,776*	*376,010*	*4.5*
ICT Equipment Imports				
Line, Transmission & Broadcasting	193,668	516,169	510,480	10.2
Switching & Data	73,055	66,312	84,866	1.5
Computer	587,077	772,816	1,110,769	6.6
Terminal & Peripheral	432,736	607,574	954,679	8.2
Components	225,191	446,853	417,260	6.4
Software Products	157,289	183,113	141,937	-1.0
Total	*1,669,016*	*2,592,837*	*3,219,991*	*6.8*

Notes: All data are current prices. Imports are cif, exports fob. Exports exclude re-exports, but import include them. Hence, these data do not reflect Victoria's balance of trade in ICT equipment.
Source: TradeData (http://www.tradedata.net) and Houghton, J.W. (2003) *Australian ICT Trade Update 2003*, Australian Computer Society and Centre for Strategic Economic Studies, Sydney and Melbourne, p36. Available http://www.cfses.com.

Figure 3.4 Victoria's exports of ICT equipment, 1992-93 to 2002-03 ($ '000)



Source: TradeData (http://www.tradedata.net) and Houghton, J.W. (2003) *Australian ICT Trade Update 2003*, Australian Computer Society and Centre for Strategic Economic Studies, Sydney and Melbourne, p37. Available http://www.cfses.com.

Table 3.3 shows the 25 largest destinations for Victoria ICT equipment exports during 2002-03 and the 25 main suppliers of ICT equipment imports into Victoria. The United States was the destination for 17% of all ICT equipment exports from Victoria during 2002-03 ($65 million), Germany was the destination for 15% and New Zealand the destination for 12%. Equipment exports are relatively concentrated, with 56% of the total going to just 5 countries and 76% going to 10 countries.

Table 3.3 Victoria's ICT equipment export and import destinations and sources, 2002-03 (AUD '000)

Exports from Victoria	$ '000	%	Imports to Victoria	$ '000	%
United States of America	64,680	17%	China	515,757	16%
Germany	56,899	15%	Malaysia	433,647	13%
New Zealand	44,967	12%	United States of America	416,885	13%
Singapore	23,625	6%	Japan	303,831	9%
Hong Kong (Sar of China)	19,532	5%	Singapore	215,561	7%
United Kingdom	18,157	5%	Taiwan	207,983	6%
Sweden	15,942	4%	Sweden	167,949	5%
Malaysia	14,575	4%	Germany	159,249	5%
Japan	14,412	4%	United Kingdom	127,193	4%
China	13,400	4%	Korea Republic of	107,643	3%
Taiwan	7,657	2%	Thailand	86,078	3%
Korea Republic of	7,518	2%	Hong Kong (Sar of China)	71,002	2%
Thailand	7,136	2%	Philippines	63,158	2%
United Arab Emirates	6,787	2%	Ireland	36,074	1%
Netherlands	6,230	2%	Indonesia	35,450	1%
India	4,715	1%	Israel	28,101	1%
Fiji	4,381	1%	Belgium-Luxembourg	27,162	1%
Indonesia	4,272	1%	France	24,501	1%
South Africa	3,263	1%	Netherlands	23,657	1%
Canada	2,878	1%	Italy	23,232	1%
France	2,774	1%	New Zealand	18,126	1%
Papua New Guinea	2,687	1%	Austria	16,245	1%
Denmark	2,215	1%	Denmark	14,531	0%
Philippines	2,182	1%	Canada	13,620	0%
Venezuela	1,853	0%	Turkey	12,417	0%
Total all countries	*376,010*	-	*Total all countries*	*3,219,991*	

Source: TradeData (www.tradedata.net). CSES Analysis.

The main sources of ICT equipment imports into Victoria during 2002-03 were: China (excluding Hong Kong) which accounted for 16% of all equipment imports ($516 million), Malaysia 13% and the United States 13%. Combined, China and Hong Kong supplied almost $600 million of ICT equipment exports into Victoria during 2002-03, 18% of total and almost double the amount imported from Japan.

3.3 Victoria's electronics production costs

Victoria (Melbourne) compares favourably with locations worldwide on electronics production costs. KPMG ranked Melbourne second only to Montreal in terms of electronics manufacturing business costs during 2003 – in a sample of the 30 largest cities.[81] From a sample of 11 countries, Australia ranked highly on most cost factors (ie. was cost competitive), including: 2nd on labour costs, 7th on facility costs, 8th on utility costs, and 4th on corporate taxation. Combined, Australian cities recorded the lowest business costs for electronics production and product testing.

3.4 Victoria's electronics industry R&D activities

There are three major ways to look at R&D activities. This section presents a brief review of the R&D activities of electronics industry manufacturers in Victoria. The next section looks more broadly at R&D focusing on electronics fields.

Expenditure on R&D by photographic, scientific, electronic and electrical equipment manufacturers in Australia amounted to $642 million during 2001-02, of which just over $176 million or 27.5% was performed in Victoria (Table 3.4). Over the five years to 2001-02, Victoria's photographic, scientific, electronic and electrical equipment manufacturers cut their R&D expenditures by 6% per annum – from $241 million in 1996-97 to $176 million in 2001-02. Over the same period, there was a 2 per cent per annum increase in R&D expenditure by equivalent electronics manufacturers in other states. Victoria's share of nation wide R&D expenditure by photographic, scientific, electronic and electrical equipment manufacturers has fallen from more than 36% to less than 28% over the last five years. These are discouraging trends.

Table 3.4 Expenditure on R&D by photographic, scientific, electronic & electrical equipment manufacturers, 1996-97 to 2001-02

	1996-97 $'000	2001-02 $'000	CAGR %	Share % 1996-97	Share % 2001-02
Victoria	240,774	176,420	-6.0	36.1	27.5
Other states	421,501	464,947	2.0	63.2	72.5
Overseas	4,431	303	-41.5	0.7	0.0
Total	*666,706*	*641,670*	*-0.8*	-	-

Source: ABS (various years) *Research and Experimental Development: Businesses Australia*, Cat No 8104.0, Canberra.

Estimates based on national shares would suggest that around 1,235 person years would have been expended on R&D by photographic, scientific, electronic and electrical equipment manufacturers in Victoria during 2001-02. Around 90% of their total R&D expenditure would

[81] KPMG (2004) *Competitive Alternatives: The CEO's guide to international business costs*, p44. Available http://www.competitivealternatives.com accessed April 2004.

probably have come from own internal funds ($159 million), $9.4 million from the Commonwealth Government and perhaps as much as $6.3 million from overseas sources.

3.5 Electronics R&D in Victoria

Electronics is an enabler of a wide range of devices and activities making the identification of electronics related R&D difficult. Interpretation of data is further complicated by the limited availability of business sector R&D data at a disaggregated level, due to confidentiality restrictions. The next section presents R&D data by field of research and the subsequent section presents data by socio-economic objective. The latter relate to the outcome or purpose (eg. environmental protection), whereas the former relate to the means or science base (eg. filtration technologies).

3.5.1 Electronics R&D in Victoria by field of research

Table 3.5 shows R&D expenditures for the three core electronics fields (ie. Electrical and Electronic Engineering, Computer Hardware and Communications Technologies) by sector for the most recent year for which data are available. Across these core electronics related fields of

Table 3.5 Electronics R&D expenditure by sector of execution, latest year

	Total $'000	Victoria $'000	Victoria's share of total %
BUSINESS, 2001-02			
Electrical & Electronic Engineering	182,611	56,282	30.8
Computer Hardware	29,078	8,097	27.8
Communications Technologies	614,332	157,278	25.6
COMMONWEALTH, 2000-01			
Electrical & Electronic Engineering	5,945	782	13.2
Computer Hardware	229	169	74.0
Communications Technologies	16,395	1,201	7.3
STATE & LOCAL, 2000-01			
Electrical & Electronic Engineering	56	0	0.0
Computer Hardware	2,211	0	0.0
Communications Technologies	722	123	17.1
HIGHER EDUCATION, 2000			
Electrical & Electronic Engineering	34,019	7,940	23.3
Computer Hardware	3,993	39	1.0
Communications Technologies	20,899	6,151	29.4
PRIVATE NON-PROFIT, 2000-01			
Electrical & Electronic Engineering	-	-	-
Computer Hardware	-	-	-
Communications Technologies	-	-	-

Source: ABS Unpublished data. CSES Analysis.

research annual expenditure in Victoria amounts to around $240 million, some 26% of total national expenditure on R&D in these fields. The largest field of R&D activity in Victoria is communications technologies, which accounts for almost 70% of total electronics related expenditure in Victoria ($165 million).

Victoria accounts for 26% of total national electronics related R&D expenditure in these fields, 31% of total expenditure on electrical & electronic engineering R&D, 28% of total expenditure on computer hardware R&D and 26% of total expenditure on communications technologies R&D. It is worth noting that a further $475 million was spent on the electronics related field of information systems R&D by businesses in Victoria during 2001-02, 32% of the national total. Despite being the major area of focus in expenditure terms, communications technologies account for a somewhat lower share of electronics related R&D in Victoria than is the case nationally. Conversely, electrical & electronic engineering and, to a lesser extent, computer hardware R&D accounts for a somewhat higher share of Victorian electronics R&D expenditure than is the case nationally.

By far the largest share of electronics R&D activity is conducted by the business sector, which accounts for around 93% of total R&D expenditure in these fields. By contrast, higher education accounts for just 6% of electronics R&D in Victoria, the Commonwealth Government for 1% and state and local government for just 0.1%. The share of expenditure by the business sector is higher in Victoria than is the case nationally, where around 90% of electronics R&D is done by businesses, and a higher 6.5% is done by higher education institutions and 2.5% by Commonwealth Government agencies.

Table 3.6 Public sector electronics R&D expenditure, 2000-01

	Australia $'000	Victoria $'000	Victoria's Share %	Share by sector in Victoria %
Commonwealth	112,644	30,482	27.1	49.7
Higher education	139,318	30,097	21.6	49.1
Private non-profit	548	539	98.4	0.9
State	7,588	161	2.1	0.3
Total	*260,099*	*61,280*	*23.6*	*100.0*

Source: ABS Unpublished data. CSES Analysis.

Not being subject to considerations of commercial confidentiality, more disaggregated data are available for public sector R&D. Public sector expenditure on all electronics related fields of research amounted to $260 million in 2000-02, of which more than $60 million (24%) was spent in Victoria (Table 3.6). State and private non-profit expenditure in electronics related fields of research in Victoria is minimal, with commonwealth and higher education institutions each accounting for almost 50% of Victoria's total expenditure ($30 million).

3.5.2 Electronics R&D in Victoria by socio-economic objective

R&D expenditure data include three socio-economic objectives that relate directly to electronics – 671200 Computer hardware and electronic equipment, 671300 Communication equipment

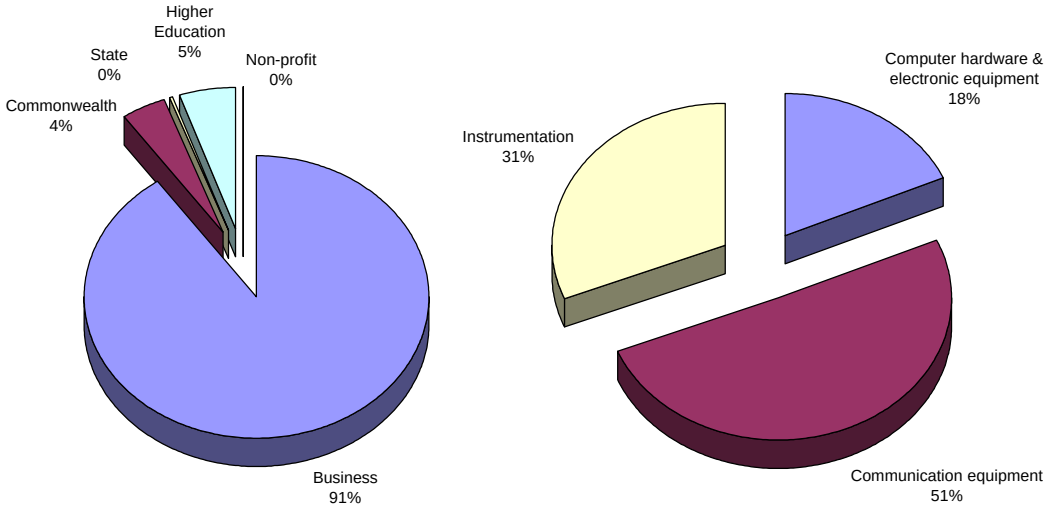
and 671400 Instrumentation.[82] Around $163 million was spent on R&D focusing on these electronics related objectives during 2000-01, approximately 36% of total national expenditure (Table 3.7). Ninety-one per cent, or $147 million of this was spent by the business sector, 5% ($8.7 million) in higher education institutions and 4% ($6.9 million) in Commonwealth Government agencies. More than 50% of total Victorian R&D expenditure on these electronics related objectives is focused on communications equipment, 30% on instrumentation and less than 20% on computer hardware and electronic equipment.

Table 3.7 Electronics R&D in Victoria by objective, 2000-01 ($'000)

	Business	Commonwealth	State	Higher Education	Non-profit
Computer hardware & electronic equipment	26,852	1,899	0	1,100	0
Communication equipment	77,113	220	120	4,832	0
Instrumentation	42,729	4,821	0	2,809	0
Total	*146,694*	*6,940*	*120*	*8,741*	*0*

Source: ABS Unpublished data. CSES Analysis.

Figure 3.5 Electronics R&D in Victoria by objective, 2000-01



Source: ABS Unpublished data. CSES Analysis.

In relative terms, Victoria has a strong focus on instrumentation and communication equipment R&D, expenditures on which account for 50% and 48% of national totals, respectively. Victorian expenditure on computer hardware and electronic equipment R&D is correspondingly lower (17%). While the business sector dominates R&D effort in all these areas of electronics

[82] This excludes 671503 Appliances and electrical machinery and equipment.

related R&D, Commonwealth Government agencies account for a relatively larger share of instrumentation R&D, and higher education institutions account for a relatively large share of communication equipment R&D. This suggests some local research strengths in these areas, which might be a focus for improving commercialisation linkages.

3.6 Employment in electronics occupations

Because electronics is a generic technology, people with electronics related skills work in a wide range of industries. At the end of June 2002, there were around 102,700 people in Australia employed in electronics occupations.[83] Employment in these occupations has declined by around 7,000 over the last three years (Table 3.8). The decline in communications tradespersons has been a major driver of this overall trend, with job growth in other areas – most notably in electrical and telecommunications trades assistants.

Table 3.8 Employment in electronics occupations, 1998 to 2002 (Thousands)

	1998	1999	2000	2001	2002	CAGR %
Electrical and electronics engineers	24.1	27.2	25.2	24.8	25.5	1.4
Electronic engineering associate professionals	15.4	15.6	16.8	16.1	14.5	-1.5
Electronic and office equipment tradespersons	34.6	33.9	37.4	32.7	36.9	1.6
Communications tradespersons	27.8	28.8	27.3	24.9	22.9	-4.7
Electrical and telecommunications trades assistants	2.4	2.3	3.2	2.7	2.8	3.9
Total Electronics Occupations	*104.4*	*107.9*	*109.8*	*101.1*	*102.7*	*-0.4*
Total employed	*8,553.1*	*8,747.4*	*9,009.4*	*9,123.9*	*9,311.4*	*2.1*
Share of all employment (%)	*1.2*	*1.2*	*1.2*	*1.1*	*1.1*	

Source: ABS (2003) *Australian Now: Australian Labour Market Statistics, 2003*, Cat No 6105.0, Canberra.

By location, these jobs are concentrated in capital city location – 73.4% compared with 64% of all occupations. Electronics jobs are relatively concentrated in NSW and the ACT, with in other states accounting for a lower share of electronics jobs than of jobs across all occupations.

In Victoria there were more than 23,800 people employed in these electronics occupations at the end of June 2002 – 23.2% of the national total and around 1% of the state's total employment. In 2001, more than 300,000 Victorian's had non-school qualifications in engineering and related technologies, and some 44,300 had IT related qualifications – 8.2% and 1.2% of Victoria's working population, respectively.

[83] Including: Electrical and electronics engineers, Electronic engineering associate professionals, Electronic and office equipment tradespersons, Communications tradespersons, Electrical and telecommunications trades assistants.

4 The Victorian electronics industry cluster survey

This section reports findings from the survey of the Victorian electronics industry undertaken for this study. It seeks to paint as full a picture as possible of the activities and capabilities of the electronics industry cluster in Victoria, with a focus on value chain, product system, learning and innovation linkages.

4.1 Electronics firms and activities

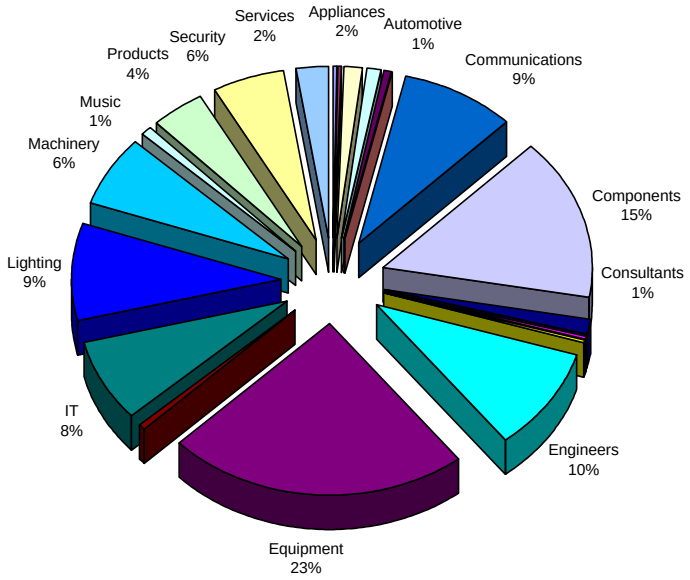
Some 2,400 electronics cluster firms were identified from industry and association membership and Yellow Pages listings. Approximately 1,650 were surveyed. Table 4.1 shows the composition of the electronics cluster firms identified (left column) and of the sample invited to participate in the survey (right column). Of the 2,375 electronics cluster firms identified, 23% were equipment producers, 15% components manufacturers, 10% engineers, 9% communications equipment producers, 9% lighting, 8% IT producers, 6% were in security and 6% were machinery producers (Figure 4.1).

Table 4.1 Electronics cluster firms in Victoria

Electronics firms identified	Count	Electronics firms sampled	Count
Equipment	558	Equipment	434
Components	368	Components	346
Engineers	229	Communications	141
Lighting	222	Engineers	135
Communications	208	IT	110
IT	186	Machinery	103
Machinery	153	Lighting	97
Security	135	Security	66
Products	95	Products	52
Services	59	Consultants	33
Appliances	36	Services	31
Consultants	33	Appliances	26
Automotive	27	Automotive	18
Music	24	Music	15
Finance	9	Building	7
Building	8	Agriculture	6
Agriculture	7	Electricity	6
Electricity	6	Aeronautical	4
Aeronautical	5	Defence	4
Defence	4	Chemicals	3
Chemicals	3	Finance	3
	2,375		*1,640*

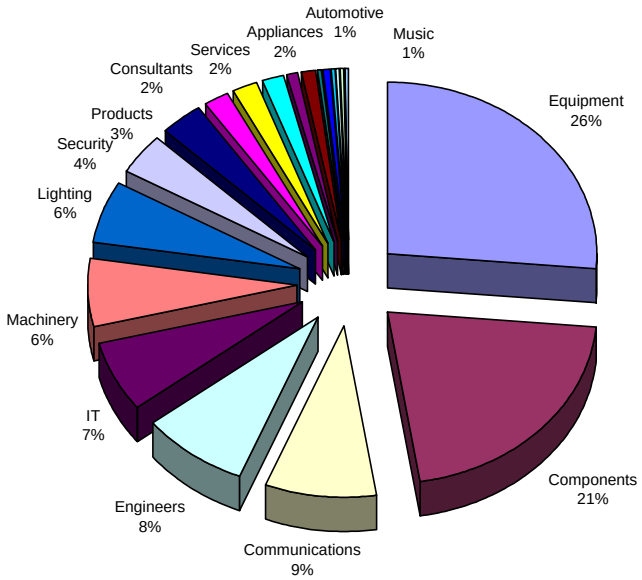
Source: Victorian Electronics Cluster Survey, Project Database (CSES). CSES Analysis.

Figure 4.1 Electronics cluster firms identified in Victoria



Source: Victorian Electronics Cluster Survey, Project Database (CSES). CSES Analysis.

Figure 4.2 Electronics cluster firms sampled in Victoria



Source: Victorian Electronics Cluster Survey, Project Database (CSES). CSES Analysis.

Sampling focused somewhat more on core electronics manufacturing and related activities, with 26% of the sampled firms being equipment producers, 21% components producers, 9% communications equipment producers and 8% engineers (Figure 4.2).

Table 4.2 Victorian electronics cluster firms by sub-category (indicative count of firms by activity)

Category	Number of firms
Lighting & Accessories–W'salers &/or Mfrs	160
Computer Equipment Supplies	155
Electronic Engineers	140
Burglar Alarms–Domestic & Commercial	134
Radio Communication Equipment &/or Service	125
Automation Systems &/or Equipment	110
Electrical Switchboards – W'salers & Mfrs	89
Electrical Switches & Control Equipment	84
Repetition Engineers	81
Instruments – Process Control	76
Electronic parts – W'salers & Mfrs	70
Detectors - Electronic	59
Scales & Weighing Equipment	58
Electronic Equipment – W'salers & Mfrs	57
Electrical Accessories – W'salers & Mfrs	56
Instruments – General	54
Electronic Equipment & Parts – Retail or Service	49
Laser Equipment	44
Fibre Optics	41
Electronic &/or Electric Testing Equipment	40
Electrical W'salers	35
Signs - Electronic	32
Electrical Appliances – W'salers & Mfrs	29
Printed Circuits	25
Testing Equipment	24
Electric Cable & Wire – W'salers & Mfrs	22
Lighting & Power–Emergency	22
Air Purification Equipment	19
Electronic Parts Assembly Services	17
Video Equipment – W'salers & Mfrs	16
Sound Engineers	15
Electrical Wire Harness W'salers & Mfrs	13
Satellite Equipment &/or Services	12
Electric Vehicles	10
Radio & Television Station Equipment	10
Unspecified	174
Other categories in which there were fewer than 10 firms	*218*

Source: Derived from Yellow Pages and industry association listings for the Victorian Electronics Cluster Survey, Project Database (CSES). CSES Analysis.

Table 4.2 shows a more detailed breakdown by subcategory of the major firm categories identified. Because of duplicate listings (which have been eliminated) it is no more than indicative of the distribution of firms' activities.

4.2 Locational clustering of electronics activities

Of the 2,375 electronics cluster firms identified, 1,788 (75%) were located in cities and 409 (17%) were in rural locations. The location of the remaining 182 could not be identified from existing listings. It is likely that many of these are firms located outside Victoria.

Table 4.3 Six major concentrations of electronics firms (number of firms by LGA)

Monash		Knox		Greater Dandenong	
Equipment	48	Equipment	50	Components	34
Components	37	Components	30	Equipment	30
Communications	20	Engineers	19	Lighting	10
Engineers	18	Lighting	15	Engineers	8
IT	15	Communications	10	Machinery	7
Lighting	15	Products	10	Products	7
Machinery	14	IT	7	Automotive	4
Security	5	Machinery	7	Security	4
Automotive	4	Security	5	IT	3
Music	4	Services	2	Communications	2
Appliances	2	Appliances	1	Consultants	2
Products	2	Consultants	1	Appliances	1
Services	2	Music	1		
Aeronautical	1				
Building	1				
Chemicals	1				
Electricity	1				

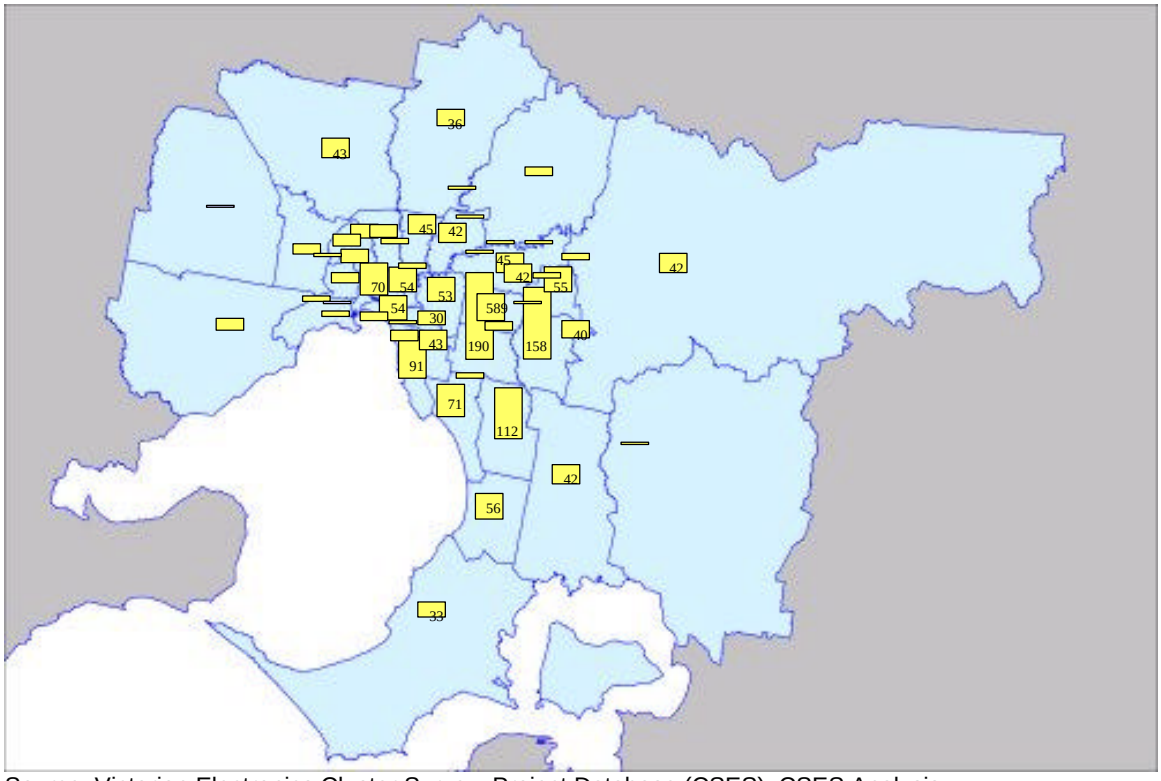
Bayside Kingston		Kingston		Melbourne	
Equipment	18	Equipment	13	IT	19
Components	16	Lighting	13	Communications	11
Engineers	13	Engineers	9	Lighting	9
Lighting	13	Machinery	8	Equipment	5
IT	6	Components	7	Components	4
Machinery	5	Security	4	Security	4
Communications	4	Communications	3	Electricity	3
Appliances	3	Products	3	Engineers	3
Products	3	Automotive	2	Machinery	3
Building	2	Consultants	2	Services	3
Security	2	IT	2	Defence	2
Services	2	Services	2	Appliances	1
Aeronautical	1	Appliances	1	Consultants	1
Chemicals	1	Finance	1	Finance	1
Consultants	1	Music	1	Products	1
Music	1				

Source: Victorian Electronics Cluster Survey, Project Database (CSES). CSES Analysis.

By local government area, Monash (190), Knox (158), Greater Dandenong (112), Bayside Kingston (91), Kingston (71), Melbourne (70), Whitehorse (58), Greater Geelong (57), Frankston (56), Maroondah (55), Port Phillip (54), Yarra and Boroondara (53) had the highest concentrations of electronics cluster firms (Table 4.4).

Table 4.3 (above) shows a breakdown of the six major agglomerations by category of activity. Communications equipment activities are clustered around Monash and neighbouring areas, with equipment and components also clustered there and in the neighbouring Knox and Greater Dandenong areas. IT and communications clustering in Melbourne (central) relates to the location of the head office activities of IT and related firms.

Figure 4.3 Electronics industry clustering: Greater Melbourne



Source: Victorian Electronics Cluster Survey, Project Database (CSES). CSES Analysis.

Figure 4.3 shows the clustering of electronics firms in the Greater Melbourne area – the stack bar heights are proportional to the number of firms by local government area. A large proportion of the electronics firms in Victoria are located in the eastern suburbs of Melbourne – in the local government areas of Monash, Knox, Greater Dandenong, Kingston / Bayside Kingston, Whitehorse, Manningham, Baroodara, Yarra, Maroondah, Glen Eira, Port Phillip, Banyule, Darebin, Casey and out as far east as the Yarra Ranges and south to Frankston. Together these areas account for some 60% of all firms identified. Around 3% of firms report central Melbourne locations, while the northern suburbs of Hume and Wittlesea are also reported as the location for a significant number of firms.

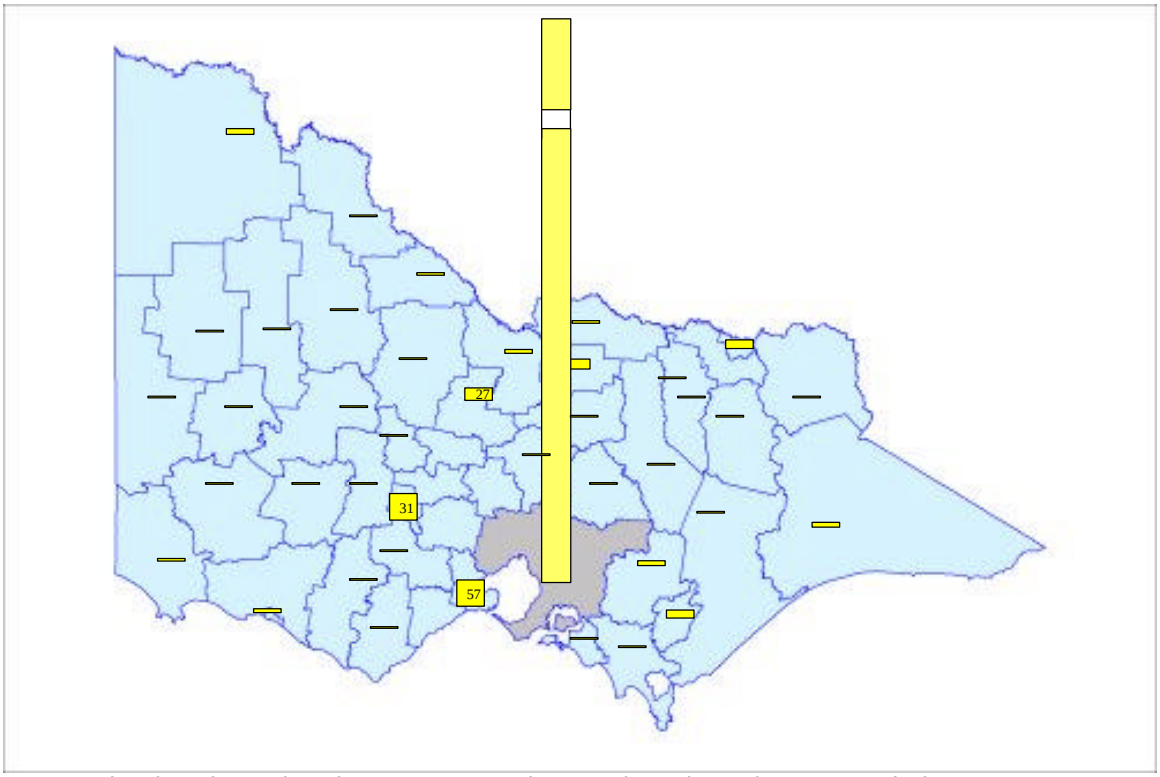
Table 4.4 Electronics firms by Local Government Area (number of firms)

Council LGA	Count	Council LGA	Count
Monash	190	Campaspe	7
Knox	158	Nillumbik, Banyule	7
Greater Dandenong	112	Whittlesea, Darebin, Banyule	7
Bayside, Kingston	91	Yarra, Darebin	7
Kingston	71	Boroondara, Stonnington	6
Melbourne	70	Brimbank, Moonee Valley	6
Whitehorse	58	Cardinia	6
Greater Geelong	57	Wangaratta Rural City	6
Frankston	56	Bayside, Glen Eira	5
Maroondah	55	Boroondara, Whitehorse	5
Port Phillip	54	Moira	5
Boroondara	53	Brimbank, Hobsons Bay	4
Yarra	53	Glenelg	4
Darebin	45	Melton	4
Glen Eira	43	Mount Alexander	4
Hume	43	Swan Hill	4
Manningham	43	Wellington	4
Banyule	42	Bass Coast	3
Casey	42	Colac-Otway	3
Yarra Ranges	42	Gannawarra	3
Whitehorse, Manningham	39	Macedon Ranges	3
Knox, Yarra Ranges	38	Mildura	3
Whittlesea	36	Murrindindi	3
Mornington Peninsula	33	South Gippsland	3
Ballarat	31	Ararat	2
Hume, Moreland, Brimbank	29	Benalla	2
Melbourne, Moonee Valley	29	Cardinia, Casey	2
Moreland	28	Central Goldfields	2
Greater Bendigo	27	Darebin, Banyule	2
Moonee Valley	26	Golden Plains	2
Wyndham	26	Hepburn	2
Bayside	23	Horsham Rural	2
Maribyrnong	22	Hume, Brimbank	2
Brimbank	21	Loddon	2
Great Shepparton	21	Mitchell	2
Nillumbik	19	Moyne	2
Melbourne, Port Phillip	18	Port Phillip, Stonnington	2
Wodonga	18	Southern Grampians	2
Latrobe	17	Surf Coast	2
Monash, Whitehorse	17	Benalla, Wangaratta	1
Melbourne, Stonnington	15	Booroondara	1
Stonnington	15	Buloke	1
Yarra Ranges, Maroondah	14	Cardinia, Yarra Ranges	1
Hobsons Bay	12	Darebin, Yarra	1
Mildura Rural City	12	Indigo	1
Monash, Kingston	12	Kinston	1
Whitehorse, Maroondah	11	Manningham, Maroondah	1
Baw Baw	10	Mansfield	1
East Gippsland	9	Melton, Brimbank	1
Moreland, Darebin	9	Moorabool	1
Moreland, Yarra	9	Mornington	1
Maribyrnong, Hobsons Bay	8	Unknown	181
Warrnambool	8	*Total*	*2,375*

Source: Victorian Electronics Cluster Survey, Project Database (CSES). CSES Analysis.

