‘New Manufacturing’
One Approach to the Knowledge Economy*

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Abstract

With the emergence of the global knowledge economy we are seeing changes in the industrial composition of economies, in the nature of activities within industries, and in the relationships between industries. In this paper we seek to shed light on the nature of those changes. We begin by questioning the commonly held notion that a knowledge economy is a services economy. We then develop an alternative framework for understanding the economic contribution of various production and service activities. In this way, we show that the goods producing and goods related service industries remain at the core of developed economies. We then present a brief sketch of the nature of 'new manufacturing' in order to highlight the increasing inter-relatedness of both sectors *and* industries in a knowledge economy. Finally, we present an example of how an alternative perspective on structural change, and on the emergence of the increasingly complex product systems which we characterise as 'new manufacturing', can be operationalised and used to inform the study of even the most traditional manufacturing industries as well as the formulation of industry policy for a knowledge economy. Implications for China's future development are discussed.

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1. Introduction

With the emergence of the global knowledge economy we are seeing changes in the industrial composition of developed economies, in the nature of activities within industries, and in the relationships between industries. Most notable are the increasing importance of services, and the increasing complexity and integration of production and distribution systems.

In this paper we seek to shed light on the nature of these changes, suggest a framework for understanding them, and outline one approach to operationalising that framework in such a way as to inform industry analysis in, and policy formulation for, the knowledge economy. In this endeavour we use New Manufacturing as the thread.[1]

2. The traditional view

Over recent years analysts have often pointed to the growth in services and decline in manufacturing and concluded that we are entering into a new economic era – referred to variously as the post-industrial society or information economy.[2] Many see a natural progression of economic development running from agriculture, through manufacturing to services, in which a service economy represents the pinnacle of development. So, is a knowledge economy a post-industrial services economy?

2.1 The appearance

The traditional approach to industrial classification sees the economy made up of a hierarchy of sectors, industries and firms. The primary sector consists of the agriculture, forestry, fishing and mining industries. The secondary sector consists of manufacturing industries and the tertiary sector consists of service industries. Within each sector, industries are seen as more or less independent groupings of firms engaged in the production of similar products or services, by means of similar production processes. Looked at through such a lens, recent structural change in developed economies appears to lend credence to the notion that a knowledge economy *is* a post-industrial services economy.

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1 The term New Manufacturing first appeared in Drucker (1990). It was promoted and championed by Quinn (1992), and has been adopted by a number of analysts since.

2 See, for example, Bell (1976), Drucker (1969), Machlup (1962) and Porat (1977).

In Australia, the share of goods industries[3] in GDP fell from 50.2 per cent in 1962-63 to 30.5 per cent in 1994-95, while the share of service industries grew correspondingly – from 48.2 per cent to 69.5 per cent (in constant prices). The contribution to GDP of manufacturing alone fell from 26.2 per cent to just 14.6 per cent over the same period (Pappas and Sheehan 1998, p. 131). By 1997-98, manufacturing accounted for just 13 per cent of GDP (DISR 1999). The contribution of the emerging service industries to Australia's GDP exceeded that of the goods producing industries for the first time during the 1970s (Sheehan and Tikhomirova 1998, p. 72). By 1997-98, services accounted for 70 per cent of Australia's GDP (Allen Consulting 1998; DISR 1999). The growing importance of services can also be seen in employment data. Over the thirty-year period from 1966 to 1996, virtually all (98 per cent) of the increase in employment in Australia occurred in the service industries (Pappas and Sheehan 1998, p. 131). By 1997-98, manufacturing accounted for just 13 per cent of employment, while services accounted for more than 80 per cent (Allen Consulting 1998).

Similar structural change has occurred in the United States, where the goods industries accounted for less than 30 per cent of GDP by the mid 1990s (Sheehan and Tikhomirova 1998, p. 72). In 1960, the goods producing industries accounted for just under 40 per cent of total employment in the US, but by 1993 they accounted for less than 25 per cent. By contrast, in-person and knowledge-based services accounted for less than 21 per cent of total US employment in 1960, compared to almost 35 per cent in 1993 (Dunlop and Sheehan 1998, p. 207). By 1995, services accounted for more than 81 per cent of total US employment, and 78 per cent of total output (DISR 1999).

Perhaps the most extreme structural shift from manufacturing to services occurred in Hong Kong. Between 1950 and 1960, the number of manufacturing establishments in Hong Kong grew rapidly, such that by 1961 manufacturing employed 40 per cent of Hong Kong's workforce, and accounted for approximately 25 per cent of GDP. Manufacturing employment continued to grow in Hong Kong, reaching a peak at 46 per cent of total employment in 1980. During the 1980s and early 1990s, Hong Kong experienced a rapid decline in manufacturing and a rapid increase in services. Manufacturing employment fell from 46 per cent of total employment in 1980 to just over 15 per cent in 1995, and the manufacturing share of GDP fell from 24 per cent in 1980 to just 9.2 per cent in 1996. By then, services accounted for some 80 per cent of Hong Kong's GDP (Berger and Lester 1997, pp. 19-27).

Through the traditional lens we see the economy as the simple sum of more or less independent sectors, industries and firms; and through that lens the evidence suggests that manufacturing is in decline while services are growing. Indeed, it has become conventional wisdom in policy circles that services represent the way of the future.

2.2 The reality

Despite this obvious growth in services and decline in manufacturing, a number of analysts have pointed out that the reality is somewhat different. Agriculture and

3 Defined here as agriculture, mining, manufacturing, construction, and electricity, gas and water.

mining were not replaced by manufacturing during the industrial revolution, but rather overlaid by it. Why then, would we expect manufacturing to be replaced by services during the information revolution?

