

Australian Government Department of Industry, Innovation and Science Office of the Chief Economist





# Global production sharing and Australian manufacturing 2016

WWW.INDUSTRY.GOV.AU/ OCE



Office of the Chief Economist



# Global production sharing and Australian manufacturing<sup>1</sup>

# Prema-chandra Athukorala

Arndt-Corden Department of Economics Crawford School of Public Policy College of Asia and the Pacific Australian National University

# Tala Talgaswatta

Economic and Analytical Services Division Department of Industry, Innovation and Science

October 2016

<sup>&</sup>lt;sup>1</sup> Omer Majeed from Australian National University provided excellent research assistance. We are grateful to Jagath Dissanayaka, Hal Hill, Abrie Swanepoel, Russell Thomson, and Nobuaki Yamashita for comments on the draft of the original report; to Andrew Lalor, Economic and Analytical Services Division, for sponsoring the project; and to Nick Yazidjoglou and Gaminda Ganewatta for their help at the formative stage of the project.



For further information on this research paper please contact

Email: chiefeconomist@industry.gov.au

#### Chief investogator:

Professor Prema-chandra Athukorala

Funded by: Strategic Research Fund Department of Industry, Innovation and Science

Sponsored by: Analytical Services Branch, Office of the Chief Economist

Project Manager: Stacey Wilkinson

#### Disclaimer

The views expressed in this report are those of the author(s) and do not necessarily reflect those of the Australian Government or the Department of Industry, Innovation and Science.

© Commonwealth of Australia 2016.

This work is copyright. Apart from use under Copyright Act 1968, no part may be reproduced or altered by any process without prior written permission from the Australian Government. Requests and inquiries concerning reproduction and rights should be addressed to <a href="mailto:chiefeconomist@industry.gov.au">chiefeconomist@industry.gov.au</a>. For more information on Office of the Chief Economist research papers please access the Department's website at: <a href="mailto:www.industry.gov.au">www.industry.gov.au</a>.



#### **Creative Commons Licence**

With the exception of the Coat of Arms, this publication is licensed under a Creative Commons Attribution 3.0 Australia Licence.

Creative Commons Attribution 3.0 Australia Licence is a standard form license agreement that allows you to copy, distribute, transmit and adapt this publication provided that you attribute the work. A summary of the licence terms is available from <a href="http://creativecommons.org/licenses/by/3.0/au/deed.en">http://creativecommons.org/licenses/by/3.0/au/deed.en</a>.

The full licence terms are available from http://creativecommons.org/licenses/by/3.0/au/legalcode.

The Commonwealth's preference is that you attribute this publication (and any material sourced from it) using the following wording:

Source: Licensed from the Commonwealth of Australia under a Creative Commons Attribution 3.0 Australia Licence. The Commonwealth of Australia does not necessarily endorse the content of this publication.

# **Acknowledgements**

The authors would like to thank Omer Majeed from Australian National University who provided excellent research assistance. The authors would like to acknowledge Jagath Dissanayaka, Hal Hill, Abrie Swanepoel, Russell Thomson and Nobuaki Yamashita for comments on the draft of the original report. The authors would also like to acknowledge the contributions of Andrew Lalor, Tim Bradley, Gaminda Ganewatta and Nick Yazidjoglou.

This project was funded by the Strategic Research Fund, of the Australian Government Department of Industry, Innovation and Science in 2015. It was sponsored by the Department's Analytical Services Branch, Office of the Chief Economist.

# Contents

1.	Purp	urpose and scope of the study					
2.	Global Production Sharing						
	2.1	2.1 The phenomenon of global production sharing					
	2.2	Drivers of global production sharing	8				
	2.3	Policy issues	9				
3.	Meth	nodology	12				
	3.1	3.1 Compilation of trade data					
	3.2	Analytical methods					
		3.2.1 Export similarity	15				
		3.2.2 Revealed comparative advantage (RCA)	15				
		3.2.3 Gravity model	16				
		3.2.3.1 Description of variables	17				
		3.2.3.2 Data sources	19				
		3.2.3.3 Estimation method	20				
4.	Global Production Sharing and Trade Patterns: The Global Context						
	4.1	Initial conditions	23				
	4.2	Recent trends	24				
	4.3	Geographic profile	26				
5.	Aust	Australia in Global Production Sharing2					
	5.1	Trends	29				
	5.2	Commodity composition	33				
	5.3	Australia–OECD export similarity/difference					
	5.4	Revealed comparative advantage					
	5.5	Direction of exports	48				
6.	Determinants of Exports						
	6.1	General inferences	51				
	6.2	Australia-Specific inferences	56				
7.	Global Production Sharing and Manufacturing Performance						
	7.1	Data compilation					
	7.2	Preliminary findings					
	7.3	Servicification of manufacturing	62				
8.	Summary of Findings and Policy Implications						
	8.1	8.1 Findings					

# **Boxes**

Box 5.1: Australian	Aircraft Industry	37

# Figures

Figure 4.1: World manufacturing exports (current prices)	24
Figure 4.2: Share of GPN products exports, in nominal and real (2005 prices) terms (per cent)	26
Figure 4.3: OECD share in world manufacturing exports, 1988–2013 (per cent)	27
Figure 5.1: Australian manufacturing exports, 1988–2013 (A\$mn)	31
Figure 5.2: Share of parts and components in manufacturing exports, 2000– 2013 (per cent)	31
Figure 5.3: Parts and components and final assembly exports (per cent)	32
Figure 5.4: Parts and components and final assembly imports (per cent)	32
Figure 5.5: Finger-Kreinin export similarity index: Australia and OECD, 1988– 2013 (per cent)	42
Figure 5.6: Australia: Direction of GPN exports (per cent)	49
Figure 7.1: Share of other business services exports of Australia (per cent) Bookmark not defined.	Error!

# **Tables**

Table 3.1: Variable definitions and data sources	21
Table 4.1: Shares of world manufacturing exports and imports, 2012/13 <sup>1</sup> (per cent)	28
Table 5.1: Summary data of manufacturing exports: Australia—OECD Comparison	30
Table 5.2: Commodity composition of parts and components exports from     Australia <sup>1</sup> (per cent)	34
Table 5.3: Australia's share in world exports of parts and components <sup>1</sup> (per cent)	36
Table 5.4: Commodity composition of final assembly exports from Australia <sup>1</sup> (per cent)	40

Table 5.5: Australia's share in world exports of final assembly <sup>1</sup> (per cent)	41
Table 5.6: Revealed comparative advantage in parts and components exports <sup>1</sup> (per cent)	45
Table 5.7: Revealed comparative advantage in final assembly exports	47
Table 5.8: Direction of manufacturing exports, 2012/13 (per cent)	50
Table 6.1: Determinants of manufacturing exports	52
Table 6.2: Determinants of manufacturing exports: Australia specific results	54
Table 7.1: Key indicators of manufacturing performance, 2010–13 (annual averages) <sup>1</sup>	60

### **Executive Summary**

The breakup of production processes into separate stages, with each country specialising in a particular stage of the production sequence, has been an increasingly important structural feature of economic globalisation in recent decades. This phenomenon, which is called 'global production sharing' in this study, opens up opportunities for countries to specialise in different tasks within vertically integrated global industries. Parts and components, and final assembly traded within global production networks ('GPN trade') have been growing at a much faster rate compared to trade in goods wholly produced within countries ('horizontal trade').

This study examines the patterns and determinants of global production sharing, with emphasis on the following issues: (a) How does Australian manufacturing fit into global production sharing? (b) What are the implications of global production sharing for the performance of and structural change in Australian manufacturing? (c) What are the policy options for effectively linking Australian manufacturing to global production networks?

The analysis is based on a new data set compiled from the United Nations (UN) *Comtrade* trade database, which systematically delineates trade in parts and components and final assembly from total manufacturing trade for the period 1988 to 2013. The study also contains a preliminary exploratory analysis of the link between GPN trade and the performance of Australian manufacturing and the emerging patterns of servicification of manufacturing driven by global production sharing.

The results show that:

- Though Australia is still a minor player in world manufacturing trade, there are early signs of Australian manufacturing reaping gains from global production sharing. GPN products now account for nearly half of the total manufacturing exports from Australia.
- The share of parts and components in total Australian manufacturing exports has shown a clear upward trend from the late 1990s and a decline in parts and components imports. Parts and components production is generally more capital and skill intensive compared to most of the final assembly undertaken within GPNs.
- Australia has a competitive edge in parts and components specialisation in several product categories including aircraft parts and associated equipment, parts of earth moving and mineral processing machines, and specialised automotive parts.
- GPN trade of OECD countries is heavily concentrated in telecommunication and sound recording equipment, electrical machinery, professional and scientific equipment, and photographic equipment. These products do not feature prominently in the Australian export product mix. However, there are early signs of some Australian export successes in these product categories.
- Relative price competitiveness (measured by the real exchange rate) is not an important determinant of GPN exports from Australia, because these exports are largely 'relationship-specific' and are also based on

long-term supplier-producer relationships. Reaping gains from Australia's comparative advantage in primary commodity (resource-based) trade and from specialisation in knowledge-intensive tasks within GPNs are, therefore, not conflicting policy goals for Australia.

The 'tyranny of distance' is not a binding constraint on exporting specialised parts and components, and some final assembly goods from Australia. There is also evidence that, in determining components exports from Australia, domestic technological capabilities are relatively more important compared to the average global experience. The quality of trade-related logistics plays an important role in export success through global production sharing.

The achievements of Australian manufacturing in the new dynamic areas of global production sharing, as documented in the study, seem to dispel the prevailing perception of the 'death of manufacturing' in Australia. This gloomy perception is a hurdle for manufacturing firms to recruit and retain talent to attract potential customers, and to avert sidestepping of potential opportunities by policy makers.

### 1. Purpose and scope of the study

Cross-border dispersion of production processes within vertically integrated global industries, which we label 'global production sharing' in this study<sup>1</sup>, has been an increasingly important structural feature of economic globalisation in recent decades. This process of international division of labour opens up opportunities for countries to specialise in different slices (tasks) of the production process in line with their relative cost advantages. For instance, a country need not set up an aircraft manufacturing plant to benefit from the growth of the global aircraft industry. It is enough to be competitive in the production of a single part (See Box 1.1). As the production processes are finely sliced across a wide range of industries, new opportunities for specialisation are created. Given this structural shift in global production, the conventional approach to analysing trade patterns, which treats international trade as an exchange of goods produced from beginning to end in a given trading partner, is rapidly losing its relevance.<sup>2</sup>

The purpose of this study is to examine the patterns and determinants of global production sharing with emphasis on the following issues: (a) How does Australian manufacturing fit into global production sharing; in particular, what opportunities are there for Australia to benefit from this new form of international exchange? (b) What are the implications of global production sharing for the performance of and structural change in domestic manufacturing in Australia? (c) What are the policy options for effectively linking Australian manufacturing to global production networks? By addressing these issues, the study aims to assist the Department of Industry, Innovation and Science (DIIS) to bring global insights and best practice to bear on its research and policy analysis in the area of trade and foreign investment relating to growth and structural adjustment in domestic manufacturing. Identification of niches of Australia's strategy to promote innovative capabilities and attracting foreign direct investment.

The study is motivated by the growing emphasis in the contemporary policy debate in Australia on factors influencing Australia's industrial future (ACOLA 2015, PC 2014, Withers et al 2015, CEDA 2014 & 2015, Government of Australia 2012). However, recent studies on this issue have taken the conventional approach to trade flow analysis, which implicitly assumes that countries trade in goods that are produced from beginning to end within the given geographical boundaries. The implications of the ongoing process of global production sharing for effective integration of domestic manufacturing into global manufacturing networks and the related policy issues have not been

<sup>&</sup>lt;sup>1</sup> The alternative terms used in the recent international trade literature include global production sharing, international production fragmentation, intra-process trade, vertical specialisation, slicing the value chain, and offshoring.

<sup>&</sup>lt;sup>2</sup> 'This phenomenon [global production sharing] calls for a change in analytical and statistical tools we use to measure and understand the real world', Pascal Lamy, former Director-General of WTO, *Financial Times*, 24, January 2011.

systematically explored. Given this information gap, the Australian mindset has not changed to accommodate current and emerging global trends in manufacturing. For instance, according to a survey of 450 top business executives and 700 public servants conducted as part of a major research project undertaken by the Australian Council of Learned Academies (ACOLA), neither business leaders nor public servants identify global production sharing as an issue of strategic importance for Australia (Withers et al. 2015). The data from the *Business Characteristics Survey* conducted by the Australian Bureau of Statistics (ABS)<sup>3</sup> are consistent with this findings: Only 1.8 per cent of all manufacturing firms on average are engaged in integrated supply chains over the period 2005–06 to 2013–14.

The study is structured as follows: Section 2 provides a stage-setting analytical overview of the process of global production sharing, patterns and determinants of network trade. It also discusses emerging opportunities for countries to specialise in line with their relative cost advantage. Section 3 discusses the methodology, the procedure followed in delineating trade based on global production sharing (henceforth dubbed 'GPN trade'<sup>4</sup>) from total manufacturing trade flows using data extracted from the United Nations (UN) trade database (UN Comtrade). Section 4 provides a stage-setting overview of the emerging trends and patterns of world GPN trade. Section 5 undertakes a comparative analysis of Australia's engagement in GPN trade, focusing on overall trends, commodity composition and directions of trade. An econometric analysis is undertaken in Section 6 using the standard gravity modelling framework to examine the determinants of inter-country differences in the degree of involvement in GPN trade in order to set the stage for further research. A preliminary analysis of the implications of global production sharing for the performance of domestic manufacturing in Australia is undertaken in Section 7. This section also contains an exploratory analysis of the 'servicification' of manufacturing - shifting of some manufacturing-related services, which were traditionally a part of manufacturing output, to servicessector firms. Section 8 summarises the key findings, followed by a discussion of the policy implications. It also makes suggestions for further research including how to improve the trade and industry databases of the country in line with the need for informing the policy debate in this era of global production.

<sup>&</sup>lt;sup>3</sup>ABS Cat. 8167.0, Selected Characteristics of Busineses, publishes data on integrated supply chain involvements of businesses.

<sup>&</sup>lt;sup>4</sup> Trade in parts and components and final assembly within production networks arising from global production sharing

The Boeing 787 Dreamliner has become an eye-catching illustrative case of how countries are engaging in an intricate web of production-sharing arrangements (Gapper 2007). The production of this fuel-saving medium-sized jet involves 43 parts and component suppliers spread over 135 production sites around the world.

The wings are produced in Japan, the engines in the United Kingdom and the United States, the flaps and ailerons in Australia and Canada, the fuselage in Japan, Italy, and the United States, the horizontal stabilizer in Italy, the landing gear in France, and the doors in Sweden and France. Offshore production accounts for 70 per cent of the many thousands of parts used in assembling the jet. Some parts are produced in foreign affiliates of the Boeing Corporation, while others are supplied under subcontracting arrangements. Boeing itself is responsible for only about 10 per cent by value of the aircraft, tail fin and final assembly, but holds rights to the 787 technology.

This pattern of 'outsourced production' around the world is in sharp contrast to Boeing's parochial emphasis on procuring components domestically: only about 1 per cent of the Boeing 707 was built outside the US in the 1950s. It is now focussing on its advantages — design, supply chain management, marketing and branding — rather than on areas where others are bound to make inroads.

Airbus, Boeing's competitor, followed Boeing's lead for its A350 jet. It closed down some component-producing plants in Europe and is outsourcing work to China and elsewhere in producing this wide-body jet, which is positioned to compete with the Boeing 787.



## 2. Global Production Sharing

#### 2.1 The phenomenon of global production sharing

Global production sharing is not a new phenomenon. There is ample anecdotal evidence of evolving trade in parts and components within branch networks of multinational enterprises (MNEs) dating back to the early 20th century (Wilkins 1970). Kindleberger (1967) used the example of growing trade in 'semi-finished material' (parts and components) between the Ford plants at Limburg in Belgium and Cologne in Germany in the mid-1960 to question the validity of the conventional approach to analysing trade-growth nexus which was 'developed almost entirely on the basis of trade in final products — that is, goods wholly produced in one country and consumed in another (p. 108–9). The US multinational corporations (MNCs) operating in the Australian automotive industry have been importing parts and components for local assembly operations and also exporting some parts and components produced in Australia within their global networks starting as early as the 1950s (Hughes 1977, Brash 1966).

What is unprecedented about the contemporary process of global production sharing is its wider and ever increasing product coverage, and its rapid spread from mature industrial countries to developing countries. Over the past four decades, production networks have gradually evolved encompassing many countries and spreading to many industries such as sport footwear, automobile, televisions and radio receivers, sewing machines, office equipment, electrical machinery, machine tools, cameras, watches, light emitting diodes, solar panels, and surgical and medical devices. In general, industries with the potential to break up the production process to minimise the transport cost are more likely to move to peripheral countries.

Until about the early 1970s, production sharing was basically a two-way exchange between the home and host countries undertaken by MNEs; parts and components were exported to the low-cost, host country for assembly and the assembled components were re-imported to the home country to be incorporated in the final product (Helleiner 1973, Grunwald and Flamm 1985, Brown and Linden 2005). As supply networks of parts and components became firmly established, producers in advanced countries have begun to move final assembly of an increasing range of products (for example, computers, mobile phones and other hand-held devices, TV sets and motor cars) to developing countries (Krugman 2008). Many of the MNEs in electronics and related industries now undertake final assembly in developing-country locations, retaining only product design and coordination functions at home.

As production operations in the host countries became firmly established, MNE subsidiaries began to subcontract some activities to local (host-country) firms, providing the latter with detailed specifications and even fragments of their own technology. Over time, many firms, which were not part of original MNE networks, began to undertake final assembly by procuring components globally through arm's-length trade, benefitting from the ongoing process of standardisation of parts and components.

These developments suggest that an increase in production-sharing based trade may or may not be accompanied by an increase in the host-country's stock of foreign direct investment (FDI) (Jones 2000, Brown et al. 2004). However, there is clear evidence that MNEs are still the leading vehicle for countries to enter global production networks. In particular the presence of a major MNE in a particular country is vital, both as a signalling factor to other foreign firms less familiar with that country and an agglomeration magnet for the development of new cluster-related activities and specialised support services (Dunning 2009, Ruwane and Gorg 2001, Wells and Wint 2000).

In recent years, the popular press has begun to pay attention to the phenomenon of 'reshoring' (also termed 'reverse offshoring' or 'onshoring'), shifting by MNEs of manufacturing facilities from overseas locations to the home country (Gray et al. 2013). There have been a number of highlypublished cases of US MNEs reshoring (or planning to restore) assembly processes from China to plants in the US. However, whether this is a new structural (lasting) phenomenon, or simply a case of some isolated instances. It remains to be seen whether the shifting production bases receiving mediaattention against the backdrop of the political rhetoric of 'bringing back manufacturing home' and the erosion of the size of the US-China wage differentials, will became a feature of the US economy. As we have already discussed, global production sharing has already expanded well beyond the domain of the MNEs headquartered in the US and the other developed countries, with a continuous widening of the product coverage. Furthermore, ...as emerging economies grow and thus demand increases in these locations while levelling in the US and other developed countries, firms might want to be...in close in proximity to demand' Gray et al. (2013, p. 31).

#### 2.2 Drivers of global production sharing

The expansion of global production sharing has been driven by three mutually reinforcing developments (Helpman 2011, Jones 2000, Jones and Kierzkowski 2001 and 2004, Yi 2003). First, rapid advancements in production technology have enabled the industry to slice up the value chain into finer, 'portable' components. As an outcome of advances in modular production technology, some fragments of the production process in certain industries have become 'standard fragments', which can be effectively used in a number of products. For instance, long-lasting cellular batteries, which were originally developed by computer manufacturers, are now widely used in mobile phones and electronic organizers; transmitters, designed originally for radios, are now used in personal computers and missiles.

Second, technological innovations in communication and transportation have shrunk the distance that once separated the world's nations, and improved speed, efficiency and economy of coordinating geographically dispersed production processes. This has facilitated, and reduced the cost of, establishing 'service links' needed to combine various fragments of the production process across countries in a timely and cost efficient manner.

Third, liberalisation policy reforms across the world over the past four decades have considerably removed barriers to trade and foreign direct investment (FDI). Trade liberalisation is far more important for the expansion of GPN trade

compared to the conventional horizontal trade. This is because, a slice/task of the production chain operates with a smaller price-cost margin, therefore profitability could be erased by even a small tariff.

There is an important two-way link between improvement in communication technology and the expansion of production sharing within global industries. The latter contributes to lowering cost of production and rapid market penetration of the final products through enhanced price competitiveness. Scale economies resulting from market expansion in turn encourage new technological efforts, enabling further product fragmentation. This two-way link has set the stage for GPN trade to expand more rapidly compared to conventional commodity-based trade (Jones 2000).

#### 2.3 Policy issues

Global production sharing opens up opportunities for countries to participate in a finer international division of labour. The nature of factor intensity of the given segments and the relative prices of factor inputs in comparison with their productivity jointly determine which country produces what tasks with a production network. It may be that workers in a given country tend to have different skills from those in other countries, and the skills required in each production block differ so that a dispersion of activity could lower marginal production cost (as in the Ricardian model). Alternatively, it may be that the production blocks differ from each other in the proportion of different factors required, enabling firms to locate labour intensive production blocks in countries where productivity-adjusted labour cost is relatively low (as in the Heckscher-Ohlin model).