Figure 4.4 shows the clustering of electronics firms around Victoria – again the stack bar heights are proportional to the number of firms by local government area. The total within the Greater Melbourne area is shown to highlight the concentration of electronics cluster firms within the City (ie. more than 80% of those firms of known Victorian location). Outside the Greater Melbourne area, Greater Geelong is the location of 57 of the firms identified, Ballarat 31, Greater Bendigo 27 and Wodonga 18.

Figure 4.4 Electronics industry clustering: Victoria



Source: Victorian Electronics Cluster Survey, Project Database (CSES). CSES Analysis.

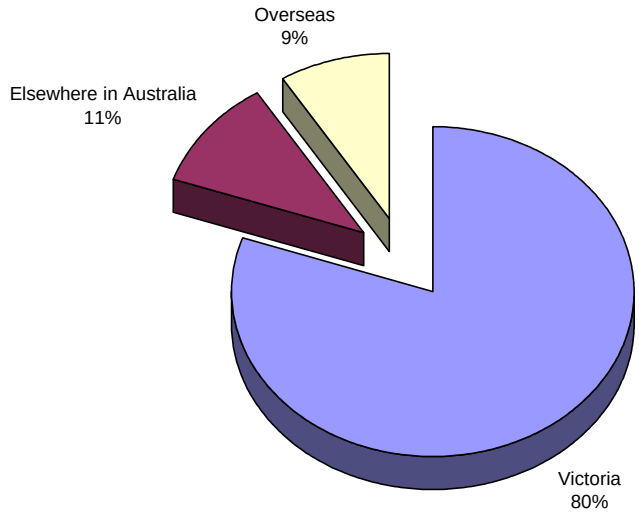
Appendix A contains a range of maps showing the location of Victorian Electronics Cluster firms by sector in the Greater Melbourne area. Because of the elimination of duplicate listings and sampling (rather than census) of non-core activities they are no more than indicative of the distribution of Victorian Electronics Cluster firms and activities.

4.3 Characteristics of firms in the electronics cluster

A questionnaire (Appendix C) was sent to almost 1,700 electronics cluster firms based in Victoria. Of the 98 respondents (6%), 75 were headquartered in Greater Melbourne and 15 in rural Victoria.[84] There were two firms based in Sydney, one each in Canberra and Brisbane, and four firms were headquartered overseas.

Responding firms earned a total of $1.64 billion during 2002-03 – an average revenue of $17.7 million per firm, up from $7.3 million in 1998-99. This suggests strong growth among this cohort of firms, with average revenues of respondents growing by 23% a year. Around 80% of the revenue earned by responding firms was derived from operations in Victoria, with a further 11% from operations elsewhere in Australia and 9% from overseas. Sixty-two firms reported earning all of their 2002-03 revenue in Victoria, 25 reported earning revenue elsewhere in Australia and 25 reported earning revenue overseas (Figure 4.5).

Figure 4.5 Location of revenue earnings, 2002-03 (per cent)



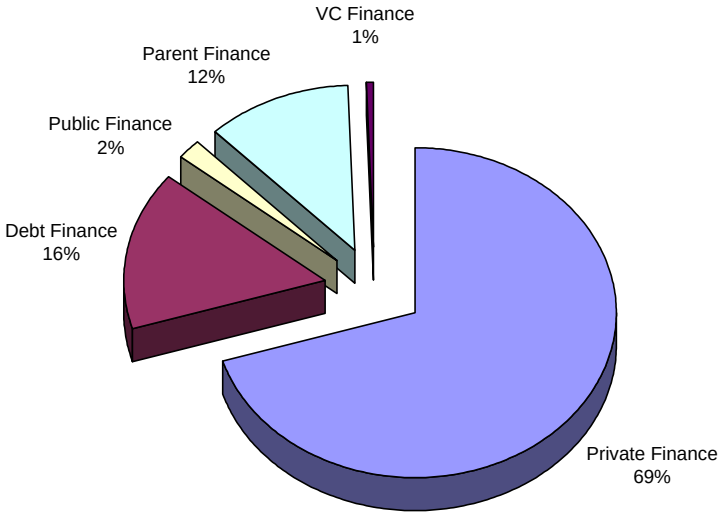
Source: Victorian Electronics Cluster Survey, Project Database (CSES).

[84] At around 6% the survey response rate was rather disappointing. However, it should be noted that the study was more ethnographic than statistical in nature (involving both survey and interviews), with the survey providing just one source of information. The material gathered from the survey was not used to generate estimates, but to provide more qualitative information about the nature and scope of cluster linkages. As such, it provided a valuable piece of the puzzle.

4.3.1 Source of financing

Most firms are financed privately, with 69% of reported financing coming from private equity (eg. self-financing, family, friends, partners, etc.). Around 12% of financing reported by respondents came from a parent firm, 2% from public financing (eg. stockmarket listing) and 16% from debt financing (eg. bank loans). Only 1% of reported funding came from venture capitalist or business angel investments (Figure 4.6). This confirms the findings of many other studies, which show that venture capital financing plays a relatively minor role.[85] It suggests that taxation policy might be a more productive focus for attention in the drive to encourage start-ups and early stage development.

Figure 4.6 Sources of finance for Victorian electronics firms (per cent)



Source: Victorian Electronics Cluster Survey, Project Database (CSES).

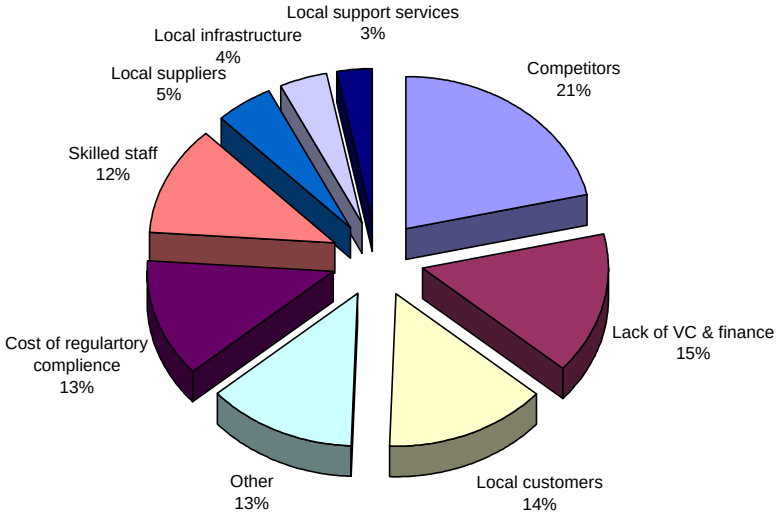
4.3.2 Barriers to growth

When looking at barriers to growth, those most cited by respondents were: strong competitors in particular markets (21% of total barriers mentioned), lack of venture capital and other finance (15%), lack of local customers (14%), cost of regulatory compliance (13%) and inability to access skilled staff (12%). Perhaps indicative of a relatively strong cluster base, lack of local suppliers, infrastructure and support services were rarely cited (Figure 4.7). There was no discernable pattern to the 'other' barriers mentioned, with nothing mentioned more than once. It

[85] Department of Employment, *Workplace Relations & Small Business* (1999) A Portrait of Australian Business, AGPS, Canberra. See also Thorburn, L. (2003) *Capitalising on the Strengths of the ACT Electronics Industry*, AEEMA, Canberra.

seems that there is strong competition for local customers, with access to capital and skilled staff and concerns over the costs of regulatory compliance among the main limiters to growth.

Figure 4.7 Barriers to growth of Victorian electronics firms (share of barrier citations)



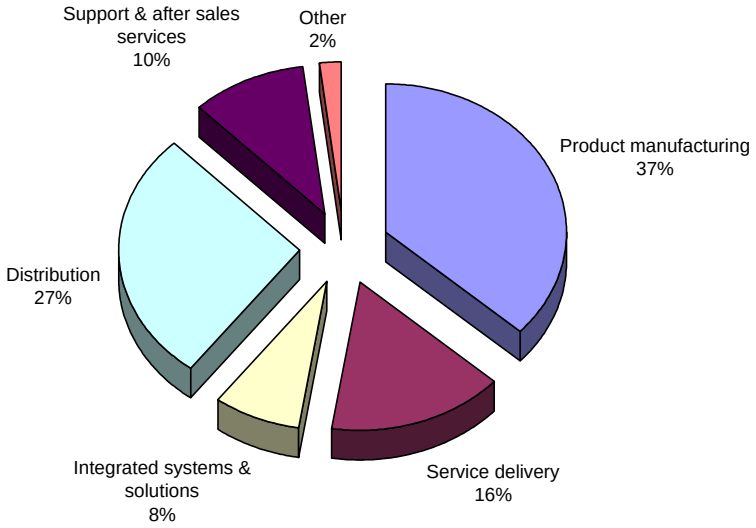
Source: Victorian Electronics Cluster Survey, Project Database (CSES).

4.4 Victoria's electronics cluster capabilities

The majority of revenue received by respondents came from manufacturing their own products (37%). The rest was derived from wholesale and retail distribution (27%), service delivery (16%), support and after sales services (10%), integrated systems and solutions (8%) and other activities (2%). The things included under 'other activities' were either to do with product development and the licensing of intellectual property or were not specified (Figure 4.8).

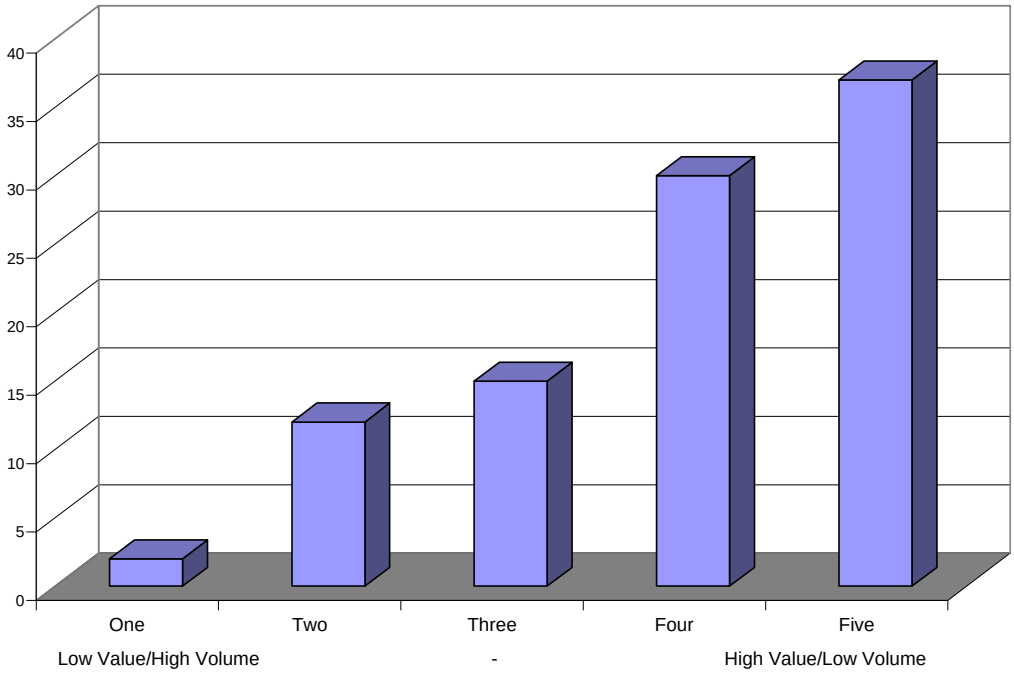
Looking at the revenue source mix within firms reveals a mix of activities. Fifty-seven respondents reported some revenue from product manufacture (58%), 44 reported revenue from wholesale and retail distribution activities (45%), 38 reported revenue from service delivery (39%), 37 reported revenue from after sales service and support (38%), 24 reported revenue from integrated systems and solutions (25%) and 4 firms mentioned other sources.

Figure 4.8 Source of revenue by activity (as a share of sales)



Source: Victorian Electronics Cluster Survey, Project Database (CSES).

Figure 4.9 Focus of activities by value and volume (number of responses)

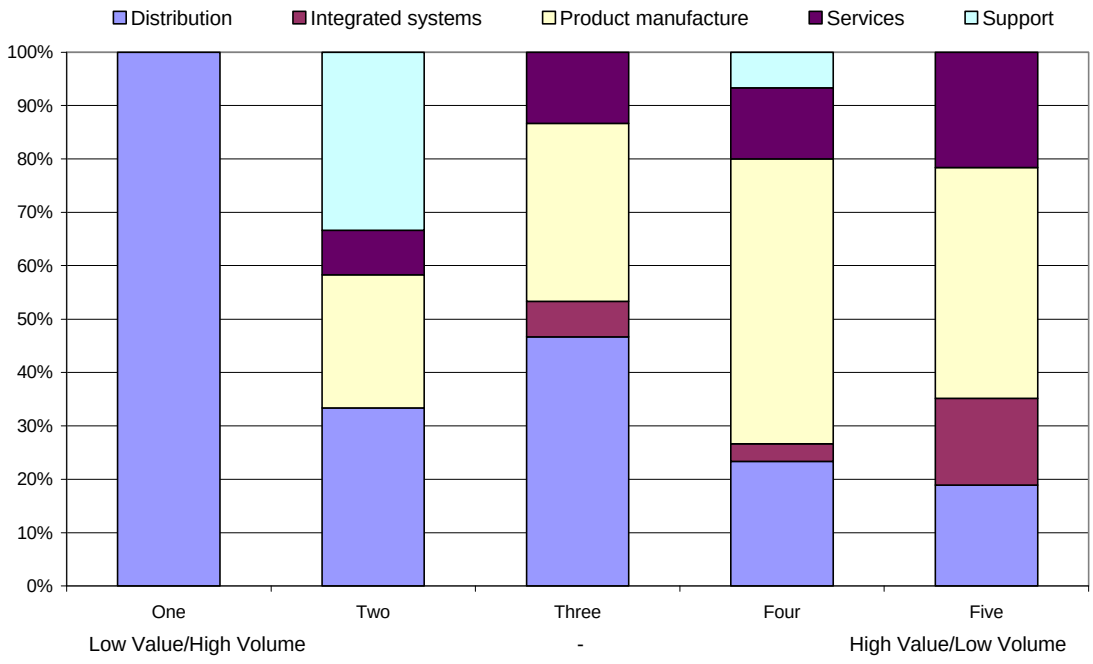


Source: Victorian Electronics Cluster Survey, Project Database (CSES).

Most respondents reported a focus on relatively High Value/Low Volume activities. When asked to place their firms activities on a continuum of volume and value, firms ranked an average of 3.9 on a Likert scale (where 1 = High Volume/Low Value and 5 = High Value/Low Volume). Two firms did not answer the question. Of the remainder, 70% of respondents (67) nominated rankings of 4 or 5 (ie. High Value/Low Volume), 15% or firms (14) nominated rankings of 1 or 2 (ie. Low Value/High Volume) and 16% (15) nominated the middle ranking (Figure 4.9).

The share of ranking on the Value-Volume scale by sector (defined by main source of sales revenue) reveals that product manufacturers are more likely to focus High Value/Low Volume activities, while wholesale and retail distributors tend to focus on Low Value/High Volume activities. Similarly, services and integrated systems and solutions providers tend to focus on activities towards the High Value/Low Volume end of the scale, whereas after sales service and support firms tend to focus on activities towards the Low Value/High Volume end. No less than 80% of the manufacturing firms chose ranks 4 or 5 on the scale (ie. High Value/Low Volume), whereas just 7.5% chose ranks 1 or 2 (ie. Low Value/High Volume) (Figure 4.10).

Figure 4.10 Value / Volume focus by sector

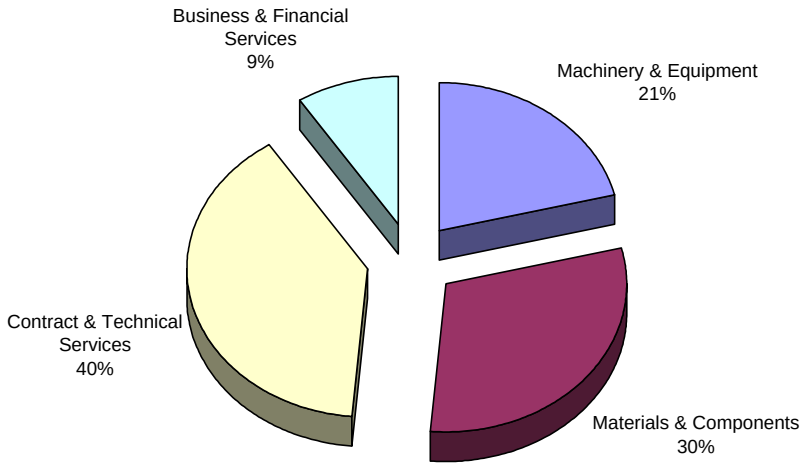


Source: Victorian Electronics Cluster Survey, Project Database (CSES).

4.4.1 Supply to electronics manufacturing

Forty respondents (41%) reported that they supplied products or services into electronics manufacturing. The largest supply grouping was contract and technical services (26 respondents), followed by materials and components (20), machinery and equipment (14) and business and financial services (6) (Figure 4.11).

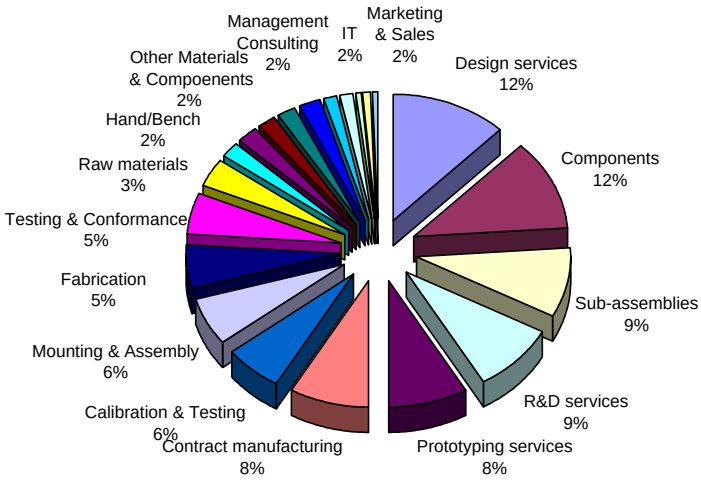
Figure 4.11 Supplies into electronics manufacturing (as a share of reported electronics manufacturing supply capabilities)



Source: Victorian Electronics Cluster Survey, Project Database (CSES).

Major electronic manufacturing supplies sourced from within the local Victorian industry cluster included: design services (18 respondents), components (17), sub-assemblies (13), R&D services (13), prototyping services (12), contract manufacturing (12), calibration and testing (9), mounting and assembly (9), fabrication (8) and testing and conformance (8) – suggesting local strengths in these areas. Other categories of supplies involved five or fewer firms (Figure 4.12).

Figure 4.12 Supplies into electronics manufacturing (as a share of reported electronics manufacturing supply capabilities)



Source: Victorian Electronics Cluster Survey, Project Database (CSES).

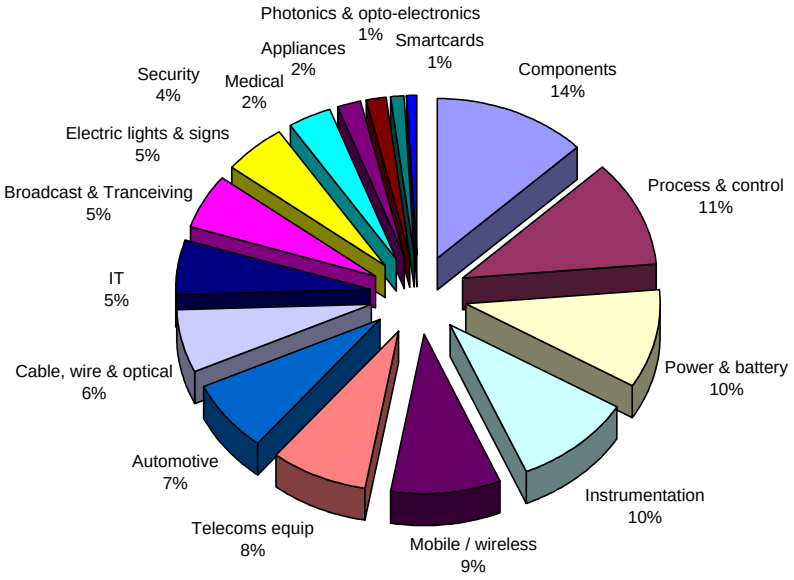
4.4.2 Electronics manufacturing

Fifty-five respondents (56%) reported electronics manufacturing activities. Among their main production capabilities were: components (14 respondents), process and control equipment (12), power and battery (11), instrumentation (11), mobile and wireless (10), other telecommunication equipment (9), automotive (8) and cable, wire and optical fibre (7) – suggesting manufacturing strengths and capabilities in these areas. There were fewer manufacturers of other categories of electronics (six or fewer) (Figure 4.13).

Firms were asked to rank their Top 3 manufacturing activities. A *weighted ranking* of reported capabilities reveals a greater emphasis on: process control, instrumentation, communications (fixed and mobile), power and battery, and automotive equipment (Figure 4.14).[86]

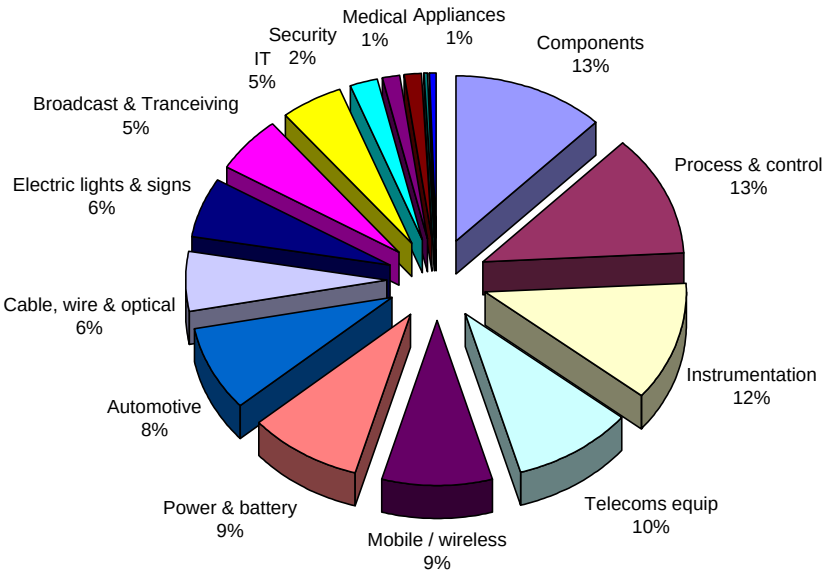
[86] Respondents were asked to rank their top 3 activities from 1=most important. A weighted ranking is produced by scoring the ranking in reverse order, summing the scores and expressing the sums as a percentage of the total score.

Figure 4.13 Electronics manufacturing activities (as a share of reported manufacturing capabilities)



Source: Victorian Electronics Cluster Survey, Project Database (CSES).

Figure 4.14 Electronics manufacturing activities (as a share of a weighted ranking reported supply capabilities)

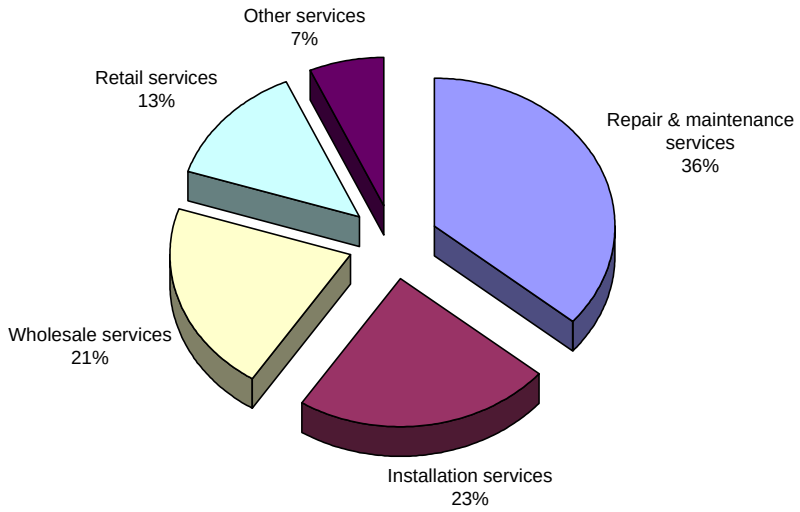


Source: Victorian Electronics Cluster Survey, Project Database (CSES).

4.4.3 Electronics related services

Forty-eight firms (49% of respondents) reported that they provided electronics services. Major services activities included: repair and maintenance (38 respondents), installation services (24), wholesale services (22), retail services (14) and other services (7). These 'other services' included: design services (4) and engineering and consulting (3).

Figure 4.15 Electronics related services activities (as a share of reported services capabilities)



Source: Victorian Electronics Cluster Survey, Project Database (CSES).

4.4.4 Export capabilities and activities

Fifty-one per cent of respondents exported during 2003 (50 firms). Of these, 31 firms (62% of exporters) reported exporting to a second market and 14 (28%) reported exporting to a third market. Exporters reported a relatively high share of export sales, suggesting that their top three markets accounted for 38% of sales – 21% to their primary market, 9.5% to their second market and 7.5% to their third market.

The most commonly cited *primary* overseas market was New Zealand (cited by 15 firms), the United States (cited by 10) and Asia (cited by 10, and including China, Indonesia, Sri Lanka, Thailand and Vietnam). These were followed by the United Kingdom and Europe (cited by 9 firms), the Middle East (cited by 4) and Papua New Guinea (cited by 1). Average sales to these export markets were quite high – 45% of turnover to Saudi Arabia for firms who exported there,

43% of turnover to the United States, 42% to China, 16% to the United Kingdom, 15% to Germany and 13% to New Zealand.

Asia was the most frequently mentioned *second* market (cited by 12 firms, and including China, India, Indonesia, Malaysia, Singapore and South Korea), followed by the United Kingdom and Europe (cited by 9 firms), the United States (5 firms), New Zealand (3 firms) and the United Arab Emirates (1 firm).[87]

Table 4.5 Principal export markets reported by exporting firms

Primary Market	Exporting Firms	Secondary Market	Exporting Firms
New Zealand	15	US	5
US	10	UK	4
China	4	China	3
Middle East	3	Singapore	3
Sweden	3	New Zealand	3
Indonesia	2	Germany	2
UK	2	Europe	2
Vietnam	2	Italy	1
France	1	Asia	1
Russia	1	Elsewhere	1
Saudi Arabia	1	Malaysia	1
Sri Lanka	1	South Korea	1
Thailand	1	Indonesia	1
Germany	1	India	1
North America	1	South East Asia	1
PNG	1	UAE	1
Ireland	1		
	50		*31*

Source: Victorian Electronics Cluster Survey, Project Database (CSES).

The most common method of managing exporting was through overseas distributors (cited 35 times by the exporting firms), and exporting directly with customers overseas (cited 31 times). Operating through their own offices overseas was cited 13 times, and internet or electronic delivery was cited 12 times. Other methods were rarely cited.[88]

These findings suggest a range of exporting capabilities covering a wide range of markets. Those exporting often have a significant export focus, with exports accounting for a high share of sales. That more than 50% of responding firms exported during 2002-03 demonstrates strong export competitiveness. The extensive use of distributors and of direct links to export customers emphasises the importance of demand-side supply chain linkages. That almost 25% of exporting firms cited the use of internet and/or electronic delivery of their exports suggests an active adoption of new methods and a strong base capability for the development of global electronic trading activities.

87 One firm did not specify the country to which it exported.

88 Respondents were able to nominate more than one method. It should be noted that these findings are based on exports to their top 3 customers only.

Table 4.6 Methods of managing exports (citation counts by method)

Method of managing exporting	Count
Overseas Distributors	35
Directly with customers overseas	31
Own office(s) overseas	13
Internet/electronic delivery	12
With local Australian office of multinationals	3
JVs with organizations overseas	0
Enter alliances with multinational firms overseas	3
Other	3

Source: Victorian Electronics Cluster Survey, Project Database (CSES).

4.5 Victoria's electronics product system

Respondents were asked about their three most important suppliers and customers. They reported on 269 suppliers and 263 customers. Detailed analysis of their responses reveals a good deal about their supply chain and product system linkages. This section examines transactional linkages (ie. those involving payments for and transfers of goods and services). Non-transactional product system linkages involving information flows, innovation and skills are explored in subsequent sections.

4.5.1 Supplier linkages and locations

Fifty-six per cent of respondents' suppliers were located in Victoria, 26% were located overseas and 16% were located elsewhere in Australia (Figure 4.16). The locational distribution of suppliers varies little between the Top 3 suppliers.

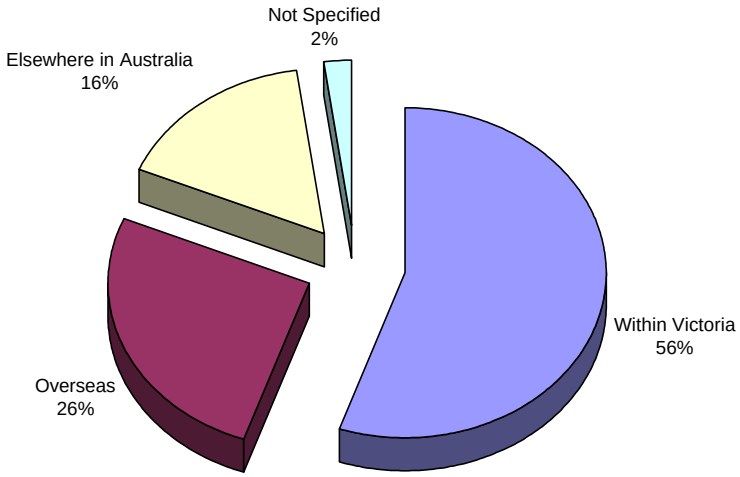
Table 4.7 Location of Top 3 suppliers (count of suppliers by location)

Location	S1	S2	S3	Top 3
Within Victoria	52	51	46	149
Overseas	25	22	23	70
Elsewhere in Australia	16	16	12	44
Not Specified	2	2	2	6
All Locations	*95*	*91*	*83*	*269*

Source: Victorian Electronics Cluster Survey, Project Database (CSES).

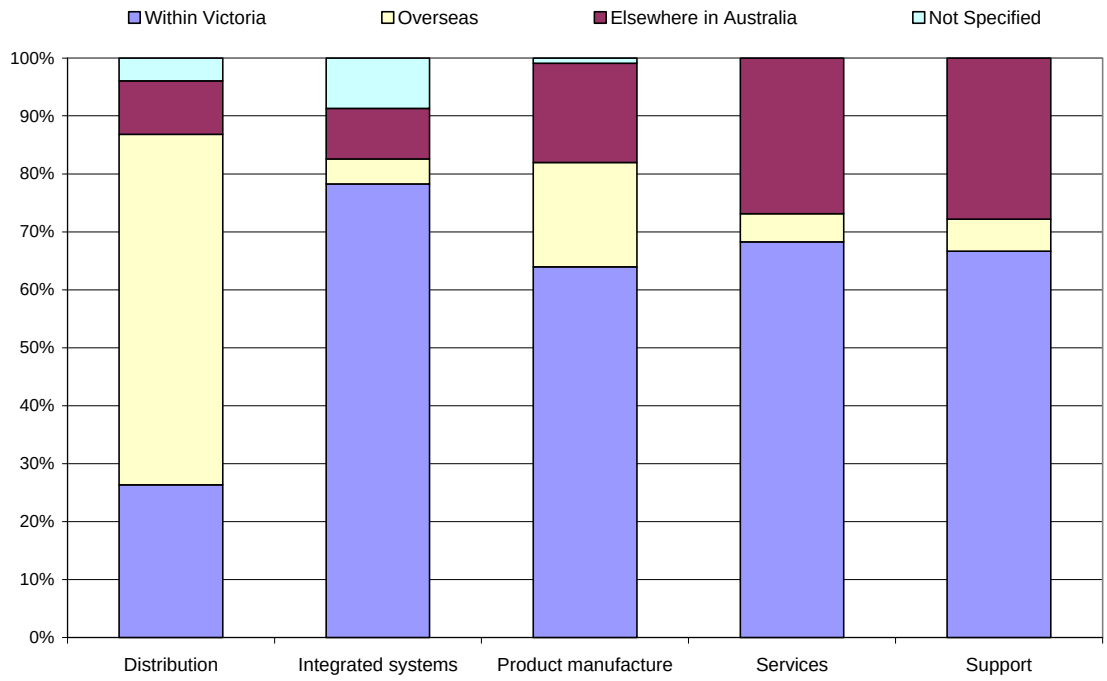
Respondent firms whose primary activity was wholesale and retail distribution, indicated that more than half (61%) of their suppliers were located overseas, suggesting that these firms are primarily importing goods from overseas and selling them in Australia. Conversely, services and support firms reported few overseas suppliers (around 5% of their suppliers were located overseas). Manufacturing firms reported the most even locational distribution of suppliers, with 64% of product manufacturers' suppliers located within Victoria, 17% located elsewhere in Australia and 18% overseas (Figure 4.17). This reflects both the need for imported materials and components, and relatively strong local and national supply chain linkages.