In *Manufacturing Matters*, Cohen and Zysman (1987) argued that many services, and much services prosperity, depends upon manufacturing; because manufacturing industries are significant consumers of services and without manufacturing there would be little demand for such services. More recently, analysts are pointing to the emergence of a heightened inter-relationship between manufacturing and services, to the extent that the traditional distinction between them is blurring.

In *Made By Hong Kong*, Berger and Lester characterise the convergence of manufacturing and services as follows.

> On the input side, activities traditionally thought of as services are key inputs to manufacturing processes, while manufacturing industries are the source of many of the most important innovations in the production of services. The convergence is even more evident on the output side. On the one hand, for today's consumers the value of manufactured products increasingly hinges on intangible attributes – design, convenience, reliability, innovativeness, fashion, cutomization, timely delivery, and so on – that, were they not embodied in the product would be classified as 'services'. On the other hand, the traditional characteristic of services – that they can neither be stored nor transported, and therefore must be produced where they are consumed – is also breaking down. Today many services can be stored electronically, transported over long distances using telecommunications technology, and delivered on demand, making them much more like manufactured products in many ways. (1997, pp. 27-28)

The *processes of production* of goods and services are also converging. Peter Drucker has observed that producing software – which we still classify as a service industry – is clearly a production activity. Indeed, the idea of 'software factories' has been around for many years. We may call it a service, but handling thousands of credit cards is clearly a production process. So is cheque clearing, and handling insurance claims. Even consulting services look increasing like flexible manufacturing, with generic 'products' or sub-assemblies being produced on an ongoing basis, ready for final customised assembly in the form of a report or solution for a specific client. Indeed, Drucker has suggested that the more services are organised as a systematic process of production, and the more they adopt production processes characteristics of manufacturing, the more productive and the more successful they tend to be (Drucker 1998).

In fact, the simple and beguiling picture of manufacturing decline and services growth, painted by traditional statistics, conceals more than it reveals. It overlooks the increasing complexity of the linkages between goods producing and service activities, and obscures the continuing centrality of manufacturing in developed economies.

2.3 The evidence

In recent work examining structural change in various economies as they make the transition from a resource to a knowledge base, Sheehan, Tikhomirova, Pappas, Dunlop and others[4] have shown that service activities are becoming increasingly important because of the shift in the pattern of consumer spending towards services as real income increases; the shift in employment towards services due, in part, to higher levels of productivity improvement in goods production than in services; and the increase in the complexity and service intensity of goods and of the processes of production and distribution. *But this does not spell the end of manufacturing*.

Australian manufacturing is becoming increasingly service intensive – both in terms of the increasing use of service inputs revealed in Input-Output tables, and in terms of increasing levels of employment in 'services jobs' within the manufacturing sector. Services inputs to manufacturing grew by 77 per cent over the 18-year period 1974-75 to 1992-93 (in constant prices). Services provided 27 per cent of all secondary inputs in 1974-75, rising to 31.5 per cent of inputs in 1992-93. And employment in business services in Australia grew by 17 per cent over the 2 years 1996 to 1998, compared to a growth of just 3.6 per cent in services overall (DISR 1999). Moreover, between 1987 and 1995, service occupations *within* manufacturing rose from 29 per cent to more than 36 per cent of all manufacturing employment (Pappas and Sheehan 1998, pp. 139, 143).

The case of Hong Kong, which seemed to epitomise the shift towards a service economy, is instructive. From the mid 1980s Hong Kong manufacturing firms shifted production activities to mainland China on a massive scale. It is estimated that in 1995 Hong Kong firms employed about five million people in China, five times the level of total manufacturing employment in Hong Kong in 1984. In a mid 1980s survey of the future location of manufacturing activities, firms reported that only 18 per cent of production activities would be undertaken in Hong Kong, while over 50 per cent of all service activities (including distribution, materials sourcing, testing, marketing, design, R&D, transport, trade, finance and corporate headquarters functions) would remain there.[5] So while production activities were sharply reduced, service activities intimately linked to, and servicing, manufacturing remained at the heart of Hong Kong's economy (Pappas and Sheehan 1998, p. 135).

The key is the increasingly complex integration of manufacturing and services in the creation, production and distribution of both goods and services which appears to characterise the emerging knowledge economy. *Hong Kong's prosperity in the early to mid 1990s was not built on services alone, but on product systems that integrated manufacturing and services activities across the Pearl River Delta region*.

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4 See Sheehan and Tikhomirova (1998), Pappas and Sheehan (1998), Dunlop and Sheehan (1998) and other papers in the same volume (Sheehan and Tegart 1998).

5 Hong Kong Trade Development Council (1996) reported in Berger and Lester (1997), and Pappas and Sheehan (1998, p. 135).

3. An alternative perspective

Can industry statistics be interpreted in such a way as to give a more accurate view of what is happening? We believe that they can, and in this section we outline an alternative approach to industrial classification which gives a different perspective on the creation, production and distribution of goods in the economy, and leads to a very different interpretation of the structural changes under way as we make the transition to a knowledge economy.

3.1 From sectors to a system of creation, production and distribution

Official industry statistics tend to lead to a fragmented view in which each industry is seen as more or less independent. A more constructive way of looking at industries is to see them embedded in, and contributing to, the wider economy – which can be thought of as a chain of '*creation Þ production Þ distribution*'.