However, successful participation in global production sharing will occur only if the costs of 'service links' associated with production sharing outweigh the gain from the lower costs of the activity abroad. Here the term service links refers to arrangements for connecting/coordinating activities into a smooth sequence for the production of the final good. Service link cost relate to transportation, communication, and other related tasks involved in coordinating the activity in a given country with what is done in other countries within the production network.

The policy regime and the domestic investment climate also need to be conducive for involvement in production sharing. The decision of a firm to outsource production processes to another country — either by setting up an officiated company or establishing an arm's length relationship with a local firm — entails 'country risks'. This is because supply disruptions in a given overseas location could disrupt the entire production chain. Such disruptions could be the product of shipping delays, political disturbances, or labour disputes (in addition, of course, to natural disasters). In many instances it is impossible to fully offset these risks by writing *complete contracts*<sup>5</sup> (Spencer 2005, Helpman 2011).

The engagement of countries in manufacturing for export within vertically integrated international industries may take several forms. It may involve the

<sup>&</sup>lt;sup>5</sup> In a complete contract there would be no gaps in terms of the contract.

exchange between two countries of certain final product (finished good) for parts and components used by the industry. Alternatively two countries may exchange different parts and components used in the production of commodities by the industry. Firms in some countries may engage in upstream activities in the value chain such as product designing and highly-specialised component production, or marketing and other head-quarter activities while leaving final assembly to other countries. Box 2.1 shows that value-addition to the national economy (or a company) from global production sharing varies among these different forms of engagements.

#### Box 2.1: The Smiling Curve

Who gains most by engaging in the value chain of a production network? How can value creation be improved over time within the value chain? The 'smiling curve' proposed by the founder of Acer Corporation, Stan Shih, is widely used as a framework for thinking about these issues (Shih 1996).

The smiling curve illustrates the value-addition potential of different components in the value chain, from product design and specialised component production at the top left, product assembly at the bottom, and branding and after-sales services at the top right. In other words the basic structure of the curve from left to right on the horizontal axis are upstream, middle and downstream of an industry. Activities on the left-hand side depend on technology, manufacturing capabilities and economies of scales. On the right-hand side, company success depends on brand names, marketing channels and logistic capability.

The main factors that determine the level of value added are entry barriers and accumulation of capability. Thus, the greatest value is captured by upstream and downstream firms, and the lowest value is captured in the middle of the value chain (assembly). Product assembly is not where most value gets added, because it is the highly mobile stage in the production process facing more and more competition. For instance, in the computer industry, entry barriers are low and profit margins are thin. By contrast, product design, manufacturers of key components (such as LCDs and memory chips) and establishment of brand names come with high entry barriers because such activities require more capital and a higher level of manufacturing capabilities.



Acer, which started in 1976 as an electronic components importer for computer assembly, had become the world's number three manufacturer of personal computers (PC) in just two decades (li and Tan 2004). Acer used its global presence and global technology and best manufacturing practices to build capabilities at both ends of the supply chain, where margins are higher than in PC assembly. It moved upstream in the manufacture of motherboards, peripherals and central processing units which required strong technological capabilities and downstream in branding, distribution, software development and e-commerce.

In some recent applications of the 'smiling curve', component production and assembly have been lumped together under the label of manufacturing at the bottom of the curve (eg. Roos 2014). This practice has given rise to the erroneous perception that 'manufacturing' is a 'dead-end' activity in the context of advanced industrialised nations. But, within manufacturing, component production, unlike final assembly (which is relatively more labour intensive) includes capital and technology intensive production processes, which requires domesticated design capabilities. As the Boeing 787 case (Box 1.1) vividly illustrates, advanced industrial economies can engage in an intricate web of component specialisation, even in the absence of clear patterns of factor price differential among them (Grossman and Rossi-Hansberg 2013).

Stan Shih invented the smiling curve for the purpose of internal communication and consensus formation within his own company (Shih 1996). As he has emphasised there can be different smile curves for different industries depending on the input structure and entry barriers. For instance, in terms of value-creation potential, assembly of some highly-specialised products such as medical devices and scientific instruments can be comparable to designing and branding these products.

Why should policy makers pay particular attention to global production sharing as part of an outward-oriented development strategy? The available evidence on the emerging patterns of global production sharing, when combined with the standard literature on gains from export-oriented development (Dornbusch 1992, Srinivasan 1999, Grossman and Helpman 1993) suggests that growth prospects would be greatly enhanced through engaging in this form of international exchange.

First, participation in GPNs is likely to have a favourable 'atmosphere creation' effect on domestic manufacturing. The very nature of the process of GPN is the continuous shaking-up of industry through the emergence of new products and production processes in place of old ones. Engaging in global production sharing is an effective way of linking domestic manufacturing to dynamic global industries of electronics, electrical goods, medical devices and transport equipment, which are the incubators of new technology and managerial skills. Thus participation in global production sharing also has the potential to yield growth externalities (spillover effects) through the transfer of technology and managerial know-how, skill development and 'atmosphere creation' effects.

Second, as GPN trade accounts for a large and increasing share of world manufacturing trade, there can be considerable gains from economies of scale and scope that arise in wider markets. In other words, this form of international exchange opens up greater opportunities for achieving economies of scale and scope. When production is fully integrated (produced in a single location) achieving scale economies is limited by volume at the end product level.

Third, specialisation in parts and components within production networks has the potential to help overcome the 'tyranny of distance', which is the trade cost disadvantage arising from geographic distance from major markets. The process opens up opportunities to specialise in high-value-to-weight components in the value chain and the growing importance of air cargo as the major mode of transport.

The second and third considerations are particularly important for Australia. The performance of Australian manufacturing has historically been constrained by the small size of the domestic market and distance-related trade costs (Gregory 1993, Krause 1984, McLean 2013, Hutchinson 2014).

### 3. Methodology

#### 3.1 Compilation of trade data

A prerequisite for analysing patterns and determinants of GPN trade is the systematic delineation of parts and components and final assembly from the standard (Customs-records based) trade data. Following the seminal paper by Yeats (2001), it has become common practice to use data on parts and components to measure GPN trade. However, parts and components are only one facet of GPN trade. There has been a remarkable expansion of network activities from parts and component production and final assembly. Moreover, the relative importance of these two tasks varies among countries and over time in a given country. This makes it problematic to use data on parts and components trade as a general indicator of the trends and evolving patterns of network trade over time and across countries. In this study, we define network trade to incorporate both components and final assembled goods exchanged within production networks.

The data used in this study for all countries except Taiwan are compiled from the *UN Comtrade* database, based on Revision 3 of the Standard International Trade Classification (SITC Rev. 3). The data for Taiwan (a country which is not covered in the UN trade data reporting system) come from the database of the Council of Economic Planning and Development, Taipei.

For the compilation of manufacturing trade data, we use the standard SITCbased definition. According to this definition products belonging to SITC Sections 5 to 8 net of SITC 68 (non-ferrous metals) are classified as manufactured goods.<sup>6</sup> Within manufactured goods, parts and components are delineated using a list compiled by mapping parts and components in the UN Broad Economic Classification (BEC) with the SITC list at the five-digit level of commodity disaggregation. The product list of the Information Technology Agreement Information of the World Trade Organisation (WTO) was used to fill gaps in the BEC list of parts and components. The full list is given in Table A1.

It is important to note that parts and components, as defined here, are only a subset of intermediate goods, even though the two terms have been widely used interchangeably in recent literature on global production sharing. Parts and components are inputs further along the production chain. Parts and components unlike the standard intermediate inputs, such as iron and steel, industrial chemicals and coal, are 'relationship- specific' intermediate inputs; in most cases they do not have reference prices, and are not sold on exchanges and are more demanding on the contractual environment (Nunn 2007, Hummels 2002). Most (if not all) of the parts and components category also do not have a 'commercial life' on their own unless they are embodied in a final product.

The 'intermediate goods' list of BEC captures both the traditional intermediate goods (such as non-ferrous metal, iron and steel bars etc.) and components ('middle products' or 'goods in process') germane to global production sharing. To get an accurate picture of global production sharing, what is relevant is only the latter (Hummels 2002). Mixing the two is particularly problematic for a trade data analysis for Australia because standard intermediate goods historically account for a large share of total manufactured exports.

There is no hard and fast rule for distinguishing between products assembled within global production networks and other traded goods that are produced from beginning to end in a given country in international trade data. The only practical way of doing this is to focus on the specific product categories in which network trade is heavily concentrated. Once these product categories are identified, trade in final assembly can be approximately estimated as the difference between parts and components — directly identified based on our list — and recorded trade in these product categories.

<sup>&</sup>lt;sup>3</sup> This definition is consistent with the Australian definition of elaborately transformed manufacturing.

Guided by the available literature on production sharing,<sup>7</sup> we identified seven product categories for final assembly products: office machines and automatic data processing machines (SITC 75), telecommunication and sound recording equipment (SITC 76), electrical machinery (SITC 77), road vehicles (SITC 78), other transport equipment (SITC 79), professional and scientific equipment (SITC 87) and photographic apparatus (SITC 88). It is quite reasonable to assume that these product categories contain virtually no products produced from start to finish in a given country. However, admittedly the estimates based on this list do not provide full coverage of final assembly in world trade. For instance, outsourcing of final assembly does take place in various miscellaneous product categories such as clothing, furniture, sporting goods, and leather products. It is not possible to meaningfully delineate parts and components and assembled goods in reported trade in these product categories because they contain a significant (yet unknown) share of horizontal trade.

A number of recent studies have analysed trade patterns using 'value added' trade data derived by combining the standard (Customs record based) trade data with national input-output tables. Apart from the highly aggregated nature of the analysis, value added trade data analysis is useful only for the accurate measurement of bilateral trade imbalances and to provide a guide to the extent to which trade shocks stemming from final export destination countries affect a given trading nation. The underlying rationale for using value added trade data is that, in the context of rapidly expanding cross-border trade in parts and components driven by global production sharing, the standard (gross) trade data (trade data based on Customs records) tend to give a distorted picture of bilateral trade imbalances of a given country<sup>8</sup> and the geographic profile of its global trade linkages.

This approach is not relevant for the present study, which aims to examine patterns and determinants of production-sharing-driven trade flows and opportunities for countries to engage in this form of international exchange. From an industrial policy perspective, what is important (for understanding a country's engagement in global value chains) is gross trade, separated into parts and components (not intermediate goods in the conventional sense) and final trade (trade in final assembly). Under global production sharing, a country specialises in a given slice (task) in the production chain, depending on the relative cost advantage and other factors, which determine its attractiveness as a production location. Trade and industry policies have the potential to influence only a country's engagement in a given slice of the value chain. Domestic value addition evolves over time as the country becomes well integrated into the value chain.9

<sup>&</sup>lt;sup>7</sup> See Krugman (2008) and the works cited therein.

<sup>&</sup>lt;sup>8</sup> In fact, this was the reason why Pascal Lamy, the former Director General of WTO, took the lead in setting up the OECD/WTO TiVD database, which has now become the main data source for for the study of value-added trade.

<sup>&</sup>lt;sup>9</sup> Even for analysing bilateral trade imbalances and analysing the spillover effects of exports on the domestic economy, the available valued-added trade data need to be treated with caution 14

#### 3.2 Analytical methods

The empirical analysis of this study comprises three main components: (a) An analytical narrative of Australia's engagement in global production sharing and its impact on domestic manufacturing, (b) An econometric analysis of the determinants (factors driving) trade flows, and (c) A preliminary discussion of the impact of global production sharing on the performance of domestic manufacturing in Australia.

The analytical narrative is based on data tabulations (tables and figures), supplemented by two standard summary measures: the Finger-Kreinin export similarity (trade overlap) index (Finger and Kreinin 1979) and the revealed comparative advantage index (Balassa 1966), both computed at the SITC 3-digit level of commodity disaggregation.

#### 3.2.1 Export similarity

The export similarity index is a useful summary measure of the similarity (differences) of the commodity structure of a given country with another country or total world trade. The index is defined by the formula

$$S(ab,c) = \left\{\sum_{i} Minimum[Xi(ac), Xi(bc)]\right\} 100,$$

where 'a' and 'b' denote two countries (or country groups) exporting to market 'c', Xi(ac) is the *share* of commodity *i* in a's exports to *c*, and Xi(bc) is the *share* of commodity *i* in *b*'s exports to *c*. If the commodity distribution of a's and b's exports are identical (that is, Xi(ac) = Xi(bc)), the index will take on a value of 100. If a's and b's export patterns are totally different the index will take on a value of zero. The index intends to compare only patterns of exports across product categories; it is not influenced by the relative size or scale of total exports.

#### 3.2.2 Revealed comparative advantage (RCA)

The RCA index measures a country's relative export performance in individual categories of a given product compared to that category's overall performance in world trade. It is defined as,

$$\mathsf{RCA} = (X_{ij}/X_{wj})/(X_{it}/X_{wt})$$

where,  $X_{ij}$  denotes country *i*'s exports of commodity *j*,  $X_{wj}$  is world exports of commodity *j*,  $X_{it}$  is country *i*'s total exports, and  $X_{wt}$  is total world exports. RCA is a measure of relative performance by country and industry, defined as a country's share of world exports of a good divided by that country's share of total world exports. When the value of RCA exceeds (is below) unity, country *i* 

because of the well-known limitations of the available I-O data and the underlying restrictive assumptions of the estimation method (Yuskavage 2013).

is said to have a revealed comparative advantage (comparative disadvantage) in commodity *j*.

This measure must be used with some caution because domestic policy measures such as production subsidies, or foreign trade barriers such as voluntary export restraints (VERs) or trade preferences that have nothing to do with comparative advantage, can influence its measured value. This limitation is not very important in its application to Australia. Export production in Australia during the period under study has taken place under virtual free trade conditions. Australian exports have also not significantly benefited, or have been adversely affected by trade policies of importing countries. Perhaps the most notable exception to this is the automobile industry.

#### 3.2.3 Gravity model

Econometric analysis of the determinants of trade flows is undertaken within the standard gravity modelling framework, which has now become the 'workhorse' for modelling bilateral trade flows.<sup>10</sup> We estimate trade equations separately for total manufacturing, parts and components and final assembly by including intercept and slope dummy variables to examine how Australia's performance differ from that of the average global patterns.

After augmenting the basic gravity model by adding a number of explanatory variables, which have been found to improve the explanatory power in previous studies, the empirical model is specified as,

$$\begin{split} &\text{InEXP}_{ijt} = \alpha + \beta_1 \text{InSBV}_{it} + \beta_2 \text{InDBV}_{jt} + \beta_3 \text{DST}_{ijt} + \beta_4 \text{InPGDP}_{it} + \beta_5 \text{InRER}_{ijt} + \\ &\beta_6 \text{InTECH}_{it} + \beta_7 \text{ FTA}_{ij} + \beta_8 \text{INST}_{it} + \beta_9 \text{InLPI}_{ijt} + \beta_{10} \text{ ADJ}_{ij} + \beta_{11} \text{ CML}_{ij} + \beta_{12} \\ &\text{CLK}_{ij} + \beta_{13} \text{EUD}_{ij} + \beta_{14} \text{EAD}_{ij} + \beta_{15} \text{AFC}_{ij} + \beta_{16} \text{GFC}_{ij} + \eta_t + \varepsilon_{ijt} \end{split}$$

where the subscripts i and j refer to the reporting (exporting) and the partner (importing) country, t is time (year) and ln denotes natural logarithms. The explanatory variables are listed and defined below, with the postulated sign of the regression coefficient in brackets.

EXP Bilateral exports

*SBV* Supply-base variable: real manufacturing output (RMF) for parts and components and GDP for final assembly and total exports of country i(+)

*DBV* Demand-base variable: real manufacturing output (RMF) for parts and components and GDP for final assembly and total exports of country j(+)

DST The distance between the economic centres of i and j (-)

<sup>&</sup>lt;sup>10</sup> The gravity model originated in Tinbergen (1962), purely as an attempt to capture empirical regularities in trade patterns. On recent attempts to provide a theoretical justification for its formulation and applications to trade flow modelling, see various contributions in Bergeijk and Brakman (2010). Head and Mayer (2014) provide an extensive survey of the relevant literature.

*PGDP* Real per capita GDP of country i and *j* (+ or -)

*RER* Real bilateral exchange rate between *i* and *j* (+)

*TECH* Technological capabilities of *i* measured by resident patent registrations (+)

*INST* Institutional quality of country i(+)

*FTA* A binary dummy which is one if both *i* and *j* belong to the same regional trade agreements (*RTA*) and 0 otherwise (+)

LPI Quality of trade related logistics of country *i* and *j* (+)

ADJ A binary dummy variable which takes the value one if *i* and *j* share a common land border and zero otherwise (+)

*CML* A dummy variable which takes the value one if *i* and *j* have a common language (a measure of cultural affinity) and zero otherwise (+)

*CLK* Colonial economic link dummy which takes the value one for country pairs with colonial links and zero otherwise (+)

*EUD* A dummy variable for the European Union member countries (which takes the value one for EU member countries and zero for the other countries)

*EAD* A dummy variable for the countries in East Asia (which takes the value one for the East Asian countries and zero for the other countries)

*AFC* A dummy (1 for 1997 and 1998 and zero otherwise) to capture trade disruption caused by the Asian financial crisis (-)

*GFC* A dummy (1 for 2008 and 2009 and zero otherwise) to capture trade disruption caused by the global financial crisis (-)

- α A constant term
- $\eta_t$  A set of time dummy variables to capture year-specific 'fixed' effects

 $\epsilon \qquad$  A stochastic error term, representing the omitted influences on bilateral trade

#### 3.2.3.1 Description of variables

The three variables, *SBV*, *DBV* and *DST* are the key gravity model variables. In the standard formulation of the model the real GDP of the reporting and partner countries is used to represent SBV and DBV. The GDP of the reporting (exporting) country is used to represent its supply capacity, whereas that of the destination nation represents is capacity to absorb (demand). The larger countries have more variety to offer and absorb in international trade than smaller countries (Tinbergen 1962). The use of this variable in our trade equation is also consistent with the theory of global production sharing, which predicts that the optimal degree of fragmentation depends on the size of the market (Jones and Kierzkowski 2001, Grossman and Helpman, 2005). However, for modelling trade in parts and components, which are mostly inputs in the production process, the use of GDP to represent supply and demand is less appropriate (Baldwin and Taglioni 2011). For this reason, we use the real manufacturing output of the reporting and partner countries as the proxies of SBV and DBV in the part and component equation.

The geographic distance (*DST*) is a proxy measure of transport (shipping) costs and other costs associated with time lags in transportation such as spoilage. Technological advances during the post-war era have contributed to the 'death of distance' when it comes to international communication costs (Cairncross 2001). However, there is evidence that geographical 'distance' is still a key factor in determining international transport costs, in particular shipping costs (Hummels 2007, Evans and Harrigan 2005). Transport cost could be a much more important influence on GPN trade than on the conventional horizontal trade, because of multiple border-crossings involved, meeting delivery requirements for just-in-time production, and the requirements for movement of managerial and technical manpower within global production networks.

Relative per capita GDP is considered a good surrogate variable for intercountry differences in the capital-labour ratio (Helpman 1987). There are also reasons to believe that relative GDP per capita has a positive effect on GPN trade because as countries grow richer, the scale and composition of industrial output could become more conducive to production sharing. In addition, more developed countries have better ports and communication systems that facilitate production sharing by reducing the cost of maintaining 'services links' involved in vertical liberalisation (Golub *et al.* 2007).

Real exchange rate *(RER)*, measured as domestic currency price of trading partner currency adjusted for relative prices of the two countries, is included to capture the impact of international competitiveness of tradable goods production on export performance. In the standard trade flow model, this variable is expected to have a positive impact on bilateral trade flows. However, we hypothesize this impact to be much weaker (or even zero for) GPN trade for the following reasons (Jones and Kierzkowski 2001; Jones 2000, Arndt and Huemer 2007, Burstein et al 2008, Athukorala and Khan 2015).

First, production units of the value chain located in different countries normally specialise in specific tasks. Therefore, the substitutability of parts and components sourced from various sources is rather limited. Second, setting up of overseas production bases and establishing the services links entail high fixed costs. Once such fixed costs are incurred, relative price/cost changes become less important in business decision making. Third, when a firm in a given country is engaged in a particular slice of a production process, its export profitability does not exclusively depend on external demand and the domestic cost of production. It also depends on supply conditions in other countries supplying parts and components and the bilateral exchange rates between them, depending on the magnitude of the share of import content in exported goods. Changes in exchange rates have offsetting effects on imports and exports and thus the net effect of exchange rate changes on exports within production networks would tend to be weaker than in the standard case of producing the entire product in the given country.

Technological capabilities (*TECH*) is a key determinant of a country's ability to move from low-value assembly activities to high-value upstream and downstreet activities within global production chains. This is particularly important for countries whose success in global production sharing does not depend on labour cost advantage. We measure TECH by the number of patent registrations by the residents of a given country (Majeed 2015).