Figure 4.16 Locations of Top 3 suppliers (count of suppliers by location)



Source: Victorian Electronics Cluster Survey, Project Database (CSES).

Figure 4.17 Locations of Top 3 suppliers by sector (count of suppliers by location)

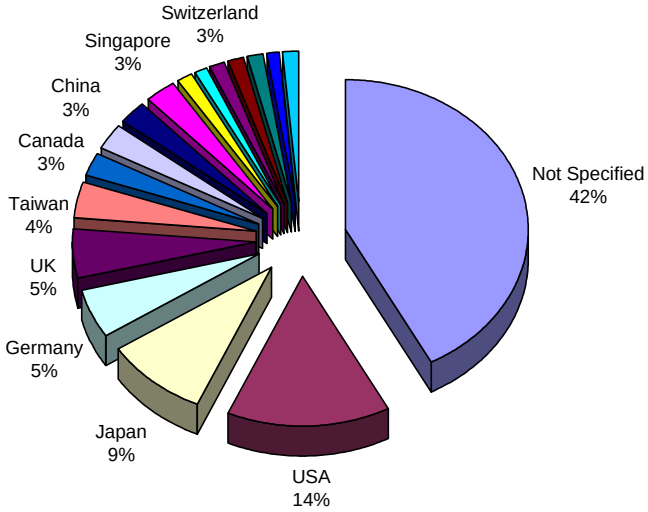


Source: Victorian Electronics Cluster Survey, Project Database (CSES).

Some 124 different suppliers' names were mentioned, with respondents preferring to keep the names of their suppliers confidential in other cases. There was no obvious clustering of supply firms or regular mention of particular names. The most commonly mentioned suppliers were: Farnell (mentioned by 3 respondents), Jaycar (3), Duet Electronics (3), Melbourne Printed Circuits (3), Precision (3), Active (2), Altronics (2), Ashdown (2), Arrow (2), Electus (2), Yazaki (2) and Radio Parts (2). Confidentiality concerns made it difficult to identify major suppliers, although given the range of activities covered such clustering would necessarily have been limited.

Overseas supplier locations reflect the scope and direction of international supply network linkages. Of those overseas suppliers for which a location was specified the major locations included: the United States, Japan, Germany, United Kingdom, Taiwan, China, Canada and Singapore (Figure 4.18).

Figure 4.18 Location of Top 3 overseas suppliers (count of suppliers by location)



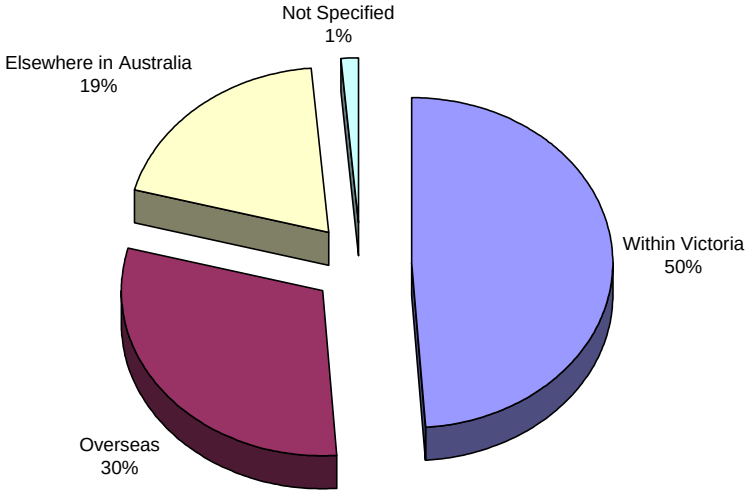
Countries with 1% or less: Italy, Sweden, New Zealand, Indonesia, Thailand, Malaysia & Somoa

Source: Victorian Electronics Cluster Survey, Project Database (CSES).

Looking at location of suppliers by share of supply costs reveals a similar picture. The Top 3 suppliers located within Victoria accounted for 50% of total Top 3 supplier supplies by value (ie. as a share of total supply costs), those located overseas accounted for 30% and those located elsewhere in Australia accounted for 19% (Figure 4.19).

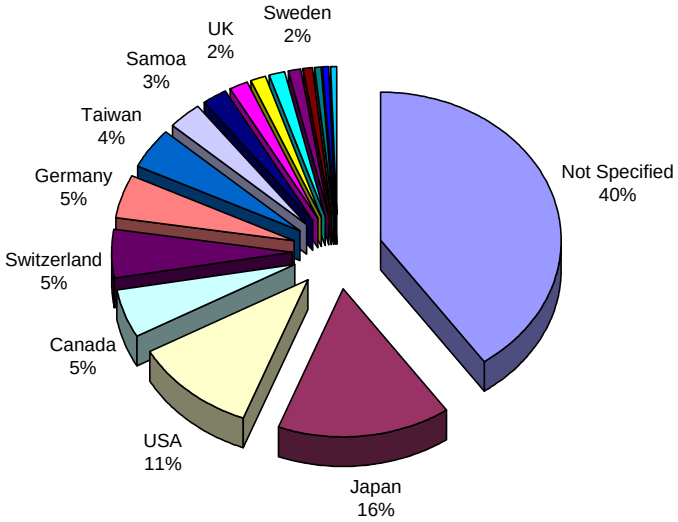
The location of overseas suppliers was not always specified, but of those for which a location was specified Japan, the United States, Canada, Switzerland, Germany and Taiwan were the locations to account for the largest shares of Top 3 supplier supplies by value (Figure 4.20).

Figure 4.19 Location of Top 3 suppliers by supply costs (percentage of supply costs)



Source: Victorian Electronics Cluster Survey, Project Database (CSES).

Figure 4.20 Location of Top 3 overseas suppliers by supply costs (percentage of supply costs)



Countries with 1% or less: Indonesia, Italy, Singapore, China, Malaysia, New Zealand & Thailand

Source: Victorian Electronics Cluster Survey, Project Database (CSES).

4.5.2 Supply-side concentration

The supply network appears to be relatively concentrated, with primary suppliers accounting for a reported 40% of supplies by value, secondary suppliers for a further 36% and tertiary suppliers for a further 23% – suggesting that the Top 3 suppliers account for 99% of total supply costs. However, 22 respondents reported that their Top 3 suppliers accounted for 100% of supply costs. These firms may have considered suppliers to be only those firms who provide tangible goods and/or production inputs.[89] Ignoring these responses, the remaining 71 reported that their Top 3 suppliers accounted for between 14% and 98% of total supply costs – still suggestive of significant supply-side concentration.

Table 4.8 shows that, on average, 55% of supply costs for after sales service and support firms are accounted for by their primary supplier (the highest percentage of any of the sectors), 18% by their second most prominent supplier and 11% by their third. In total, the Top 3 suppliers to support firms account for 84% of their total supply costs. Wholesale and retail distributors also depend upon relatively few suppliers, with their Top 3 suppliers accounting for 81% of supply costs and their principal supplier for almost 53%. Manufacturers and services firms face a somewhat less concentrated supply network. In the case of manufacturers this reflects the use of a range of supplies.

Table 4.8 Percentage of supplies from Top 3 Suppliers by sector (percentage of supply costs)

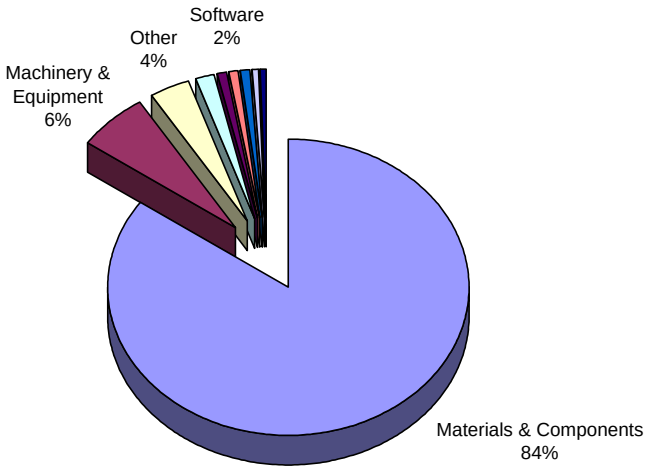
Sector	Supplier 1	Supplier 2	Supplier 3	Top 3 Suppliers
Support	55%	18%	11%	84%
Distribution	53%	18%	10%	81%
Services	38%	21%	14%	74%
Integrated systems	39%	19%	13%	70%
Product manufacture	33%	17%	10%	59%
All	41%	18%	11%	70%

Source: Victorian Electronics Cluster Survey, Project Database (CSES).

Looking at the supplies provided by the Top 3 suppliers it is clear that materials and components predominate, accounting for more than 80% of all Top 3 supplier supplies by value. Machinery and equipment comes a distant second as a supply category, accounting for just 6% of Top 3 supplier supplies by value (Figure 4.21). This reflects the proportion of manufacturers in our sample, as well as the importance of materials and components inputs.

[89] Alternatively, these firms have misread the question and have adjusted the figures so their answers added to 100%. These same firms also reported that their top 3 customers account for 100% of their sales.

Figure 4.21 Items supplied by Top 3 suppliers by cost (share of supply costs)



Accounting for 1% or less: Technical Services, Banking & Financial Services, and IT Software & Services

Source: Victorian Electronics Cluster Survey, Project Database (CSES).

4.5.3 Customer linkages and locations

Fifty-one per cent of the 263 Top 3 customers mentioned by respondents were located within Victoria, with 33% located elsewhere in Australia and 15% located overseas (Figure 4.22). The locational distribution of customers varies little between the Top 3 (Table 4.9).

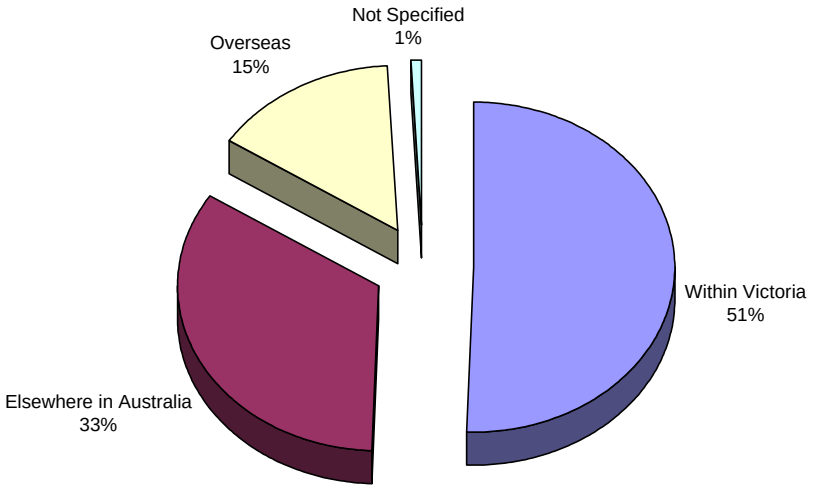
Table 4.9 Location of Top 3 customers (count of customers by location)

Location	C1	C2	C3	Top 3
Within Victoria	54	40	39	133
Elsewhere in Australia	28	33	27	88
Overseas	11	16	13	40
Not Specified	0	0	2	2
All Locations	93	89	81	263

Source: Victorian Electronics Cluster Survey, Project Database (CSES).

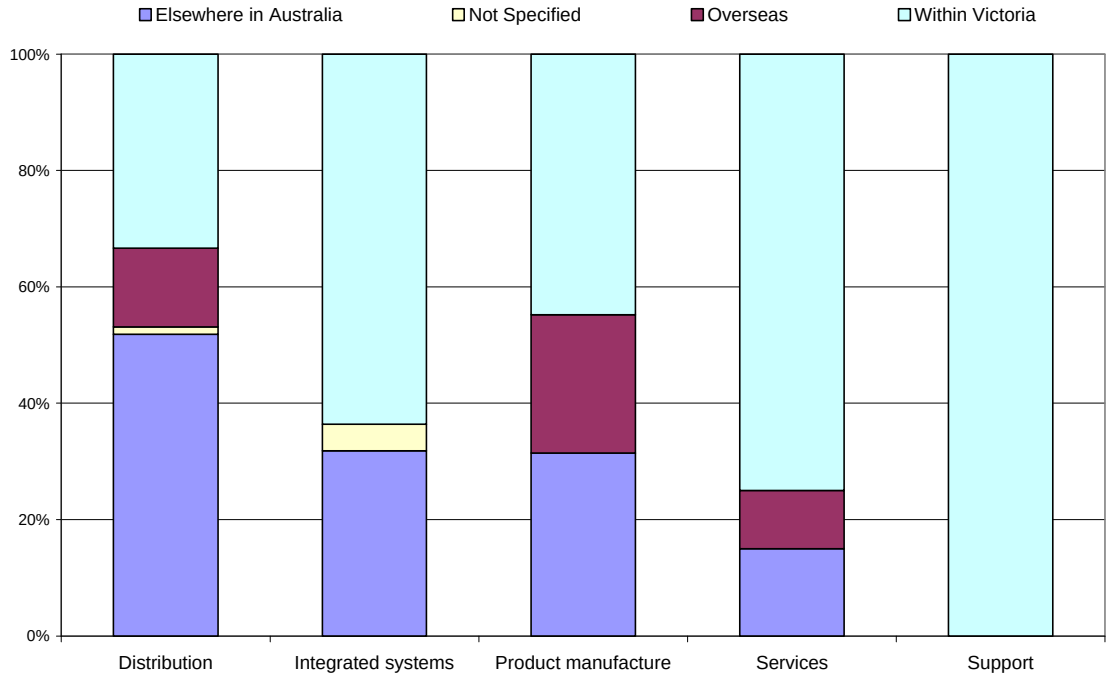
Product manufacturers were most likely to have customers overseas (24% of their Top 3 customers). Wholesale and retail distributors were the only sector to nominate a higher numbers of customers elsewhere in Australia than in Victoria. Not surprisingly, services

Figure 4.22 Locations of Top 3 customers (count of customers by location)



Source: Victorian Electronics Cluster Survey, Project Database (CSES).

Figure 4.23 Location of Top 3 customers by sector (count of customers by location)



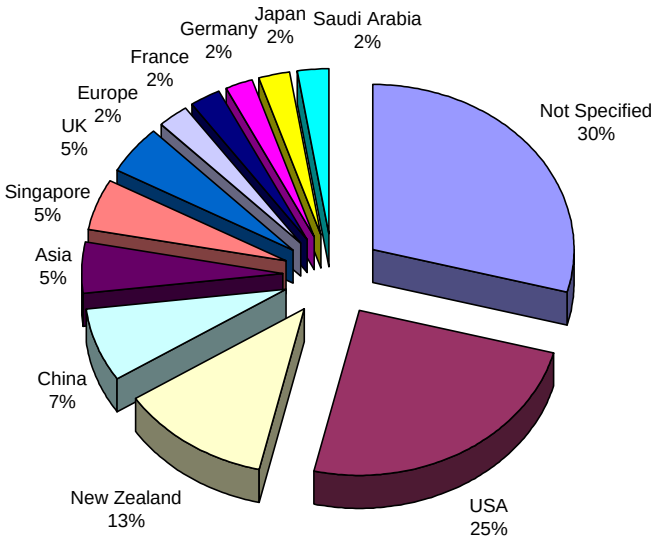
Source: Victorian Electronics Cluster Survey, Project Database (CSES).

providers reported a strong concentration of local customers – services providers reported 75% of Top 3 customers within Victoria, and after sales service and support firms reported that all of their top3 customers were within Victoria (Figure 4.23). Customers are more local than are suppliers.

Seventy-one different customers names were given, with respondents preferring not to name their major customers in other cases. Of those named, the only customers mentioned more than once were: the Defence Department, Holden, NSW State Rail, NEC, Siemens, Telstra, and Toyota (twice each). Again confidentiality concerns played a part in making it difficult to identify lead customers and clients.

Overseas customer locations reveal information about cluster supply capabilities. Many respondents did not specify customer locations, but those that did cited the United States (25% of overseas Top 3 customers), New Zealand (13%), China (7%), Singapore, other Asia (not specified) and the United Kingdom (5%) (Figure 4.24).

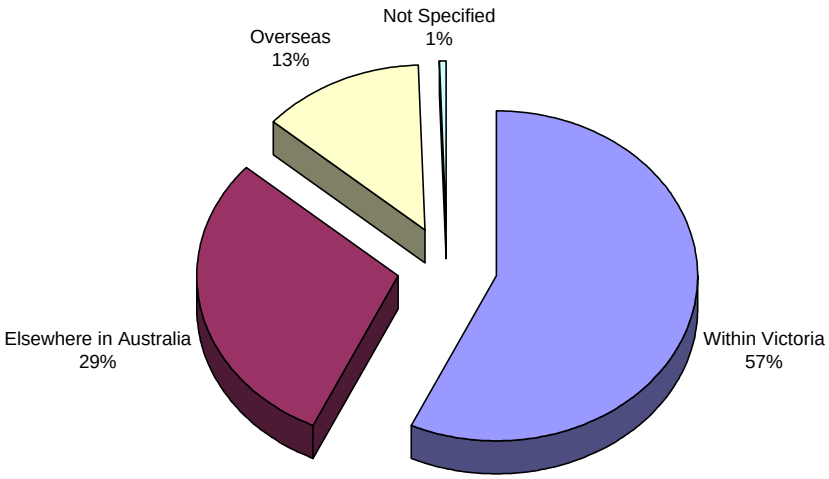
Figure 4.24 Location of Top 3 overseas customers (number of customers by location)



Source: Victorian Electronics Cluster Survey, Project Database (CSES).

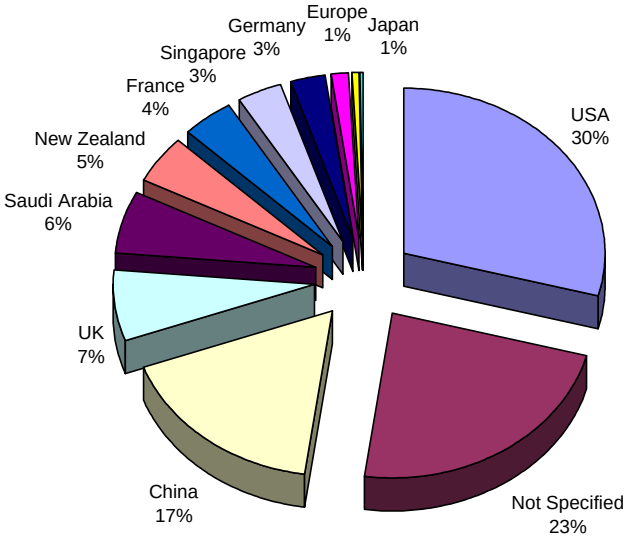
Looking at the location of customers by sales revenue reveals a broadly similar picture. The Top 3 customers located within Victoria accounted for 57% of total Top 3 customer sales revenues (ie. as a share of the sum of average sales revenues), those located elsewhere in Australia accounted for 29% and those located overseas (ie. export customers) accounted for 13% (Figure 4.25).

Figure 4.25 Location of Top 3 customers by sales revenues (percentage of sales)



Source: Victorian Electronics Cluster Survey, Project Database (CSES).

Figure 4.26 Location of Top 3 overseas customers by sales revenues (percentage of sales)



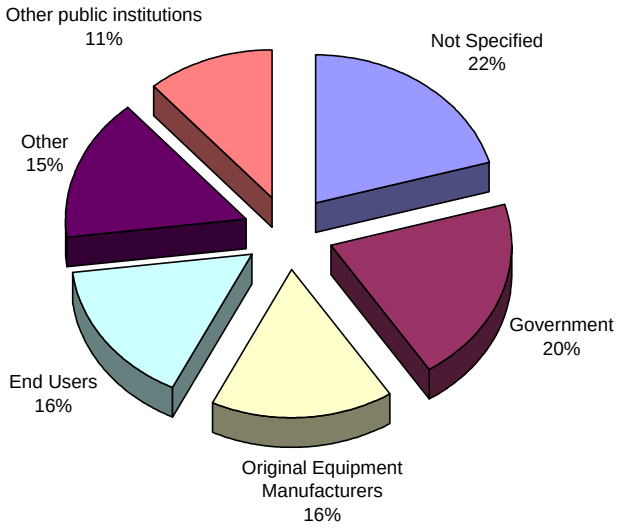
Source: Victorian Electronics Cluster Survey, Project Database (CSES).

The location of those overseas customers was not always specified, but those for which a location was specified included: the United States (30%), China (17%), United Kingdom (7%), Saudi Arabia and New Zealand (Figure 4.26). Again, relatively broad and deep export linkages are apparent.

4.5.4 Demand-side concentration

The Top 3 customers accounted for between 8% and 98% of sales for 74 of the respondents, while 19 respondents reported that their Top 3 customers accounted for 100% of their sales revenue. Table 4.10 shows that the Top 3 customers for services firms accounted for the greatest percentage of sales revenue (74%). Distributors, however, were more likely to have a greater range of customers, with their Top 3 customers accounting for less than half (44%) of their sales revenue and the primary customer accounting for just 25%. Evidently, demand-side concentration is somewhat lower than supply-side concentration.

Figure 4.27 Types of customers among Top 3 by value of sales (percentage of sales)



Source: Victorian Electronics Cluster Survey, Project Database (CSES).

The distribution of customers within the Top 3 by type shows the range of markets into which Victorian electronics cluster firms sell. By value of sales, government (20% of Top 3 customers' average sales values), OEMs (16%), business and household end users (16%) and other public organizations (11%) are the major customer types (Figure 4.27).

Table 4.10 Percentage of sales Top 3 customers by sector (percentage of sales)

Sector	Customer 1	Customer 2	Customer 3	Top 3 Customers
Services	46%	19%	9%	74%
Integrated systems	44%	15%	6%	65%
Product manufacture	40%	14%	11%	65%
Support	26%	20%	10%	56%
Distribution	25%	12%	7%	44%
All	36%	15%	9%	60%

Source: Victorian Electronics Cluster Survey, Project Database (CSES).

4.5.5 Power and governance in the supply chain

Respondents were asked about the presence of a dominant supplier in the supply chain. Overall, 52% said there was no dominant player and 48% said there was (Table 4.11). Distributors were the most likely to say that there was a dominant player – firms mentioned included: Allen Bradley, Panasonic, Phillips and Yazaki. More than half of the services providers also reported that there was a dominant player. Firms dominating supply chains that were mentioned by the non-distribution firms included: Avocent, GME, Invetech, ICOM, Perkin Elmer, Protel, RF, Rockwell Automation, Roland Japan, Siemens, SMC Pneumatics and Telstra. However, these firms were only mentioned once. Thirteen of the firms mentioned as dominant in the supply chain were multinationals and three were indigenous Australian firms.

Table 4.11 Presence of a dominant player in the supply chain (per cent)

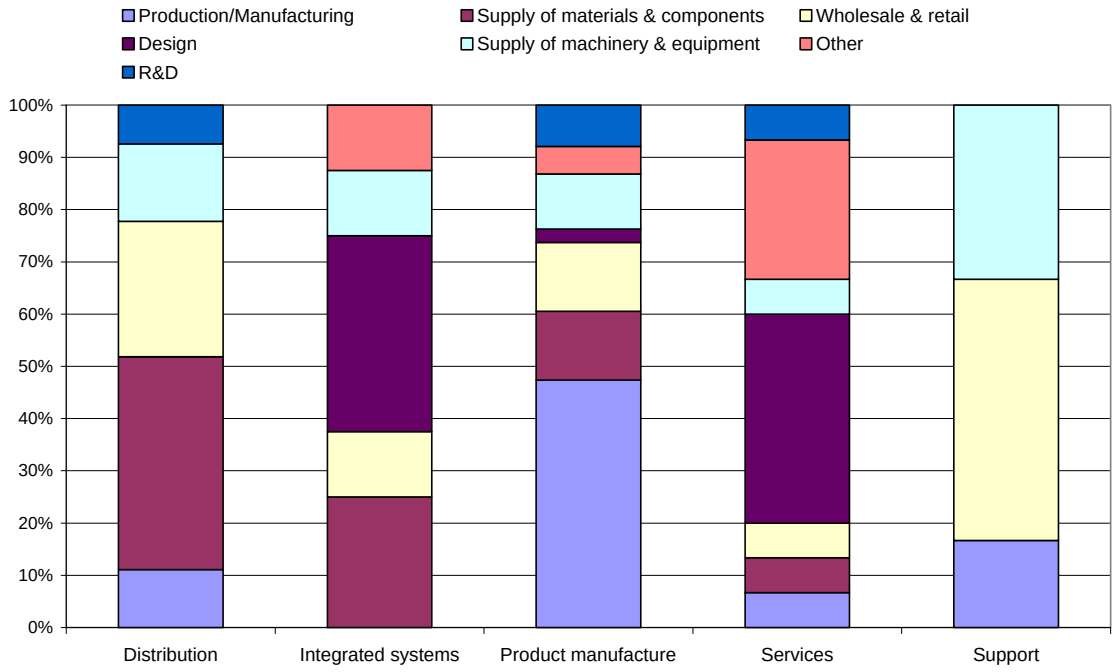
Sector	No	Yes
Distribution	36	64
Integrated systems	63	38
Product manufacture	60	40
Services	47	53
Support	71	29
Total	*52*	*48*

Source: Victorian Electronics Cluster Survey, Project Database (CSES).

Respondents were also asked to identify the location of value in the supply chain, that is, where "the money is made". The most frequently mentioned location of value was production / manufacturing, followed by supply of materials and components. Different types of firms reported different sources of value in their supply chains (Figure 4.28). Distributors claimed that the value lies in the supply of materials and components, followed by wholesale and retail. Integrated systems firms claimed design to be the most valuable link in the supply chain, as did service firms. Product manufacturers most frequently nominated production / manufacturing as the key source of value, while support firms listed the fewest number of options – with wholesale and retail being the primary source of value they nominated, followed by supply of

machinery and equipment, and production / manufacturing. Perhaps surprisingly, none of the respondents thought that supply chain value lay in branding and marketing.

Figure 4.28 Sources of value in the supply chain by sector

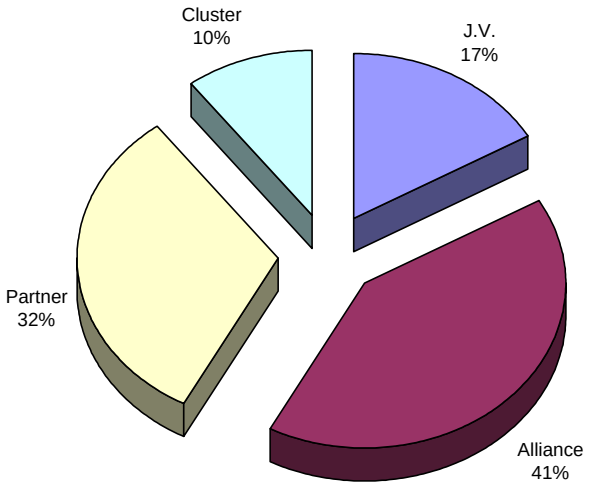


Source: Victorian Electronics Cluster Survey, Project Database (CSES).

4.6 Non-transactional cluster linkages

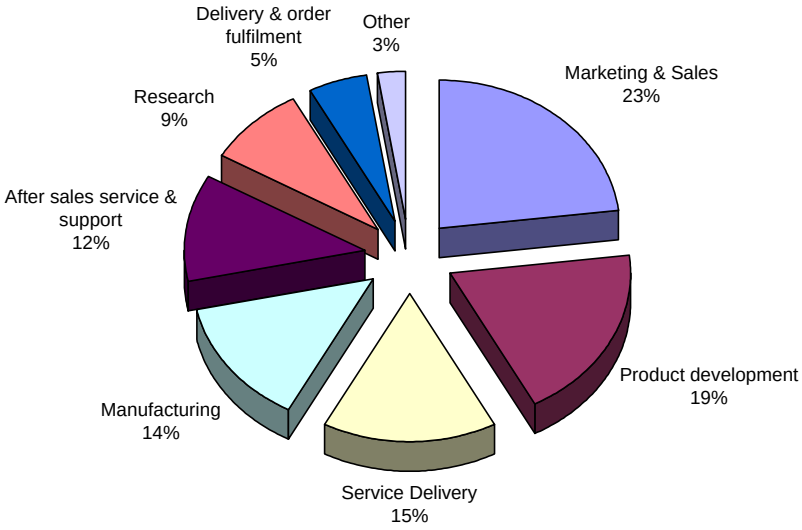
There are various types of linkages that firms engage in, outside the immediate supply chain linkages discussed above, which can play a vital role in the overall electronics product system. Thirty-six of the 98 respondents (37%) reported they were involved in some form of linkage with another company or organization (eg. a joint venture, alliance, partnering or cluster relationship). Seventy-eight links were reported in total (Table 4.12). Alliance relationships were the most common, with 41% of those firms reporting linkages involved in alliances, compared with 32% involved in partnering, 17% in joint ventures and just 10% reporting an involvement in formal cluster linkages (Figure 4.29).

Figure 4.29 Types of linkages (percentage of reported links)



Source: Victorian Electronics Cluster Survey, Project Database (CSES).

Figure 4.30 Purpose of linkages (percentage of reported links)



Source: Victorian Electronics Cluster Survey, Project Database (CSES).

The primary purpose of forming the linkage relationships reported by respondents was marketing and sales, which accounted for 23% of all the linkages reported. Product development was the second most widely cited purpose, accounting for 19% of the reported linkages. These were followed by: service delivery 15%, manufacturing 14%, after sales service and support 12% and research 9% (Figure 4.30). The most commonly mentioned linkages by type and purpose were: product development alliances (12%) followed by marketing and sales partnerships (10%). These results show the importance and range of product system linkages for Victorian electronics cluster firms.

Table 4.12 Count of linkages by type and purpose (number of reported links)

Linkage Type	J.V.	Alliance	Partner	Cluster	Total
Marketing & Sales	2	5	8	3	18
Product development	3	9	3	0	15
Service Delivery	1	4	4	3	12
Manufacturing	4	3	3	1	11
After sales service & support	1	3	4	1	9
Research	2	5	0	0	7
Delivery & order fulfilment	0	1	3	0	4
Other	0	2	0	0	2
Total	*13*	*32*	*25*	*8*	*78*

Source: Victorian Electronics Cluster Survey, Project Database (CSES).

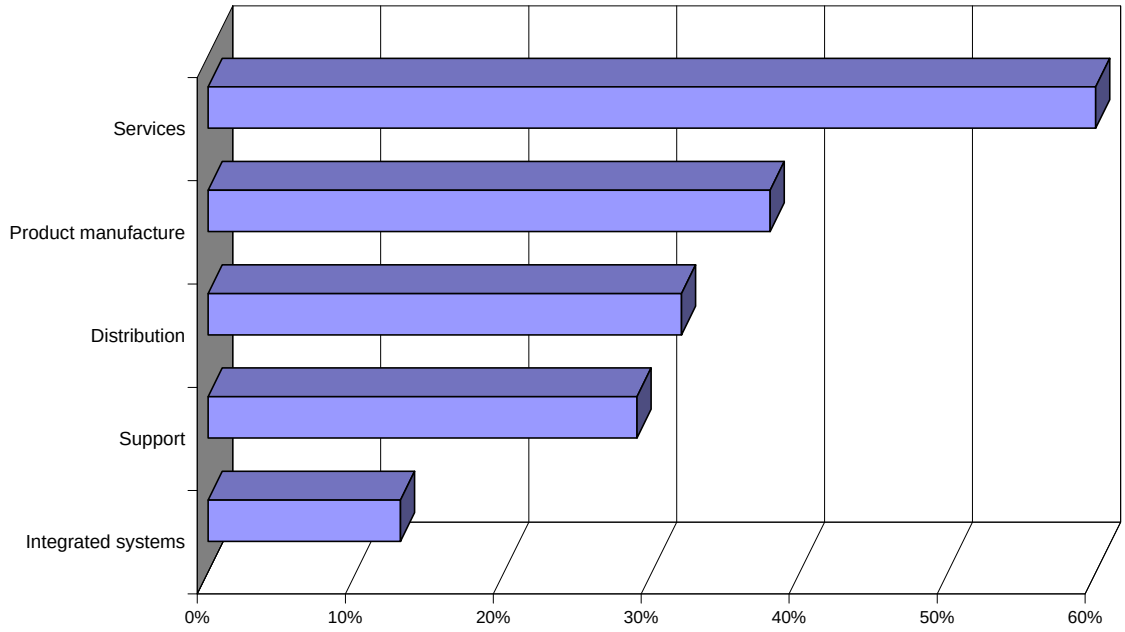
Table 4.13 shows that more than half the services firms (60%) reported links, compared with just over one-third of the product manufacturers (38%), almost one-third of the distributors (32%), 29% of the support firms and just 13% of the integrated systems suppliers. Support firms had the densest links with an average of 4 links per firm. This reflects the frequency of outsourced after sales and support services among international equipment manufacturers.