Categorising industries in these terms suggests the schema outlined in Table 1. Agriculture, mining, manufacturing, energy and construction are grouped together as *Goods Producing Industries*. Those services contributing directly to the creation, production and distribution of goods are grouped together as *Goods Related Service Industries* (including distribution and knowledge-based business services). The remaining *Service Industries* (including all in-person services, as well as government and defence) make up the third group.[6]

6 Adapted from Berger and Lester (1997) and various papers in Sheehan and Tegart (1998).

Table 1. An alternative classification of sectors and industries

Industry	*Statistical division / Subdivision*
Goods producing industries	
Agriculture, forestry and fishing	A / 01 02 03 04
Mining	B / 11 12 13 14 15
Manufacturing	C / 21 22 23 24 25 26 27 28 29
Energy (Electricity, gas and water)	D / 36 37
Construction (Building and construction)	E / 41 42
Goods related services industries	
Distribution services:	
Wholesale	F / 45 46 47
Retail	G / 51 52 53
Transport and storage	I / 61 62 63 64 65 66 67
Knowledge-based / business services:	
Communications services	J / 71
Finance and insurance services	K / 73 74 75
Property and business services	L / 77 78
Services industries	
In-person services:	
Accommodation, cafes and restaurants	H / 57
Education services	N / 84
Health and community services	O / 86 87
Cultural and recreational services	P / 91 92 93
Personal and other services	Q / 95 96 97
Government and defence:	
Government administration and defence	M / 81 82

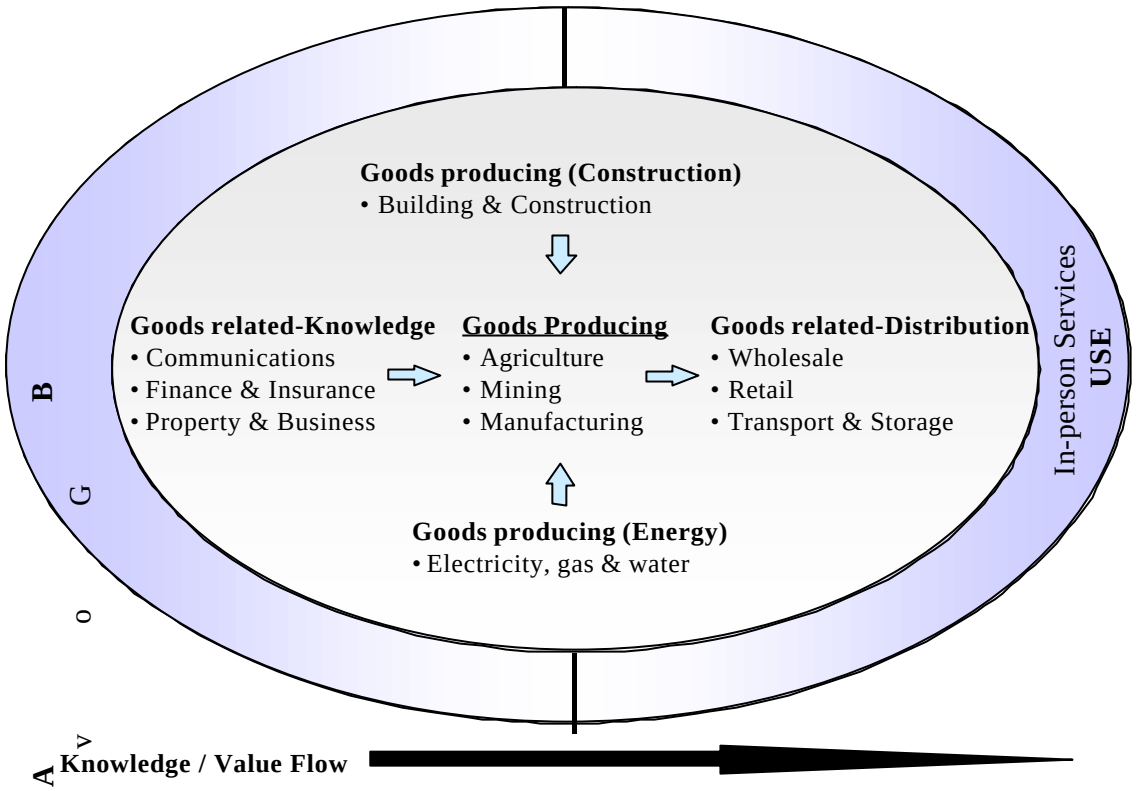
Note: Existing Australian statistical divisions and subdivisions are included to demonstrate ready concordance with existing national statistics.

The advantage of mapping industries in this way is that it allows us to explore their inter-relations, while preserving the traditional structure of industrial classification sufficiently to allow a simple and relatively direct concordance with official national and international statistical categories. In addition, this schema readily maps onto key analytical dimensions – such as the common classification of industries into capital intensive, knowledge intensive, and labour intensive; and the closely related Reichian classification of work into routine production, symbolic analytical, and in-person occupations (Reich 1992).

This schema can be shown graphically (Figure 1). It suggests a broad base for economic activity which includes government and defence services, and a consumer/user base which includes most in-person services. At the core of the economy are the goods producing industries, linked into a value chain which sees inputs coming from knowledge-based business services and goods related construction and energy industries, and outputs going to goods related distribution service industries.[7]

[7] The main variation from the standard goods/services classification is to separate out those service industries which are directly related to the creation, production and distribution of goods – namely

Figure 1. A system of creation, production and distribution



This schema draws out a number of features that have all too often been overlooked, and yet are now perceived to be critical features of emerging knowledge economies. Importantly, *it highlights the relation between manufacturing and services in the overall system of creation-production-distribution*, and it places an integrated manufacturing-services product system at the heart of the economy.

Looked at in this way, structural change in the Australian economy seems rather different (Table 2). Although employment in the goods producing industries remained static over the decade 1985-86 to 1995-96, it increased by more than 28 per cent in goods related service industries. Such that employment in the combined goods producing and good related industries increased by more than 764,000 between 1985-86 and 1995-96, and still accounts for almost 69 per cent of total employment in Australia.

construction, energy, transport and storage, wholesale and retail, and knowledge-based business services – from in-person, government and defence services.