The free trade agreement dummy variable (FTA) is included to capture the impact of tariff concessions offered under these agreements. In theory, GPN trade is considered to be relatively more sensitive to tariff changes (under an FTA or otherwise) compared to the conventional horizontal trade because normally a tariff is incurred each time a good in process crosses a border (Yi 2003). However, in reality, the trade effect of any FTA would depend very much on the nature of the rules of origin (ROOs) built into it and resultant increase in transaction costs involved in FTA implementation (Athukorala and Kohpaiboon 2013, Krishna 2006). The conventional value-added criterion is not virtually applicable to GPN trade because the products involved have a low domestic content by their very nature. The only viable option is to use the so-called 'change-in-tariff-lines-based' ROOs. But the application of such ROOs leads to administrative complications because in some cases final goods and the related components, belong to the same tariff codes. Moreover, the process of global production sharing is characterised by the continuous emergence of new products. This naturally opens up room for unnecessary administrative delays and the tweaking of rules as a means of disguised protection.

The remaining variables represent various aspects of the cost of "service links" involved in connecting production blocks/tasks within global production networks. The institutional quality index (INST) captures various aspects of governance that directly affect property rights, political instability, policy continuity and other factors which have a bearing on the ability to carry out business transaction. The logistic performance index (LPI) measures the quality of trade-related logistic provisions. Adjacency (ADJ) and common business language (CML), and colonial links (CLK) can facilitate trade by reducing transaction cost and through better understanding of each other's culture and legal systems. The European Union dummy (EUD) is expected to capture the possible implications of economic integration among these countries for GNP trade. The East Asia dummy (EAD) is included to test whether the importance of the region as a center of regional production network's still holds after controlling for the other relevant variables. Finally, AFC and GFC dummy variables are included to control for the trade disruptions during the East Asian financial crisis and the recent global financial crisis.

#### 3.2.3.2 Data sources

The equation is estimated using annual data compiled from the exporter records in the UN trade data system (*Comtrade* database) during the period 1996-2013. Our data set covers export trade of 44 countries each of which accounted for 0.01 per cent or more of total world manufacturing exports in 2005. These countries account for over 98 per cent of total world manufacturing exports. The trade data in nominal US\$ terms are converted into real terms using US import price indices extracted from the US Bureau of

Labour Statistics database. The explanatory variables are listed with details on variable construction and data sources in Table 1.

#### 3.2.3.3 Estimation method

We estimate the export equation separately for total manufacturing, parts and components and final assembly by including intercept and slope dummy variables to examine how Australia's performance differs from that of the other countries. This approach is equivalent to estimating separate regressions for Australia, but it has the added advantage of providing a direct test of the statistical significance of the differences between the estimated coefficients.

#### Table 3.1: Variable definitions and data sources

Label	Definition	Data source/variable construction		
EXP	Bilateral exports in US\$ measured at constant (2000) price, for 44 countries: Argentina, Australia, Belgium, Bangladesh, Brazil, Canada, Switzerland, China, Costa Rica, Czech Republic, Germany, Denmark, Spain,	Exports (at CIF price, US\$): compiled from UN COMTRADE database.		
	Finland, France, United Kingdom, Hong Kong, China HKG, Hungary, Indonesia, India, Ireland, Israel, Italy, Japan, Rep. of Korea, Sri Lanka, Mexico, Malaysia, Netherlands, Norway, Pakistan, Philippines, Poland, Portugal, Russian Federation, Singapore, Slovak Republic, Slovenia, South Africa, Sweden, Thailand, Turkey, United States, USA and Vietnam.	Exports values are deflated by US import price indices extracted from the US Bureau of Labour Statistics data base (http://www.bls.gov/ppi/home. htm)		
GDP, RMF, PGDP	GDP, manufacturing output, and per capita GDP (at constant 2000 price).	World Development Indicator database, The World Bank.		
DST	Weighted distance measure from the French Institute for Research on the International Economy (CEPII), which measures the bilateral great- circle distance between major cities of each country.	French Institute for Research on the International Economy (CEPII) database.		
RER	Real exchange rate: $RER_{i} = NER_{i} * \frac{P_{j}^{D}}{m}$	Constructed using data from World Bank, World development Indicators database. The mean-		
	where, NER is the nominal bilateral exchange rate index (value of country j's currency in terms of country i's currency), $P^W$ is price level of country j measured by the producer price index and $P^D$ is the domestic price index of country i measured by the GDP deflator. An increase (decrease) in RER <sub>ii</sub> indicates improvement (deterioration) in country's international competitiveness relative to country j.	adjusted RER is used in the model. This variable specification assumes that countries are in exchange rate equilibrium at the mean.		
TECH	Technological capability proxied by patent applications by the residents of a given country.	World Development Indicator, World Bank		
		http://data.worldbank.org/data- catalog/world-development- indicators		
FTA	A binary dummy variable which is unity if both country i and country j are signatories to a given regional trading agreement.	CEPII database		
INS	Institutional (governance) quality (by political stability and absence of violence) measured on a scale of -2.5 (worst performance) to 2.5 (best	World Governance Indicators database, World Bank		
	performance).	http://data.worldbank.org/data- catalog/worldwide-governance- indicators		
LPI	World Bank logistic performance index.	LPI database, World Bank		
	Logistic quality of a country assessed on a scale of 1 (worst performance) to 5 (best performance), based on six indicators: (1) efficiency of the clearance process by customs and other border agencies; (2) quality of transport and information technology infrastructure; (3) ease and affordability of arranging international shipments; (4) competence of the local logistics industry; (5) ability to track and trace international shipments; (6) domestic logistic costs; (7) timeliness of shipment in reaching destination (Arvis et al., 2007).	http://lpi.worldbank.org/		
ADJ	A binary dummy variable which is unity if country i and country j share a common land border and 0 otherwise.	CEPII database		
CML	A dummy variable which is unity if country i and country j have a common language and zero otherwise.	CEPII database		
CLK	A dummy variable which is unity for country pairs with colonial links and zero otherwise.	CEPII database		

Of the three standard panel data estimation methods (pooled OLS, randomeffects, and fixed-effects estimators), the fixed effect estimator is not appropriate for estimating the model because it contains a number of timeinvariant explanatory variables, which are central to our analysis. In experimental runs, we used both the pooled OLS estimator and the randomeffects estimator (REE). The Breusch-Pagan Lagrange Multiplier test favoured the use of REE over the OLS counterpart. However, the REE estimator can yield biased and inconsistent coefficient estimates if one or more explanatory variables are endogenous (that is, if they are jointly determined together with the dependent variable). In our case, there are reasons to suspect that FTA and reporting-country GDP are potentially endogenous for a number of reasons (Brun et al 2005; Baier and Bergstrand 2007).

The endogeneity problem is particularly important in estimating the impact of FTA on bilateral trade flows because the trade agreements are normally signed between the countries that already have achieved certain level of bilateral trade. Unobserved characteristics of some country pairs that may facilitate FTAs such as political links and security concerns can also result in the correlation of FTA dummies with the error term. There can also be reverse causation running from trade to GDP, even though the potential endogeneity problem may not be as important as in the case of the FTA variable in the context of a cross-country gravity model. Given these concerns, we reestimated the model using the instrumental variable estimator proposed by Hausman and Tayler (1981) (henceforth HTE estimator). The HTE redresses the endogeneity problem in cross-section gravity models by using instruments derived exclusively from within the model to capture various dimensions of the data. Its superiority over REE in generating consistent coefficient estimates of the gravity model has been demonstrated by a number of recent studies.<sup>11</sup>

<sup>&</sup>lt;sup>11</sup> See Egger (2005) and Serlenga and Shin (2007), and the works cited therein.

# 4. Global Production Sharing and Trade Patterns: The Global Context

#### 4.1 Initial conditions

By the late 1960s there was ample evidence that global production sharing was bound to become an increasingly important facet of the evolution of global production and trade patterns (van Dam 1971 and 1972, Grunwald and Flamm 1985, Helliner 1973). The early evidence came from case studies of overseas operations of multinational enterprises and analysis of import flows to developed countries (mostly to the US) under tax concessions given for overseas assembly and component manufacturing. The national trade data reported by countries under the first version of the Standard International Trade (SITC) system at the time did not provide for delineating trade related with global production sharing from the reported trade data.

Trade data based on the first round of revisions to (SITC Rev 2) introduced in the late 1980s enabled for the first time separating component trade from the data reported under the machinery and transport equipment section (Section 7) of SITC. Yeats (2001) undertook the first quantification of component in machinery and transport equipment trade using the new data, focusing on the world trade of OECD countries. According to his analysis components accounted for 30 per cent of total trade in machinery and transport equipment<sup>12</sup> of these countries in 1996, compared to around 15 per cent in the mid-1980s. Subsequently Ng and Yeats (2003) extended the country coverage of the analysis to Asian countries. They found that component exports from these counties recorded a five-fold increase over the period 1984–1996, compared to an approximately three-fold increase in total merchandise exports.

A number of studies have used the input-output technique to measure the degree of dependence of manufacturing production and trade of selected countries on global production sharing (Hummels et al. 2001, Johnson and Noguera 2012, Dean et al 2011, Koopman et al. 2014). Hansen *et al.* (2001 and 2005) have measured the extent of GPN trade in trade flows between US multinational enterprises and their foreign affiliates. All these studies, regardless of the yardstick used, indicate the growing importance of production sharing in world trade. In addition to these direct estimates, there is a large number of case studies and media commentaries on the nature and growing importance of production sharing in world trade.

<sup>&</sup>lt;sup>12</sup> The products belonging to Section 7 roughly account for more than 40 per cent of total manufacturing.

#### 4.2 Recent trends

Figure 4.1 depicts the value of world manufacturing exports disaggregated into components, final assembly and GPN exports (parts & components + assembly) over the period 1988-2013. World GPN exports recorded a six-fold increase, from US\$ 858bn to US\$5,465bn between 1988/89 and 2012/13.<sup>13</sup>



A close look at the time patterns over the period, however, shows a slowing down of GPN trade from about 2005/06 compared to the first half of the decade. For instance, the share of GPN exports increased from 49.9 per cent in 1988/89 to 53.6 per cent in 2005/06 and declined to 47.9 per cent in 2012/13. Whether this slowdown reflect a structural, rather than a cyclical phenomenon has become the subject of debate as part of the growing concerns about global trade slowdown relative to growth of world GDP in recent years.<sup>14</sup> Various possible structural factors suggested in the debate include saturation of opportunities for global production sharing; a move away from highly-fragmented, globally-spanning production networks towards a greater reliance on regional production networks; adaption of new technologies such as 3D printing ('adaptive manufacturing'); and a decline in imports of parts and

<sup>&</sup>lt;sup>13</sup> In order to minimise the effect of possible random shocks and measurement errors, two-year averages are used in intertemporal comparison throughout this report.

<sup>&</sup>lt;sup>14</sup> There is a general consensus that GPN was a factor in the rapid growth of global trade relative to production in the 1990s and the first half of first decade in the new millennium (Krugman 1995, Bems et al. 2013). The more international production is fragmented across countries, the greater the associated gross trade flows relative to GDP, which is a value added concept.

components by China as the domestic supply capabilities developed in that country (Hoekman 2015, Constantinescu et al. 2014).

Our hypothesis is that data in current US\$ terms understate the relative importance of GPN trade in world trade. Global production sharing essentially means restructuring production processes across countries mainly in order to reap relative cost advantages (tasks are located where they can be performed more cheaply). The global spread of the production process of a given product also means that increasing returns can take place throughout the industry (rather than at the individual firm level).<sup>15</sup> If the production is fully integrated (that is, the entire production process takes place in one location), achieving scale economies is limited by volume at the end product level. However, with global production sharing it is possible to achieve a level of production beyond the absorption capacity of the domestic market. This will enhance the gains from scale. Consequently, we could expect products traded within global production networks to experience slower price increases relative to other traded products which are produced from beginning to end within given national boundaries.

To test this hypothesis, we calculated the share of GPN products in total world manufacturing exports using constant-price (real) export values. For this purpose we constructed price indices for total manufacturing and GPN products by applying world trade weights to four-digit import price indices (based on the Harmonise System) available from the US Bureau of Labour Statistics. The price indices and the real export value data are reported in Tables A4 and A5. The GPN shares in manufacturing trade nominal and real export data are reported in Figure 4.2.

<sup>&</sup>lt;sup>15</sup> Allyn Young (1928) was the first to draw attention to this possibility in a seminal contribution to the debate in the 1920s and 1930s concerning the concept of a downward sloping supply curve facing firms.



Figure 4.2: Share of GPN products exports, in nominal and real (2005 prices) terms (per cent)

The price of GPN products shows a clear declining trend over the past oneand-a half decades (Table A5). As a result, the GPN share calculated in world manufacturing trade differs notably from that of the share computed using nominal value (Figure 2). The nominal value series shows a declining trend from 2000, with the rate of decline increasing sharply from about 2005. By contrast the real export share does not indicate such a long-term decline, after allowing for the notable contraction in the aftermaths of the global financial crisis and the subsequent slow recovery. In real terms, GPN trade accounted for over 54.2 per cent of world manufacturing trade in 2012/13, up from 42.4 per cent in 1988/89. Thus, a slowdown in GPN trade revealed by data in current US\$ terms masks relative price adjustment associated with rapid growth in real terms of cross border trade within production networks.

#### 4.3 Geographic profile

Over the past three decades there has been a palpable structural shift in world manufacturing trade from the OECD countries (developed countries) <sup>16</sup> to developing countries. The share of developed countries in total world manufacturing exports declined from 80.5 per cent in 1988/89 to 48.5 per cent in 2012/13 (Figure 4.3). The decline was much sharper in GPN exports, from 83.8 per cent to 47.5 per cent, and components within GPN exports, from 84.2 per cent to 45.5 per cent. It is clear that the structural shift in manufacturing

<sup>&</sup>lt;sup>16</sup> Unless otherwise stated, we use the term 'OECD countries' to refer to the 25 countries which became members of the OECD before 1990. See Appendix Table A2 for the country list. This country group closely match with 'developed countries' in the standard UN Country Classification.



trade from developed to developing countries has been facilitated by the ongoing process of global production sharing.



#### Source: Appendix Table A3

Among the non-OECD (developing) countries, the biggest gainers of export market shares are the countries in East Asia (Northeast and Southeast Asia), in particular those in developing East Asia (East Asian countries excluding Japan) (Table 4.1). Export market share gains of these countries are closely associated with their prominent role within global production networks. In 2012/13, East Asia accounted for 40.7 per cent of world manufacturing exports and 48.3 per cent of total world GPN exports. China alone accounted for 17.8 per cent of world GPN exports. The data clearly show that global production sharing in developing countries is predominantly an East Asian phenomenon. Countries in Africa, Latin America and other parts of the developing world still account for around 5 per cent of total GPN exports. The country profiles on the import side are broadly similar to those on the export side, reflecting the fact that engagement in global production sharing naturally involves both importing and exporting.

Table 4.1: Shares of world	d manufacturing	exports and imports. 2012/	13 <sup>1</sup> (per cent)
	J		

Country		Exp	orts			Imp	Final Assembly     GPN Products       28.8     24.0       3.7     3.7       14.2     10.6       2.5     2.4			
	Total Mfg	Parts & Components	Final Assembly	GPN products	Total Mfg	Parts & Components	Final Assembly	GPN Products		
Northeast Asia	34.0	36.3	44.8	40.3	19.6	19.8	28.8	24.0		
Japan	5.6	6.7	6.9	6.8	3.6	3.6	3.7	3.7		
China, PRC	16.9	15.9	19.8	17.8	8.3	7.3	14.2	10.6		
Taiwan	2.5	3.9	3.4	3.7	2.3	2.3	2.5	2.4		
Korea, Rep.	4.0	4.1	6.2	5.1	1.3	1.2	1.5	1.4		
Southeast Asia	6.7	8.3	7.7	8.0	6.8	8.6	6.9	7.8		
South Asia	1.8	0.8	0.4	0.6	1.9	1.7	1.2	1.4		
India	1.6	0.8	0.4	0.6	1.6	1.5	0.9	1.2		
Western Asia	2.0	0.9	1.0	1.0	3.6	2.8	3.4	3.1		
Oceania	0.3	0.3	0.2	0.3	1.8	1.3	2.4	1.8		
Australia	0.3	0.3	0.2	0.2	1.5	1.1	2.0	1.5		
New Zealand	0.1	0.0	0.0	0.0	0.2	0.2	0.3	0.2		
North America	8.8	9.3	7.6	8.5	17.0	18.1	18.2	18.1		
USA	7.1	7.7	5.6	6.7	14.0	14.8	15.7	15.2		
Canada	1.8	1.6	2.0	1.8	3.0	3.3	2.5	2.9		
EU	35.8	34.6	27.8	31.4	32.3	32.0	24.2	28.4		
EU15	31.4	28.8	24.4	26.7	29.1	27.7	22.9	25.4		
Western Europe, other	1.9	1.3	1.4	1.4	2.1	1.4	1.9	1.6		
CIS <sup>2</sup>	1.5	0.8	0.7	0.7	3.7	3.0	3.0	3.0		
Africa	0.9	0.5	0.6	0.6	2.6	2.0	2.6	2.3		
Latin America <sup>3</sup>	3.7	4.3	4.6	4.4	6.9	7.7	5.4	6.6		
Other countries	2.6	2.6	3.2	2.8	1.7	1.6	2.0	1.9		
World	100	100	100	100	100	100	100	100		
Memorandum items										
OECD	59.9	60.4	54.3	57.5	52.4	51.1	47.8	49.6		
OECD-25 <sup>4</sup>	48.1	46.3	40.1	43.3	52.4	51.1	47.8	49.6		

Notes: (1) Data are two-year averages; (2) The Commonwealth of Independent States; (3) Including the Caribbean; (4) Countries which became OECD member before 1990 (See Appendix Table A2)

Source: Compiled from UN Comtrade Database

# 5. Australia in Global Production Sharing

#### 5.1 Trends

Data on manufacturing exports from Australia, disaggregated into components, final assembly and total GPN exports, are plotted in Figure 4. Between 1988/89 and 2000/01, total manufacturing exports recorded a fivefold increase, from A\$5.6bn to 28.3bn, and the share of manufacturing in total merchandise trade increased from 13.4 per cent to 23.1 per cent. During the ensuing years exports slowed with a greater degree of volatility. By 2013/14, the share of manufacturing in total merchandise export had declined to 12.4 per cent. However, interestingly exports of GPN products remained less volatile during this period and have contributed disproportionately to export expansion in recent years. The share of these products in total manufacturing exports increased from 43.8 per cent to 47.5 per cent between 2009/10 and 2013/14. Within the GPN category, parts and components exports have increased at a faster rate compared to final assembly. In summary, GPN exports, in particular exports of parts and components, seem to have been remarkably resilient to the Dutch Disease effect, the possible adverse impact of exchange rate appreciation, during the commodity boom. This pattern is consistent with the postulate (discussed in Section 3) that trade within production networks, in particular parts and component trade, has some structural peculiarities that could weaken the impact of real exchange rate (relative price) changes.

Australia is a small player in world manufacturing trade (Table 5.1). Its share in total world manufacturing remained around 0.28 per cent during the period under study without showing any trend. However, Australia's share in world exports of GPN products increased from 0.22 per cent to 0.25 per cent between 1990/01 and 2012/13, underpinned by an increase in the share of parts and components, from 0.24 per cent to 0.28 per cent. Australia's share of total manufacturing exports of OECD countries increased from 0.35 per cent to 0.54 per cent between these years, with the share of GPN exports increasing from 0.27 per cent to 0.36 per cent.

	Total manufacturing	Parts & components	Final assembly	GPN products	Other manufacturing			
OECD share in world expo	orts (per cent)							
1990/01	78.3	81.3	81.7	81.5	74.9			
2000/01	66.6	64.7	72.5	67.6	65.2			
2005/06	59.8	56.0	63.3	58.9	61.0			
2012/13	48.2	45.6	48.8	47.0	49.4			
Australia's share in world	exports (per cent)							
1990/01	0.27	0.24	0.19	0.22	0.33			
2000/01	0.33	0.27	0.38	0.31	0.35			
2005/06	0.28	0.23	0.31	0.25	0.32			
2012/13	0.26	0.28	0.23	0.25	0.28			
Australia's share in OECD	exports (per cent)							
1990/01	0.35	0.30	0.24	0.27	0.44			
2000/01	0.49	0.31	0.26	0.29	0.48			
2005/06	0.47	0.33	0.29	0.31	0.52			
2012/13	0.54	0.38	0.33	0.36	0.58			
OECD export composition	(per cent)							
1990/01	100	30.3	23.4	53.7	46.3			
2000/01	100	34.5	23.1	57.6	42.4			
2005/06	100	31.1	22.6	53.7	46.3			
2012/13	100	25.4	21.8	47.3	52.7			
Australia's export composition (per cent)								
1990/01	100	26.0	15.9	41.9	58.1			
2000/01	100	29.3	24.8	54.1	45.9			
2005/06	100	25.5	23.2	48.8	51.2			
2012/13	100	27.2	18.7	45.9	54.1			

#### Table 5.1: Summary data of manufacturing exports: Australia—OECD Comparison

Notes: Countries which became OECD member before 1990

Source: Compiled from UN Comtrade database in current US\$

In terms of the relative importance of GPN products, Australia's export composition is similar to that of OECD countries. One notable difference, which is relevant for the subsequent analysis of this report, relates to parts and components exports. The share of parts and components in Australian manufacturing exports has increased continuously, from 25.5 per cent in 2005/06 to 27.2 per cent in 2012/13, whereas in OECD countries this share has declined from 31.1 per cent to 25.4 per cent (Table 4.1, Figure 5.2).