Table 4.13 Count of links by sector (number of reported links)

Sector	J.V.	Alliances	Partners	Clusters	Total Links	Share of total firms
Distribution	0	5	9	1	15	32%
Integrated systems	0	0	2	1	3	13%
Product manufacture	8	20	5	1	34	38%
Services	1	6	6	5	18	60%
Support	4	1	3	0	8	29%
Totals	*13*	*32*	*25*	*8*	*78*	*33%*

Source: Victorian Electronics Cluster Survey, Project Database (CSES).

Figure 4.31 Linkages by sector (percentage firms reporting links)



Source: Victorian Electronics Cluster Survey, Project Database (CSES).

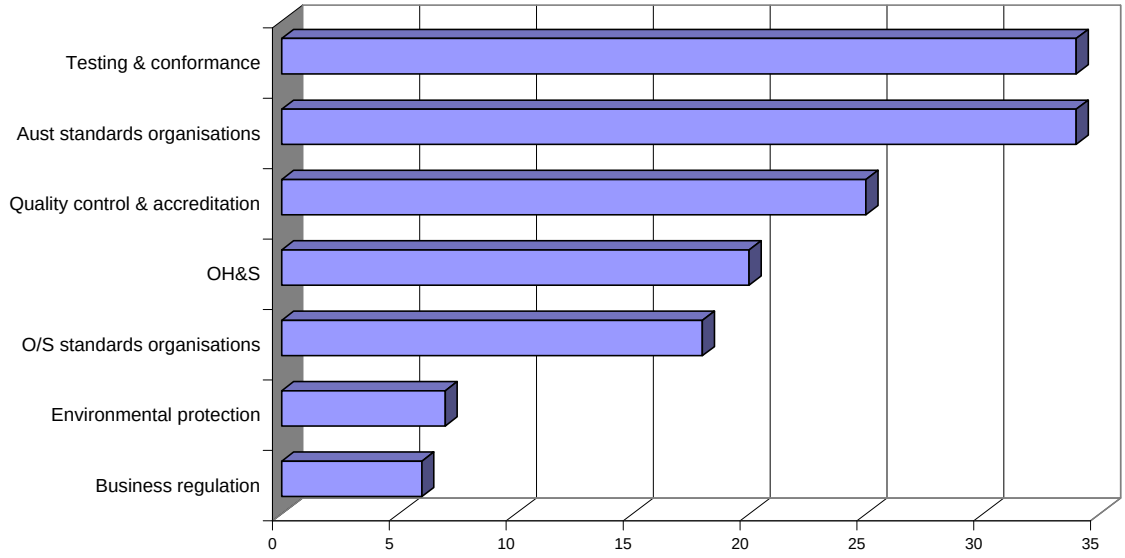
When asked whether their firm has close and/or regular interactions with other organizations, firms reported an average of 1.5 occurrences for standards and compliance (149 occurrences of such linkages in total), and an average of 1.4 occurrences for support and development (137). The most commonly cited *standards and compliance* relationships were: with Australian standards organizations (34), and testing and conformance (34) (Figure 4.32). When combined with the occurrences of linkages relating to overseas standards organizations (18) the importance of standards issues for electronics cluster firms is apparent.

Table 4.14 Regular linkages and interaction (number of links)

Standards & Compliance	Count	Support & Development	Count
Aust standards organizations	34	Industry Groups	33
Testing & conformance	34	Business Networks	24
Quality control & accreditation	25	R&D	22
OH&S	20	Education & training	19
O/S standards organizations	18	Fed Govt Programs	18
Environmental protection	7	State Govt Programs	15
Business regulation	6	Support & Development Other	1
Standards & Compliance Total	*149*	*Support & Development Total*	*137*

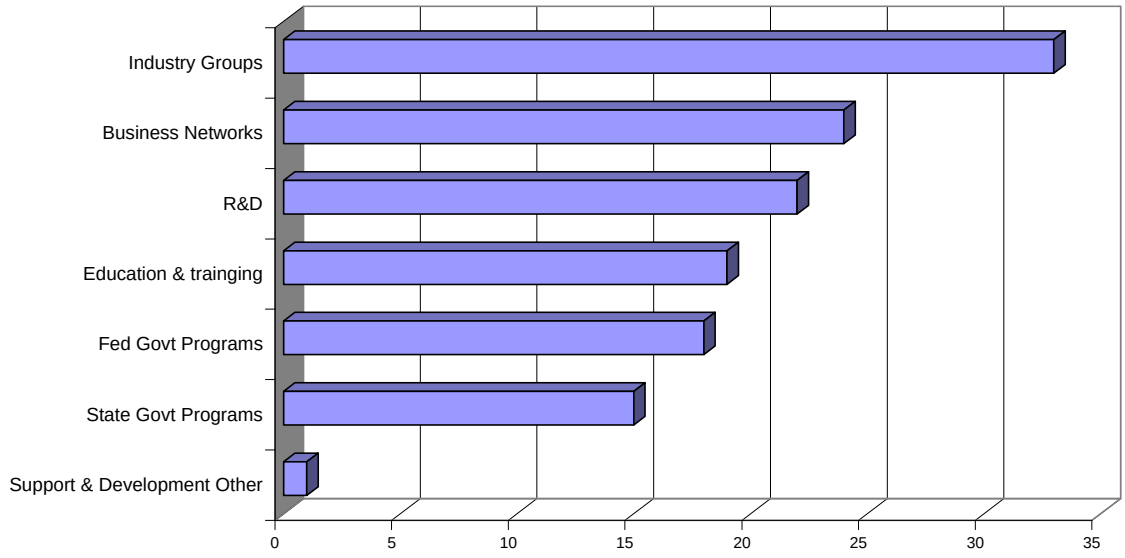
Source: Victorian Electronics Cluster Survey, Project Database (CSES).

Figure 4.32 Standards and compliance related linkages (number of links)



Source: Victorian Electronics Cluster Survey, Project Database (CSES).

Figure 4.33 Support and development related linkages (number of links)



Source: Victorian Electronics Cluster Survey, Project Database (CSES).

For *support and development*, the most common linkages were with industry groups (33), followed by business networks (24), R&D (22), education and training (19) and government programs (33) – for both State and Commonwealth governments (Figure 4.33). These data show both the extent and complexity of electronics cluster relationships and reveal something of the focus of cluster and network relationships.

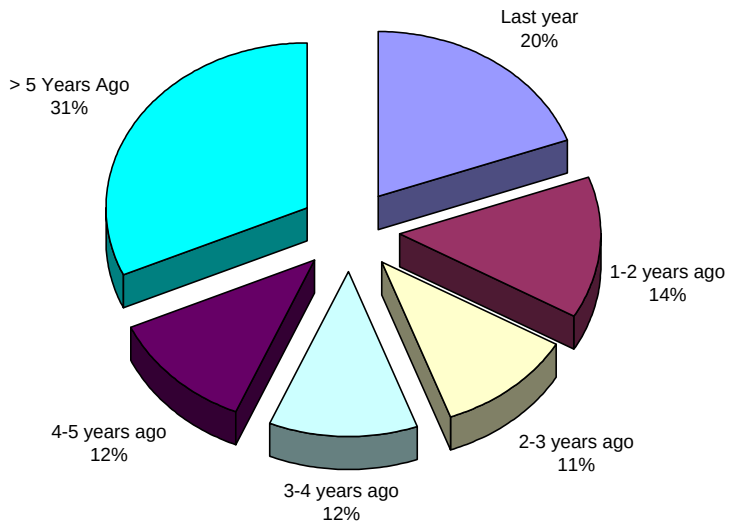
4.7 Innovation, information and knowledge flows

This section looks at a range of indicators of the level of innovation and the role that innovation relationships play in the Victorian Electronics Cluster. It looks at the sources of information and ideas, control of quality and management of knowledge, as well as more formal research and development activities.

4.7.1 Introduction of new products and services

Respondents reported that 20% of their products and services (by sales revenue) had been introduced within the last year, suggesting a high rate of innovation. Moreover, 57% of 2002-03 sales revenue was earned from products or services introduced within the last 4 years, and just 31% was earned from products or services that are more than 5 years old (Figure 4.34).

Figure 4.34 Percentage of sales revenue from products and services by year of introduction



Source: Victorian Electronics Cluster Survey, Project Database (CSES).

Manufacturing and services firms had the highest proportion of revenue from products/services introduced within the last 12 months (23%), followed by integrated systems and solutions providers (19%) and support and after sales services providers (17%). At a more detailed level, respondents manufacturing power supplies reported the highest percentage of products and services introduced in the last twelve months, followed by manufacturers of industrial process control equipment, components and assemblies. Services providers had a larger share of revenue coming from products and services introduced more than 5 years ago (approximately 40%).

Table 4.15 Percentage of sales revenue from products and services by year of introduction and sector (per cent)

Sector	Last Year	1-2 Yrs Ago	2-3 Yrs Ago	3-4 Yrs Ago	4-5 Yrs Ago	More Than 5 Yrs Ago
Product Manufacture	23	12	14	12	14	26
Distribution	14	11	14	14	16	31
Services	23	12	7	8	8	43
Integrated systems	19	23	5	22	1	31
Support	17	28	3	3	11	40
Totals	*20*	*14*	*11*	*12*	*12*	*32*

Source: Victorian Electronics Cluster Survey, Project Database (CSES).

4.7.2 Knowledge management and quality control

There appears to be somewhat more emphasis on quality control than knowledge management, although both are widely practised. Forty per cent of firms reported having formal quality accreditation procedures, 66% reported having formal quality management procedures in place, and 43% reported having formal knowledge management systems in place (Table 4.16).

Table 4.16 Percentage of firms with knowledge & quality management systems by sector (per cent)

Sector	Formal Quality Accreditation Procedures (%)	Formal Quality Management Procedures (%)	Formal Knowledge Management Systems (%)
Distribution	54	68	41
Integrated systems	50	75	50
Product Manufacture	45	68	50
Services	13	60	33
Support	50	57	29
All	*40*	*66*	*43*

Source: Victorian Electronics Cluster Survey, Project Database (CSES).

Distributors were most likely to have formal quality accreditation procedures (54%), while 45% of manufacturing firms and 13% of services firms reported having them. Integrated systems firms were most likely to have formal quality management procedures in place (75%), with 68%

of distribution and manufacturing firms also reporting having formal quality management procedures in place. Fifty per cent of product manufacturers and integrated systems and solutions providers reported having formal knowledge management procedures.

4.7.3 Sources of information and ideas

The type and number of sources of ideas and information about new technical developments and new products and services reveals a good deal about the innovative and absorptive capacity of firms (ie. their capacity to absorb new ideas and implement innovations). This sections looks at each in turn.

Technical developments

When asked where they get information about *new technical developments*, respondents reported 443 sources – an average of 4.5 sources per firm. The number of sources identified is widely used as an indicator of absorptive capacity. Services providers reported the highest number of sources, with an average of 5.1 per firm, manufacturing firms reported an average of 4.8 sources, while distribution, integrated systems and solutions and after sales service and support firms reported an average of 4 sources per firm.

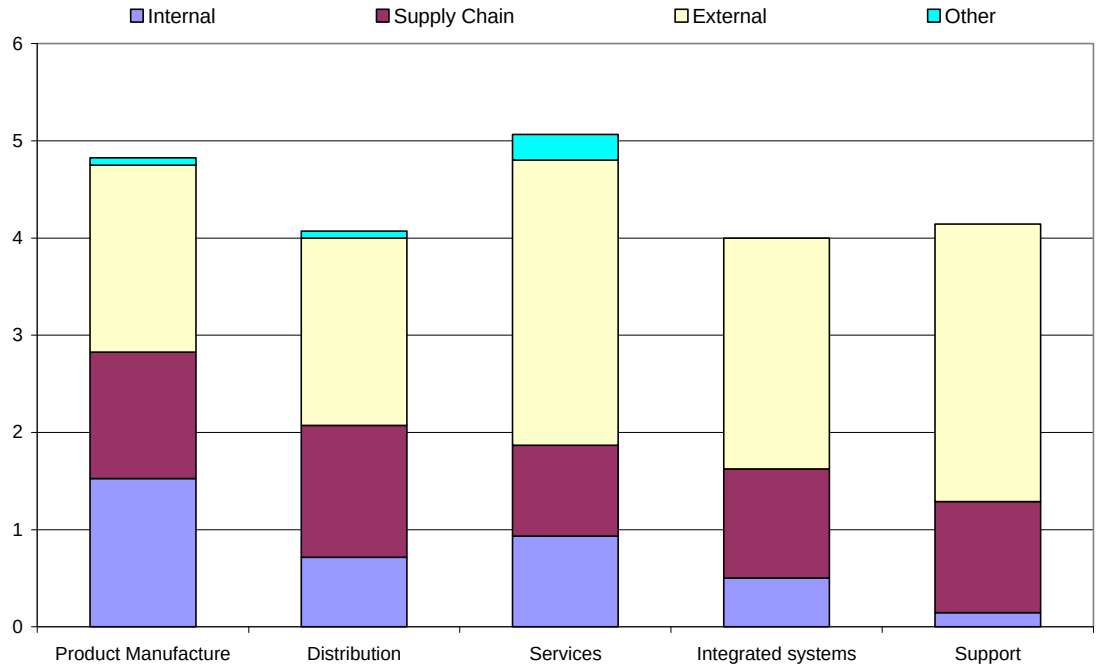
Table 4.17 Sources of information about new technical developments (count)

	Distribution	Integrate	Manufacture	Services	Support	All
In-house R&D group	9	3	28	3	0	43
Other internal sources	8	0	16	5	0	29
R&D institution, uni, or TAFE	2	0	11	5	0	18
New employees	1	1	6	1	0	9
Suppliers	23	6	24	9	5	67
Customers	15	3	28	5	3	54
Professional or industry assoc	2	2	13	10	5	32
Professional publications & journals	11	4	18	9	5	47
Trade & industry mags	19	6	23	10	8	66
Discussions at conferences & trade shows	16	6	15	7	2	46
Discussions at industry networking functions	6	1	8	8	0	23
Other	2	0	3	4	0	9
Totals	*114*	*32*	*193*	*76*	*28*	*443*

Source: Victorian Electronics Cluster Survey, Project Database (CSES).

External sources, such as professional or industry associations, professional publications and journals, trade and industry magazines, discussions at conferences and trade shows or at industry networking functions, dominated for all sectors. The second most important group of sources of information and ideas was firms along the supply chain (ie. suppliers and customers). This reflects the importance of demanding customers and major suppliers as drivers of innovation through the supply chain. Less that 2.5% of the sources mentioned related to R&D institutions, universities or TAFE colleges. Less that 20% of all sources were internal, again emphasising the importance of product system linkages for innovation.

Figure 4.35 Average number of sources on new technical developments by source and sector (count)



Source: Victorian Electronics Cluster Survey, Project Database (CSES).

Product & service developments

Respondents were asked to rank the relative importance of the same sources of information and ideas for the introduction of *new products or services*. They reported 384 sources, an average of 3.9 per firm. Again it was services firms that identified the highest number of sources (5). Manufacturers identified an average of 4 sources and other firms an average of between 3.4 and 3.9. This suggest that the absorptive capacity of services and manufacturing firms is likely to be higher than wholesale and retail distribution firms.

Again, external sources, such as professional or industry associations, professional publications and journals, trade and industry magazines, discussions at conferences and trade shows or at industry networking functions dominated for all sectors, and the second most important group of sources of information and ideas was firms along the supply chain (ie. suppliers and customers). Again, this emphasises the importance of external and supply chain linkages for innovation. Less that 1.5% of the sources mentioned were internal, and less than 1% related to in-house R&D. Given the focus on in-house R&D (see below) this is perhaps surprising. It seems that in-house activities may be focused on development, and ideas come from elsewhere (outside the firm).

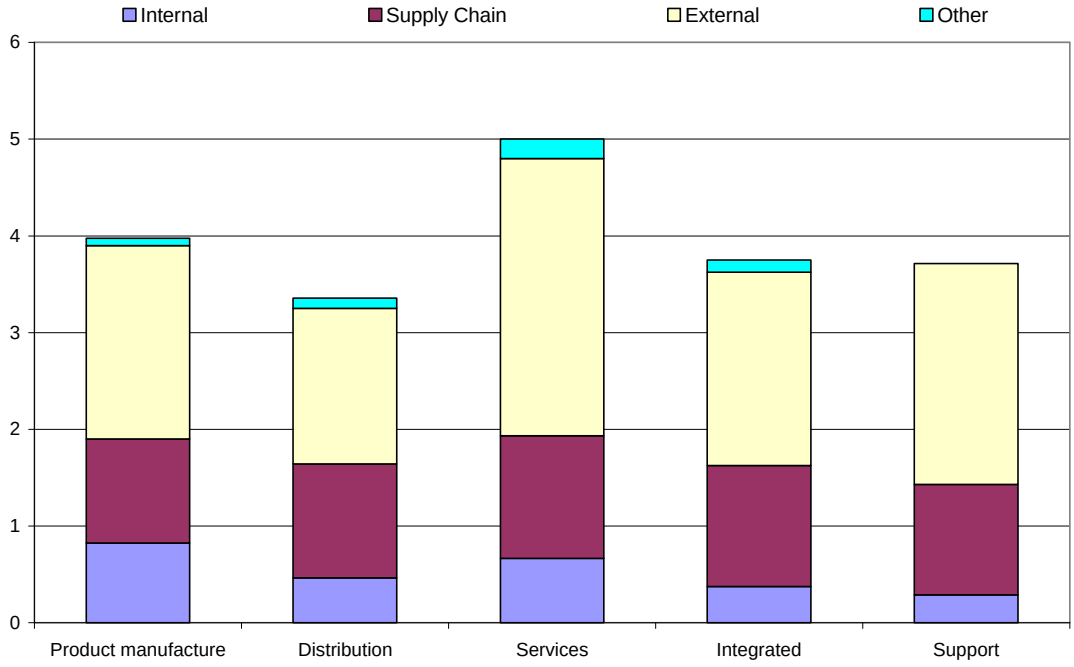
Table 4.18 Sources of information about new product or service developments (counts)

	Distribution	Integrate	Manufacture	Services	Support	All
In-house R&D group	6	2	17	4	0	29
Other internal sources	6	0	10	3	2	21
R&D institution, uni, or TAFE	1	0	3	2	0	6
New employees	0	1	3	1	0	5
Suppliers	22	7	24	11	6	70
Customers	11	3	19	8	2	43
Professional or industry assoc	1	1	10	7	5	24
Professional publications & journals	9	5	18	9	6	47
Trade & industry mags	19	5	25	12	4	65
Discussions at conferences & trade shows	12	4	17	7	1	41
Discussions at industry networking functions	4	1	10	8	0	23
Other	3	1	3	3	0	10
Totals	*94*	*30*	*159*	*75*	*26*	*384*

Source: Victorian Electronics Cluster Survey, Project Database (CSES).

These linkages play a critical role in technology diffusion and the diffusion of best practice throughout the electronics product system, and their strength and depth underpins the capacity of firms within the Victorian electronics cluster to innovate.

Figure 4.36 Average number of sources on new product developments by source and sector (count)



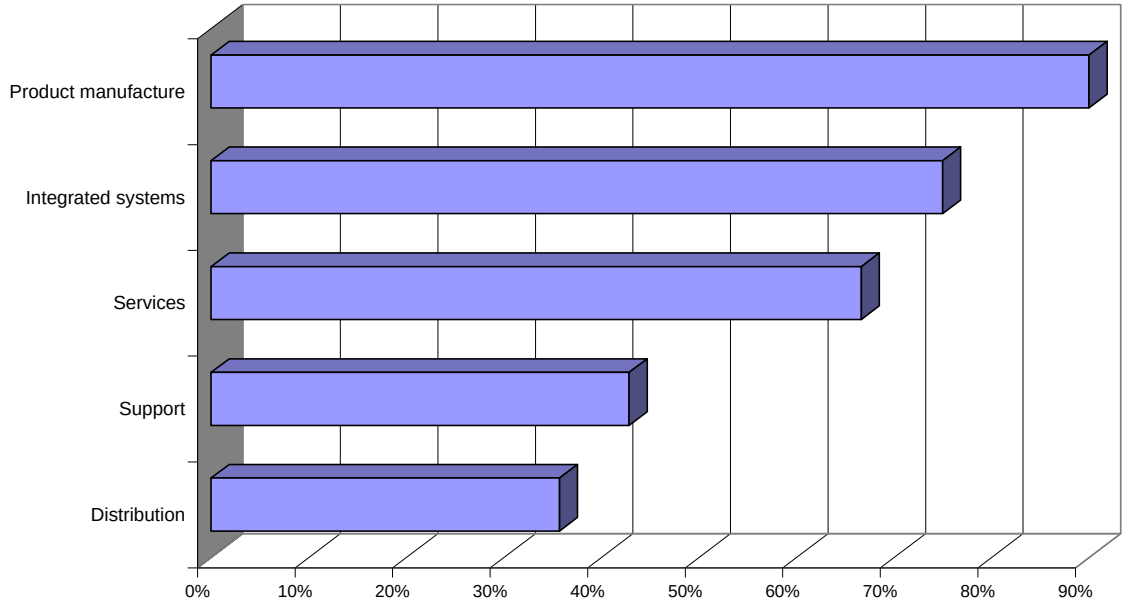
Source: Victorian Electronics Cluster Survey, Project Database (CSES).

4.7.4 Research & development activities

Two thirds of respondents (66%) reported that they performed formal R&D during 2002-03. Firms that reported doing formal R&D said that they spent an average 14% of turnover. Levels of R&D have remained steady over the past five years, during which the average R&D expenditure was around 13% of turnover. This is a high level of R&D activity, indicative of a significant investment in continued innovation.

Figure 4.37 shows that 90% of product manufacturers and 75% of integrated systems and solutions providers reported that they performed formal R&D. Two-thirds of services providers reported formal R&D activities, as did 36% of firms whose sales revenues came primarily from the distribution of goods.

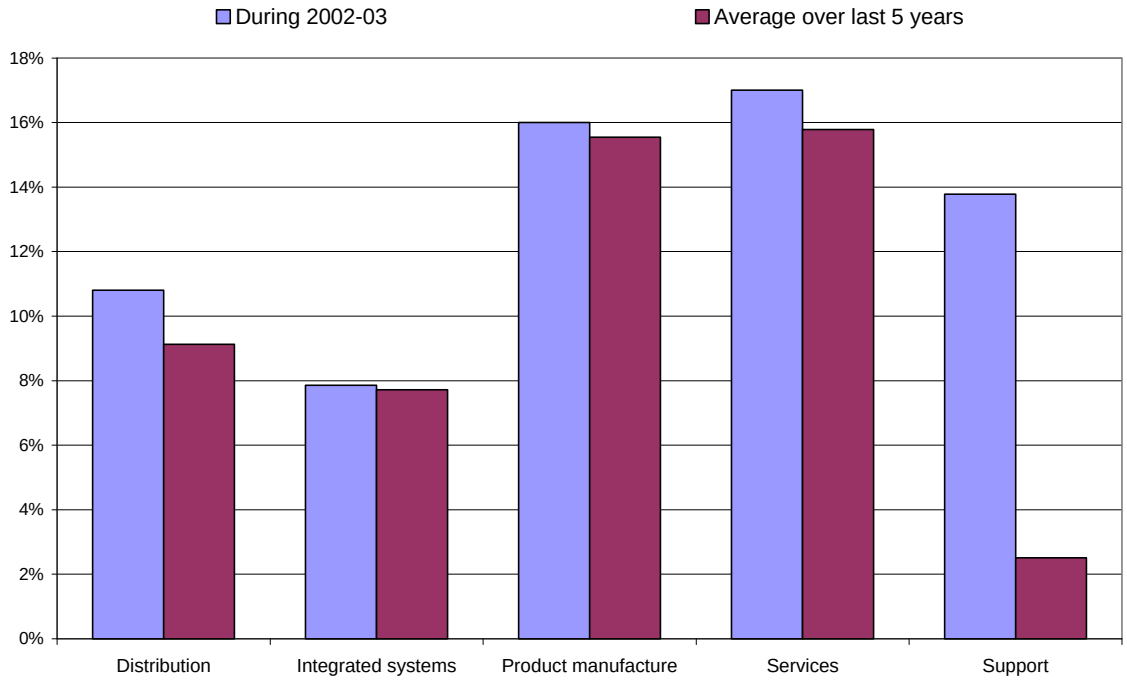
Figure 4.37 Percentage of firms doing formal R&D by sector (per cent)



Source: Victorian Electronics Cluster Survey, Project Database (CSES).

Two groups of respondents reported higher levels of R&D spending as a per cent of sales than did others (Figure 4.38) – services firms (which spent an average of 17% of turnover on R&D during 2002-03), and product manufacturers (which spent an average of 16%). No doubt the high level of R&D spending among services firms relates to software development activities. Something of a resurgence of R&D spending is also evident, suggesting that the recovery from the 'dot com' crash has encouraged renewed investment in innovation.

Figure 4.38 Percentage of turnover spent on R&D by sector



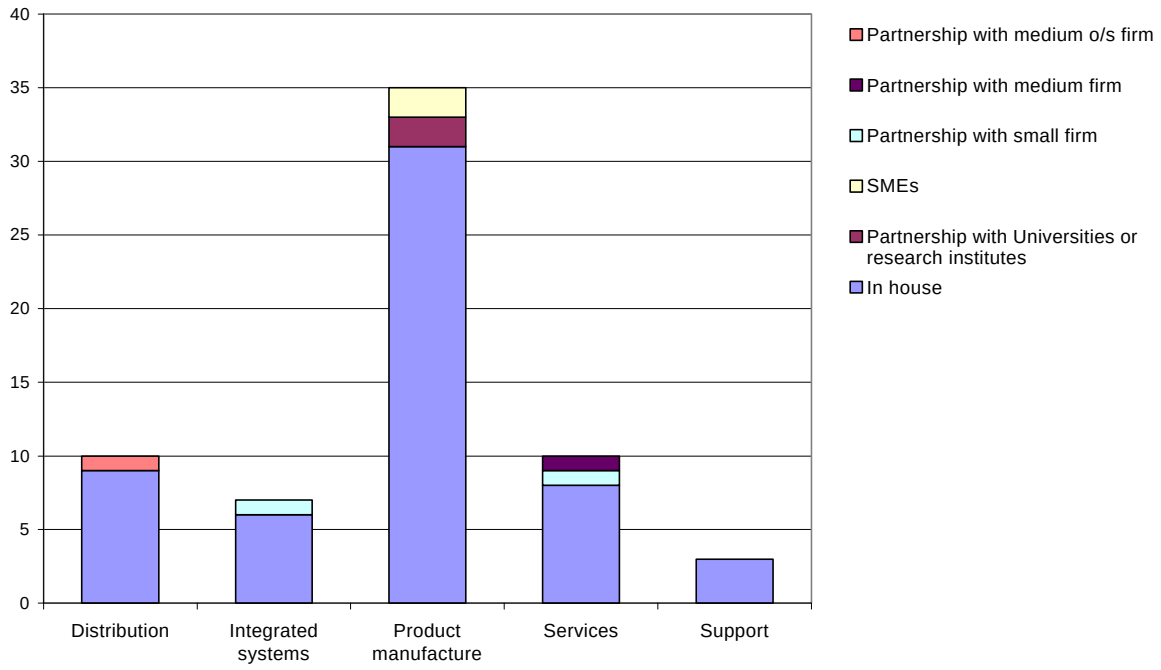
Source: Victorian Electronics Cluster Survey, Project Database (CSES).

Methods of conducting R&D & location of activities

As a group, 88% of all those conducting R&D reported that the main method was in-house R&D (Figure 4.39). A small proportion contracted R&D services from either small or medium sized firms. There was only one R&D link with an overseas firm and two R&D partnerships with universities or research institutes. This suggests relatively low levels of R&D cluster linkages, with the vast majority of firms preferring to conduct R&D in-house. This is in part due to the nature of electronics R&D, which tends to be somewhat more experimental than theoretical and thus tends to be conducted in-house within the private sector, rather than being contracted to public sector organizations. As noted in Section 3 (above), the business sector accounts for more than 90% of all electronics related R&D activity (by value) in Australia. As technologies converge, however, there may be more need to develop linkages with other R&D sources.

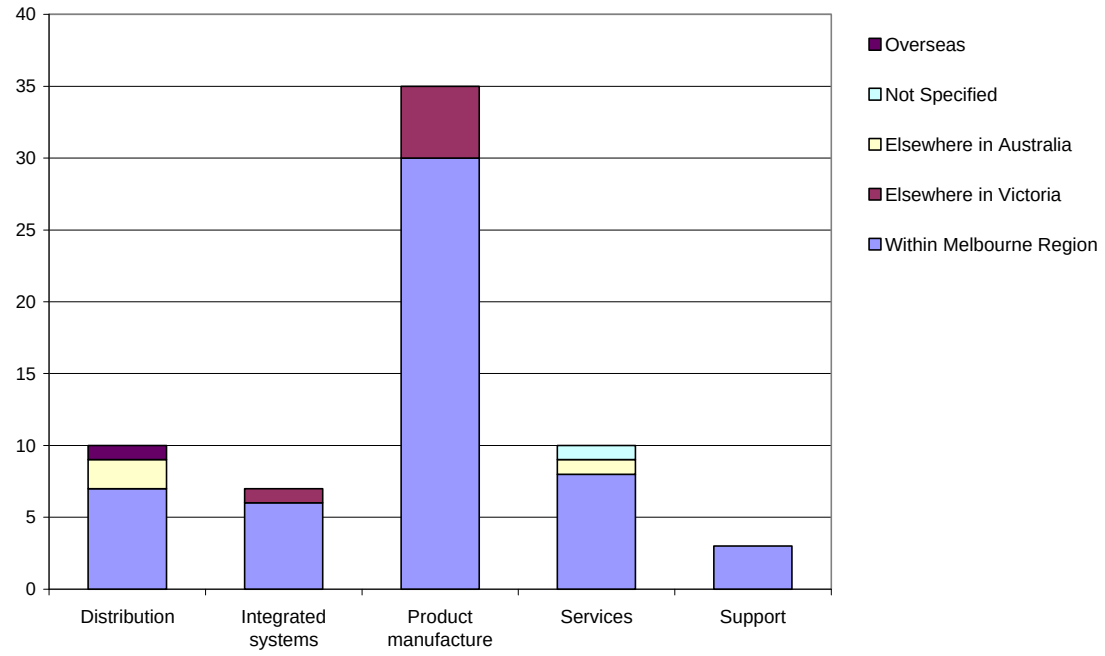
When asked where their R&D activity was carried out, 54 of the 65 respondents who answered this question (83%) reported that it was conducted in Melbourne (Figure 4.40). Nine per cent conducted their research elsewhere in Victoria and 5% conducted it elsewhere in Australia. Just 2% reported that they conducted their R&D overseas.

Figure 4.39 Main method of R&D by sector (number of firms)



Source: Victorian Electronics Cluster Survey, Project Database (CSES).

Figure 4.40 Location of R&D by sector (number of firms)

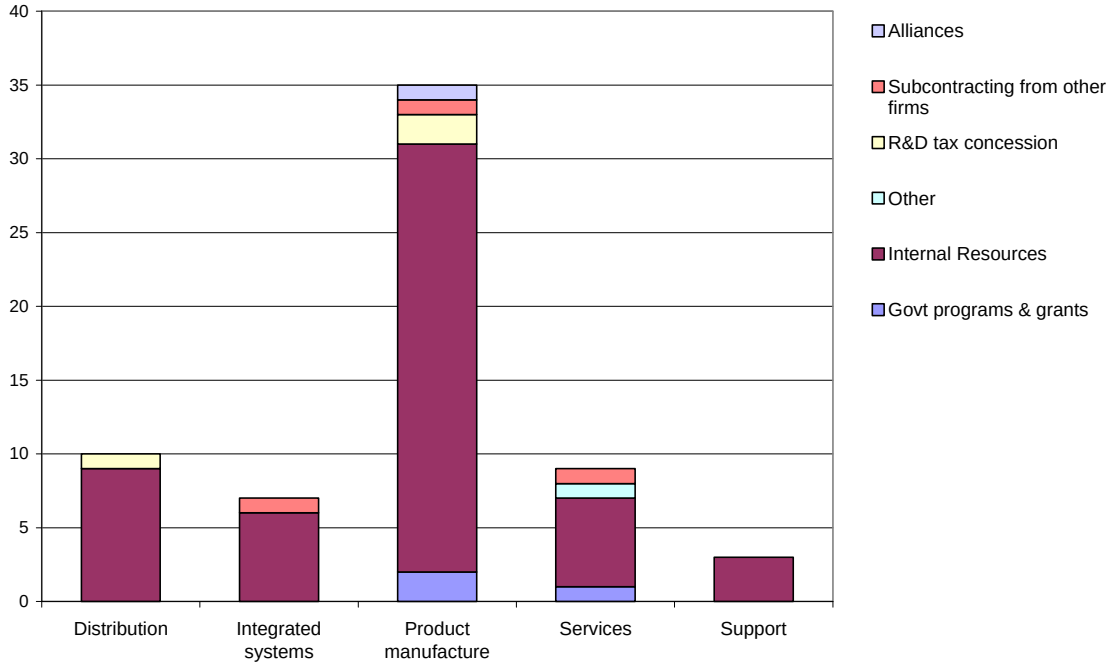


Source: Victorian Electronics Cluster Survey, Project Database (CSES).