Table 2. Employment by industry in Australia, 1985-86 and 1995-96

Industry	*Employed*	*1985-86 per cent share*	*Employed*	*1995-96 per cent share*
Goods producing industries				
Agriculture, forestry and fishing	427.9	6.2	421.9	5.1
Mining	105.8	1.5	85.3	1.0
Manufacturing	1,128.8	16.5	1,111.4	13.4
Energy (Electricity, gas and water)	144.1	2.1	80.8	1.0
Construction (Building & Construction)	477.3	7.0	600.3	7.2
Total	*2,283.9*	*33.3*	*2,299.7*	*27.8*
Goods related services industries				
Distribution services:				
Wholesale	425.9	6.2	499.1	6.0
Retail	947.8	13.8	1,226.8	14.8
Transport and storage	363.9	5.3	388.3	4.7
Knowledge-based / business services:				
Communications services	151.7	2.2	158.4	1.9
Finance and insurance services	294.5	4.3	315.6	3.8
Property and business services	451.8	6.6	795.8	9.6
Total	*2,635.6*	*38.5*	*3,384.0*	*40.8*
The Combined Goods Sector	***4,919.5***	***71.8***	***5,683.7***	***68.6***
Services industries				
In-person services:				
Accommodation, cafes and restaurants	228.3	3.3	380.6	4.6
Education services	452.3	6.6	584.7	7.1
Health and community services	571.2	8.3	757.0	9.1
Cultural and recreational services	126.7	1.8	187.6	2.3
Personal and other services	221.5	3.2	314.9	3.8
Government and defence:				
Government administration and defence	330.2	4.8	378.7	4.6
Total	*1,930.2*	*28.2*	*2,603.5*	*31.4*
Total all industries	**6,849.7**	**100.0**	**8,287.2**	**100.0**

Source: Australian Bureau of Statistics, *The Labour Force*, Cat. No. 6203.0.

These numbers clearly demonstrate that industries concerned with the creation, production and distribution of goods remain a major force in the economy; and form the kind of integrated manufacturing-services product system that appears to be characteristic of emerging knowledge economies.[8]

8 It is interesting to note that Chris Freeman identified both the rapid growth in information services *and* the integration of services and manufacturing as defining characteristics of the fifth Kondratieff or techno-economic paradigm as early as 1987 (1987, p. 75).

3.2 'New Manufacturing' - From industries to product systems

Whereas the traditional framework leads to a view of industries in isolation, what we now see is product systems in which manufacturing and services are combined in the creation, production and distribution of goods and services. There are many ways to approach these integrated goods producing and related services systems. They can be seen as clusters,[9] sectoral innovation systems,[10] complex product systems,[11] service-enhanced or new manufacturing[12] systems. But in whatever guise, the key feature is the integration of a range of industries into increasingly tightly coupled systems which affect the creation, production and distribution of goods and services. The advantage of using New Manufacturing as the starting point is that it highlights the critical role of services and the product system linkages between industries, while also bringing out the centrality of manufacturing.

As Peter Drucker observed:

> …the systems approach embeds the physical process of making things, that is, manufacturing, in the economic process of business, that is, the business of creating value. (1992, p. 301)
>
> As soon as we define manufacturing as the process that converts things into economic satisfactions, it becomes clear that producing does not stop when the product leaves the factory. Physical distribution and product service are still part of the production process and should be integrated with it, coordinated with it, managed together with it. (1992, p. 314)

And this integration, New Manufacturing, is increasingly evident in developed economies.

More than half the manufacturers surveyed in the *1998 Vision in Manufacturing* study, reported going beyond their existing product lines, and developing new, related services-based businesses in order to create value for customers (Deloitte Consulting 1998, p. 21). For example, manufacturers of industrial machinery no longer simply sell hardware, they supply integrated systems consisting of the equipment itself, electronic controls, information systems, software packages, reliability guarantees, and operating and maintenance support. It is not unusual for them to send employees to customers' factories for months or even years at a time to help train, operate and maintain their equipment (Berger and Lester 1997, p. 32).

Similarly, aerospace manufacturers are streamlining marketing, sales and after sales service to provide their customers with product-maintenance solutions. Boeing's spare parts business moved onto the Internet in November 1996, allowing its customers around the world to check parts availability and pricing, order parts, and track the

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9 See, for example, Porter *The Competitive Advantage of Nations* (1990) and related 10 country 'Porter Studies'. Roelandt and den Hartog (1999) provides an overview of cluster analysis activities in the OECD. See also Roelandt (1998) and Porter (1998, pp. 77-90).

10 See, for example, Breschi and Malerba (1997, pp. 130-152), and other works in the same volume.

11 See, for example, Gann (1996, 1997), Gann and Slater (1998) and other work from the Complex Product Systems Innovation Centre (CoPS).

12 See Drucker (1990, 1992, 1998) and Quinn (1992).

status of their orders online. Within a year, 50 per cent of Boeing's customers were using the Internet for 9 per cent of all parts orders and a much larger percentage of customer service inquiries. Boeing's spare parts business processed about 20 per cent more shipments per month in 1997 than it did in 1996 with the same number of data entry people. And, because customers can satisfy many service requests online, as many as 600 phone calls to customer service representatives are avoided each day (Quinn 1992, p. 180).

With the balance of power shifting towards customers, manufacturers must be able to meet rising expectations. This means customising products and services to meet local requirements, and it means getting closer to customers. For example, manufactures of denim jeans must deliver not just a carefully sewn pair of jeans at a competitive price, but jeans made for diverse new customers, located with new electronic technologies, and custom cut to the individual's measurements electronically transmitted to the sewing site – as Levi Strauss does (Berger and Lester 1997, p. 31).