2000–2013 (per cent)



Source: Based on data compiled from UN Comtrade database

The data on parts and components and final assembly in Australian manufacturing exports and imports are compared in Figures 5.3 and 5.4, respectively. The share of parts and components in total manufacturing exports varied in the rage of 23–30 per cent during 1988–2014, showing a clear upward trend from about 2006. By contrast the share of final assembly declined continuously from about the early 2000s to 2010, and then continued to remain well below that of parts and components, notwithstanding a mild upward trade in the past three years. On the import side we see a reverse pattern: parts and components share declining continuously over the past decade or so with the share of assemble products remaining much higher (around 30 per cent). These contrasting patterns are consistent with the general factor proportion

characteristics of parts and components and the Australian resource endowment. Parts and components production is generally more capital and skill intensive compared to most final assembly undertaken with global production networks.



Source: Based on data compiled from UN Comtrade database



Figure 5.4: Parts and components and final assembly imports (per cent)

### 5.2 Commodity composition

Data on the commodity composition of parts and components exports from Australia and the share of these products in total world exports are summarised in Tables 5.4 and 5, respectively. Australia's shares in world exports of these products are given in Table 5.4 and 5.5.

Among the parts and component exports, the product class of aircraft parts (SITC 7929) stands out for its impressive growth performance. Its share in Australia's total parts and components exports increased from 8.2 per cent in 2000/01 to 13.4 per cent in 2012/13 (Table 5.2). In 2012/13, Australia accounted for 1.7 per cent of total world exports of aircraft components, compared to 0.6 per cent in 2000/01 (Table 5.3).

The emergence of aircrafts components as a new dynamic item in Australia's export composition has been underpinned by the consolidation of the presence of Boeing and Airbus, the world's two major aircraft producers in the world. Australia is well placed to benefit from the rapid global expansion of aircraft production networks given the skill base and managerial talent developed over the past century, and a highly-successful public-private collaborative effort to gain a global niche in the production of carbon fibre composite materials over the past two decades (Box 3.1).

The other products that have indicated notable increases in exports shares are parts of earth moving machines (SITC 7239), transmission apparatus for radiotelephony (SITC 7643), parts of machines for mineral processing machines (SITC 7283) and parts of machines for mineral processing (SITC 7429). Motor vehicle parts other than bodies (SITC 7843) accounts for the second largest share in exports after aircraft parts, but this share has declined from 10.8 per cent to 8.8 per cent between 2000/01 and 2012/13.

The shares of the other items in total parts and component exports do not show a clear time pattern, but overall there has been an increase in the degree of concentration of export in more dynamic products. For instance the aggregate share of the SITC 4-digt items not listed in Table 5.2 declined from 21.9 per cent in 1990/91 to 7.3 per cent in 2012/13. Also, in a comparison across all products, we can see a shift away from the conventional (mostly domestic resource based) parts and components (which are classified under SITC Section 6) to more dynamic items belonging to machinery and transport equipment (SITC 7) and miscellaneous manufacturing (SITC 8). A notable exception is motor vehicle parts other than bodies.

SITC Code	Product description	1990/91	2000/01	2012/13
7929	Aircraft parts (excluding tyres and electrical parts)	8.2	7.5	13.4
7843	Motor vehicle parts other than bodies	10.2	10.8	8.8
7239	Parts of earth moving machines	3.1	2.8	8.6
7599	Parts/accessories of data processing/storage machines	9.2	13.5	7.1
7643	Transmission apparatus for radio-telephony	1.4	2.0	3.7
7283	Parts of machines for mineral processing	0.9	1.3	2.9
7132	Engines for propelling vehicles	9.8	4.6	2.4
7429	Parts of pumps and liquid elevators	1.0	0.8	2.2
7725	Electrical apparatus for switching/protecting electrical circuits	2.2	3.8	2.0
6956	Plates, sticks and tips for tools	0.7	0.9	1.8
7285	Parts of specialised industrial machinery	0.9	2.0	1.8
7726	Boards and panels for electrical control	0.5	0.5	1.7
7139	Parts for internal combustion engines	3.6	1.9	1.6
7724	Reciprocating positive displacement pumps	1.2	1.0	1.6
7478	Taps/cocks/valves	0.5	0.5	1.6
7919	Railway or tramway track fixtures and fittings	0.4	0.3	1.3
7523	Digital processing units	2.1	1.3	1.2
7783	Accessories of motor vehicles except bodies	0.8	0.6	1.2
7449	Parts for lifting, handling and loading machinery	0.9	0.8	1.2
7529	Data-processing equipment	0.8	1.2	1.0
7649	Parts of sound recording equipment	1.0	2.7	0.9
6299	Hard rubber parts	0.5	0.3	0.9
7763	Diodes, transistors and similar semiconductor devices	0.3	0.6	0.9
7788	Parts of electrical machinery	1.0	1.3	0.9
7731	Insulated wire, cable electric conductors	3.1	2.2	0.9
7131	Internal combustion piston engines for aircraft and parts	0.6	0.7	0.9
7484	Gears and gearing and other speed changer	0.6	0.1	0.9
7189	Engines and motors for electric rotary converters	0.2	0.1	0.8
6648	Vehicle rear-view mirror	1.0	0.9	0.8
7728	Parts suitable for electrical apparatus	0.7	0.6	0.8
7489	Parts of gear/flywheel/clutches	0.4	0.3	0.7
7526	Input or output units for automatic data-processing machines	0.7	0.6	0.7

 Table 5.2: Commodity composition of parts and components exports from Australia<sup>1</sup> (per cent)

SITC Code	Product description	1990/91	2000/01	2012/13
7439	Parts of centrifuges and purifying machines	0.3	0.3	0.7
8741	Parts of surveying and navigating instruments	0.3	0.3	0.7
7479	Parts of valves, taps and cocks	0.5	0.4	0.7
7527	Data storage units	0.1	0.3	0.7
8912	Parts of military equipment	0.2	0.0	0.7
8749	Parts and accessories for other machines and appliance	1.6	1.3	0.7
7149	Parts of the engines and motors of reaction engines	1.5	0.2	0.6
7499	Machinery parts, not containing electrical connectors	0.5	0.7	0.6
7415	Air-conditioner parts	0.8	1.0	0.6
7853	Parts and accessories of cycles	0.0	0.3	0.6
7148	Gas turbines	0.3	0.3	0.5
7219	Parts of agricultural machinery	0.8	0.5	0.5
7787	Parts of electrical machines and apparatus	0.2	0.6	0.5
	Other <sup>2</sup>	24.5	25.6	15.9
	Total	100	100	100
	US\$ million	1,638	4,325	8,032

Notes: (1) Products are listed by ascending order based on export shares for 2012/13. Figures are two-year averages; (2) Fourdigit items, each of which accounts for less than 0.5 per cent of the total value

Source: Compiled from the UN Comtrade database using the procedure discussed in Section 3.1

Sľ Co	TC Product description	1990/91	2000/01	2012/13
74	41 Parts for works trucks for short transport of goods	0.4	3.0	3.2
72	83 Parts of earth moving machines for mineral processing	1.1	2.7	3.0
71	31 Internal combustion piston engines for aircraft and parts	1.1	2.2	2.5
66	48 Vehicle rear-view mirror	4.5	4.2	2.1
88	12 Parts of cinematographic cameras and projectors	1.0	3.7	2.0
79	29 Aircraft parts (excluding tyres, engines and electrical parts)	0.6	0.9	1.7
87	49 Parts and accessories for other machinery	4.0	3.6	1.5
89	12 Parts of military equipment	0.1	0.1	1.5
88	13 Parts of photographic and cinematographic equipment	0.2	0.3	1.4
81	38 Portable lamp parts	0.9	0.5	1.4
72	48 Parts for leather machines	0.1	0.1	1.4
72	39 Parts of earth moving machines	0.6	0.8	1.4
77	24 Electrical apparatus for switching or protecting electrical circuits	0.8	1.3	1.3
74	29 Parts of pumps and liquid elevators	0.6	0.7	1.1
73	74 Parts of machinery/apparatus for soldering, brazing or welding	1.8	2.6	1.1
71	89 Engines and motors for electric rotary converters	0.4	0.5	1.0
87	41 Parts of surveying and navigating instruments	0.4	0.8	1.0
79	19 Railway or tramway track fixtures and fittings	0.4	0.3	0.9
72	72 Parts of food-processing machinery	1.3	1.0	0.7
72	69 Parts of type-founding or typesetting machines	0.3	0.9	0.7
89	28 Labels paper and paperboard	0.7	1.1	0.7
75	99 Parts/accessories of data processing/storage machines	0.3	0.4	0.6
74	89 Parts of gear/flywheel/clutches	0.5	0.5	0.6
74	68 Ball- or roller bearings	0.4	0.3	0.6
74	53 Weighing machinery parts	0.3	0.4	0.5
74	99 Machinery parts, not containing electrical connectors	0.3	0.6	0.5
87	11 Parts of binoculars, monocular, other optical telescopes	0.1	0.4	0.5
74	52 Parts of dishwashing machines (other than household-type)	0.1	0.4	0.5
74	49 Parts for lifting, handling and loading machinery	0.3	0.5	0.5
77	58 Parts of electrothermic appliances	0.1	0.2	0.5

### Table 5.3: Australia's share in world exports of parts and components<sup>1</sup> (per cent)

Notes: Products are listed by ascending order based on export shares for 2012/13. Figures are two-year averages

Source: Compiled from the UN Comtrade database using the procedure discussed in Section 3.1  $\,$ 

#### Box 5.1: Australian Aircraft Industry

The recent expansion of Australian aircraft industry through integrating into the value chain of the world aircraft industry is based on manufacturing talents and technological capabilities developed over a hundred years. It has also been aided by a successful collaborative initiative by the Australian government and private sector partners in developing domestic technology for the production of carbon fibre composite materials (composites, for short).

The history of aircraft production in Australia dates back to 1914–18 when the Australian government experimented with local production of military aircrafts (Butlin 1955). Based on the lessons learned from this initial ineffectual effort, during the inter-war years the government retreated to a policy of encouragement of private enterprise. A number of aircraft companies, mainly catering for the needs of the Royal Australian Air Force (RAAF), emerged during the next two decades. Of these, the only company which managed to survive the Great Depression was De Havilland Aircraft Proprietary Ltd (established in 1929).

In October 1936, the Commonwealth Aircraft Corporation (CAC), a syndicate of private companies, was established for manufacturing of aircrafts and engines. CAC joined hands with the RAAF to produce small military aircrafts by modifying models from the US and the UK to permit the use of material readily obtainable in Australia. The aim was to achieve self-sufficiency in the production of aircrafts and to upgrade the RAAF's strike capability. The US and UK governments supported the Australian initiatives because the location of light aircraft construction in Australia, with service and repair facilities, helped achieve a degree of regional specialisation and conserve shipping space during the war years. A total of 3,486 aircrafts were produced during 1939–1945. In the peak year of 1944, the industry employed over 44,000 workers. The expansion of aircraft production spawned a large network of subcontractors involved in producing components and providing specialist services (Butlin and Schedvin 1977).

The lofty notion of self-sufficiency for the RAAF came to very little. Even during the war years the RAAF had to rely on American suppliers to meet Australian operational requirements. In the postwar era Australia could not compete in price or quality with the large international civil aircraft manufacturers. However, a number of aircraft manufacturing firms continued to survive by providing repair and ancillary services to RAAF, producing small passenger aircrafts, and (from about the early 1970s) by undertaking component production for large overseas producer. Over the past decade or so, some of these companies have gained a new lease of life benefiting from the expansion of production sharing arrangements in the world aircraft industry.

The recent expansion of the Australian aircraft industry has been significantly abided by a successful public–private collaborative effort to gain a global niche in the production of composites. Composites are important in aerospace and automotive industries because they have similar strength to metals, but lighter weight with consequent reduction in energy consumption, and also have fewer corrosion problems. The recent rapid growth of aircraft parts and component exports from Australia a main success from this investment.

Over the past 20 years, Australia has developed considerable research capability in the design, manufacture and performance of composites primarily through the Corporate Research Centre for Advanced Composite Structures (CRC–ACS). CRC–ACS is funded by industry partners and the Australian government under the Cooperative Research Centre Program. CSIRO, The Australian Future Fibre Research and Innovation Centre and a number of Australian universities including

Deakin and RMIT Universities are active partners of the program (ACTSE 1988, Bremer Company 2015).

The following company case summaries help understand the ongoing changes in the Aircraft industry against the backdrop of the globalisation of Aircraft manufacturing.

### **Boeing Aerostructures Australia**

Boeing Aerostructures Australia (BAA) was set up in 1996 by Boeing USA by acquiring Aerospace Technologies Australia (formerly Commonwealth Aircraft Corporation (CAC), set up in 1936). In 2000 it expanded operations by acquiring Hawker de Havilland (set up in 1929).

BAA is Boeing's largest manufacturing operation outside North America. It is a Tier 1 partner to the Boeing 787 Dreamliner program, the sole supplier of its moveable trailing edges. The Boeing 787 Dreamliner contract of BAA is Australia's largest aerospace contract ever (20 years), valued at \$5 billion. BAA is also the sole source of B737 ailerons, moveable leading edges of B747, and cove lip doors, elevators and rudders of B777. BAA works with a large number of small Australian companies.

### **Airbus Group Australia Pacific**

Australian Aerospace Engineering (AAE), a Brisbane-based company specialising in airframe, tail boom and composite structures, has been a supplier of components to Airbus Helicopters (formerly Eurocopter), the helicopter manufacturing division of Airbus Group, for over two decades. Airbus Helicopters is the largest in the world in terms of turbine helicopter production. It has four major plants in Europe and two subsidiaries and partners around the world.

In 2014 Airbus Helicopters obtained full ownership AAE and renamed it Airbus Group Australia Pacific (ABAP). ABAP now represents Airbus Group, Airbus Helicopters and Airbus Defence and Space in Australia and the Pacific region.

### Mahindra & Mahindra

The Indian car company, Mahindra & Mahindra (M&M) entered the Australian aircraft industry in 2009 by acquiring majority ownership in two Australian companies: Aerostaff Australia and GippsAero (formerly Gippsland Aeronautics), both of which have an operational history dating back to the early 1970s. M&M aims to expand component production capacity of the two companies to meet the growing needs of the civil and defence aircraft production in the world, an attempt to enter the global aerospace supply chain.

Aerostaff Australia is a manufacturer of precision close-tolerance aircraft components and assemblies for large original equipment manufacturers (OEMs) in the global aircraft industry. GippsAero is manufacturer of single engine utility aircrafts. The company started operations in 1970s at Latrobe Valley Airport as an aircraft maintenance and modification business. Airvan 8 produced by GippsAero is one of the most rugged and versatile aircraft in that class. Certified in 38 countries, more than 200 Airvan 8s are in service in Australia, Africa, North America, Europe and many other countries. The Airvan 8 will soon be joined by Airvan 10, a 10-seater turboprop aircraft.

Following the acquisition of the two Australian companies, Mahindra Aerospace has begun developing a 25,000 sq. m. facility in Gengaluru in India to produce airframe parts and assemblies. The facility was inaugurated in 2013 and is now delivering aerospace sheet metal parts and assemblies for global aircraft manufacturers including Airbus.

### Lovitt Technologies Australia

This company was founded in 1954 as George Lovitt manufacturing Pty to produce cutting tools component for the automotive industry. Located in Montmorency (Victoria), today it is a provider of precision machine tools, components, parts and assemblies to aerospace and defence industries. It is a supplier to Boeing Australia, Airbus and many other aircraft producers in the world.

Data on the commodity composition of GPN final assembly exports from Australia and the share of these products in total world exports are summarised in Tables 5.4 and 5.5. Motor vehicles (motor vehicles for the transport of goods (SITC 7821) and passenger motor vehicles (SITC 7812) still account for over a half of the total assembly exports, but their share has declined in recent years. The most notable export share gains are associated with medical equipment and measuring instruments. Between 1990/01 and 2012/13, the shares of mechanotherapy appliances (SITC 8723) exports increased from 0.3 per cent to 7.3 per cent, and that of medical, surgical or veterinary science instruments (SITC 8722) increased from 2.5 per cent to 5.6 per cent. In 2012/13, Australia accounted for 5.5 per cent of the total world exports of mechanotherapy appliances, up from 0.3 per cent in 1990/91. The share of light aircrafts (<2000kg) (SITC 7921–4) accounted for 3.6 per cent of total final assembly exports, compared to 1.2 per cent in 1990/91 (Table 5.4).

SITC code	Product description	1990/91	2000/01	2012/13
7821	Motor vehicles for the transport of goods	25.7	29.2	28.9
7812	Passenger motor vehicles	24.5	28.3	25.3
8723	Mechanotherapy appliances	0.3	0.8	7.3
8722	Medical, surgical or veterinary science instruments	2.5	3.4	5.6
7921–4	Aircrafts (SITC 7921,7922,7923 and 7924)	1.2	1.4	3.6
8744	Instruments and apparatus for physical or chemical analysis	2.7	2.1	3.1
7522	Digital automatic data-processing machines	3.5	0.6	2.1
7788	Electrical machinery and equipment	0.9	1.3	2.0
8742	Drawing, marking-out or mathematical calculating instruments	0.5	0.6	1.6
8741	hydrological, meteorological or geophysical instruments	0.3	0.8	1.6
7931	Yachts and other vessels for pleasure or sports	5.0	1.7	1.4
7638	Sound-recording/reproducing apparatus	0.3	0.4	1.1
7648	Telecommunications equipment	0.6	0.3	0.9
8745	Measuring, controlling and scientific instruments	0.2	0.2	0.9
8746	Automatic regulating or controlling instruments	0.1	0.3	0.8
8842	Drawing, marking-out or mathematical calculating instruments	0.3	0.2	0.8
7932	Ships, boats and other vessels	6.1	4.0	0.8
7758	Electro-thermic appliances	0.9	0.4	0.8
7741	Electro-diagnostic (other than radiological) apparatus	0.5	0.4	0.7
7642	Microphones and stands therefor	0.2	0.3	0.7
8853	Wrist-watches, pocket watches and other watches	0.1	0.6	0.7
7832	Semi-trailer tractors	0.1	0.4	0.6
8743	Lenses, prisms, mirrors and other optical elements	0.2	0.2	0.6
8747	Oscilloscopes, spectrum analysers and other instruments	0.9	1.2	0.6
7822	Special-purpose motor vehicles	0.6	0.3	0.5
	Other <sup>2</sup>	21.9	20.6	7.3
	US\$ million	1,331	5,096	7,193

### Table 5.4: Commodity composition of final assembly exports from Australia<sup>1</sup> (per cent)

Notes: (1) Products are listed by ascending order based on export shares for 2012/13. Figures are two-year averages; (2) Fourdigit items, each of which accounts for less than 0.5 per cent of the total value

Source: Compiled from the UN Comtrade database using the procedure discussed in Section 3.1

SITC code	Product description	1990/91	2000/01	2012/13
8723	Mechanotherapy appliances	0.3	1.4	5.5
7921–4	Aircrafts (SITC 7921,7922,7923 and 7924)	1.1	1.9	3.6
8839	Photographic plates and films	0.2	1.0	1.6
7643	Transmission apparatus for radio-telephony/radio-telegraphy	0.4	0.2	1.4
8741	hydrological, meteorological or geophysical instruments	0.1	0.8	1.0
7931	Yachts and other vessels for pleasure or sports	2.0	1.6	0.9
7919	Rail locomotives	2.3	1.7	0.8
8812	Cinematographic cameras and projectors	0.1	0.7	0.8
8745	Measuring, controlling and scientific instruments	0.1	0.3	0.7
8711	Binoculars, monocular, other optical telescopes	0.1	0.1	0.7
8744	Instruments and apparatus for physical/chemical analysis	0.6	1.0	0.6
8813	Photographic and cinematographic equipment	0.1	0.1	0.6
8722	Medical, surgical or veterinary science instruments	0.4	0.8	0.6
8842	Spectacles and spectacle frames	0.2	0.3	0.5
8831	Photographic plates and film	0.2	3.3	0.5
8811	Photographic (other than cinematographic) cameras	0.0	0.2	0.5
7512	Postage-franking machines	0.1	0.3	0.5

#### Table 5.5: Australia's share in world exports of final assembly<sup>1</sup> (per cent)

Notes: Products are listed by ascending order based on export shares for 2012/13. Figures are two-year averages

Source: Compiled from the UN Comtrade database using the procedure discussed in Section 3.1

Australia's share in world light aircrafts exports increased from 1.1 per cent to 3.6 per cent between 1990/91 and 2012/13 (Table 5.5).

Various categories of measuring, scientific, and medical/surgical equipment have recorded increases in their shares in total GPN final assembly exports from Australia as well as in total world exports. As in the case with parts and components exports, a comparison across all GPN final products shows a shift away from the conventional (mostly domestic resource based) products to more dynamic products within global production networks. There has also been an increase in the degree of concentration of exports in more dynamic products. The share of products not listed in Table 5.3 in total GPN final assembly exports declined from 24.5 per cent in 1990/01 to 15.9 per cent in 2012/13.