Sources of R&D funding

Figure 4.41 shows that firms relied primarily on internal resources to fund R&D. Fifty-three of 65 respondents (82%) to this question named 'internal sources' as the *main* source of R&D funding. There was little use of R&D alliances to fund activities. Government programs and the R&D tax concession ranked second highest as a source of R&D funding, but was only cited as the *main* source of funds by 5% of those conducting R&D. One can only assume that these methods of funding are important to some firms, even if they are not the *primary* source of funding for most.

Figure 4.41 Main source of R&D funding by sector

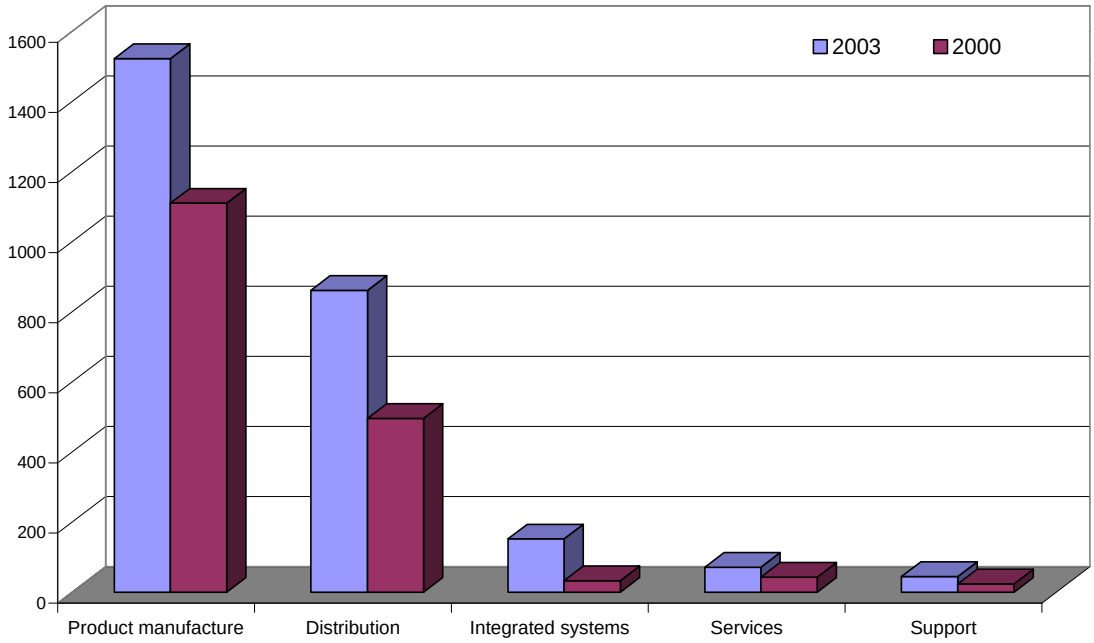


Source: Victorian Electronics Cluster Survey, Project Database (CSES).

4.8 Employment, skills and training

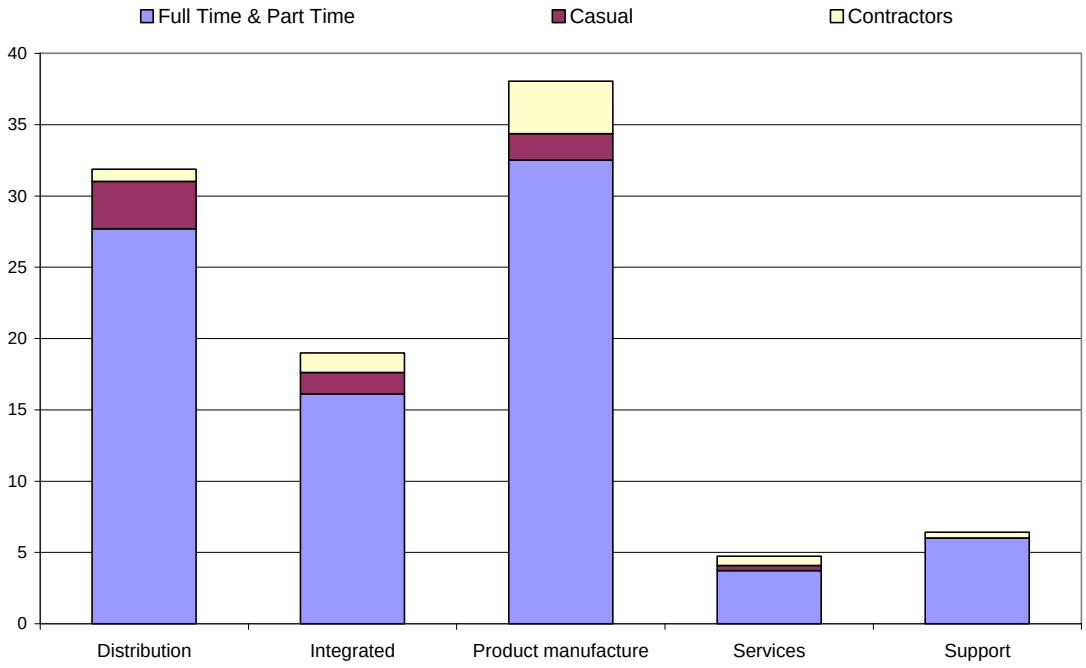
Responding firms employed a total of 3,092 people in 2003, of whom 2,650 (86%) are located in Victoria. Firms had an average of 32 staff, of whom just over one staff member, on average, was a contractor. There appears to have been a moderate increase in employment in the last three years. Respondents reported that they had an average of 27 employees in 2000, a compound annual growth of 12.5% – in line with the 23% per annum increase in revenue reported earlier (Figure 4.42). Respondent firms spent an average of $1.7 million on employee wages and salaries and a further $258,666 on contractors – suggesting an average salary in excess of $54,000 per annum.

Figure 4.42 Victorian staff by sector, 2000 and 2003 (number)



Source: Victorian Electronics Cluster Survey, Project Database (CSES).

Figure 4.43 Average Victorian staff per firm by sector, 2003 (number)



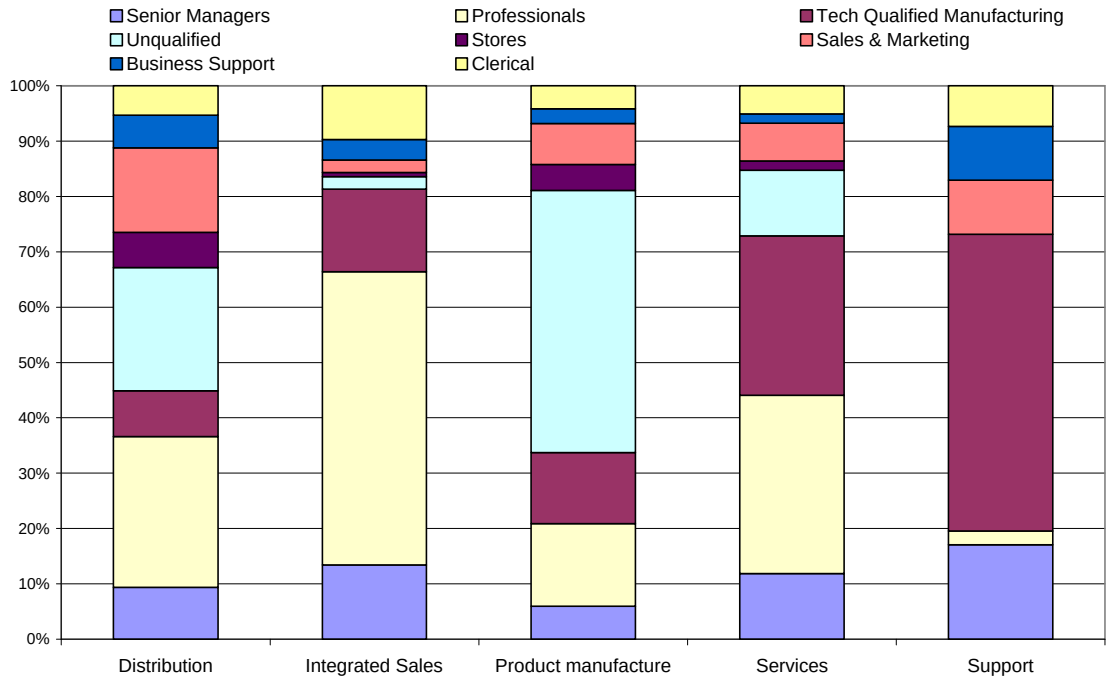
Source: Victorian Electronics Cluster Survey, Project Database (CSES).

Within Victoria, product manufacturers were the largest employers, with 1,522 employees at an average of 38 staff per firm. Distribution firms had an average of 32 staff and integrated systems and solutions firms an average of 19. Services firms were the smallest with an average of fewer than six staff each. Use of casual employees was low, except by wholesale and retail distributors (Figure 4.43).

4.8.1 Skills profile

Table 4.19 and Figure 4.44 show the percentage of Victorian staff in each employment and skill category by sector. Professionals make up 53% of integrated systems and solutions provider employees, while services firms employ mainly technically qualified staff and trades people.

Figure 4.44 Victorian employees by category and sector (per cent)



Source: Victorian Electronics Cluster Survey, Project Database (CSES).

Table 4.19 Percentage of Victorian employees by category and sector

Sector	Senior Managers	Prof	Tech Qualified	Un-Qualified	Stores	Sales & Marketing	Business Support	Clerical
Distribution	9	27	8	22	6	15	6	5
Integrated	13	53	15	2	1	2	4	10
Manufacture	6	15	13	47	5	7	3	4
Services	12	32	29	12	2	7	2	5
Support	17	2	54	0	0	10	10	7
All	8	21	13	36	5	9	4	5

Source: Victorian Electronics Cluster Survey, Project Database (CSES).

Ninety-three per cent of employees in after sales service and support firms were reported to have a certificate (including a trade certificates), while the remaining staff hold graduate diplomas in fields other than science (Table 4.20). As a group, the most common qualification held by staff was a bachelor degree in a science field, followed by trade certificate. Fully 14% of responding Victorian electronics firms' staff hold higher degrees, and 42% hold bachelors degrees.

Table 4.20 Qualifications of Victorian Employees by Sector

	Distribution	Integrated	Manufacture	Services	Support	All
Higher Degree - science	5	21	10	16	0	9
Higher Degree - other	7	6	4	2	0	5
Grad. Dip - science	4	3	5	20	0	5
Grad. Dip - other	0	0	5	0	7	2
Bachelor Sci	36	62	30	39	0	35
Bachelor Other	10	1	7	2	0	7
Adv dip	2	0	5	7	0	4
Trade Cert	35	6	34	14	93	31

Source: Victorian Electronics Cluster Survey, Project Database (CSES).

4.8.2 Education and training practices

When asked if their firm has formal education and training policies or procedures to allow employees to further their education and develop skills, 42% of respondents said that they had (Table 4.21). After sales services and support firms were most likely to have formal education and training policies or procedures in place (57%), followed by wholesale and retail distribution firms (52%). Little more than one-third of manufacturing and services delivery firms had formal education and training policies or procedures in place. In the case of services firms, this reflects the relatively small size of firms in the sector. It is, perhaps, disappointing that there are not more electronics manufacturing firms with formal education and training policies or procedures.

Table 4.21 Formal training policies by sector (per cent)

Sector	No (%)	Yes (%)
Distribution	47	53
Integrated systems	71	29
Product manufacture	63	37
Services	67	33
Support	43	57
All	*58*	*42*

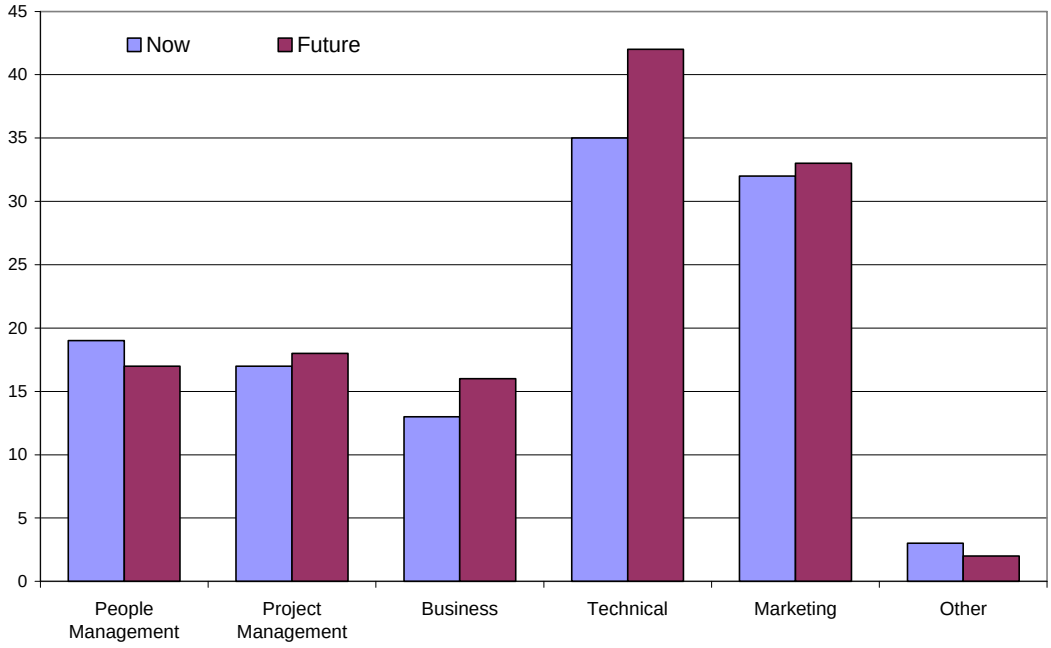
Source: Victorian Electronics Cluster Survey, Project Database (CSES).

4.8.3 Skills supply concerns

"To be competitive in today's global environment we must continue to enhance local expertise and skills. Australian firms are increasingly competing in the international market place to attract and retain skilled staff. Skills shortages can affect the capacity of business to carry out R&D and other knowledge-based activities and impact on investment in vital areas of the economy."[90] Hence, skills supply is crucial.

When asked if they thought any skills were in short supply now or if they foresaw any that may be in short supply in the future, more than 80% of respondents identified skills shortages. They listed technical, professional and engineering skills as those in short supply, both now and in the future (Figure 4.45). This was followed by marketing and sales skills.

Figure 4.45 Skills in short supply now and in the future (responses)



Source: Victorian Electronics Cluster Survey, Project Database (CSES).

Twenty-nine per cent of the *current skills shortages* mentioned were for technical, professional and engineering skills, and 27% were for marketing and sales skills. Relatively fewer respondents were concerned about shortages of business skills (11%), project management (14%) or people management skills (16%).

Perceptions about possible *future skills shortages* were similar, with 33% of the expressions of concern relating to technical, professional and engineering skills, and 26% to marketing and sales skills.

[90] DITR/DCITA (2003) *Electronics Industry Action Agenda*, Department of Industry, Tourism and Resources & Department of Communications, Information Technology and The Arts, Canberra.

4.9 Main points arising from the survey

The survey revealed a complex picture from which a number of points emerge. We found:

- A strong local focus, with 80% of sales revenue earned within Victoria, 11% elsewhere in Australia and 9% from activities overseas.
- The majority of firms focus on relatively High Value / Low Volume activities, and most rely on private financing, with few relying on debt financing and a mere handful attracting venture capital of angel investors.
- Firms engage in a range of activities, with 41% suppling products or services to electronics manufacturers, 56% undertaking electronics manufacturing activities, and 49% providing electronics related services.
- Supply strengths include: design services, components, sub-assemblies, R&D services, prototyping services, contract manufacturing, calibration and testing, mounting and assembly, fabrication, and testing and conformance.
- Manufacturing strengths include: components, process and control equipment, power and battery, instrumentation, mobile and wireless, other telecommunication equipment, automotive, and cable, wire and optical fibre.
- Services strengths include: repair and maintenance, installation services, wholesale and services, design services, engineering and consulting.
- Fifty-one per cent of firms exported in 2003, with exports accounting for a relatively high share of sales. The extensive use of distributors and direct links to export customers emphasise the importance of demand-side supply chain linkages, and that almost 25% of exporting firms cited the use of internet and/or electronic delivery suggests an active adoption of new methods and a strong base capability for future development.
- On the supply-side, we found that 56% of respondents' Top 3 suppliers were located in Victoria, 26% were located overseas and 16% were located elsewhere in Australia.
- On the demand-side, 51% of Top 3 customers were located within Victoria, 33% were located elsewhere in Australia and 15% located overseas.
- Twenty per cent of products and services (by sales revenue) have been introduced within the last year, and 57% within the last 4 years.
- Two-thirds performed formal R&D and they spent an average 14% of turnover doing so. Eighty-eight per cent of those conducting R&D did so in-house, and 83% reported that their R&D was conducted in Melbourne.
- Responding firms employ a total of 3,092 people, of whom 2,650 (86%) are located in Victoria. They spent an average of $1.7 million on employee wages and salaries – suggesting an average salary in excess of $54,000 per annum.
- Skills shortages include professional and engineering, marketing and sales skills.

5 Capabilities and emerging opportunities

This section looks at cluster capabilities and emerging opportunities. It begins with an overview of the Victorian electronics product system, then explores the key cluster dimensions operating within the electronics industry in Victoria. In doing so it focuses on strengths, weaknesses, opportunities and threats.

5.1 Victoria's electronics product system

In mapping the Victorian Electronics Cluster we place electronics firms (defined by technologies, solutions and/or markets) at the centre. The major technology solutions produced within the Victorian Electronics Cluster include: wireless and mobile; photonics and optoelectronics; automotive electronics; medical and scientific instruments; IC design, PCBs and contract manufacturing services; and industrial and process control systems. Producers are characterised as high value/low volume, medium value/medium volume or low value/high volume. In Victoria the focus is primarily on high value/low volume activities, customisation for specific applications and integration into solutions (Figure 5.1).

The *supply network* includes the suppliers of business services (eg. business support, marketing, financial, etc.); suppliers of contract services (eg. R&D, design, prototyping, manufacturing, testing, etc.); specialist suppliers of machinery and equipment (eg. hand and bench tools, testing and assembly equipment, etc.); and suppliers of materials and components (eg. raw materials, components and sub-assemblies, packaging, etc.).

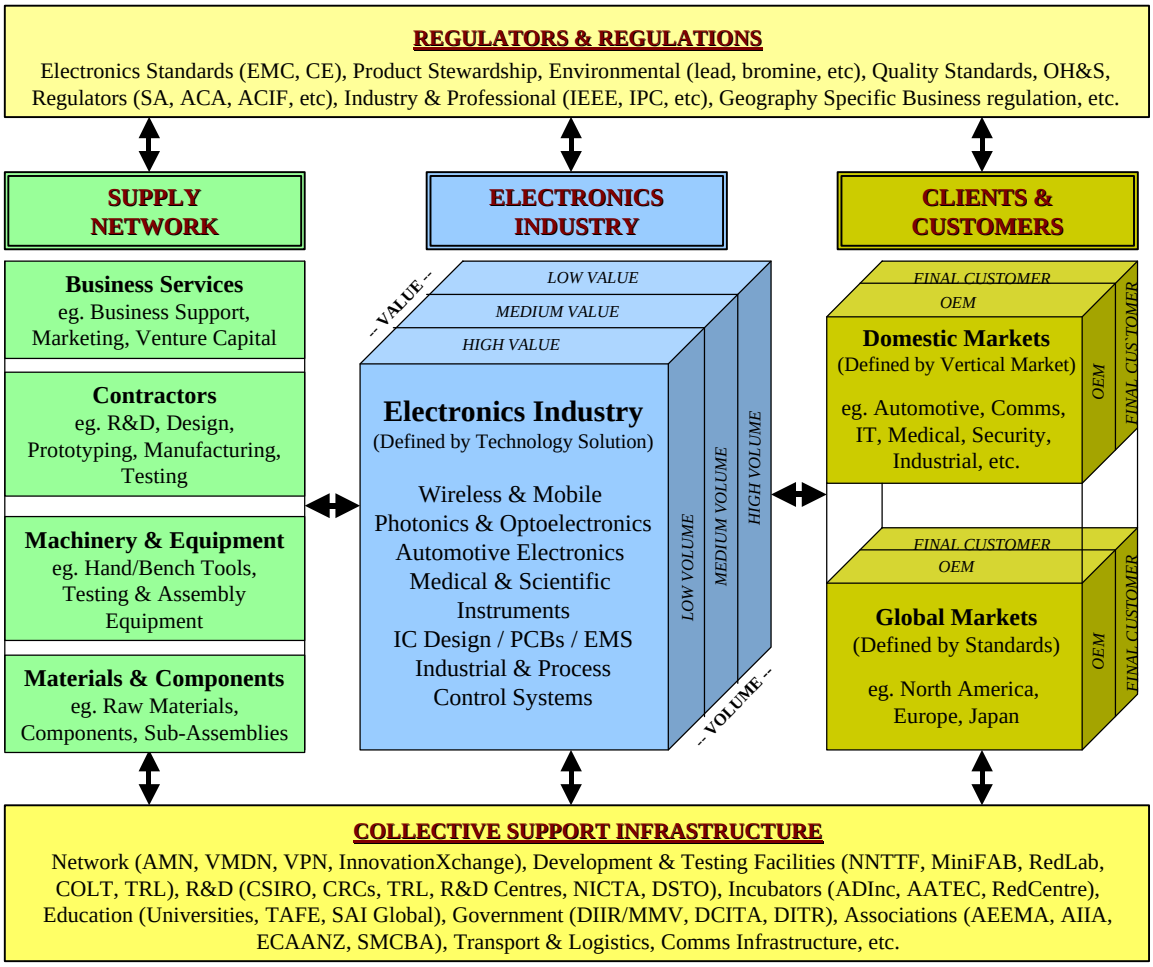
Clients and customers include a number of Australian domestic markets defined by vertical market (eg. automotive, communications, IT, medical, security, industrial, etc.) and global markets defined to a large extent by standards blocs (eg. North America, Europe, Japan, etc.). Customers are characterised as OEM (ie. intermediate customers) or final customers. OEM activities are significant in Victoria.

The *regulatory framework* includes all the actors and activities involved in setting and monitoring electronics related standards (eg. EMC, CE, etc.), product stewardship requirements (eg. disposal of used product), a range of environmental regulations (eg. lead free solder, non-bromine flame retardants, etc.), quality standards and accreditation, OH&S and a wide range of jurisdictionally specific business regulation. Major Australian actors include Standards Australia, the Australian Communications Authority and the Australian Communications Industry Forum, such professional bodies as IEEE and IPC, etc.

The *collective support infrastructure* includes a range of industry networks (eg. AMN, VMDN, VPN, InnovationXchange, etc.), shared development and testing facilities (eg. NNTTF, MiniFAB, RedLab, COLT, Synchrotron, etc.), R&D services and IP providers (eg. CSIRO, CRCs, university R&D centres, NICTA, DSTO, etc.), venture capital and incubator facilities (eg. AATEC, Australian Distributed Incubator, Redcentre, Information City, Monash STRIP, etc.), education and training organizations involved in electronics cluster related skills

development (eg. Universities, TAFEs and such programs as ChipSkills), governments and government agencies (eg. DIIR/MMV, DCITA, DITR, etc.), industry associations (eg. AEEMA, AIIA, ECAANZ, SMCBA, etc.) and the telecommunications and transport & logistics infrastructure. Appendix B presents a more detailed review of the collective support infrastructure for Victoria's electronics cluster.

Figure 5.1 The Victorian electronics cluster: An overview



Source: Centre for Strategic Economic Studies.

There are many forms of clusters and clustering. Clusters can be technology based (eg. photonics), customer based (eg. automotive), product based (eg. smartcards), needs based (eg. access to skills) and/or resource based (eg. energy or minerals resources). Clusters can also be characterised as: *vertical clusters*, involving firms linked through buyer-seller relations; *horizontal clusters*, involving firms that share a common end product market, use a common technology or science base, use common skills, require similar resources and conditions; or *halo clusters*, involving the presence of a central actor (eg. a multinational firm) around which supply and support firms cluster. In practice, clusters usually present a mixture of these things. All forms, as well as mixed forms, can be observed in the Victorian electronics industry.

5.2 Vertical market and halo clusters

There are a number of key vertical markets into which Victorian-based electronics and related firms sell. These include:

- *Automotive* – with suppliers include: Robert Bosch, Siemens VDO, Australian Arrow, Denso International / Australian Automotive Air, Air International, AME Systems, Flexdrive Cables (mechanical and electronic instrumentation), PBR (Brakes), Hella Australia, Sumitomo (Connectors and Drives), etc. As noted, automotive electronics manufacturing is a significant activity, it is experiencing world market growth and is an area that is highly prospective for further local cluster development.
- *Communications and IT* – with suppliers including: Siemens, NEC, Extel, Halipex, G&D, VPI Systems, Diamond Australia, RFS, CEOS, CommTel, InterCel, Cablex, Ipex (Volante), Aegis, Alfatron, etc. Victoria has considerable strengths in communications, and while it has been severely affected by the recent downturn in telecommunication investment worldwide, communications remains a significant area of opportunity for Victorian suppliers. Increasing build-to-order is bringing new opportunities for IT related assembly activities.
- *Medical Devices* – with suppliers including: GBC, Varian, Medtron, Vision Systems (BioSystems), Compumedics, Norwood Abby, etc. While relatively small and fragmented the medical and scientific devices area has a strong local user base in Victoria.
- *Security* – with suppliers including: Interlogix (GE Security), Inner Range, Nidac, ACD Digital, Vision Systems (Fire & Security), Intelligent Fire Systems, etc. Security is an area with strong growth potential in an era of heightened domestic and international security concern.
- *Industrial Process and Control* – with suppliers including: ANCA, Datataker, IPC Global, Innovonics, Intermoco (Australon), Moonlighting, NeoProducts, Robotron, Traffic Technologies, Atco Controls, Schneider Electric, Bytecraft Automation etc. Both industrial process control and instrumentation are areas of local strength and opportunity.
- *Instrumentation* – with suppliers including: Agilent Technologies, Gedge, Phasefale, Datataker, Hawk Measurement, Contrec, Kingfisher, Alfa-Tek, McVan etc. Like industrial process control, instrumentation offers opportunities to develop and market local capabilities.
- *Power Supplies* – with suppliers including: Rectifier Technologies, Setec, Selectronic, Thycon, Thytec, Arlec, etc. There is a large and growing market for a wide range of power supplies, increasing focus on mobility, security and uninterruptible power supply. There is also growing interest in electric and hybrid vehicles, for which power supply technologies are crucial.
- *Contract manufacturing and PCBs* – with suppliers including: Precision Australia, AEMS, Labtam, Duet, Millison, Clevertronics, EDPM, Unique Micro Design, etc. The

emerging trend for increased customisation and build-to-order promises to provide new opportunities for contract manufacturers.

The following sections explore each of these areas in turn.[91]

5.2.1 Automotive

Automotive suppliers include: Robert Bosch, Siemens VDO, Australian Arrow, Denso International / Australian Automotive Air, Air International, AME Systems, Flexdrive Cables (mechanical and electronic instrumentation), PBR (Brakes), Hella Australia, Sumitomo (Connectors and Drives), etc.

- *Robert Bosch* employs almost 2,000 people and generates annual sales of around $850 million, of which some $520 million is from own manufactured equipment and $365 is from exports. Around 75% of sales are original equipment to the automotive industry. Robert Bosch has invested $30 million in a wafer manufacturing facility in Melbourne.
- *Australian Arrow*, a subsidiary of the Yazaki Corporation, is the largest supplier of wire harnesses to the Australian automotive industry. AAPL manufactures a range of remote entry, engine control, embedded security and telemetric systems for the world's leading car makers.
- *Australian Automotive Air* employs around 450 people in the manufacture of automotive air-conditioning and radiator components and, more recently, instrument clusters. There are a further 100+ employees at the Denso Corporate Office in Melbourne.
- *AES (Automotive Electronic Specialists)* designs and manufactures the Execulog & Fleetcom brands of on-board-computers for the bus and transport industries. These on-board computer systems are installed into the driver's cabin where they monitor important vehicle and driver parameters.
- *Siemens VDO* is a supplier of instrument clusters to some of the world's leading car makers.
- Ararat based *AME Systems* manufactures wiring harness and signal distribution systems for automotive and other transport applications. Employing around 230 people, AME specialises in low to medium volume manufacture of electrical harness to the OEM market.

Production, employment and sales data all suggest considerable strength in automotive electronics in Victoria. Forecast world growth data suggest that it is an area of considerable growth potential, as the electronics content of vehicles increases and new areas of opportunity emerge – such as tracking, navigation, telemetry and the introduction of electric and hybrid vehicles. The recent establishment by Toyota of an R&D centre focusing on electric vehicles could provide opportunities and impetus in this area. There are local strengths among suppliers,

[91] These lists are indicative of firms and activities, and are by no means exhaustive.

and many are significant exporters. There are also rapidly developing opportunities in Intelligent Transport Systems.[92]

The automotive product system tends to be dominated by the large multinational vehicle assemblers. They are demanding customers, which can help drive innovation through the system. However, they also wield considerable power within the value chain, and tend to put strong downward pressure on supplier prices. Obviously, the fate of the local automotive assembly industry is important to automotive electronics suppliers, and the limited extent of the local market for vehicles and the cost pressures facing automobile exports from Australia are limiting factors. Nevertheless, leading automotive electronics and related suppliers are by no means wholly dependent upon local customers, with many already exporting a substantial proportion of their output. The danger lies further down the track, in how linkages between global vehicle assemblers can be created and maintained if the assembler has no local production presence.

Clearly, such a scenario implies the need for enhanced international linkages, partnerships and alliances. Local suppliers may need to consolidate or operate in more closely linked horizontal supplier alliances, in order to gain the scale necessary to be able to afford the production and development equipment and software necessary to enable them to compete successfully on global markets. Demonstrator projects, such as the aXcess car, will also be important in raising the awareness of potential overseas customers about Australia's local supplier strengths.

5.2.2 Communications and IT

While it is difficult to separate information technology and communications, especially when dealing with the major multinational firms involved, there are significant local strengths and opportunities in communications. ICTs suppliers include: Siemens, NEC, Extel, Halipex, G&D, VPI Systems, Diamond Australia, RFS, CEOS, CommTel, InterCel, Cablex, Ipex (Volante), Aegis, Alfatron, etc.

- *Siemens Australia* provides a wide range of products and services in electronics, electrical engineering and ICTs, delivering solutions to information & communications, automation and control, power, transportation, medical solutions, components, lighting and financial services. In 2002, Siemens Australia's sales were close to $1.2 billion, and Siemens employs around 2,900 people in Australia and New Zealand. Siemens has been recognised under the Federal Government's Partnership for Development program for its investments of $140 million in research and development and $235 million in exports of goods and services since 1994.

[92] Intelligent Transport Systems (ITS) is a growing industry which is significant in term of its own scale and as the delivery mechanism for domestic and global supply chains. In Australia, ITS has been defined as: "The application of modern computer and communication technologies to transport systems, to increase efficiency, reduce pollution and other environmental effects of transport and to increase the safety of the travelling public." The multi-billion dollar ITS market is thriving. In 2000 the annual market for transport technologies was estimated at $800 million for Europe and $2 billion in the US. See http://www.its-australia.com.au/.

- *NEC* offers a wide variety of notebooks, desktops and PC servers. NEC also designs, develops and manufactures an extensive range of communications products from satellite earth stations, microwave radio, PABX, routers, broadband DSL, mobile telephones and networks, mobile satellite telephones and networks to fibre optics equipment. NEC recently invested $70 million in establishing a 3G R&D centre in Melbourne, and invests more than $10 million a year in R&D locally.
- *Extel Communications* supplies a range of access network solutions, encompassing pair gain systems, ISDN extenders and solutions for expanding DSL coverage. Extel solutions connect more than half a million subscribers in 14 countries. The company has continually upgraded its manufacturing facility to improve quality, efficiency and cost competitiveness. Extel's manufacturing capabilities include: multi-layer printed circuit board assembly using convection and vapour phase technologies; surface mount assembly capability (22,800 components per hour, through hole assembly, mechanical assembly and cable assembly); in-circuit testing using 'Bed of Nails' test sets; and computer controlled functional testing. Extel also provides contract manufacturing services to external customers.
- *Halipex* designs and makes optical access devices for telecommunications carriers that are used to connect customers to the optical fibre backbone.
- *G&D (Giesecke & Devrient) Australasia* is a fully owned subsidiary of Giesecke & Devrient in Germany, one of the worlds largest smartcard manufacturers. G&D has established a full scale smartcard manufacturing facility in Melbourne where it currently produces SIM cards for the GSM mobile telephone market and cards for pre-paid telecommunications. G&D is also providing packaging and fulfilment services.
- *VPI Systems* provides network optimisation software that enables service providers to generate more revenue from their existing networks and reduce capital expenditures. Major corporations deploying VPI software included: AT&T, MCI, Sprint, Deutsche Telekom, Alcatel, Cisco, Fujitsu, JDS Uniphase, Lucent and Siemens. VPI Systems is a privately held company with headquarters in New Jersey, and service and development centres in New Jersey, Germany, Australia and Belarus.
- *Diamond Australia* offers a range of products for fibre optic networks, specialising in custom made products. Diamond operates one of the largest production facility for fibre optic connectors in Australia. Customers include: Telstra, Nortel, Siemens, Defence Material Organisation, BAe Systems, Agilent, Altamar Networks and Marconi. Diamond manufactures the bulk of its products locally to ensure quick turnaround.
- *RFS (Radio Frequency Systems)* is a designer, manufacturer, supplier and installer of wireless solutions and radio frequency sub-systems. For defence RFS designs, manufactures and installs a range of communication antennas for HF, VHF, UHF and microwave frequencies.
- *CEOS* arose from the University of Melbourne’s Photonics Research Laboratory, and focuses primarily on broadband telecommunications, opto-electronics and design services. A recent partnering deal with Hitachi will focus on the development and

application of Passive Optical Network technology for the delivery of high-speed broadband to the home or business premises.