Network equipment manufacturer Cisco builds virtually all its products to order. Before the company established its Internet sales capability in mid 1996, ordering a product was a complicated and time-consuming process. Today, an engineer at a customer's site can sit down at a PC, configure the product online, know immediately if there are any errors, and route the order to the procurement department. Because the customer's pricing structure is already programmed into the Cisco site, an authorised purchaser can complete the order with a few keystrokes. And, rather than calling Cisco for order status, invoice or account information, a customer with the proper authorisation can access the information directly on Cisco's Web site (US Department of Commerce 1998, p. 20). Cisco now report that more than 80 per cent of its customer inquiries are answered online, 80 per cent of sales are completed online, and 55 per cent of orders pass through their system without being touched by anyone (*The Economist* 1999a).

Even aerospace manufacturers are customising their products. Having invested heavily in flexible automation, Boeing is now able to modify internal seating, baggage, storage, and maintenance systems to suit almost any configuration of its aircraft that customers could possibly want. And Boeing increasingly involves its customers in aircraft design and development in order to better serve their needs (Quinn 1992, p. 180).

Indeed, it is becoming increasingly common for leading manufacturers to partner with customers to identify their requirements, anticipate their needs and provide more customer-perceived value. Market leaders are leveraging Internet technologies to link real-time business processes directly with suppliers and customers to improve customer service, increase responsiveness and expedite delivery – just as Boeing has done (Deloitte Consulting 1998, pp. 28-29). Elevator manufacturer Otis has used service technologies *and* coalitions across service industries to gain market position.

First, Otis introduced its OtisLine service to coordinate maintenance efforts across the United States. Highly trained operators take all incoming trouble calls, record critical information on computers and dispatch service crews directly via a paging system. From the computer records problem patterns can be identified and design changes

made to improve the on-site operation of Otis elevators. Design engineers also benefit from the information on operating conditions and faults, and have been able to improve their products as a result. Second, realising that architects specify elevator systems, Otis created downstream coalitions by making its design software available in architecture offices. This put architects directly in touch with Otis design and engineering, lowered architects' costs, opened up the possibility of increased customisation and developed customer loyalty. Otis may have no inherent advantage over competitors in the manufacture of elevator boxes, cables and motors, but it can capture advantage through information, customisation and support services (Quinn 1992, p. 181).

Market leaders are also focusing on innovation – trying to become faster and more efficient in the development cycle. More than 45 per cent of the firms surveyed for the *1998 Vision in Manufacturing* report were using computer aided design and manufacture (CAD/CAM), to integrate design, development and manufacturing (Deloitte Consulting 1998. p. 24). In the early 1980s American carmakers took between 4 and 6 years to take a car from concept to mass production. Today, all parties involved in designing a new platform or vehicle – designers, engineers, suppliers, and manufacturing and assembly personnel – work as a team, contributing to the process from beginning to end. As a result of computerisation, steps that used to take weeks or months can be done in days. Through the use of CAD/CAM and computer-aided engineering (CAE), the whole team can share files and use 3-D modelling techniques to design the vehicle and see how parts fit together, without building prototypes by hand. When the final design is agreed, CAM data is loaded into machines that build the tooling and prototype parts. This has cut the time it takes to develop and build a new vehicle to around 2 years.[13]

Supply chain integration is also critical. In the *1998 Vision in Manufacturing* survey, 68 per cent of executives reported a commitment to customer integration, and 73 per cent to integration with suppliers. Manufacturers are tightening and extending their supply chains, and turning to IT as the key enabler. Technology platforms, such as EDI (Electronic Document Interchange) and ERP (Enterprise Resource Planning) are integrating suppliers, manufacturers and retailers into increasingly seamless chains of creation, production and distribution (Deloitte Consulting 1998, pp. 37-39).

What these examples of the practices of leading manufacturers around the world suggest is that services and manufacturing are now so entwined and mutually supporting that success in either goes to those who effectively utilise the combined potential of both (Quinn 1992, p. 174). As Peter Drucker has observed: the starting point is not making goods, but services to enable the customer to get the fullest benefit from the goods – making things is a cost centre, service is the profit centre (1998). These examples also demonstrate the increasingly complex integration of production and service activities into product systems – systems which escape notice when seen through the lens of traditional industrial classification, and yet they lie at the very heart of the emerging knowledge economy.

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13 Derived from Pittman reported by US Department of Commerce (1998, p. 16).

4. Operationalising this alternative perspective

The remaining question is how do alternative perspectives on the creation, production and distribution of goods, and on 'new manufacturing' product systems, inform industry studies. How can we operationalise this alternative perspective in ways that contribute to our understanding of the operation of industries within the economy, and to the formulation of industrial policy for the emerging knowledge economy?

In a recent project supported by the Australian Department of Industry, Science and Resources and conducted by the Australian Expert Group in Industry Studies (AEGIS) at the University of Western Sydney, we have been investigating the Textile, Clothing and Footwear (TCF) industries in Australia, with a view to considering their role and future in the era of the global knowledge economy.[14] As a part of that project we have adapted a mapping framework developed for the Information Technology (IT) Industries,[15] and applied it in a preliminary analysis of TCF.[16]

This mapping framework moves beyond traditional industrial classification systems in that it is 2-dimensional. It includes a vertical *product-services* dimension, reflecting the increasingly complex interlinkages between manufacturing and services; and a horizontal *knowledge intensity* dimension, reflecting increasing information or knowledge intensity. The framework moves beyond the traditional view of industries in isolation, but it is different from an Input-Output view of industries in that it focuses on a product system which affects the transformation of materials into products – rather than simply on inter-industry transactions.