### 5.3 Australia–OECD export similarity/difference

How does the commodity composition of GPN exports from Australia compare with that of other OECD countries? The Finger-Kreinin export-similarity index is a useful summary measure for addressing this issue. The index calculated for Australian and OECD exports of total manufacturing, parts and components and final assembly are plotted in Figure 5.5. The index has been well below the level of perfect similarity (100) throughout, showing a notable difference in the commodity composition of Australia compared to the average patterns of OECD countries. The differences tended to narrow in the second half of the 1990s, but has continuously widened since then. The prime driver behind the growing dissimilarities has been the emerging patterns of Australia's parts and components exports.



Figure 5.5: Finger-Kreinin export similarity index: Australia and OECD, 1988–2013 (per cent)

A comparison of the data reported in Tables 5.1 and 5.3 (Australian data), and those in Appendix Tables A-6 and A-7 (OECD data) help to understand the sources of widening divergence of the Australian GPN exports patterns from the OECD patterns. Motor vehicle parts (SITC 7843) is the single most important item on the parts and components export list of OECD countries (Table A6). This item accounted for 15.5 per cent of total parts and components exports from these countries, up from 12.9 per cent in 1990/01. Motor vehicle parts still account for significant share in Australian exports, but this share has declined over time. By contrast, rapid increase in the share of aircraft parts is a unique feature of Australia's engagement in global production networks.

In spite of structural changes in the product mix noted earlier, resource-based manufacturing industries (products belonging to SITC 6) and also heavy

Source: Based on data compiled from the UN Comtrade database

machinery industries (roughly SITC codes 71 to 75) still account for a larger share of Australia's GPN final assembly exports. Medical and surgical equipment accounts for a relatively larger share of GPN final assembly exports from Australia compared to the OECD average patterns. Products in which GPN trade has been heavily concentrated in OECD countries such as telecommunication and sound recording equipment (SITC 76), electrical machinery (SITC 77), professional and scientific equipment (SITC 87), and photographic equipment (SITC 88) do not figure prominently in the Australian export product mix.

What explains the lacklustre export performance of automobile exports from Australia? The human capital base developed over a half-a-century of importsubstitution based industrialisation and incentives provided by the government do not seem to have helped. The industry has also been the largest beneficiary of various industry assistance programs of the Australian Government (Productivity Commission 2014). It is necessary to look into the peculiarities of automobile production in order to understand its unique export performance record.

### 5.4 Revealed comparative advantage

What are the GPN products in which Australia has performed better in world markets compared to its overall export performance? The RCA indices given in Table 5.6 and 5.7 help answering this question. To make the emerging patterns clear, products are classified into three groups: *RCA increasing products* (products with a continuous increase in RCA), *RCA maintaining products* (RCA>1) and *new RCA products* (products with RCA <1 in 1990/91 and/or 2000/01, but RCA>1 in 2012/13). In each group, products are listed in descending order of the measured RCA of 2012/13. Only the products with RCA>1 in 2012/13 ('RCA products') are listed in the tables.

Among parts and component exports, 18 products belong to RCA increasing product category (Table 5.6). Parts of trucks for short distance transport (SITC 7441), parts of mineral processing machines (SITC 7283), aircraft parts (SITC 7929), parts of portable electrical lamps (SITC 8138) and parts of earth moving machines (SITC 7239) top the list in that order. Among the final assembly products (Table 5.7), there are only three items belonging to RCA increasing product category: mechanotherapy appliances (SITC 8732), aircraft (7922) and TV/radio transmitters (SITC 7643).

Interestingly, motor vehicles, which account for the largest share of total final assembly exports from Australia (Table 5.5) are not among the RCA products listed in Table 5.7. This suggests that export performance of automotive industry is predominantly driven by industry assistance provided by the government rather than the industry's comparative advantage in world trade. However, the Australian automotive industry seems to have a competitive edge in some specialised automotive parts such as parts of trucks for short distance transport (SITC 7441) vehicle rear-view mirrors (SITC 6648), parts of engines (SITC 7189), parts of valves, taps and cocks (SITC 7429).

It appears that Australia is maintaining revealed comparative advantage in exporting 18 product categories belonging to parts and components during the

last two decades (Table 5.6). Among these categories, vehicle rear-view mirrors (SITC 6648), movie projector parts (SITC 8812) and parts and accessories for other machines and appliances (SITC 8749) are the most prominent. The presence of a larger number of new products (28) in the new RCA products sub-category is indicative of an important structural change in Australia's engagement in global production sharing. Parts of military equipment (SITC 8912), parts of leather machines (SITC 7248) and photographic and cinema laboratory equipment (SITC 8813) are some examples of this variation in product mix.

With regard to final assembly exports, Australia appeared to maintain a comparative advantage in five major product categories over the last two-anda-half decades (Table 5.7). Among these five assembly products, instruments for physical or chemical analysis (SITC 8744), medical, surgical or veterinary science instruments (SITC 8722) and medical furniture (SITC 8724) are the most consistent and stable final assembly exports. Australia also has gained comparative advantage in a wide range of final assembly exports (new RCA products, Table 5.7).

A unique feature of Australian GPN exports (both parts and components and final assembly) compared to the OECD countries is the heavy concentration of RCA products in traditional industries meeting the requirements of agriculture, mining, construction and transport sectors. Overall, products belonging to electronics and electrical industries do not figure prominently. However, a comparison of changing RCA status of products over time shows some early signs of a structural shift in favour of the products in the latter groups. For instance, the category of new RCA products include parts of data processing machines (SITC 7527), parts of electro-thermic appliances (SITC 7758), electromechanical hand tools (SITC 7788), photographical and cinema laboratory equipment (SITC 8813) and telescope parts (SITC 8711).

SITC Code	Product description	1990/91	2000/01	2012/13
RCA incl	reasing products			
7441	Parts of work trucks for short distance transport	1.5	8.6	11.0
7283	Parts of mineral processing machines	3.8	7.8	10.3
7929	Aircraft parts (excluding tyres and electrical parts)	2.1	2.9	5.8
8138	Parts of the portable electric lamps	3.1	3.5	5.0
7239	Parts of earth moving machines	2.1	2.4	4.7
7724	Electrical apparatus for switching/protecting electrical circuits	2.7	3.7	4.6
7429	Parts of valves, taps and cocks	2.0	2.1	3.9
7189	Parts of engines (other)	1.4	1.5	3.5
8741	Parts of survey instruments	1.3	2.5	3.4
7919	Rail/tram parts	1.5	1.0	2.9
7489	Parts of gear/flywheel/clutches	1.6	1.6	2.2
7599	Parts/accessories of data processing/storage machines	1.2	1.3	2.2
7499	Nonelectrical machine parts	1.1	1.8	1.8
7449	Lifting equip parts	1.1	1.3	1.7
7453	Parts of welding machines	1.1	1.2	1.8
7413	Parts of Industrial or laboratory furnaces	1.4	1.2	1.4
7499	Nonelectrical machine parts	1.1	1.8	1.8
7449	Lifting equip parts	1.1	1.3	1.7
RCA mai	intaining products			
6648	Vehicle rear-view mirror	16.1	12.3	7.2
8812	Movie projector part	3.6	10.7	6.8
8749	Parts and accessories for other machines and appliances	14.1	10.5	5.0
7374	Parts of gas welders	6.2	7.7	3.7
7272	Parts of Industrial food processing machines	4.5	2.8	2.5
7269	Printing press parts	0.9	2.7	2.4
8928	Labels and paper boards	2.4	3.2	2.3
7468	Ball/roller bearings	1.6	1.1	1.9
7471	Pressure reducing valves	5.7	4.2	1.5
7787	Parts of electrical machines with individual functions	1.3	1.9	1.3
7479	Tap/cock/valve parts	1.8	1.3	1.2
7451	Parts of tools of household laundry equipment	3.4	2.1	1.2
8747	Elec/rad meter parts	1.3	2.3	1.2
7474	Safety/relief valves	2.0	1.1	1.2

## Table 5.6: Revealed comparative advantage in parts and components exports<sup>1</sup> (per cent)

SITC Code	Product description	1990/91	2000/01	2012/13
7219	Parts of agricultural machines	2.2	1.9	1.2
7483	Articulated link chain parts	1.2	1.1	1.1
7284	Isotopic separators	9.9	3.5	1.0
7132	Diesel engines	3.4	1.8	1.0
New RCA	A products			
8912	Parts of military equipment	0.5	0.2	5.1
7248	Parts for leather machines	0.4	0.4	4.9
8813	Photographic and cinema laboratory equipment	0.9	0.8	4.8
8711	Binoculars/telescope parts	0.2	1.1	1.8
7452	Packing machines etc. parts	0.4	1.1	1.7
7758	Parts of electro-thermic appliances	0.5	0.7	1.6
6956	cutting blades, for machines or for mechanical appliances	0.6	0.9	1.5
8911	Prats of armoured tanks	0.2	0.4	1.5
8857	Parts of clocks	0.2	0.5	1.5
7482	Bearing housings and plain shaft bearings	2.0	0.7	1.4
7439	Parts filters and purifiers	0.8	0.9	1.4
8919	Military weapon part	2.1	0.3	1.4
6638	Asbestos friction materials	0.4	0.3	1.3
7484	Gears and gearing	1.3	0.2	1.3
6579	Machinery belts	1.8	0.6	1.3
7285	Parts of food processing machines and mechanical appliances	0.7	1.8	1.3
7529	Data-processing equipment parts	0.9	0.9	1.2
7784	Prats of electromechanical hand tools	0.7	1.1	1.2
7148	Gas turbines	0.6	0.6	1.1
7492	Metal clad gaskets	0.3	0.6	1.1
6299	Uh non-cell rub articles	0.9	0.5	1.1
8811	Flashlight parts/access	0.3	0.4	1.1
6292	Conveyor or transmission belts	0.5	0.3	1.0
7456	Spraying machinery parts	1.1	0.8	1.0
7726	Switchboards >1000v	0.6	0.6	1.0
7444	Parts of hydraulic hoists	1.0	0.7	1.0
6214	Tubes, pipes and hoses, of unhardened vulcanized rubber	0.3	0.7	1.0
7853	Parts and accessories of cycles	0.0	0.6	1.0

Notes: Products are listed in descending order based on the figures for 2010/11. Items for with RCA < 1 in all years are not reported Figures are two-year averages

Source: Compiled from the UN Comtrade database using the procedure discussed in Section 3.1

Table 5.7: Revealed	comparative	advantage in final	assembly exports
		<b>J</b>	

SITC Codes	Product description	1990/91	2000/01	2012/13
RCA incre	asing products <sup>1</sup>			
8723	Mechano-therapy appliances2	1.0	4.1	18.7
7922	Aircraft <2000kg	2.5	3.6	8.0
7643	TV/radio transmitters	1.3	1.6	4.8
RCA main	tain products			
7931	Yachts and other vessels for pleasure or sports	6.9	4.8	3.1
7919	Railway or tramway track fixtures	8.4	4.9	2.8
8744	Instruments for physical or chemical analysis	2.2	2.8	2.2
8722	Medical, surgical or veterinary science instruments	1.3	2.3	1.9
8724	Medical furniture	1.3	1.5	1.1
New RCA	exports			
8839	Developed cinema films	0.8	2.9	5.7
8741	Survey instruments	0.4	2.2	3.4
8812	Movie projectors	0.5	2.0	2.7
8745	Thermo- / hydro-meters	0.5	0.9	2.5
8711	Optical telescopes	0.5	0.3	2.4
8813	Photo/cine lab equip	0.5	0.4	1.9
7921	Helicopters <2000kg	0.9	1.5	1.9
8842	Spectacles and correctives	0.6	0.9	1.8
8831	Developed cine film 35mm	0.8	9.6	1.7
8811	Still cameras	0.1	0.7	1.7
7512	Postage-franking machines	0.3	0.9	1.7
7923	Aircraft (2001–15000kg)	0.1	0.2	1.6
7853	Invalid carriages	0.3	1.0	1.3
8853	Wrist-watches, pocket watches and other watches	0.2	3.5	1.3
8742	Measuring/checking instruments	0.4	0.8	1.3
7648	Radar apparatus	0.3	1.0	1.3
8843	Mounted optical laments	0.4	0.5	1.3
8721	Dental instruments	0.3	1.9	1.3
7788	Electric alarms	0.6	1.2	1.1
8714	Microscopes	0.1	0.6	1.1

Notes: (1) Products are listed in descending order based on the figures for 2010/11. Items for with RCA < 1 in all years are not reported. Figures are two-year averages; (2) Appliances used for exercise prescribed for heel-drop exercises for Achilles tendon injury

Source: Compiled from the UN Comtrade database using the procedure discussed in Section 3.1

### 5.5 Direction of exports

In Section 3.2 we observed a palpable shift in the source-country composition of GPN trade from advanced industrial countries to countries in East Asia. Has this structural shift been reflected in the geographic profile of Australian exports? This issue is central to the contemporary Australian policy focus on reaping gains from East Asian economic dynamism. The data summarised in Table 5.8 and depicted in Figure 5.6 help address this issue.

OECD countries still account for over half of total GPN exports, with the US continuing to remain the largest single destination. The East Asian share of total GPN exports from Australia is significantly larger (27.7 per cent in 2012/13), compared to the OECD average (16.2 per cent) (Table 5.8, Memo items). However, there is no evidence of a *distinct* East Asian bias in GPN exports. The East Asian share of GPN exports has varied in the range of 28 per cent to 33 per cent over the period 2000 to 2014, without showing any clear upward trend in line with East Asia's growing importance in global production sharing (Figure 5.6). The share of exports to China has varied in the narrow range of 4 per cent to 5.3 per cent over the past ten years, notwithstanding that country's role as the major importer of components in the region to be used in final assembly within global production networks (Athukorala 2009). Among the East Asian countries, the countries in Southeast Asia account for a much larger share of manufacturing exports of all product groups compared to Northeast Asia (including China).

When Australian GPN exports are disaggregated into parts and components and final assembly, there is no clear difference between OECD countries and East Asia in terms of the relative importance of these two product groups. In both cases, parts and components account for a much larger share (Table 5.8). A notable feature of final assembly exports is the significant share (24.4 per cent) going to West Asia (Middle-East oil rich countries). Disaggregated data shows that motor vehicles continue to account for a large share (over a half). But exports of a number of other final GPN goods have also increased in recent years. The geographic profile of Australian manufacturing exports (both GPN products and other) show a distinct Oceania bias, with New Zealand accounting for a much larger share of Australian exports relative to that country's position in global trade. This pattern is consistent with the view that 'remoteness' from major trading centres in the world, in addition to the geographic distance, plays a role in determining bilateral trade flows (Head and Mayer 2014).

Figure 5.6: Australia: Direction of GPN exports (per cent)



Source: Based on data compiled from UN Comtrade database

Destination		Austr	alia			OECD o	countries	
country/region	Total Mfg	Parts and components	Final assembly	GPN products	Total Mfg	Parts and components	Final assembly	GPN products
North-east Asia	17.2	15.4	8.7	13.2	11.1	12.5	11.9	11.9
Japan	2.6	1.8	0.9	1.4	1.7	1.5	1.3	1.3
China	7.0	6.1	3.0	5.9	5.9	7.3	7.3	7.3
Hong Kong &Macao	3.3	3.7	2.7	3.2	1.4	1.6	1.2	1.2
Korea, Rep	4.2	2.4	2.1	2.6	2.1	2.1	2.1	2.1
Taiwan	2.3	1.2	1.3	1.4	2.8	1.6	2.7	2.7
Southeast Asia	14.6	14.6	12.2	13.5	1.4	1.5	4.3	4.3
South Asia	2.4	1.0	1.1	1.6	3.8	5.6	1.2	1.2
India	1.4	0.7	0.7	1.2	1.0	1.1	0.8	0.8
Central Asia	0.1	0.1	0.2	0.1	0.2	0.2	0.3	0.3
Western Asia	7.2	4.3	24.6	12.1	4.8	4.9	6.3	6.3
Oceania	22.7	22.5	23.4	24.4	1.5	1.4	2.3	2.3
Australia					1.2	1.1	1.7	1.7
New Zealand	16.3	14.6	16.4	15.8	0.2	0.2	0.3	0.3
North America	15.6	23.0	13.9	16.1	14.7	16.1	17.5	17.5
USA	14.4	21.5	12.7	14.6	10.8	11.6	13.3	13.3
Canada	1.2	1.5	1.1	1.5	3.9	4.5	4.2	4.2
EU	10.7	11.4	7.4	9.8	44.2	39.8	37.9	37.9
EU15	10.4	11.0	7.2	9.5	39.0	33.3	33.6	33.6
Western Europe, other	1.1	0.6	1.3	0.5	3.1	2.2	2.7	2.7
CIS	0.3	0.4	0.5	0.5	2.9	2.7	3.6	3.6
Africa	3.2	4.1	3.3	4.2	2.8	2.9	3.3	3.3
Latin America & Caribbean	2.6	2.6	2.3	2.6	6.6	8.3	6.1	6.1
Other (unclassified) countries	2.4	0.0	1.3	1.4	2.9	1.9	2.6	2.6
Total	100	100	100	100	100	100	100	100
Memo items								
OECD	52.3	55.3	43.2	47.3	71.4	68.9	67.0	67.0
OECD (mature)	46.1	51.1	39.7	43.2	59.8	54.3	56.9	56.9
East Asia	31.8	30.0	20.9	26.7	12.4	14.1	16.2	16.2
Developing East Asia	29.2	28.2	20.0	25.3	10.8	12.6	15.0	15.0
Developing countries	47.8	44.7	56.8	52.7	28.6	31.1	33.0	33.0

## Table 5.8: Direction of manufacturing exports, 2012/13 (per cent)

Source: Compiled from UN Comtrade database

# 6. Determinants of Exports

This section discusses the determinants of inter-country differences in export performance based on the estimation of the gravity model specified in Section 3. The preferred Hausman and Tayler Estimator (HTE) estimates of the trade equation are reported in Table 6.1. The coefficient estimates for Australia derived from the overall regression are given in Table 6.2. Note that we have deleted the dummy variables for the Asian financial crisis and the global financial crisis (*DAFC* and *DGFC*) from the final estimates because these two variables turned out to be statistically insignificant in experimental runs in all cases. It seems that the effects of the two crises are well captured in the model by the time dummies. The following interpretation of the regression result are arranged under two subheadings, general inferences and Australia-specific inferences.

### 6.1 General inferences

Ξ.

The coefficients of the standard gravity variables (GDP, RMF and *DST*) are statistically significant with the expected signs in all equations. The magnitude of the coefficient of the distance, *DST* (between -0.81 to -1.09) is consistent with the results of previous gravity model applications to modelling trade flows (Head and Mayer 2014).