- *CommTel Network Solutions* provides design, engineering and integration services for telecommunications systems based on the application of new and advanced optical fibre transmission technologies, including photonics, to the power utility, oil and gas, transport and emerging communication carrier markets. CommTel ranked 40 in the Business Review Weekly's Fast 100 list of rapidly growing companies in 2003.
- *InterCEL* is a supplier of GSM/GPRS cellular data solutions in the Australian market. Incorporated in 1989 the company has been providing innovative and reliable cellular communication solutions. InterCEL supplies the full range of Wavecom products as well as its own in-house designed modems and CTS Solutions. InterCEL can offer services to end users who require cellular communication solutions such as automated meter reading, fleet management and in-vehicle solutions, security monitoring and SMS gateway hardware.
- *Interworld Electronics* offers a range of reliable industrial rack mount PC computers, computer telephony and application software, data acquisition hardware and data communications hardware.
- *Cablex* is a specialist manufacturer of wiring looms, harnesses and fibre optic terminations, and offers a range of telecommunications, defence, electronic, automotive and whitegoods wiring looms.
- *Ipex Information Technology Group* (recently acquired by Volante) is a provider of IT solutions. Ipex capabilities span manufacturing, system design and integration, business consulting and software development and a range of services through to managing entire IT environments. These are now combined with capabilities and scale of the Volante Group.

Multimedia Victoria claims that Victoria's telecommunications industry has a turnover of almost $10 billion, employs 20,000 people and has one of the largest R&D clusters in the Asia Pacific (including: Telstra, NEC, Fujitsu, Siemens, Nortel Networks, Agilent and Bandspeed).[93]

There is no doubt that the decline Telstra's local purchasing and R&D activities has had a major impact in the communications area, and the withdrawal of Ericsson's manufacturing and more recently R&D activities, as well as those of others, added to a significant slowing of activities. This has been exacerbated by the 'dot com' collapse of telecommunications investment worldwide and by the relatively slow adoption of broadband in Australia. Large demanding customers and major lead projects are vital sources of demand and innovation, but they are now fewer than they have been in the past.

The Victorian government has been active in leveraging public sector demand aggregation in an attempt to foster broadband rollout. While much attention has been focused on ADSL, it is in some senses an interim technology. One area of considerable promise now emerging in Victoria

[93] MMV (2003) *ICT Excellence*, p1. Available http://www.mmv.vic.gov.au/industry accessed May 2004.

is fibre-to-the-home (FTTH), which opens up a huge opportunity for photonics and fibre, and a wide range of related electronics. A number of local groups are forming around FTTH, including CommTel, CEOS, Broadband Networks and Hitachi – with CEOS and Hitachi, and Telstra and Alcatel cooperating on projects. Moreover, it is likely that adoption of FTTH would lead to a flow on effect, with the emergence of major opportunities for IT applications and content following any major developments. Consequently, despite recent difficulties, communications remains an area of great promise and of considerable local strength.

5.2.3 Medical Devices

Medical devices suppliers include: GBC, Varian, Medtron, Vision Systems (BioSystems), Compumedics, Norwood Abby, etc.

- *GBC Scientific Equipment* is one of the largest Australian-owned designers and manufacturers of analytical scientific equipment, employing more than 100 people and selling to more than 100 countries. GBC derives 90% to 95% of its income from exports.
- *Varian* generates the majority of its income from the professional and scientific equipment manufacturing. It generated around $125 million in revenue during 2003 and employs around 425 people. Varian invested more than $10 million in R&D during 2001-02.
- *Vision Systems* is a locally owned company that focuses on electronic equipment manufacturing. In 2003, Vision Systems generated some $130 million from sales, of which Vision BioSystems realised around $30 million. Vision Systems invested almost $6.5 million in R&D during 2001-02.
- *Compumedics* produces computer-based medical monitoring and diagnostic equipment. Its products for sleep disorders are world-leading and the majority of Compumedics' income is from export sales. During 2003, Compumedics earned $32 million and spent $6.7 million on R&D. Compumedics has grown revenues 35% a year over the last 5 years.
- *Norwood Abbey* was established in 1998 to develop and commercialise medical laser technologies based on electromagnetic and mechanical energy. A major focus is drug delivery. Norwood employs 23 people and earned consolidated revenue of $436 million during 2003.

While there are many interesting developments and opportunities in the area of medical devices, tight budgets among purchasers and the difficulties of integrating devices has meant that there have been a limited number of lead and demonstrator projects. Local industry development may be fostered through a somewhat wider perspective focussing on medical and scientific, rather than more narrowly on medical devices. Again, however, cross-fertilisation of areas of local strength, such as in biotechnology and life sciences, photonics and wireless communications, offers significant opportunities. Support for projects like the aXcess car in such areas as remote

monitoring in healthcare could provide significant opportunities to combine and showcase local strengths.

5.2.4 Security

Security suppliers include: Interlogix (GE Security), Inner Range, Nidac, ACD Digital, Vision Systems (Fire & Security), Intelligent Fire Systems, etc.

- *GE Security / Interlogix* develops and manufactures electronic security and access control systems.
- *Inner Range* produces integrated intruder alarm, access control and automation systems. As well as being a major market player in Australasia, Concept products are gaining market share in European and Asian markets. Inner Range has formed a number of strategic partnerships to focus on the integration of security and automation systems.

Table 5.1 Strengths, Weakness, Opportunities and Threats

STRENGTHS	WEAKNESSES
• Competencies within its people and companies • Well trained engineers and other skilled labour • Adaptive and innovative thinkers • Flexible and agile manufacturing capabilities • Competitive R&D capabilities and fast turnaround times • Cost effective Contract Electronics Manufacturers (CEMs) • Strong long-term customer and supplier relationships • Recognition by Australians of the benefits of • advanced technology • Stable political and economic environment	• The Australian market is limited, small and isolated, lacks growth and capabilities in certain areas • Some lag in deploying the latest infrastructure technologies • Distance from international markets limits Australia's ability to successfully interact globally • Lack of cohesion in the investment attraction strategies and incentives used by various Governments in Australia • The Australian supply chain is underdeveloped and hence poorly utilised • The industry is fragmented and lacks critical mass • Lack of credibility as a manufacturing location
OPPORTUNITIES	**THREATS**
• Fostering indigenous industry • Developing clusters to retain and attract new business activities • Marketing the capabilities of the Australian electronics industry both nationally and internationally • Encouraging better collaboration between industry, universities and centres of excellence • Fully exploiting the opportunities that Multinational Corporations offer • Developing focussed areas of technologies for export, including our R&D capabilities	• Growing importance and competitiveness of low cost manufacturing nations such as China and India • The pace of international development is outstripping Australian technology • Long lead-times to revitalise the industry • Confusion of whether to react to market needs or invest in visionary technology and concepts is ever present

Source: DITR/DCITA (2003) *Electronics Industry Action Agenda*, Department of Industry, Tourism and Resources & Department of Communications, Information Technology and The Arts, Canberra, p14.

- *Nidac Security* designs and manufactures a range of alarm, access control and related back-to-base communications systems.
- *Vision Systems* is an international high technology company with a focus on products and services in the medical and fire and security sectors. Its fire and security activities include production of early warning smoke detection, surveillance and security systems. In 2003, Vision Systems generated some $130 million from sales, of which Vision Systems Fire & Security realised around $87 million.

With heightened interest in all forms of security worldwide there is new interest in security technologies and new opportunities are emerging in security related equipment and applications. Government and/or Defence-based lead projects could contribute to a more coordinated development of solutions for security markets.

5.2.5 Industrial & process control

Industrial Process Control suppliers include: ANCA, Datataker, IPC Global, Innovonics, Intermoco (Australon), Moonlighting, NeoProducts, Robotron, Traffic Technologies, Atco Controls, Schneider Electric, Bytecraft Automation, etc.

- *ANCA* is a manufacturer of CNC grinding equipment. All activities related to machine design and build, CNC design and build, system and application software development are conducted within ANCA, and it sells and supports its products worldwide through a network of fully owned subsidiaries. ANCA has around 250 employees and sales of around $60 million.
- *DataTaker* is a supplier of data loggers and data recording equipment to a broad range of customers throughout industry, public utilities, scientific and educational institutions.
- *IPC Global* (formerly Industrial Process Controls) is a supplier of materials testing systems, intended primarily for applications in the research and quality control/quality assurance areas of road pavement construction, civil engineering and the manufacturing industry.
- *Innovonics* supplies Passenger Information Systems (PIS), CCTV security & infotainment solutions, on-board communication solutions and ‘off-board’ wireless solutions to the public transport and fleet markets. Innovonics also produces data recorders for industrial applications. Innovonics employs about 50 staff and generates around $12 million in annual revenue.
- *Intermoco* provides remote monitoring and control services, focusing on the design, development and marketing of a range of products and solutions for application in the monitoring and control systems industry.
- *NeoProducts* has designed, developed and manufactured a range of products, including medical devices, such as a dispensing system for refrigerated bio-medical products, and a device that allows transdermal administration of drugs. NeoProducts also designs and manufactures touchscreen kiosks, including a kiosk located in pharmacies throughout

the United Kingdom which measures blood pressure, heart rate, weight and body mass and provides a body fat analysis on a pay-per-use basis.

- *Robotron* is an R&D, manufacturing, marketing and investment group. Its products include: radio receivers and antennas, monitoring and surveillance systems, automatic reading machines for the blind, internet software and digital compasses for robotic applications.

Both industrial process control and instrumentation are areas of local strength and opportunity.

5.2.6 Instrumentation

Instrumentation suppliers include: Agilent Technologies, Gedge, Phasefale, Datataker, Hawk Measurement, Contrec, Kingfisher, Alfa-Tek, McVan, etc.

- *Agilent Technologies* is a leading designer, developer, manufacturer and provider of communications components as well as electronic and optical test, measurement and monitoring instruments, systems and solutions.
- *Gedge Systems* produces digital weight indicators and batch controllers for a range of industrial weighing applications.
- *Phasefale* began in 1970 selling a motor protection relay for refrigerators, and grew with the introduction of a supermarket temperature alarm system and other products. During the 1980s Phasefale's product range continued to target supermarket refrigeration, and the customer base grew to include the majority of refrigeration contracting companies nationally. Phasefale also started to contract out its production machinery and design services, and developed a business centred on servicing other companies' production and design requirements. Today, the company employs around 25 people, with products targeting the refrigeration industry, industrial, laboratory equipment and air conditioning and heating markets.
- *Hawk Measurement* manufactures and supplies ultrasonic pressure sensors and level measurement systems, to users in mining, power generation, food, chemical, waste treatment and other industries where harsh conditions and critical processes demand robust performance.
- *DataTaker* supplies of data loggers and data recording equipment to a broad range of customers, including public utilities, scientific and educational institutions.
- *Contrec* is a subsidiary of the Dutch company Delft Instruments, which specialises in the design, manufacture and sale of electronic instrumentation for the process control and petroleum industries. Contrec manufactures a range of instruments for: petroleum measurement, gas, steam and energy measurement, blending and batch control, truck loading systems and on truck metering. More than 65% of Contrec products are exported.

- *CPE Systems* specialises in developing customised test and measurement solutions to spec, which typically include commercial off-the-shelf components, purpose built hardware and custom software solutions.
- *Kingfisher* is a manufacturer of optical fibre test equipment, which provides measurement solutions to thousands of specialist engineers and technicians performing optic cable testing and installation. Products include optical power metres, laser LED sources, optical talk sets, return loss meters and optical attenuators.
- *Alfa-Tek* provides development tools and components to technology businesses in Australia, New Zealand and the Pacific region, Singapore, Malaysia and Indonesia. Products include: in-circuit emulators, device emulators (ROM, flash etc.), device programmers, converters and adaptors, compilers, debuggers (BDM and Target monitor type), simulators, real time kernals (RTOS), logic analysers and UV erasers.

Like industrial process control, instrumentation offers opportunities to develop and market local capabilities.

5.2.7 Power Supplies

Power Supplies suppliers include: Rectifier Technologies, Setec, Selectronic, Thycon, Thytec, Arlec, etc. A number of these local suppliers supply the telecommunications industry.

- *Rectifier Technologies Pacific,* a member of ICE Corporation. ICE is the Holding Company for Rectifier Technologies Pacific and Protran Technologies, both of which are based in Blackburn. RTP is a global leader in the research and development of switch mode rectifiers, and Protran is a manufacturer of custom wound magnetic components used in power electronics and industrial applications for the telecommunications industry. ICE revenues reached almost $15 million during 2003. RTP recently won an R&D START Grant to work on a compact rectifier. The project is expected to lead to a trebling of staff and is likely to open up more export opportunities for the company, particularly in the United States and Europe.
- *SETEC* also designs and manufactures power solutions for the OEM and telecommunications industries. SETEC exports to countries around the globe, including the United States, Europe, China and New Zealand.
- *Selectronic Australia* designs and manufactures a range of wire wound components and high quality sine wave power inverters.
- *Thycon* has over 30 years experience in researching, designing and manufacturing power conversion equipment. Founded in Melbourne in 1968 Thycon focuses on manufacturing power conversion products for the industrial, resource and commercial sectors. The company expanded from variable speed DC drives to voltage/current regulated static power supplies, airfield lighting regulators, cycloconverters, line conditioners, high current rectifiers, inverters, uninterruptible power supplies, static frequency converters, unity power factor and harmonic reduction units. R&D expenditure has continuously exceeded 10% of revenue.

- *Thytec Australia* also designs and manufactures power technology to meet telecommunication needs. Inverters manufactured by Thytec have a track record for high reliability under extreme conditions.

There is a large and growing market for a wide range of power suppliers, increasing focus on mobility, security and uninterruptible power supply. There is also growing interest in electric and hybrid vehicles, for which power supply technologies are crucial.

5.2.8 Contract manufacturing and PCBs

Contract manufacturing & PCBs suppliers include: Precision Australia, AEMS, Labtam, Duet, Millison, Clevertronics, EDPM, Unique Micro Design, etc.

- *Precision Australia* supplies PCBs and can design, manufacture and assemble locally. It has two plants, which both specialise in providing specific products and services. The Melbourne factory is a fast turnaround, high-technology prototype service plant. Adjacent to it is an assembly division suitable for small, fast turnaround, high-technology boards.
- *AEMS* is an electronics manufacturing services firm which designs, manufactures and distributes a range of electronic products for OEMs and customers in the audio, automotive, defence, banking, gaming, medical, security, telecommunications and traffic management markets. AEMS also offers a range of specialist support services, including product service and repair, brokerage of surplus equipment and components and RTO-approved training.
- *Labtam* is a designer, developer and manufacturer of computer and electronic products. Founded 1972, Labtam immediately began selling into global markets. In the 1980s, Labtam entered into computer manufacturing, designing and manufacturing a range of UNIX workstations. In 1989, Labtam produced the world's first RISC X terminals, and in 1993 delivered the first fully integrated ISDN X terminal. Since 1991, major technology sales have been made to Hyundai in Korea, A Plus in Taiwan and NCR in the United States. Labtam currently focuses on R&D, manufacturing and system integration. Capabilities include: surface-mount and through-hole PC board assembly, prototype to high volume production, packaging and distribution, product test and burn-in, box-build and system integration, warranty and repair services.
- *Millison Technology* is a contract electronics manufacturing service provider. Established in 1990, Millison Technology provides a full range of manufacturing and assembly services to industry, specialising in surface mount and mixed technology assembly as well as the conversion of existing through-hole products to surface mount. Millison’s services include: electronics assembly, PTH to SMT conversion, PCB design services, hardware, firmware and software design.
- *Clevertronics* is a manufacturer and distributor specialising in exit and emergency lighting, commercial fluorescent lighting, monitoring systems for exit and emergency lighting and lighting control systems. Its computer monitoring systems are among the

most advanced on the market. Clevertronics is also using its powerline technology to expand into the 'distributed intelligent devices' market, encompassing lighting control, building management and security.

There are a number of local contract manufacturers or electronics manufacturing services suppliers and non-specialist supplies who provide contract manufacturing services as an adjunct to own-production. This mirrors international trends, with increasing globalisation, specialisation and the fragmentation of value chains. It is a trend that suggests a need for an intensification of both horizontal and vertical linkages within the electronics product system – between specialist manufacturers and assemblers, and between designers and manufacturers. Networks, clusters and alliances promoting and enabling deep linkages between electronics SMEs and facilitating access to share infrastructure such as equipment and design software will be an essential ingredient for future success. The emerging trend for increased customisation and build to order promises to provide new opportunities for contract manufacturers able to supply a range of services suitably scaled for the Australian and regional Pacific markets.

5.2.9 Other markets and activities

There are a number of other vertical markets worthy of mention. In defence and avionics, for example, there are a number of firms looking to the new fighter project and there is a lot of work in ‘continue life projects’ re-fitting and re-conditioning existing equipment (eg. re-fits).

There are also a number of firms engaged in the provision of more generic electronics and related equipment. These include, for example: Olex Cables, which produces more than 20,000 different cables and is Australia's largest power cable manufacturer, and is consolidating its Australian manufacturing activities in Victoria; and Corning Cable Systems. Closely related to the automotive electronics and telemetry are firms like Raywood, a local supplier and exporter of taxi global positioning systems to Dubai and the United States. These, and many others, represent local strengths.

5.3 Technology and horizontal clusters

The electronics industry reveals a complex interplay between technologies, applications and markets. Particular technologies can support an range of applications and feed into a number of vertical markets. In Victoria, wireless communications and photonics are among the leading examples of this phenomenon.

There has long been a major emphasis on, and significant competence in wireless and mobile communications. This is now increasingly translating into applications of wireless and mobile technologies in a number of vertical markets (eg. communications, automotive, health, defence, transport & logistics, etc.) for monitoring and telemetry as well as the more direct wireless applications in mobile communications. This focus feeds through the entire value system, from ASIC designs, through the fabrication and integration of DSPs, etc.

Photonics has suffered in the recent downturn in telecommunication investment. Nevertheless, it remains a strong area of focus and activity in Victoria, and elsewhere in Australia. The

Victorian Photonics Network was established in 2002 and is a free, membership-based industry network focused on supporting and developing the photonics cluster in Victoria.[94] Victoria's photonics cluster covers a number of areas that all have considerable prospects for growth, including: communications, medical, bio-photonics and micro-photonics, defence, intelligent transport systems and security.

Early photonics activity in Victoria focussed on telecommunications, with optical fibre research at Telstra Research Laboratories (TRL) providing an important base for the development of the photonics industry. Despite the recent weakness in the global market for communications, future requirements for bandwidth will likely ensure that communications related photonics will be an important driver. Strong local medial research groups in universities and hospitals are also providing opportunities for the photonics industry. Photonics is now following the path of wireless/mobile and translating technological strengths into vertical market applications. It will also be important to exploit the synergies of convergence in photonics, microelectronics and nanotechnology, and build on local strengths by fostering linkages between players.

5.4 Structure and structural change

The Victorian electronics industry structure can be represented as a pyramid. At the top are the multinationals with a strong base in Australia and linkages into global markets. In the centre are a relatively small number of Australian SMEs. The base is made up of many thousands of micro firms. Value is the inverse, with much of the sales and export value concentrated with the small number of multinationals and larger indigenous firms, and relatively little value realised at the micro enterprise level (Figure 5.2). There is a need to focus leverage where it is likely to be most effective, while creating linkages that suit all players.

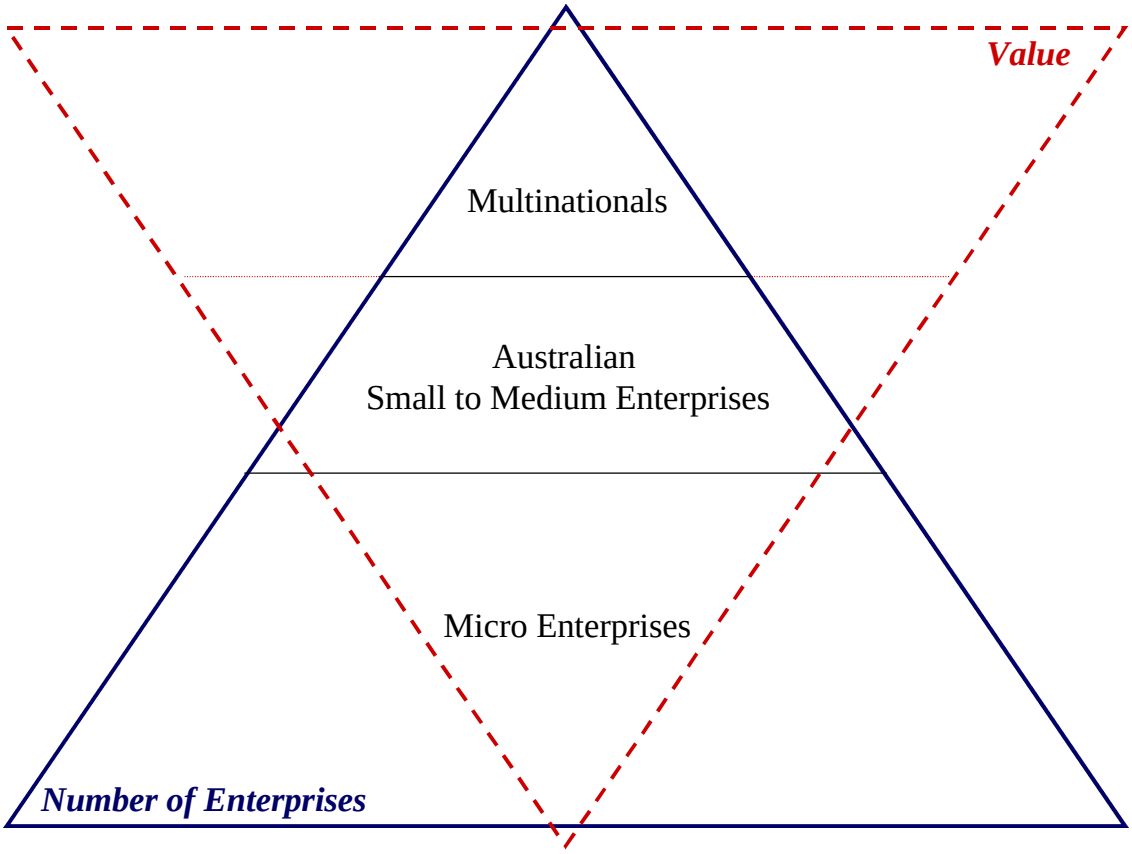
As noted, the evolution of the electronics industry can be seen as a fragmentation of the value chain, with separation of activities and increasing specialisation along a dimension running from basic manufacturing assembly to high-value, knowledge-intensive services (Figure 5.3). Integrated OEM design, verification, manufacturing, assembly, distribution, maintenance and repair is increasingly giving way to the fragmentation of these activities and to firm and regional specialisation – with the formation of highly specialised production clusters participating in global production systems. At the same time there are cross-cutting trends, with labour-intensive, volume manufacturing shifting to contract manufacturers in Asia, while Europe and the United States retain the high-end, knowledge intensive stages of the value chain, such as product development and R&D.[95] But, high unit volume products evolve quickly from small scale manufacturing near design centres of gravity, to large scale manufacturing near market

[94] MMV (2004) *Victorian Photonics Network*. Available http://www.mmv.vic.gov.au/photonics accessed May 2004.

[95] E-business Watch (2003) *ICT and e-business in the Electrical Machinery and Electronics Sector*, European Commission, Sector Report 11/II, p14. Available http://www.ebusiness-watch.org/marketwatch/ accessed April 2004.

centres of gravity and, finally, to large scale manufacturing near low cost labour centres of gravity.[96]

Figure 5.2 The structure of the electronics industry



Source: Centre for Strategic Economic Studies.

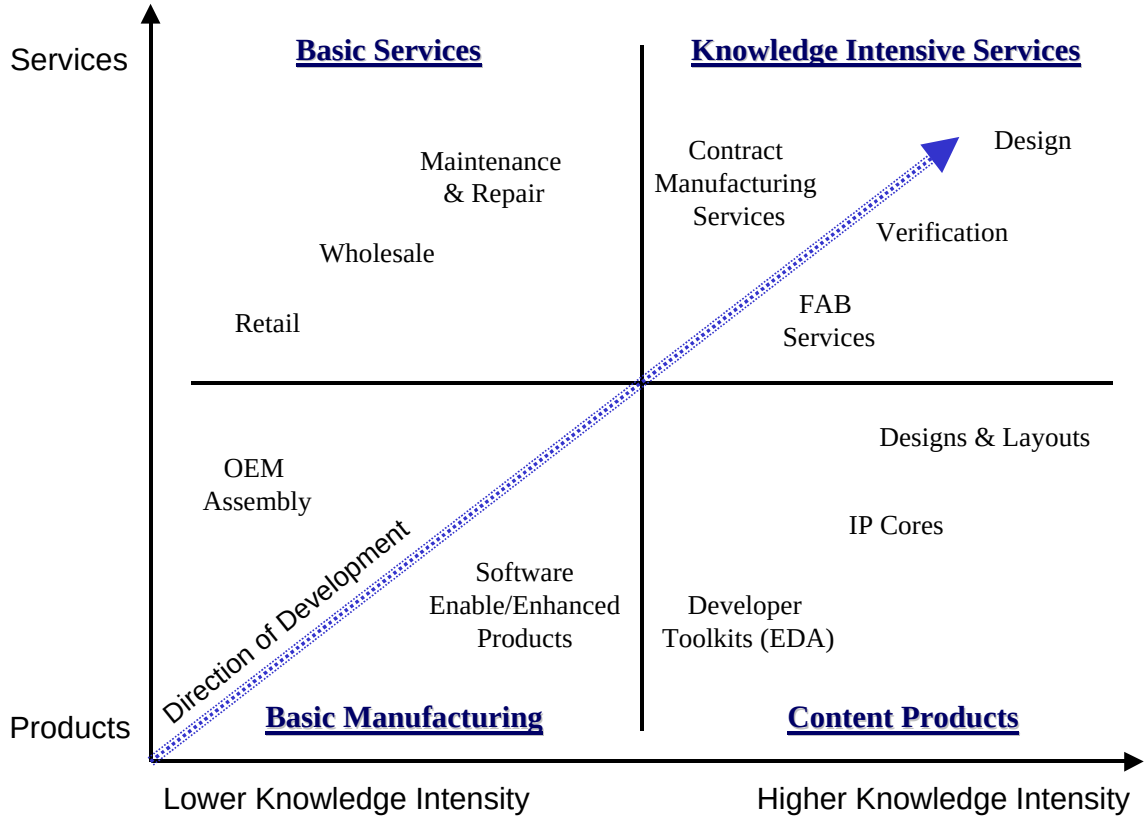
Unable to compete with Asian locations on labour costs, and remote from major markets, Australia's electronics industry must seek to maintain a position as a design and development 'centre of gravity'. To do so, Australia must develop effective linkages between global markets and emergent high value services (eg. design and verification) and IP-based products (eg. IP cores, designs and layouts), and those linkages must take account of the very different scale and capabilities of major multinationals, local SMEs and micro services and content businesses.

Ultimately, however, products can become so commoditised that they provoke the emergence of business models based on differentiation through customisation. One example is that of desktop PCs, which are increasingly being built to order. Coupled with local purchasing preferences in outsourcing contracts, this has led to the development of local (final) assembly of PCs and flexible customisation. There are now hundreds of local desktop PC assemblers in Australia. Most are small shop-front operations, but there are a handful of significant players (eg. Ipex (Volante), Optima, etc.). This suggests that fragmentation of the supply chain and

96 NEMI (2003) *Technology Roadmaps: December 2003*, NEMI, p11. Available http://www.nemi.org/

commoditisation of products can come full-circle, bringing new opportunities for assembly activities.

Figure 5.3 Dimensions of specialisation and development in electronics



Source: Centre for Strategic Economic Studies.

5.4.1 Networks and clusters

This structural change in the industry is one of the major issues to be faced. Traditionally Australian firms have tended to seek to be vertically integrated, to internalise as much of the process as possible. The advantages of such vertical integration lie in extending control over supply, quality, compatibility and integration. With increasing costs for plant and design software, however, firms can no longer expect to be able to do everything in-house. Increasingly firms will need to integrate horizontally (ie. with other firms in a similar position in the supply network). Competition is no longer simply between products and services, but also between business models and value chains.[97] Indeed, global markets now feature competition between entire production systems, often orchestrated by multinational firms, rather than between

[97] Waraniak, J. (2000) *Driving Web-Enabled Market Efficiency*, Federal Reserve Bank of Chicago, Detroit, MI.

individual factories or firms.[98] Value chains are turning into networks, moving beyond the management of backward linkages to suppliers and forward linkages to customers, and becoming deeper, more complex, horizontal and modular.

Box 5.1 Major trends in electronics manufacturing

Briggs (2000) noted that the main trends in global manufacturing to have emerged include:

- Globalisation of both production and markets;
- IT/e-commerce capabilities and the impacts on business models, communication and integration;
- Customisation and the demand for increasingly customer focused and flexible production;
- Demographic changes, which affect the location and availability of skills and labour markets, as well as shifting market tastes and demands; and
- Environmental and sustainability issues, which affect the viability and sustainability of production systems.

In view of these trends the internal responses which companies should focus on include:

- Human resources issues – relating to open, agile, lean, non-hierarchical organizations without boundaries sharing personnel; skills generation, continual learning, ability to adapt, multi-discipline / multi-technology, with radical redefinition of functions within companies; and fostering a culture of innovation;
- Using regulations as a positive force – as a potential competitive advantage to companies that are prepared to build links with regulators and bring regulators into the network;
- Intellectual capital/knowledge management – where the worker becomes an intellectual contributor, the firm focuses on IP retention; second tier companies are key knowledge holders, and organizations are shaped around knowledge management;
- Agility and dynamic supply chain network developments;
- Innovation and learning throughout the system;
- Specialisation and migration to higher value-added activities as a key element of the business model, with a restructuring of manufacturing enterprises into makers, innovators and integrators; and
- Development of clear core competencies that will create a barrier to new entrants.

In order to achieve the required level of responsiveness and flexibility to market changes, companies will need to build and extend their networks of contacts across the range of their functions.

Source: Briggs, H. (2000) *Emerging Global Manufacturing Trends, Informan 2000*, Institute for Manufacturing, University of Cambridge. Available http://www.foresight.gov.uk/ accessed April 2004.

[98] UNCTAD (2002) *World Investment Report 2002: Transnational Corporations and Export Competitiveness*, United Nations, New York and Geneva, pxxi.

The size of the Australian market and of leading customers' demand in local vertical markets acts as a limiter to the ability of local firms to specialise and achieve scale simultaneously. In most areas, demand in Australia does not support the level of capital expenditure, specialisation and scale required in order to thrive. Consolidation among the smaller players in the industry is likely to be necessary, with the formation of deep networks, clusters and alliances a partial alternative. Support for such networks, clusters and alliances is essential. Victoria's microelectronics and photonics networks, which operate with modest support from the Victorian Government, are a successful model for the creation of deeper horizontal linkages within the local industry. Perhaps the only danger lies in having too many such networks, thus limiting the *de facto* scale achievable and becoming too fragmented to generate the range of vertical and horizontal linkages required.

Box 5.2 The Future of the Victorian Microelectronics Industry

The industry will continue to experience change, sometimes dramatic, as the fortunes of industries and businesses that microelectronics supports rise and fall. Microelectronics design is complex, and the skills required to be effective are demanding and subject to continuous revision. The high capital cost of both research and development tools, skill development and fabrication facilities will continue to result in periodic under- and over-capacity and the resultant volatile marketplace for microelectronics skills and products

On a long-term basis, the global industry appears to have an insatiable appetite for people with the necessary skills, despite the massive capital costs and research and development costs associated with microelectronic product development. The projections for long-term growth indicate that microelectronics will be one of the fastest growing industries for a long time.

The increasing complexity and cost of the process of microelectronics design increases the challenge for a relatively small local industry to remain viable while subject to substantial forces of change. However, Victoria and Australia have substantial comparative advantages in high value added electronics research and development, and our skills base will become an increasingly important competitive advantage in the global product development business.

It is likely that robust, sustainable long term growth in the Victorian microelectronics industry will include the development of locally controlled businesses built on a convergence of technology areas where Australia has a position of strength, and possibly not in traditional communications markets. Photonics, biomedical electronics and automotive applications are examples of potential candidate vehicles for such growth. The increasing diversity in the application of microelectronic technology will eventually result in new opportunities for growth and a more sustainable industry environment.

Growth will also come from close partnerships with the rest of the global technology industry, the continued development of a highly skilled workforce, and the development of an environment in which Victoria is able to compete effectively for investment in research and development. Finally, growth will come from increased collaboration within the local industry, to achieve through synergies our own "Silicon Valley effect". This includes cooperation with the venture capital and investment community and technology and business partners everywhere.

Source: VMDN (2004). See http://www.mmv.vic.gov.au.