4.1 The textile, clothing and footwear product system

The space created by this 2-dimensional framework is broken into regions, positioning the major TCF *and* related industries according to their relative knowledge intensity and whether they produce a product or a service. Using the same principle, we subdivide each of these regions into product/service classes. Products or services are placed higher on the vertical product-service dimension when they are closer to the end users and to final consumption, and lower on the vertical product-service dimension when they are component parts of textile, clothing and footwear. They are placed towards the left-hand end of the knowledge intensity dimension when they are simple tasks or products, and further towards the right-hand end when there is more information or knowledge value-adding involved in their application.

This structured classification builds the picture of the TCF *and* related industries depicted in Figure 2. It divides the industries into five main *industry* groups:

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14 Using the textile, clothing and footwear industries as an example highlights the fact that the knowledge economy is important for relatively low technology industries, not just high technology industries. Textiles, clothing and footwear also account for a substantial share of China's total exports.

15 See, for example, Houghton, Pucar and Knox (1996a, 1996b), Hawkins, Mansell, and Steinmueller (1997) and Houghton (1999a, 1999b, and 1999c).

16 This approach has also been adopted in an AEGIS study of the Building and Construction Industries in Australia, see http://www.isr.gov.au/industry/building/mapping.pdf

contractors; wholesale, retail and design; the textile, clothing, footwear and leather manufacturing industries (in the centre); fibre and materials suppliers; and machinery and equipment suppliers. Each is divided into four product/service classes. These industry groups are surrounded by a regulatory framework, on the one hand, and a collective support infrastructure, on the other. In this way, *the core TCF industries are situated in the wider product system which affects the creation, production and distribution of textiles, clothing and footwear.*[17]

4.2 What drives the textile, clothing and footwear product system?

At AEGIS, we developed this map of the TCF and related industries in order to scope and explore the 'sectoral innovation system'.[18] Hence, the identification of drivers of innovation within that product system was a key step in our efforts to understand the dynamics of the TCF industries. Situating the core TCF industries in the wider system of the creation, production and distribution of textiles, clothing and footwear allowed us to identify drivers *within the system as a whole* – not just within the TCF manufacturing industries themselves.

What we found was that the drivers of innovation typically involved the integration of manufacturing and services and, as the preceding discussion would lead one to expect, service-enhanced or new manufacturing. We identified 6 major drivers of innovation in Australian TCF manufacturing, namely: retailers, brand owners, textile and fashion designers, machinery and equipment suppliers, materials suppliers, and government standards and regulations.[19] So, in essence, innovation in the TCF manufacturing industries is driven by the services and supply activities that surround them in our map.

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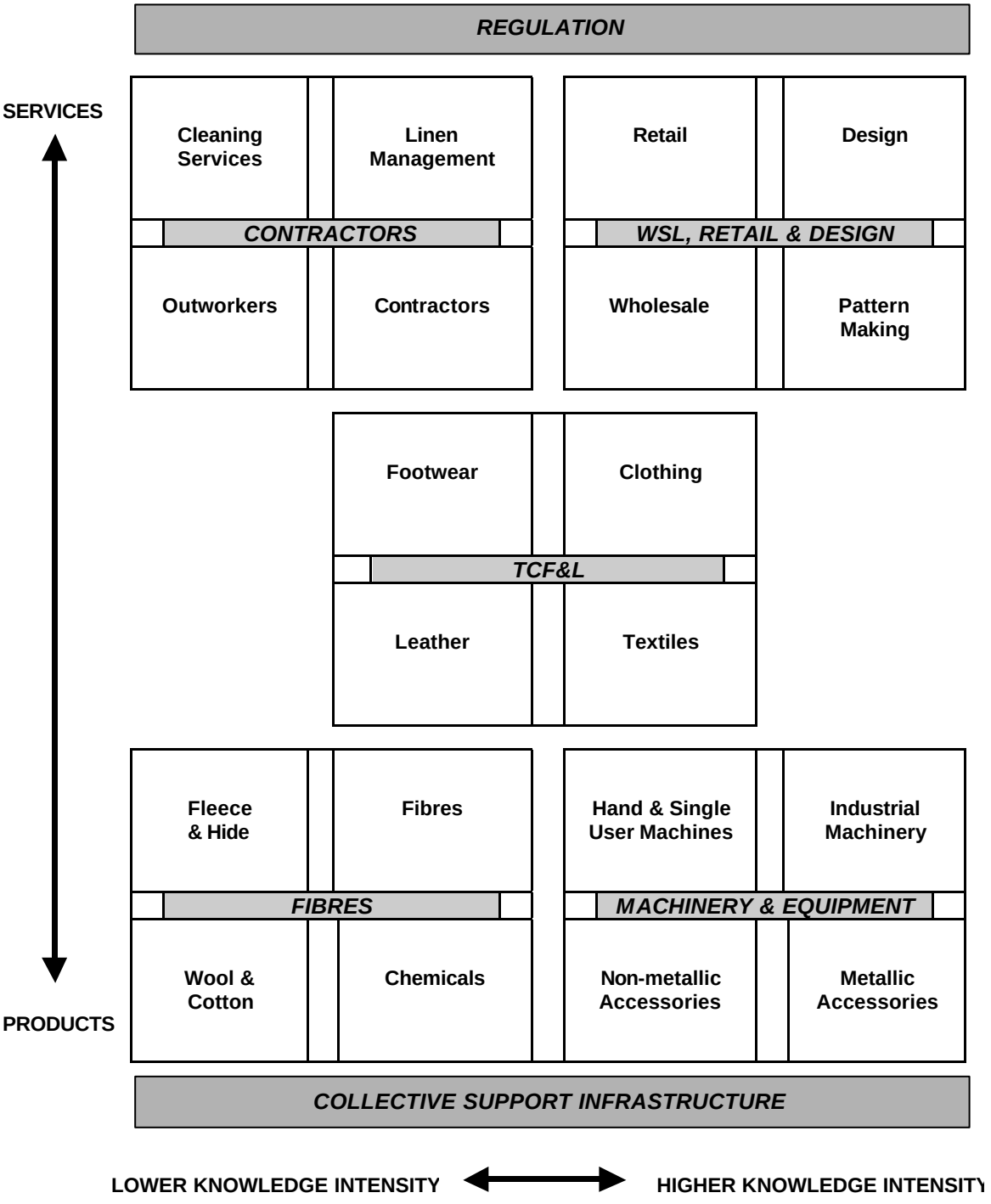
17 This map can be thought of as sketching the TCF cluster, the TCF sectoral innovation system, or the TCF product system – using the jargon of various literatures.