### Table 6.1: Determinants of manufacturing exports

Variables	Total manufacturing	Parts & components	Final assembly	Conventional (horizontal) exports
Ln Real GDP (RGDP), reporter	1.23***		1.81***	1.03***
	(0.03)		(0.06)	(0.03)
Ln Real GDP (RGDP), partner	1.38***		2.14***	1.19***
	(0.03)		(0.06)	(0.03)
Ln Real Manufacturing output (RMF), reporter		1.39*** (0.03)		
Ln Real Manufacturing output (RMF), partner		1.10*** (0.03)		
Ln Distance (DST)	-0.86***	-0.81***	-1.09***	-0.95***
	(0.06)	(0.10)	(0.10)	(0.05)
Ln Relative per capital GDP (RPGDP)	-0.00**	-0.01***	0.01***	-0.01***
	(0.00)	(0.00)	(0.00)	(0.00)
Ln Bilateral real exchange rate (RER)	0.01***	-0.01	-0.01*	0.01***
	(0.00)	(0.00)	(0.01)	(0.00)
Ln Technology base, reporter (TECH)	0.07***	0.22***	0.05***	0.09***
	(0.01)	(0.01)	(0.02)	(0.01)
FTA membership dummy (FTA)	0.34***	0.47***	0.69***	0.22***
	(0.02)	(0.04)	(0.05)	(0.02)
Institutional quality (INST), reporter	-0.06***	0.04**	-0.05**	-0.05***
	(0.01)	(0.02)	(0.02)	(0.01)
Ln Logistic quality (LPI), reporter	0.93***	1.02***	1.16***	0.79***
	(0.12)	(0.18)	(0.24)	(0.13)
Contiguity dummy (ADJ)	-0.03	-0.44	-0.60*	0.11
	(0.21)	(0.35)	(0.36)	(0.18)
Common language dummy (CML)	0.38***	0.70***	0.15	0.48***
	(0.13)	(0.23)	(0.22)	(0.11)
Colony dummy (CLK)	-0.32	0.12	-0.93**	0.01
	(0.22)	(0.37)	(0.39)	(0.20)
European Union dummy (EU)	-0.13	0.40	-0.30	-0.17
	(0.15)	(0.24)	(0.27)	(0.14)
East Asia dummy (EAS)	1.68***	1.97***	1.79***	1.37***
	(0.18)	(0.31)	(0.32)	(0.16)
Constant	-51.47***	-47.06***	-87.70***	-40.77***
	(1.18)	(1.31)	(2.23)	(1.17)
Australia dummy (AD) variables				
AD*RGDP, Australia	-0.03		-1.22**	0.14
	(0.32)		(0.62)	(0.33)
AD*RGDP, partner	-0.22		-1.24***	0.09
	(0.24)		(0.47)	(0.25)

Variables	Total manufacturing	Parts & components	Final assembly	Conventional (horizontal) exports
AD*RMF, reporter		1.09 (1.48)		
AD*RMF partner		-0.23 (0.21)		
AD*RPGDP	-0.00	0.04***	0.00	-0.01
	(0.01)	(0.01)	(0.02)	(0.01)
AD*RER	0.05*	0.09**	0.06	0.07***
	(0.03)	(0.04)	(0.05)	(0.03)
AD*TECH	0.17	0.67	1.27**	0.40
	(0.26)	(0.50)	(0.50)	(0.27)
AD*FTA	-0.56***	-0.53***	-0.97***	-0.53***
	(0.15)	(0.20)	(0.29)	(0.15)
AD*INST	0.27 (0.18)	0.94*** (0.28)	0.32 (0.35)	0.14 (0.19)
AD*LPI	1.29	-2.78	7.36	3.45
	(3.23)	(5.12)	(6.36)	(3.40)
AD*CML	0.26	0.41	0.88	0.08
	(0.60)	(1.03)	(1.05)	(0.53)
AD*CLK	0.70	0.90	1.41	0.36
	(1.74)	(2.72)	(3.06)	(1.56)
AD	26.91***	-14.42	53.94***	16.80*
	(10.42)	(33.24)	(19.63)	(10.30)
Observations	30,570	24,546	30,100	30,060
Number of country pairs	1,845	1,672	1,843	1,838

Notes: Heteroscedasticity corrected standard errors are given in brackets. The statistical significance of regression coefficients denoted as: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Table 6.2: Determinants	of manufacturing	exports: Austra	alia specific results
	J		

Variables	Total manufacturing	Parts & components	Final assembly	Conventional (horizontal) exports
Ln Real GDP (RGDP), Australia	1.20*** (0.32)		0.60*** (0.22)	1.16*** (0.33)
Ln Real GDP (RGDP), partner	1.17*** (0.24)		0.90* (0.46)	1.28*** (0.24)
Ln real Manufacturing output (RMF), Australia		2.49 (1.49)		
Ln real Manufacturing output (RMF), partner		0.86*** (0.21)		
Ln Distance (DST)	-3.52***	-1.94	-2.05*	-4.30***
	(0.73)	(1.17)	(1.21)	(0.66)
Ln Relative per capital GDP (RPGDP)	-0.01	0.03***	0.01	-0.02
	(0.01)	(0.01)	(0.02)	(0.01)
Ln Bilateral real exchange rate (RER)	0.06***	0.07*	0.04	0.08***
	(0.02)	(0.04)	(0.05)	(0.03)
Ln Technology base, reporter (TECH)	0.14***	0.43***	0.10***	0.18***
	(0.02)	(0.03)	(0.04)	(0.01)
FTA membership dummy (FTA)	-0.22	-0.06	-0.28	-0.30*
	(0.15)	(0.20)	(0.29)	(0.15)
Institutional quality (INST), Australia	0.22	0.98***	0.27	0.09
	(0.18)	(0.28)	(0.35)	(0.19)
Ln Logistic quality (LPI), reporter	2.22 (3.22)	-1.76 (5.11)	8.52 (6.35)	4.23 (3.39)
Common language dummy (CML)	0.64 (0.59)	1.12 (1.01)	1.02 (1.03)	0.56 (0.52)
Colony dummy (CLK)	0.38	1.03	0.48	0.37
	(1.73)	(2.70)	(3.04)	(1.55)

Notes: The results reported in this table are derived from the overall regressions reported in Table 6.1. The coefficients are the linear combinations of each of the base coefficient and the coefficient of the Australia dummy. The standards errors (derived from the covariance of the two coefficients) are given in brackets. The statistical significance of the regression coefficients is denoted as \*\*\* p<0.01, \*\* p<0.05, \* p<0.10

The result for the relative per capita income variable (R*PGDP*) is mixed. The coefficient is statistically significant with the negative sign in the parts and component equation suggesting a relative labour intensity bias associated with export expansion. The reverse impact seems to apply for final assembly as well, but the estimated impact is small in both cases (0.01).

The results for the real exchange rate variable (*RER*) support our hypothesis that global production sharing weakens the link between international price changes and trade flows. The coefficient of *RER* is not statistically different from zero in the equation of parts and components. It is marginally significant in the equation for final assembly with an unexpected sign. By contrast, the

estimated effect of RER on horizontal exports (and hence on total exports) is highly significant with the expected (positive) sign.

The coefficient of *TECH* is statistically significant in all four equations suggesting that the domestic technology base is an important determinant of manufacturing export performance in general. However, the coefficient of the parts and component (0.22) is much larger compared to that of final assembly (0.05). This difference is consistent with the postulate that specialisation in parts and components within global production networks is generally more technology intensive compared to final assembly (See Box 2.1).

The coefficient of the free trade agreement variable (*FTA*) is statistically significant in all four equations, but it is larger in magnitude in the two GPN exports equations. This result is consistent with the fact that tariffs on final electrical and transport equipment still remain high in most countries. The coefficient of this variable for parts and components is smaller (0.47) compared to that for final assembly (0.69). This result is consistent with the fact that almost all countries permit duty free entry of parts and components as part of their export promotion policy package (WTO 2015). These results, however, need to be interpreted with care because it could well reflect co-existence, rather than causation: there is a general tendance for trading partners with historically well-established trade links to enter into FTAs than others.

Institutionally quality (*INST*)<sup>17</sup> seems to have a positive and statistically significant effect only on parts and component exports. This is consistent with the fact that institutional quality is closely associated with the service link costs involved in global production sharing. Timely delivery of parts and components is vital for the smooth functioning of closely-knit tasks within the value chain.

The coefficient of the logistic performance variable (*LPI*) is statistically significant in all four equations. The magnitude of the coefficient of this variable for parts and component (1.02) and final assembly (1.16) is larger than that of conventional (horizontal) exports (0.79). This difference (which is statistically significant) is consistent with the view that the quality of trade related logistics is a much more important for a country's success in expanding GPN trade.

The common language variable *(CML)* seems to have a highly significant impact on parts and comment exports. The use of a common language generally reduces service link cost. Surprisingly the coefficient of this variable is not statistically significant in the equation for final assembly export. This presumably reflects China's dominance in the world final-assembly trade.

Finally, the coefficient of the East-Asia dummy (*EAS*) is highly significant with the expected sign in all four regressions. The coefficient *EAS* in the two GPN equations are much larger than that in the horizontal export equation, indicating a strong 'GPN bias' in intra-East Asian trade. More specifically, the results

<sup>&</sup>lt;sup>17</sup> In experimental runs we used three other alternative indicators of institutional quality (governance), (rule of law, government effectiveness, control of corruption) from the World Bank's World Governance Indicators database. The results were comparable in the standard OLS estimation. However, we were not able to use these indicators in FE and HT estimations because of data gaps.

suggest that Intra East-Asia exports of GPN products are five to six times larger (whereas horizontal exports are only three times larger) than predicted by the other explanatory variables in the model.<sup>18</sup> Interestingly the coefficient of the EU dummy is not statistically significant in all four regressions. It seems that there is no distinct intra-regional bias in EU exports after controlling for the other explanatory variables, in particular the *FTA* dummy.

### 6.2 Australia-Specific inferences

The coefficients of most of the dummy interaction variables are not statistically significant (Table 6.1). This suggests that the above inferences relating to these variables are generally applicable to exports from Australia as well.

A notable Australia specific finding is that the 'tyranny of distance' is a much more binding constraint on exports of conventional (horizontal) goods and hence on total manufacturing exports. The coefficient of DST in the equations for horizontal goods (-4.30) and total manufacturing (-3.52) are highly significant and it is more than three times larger in magnitude compared to the all-country coefficient (-0.95 and -0.86, respectively). By contrast, the coefficient of DST in the equations for parts and components is not statistically significant, suggesting that distance does not place Australia at a specific disadvantage in exporting parts and components compared to the all-country experience. The coefficient of DST related to final assembly exports is marginally significant (at the 10 per cent level)) presumably because shipping is the only mode of transport for some final assembly products such as motor vehicles and agricultural machinery. However, overall, it seems that fitting into global production networks help Australian manufacturing to circumvent the 'tyranny of distance'.

The coefficient of *RGDP* is statistically significant with the positive sign only in the component regression. This finding is consistent with the view that Australia has comparative advantage in the production of relatively more capital parts and components within production networks compared to the other countries

The coefficient of the real exchange rate variable (RER) in the final goods equation is not statistically different from zero. It is marginally statistically significant (at the 10 per cent level) for components with the expected (positive) sign, but the magnitude of the coefficient is small (0.07). Thus, overall, the results are consistent with our postulate that relative price competitiveness is not a major determinant of GPN trade.

<sup>&</sup>lt;sup>18</sup> Note that, as the model was estimated using all variables (other than the dummy variables), the comparable figure for any dummy coefficient is, [exp(dummy coefficient) -1]. Thus the comparable coefficients of ESA in the four equations are 4.4, 6.2, 5.0 and 3.0, in that order.

The domestic technology base seems to give an edge to Australian manufacturing in exports of both parts and components and final assembly. The estimated Australian coefficient of *TECH* is statistically significant and its magnitude is much larger compared to the all-country coefficients (Australia: +0.43 and +0.10 from Table 6.2; all-country coefficients +0.22 and +0.05). The coefficient of the parts and components equation (0.43) is four times of that of the final assembly equation (0.10). This is consistent with the greater technology intensity of parts and components production compared to final assembly. Overall, the Australian results relating to TECH variables are consistent with the patterns revealed in our RCA analysis. The results for the FTA variable suggest that FTA membership<sup>19</sup> has not so far helped expansion of Australian manufacturing exports over and above the other determinants of trade flows.

Institution quality (*INST*) seems to give Australian manufacturing a distinct competitive edge in parts and component exports over the other countries. The coefficient of *INST* for Australia in the equation for parts and components is as large as 0.98 compared to the all-country coefficient of mere 0.04.

# 7. Global Production Sharing and Manufacturing Performance

### 7.1 Data compilation

This section provides a preliminary analysis of the role of global production sharing on the performance of Australia manufacturing. An in-depth analysis is not possible given the current state of data availability. This preliminary analysis intends to set the scene for a full-pledged analysis based on a fresh data gathering/compilation effort.

The readily available data on Australian manufacturing (ABS Cat. 8155.0) cover four key variables: value added, sales (gross output), wages and salaries, and employment (number of workers) at the 4-digit level of the Australia New Zealand Standard Industry Classification (ANZSIC). The data are currently available only for the period 2010–11 to 2013–14. Data on business R&D for 4-digit ANZSIC industries are also available from the ABS sources for three years (2009–10 to 2011–12). To analyse the impact of GPN trade on manufacturing performance, we converted fiscal-year based data to calendar-year data and then linked to SITC-based trade which we have used in our trade pattern analysis. A concordance has not yet been developed by the ABS at a sufficiently disaggregated level to link ANZSIC based data to the trade data based on the Standard International Trade Classification System (SITC) (or the Harmonised System). For the purpose of this analysis we, therefore, linked trade data to ABS manufacturing and R&D data by concording

<sup>&</sup>lt;sup>19</sup> During the period under study, Australian has been an FTA partner with New Zealand (throughout the entire period under study), Singapore (since 2004), Thailand (since 2005), and the USA (since 2005).

both to the Standard Industry Classification (SITC).<sup>20</sup> The analysis covers the four-year period 2010–2013 with the ABS data converted prorate onto calendar -year basis.<sup>21</sup>

We compiled data on seven manufacturing performance indicators: output (value added), employment (number of workers), labour productivity (value added per worker), real wage, R&D/sales ratio, unit labour cost, and wage share in value added; and three indicators of domestic manufacturing and foreign trade interface: export-sales ratio, import-sales ratio and import penetration ratio. Output and labour productivity are measured in constant (2010) prices using the producer price index of manufacturing. Real wage is estimated by deflating nominal wage by the consumer price index. Unit labour cost measures the average cost of labour per unit of output (value added) and it, in a broader sense, indicates how much output the economy receives relative to the cost of labour involved in the production process. Import penetration is measured as the ratio of total imports to total domestic absorption (total domestic output + imports - exports). It is a better indicator of the degree of import competition faced by a given industry: because a greater degree of export orientation helps withstand import competition.

### 7.2 Preliminary findings

Annual averages (for the four years from 2010 to 2013) of the manufacturing performance indicators are summarised in Table 7.1. Here we are interested in identifying performance differences of industries engaged in global production sharing compared to the other industries. The two groups of industries are identified based on the RCA estimates reported in Section 5.4 (Table 5.6 and 5.7). Accordingly, industries of which parts and components and/or final assembly exports had a RCA index of above unity (RCA> 1) in 2012–13 are defined as industries engaged in global production sharing. Industries with RCA value below 1.0 are defined as non-RCA industries. In the following discussion we refer to these industries as 'RCA industries'.

The available 4-digit manufacturing data do not permit separating parts and components production and final assembly. Also matching of RCA products identified at the SITC-4 digit level with 4-digit ISIC industries invariably involves a considerable degree of arbitrariness. The following inferences, therefore, need to be treated only as suggestive in broader terms.

<sup>&</sup>lt;sup>20</sup> ANZSIC-SITC concordance was obtained from the ABS website and the SITC-ISIC concordance from the UN Statistical Office database.

<sup>&</sup>lt;sup>21</sup> The Industrial Statistical Database (INDSTAT5-2014) of the United Nations Industrial Organization (UNIDO) contains data on Australian manufacturing for the period from 1988 to 2012 at the ISIC 4-digit level (based on ABS sources). However, we abandoned an initial attempt to back cast the data coverage beyond 2010 for two reasons: (a) data on some variables were missing in the UNIDO database for a number of years and (b) (more importantly) it was not possible to reconcile the ABS and UNIDO data for a number of ISIC 4-digit industries for the two three overlapping years (2010–2013) for with data are available from both sources.

The RCA industries accounts for about 27 per cent of total manufacturing output and employments. Labour productivity of RCA industries varies in the range of \$67,170 <sup>22</sup>(machine tools) to \$110,041 (machines for mining and construction), with railway/tramway locomotives (\$108,328), medical and surgical equipment (\$103,684), electronic valves (\$102,749), and aircraft and space craft (\$95,488) occupying the upper end of the distribution. The average labour productivity of these industries (\$91,447) is however only marginally higher than that of the non-RCA industries (\$89,863).

The R&D intensity of operation of RCA industries, measured by the R&D-sales ratio, is generally higher in RCA industries (3.1 per cent) compared to the non-RCA industries (1.0 per cent) as well as the overall industry average (1.3 per cent). This difference is also consistent with our econometric results that Australia's comparative advantage in global production sharing is closely associated with the country's technological capabilities. Among the RCA industries, electronic valves (12.6 per cent), TV/radio receiver (9.0 per cent), TV transmitters (7.3 per cent), medical and surgical equipment (7.0 per cent), measuring appliances (5.2 per cent) occupy the top five positions in the intensity ranking. Interestingly, the R&D-sales ratio of the aircraft industry is below average (1.4 per cent), presumably because this industry relies on the related general R&D base of the country and foreign technology.

The average real wage in RCA industries (\$59,094) is significantly higher than that of non-RCA industries (\$49,976). The average real wage in the aircraft industry (\$73,737), the largest parts and components exporting Australian industry, is 50 per cent higher than the overall industry average (\$49,020). The unit labour cost is also generally highest in RCA industries, with the aircraft industry exhibiting the largest number (\$0.93). The upshot is that labour cost is not an important determinant of export success in highly specialised niche segments in the value chain of global production networks.

The average degree of exposure to import competition, measured by the import penetration ratio, is notably higher in RCA industries (23.8 per cent) compared to non-RCA industries (13.0 per cent). Also at the 4-digit level, the degree of export orientation and import dependence among RCA industries seem to go together. These patterns are consistent with the fact that, within global production networks, export performance essentially involves adding value to imported segments of the globally integration production processes.

<sup>&</sup>lt;sup>22</sup> All dollar values reported in this analysis are in current proices.

ISIC code	Product category	Value added (\$m)	Employment (number)	Labour Productivity (\$)	Real wage (\$)	R&D/Sale ratio <sup>1</sup>	Unit Iabour cost (\$)	Wage/value- added ratio ( per cent)	Export/ sales (per cent)	Import/ sales (per cent)	Import penetration ( per cent)
										(A) RCA	A industries <sup>2</sup>
3530	Aircraft and spacecraft <sup>3</sup>	1,274	13,379	95,488	73,737	1.4	0.93	78.9	25.3	26.3	26.0
3430	Parts/accessories for automobiles (except bodies)	1,287	14,875	86,587	49,904	3.1	0.69	58.7	18.1	27.7	25.2
3220	TV/radio transmitters; line comm. Apparatus	454	5,200	87,415	58,128	7.3	0.80	67.8	17.6	237.4	74.2
3320	Optical & photographic equipment	85	1,204	71,000	44,163	3.1	0.75	63.4	16.1	68.1	44.6
2924	Machinery for mining & construction	1,206	10,945	110,041	65,662	2.0	0.72	60.7	15.9	27.6	24.7
3311	Medical, surgical and orthopaedic equipment	1,157	11168	103,648	49,188	7.0	0.57	48.4	14.8	68.6	40.8
3120	Electricity distribution & control apparatus	925	10,221	90,804	59,094	1.3	0.79	66.5	12.9	44.4	33.7
2929	Other special purpose machinery	414	4,904	84,426	48,601	2.8	0.69	58.7	12.0	28.5	24.4
3210	Electronic valves, tubes, etc.	593	5,808	102,749	59,008	12.6	0.69	58.7	9.6	80.3	47.0
2913	Bearings, gears, gearing & driving elements	601	7,110	84,608	49,803	1.7	0.71	60.0	9.6	51.8	36.4
2912	Pumps, compressors, taps and valves	2,015	24,037	83,877	49,264	1.4	0.71	59.9	8.1	31.1	25.3
3312	Measuring/testing/navigating appliances.	706	7,259	97,318	61,796	5.2	0.77	64.8	7.7	126.1	57.7
3110	Electric motors, generators and transformers	925	10,221	90,804	59,094	1.8	0.79	66.5	5.4	35.0	27.0
2911	Engines & turbines (excluding 3410)	601	7,110	84,608	49,803	1.7	0.71	60.0	5.3	43.4	31.4
2915	Lifting and handling equipment	672	7,011	95,882	59,051	2.2	0.74	62.8	5.1	19.4	17.0

# Table 7.1: Key indicators of manufacturing performance, 2010–13 (annual averages)<sup>1</sup>

ISIC code	Product category	Value added (\$m)	Employment (number)	Labour Productivity (\$)	Real wage (\$)	R&D/Sale ratio <sup>1</sup>	Unit Iabour cost (\$)	Wage/value- added ratio ( per cent)	Export/ sales (per cent)	Import/ sales (per cent)	Import penetration ( per cent)
3592	Bicycles and invalid carriages	72	994	72,606	40,344	1.2	0.67	56.6	3.4	25.5	20.9
2922	Machine tools	388	5,775	67,170	41,305	3.3	0.74	62.7	3.3	15.2	13.6
3130	Insulated wire and cable	272	2,783	97,620	59,283	0.7	0.73	61.9	3.2	14.5	13.1
3520	Railway/tramway locomotives	673	6,214	108,328	60,368	1.1	0.67	56.7	3.0	54.8	36.1
3190	Other electrical equipment	2,392	25,564	93,734	59,101	3.4	0.76	64.3	2.7	15.9	14.1
3150	Lighting equipment and electric lamps	334	4,659	71,659	43,175	0.8	0.72	61.3	2.5	17.6	15.3
2925	Food/beverage/tobacco processing machinery	414	4,904	84,426	48,601	2.8	0.69	58.7	2.0	3.7	3.6
2927	Weapons and ammunition	1,596	19,956	80,019	46,937	0.7	0.71	59.8	1.6	7.8	7.4
2921	Agricultural and forestry machinery	495	7,029	70,389	39,113	2.0	0.67	56.6	1.4	7.6	7.2
2930	Domestic appliances	589	5,937	99,198	52,875	0.0	0.64	54.4	1.0	3.0	2.9
3230	TV and radio receivers and associated goods	1,047	11,008	95,456	58,581	9.9	0.74	62.7	0.7	10.9	9.9
3140	Accumulators, primary cells and batteries	925	10,221	90,804	59,094	1.3	0.79	66.5	0.7	12.5	11.2
3330	Watches and clocks	706	7,259	97,318	61,796	5.2	0.77	64.8	0.1	19.5	16.3
	Total	22,817	252,756	91,447	55,567	3.1	0.73	62.0	7.3	35.0	23.8
	(b) Non-RCA industries <sup>4</sup>	27,263	321,200	89,863	49,976	1.0	0.67	56.9	1.5	35.9	13.0
	(C) Total manufacturing	84,534	925,735	91,315	49,020	1.3	0.65	54.7	1.9	42.1	30.1

Notes: (1) Industries are ranked by descending order of the degree of export orientation (measured by the exports-sales ratio); (2) The data are annual average of three years (2009–10, 2010–11 and 2011–12); (3) I ndustries of which parts and components and/or final assembly exports had an RCA index of above unity (RCA> 1) in 2012–13; (4) Includes aircraft engines and other parts and components (5) Industries with recorded exports but RCA < 1. For a complete listing of these industries data for individual industries, see Appendix A-8

Source: Compiled from ABS, Australian Industry Statistics (Cat. 8155.0) and Research and Developmental Statistics (Cat. 8104.0)

### 7.3 Servicification of manufacturing

An important aspect of global production sharing is that manufacturing firms increasingly contract out (to their own affiliated firms or to other firms) numerous knowledge-intensive business services, which are historically embodied in the value of a given product. At the same time, many 'production' firms have begun to rely on contract manufactures to undertake production while focussing solely or mainly on downstream services activities in the value chain such as e-commerce and sales promotion. There are also emerging cases of some high-tech firms selling their products as part of a total care package of aftersales services and solutions. Consequently the traditional distinction between manufacturing and services is becoming increasingly blurred because of on-going process of global production sharing (Roos 2014, Bryson and Daniels 2010, Neel 2008, Bhagwati 1984).