5.4.2 Shared infrastructure

The viability of local electronics SMEs and of local networks and clusters will depend, in part, upon access to appropriate shared infrastructure. In electronics, unlike other areas, both the equipment and the software for design are getting more expensive (not less). As a result, it is getting more difficult for smaller firms to afford the latest capital equipment and to keep up with developments in design, development and production technology. Limited use testing and conformance related equipment and systems are also becoming prohibitively expensive for SMEs.

Shared infrastructure is essential for the future development of the electronics industry, with access to equipment and software in the design, testing and conformance space a key problem. The Australian Microelectronics Network (AMN) suggested that, around the world, twenty-two countries have identified similar problems and developed shared access systems to support the design and fabrication of integrated circuits.[99] Locally, there are a number of initiatives directed to this problem and much progress is being made. Nevertheless, these initiatives require commitment and would benefit from further support. It might also be beneficial to learn from the experience of other fields, such as that of consortial purchasing and national site licensing of scientific and professional publications, and apply similar approaches and solutions to such areas as the consortial licensing of design software.

5.4.3 Lead projects

One major problem facing local electronics firms is the lack of, and decline in large demanding 'informed' clients – exacerbated by major privatisations, risk aversion and disinvestment by some major multinationals. Government, through privatisation, outsourcing and other purchasing controls has also reduced its role as a lead purchaser. Consequently, while there have been many gains made in such areas as R&D funding, and there are many firms with innovative technologies and products, the opportunities to participate in the development of solutions in lead projects are few and far between. Finding ways to support more lead/demonstration projects with deeper pockets and longer time horizons would be beneficial.

There are a number of areas of strength and promise that could benefit from the establishment of such lead projects. For example, it is apparent that remote monitoring and telemetry will be important in all sorts of applications and markets (eg. health monitoring of home-based patients). There are also clear local strengths in the area. What is lacking is lead projects that facilitate the development of the devices needed and support trials of them in the field, enabling clients, suppliers and researchers to work closely on translating technologies and supply capabilities into marketable solutions.

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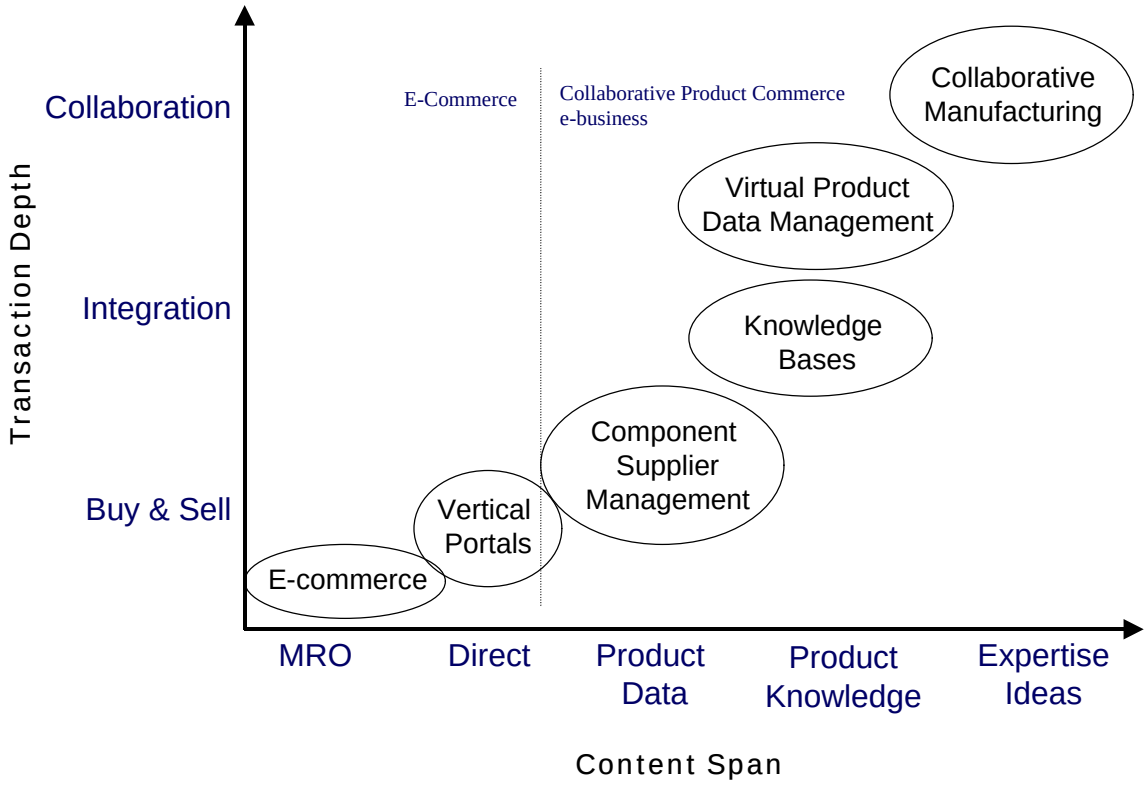
[99] AMN (2004) 'The Australian Microelectronics Network has invested in a remotely accessible Agilent semiconductor tester for members' use,' *AEE* 34(10) October 2001, p24.

There are also likely to be opportunities for the development of lead projects in e-science. The very nature of research is changing rapidly, due in part to the impacts of ICTs.[100] There are a number of major facilities (eg. Australian Synchrotron, Square Kilometre Array, etc.) and a number of network and grid initiatives (eg. AREN, GrangeNet, etc.) that might provide opportunities for the development and implementation of local electronics and related technologies.

5.4.4 Supply chain management

A common thread throughout analyses of the electronics industry is the need for deeper linkages, both vertically throughout the supply chain and horizontally between firms in particular markets. Collaboration and supply chain management, of a kind that goes beyond management of the supply network to support deep integration and collaboration, are critical (Figure 5.4). Local partnering and the use of B2B e-marketplaces can be developed further, but there is also an emerging need for a shift from e-commerce (ie. electronic trading) to e-business (ie. using networked systems to manage and participate in collaborative production systems).

Figure 5.4 Collaborative product commerce



Source: Gartner Group. Cited by Waraniak, J. (2000) *Driving Web-Enabled Market Efficiency*, Federal Reserve Bank of Chicago, Detroit, MI.

100 Houghton, J.W. Steele, C. & Henty, M. (2003) *Changing Research Practices in the Digital Information and Communication Environment*, DEST, Canberra.

Needs-based projects are generally more successful, and one possible approach to deepening product system collaboration would be to harness the demands for information exchange and collaboration created by emerging regulatory demands for 'product stewardship' and control of 'materials of concern'. A lead project in the e-business collaboration space might involve embracing compliance demands and using them as the driver for the development and deployment of an integrated e-business knowledge management system, with suitable metadata and access management standards. Such a system might provide both the foundation for an infrastructure for greater vertical and horizontal collaboration within the industry and a process for collaborative project development and management that is more widely applicable.

5.5 Key points

While there are many trends affecting the Victorian electronics cluster and many issues involved, preliminary analysis suggests the following key points.

Structure

Firms in the local electronics industry are of three main types: multinational majors, Australian SMEs that are linked into markets and growing, and many micro businesses – some of which do not seek to grow their business, being what might be described as 'lifestyle businesses' rather than growth driven enterprises. This is not a criticism, but rather a call for recognition. Rather than lamenting a lack of hard-nosed entrepreneurialism, we should focus on adjusting policy approaches to the businesses we have.

The implications of this situation include: a need to focus on fostering SMEs and their links into global production systems, and a need for new policy approaches to the micro businesses (particularly the high knowledge–high value ones) that takes account of how they might better be mobilised and engaged in global production systems.

Structural change

There is increasing fragmentation of functions within the value chain and disbursement of production activities globally. This fragmentation is variously referred to as deverticalisation (ie. the decline of vertically integrated OEM production) and horizontal fragmentation. It is driven by outsourcing, facilitated by standardisation and is both a driver and consequence of globalisation.

The implications of this include: a greater need for supply chain management, moving e-commerce towards more deeply integrated e-business, enhanced ways of linking local producers into global production systems, and an increased focus on standards and on quality accreditation, prequalifying, etc. Enabling local electronics SMEs and micro businesses also depends, in part, upon access to shared infrastructure, such as design software, manufacturing, testing and conformance facilities, and upon enhanced IP management and access (eg. collective access to IP Cores, etc).

Innovation

A feature of fragmented supply systems is that they make innovation and learning difficult. Staying informed and in touch is vital.

The implications of this include: the need for increased attention to innovation and learning linkages around the system (eg. between R&D and educational institutions and SMEs); the importance of participating in R&D relationships, missions, etc.; the importance of value system linkages and close relations with buyers and suppliers, who are often important sources of ideas and demanding requirements that drive innovation; the importance of participation in the development of standards and standards monitoring; and the importance of quality management systems, accreditation, prequalification, etc. One widely noted 'missing ingredient' is a sufficient number of lead projects. The role of major local purchasers has changed, with fewer opportunities for high-profile, longer-term development projects. There is a need to find new ways to generate lead projects in areas in which there are opportunities to develop local technologies into market ready solutions.

Compliance

There are number of major compliance issues, including: materials of concern (eg. lead, bromine, etc.) and product stewardship issues, which are being pushed back up the supply chain to producers. It is not merely an add-on. Both materials of concern and product stewardship need to be designed in, making it a design and development issue too.

The implications of this include: the increased importance of testing and conformance infrastructure, to enable firms to demonstrate and meet standards (domestic, regional and global); a need to keep close contact with international standards and international developments in compliance; and the increased importance of linkages through the supply chain, supply chain management, knowledge management and the sharing of key information about products, processes and practices.

Local issues

There is also a range of more local issues, such as: skills and trade skills development, with widespread concern about shortages of trades and higher skills and the lack of training support; gaining and maintaining access to global production systems; the development of local firms within highly fragmented global production systems; a need to focus on the research, design and development end of the spectrum of industry activities; and how to effectively mobilise the many micro businesses and 'lifestyle' independents.

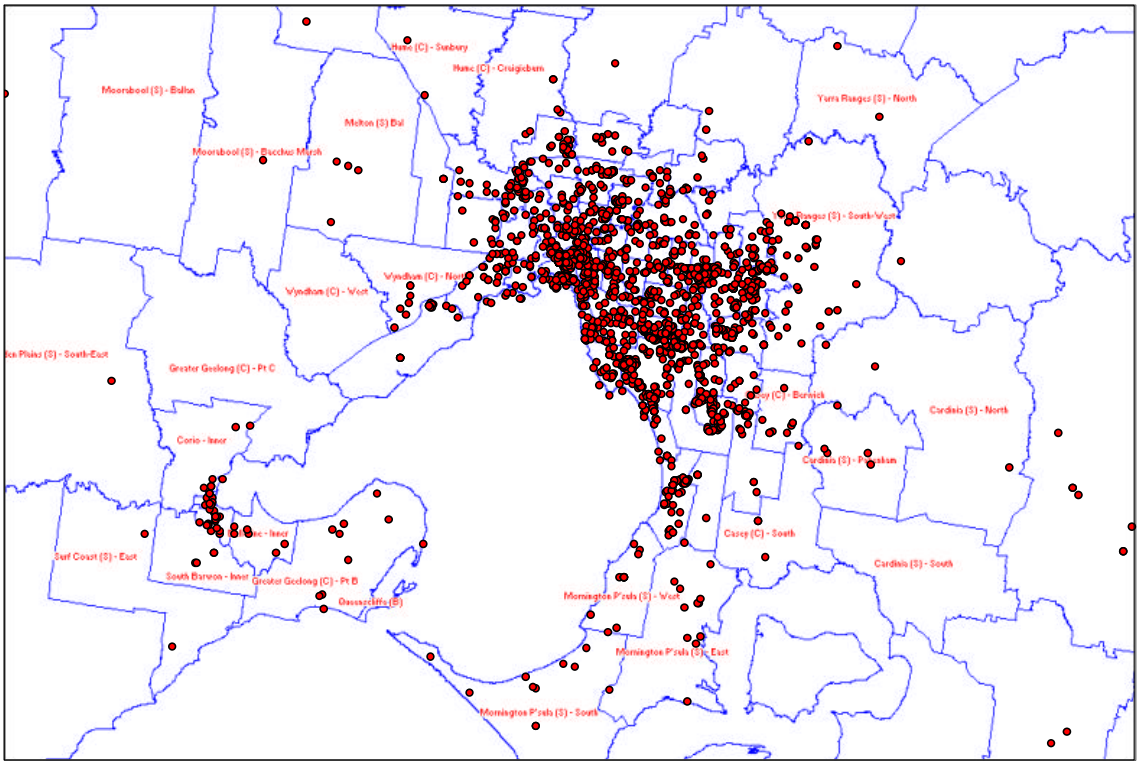
While all of these challenges are real and immediate, many suggest ways forward and the adoption of responses which, if not known, are at least emergent.

Appendix A Electronics clustering in Greater Melbourne

This appendix presents a number of maps showing the location of electronics clusters in the Greater Melbourne area. Firms are shown by postcode location. Because of the elimination of duplicate listings and sampling of non-core activities they are no more than indicative of the distribution of Victorian Electronics Cluster firms and activities.

Figure A1 shows the location of the firms identified for this study, and subsequent Figures show the location of firms by sector (ie. communications, components, equipment, IT, lighting, machinery, security and engineers).

Figure A1 Electronics industry clustering: Greater Melbourne (All Sectors)



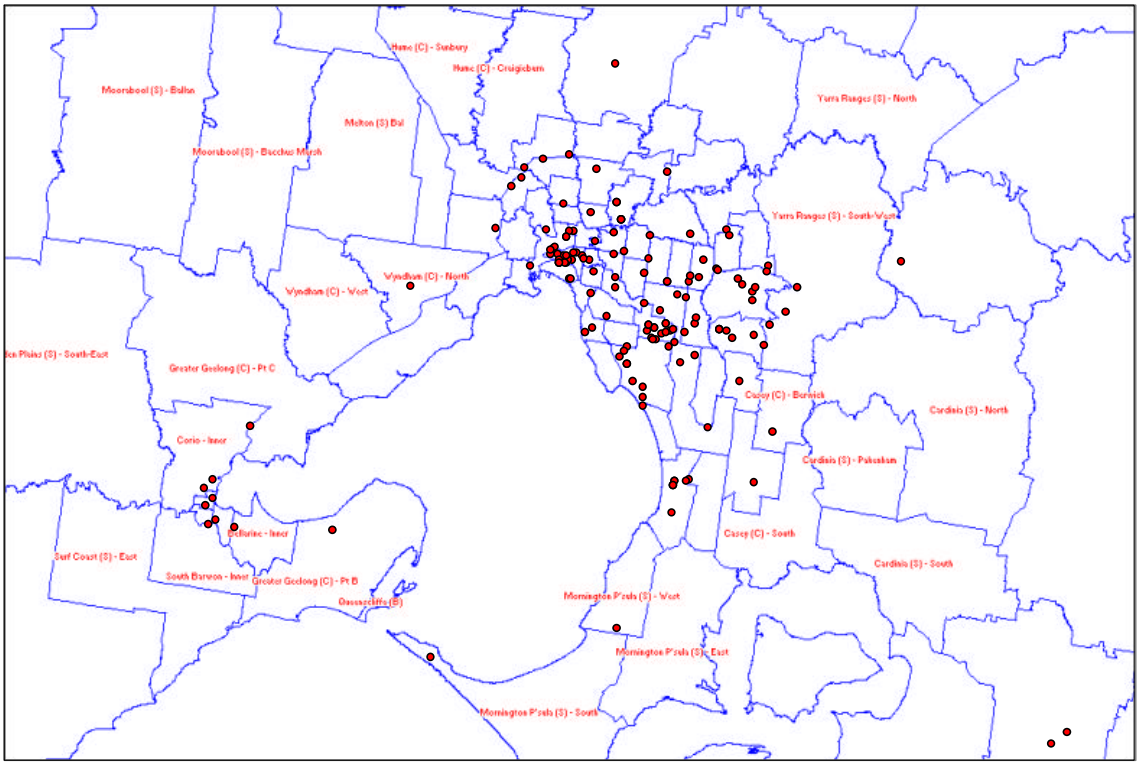
Source: Victorian Electronics Cluster Survey, Project Database (CSES). CSES Analysis.

As noted in Section 4, a large proportion of the electronics cluster firms in Victoria are located in the eastern suburbs of Melbourne – in the local government areas of Monash, Knox, Greater Dandenong, Kingston/Bayside Kingston, Whitehorse, Manningham, Baroodara, Yarra, Maroondah, Glen Eira, Port Phillip, Banyule, Darebin, Casey and out as far east as the Yarra Ranges and south to Frankston. Together these areas account for some 60% of all firms identified. When account is taken of the 'natural' dispersion of wholesale and retail activities, it is apparent that the concentration of production activities is significant. The Top 10 postcodes

account for 25% of all firms identified, and the Top 10 Local Government Areas account for 39% of all firms identified.

Figure A2 shows the clustering of communications firms. The Top 10 postcodes account for 32% of all communications firms identified, and the Top 10 Local Government Areas account for 46% of all communications firms identified.

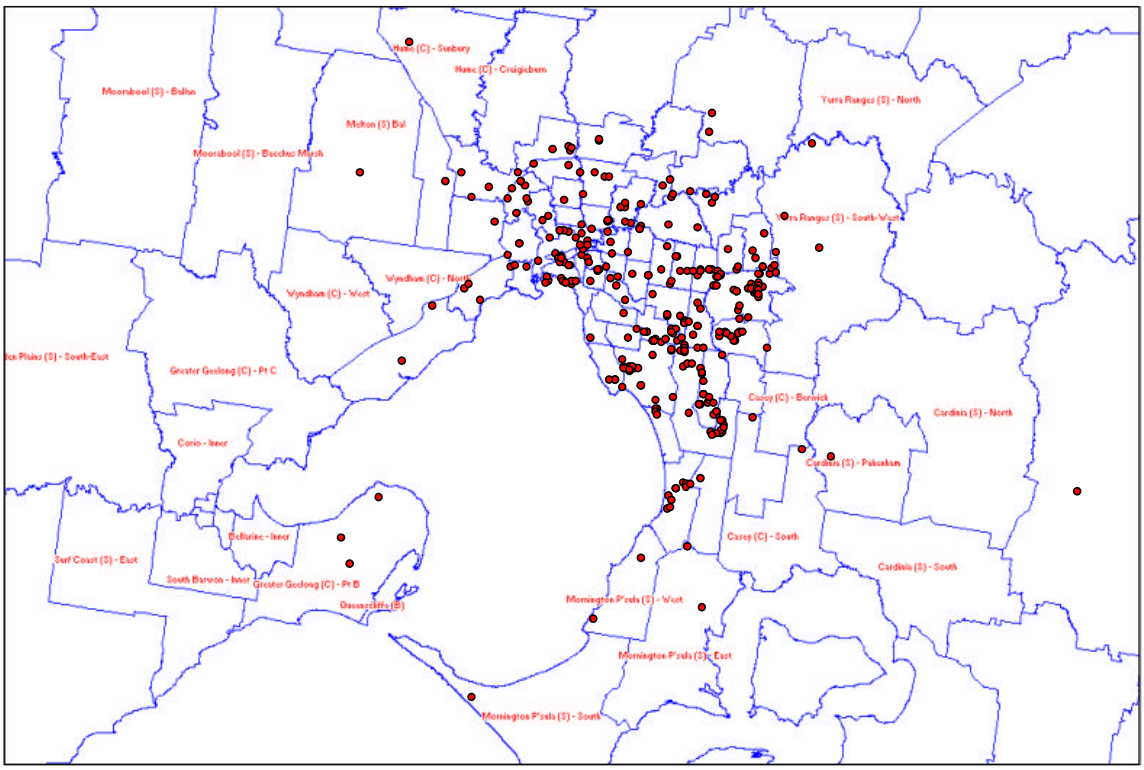
Figure A2 Electronics industry clustering: Greater Melbourne (Communications)



Source: Victorian Electronics Cluster Survey, Project Database (CSES). CSES Analysis.

Figure A3 shows the clustering of components firms. The Top 10 postcodes account for 31% of all components firms identified, and the Top 10 Local Government Areas account for 45% of all components firms identified.

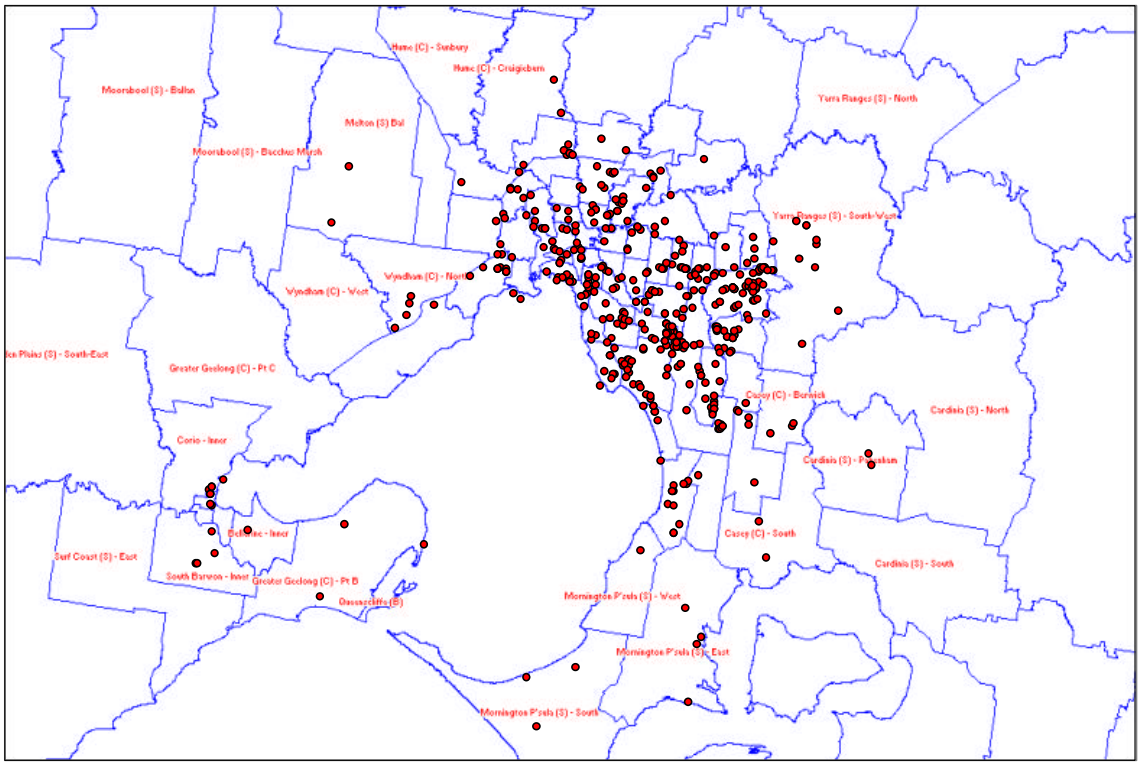
Figure A3 Electronics industry clustering: Greater Melbourne (Components)



Source: Victorian Electronics Cluster Survey, Project Database (CSES). CSES Analysis.

Figure A4 shows the clustering of equipment firms. The Top 10 postcodes account for 29% of all equipment firms identified, and the Top 10 Local Government Areas account for 41% of all equipment firms identified.

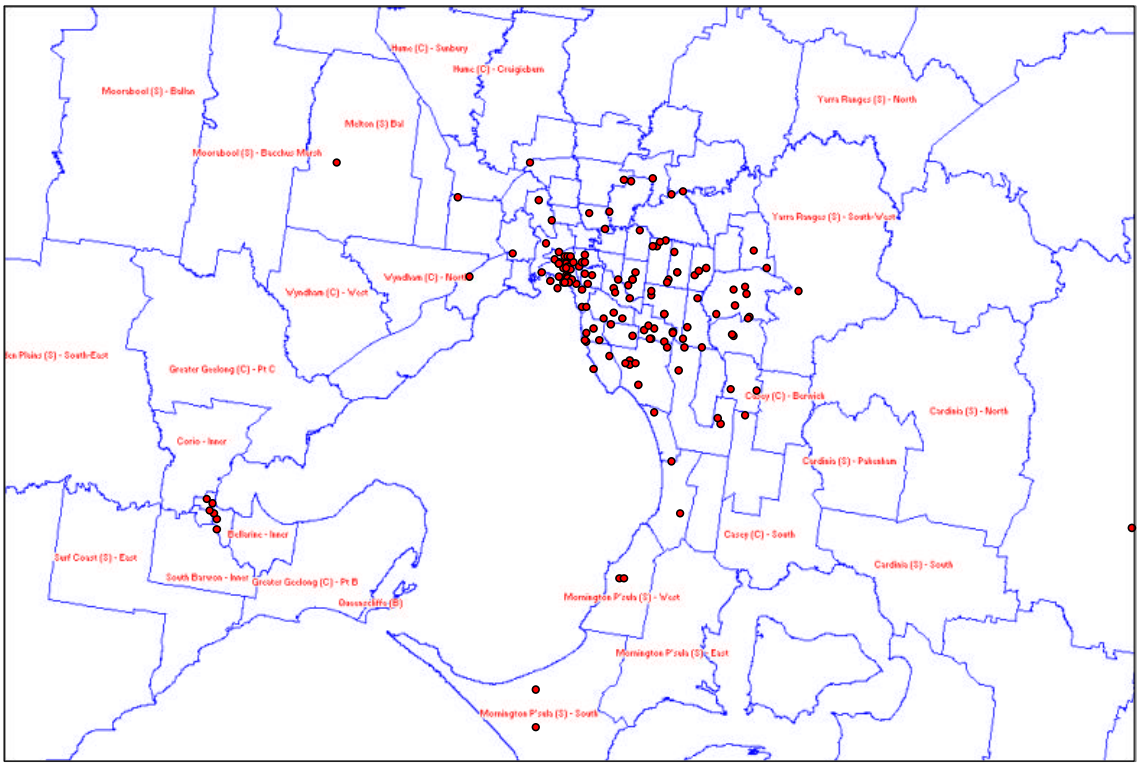
Figure A4 Electronics industry clustering: Greater Melbourne (Equipment)



Source: Victorian Electronics Cluster Survey, Project Database (CSES). CSES Analysis.

Figure A5 shows the clustering of IT firms. The Top 10 postcodes account for 36% of all IT firms identified, and the Top 10 Local Government Areas account for 46% of all IT firms identified.

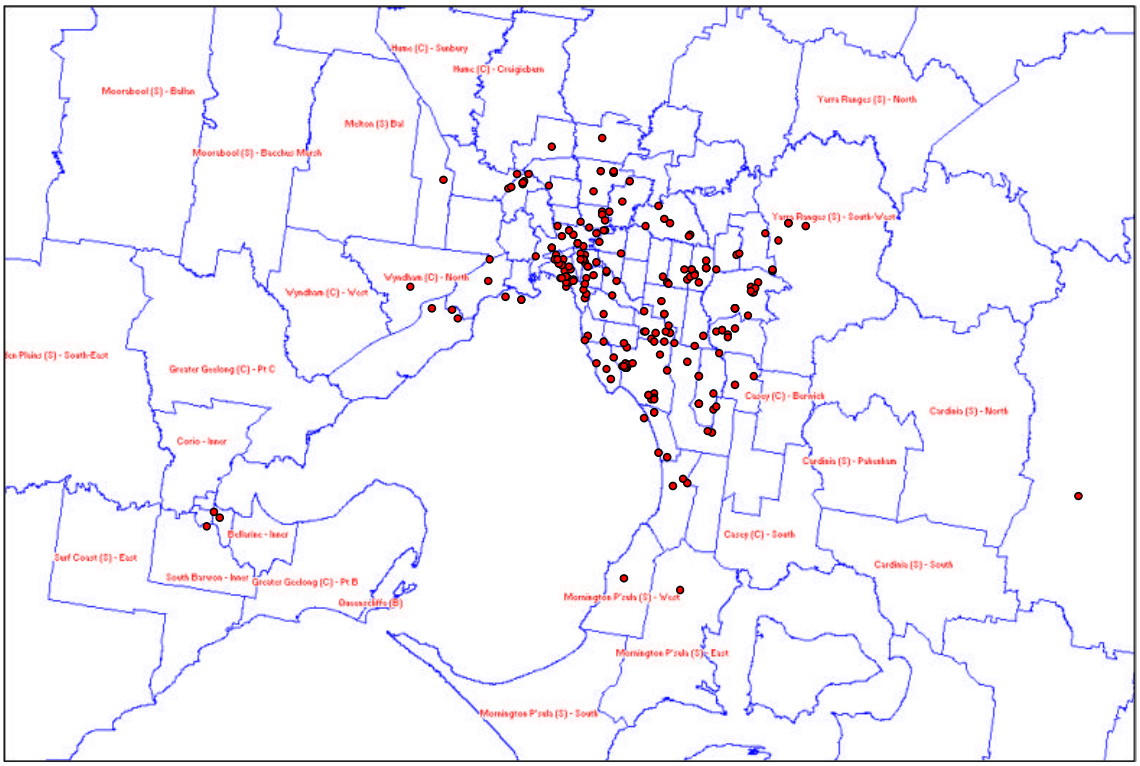
Figure A5 Electronics industry clustering: Greater Melbourne (IT)



Source: Victorian Electronics Cluster Survey, Project Database (CSES). CSES Analysis.

Figure A6 shows the clustering of lighting firms. The Top 10 postcodes account for 31% of all lighting firms identified, and the Top 10 Local Government Areas account for 41% of all lighting firms identified.

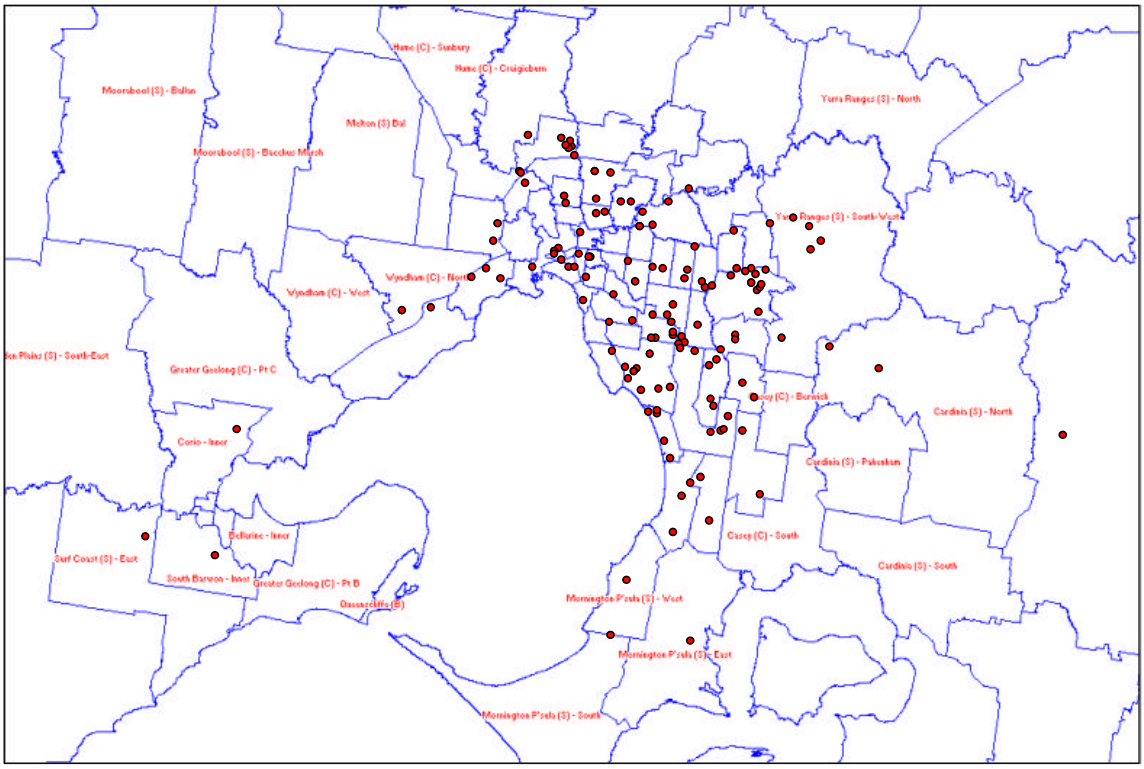
Figure A6 Electronics industry clustering: Greater Melbourne (Lighting)



Source: Victorian Electronics Cluster Survey, Project Database (CSES). CSES Analysis.

Figure A7 shows the clustering of machinery firms. The Top 10 postcodes account for 32% of all machinery firms identified, and the Top 10 Local Government Areas account for 44% of all machinery firms identified.