18 See Breschi and Malerba (1997) and other works in the same volume.

19 Because the study focused on industry drivers of innovation (the demand side), research institutions (the supply side) are not specifically identified as drivers.

Figure 2. The textile, clothing and footwear product system



Source: Derived from the AEGIS study, Mapping the Textiles, Clothing, Leather and Footwear Industries Cluster (1999, DISR, Canberra).

For example, in the context of defining the characteristics of their major lines or in-house brands, ***retailers*** often specify products in considerable detail. They may specify: the quality of the garments, their replicability (ensuring a quality standard) through specifying production methods (for example, the retailer may demand that assembly not be subcontracted to outworkers), the design and cut of garments, the textiles to be used (including, for example, specific ratios to be used in fabric blends), the fibres to be used (for example, the wool grade), the production of fibres and yarns (for example, the chemicals used by cotton or wool growers), and even the chemical composition of man-made fibres and textiles or of rubber compounds to be used in shoes. Hence, the retailer's demands drive innovation through the product system – sometimes from the retailer right through textile and clothing manufacturing firms, and into to the chemicals industry and primary producers that supply them.

UK-based Marks and Spencers used to be the leading example of this approach, but they have recently reduced control over their supply networks. We found that clothing retailers in Australia were also reducing their intervention in supply networks, but volume and discount retailers are still exercising considerable control over suppliers. Retailers specialising in higher-priced 'labels' appear to rely more upon the brand holder to develop new lines and maintain quality (AEGIS 1999).

In such cases, ***intellectual property (IP) or brand holders*** are the drivers. The best example of this branding and licensed manufacturing is in sports shoes, involving companies like Adidas, Reebok, and Niké. Such companies often dictate the design, define manufacturing processes, and even specify the composition of the rubber compounds and materials to be used – thus driving innovation in the product system right through footwear assembly, and back into the chemicals and rubber industries that supply them. A small number of manufacturers in Australia report considerable involvement by IP holders in product development and quality control. Examples include: Dunlop-Slazenger, Dr. Scholl Footwear, and the US-based outdoor clothing label London Fog (AEGIS 1999).

Sometimes textile and fashion ***designers*** drive the product system and promote innovations. For example, a fashion design house may specify the cut, textiles, blends, and fibres to be used, thus driving innovation in the product system from design services right through the TCF manufacturing industries, and back to the primary producers of cotton and wool, and the chemicals industries that produce man-made fibres. In the Australian TCF industries leading designers are reported to be significant drivers of new product development, although the majority of companies we studied seemed to rely on 're-developing' products they have seen in Europe.

In some cases technology embodied in ***machinery and equipment*** dictates. For example, new laser cutting, knitting or weaving machines may change production possibilities and, thereby, introduce new design possibilities and, in turn, new demands on manufacturers. Some Australian textile manufacturers reported strong linkages between their manufacturing operations and machinery suppliers, even when those suppliers were overseas. One textile manufacturer told us: 'It's a specialist function … establishing a partnership with them [machinery suppliers], making sure that the communication line is open, and that we are constantly updated on new

technologies … If you don't keep up-to-date in this business you are dead' (AEGIS 1999). Interestingly, it seems to be a two-way street. One manufacturer told us: 'It's really driven by machinery companies in Germany, Switzerland and Japan' (AEGIS 1999). While another told us: 'In the early 1980s we had computerised cutting and Gerber had slow-speed/high-depth cutters or high-speed/low-depth cutters. Neither met our needs, and there was nothing in between, so my father worked with them on the design of a high-speed/medium-depth cutter … and Gerber had 30 units sold over the next 2 days' (AEGIS 1999).

Sometimes ***materials suppliers*** drive innovation. For example, materials suppliers of natural and/or synthetic fibres might push innovation up through the product system, offering new production process, design and product possibilities, and promoting them through marketing – as has happened in the case of the Australian Woolmark. Indeed, the majority of clothing manufacturers we surveyed in Australia reported that they introduced innovations by working together with their fabric or textile suppliers. Examples cited included: chlorine-resistant fabrics for swimwear, and textiles for reduced pilling (AEGIS 1999).

Regulations almost always play some role in innovation. Regulations, in the form of product and safety standards, sometimes drive product development right through the system from retailer, through manufacturer to materials supplier. Work safety wear, and making children's clothing fireproof, are two areas of regulation commonly cited.[20] An Australian technical textiles manufacturer told us: 'One of the main forces shaping product development is occupational health and safety and company liability. We have defined products, including: bullet-proof vests, anti-stab and anti-needle protection, fire protection, workwear for furnaces to protect from molten metals splash, and defensive clothing for chemical and biological exposure. All very demanding and carefully regulated environments' (AEGIS 1999).

5. Concluding remarks

The important thing to notice about these examples is that change within the TCF manufacturing industries – some of the most traditional manufacturing industries – is often driven by the supply and services industries that surround them. Driven, that is, by the type of service-enhancement that characterises new manufacturing, and that increasingly characterises the core-integrated creation, production and distribution activities which underpin economic activity in the emerging knowledge economy.