This phenomenon, which we term as 'servicification'<sup>23</sup>, is not yet captured in national data reporting systems in Australia and most (if not all) other countries. The failure to distinguish between these 'manufacturing-related services from traditional services, therefore, could create a statistical illusion that manufacturing is becoming less important in the national economy. The underestimation of the role of manufacturing due to servicification is greater when the production processes move from simple assembly activities towards higher value added activities (move from the bottom of the smiling curve to its right or left).

Servicification also poses a challenge for trade and industry policy formulation because not only the conventional forms of trade protection but also barriers targeted at services could affect manufacturing. In the context where manufacturing increasingly uses imported services and provides services abroad, often as part of selling manufactured goods, there is a strong case for treating services and manufacturing together in policy making.

Official statistics on manufacturing performance are commonly collected at the establishment or firm level. But much of servicification takes place at the industry group level. Manufacturing firms often assign services activities to subsidiary firms within their business group, which in the collection of official statistics would be treated as part of the services sectors. Creating a database to better capture servicification calls for reformulating data collection systems to accommodate this business group behaviour of separating services from conventional manufacturing. A recent firm-level study of Swedish manufacturing has found the share of manufacturing in the economy is significantly larger than previously thought (based on National Accounts data) when activities of manufacturing groups, rather than establishments are appropriately accounted for (Lodofalk 2013).

Neely (2008) examines servicification of manufacturing covering 10,028 firms (each employing 100 or more) in 25 countries, including Australia. The list of firms includes 109 Australian manufacturing firms. Among the 16 OECD

<sup>&</sup>lt;sup>23</sup> An alternative term used in recent studies is 'sevitization'.

countries covered in the data, the percentage of manufacturing firms engaged in services trade as part of their manufacturing activities ('servitized' firms) varies between 11.6 per cent (Japan) to 58.6 per cent (USA) with a country average of 29.3 per cent. Australia ranks 12th in the OECD ranking, with 22.7 per cent of manufacturing firms engaged in services (Neely 2008, Table 5.2). These individual company-level data perhaps understate the degree of servicification because of the failure to capture the servicification occurring at the business group level.

A readily available indicator for getting a tentative idea of the international dimension of servicification is the data series of 'other business services' in the balance of payments accounts. This category captures many of the information technology related services, and management and consultancy services, which are central to the process of global production sharing. The other business services exports as a percentage of total services exports are plotted in Figure 7.1. It clearly shows that these services exports have grown much faster than 'traditional' services. This suggests that an analysis that overlooks 'servicification' could understate the role of global production sharing in manufacturing.



Figure 7.1: Share of other business services exports of Australia (per cent)

Source: ABS, Balance of Payments and International Investment Position (cat. no. 5302.0)

# 8. Summary of Findings and Policy Implications

### 8.1 Findings

Global production sharing has become an integral part of the global economic landscape. Trade within global production networks has been expanding more rapidly than conventional horizontal trade. The expansion of global production sharing has made inputs and capital increasingly mobile across national boundaries (inputs are no longer trapped in national boundaries), and hence the patterns of production and trade has become more sensitive to intercountry differences in trade and investment policies.

Australia is still a minor player in global production sharing, but at the disaggregated levels we can observe a number of bright signs. There are early signs of Australian manufacturing reaping gains from joining global production networks, specifically focussing on specialised tasks which are generally consistent with the country's comparative advantage in skill-intensive production. Australia's share of total OECD exports of GPN products has doubled over the past decade. In particular, the share of parts and components in Australian exports has increased continuously (from 0.24 per cent in 1990–01 to 0.28 per cent in 2012–13), whereas in the OECD countries this share has declined from 81.3 per cent to 45.6 per cent during the same period. In 2012–13, parts and components and final assembly products accounted for 46 per cent of Australian manufacturing exports.

The disaggregated trade data (at the 4-dgit SITC level) analysis shows that Australia has a distinct competitive edge in parts and components specialisation in several product categories including aircraft parts and associated equipment, parts of earth moving and mineral processing machines, and specialised automotive parts. The finally assembly products in which Australia has a competitive edge include medical and surgical equipment, light aircrafts, measuring and scientific equipment, and instruments for chemical analysis.

There is clear evidence of a shift in the composition of parts and components exports from the conventional resource based parts and components to more dynamic products, with aircraft components playing a leading role. A notable exception compared to the OECD trade patterns is the automotive parts category; the share of this product category, though still accounting for nearly a third of total parts and components exports, has continuously declined in recent years. Among final (assembled) GPN products, Australia seems to have a competitive edge in medical devices, measuring and scientific equipment and aircrafts. Products in which GPN trade has been heavily concentrated in OECD countries such as telecommunication and sound recording equipment (SITC 76), electrical machinery (SITC 77), professional and scientific equipment (SITC 87), and photographic equipment (SITC 88) do not figure prominently in the Australian export product mix. However, there are early signs of some export successes in these product categories.

In summary, the findings of the commodity-level analysis support our hypothesis that the ongoing process of global production sharing has opened up opportunities for Australia to specialise in parts and components, and final assembly, which are not generally subject to the tyranny of distance in world trade because the main mode of transport is air shipment. These emerging export patterns are consistent with Australian resource endowment.

Due to data limitations, we were not able to undertake an in-depth analysis of the impact of global production sharing on the performance of domestic manufacturing. Our preliminary results, however, show some distinctive features of the industries in which Australia has a revealed comparative advantage in GPN trade compared to the other industries: the degree of export orientation, R&D intensity, real wage, labour productivity, import dependence and exposure to import competition (measured by the import penetration ratio) are generally higher in these industries compared to the other industries.

The generally higher R&D-sales ratio of these industries is consistent with our earlier inference that Australia's comparative advantage within global production networks is rooted in its technological capabilities. At the same time, a higher average real wage combined with higher labour productivity in industries is indicative of Australia's potential for specialising in skill intensive tasks in the global value chain. The inter-industry patterns of import dependence are consistent with the view that exporting and importing are essentially 'two sides of the coin'. A comprehensive firm-level analysis is warranted to validate these preliminary findings.

Our econometric analysis of the determinants of GPN trade confirms the importance of trade-related logistics (measured by the World Bank logistic performance index) for export success through global production sharing. Another interesting Australia-specific finding of this analysis is that the 'tyranny of distance' is not a binding constraint on exporting specialised parts and components and some final assembly goods from Australia. These are generally products that are suitable for air transport. There is also evidence that domestic technological capabilities are relatively more important compared to the average global experience in determining components exports from Australia.

According to our econometric analysis and the analytical narrative of export patterns, relative price competitiveness (captured in our analysis by the real exchange rate) does not seem to be an important determinant of GPN exports. These exports are predominantly 'relationship-specific' and are also based on long-term supplier-producer relationships. This evidence suggests that reaping gains from Australia's comparative advantage in primary commodity (resourcebased) trade and from specialisation in knowledge-intensive tasks within global production networks are not conflicting policy goals. The econometric evidence also suggests that the FTA membership has so far not helped expansion of manufacturing exports from Australia.<sup>24</sup>

<sup>&</sup>lt;sup>24</sup> It is important to note that this finding relates specifically to the average impact on *manufacturing* exports of the four FTAs (see note 20), which were in operation during the period under study. It is not possible to generalise from this finding for the impact of these FTAs on primary products exports from Australia or for the trade effects of other FTAs. The trade effect of a given FTA

### 8.2 Policy implications

Overall, our findings are consistent with the message of a recent policy report by the Committee for Economic Development of Australia that 'Rumours of the death of manufacturing in Australia, perpetuated by the media's constant reporting of factory closures, and large multinationals exiting manufacturing, is generally exaggerated' (CEDA 2014). Effective policy making in this era of global production sharing needs to be based on an identification of specific manufacturing niches through a disaggregated analysis of trade patterns rather than looking at evidence depicting the broader picture. However, in the Australian policy debate so far the term 'advanced manufacturing' has been used in the conventional sense without distinguishing GPN trade within overall manufacturing. Our disaggregated analysis of parts and components and final assembly exports within global production networks will also be helpful in identifying specific products within advanced manufacturing for policy attention.

We believe that the findings of this study are relevant for strengthening the case for Advanced Manufacturing Growth Centre policy initiatives of the department and informing the on-going policy dialogue on its implementation and likely outcomes. In particular, the findings have implications for (a) linking Australian manufacturers with global companies and their supply chains, (b) connecting Australian manufacturers with local and global companies to improve access to and use of specialised management and workplace skills, (c) reforming regulations to encourage investment, transformation and growth of the manufacturing sector, (d) improving the perceptions of manufacturing amongst Australians.

There is a clear case for institutional initiatives for creating a wider shared understanding of the phenomenon of global production sharing in the business and policy communities. The poor perception of manufacturing in Australia is a hurdle for successful industry participants. The manufacturing sector struggles to attract and retain talent. The perception of manufacturing could be improved, by highlighting achievements in new dynamic areas of specialisation.

The findings of this study give credence to the case made in a number of recent influential studies for further reforms to improve Australia's export performance (Withers et al 2015, CEDA 2015, Government of Australia 2012). Compared to the first four decades of the post-World War Two era, Australia's policy reforms since the early 1980s have certainly achieved a great deal in unshackling the economy and integration into the world economy. However, there is an unfinished agenda of 'behind-the-border' reform still to be undertaken.

depends on a number of factors including the degree of trade complementarity between the member countries, the levels of non-FTA tariffs and the rules of origin (the criteria used in determining the eligibility for tariff concessions offered)
The relative importance attached by firms to 'service link' costs compared to labour cost is much more important in this new form of international exchange. This means that the overall business climate of the host country is the ultimate draw for investors in this area: just offering incentives for investors cannot compensate for the lack of such a base. International vertical integration of manufacturing naturally increases the risk associated with supply delays and disruptions in a given location within the production network, because it can bring the operation of the entire production network to a halt.

The ongoing process of global production sharing calls for a change in national data reporting systems, and analytical and statistical tools we use to measure and understand world trade and the trade-industry nexus. Linking trade data at the firm/establishment level with production data is vital for clearly identifying the niche areas of specialisation within global production systems and monitoring the achievement of the manufacturing industry in those areas. It is also important to improve/restructure the national data reporting system in order to better capture the growing importance of the role of services in manufacturing.

# Appendix

Table A.1: Parts and components, at the five-digit level of SITC Rev 3

SITC code	Product description	SITC code	Product description
58291	Cellular plastic sheet	71381	Spark-ign piston eng nes
58299	Non-cellular plast sheet	71382	Diesel engines nes
59850	Doped chemicals (electr)	71391	Parts nes spark-ign engs
61290	Leather manufactures nes	71392	Parts nes diesel engines
62141	Uh rubber tube no fittng	71441	Turbo-jets
62142	Uh metal-reinf rubr tube	71449	Reaction engines nes
62143	Uh text-reinf rubbr tube	71481	Turbo-propellers
62144	Uh nes-reinf rubber tube	71489	Other gas turbines nes
62145	Uh rubber tube + fitting	71491	Parts nes turbo-jet/prop
62921	Conveyor/etc belts v	71499	Parts nes gas turbines
62999	Uh non-cell rub articles	71610	Electric motors <37.5w
65621	Woven textile labels etc	71620	Dc motor(>37w)/generator
65629	Non-woven text label etc	71631	Ac,ac/dc motors >37.5w
65720	Non-woven fabrics nes	71632	Ac generators
65751	Twine/cordage/rope/cable	71651	Gen sets with pistn engs
65752	Knotted rope/twine nets	71690	Pts nes motors/generator
65771	Textile wadding nes etc	71819	Parts nes hydraul turbin
65773	Industrial textiles nes	71878	Nuclear reactor parts
65791	Textile hosepiping etc	71899	Parts nes of engines nes
65792	Machinery belts etc,text	72119	Agric machinery parts
66382	Asbestos manuf-friction	72129	Pts nes of machy of 7212
66471	Tempered safety glass	72139	Pts nes dairy machinery
66472	Laminated safety glass	72198	Parts wine/etc machines
66481	Vehicle rear-view mirror	72199	Pts nes agric machines
66591	Laboratory etc glass	72391	E-m bucket/grab/shovels
66599	Other glass articles nes	72392	Bulldozer etc blades
69551	Band saw blades	72393	Boring/sink machry parts
69552	Steel circular saw blade	72399	Pts nes earth-movg mach
69553	Circular saw blades nes	72439	Sew mch needles/furn/pts
69554	Chain saw blades	72449	Pts nes textile machines
69555	Straight saw bl for metl	72461	Auxil weave/knit machine
69559	Saw blades nes	72467	Weaving loom parts/acces
69561	Cutting blades for machn	72468	Loom/knitter etc pts/acc
69562	Carbide tool tips etc	72488	Parts for leather machns
69563	Rock etc drilling tools	72491	Washing machine parts
69564	Parts to insert in tools	72492	Textile machinry pts nes

SITC code	Product description	SITC code	Product description
69680	Knives and blades nes	72591	Paper manuf machine pts
69915	Base mtl vehicle fitment	72599	Paper product mach parts
69933	Base metal buckles etc	72635	Printing type,plates,etc
71191	Pts nes of boilers 711.1	72689	Parts of bookbind mchn
71192	Pts nes boiler equ 711.2	72691	Type-setting machn parts
71280	Stm turbine(712.1) parts	72699	Printing press parts
71311	Aircraft piston engines	72719	Cereal/dry legm mach pts
71319	Pts nes a/c piston engs	72729	Indus food proc mach pts
71321	Recip piston engs<1000cc	72839	Pts nes of machy of 7283
71322	Recip piston engs>1000cc	72847	Isotopic separators
71323	Diesel etc engines	72851	Glass-working machy part
71332	Marine spark-ign eng nes	72852	Plastic/rubber mach part
71333	Marine diesel engines	72853	Tobacco machinery parts
72855	Parts nes, machines 7284	74790	Tap/cock/valve parts
73511	Tool holder/slf-open die	74821	Ball/roll bearing housing
73513	Metal mch-tl work holder	74822	Bearing housings nes
73515	Dividing head/spec attach	74839	Iron/stl articulated link chain parts
73591	Pts nes metal rmvl tools	74840	Gears and gearing
73595	Pts nes mtl nonrmvl tool	74850	Flywheels/pulleys/etc
73719	Foundry machine parts	74860	Clutches/sh coupling/etc
73729	Roll-mill pts nes, rolls	74890	Gear/flywheel/cltch part
73739	Mtl weld/solder eq parts	74920	Metal clad gaskets
73749	Parts gas welders etc.	74991	Ships propellers/blades
74128	Furnace burner parts	74999	Mach parts nonelec nes
74135	Elect furnace/oven parts	75230	Digital processing units
74139	Parts ind non-el furn/ov	75260	Adp peripheral units
74149	Pts nes indus refrig equ	75270	Adp storage units
74155	Air-conditioners nes	75290	Adp equipment nes
74159	Air-conditioner parts	75991	Typewrtr parts,acces nes
74172	Water proc gas gen parts	75993	Dupl/addr mach parts etc
74190	Parts indus heat/cool eq	75995	Calculator parts/access.
74220	Piston eng fuel/wtr pump	75997	Adp equip parts/access.
74291	Pump parts	76211	Mtr vehc radio/player
74295	Liquid elevator parts	76212	Mtr vehc radio rec only
74363	Engine oil/petrol filter	76281	Other radio/record/play
74364	Engine air filters	76282	Clock radio receivers
74391	Parts for centrifuges	76289	Radio receivers nes
74395	Parts filters/purifiers	76432	Radio transceivers
74419	Trucks pts nes	76491	Telephone system parts
74443	Jacks/hoists nes hydraul	76492	Sound reprod equip parts

SITC code	Product description	SITC code	Product description
74491	Parts for winches/hoists	76493	Telecomm equipmt pts nes
74492	Lift truck parts	76499	Parts etc of sound equip
74493	Lift/skip h/escalat part	77111	Liquid dielec transfrmrs
74494	Lifting equip parts nes	77119	Other elec transformers
74519	Pts nes of tool of 7451	77125	Inductors nes
74529	Packing etc mchy pts nes	77129	Pts nes elec power mach.
74539	Weighng mach wts,pts nes	77220	Printed circuits
74568	Spraying machinery parts	77231	Fixed carbon resistors
74593	Rolling machine parts	77232	Fixed resistors nes
74597	Automatic vending machs	77233	Wirewound var resistors
74610	Ball bearings	77235	Variable resistors nes
74620	Tapered roller bearings	77238	Elect resistor parts
74630	Spherical roller bearing	77241	High voltage fuses
74640	Needle roller bearings	77242	Auto circuit breakr
74650	Cyl roller bearings nes	77243	Other auto circuit brkrs
74680	Ball/roller bearings nes	77244	Hi-volt isolating switch
74691	Bearing ball/needle/roll	77245	Limiter/surge prtect etc
74699	Ball etc bearng part nes	77249	Hi-volt equipment nes
74710	Pressure reducing valves	77251	Fuses (electrical)
74720	Pneumat/hydraulic valves	77252	Automatic circuit breakr
74730	Check valves	77253	Circuit protect equi nes
74740	Safety/relief valves	77254	Relays (electrical)
74780	Taps/cocks/valves nes	77255	Other switches
77257	Lamp holders	77831	Ignition/starting equipm
77258	Plugs and sockets	77833	Ignition/starting parts
77259	El connect equ nes<1000v	77834	Veh elect light/etc equ.
77261	Switchboards etc <1000v	77835	Veh elect light/etc part
77262	Switchboards etc >1000v	77861	Fixed power capacitors
77281	Switchboards etc unequip	77862	Tantalum fixd capacitors
77282	Switchgear parts nes	77863	Alum electrolyte capacity
77311	Winding wire	77864	Ceram-diel capacit sngle
77312	Co-axial cables	77865	Ceram-diel capacit multi
77313	Vehicle etc ignition wir	77866	Paper/plastic capacitor
77314	Elect conductor nes <80v	77867	Fixed capacitors nes
77315	El conductor nes 80–1000	77868	Variable/adj capacitors
77317	El conductor nes >1000v	77869	Electrical capacitr part
77318	Optical fibre cables	77871	Particle accelerators
77322	Glass electric insulator	77879	Parts el equip of 778.7
77323	Ceramic elect insulators	77881	Electro-magnets/devices
77324	Other electrc insulators	77882	Elec traffic control equ

SITC code	Product description	SITC code	Product description
77326	Ceram elec insul fit nes	77883	Elec traffic control pts
77328	Plastic el insul fit nes	77885	Electric alarm parts
77329	Other elec insul fit nes	77886	Electrical carbons
77423	X-ray tubes	77889	Elec parts of machy nes
77429	X-ray etc parts/access.	78410	Motor veh chassis+engine
77549	Electr shaver/etc parts	78421	Motor car bodies
77579	Parts dom elect equipment	78425	Motor vehicle bodies nes
77589	Domest el-therm app part	78431	Motor vehicle bumpers
77611	Tv picture tubes colour	78432	Motor veh body parts nes
77612	Tv picture tubes monochr	78433	Motor vehicle brake/part
77621	Tv camera tubes etc	78434	Motor vehicle gear boxes
77623	Cathode-ray tubes nes	78435	Motor veh drive axle etc
77625	Microwave tubes	78439	Other motor vehcl parts
77627	Electronic tubes nes	78535	Parts/access motorcycles
77629	Electrnic tube parts nes	78536	Parts/acces inv carriage
77631	Diodes exc photo-diodes	78537	Parts,acces cycles etc
77632	Transistors <1watt	78689	Trailer/semi-trailer pts
77633	Transistors >1watt	79199	Rail/tram parts nes
77635	Thyristors/diacs/triacs	79283	Aircraft launchers etc
77637	Photo-active semi-conds	79291	Aircraft props/rotors
77639	Semi-conductors nes	79293	Aircraft under-carriages
77649	Integrated circuits nes	79295	Aircraft/helic parts nes
77681	Piezo-elec crystals,mntd	79297	Air/space craft part nes
77688	Piezo-elec assmbly parts	81211	Radiators, parts thereof
77689	Electrnic compon pts nes	81215	Air heat/distrib equipmt
77812	Electric accumulators	81219	Parts for c-heat boilers
77817	Primary batt/cell parts	81380	Portable lamp parts
77819	Elec accumulator parts	81391	Glass lighting parts
77821	Elec filament lamps nes	81392	Plastic lighting parts
77822	Elec discharge lamps nes	81399	Lighting parts nes
77823	Sealed beam lamp units	82111	Aircraft seats
77824	Ultra-v/infra-r/arc lamp	82112	Motor vehicle seats
77829	Pts nes of lamps in SITC 7782	82113	Bamboo/etc seats/chairs
82119	Parts of chairs/seats	89395	Plastc furniture fittngs
82180	Furniture parts	89890	Musical instr parts/acc.
84552	Girdles/corsets/braces	89935	Cig lighter parts/access
84842	Headgear plaited	89949	Parts nes umbrella/canes
84848	Parts for headgear	89983	Buttons/studs/snaps/etc
87119	Binoc/telescope part/acc	89985	Slide fasteners
87139	Electron/etc diffr parts	89986	Slide fastener parts