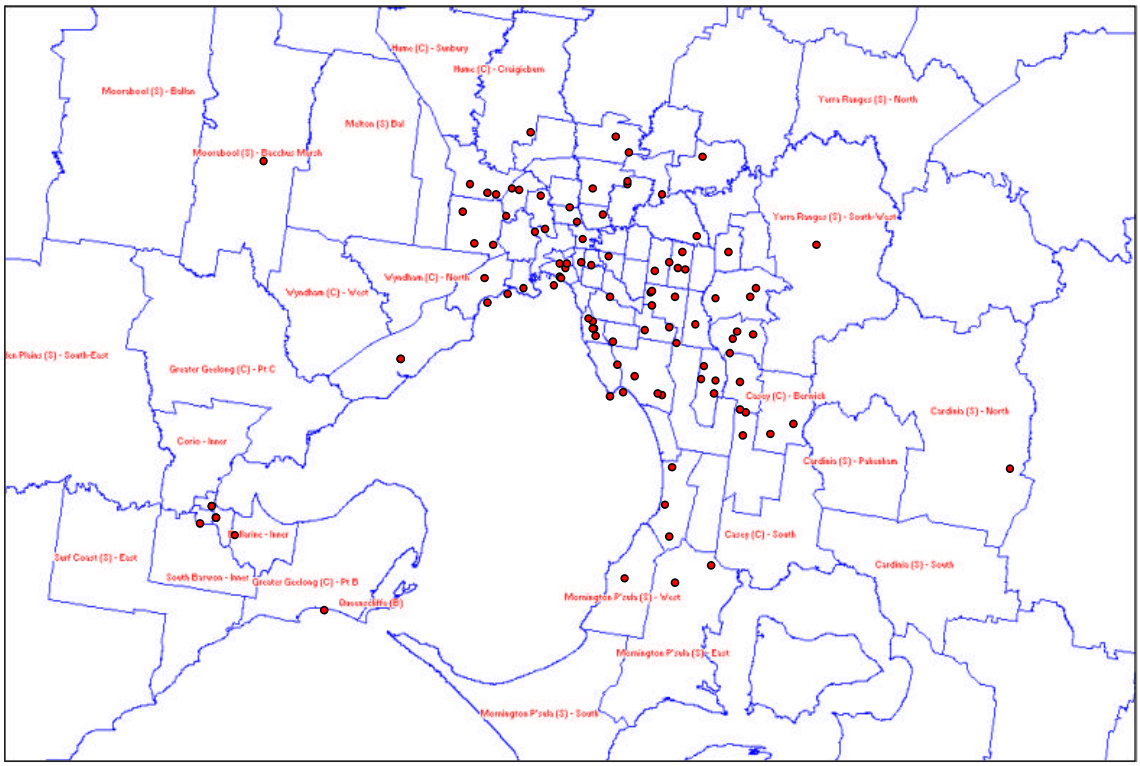
Figure A7 Electronics industry clustering: Greater Melbourne (Machinery)



Source: Victorian Electronics Cluster Survey, Project Database (CSES). CSES Analysis.

Figure A8 shows the clustering of security firms. The Top 10 postcodes account for 23% of all security firms identified, and the Top 10 Local Government Areas account for 46% of all security firms identified.

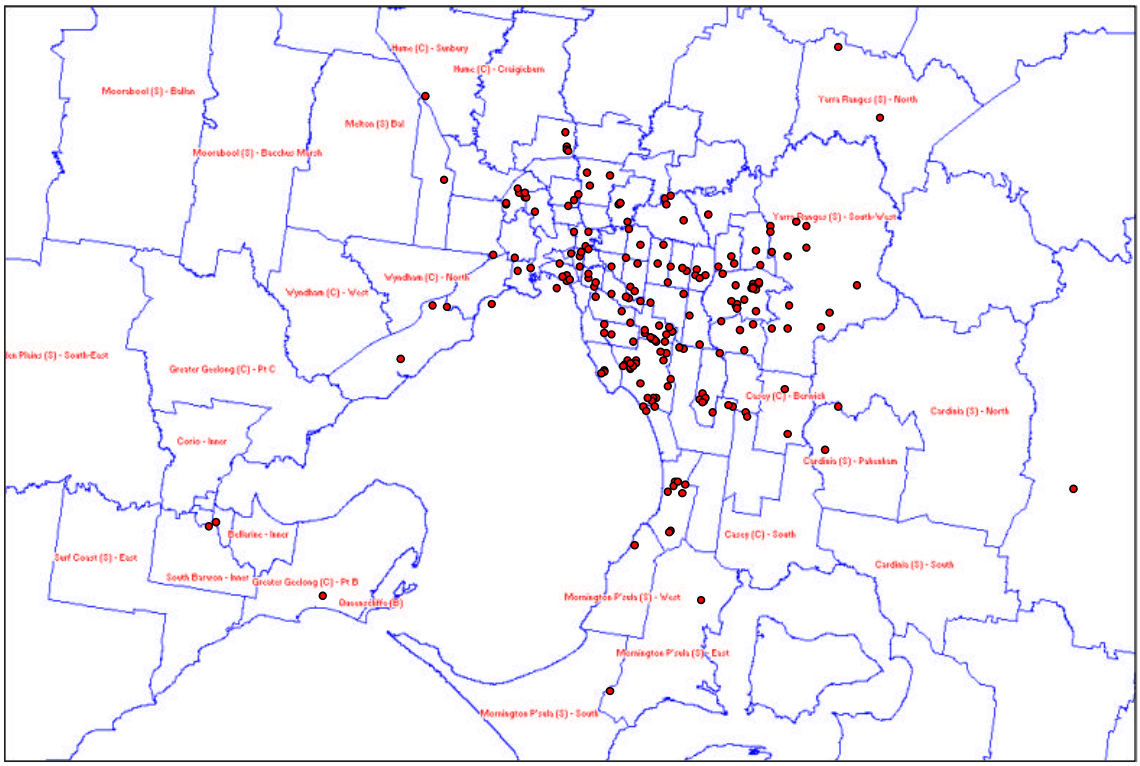
Figure A8 Electronics industry clustering: Greater Melbourne (Security)



Source: Victorian Electronics Cluster Survey, Project Database (CSES). CSES Analysis.

Figure A9 shows the clustering of engineers. The Top 10 postcodes account for 27% of all engineers (services) firms identified, and the Top 10 Local Government Areas account for 41% of all engineers (services) firms identified.

Figure A9 Electronics industry clustering: Greater Melbourne (Engineers)



Source: Victorian Electronics Cluster Survey, Project Database (CSES). CSES Analysis.

Appendix B Victoria's collective support infrastructure for electronics

This appendix explores the key elements of Victoria's 'collective support infrastructure' for electronics. It is indicative, rather than exhaustive, and is intended to supplement the survey of electronics and related firms. A number of organizations mentioned span across the various support infrastructure activities included, but have been included in the area of major focus only.

R&D conduct and commercialisation

As noted, by far the largest share of electronics R&D activity is conducted by the business sector, which accounts for more than 90% of total R&D expenditure in Victoria in electronics related fields. Nevertheless, there are important public sector and collaborative R&D activities in Victoria.

Melbourne hosts nodes of 6 of the 7 ICT related CRCs (ie. Australian Photonics CRC, Australian Telecommunications CRC, CRC for Enterprise Distributed Systems Technology, CRC for Sensor Signal and Information Processing, CRC for Smart Internet Technology, CRC for Spatial Information, CRC for Technology Enabled Capital Markets, and CRC for Interaction Design) and is the principal location for one (ie. CRC for Spatial Information). There are a number of other CRCs with activities relating to electronics manufacturing and development, including the CRC for Intelligent Manufacturing Systems and Technologies and the CRC for Cochlear Implant and Hearing Aid Innovation, which are both centred in Melbourne, and the CRC for MicroTechnology, which has a Melbourne node. At the time of writing, the renewal of CRC funding for the Australian Photonics CRC and the CRC for Satellite Systems is in doubt.

The CSIRO has 21 locations in Victoria, with activities including manufacturing and infrastructure technology, mathematical and information sciences, and molecular science. The CSIRO's ICT Centre was established in 2003 with a node in Melbourne. CSIRO's Clayton centre, co-located with Monash University, Telstra Research Laboratories and now the Australian Synchrotron is a focal point of much high-technology activity in Melbourne.

DSTO has 2 major locations in Victoria, Fisherman's Bend and Maribyrnong. DSTO Melbourne claims to "work closely with industry, universities and other research agencies to extend and strengthen Australia's defence capabilities. DSTO spends up to 10% of its budget sourcing research, development and technical support from industry and other research and development organizations, particularly universities, through collaborative and commercial arrangements."[101]

101 See *DSTO Melbourne* (http://www.dsto.defence.gov.au/corporate/directory/dstomelbourne.pdf).

Major University-based R&D activities in Victoria include:

- *La Trobe* – Department of Electronic Engineering, which offers an electronic engineering course with specialisations in Biomedical, Communications, Electronic Systems or Optical Engineering.
- *Monash* – Department of Electrical and Computer Systems Engineering, which has research specialisations in biomedical engineering, computer architecture, control, electronics, power engineering, robotics and telecommunications, and operates the Advanced Computing and Simulation Laboratory (AXL).
- *Melbourne University* – Department of Electrical and Electronic Engineering, including the Photonics Research Laboratory (PRL) and the ARC Special Centre for Ultra-Broadband Information Networks (CUBIN).
- *RMIT* – Microelectronics and Materials Technology Centre Research, which focuses on integrated optics and optoelectronics materials and devices, advanced solid-state sensor technology, microwave hybrid circuit fabrication, micro machine technology and advanced materials.
- *Swinburne University* – Optronics and Laser laboratories (SOLL). *Swinburne Industrial Research Institute* – an organization for applied research and technology diffusion to industry with a mission to provide innovative solutions to entrepreneurial industries.
- *Victoria University* – Centre for Telecommunications and Microelectronics, which has expertise in many of the key enabling technologies that underpin the development of telecommunication systems, microelectronics design, integrated systems testing and signal processing.[102]

There are also a number of ARC Centres of Excellence and other related centres, including:

- ARC Centre of Excellence in Quantum Computer Technology – which includes the University of Melbourne as a node.
- ARC Centre of Excellence for Ultrahigh-bandwidth Devices for Optical Systems – which includes Swinburne University of Technology.
- Photonics institute.
- Nanotechnology Victoria – which brings a focus to the nanotechnology related R&D and commercialisation activities of Victoria's major universities.
- Bioinformatics activities – led by the Victorian Bioinformatics Consortium.

All of the centres of activity provide important innovation nodes and encourage the development of wider and deeper linkages with the Victorian electronics industry.

[102] See The Victorian Microelectronics Designers' Network. (http://www.mmv.vic.gov.au/web5/MDN.nsf).

Testing and conformance infrastructure

Victoria hosts and has access to a number of key facilities which provide the necessary supporting infrastructure for innovation. These include:

- NNTTF – National Networked Tele Test Facility, of which the Victorian node provides state-of-art testing environment for electronics and microelectronics teaching, research and development. The facility enables designers to test and prototype VLSI circuits and SoC, prior to production, and a microelectronics design laboratory provides the necessary infrastructure for teaching, research and development in microelectronics engineering and associated areas.
- MiniFAB – MiniFAB is Australia's only open access microfabrication facility. It is the focus of a community of micro, bio and nano technology related developers seeking to move their work past the proof of concept phase, through validation, and ultimately into commercialisation. MiniFAB provides access to fabrication facilities for product development using its own cleanrooms and micromachining infrastructure.
- TRL – Telstra Research Labs, which support a microelectronics reliability testing and analysis facility.

Technology diffusion and networking

Victoria boasts a number of technology diffusion and networking groups. These include:

- AMN - Australian Microelectronics Network (AMN) is a national non-profit membership-based network of microelectronics engineers, which aims to create an environment conducive to the development of commercial microelectronics firms in Australia. AMN's technology advice covers: FPGA, Digital ASIC, Analog IC, Mixed Signal IC, RF IC, MMIC, System On Chip, Bipolar process, MEMS and Optoelectronics.
    - VCX - through a partnership with VCX, AMN provides an online trading facility for access to IP cores used in integrated circuit design.
    - MRC – a proposed Microelectronics Resource Centre aims to invest in appropriate EDA tools and sublicense their use to start-ups and SMEs on a short-term pay per use basis. By aggregating start-up and SME demand in this way, the MRC will address market failure by offering the tools at market competitive prices. The MRC also proposes to offer a limited portfolio of related services to facilitate microelectronic device fabrication.
- VMDN - The Victorian Microelectronics Designers' Network is an industry networking organization, which focuses on supporting and developing the microelectronics industry by providing access to a range of networking activities and services.
- InnovationXchange Network – a membership-based network which provides access to a range of network services relating to business advice, technology development, research, education and training and government programs.

Venture capital, angel, early phase investment and incubators

Victorian accounted for $1.3 billion of venture capital investment in June 2003, 38% of the national $3.5 billion invested. Nationwide, VC investment in IT, media, electronics and communications amounted to $717 million, 21% of the total invested.[103] There are a number of venture capital and business angel investors operating in Victoria.

- AVCAL's directory of members provides information on ICT and electronics related early stage investors.
- Business Angels can also be readily located through various networked organization. See, for example, http://www.businessangels.com.au/consult.html.

There are a number of incubators and technology park facilities in Victoria that focus on, and/or cater for electronics firms.[104] These include:

- Australian Distributed Incubator, which helps ICT start-up companies;
- Caribbean Park, a technology-based incubator;
- Digital Harbour, which is intended to be an integrated development, featuring high-technology offices, showrooms, laboratories, business incubators and education facilities.
- Information City, a business network which assists in the growth of early stage ICT ventures;
- La Trobe R&D Park, which offers a business development environment for start-up, small and large mature technology-based businesses;
- Monash Science Technology Research and Innovation Precinct (STRIP), which offers a range of research facilities and support infrastructure.
- Redcentre, which manages commercial opportunities in photonics, micro-technologies and microelectronics;
- The Interactive Information Institute (I-Cubed), a collaboration between RMIT, commercial partners and the Victorian Government which seeks to assist in transforming student ideas into commercial realities;
- Gippsland Regional Economy & Ecological Network Inc. (GREEN), which assists enterprises engaged in IT, multimedia based service delivery and renewable energy development.
- Greenhill Enterprise Centre, located in Ballarat is a regional IT incubator;

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103 Australian Bureau of Statistics (2003) *Venture Capital Australia, 2002-03*, Cat No 5678.0, Canberra.

104 See DIIR (2003) *Incubators & Technology Parks in Victoria*, Melbourne. Available http://www.mmv.vic.gov.au/web5/MMV.nsf/ImageLookup/SpotlightonVictoria/$file/Incubators%20&%20Technology%20Parks.pdf

- Ballarat Technology Park, which provides optical fibre and network facilities designed specifically to support IT companies; and
- Bendigo Information, Communication and Technology Centre, which focuses on the development of software and telecommunications applications.
- AATEC – Australian Advanced Technology Enterprise Centre (AATEC), which seeks to provide critical support for early stage start-up companies developing and commercialising advanced electronics products and technologies. The Enterprise Centre will provide a workspace and facilities to early stage electronics companies at no cost. Initial areas of focus will include: wireless/mobile, biotechnology, microelectronics & reconfigurable logic, digital signal processing and embedded systems, optoelectronics, robotics and industrial control, micro-electro mechanical systems (MEMS) and microtechnology.

Education and training

- University courses – there are 6 universities in Melbourne offering courses specific to the electronics industry. These include: La Trobe University Department of Electronic Engineering, Monash University Faculty of Engineering, RMIT University Faculty of Engineering, Swinburne University of Technology School of Engineering and Science, University of Melbourne Department of Electrical and Electronic Engineering, and Victoria University's School of Electrical Engineering.
- Chipskills – The Chipskills program was developed through the collaboration of the Victorian Government, industry partners and 4 local universities: Victoria University, RMIT, Swinburne University of Technology and La Trobe University. It offers a masters-level academic course that has been developed specifically to provide the skills needed in the microelectronics industry. Partner universities share access to electronic design automation software, including full toolsuites. The Victorian Government contributed more than $7 million to the establishment of Chipskills.
- TAFE and other – Victorian TAFE colleges provide a number of courses relating to trade and higher qualifications in electronics related fields (See http://www.tafe.vic.gov.au/StudyAreas/Detail.asp?ID=1656).

Appendix C Questionnaire

Purpose of Collection

Federal Cabinet approved the Electronics Industry Action Agenda in June 2003. The Australian Electrical & Electronic Manufacturers' Association (AEEMA) has been given the responsibility for the co-ordination of the implementation of the Action Agenda, the co-ordination of the State & Territory based mapping, and the compilation of the national overview. This survey, initiated by AEEMA, is part of the national Cluster Mapping programme which aims to generate a better understanding of electronics industry capabilities within each state.

Definitions

The electronics industry includes companies that design, produce, service, install and distribute products & systems made from electronic and photonic components and which may contain embedded or loaded software to provide an operational device or network. It also includes companies that provide services to support the production of electronic and photonic components (including microchips and optical fibre), products and systems and key 'vertical market' users (eg. automotive manufacturing).

Responding to the Survey

The survey is intended to be completed by the CEO or a senior executive of the company to which it is addressed. We realise your time is valuable and limited, and understand that in some cases it would take too long to provide exact answers. Therefore we invite you to use your judgement and provide approximations. We estimate that this questionnaire will take only 30 minutes to complete. The form has been designed to fill in using MS Word. Simply use the mouse to click onto the box you wish to fill in and type. You should use 'Over Type' mode. Use the 'INS' key to toggle between 'insert' and 'overtype' so that your typing simply replaces the spaces in the form, rather than disrupting its format. If you prefer, you can print the form, fill it in by hand and fax it back.

Confidentiality

The data provided will be used for the express purpose of mapping the size and growth of the electronics industry and other relevant broad industry statistics. Data will be published in aggregate form only and no company or individual will be identified in the final report. The information collected on individual firms will be held in strict confidence and will not be made public or used for any other purpose. AEEMA will destroy the survey forms on completion of the Survey and no personal details will be kept.

Due Date – 28th May 2004

Please complete this form and fax it back to (03) 9248 1350 or save it as a new document and e-mail it to John.Houghton@vu.edu.au by 28th May.

Section 1 – Your Firm's Activities

We would like to begin with some background information about your firm's activities, products and markets. We realise your time is valuable and understand that in some cases it would take too long to provide exact answers. Therefore we invite you to use your judgement and provide approximate answers wherever necessary.

1. Is your firm headquartered in Victoria?……

Yes	*No*

2. *If not,* where is your firm's head office?……

City	*Country*

3. What was your firm's total revenue in:

a) The financial year to June 2003 (*in thousands*)? …	$	,000
b) Five years ago (*in thousands*)? ……	$	,000

4. Approximately what share (*percentage*) of your firm's 2002-03 revenue was earned by:

a) Your office/operations in Victoria?……	%
b) Your office/operations elsewhere in Australia?……	%
c) Operations overseas?……	%

5. Approximately what share (*percentage*) of your firm's financing comes from:

a) Private equity (eg. self-financed, family, friends & partners)?……..	%
b) Public funding (eg. through stockmarket listing)?…….	%
c) Bank overdraft or loan (debt)?……	%
d) Venture capital or business angel?…….	%
e) Parent company?…….	%

6. What are your firm's main activities (*as an approximate percentage of sales*)?

a) Product manufacturing..……		%
b) Service delivery..……..		%
c) Integrated systems or solutions……		%
d) Wholesale, retail & distribution..…….		%
e) Support, after sales service & repair…….		%
f) Other (please specify)….		%

7. Where would you place your firm's activities on a continuum of Volume and Value (*please tick one box only*)?

High Volume / Low Value | | | | | | High Value / Low Volume

Questions 8 to 11 are about your firm's products and services. Please answer the one that applies to your major activities in Victoria.

8. *If your firm <u>supplies</u> electronics manufacturers*, what products and services do you supply? (*Please rank the Top 3 from 1 = most important*)

A) Machinery & Equipment	*Rank*
a) Hand/Bench……..	
b) Calibration & Testing……..	
c) Mounting & Assembly…….	
d) Fabrication……	
e) Other (please specify)……..	

B) Materials & Components	*Rank*
a) Raw materials…….	
b) Chemicals & Gasses……..	
c) Components……	
d) Sub-assemblies……..	
e) Other (please specify)……	

C) Contract & Technical Services	*Rank*
a) R&D services……..	
b) Design services……..	
c) Prototyping services……	
d) Testing & Conformance…….	
e) Contract manufacturing……..	
f) Other (please specify)…….	

D) Business & Financial Services	*Rank*
a) Banking & Finance…….	
b) Venture Capital……..	
c) Management Consulting……	
d) IT services…….	
e) Marketing & Sales……	
f) Other (please specify)……	

9. *If your firm is an <u>electronics manufacturer</u>*, what products do you manufacture?

(Please rank the Top 3 from 1=most important)	*Rank*
a) Automotive electrics & instruments…….	
b) Medical & surgical equipment and devices..……	
c) IT (Computers & Business Machines)…….	
d) Telecommunications equipment (terrestrial / fixed line)…….	
e) Mobile / wireless communications equipment…….	
f) Broadcasting and transceiving equipment……...	
g) Cable, wire & optical fibre ……...……..	
h) Power supplies & batteries …….	
i) Electric light and sign equipment……	
j) Industrial process and control equipment……	
k) Instrumentation (scientific & technical)……..	
l) Photonics & Opto-electronics…….	
m) Components and sub-assemblies…….	
n) Smartcards……	
o) Household appliances……...	
p) Security & alarm systems & equipment ……..	
q) Other (please specify)……	

10. *If your firm is an <u>electronics services provider</u>*, what services do you provide?

(Please rank the Top 3 from 1=most important)	*Rank*
a) Installation services……	
b) Repair & maintenance services……..	
c) Wholesale services…….	
d) Retail services……	
e) Other (please specify)……	

11. *If your firm is a <u>user of electronic products</u>*, what industry are you in?

(Please tick or put an 'X' in one box only)

A) Manufacturing	*Tick*
a) Automotive……	
b) Aviation / Aerospace…….	
c) Other transport (Marine, Rail, etc)	
d) Pharmaceutical / Biotechnology…	
e) Scientific & Medical equipment…	
f) ICT equipment……...	
g) Food & food processing……	
h) TCF&L…….	
i) Other (please specify)	

B) Business Services	*Tick*
a) Banking & Finance services……	
b) IT & Business services……	
c) Communication & Media……	
d) Construction & Property…….	
e) Transport & Storage……	
f) Accommodation & Tourism……	
g) Wholesale & Retail…….	
h) Cultural & Recreational……...	
i) Other (please specify)	

C) Primary production	*Tick*
a) Agriculture……	
b) Forestry & Fisheries…….	
c) Mining……..	
d) Energy & Water Supply……...	
e) Other (please specify)	

D) Government Services	*Tick*
a) Government……	
b) Defence……..	
c) Medical & Health……...	
d) Education……	
e) Other (please specify)	

12. *If you export,* what are your most significant country export markets, and approximately what percentage of your total sales go there?

Country Market	*Name of country*	*% of total sales*
Country A……		%
Country B……		%
Country C……		%

13. *If you export,* what are the main ways you manage your exporting?

(Please tick or put an 'X' in one for each country market)	*A*	*B*	*C*
a) Use overseas distributors……...			
b) Have own office(s) overseas…….			
c) Enter joint ventures with organizations overseas……..			
d) Enter alliances with multinational firms overseas…….			
e) Work directly with customers overseas…….			
f) Work with local Australian office of multinationals…….			
g) Use internet / electronic delivery……...			
h) Other (please specify)…			

14. What has been the <u>main</u> barrier to the growth of your firm (leaving aside cyclical market conditions)?

(Please rank the Top 3, from 1=most important)	*Rank*
a) Poor local infrastructure……..	
b) Inability to access skilled staff……	
c) Strong competitors in particular markets……	
d) Lack of local suppliers……...	
e) Lack of local customers……..	
f) Lack of local support services…….	
g) Lack of venture capital & other finance……..	
h) Cost of regulatory compliance……...	
i) Other, please specify…	

Section 2 – Suppliers, Customers and Supply Chain Relations

We would like to know about your supply chain relationships and the importance of local, national and international linkages.

Suppliers include <u>all</u> organizations that provide goods and services to your firm – including accountants, financial institutions, R&D institutions, educational and training organizations – as well as the suppliers of components or direct inputs.

Customers are organizations or individuals who purchase your goods and services. They may other firms or end users.

The *supply chain* refers to the entire chain of activities from raw materials to end products.

15. Who are your 3 main <u>suppliers</u> (by value), and approximately what share of your supply costs do they represent?

(If you prefer not to name them, leave the name out and we will identify them as S1, 2 & 3)

	Name of Supplier	*% of supply costs*
Supplier 1 (S1)……		%
Supplier 2 (S2)……		%
Supplier 3 (S3)……		%

16. Where are these <u>suppliers</u> located?

(Please tick one box for each supplier)	*S1*	*S2*	*S3*
a) Within Victoria……..…..			
b) Elsewhere in Australia.……..			
c) Overseas……..……			
d) *If overseas*, please specify country location.….			

17. What is the main item supplied to you by each of these <u>suppliers</u>?

(Please tick one box for each supplier)		*S1*	*S2*	*S3*
a)	Materials & Components……			
b)	Software to be embedded in your products or services...			
c)	Machinery & Equipment used in production……..			
d)	Technical Services (eg. R&D, design, prototyping)…..			
e)	IT Applications Software & Services..……			
f)	Business Services (eg. Marketing)..……			
g)	Banking & Financial Services……..……..			
h)	Human Resources & Recruitment Services……			
i)	Other (please specify)…			

18. Who are your 3 main <u>customers</u> (*by sales value*), and approximately what share of your sales revenue do they represent?

(If you prefer not to name them, leave the name out and we'll identify them as C1, 2 & 3)

	Name of Customer	*% of sales revenue*
Customer 1 (C1)……		%
Customer 2 (C2)……		%
Customer 3 (C3)……		%

19. Where are these customers located?

(Please tick one box for each customer)	*C1*	*C2*	*C3*
a) Within Victoria…….….			
b) Elsewhere in Australia.……..			
c) Overseas……..……			
d) *If overseas*, please specify country location.….			

20. What type of organization is each of your 3 main customers?

(Please tick one box for each customer)	*C1*	*C2*	*C3*
a) Firms that are end users……			
b) Firms that are Original Equipment Manufacturers…...			
c) Government……..			
d) Other public institutions (eg. CSIRO, Universities).…			
e) End / Household consumers…….			
f) Other (please specify)…			

21. Is there a dominant player in the 'supply chain' that your firm operates in? (eg. a firm with significant market share, major supplier or buyer)…….	*Yes*	*No*

***If yes*, what is its name?** (*optional*)…..……

***If yes*, what type of organization is it?**

(Please tick or put an 'X' in one box only)	*Tick*
a) Multinational firm…….	
b) Indigenous Australian firm……...	
c) Government organization…….	
d) Non-government, not-for-profit organization……...	
e) Other, please specify…	

22. Where is the value in the 'supply chain' that your firm operates in (ie. where the money is made)?

(Please tick or put an 'X' in one box only)	*Tick*
a) Research & development…….	
b) Design……..	
c) Supply of machinery & equipment……..	
d) Supply of materials & components…….	
e) Production / manufacturing…….	
f) Branding & marketing…….	
g) Wholesale & retail……...	
h) Other, please specify…	

23. Is your firm involved in any joint ventures, alliances, partnerships or network?

(Please tick or put an 'X' where applicable)	*J.V.*	*Alliance*	*Partner*	*Cluster*
a) Research…….				
b) Product development ……				
c) Manufacturing……				
d) Service delivery…….				
e) Marketing & Sales……..				
f) Delivery & order fulfilment……				
g) After sales service & support ……				
h) Other (please specify)..				

24. Does your firm have close and/or regular interactions with other organizations?

A) Standards & Compliance	*Tick*
a) Australian standards organizations	
b) Overseas standards organizations.	
c) Environmental protection…….	
d) OH&S……..	
e) Testing & Conformance……..	
f) Business regulation……..	
g) Quality control & accreditation..	
h) Other (please specify)…….	

B) Support & Development	*Tick*
a) Education & Training…….	
b) R&D……...	
c) Business Networks…….	
d) Industry Groups…….	
e) Federal Government Programs..	
f) State Government Programs…..	
g) Other (please specify)……	

Section 3 – Innovation

To help us understand the ways in which your firm develops new products and services and implements new processes, please specify the sources of information, ideas, and the nature and extent of Research and Development (R&D) activities undertaken that contribute to this process.

25. Approximately what share (percentage) of your current sales revenue come from products or services that were:

(Please estimate percentage share of sales)	*% of sales*
a) Introduced within the last year?…….	%
b) Introduced between 1 and 2 years ago? ……	%
c) Introduced between 2 and 3 years ago? ……	%
d) Introduced between 3 and 4 years ago? ……	%
e) Introduced between 4 and 5 years ago? ……	%
f) Introduced more than 5 years ago? ……..	%
	100 %

26. Does your firm have <u>formal quality accreditation</u>? ……	*Yes*	*No*

27. Does your firm have any formal <u>quality management</u> procedures or systems in place for all or part of your operations? ……	*Yes*	*No*

28. Does your firm have any <u>formal knowledge management</u> system(s) in place?……..	*Yes*	*No*

29. From where do you get information about new <u>technical</u> developments?

(Please rank as many as apply, from 1=most important)	*Rank*
a) In-house R&D group……	
b) Other internal sources (eg. existing employees)……...	
c) R&D institution, university or TAFE?…….	
d) New employees…….	
e) Suppliers……...	
f) Customers……	
g) Professional or industry associations……	
h) Professional publications & journals……	
i) Trade and industry magazines……..	
j) Discussions at conferences & trade shows……...	
k) Discussions at industry networking functions……..	
l) Other, please specify…	

30. From where do you get information about new <u>products or services</u>?

(Please rank as many as apply, from 1=most important)	*Rank*
m) In-house R&D group……	
n) Other internal sources (eg. existing employees)……...	
o) R&D institution, university or TAFE?…….	
p) New employees…….	
q) Suppliers……...	
r) Customers……	
s) Professional or industry associations……	
t) Professional publications & journals……	
u) Trade and industry magazines……..	
v) Discussions at conferences & trade shows……...	
w) Discussions at industry networking functions……..	
x) Other, please specify…	

Section 4 – Research & Development

The next 4 questions concern formal research & development (R&D). If your firm does not do any formal R&D (either internally or externally) please tick here ☐ and skip to the next section on 'Employment, Skills & Training'

31. Approximately what percentage of your firm's turnover was spent on R&D?

a)	During the financial year ended June 2003……..	%
b)	Average annually during the last 5 years…….	%

32. What is the <u>main</u> way your firm's R&D is conducted?

(Please tick or put an 'X' in one box only)		*Tick*
a)	In house (ie. within your firm)……..	
b)	In partnership with other firms of <100 employees……..	
c)	In partnership with other Australian firms of >100 employees……	
d)	In partnership with overseas enterprises of >100 employees……...	
e)	In partnership with Universities or research institutes…….	
f)	Contracted out to small to medium enterprises (SMEs)……...	
g)	Contracted out to multinational enterprises (MNEs)……	
h)	Contracted out to Universities or research institutes……	
i)	Other, please specify…	

33. Where is this R&D activity (*identified in Q32*) located?

(Please tick or put an 'X' in one box only)		*Tick*
a)	Within the Melbourne region……..……..	
b)	Elsewhere in Victoria……	
c)	Elsewhere in Australia……..	
d)	Overseas (please specify the country)…	

34. What are your firm's main sources of R&D funding?

(Please rank as many as apply, from 1=most important)		*Rank*
a)	Internal resources (eg. funded from sales revenue)…….	
b)	Alliances and cooperative arrangements (eg. R&D cooperatives, CRCs)……..	
c)	Government programs and grants (eg. R&D START)……	
d)	R&D tax concession……	
e)	Subcontracting from other firms…….	
f)	Other, please specify…	

Section 5 – Employment, Skills and Training

We would like to know something about your firm's employees and skills. The answers to these questions will enable us to understand the State's skills profile and the skills required in the industry.

35. For the financial year to June 2003, what was your firm's approximate wages & salary expenditure (*excluding contractors*)?……. $

36. For the financial year to June 2003, what was your firm's approximate expenditure on contractors & agency staff?…….. $

37. Approximately how many people did your firm employ (*full time equivalent*)?

	June 2003		*June 2000*	
	Victoria	*Total*	*Victoria*	*Total*
a) Full time or part time…….				
b) Casual…….				
c) Contractors or agency staff…				

38. What, *if any*, skills are in short supply in your firm now, or do you foresee may be in short supply in the future?

(Please tick or put an 'X' in as many as apply)	*Now*	*Future*
a) People management skills……..		
b) Project management skills……..		
c) Business, finance & administration skills (incl. IT)……...		
d) Technical, professional & engineering skills…….		
e) Marketing & sales skills…….		
f) Other, please specify…		

39. Approximately how many of your firm's <u>Victorian</u> employees are:

(Please enter approximate number)	*Number*
a) Senior Managers…….	
b) Professionals (eg. IT programmers, engineers, etc)……...	
c) Technically qualified manufacturing, production & tradespersons……...	
d) Unqualified manufacturing, production & tradespersons……..	
e) Storepersons, transport workers, etc.…….	
f) Sales, marketing and customer service……..	
g) Business support professionals (eg. accountants, auditors, etc)……	
h) Clerical…….	
i) Other, please specify…	

40. Does your firm have formal education & training policies or procedures in place to ensure that employees further their education/develop skills?….	*Yes*	*No*

41. Approximately how many of your firm's <u>Victorian</u> employees have the following qualifications?

(Please enter approximate number of Full Time Equivalent staff)	*Number*
a) Postgraduate / higher degree in science or technology field……	
b) Postgraduate / higher degree in other fields……..	
c) Graduate diploma or certificate in science or technology field……	
d) Graduate diploma or certificate in other field…….……..	
e) Bachelor degree (including honours) in science or technology field……...	
f) Bachelor degree (including honours) in other field…….……	
g) Advanced diploma…….……...	
h) Certificate (including trade certificate)……	
i) Other, please specify…	

42. Are there any comments you would like to add?

Thank you for your time.

Please return this form by fax to Ph. (03) 9248 1350 or save it as a new document and e-mail it to John.Houghton@vu.edu.au