An awareness of the characteristics of the emerging knowledge economy, and of such developments as new manufacturing, is important in our efforts to understand even the most traditional manufacturing industries. Focusing on new manufacturing gives us a way of seeing the increasing knowledge intensity that characterises the emerging knowledge economy by showing something of how knowledge intensive goods (e.g. textile machinery) and services (e.g. textile or fashion design) enhance the value of

[20] A recent development in Australia is heightened activity by the Australian Competition and Consumers' Commission (ACCC) in regard to product liability in the area of discount clothing.

even the most basic manufactures, and how the integration of goods and services in a system of creation, production and distribution lies at the core of the emerging knowledge economy.

These developments have profound implications for both developed and developing economies. If manufacturing is to be increasingly integrated with related service-based activities, it may be that it will be increasingly difficult to geographically separate high value manufacturing from its related services. While relatively low value manufacturing (mass production) can be located to take advantage of relative low wage and other cost locations, higher value, flexible and service-enhanced manufacturing (new manufacturing) must be located where it can be integrated with its related services – such that it is more likely to locate where there are highly developed service industries, closer to customers, and/or where highly developed information and communication technology and transport and distribution systems are capable of linking it seamlessly into global chains of creation, production and distribution.

Hence, competing for investment as a low cost producer may not only consign a country or region to relatively low value mass production, but also leave that country or region competing for a smaller and smaller share of global economic activity. For China, further developing coastal regions, such as the Pearl River Delta, must increasingly focus on developing the core related services around the manufacturing base already existing in, for example, electronics and textiles, clothing and footwear, and on developing the information and communication technology, transport and distribution systems capable of linking its manufacturing base more or less seamlessly into global chains of creation, production and distribution.

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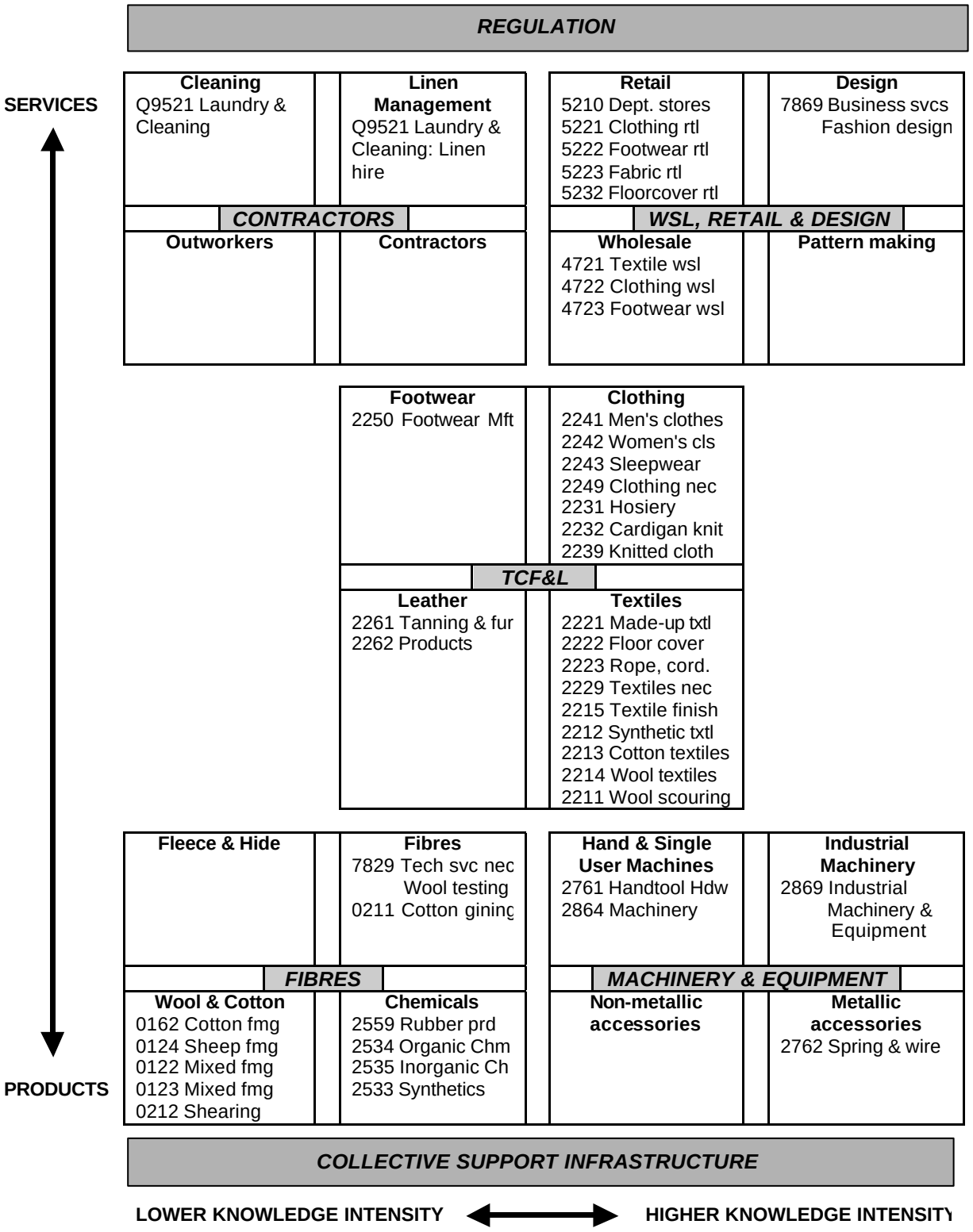
Appendix
The Textile, Clothing and Footwear Product System (ANZIC mapping)



Source: Derived from the work of John Houghton for AEGIS (1999), *Mapping the Textile, Clothing, Leather and Footwear Industries Cluster*, DIST, Canberra.