SITC code	Product description	SITC code	Product description
87149	Microscopes parts/access	89129	War munitions/parts
87199	Parts/access for 8719	89191	Pistol parts/accessories
87319	Gas/liq/elec meter parts	89195	Shotgun/rifle parts nes
87325	Speed etc indicators	89199	Military weapon part nes
87329	Meter/counter parts/acc.	89281	Labels paper,paperboard
87412	Navigation inst parts/acc		
87414	Survey instr parts/acc.		
87424	Pts nes inst in SITC 8742		
87426	Meas/check instr parts/acc		
87439	Fluid instrum parts/acc		
87454	Mech tester parts/accs		
87456	Thermometer etc parts/acc		
87461	Thermostats		
87463	Pressure regulators/etc		
87469	Regul/cntrl inst parts/acc		
87479	Elec/rad meter parts/acc		
87490	Instrument part/acc nes		
88113	Photo flashlight equipmt		
88114	Camera parts/accessories		
88115	Flashlight parts/access		
88123	Movie camera parts/acc.		
88124	Movie projector part/acc		
88134	Photo equip nes part/acc		
88136	Photo,cine lab equip ne		
88422	Spectacle frame parts		
88431	Camera/etc objectiv lens		
88432	Objective lenses nes		
88433	Optical filters		
88439	Mounted opt elements nes		
88571	Instr panel clocks/etc		
88579	Clocks nes		
88591	Watch cases,case parts		
88592	Watch straps/bands metal		
88593	Watch strap/band non-mtl		
88597	Clock cases,case parts		
88598	Clock/watch mmnts unass		
88599	Clock/watch parts nes		
89111	Armoured tanks/etc		

#### Table A.2: Countries covered in the comparative analysis

1Australia35Argentina2Austria36Bangladesh3Belgium37Brazil4Canada38China5Denmark39China, Hong Kong SAR6Finland40Colombia7France41Costa Rica8Germany42India9Greece43Indonesia10Iceland44Malaysia11Ireland45Pakistan12Italy46Philippines13Japan47Russian Federation14Luxemburg48Singapore15Netherlands49South Africa16New Zealand52Thailand17Norway51Taiwan, China18Portugal52Thailand19Spain53Vietnam20SwetenItaliand21GwitzertandItaliand22TurkeyItaliand23United KingdomItaliand24USAItaliand25PolandItaliand26PolandItalian27Czech Rep.Italian28EstoniaItalian29HungaryItalian30IsraelItalian31KoreaItalian32MexicoItalian33SloveniaItalian34SloveniaItalian <t< th=""><th>OECD coun</th><th>tries (membership before 1990)</th><th>Developing</th><th>countries</th></t<>	OECD coun	tries (membership before 1990)	Developing	countries
2Austria36Bangladesh3Belgium37Brazil4Canada38China5Denmark39China, Hong Kong SAR6Finland40Colombia7France41Costa Rica8Germany42India9Greece43Indonesia10Iceland44Malaysia11Ireland45Pakistan12Italy46Singapore13Japan47Russian Federation14Luxemburg48Singapore15Netherlands50Srit Lanka16Noway51Taiwan, China17Noway51Taiwan, China18Portugal52Thailand19SwaichSuit Artica20Switzerland52Thailand21Inited KingdomSuit Artica22TurkySuitzerland23PolandSuitzerland24QanSuitzerland25PolandSuitzerland26SingaporeSuitzerland27SizerlandSuitzerland28PolandSuitzerland29HungarySuitzerland21SuitzerlandSuitzerland22SuitzerlandSuitzerland23BolandSuitzerland24SuitzerlandSuitzerland25Gerk Rep.Suitzerland <td< td=""><td>1</td><td>Australia</td><td>35</td><td>Argentina</td></td<>	1	Australia	35	Argentina
3Belgium37Brazil4Canada38China5Denmark39China, Hong Kong SAR6Finland40Colombia7France41Costa Rica8Germany42India9Greece43Indonesia10Iceland44Malaysia11Ireland45Pakistan12Italy46Philippines13Japan47Russian Federation14Luxenburg48Singapore15Netherlands49South Africa16New Zealand52Thailand17Noway53Vietnama18Portugal53Vietnama19Spain53Vietnama20Switzerland53Vietnama21United KingdomSitarika22TurkeySitarika23QiandSitarika24UsiSitarika25PolandSitarika26SitarikaSitarika27Scech Rep.Sitarika28EstoniaSitarika29HungarySitarika30IsraelSitarika31KoreaSitarika32MainganSitarika33SitarikaSitarika34SitarikaSitarika35SitarikaSitarika36SitarikaSitarika37 </td <td>2</td> <td>Austria</td> <td>36</td> <td>Bangladesh</td>	2	Austria	36	Bangladesh
4Canada38China5Denmark39China, Hong Kong SAR6Finland40Colombia7France41Colombia8Germany41Colombia9Greece43Indonesia10Iceland44Malaysia11Ireland45Pakistan12Italy46Philippines13Japan47Russian Federation14Luxemburg48Singapore15Netherlands49South Africa16New Zealand50Sri Lanka17Norway51Taiwan, China18Portugal53Vietnam20SwedenSiVietnam21Unike Kingdom53Vietnam22TurkeySiTaiwan, China23Uniter KingdomSiVietnam24USAUSASiCOCOUNTION (Sing Colspan="4">Si25PolandSi26AinaSiSi27Czech Rep.SiSi28EstoniaSiSi29HungarySiSi20KareaSiSi21MainaSiSi22VietnamSiSi23JoinaSiSi24SiSiSi25AinaSiSi26KareaSiSi	3	Belgium	37	Brazil
5Denmark39China, Hong Kong SAR6Finland40Colombia7France41Costa Rica8Germany42India9Greece43Indonesia10Iceland43Malaysia11Ireland45Pakistan12Italy46Philippines13Japan47Russian Federation14Luxemburg48Singapore15Netherlands49South Africa16New Zealand50Sri Lanka17Norway51Taiwan, China18Portugal53Vietnam20Sweiterland53Vietnam21Switzerland53Vietnam22TurkeySuitarkaSuitarka23Ointed KingdomSuitarkaSuitarka24USASuitarkaSuitarka25PolandSuitarkaSuitarka26ChileSuitarkaSuitarka27Zech Rep.SuitarkaSuitarka28StoniaSuitarkaSuitarka29HungarySuitarkaSuitarka31KoreaSuitarkaSuitarka32KoreaSuitarkaSuitarka33SloveniaSuitarkaSuitarka34SloveniaSuitarkaSuitarka34SloveniaSuitarkaSuitarka34SloveniaSuitarkaSuitarka <td>4</td> <td>Canada</td> <td>38</td> <td>China</td>	4	Canada	38	China
6Finland40Colombia7France41Costa Rica8Germany42India9Greece43Indonesia10Iceland44Malaysia11Ireland44Pakistan12Italy60Philippines13Japan47Russian Federation14Luxemburg48Singapore15Netherlands49South Africa16New Zealand50Sri Lanka17Norway51Taiwan, China18Portugal52Thailand19Spain53Vietnam20Sweten54Vietnam21Switzerland53Vietnam22Turkey54Sinapore23United Kingdom54Vietnam24USASinaiSinai25PolandSinaiSinai26AliaSinaiSinai27Zech Rep.SinaiSinai28StoniaSinaiSinai29HugaynSinaiSinai21SiraeiSinaiSinai22PolandSinaiSinai23SiteiniaSinaiSinai24SiteiniaSinaiSinai25HaigynSinaiSinai26SiraeiSinaiSinai27SiraeiSinai28SiraeiSinai <tr< td=""><td>5</td><td>Denmark</td><td>39</td><td>China, Hong Kong SAR</td></tr<>	5	Denmark	39	China, Hong Kong SAR
7France41Costa Rica8Germany42India9Greece43Indonesia10Iceland44Malaysia11Ireland45Pakistan12Italy46Philippines13Japan47Russian Federation14Luxemburg48Singapore15Netherlands49South Africa16New Zealand50Sri Lanka17Norway51Taiwan, China18Portugal53Vietnam20SwedenSaviSavi21Switzerland53Vietnam22TurkeySaviSavi23Quined KingdomSaviSavi24USASaviSavi25PolandSaviSavi26Cizec Rep.Savia27StoriaSavia28GistaiSavia29HungarySavia30IsraelSavia31KoreaSavia32MexicoSavia33SloveniaSavia34SloveniaSavia34SloveniaSavia	6	Finland	40	Colombia
8Germany42India9Greece43Indonesia10Iceland43Malaysia11Ireland45Pakistan12Italy46Philippines13Japan47Russian Federation14Luxemburg48Singapore15Netherlands49South Africa16New Zealand50Sri Lanka17Norway51Taixan, China18Portugal53Vietnam20SwedenSainSaina21Switzerland53Vietnam22TurkeySainaSaina23Obied KingdomSainaSaina24USASainaSaina25PolandSainaSaina26StoriaSainaSaina27StoriaSainaSaina28StoriaSainaSaina29HungarySainaSaina21SiralaSainaSaina23SiralaSiralaSaina24USASainaSaina25PolandSainaSaina26SiralaSainaSaina27SiralaSirala28SiralaSirala29HungarySaina30IsraelSaina31SiralaSirala32SiralaSirala33SiralaSirala34	7	France	41	Costa Rica
9Greee43Indonesia10Iceland44Malaysia11Ireland45Pakistan12Italy46Philippines13Japan47Russian Federation14Luxemburg48Singapore15Netherlands49South Africa16New Zealand50Sri Lanka17Norway51Taiwan, China18Portugal52Thailand19Spain52Thailand20Sweden52Thailand21Switzerland53Vietnam22Turky54Suterland23Ottek Kingdom54State24USASuterland54State25PolandSuterland54State26ChileSuterland54State27KoreaSuterland54State28BolniaSuterland54State29HungarySuterlandSuterland5431KoreaSuterlandSuterlandSuterland32StateSuterlandSuterlandSuterland29HungarySuterlandSuterlandSuterland31KoreaSuterlandSuterlandSuterland32StateSuterlandSuterlandSuterland33SloveniaSuterlandSuterlandSuterland34SloveniaSuterland </td <td>8</td> <td>Germany</td> <td>42</td> <td>India</td>	8	Germany	42	India
10leeland44Malaysia11Ireland45Pakistan12Italy46Philippines13Japan47Russian Federation14Luxemburg48Singapore15Netherlands49South Africa16New Zealand50Sri Lanka17Norway51Taiwan, China18Portugal52Thailand19Spain53Vietnam20Sweden21Switzerland53Vietnam22Turky23United Kingdom24USA25Poland26Chile27Estonia28Estonia29Hungary30Israel31Korea32Slovenia34Slovenia	9	Greece	43	Indonesia
11Ireland45Pakistan12Italy46Philippines13Japan47Russian Federation14Luxemburg48Singapore15Netherlands49South Africa16New Zealand50Sri Lanka17Norway51Taiwan, China18Portugal52Thailand19Spain53Vietnam20Switzerland53Vietnam21Switzerland54Vietnam22TurkeyVietnamVietnam23United KingdomVietnam24USAVietnam25PolandVietnam26ChileVietnam27Izech Rep.Vietnam28EstoniaVietnam29HungaryVietnam30IsraelVietnam31KoreaVietnam32MexicoVietnam33SloveniaVietnam34Slovak repVietnam	10	Iceland	44	Malaysia
12Italy46Philippines13Japan47Russian Federation14Luxemburg48Singapore15Netherlands49South Africa16New Zealand50Sri Lanka17Norway51Taiwan, China18Portugal52Thailand19Spain53Vietnam20Switzerland53Vietnam21Switzerland54Suitzerland22Turkey23United Kingdom24USAPoland25Poland-26Chile27Izech Rep28Estonia29Hungary30Israel31Korea32Mexico33Slovenia34Slovak rep	11	Ireland	45	Pakistan
13Japan47Russian Federation14Luxemburg48Singapore15Netherlands49South Africa16New Zealand50Sri Lanka17Norway51Taiwan, China18Portugal52Thailand19Spain53Vietnam20Sweden21Switzerland22Turkey23United Kingdom24USAPoland25Poland-26Chile27Czech Rep28Estonia29Hungary30Israel31Korea32Slovenia34Slovak rep	12	Italy	46	Philippines
14Luxemburg48Singapore15Netherlands49South Africa16New Zealand50Sri Lanka17Norway51Taiwan, China18Portugal52Thailand19Spain53Vietnam20SwedenVietnam21SwitzerlandVietnam22TurkeyVietnam23United KingdomVietnam24USAVietnamPoland25Poland26ChileVietnam27Zech Rep.Vietnam28EstoniaVietnam29HungaryVietnam30IsraelVietnam31KoreaVietnam32NexicoVietnam33SloveniaVietnam34Slovak repVietnam	13	Japan	47	Russian Federation
15Netherlands49South Africa16New Zealand50Sri Lanka17Norway51Taiwan, China18Portugal52Thailand19Spain53Vietnam20Sweden53Vietnam21Switzerland54Trakve22Turkey54State23United Kingdom54State24USA54StatePoland25Poland5426Chile54State27Zeach Rep.54Stonia28Estonia54Stonia30Israel54Stovenia31Korea54Stovenia33Slovenia54Stovenia34Slovak rep54Stovenia	14	Luxemburg	48	Singapore
16New Zealand50Sri Lanka17Norway51Taiwan, China18Portugal52Thailand19Spain53Vietnam20SwedenVietnam21SwitzerlandVietnam22TurkeyVietnam23United KingdomVietnam24USAVietnamCECD courser (new members)25PolandVietnam26ChileVietnam27Czech Rep.Vietnam28EstoniaVietnam30IsraelVietnam31KoreaVietnam32MexicoVietnam33SloveniaVietnam34Slovak repVietnam	15	Netherlands	49	South Africa
17Norway51Taiwan, China18Portugal52Thailand19Spain53Vietnam20Sweden53Vietnam21Switzerland	16	New Zealand	50	Sri Lanka
18Portugal52Thailand19Spain53Vietnam20Sweden53Vietnam21Switzerland22Turkey23United Kingdom24USAOECD courses (new members)25Poland-26Chile27Czech Rep28Estonia29Hungary30Israel31Korea32Bovnia34Slovak rep	17	Norway	51	Taiwan, China
19Spain53Vietnam20Sweden21Switzerland22Turkey23United Kingdom24USA <b>DECD course (new members)</b> 25Poland-26Chile-27Czech Rep28Estonia-29Hungary-30Israel-31Korea-32Bexico-33Slovenia-34Slovak rep-	18	Portugal	52	Thailand
20Sweden21Switzerland22Turkey23United Kingdom24USADECD courses (new members)25Poland26Chile27Czech Rep.28Estonia29Hungary30Israel31Korea32Mexico33Slovenia34Slovak rep	19	Spain	53	Vietnam
21Switzerland22Turkey23United Kingdom24USADECD courses (new members)25Poland26Chile27Czech Rep.28Estonia29Hungary30Israel31Korea32Mexico33Slovenia34Slovak rep	20	Sweden		
22Turkey23United Kingdom24USADECD course (new members)25Poland26Chile27Czech Rep.28Estonia29Hungary30Israel31Korea32Mexico33Slovenia34Slovak rep	21	Switzerland		
23United Kingdom24USADECD courses (new members)25Poland26Chile27Czech Rep.28Estonia29Hungary30Israel31Korea32Mexico33Slovenia34Slovak rep	22	Turkey		
24USA <b>DECD CUMPERS INFORMATION</b> 25Poland26Chile27Czech Rep.28Estonia29Hungary30Israel31Korea32Mexico33Slovenia34Slovak rep	23	United Kingdom		
OECD course (new members)25Poland26Chile27Czech Rep.28Estonia29Hungary30Israel31Korea32Mexico33Slovenia34Slovak rep	24	USA		
25Poland26Chile27Czech Rep.28Estonia29Hungary30Israel31Korea32Mexico33Slovenia34Slovak rep	OECD cour	tries (new members)		
26Chile27Czech Rep.28Estonia29Hungary30Israel31Korea32Mexico33Slovenia34Slovak rep	25	Poland		
27Czech Rep.28Estonia29Hungary30Israel31Korea32Mexico33Slovenia34Slovak rep	26	Chile		
28Estonia29Hungary30Israel31Korea32Mexico33Slovenia34Slovak rep	27	Czech Rep.		
29Hungary30Israel31Korea32Mexico33Slovenia34Slovak rep	28	Estonia		
30Israel31Korea32Mexico33Slovenia34Slovak rep	29	Hungary		
31Korea32Mexico33Slovenia34Slovak rep	30	Israel		
32     Mexico       33     Slovenia       34     Slovak rep	31	Korea		
33     Slovenia       34     Slovak rep	32	Mexico		
34 Slovak rep	33	Slovenia		
	34	Slovak rep		

	World					OECD <sup>1</sup>			Australia			
	Total manufacturing	Parts & components	Final assembly	GPN products	Total manufacturing	Parts & component	Final assembly	GPN products	Total manufacturing	Parts & components	Final assembly	GPN products
1988	1463528	376077	342342	718420	1218205	327681	290840	618522	4114	1040	602	1642
1989	1967031	558231	438772	997003	1525257	452037	357710	809747	4704	1147	697	1844
1990	2255933	650149	504669	1154818	1773545	529950	413108	943058	5802	1495	907	2402
1991	2344824	691184	528182	1219366	1827686	560424	431021	991445	6802	1780	1105	2885
1992	2675584	790541	589118	1379658	1963727	609088	466631	1075718	7455	1843	1267	3110
1993	2644322	804280	568042	1372322	1880264	602995	438727	1041722	8197	2160	1387	3547
1994	3046017	962932	635075	1598007	2135809	703517	479587	1183104	10145	2773	1635	4408
1995	3657013	1190336	717448	1907784	2518892	846464	531678	1378142	11851	3387	1851	5238
1996	3810288	1262311	764393	2026704	2568053	873899	553098	1426997	13081	3811	2300	6111
1997	4012783	1357583	819181	2176764	2673612	921883	593387	1515270	13816	4001	2813	6813
1998	4081493	1382537	864020	2246557	2721381	933739	626438	1560176	11150	3104	2028	5132
1999	4217931	1476759	898258	2375017	2917650	992246	679882	1672128	12169	3247	2748	5995
2000	4620355	1682106	969871	2651978	3063282	1082809	703201	1786010	14947	4425	3618	8044
2001	4429799	1531207	952583	2483790	2962016	996601	689842	1686443	14581	4225	3709	7934
2002	4696637	1590638	1019479	2610117	3063783	992579	720932	1713511	15342	4204	4196	8400
2003	5407406	1810202	1161852	2972054	3470941	1094848	808183	1903031	17094	4616	4207	8823
2004	6495261	2166221	1388219	3554440	4050868	1262728	929805	2192534	19165	5052	4525	9577
2005	7168326	2380461	1521496	3901956	4339325	1351960	979703	2331662	21378	5378	5178	10557
2006	8152631	2717822	1746734	4464555	4823057	1500360	1088349	2588710	21797	5653	4838	10491
2007	9308135	2640449	2059983	4700432	5201027	1368631	1195972	2564602	24835	5917	5503	11420

	World				OECD <sup>1</sup>			Australia				
	Total manufacturing	Parts & components	Final assembly	GPN products	Total manufacturing	Parts & component	Final assembly	GPN products	Total manufacturing	Parts & components	Final assembly	GPN products
2008	10186375	2805646	2214447	5020092	5567915	1437051	1238038	2675089	27272	6542	6586	13128
2009	8029468	2166695	1732583	3899278	4250038	1079061	878952	1958012	21936	5254	4373	9627
2010	9678840	2649826	2143171	4792998	4885260	1257048	1052669	2309717	25274	6291	4826	11117
2011	11174017	2984979	2400606	5385585	5575361	1423730	1186947	2610677	29509	7921	5313	13234
2012	11078029	2973461	2411445	5384906	5390594	1375641	1182481	2558122	30551	8236	5604	13840
2013	11467511	3091480	2454461	5545940	5479686	1389490	1190053	2579543	28570	7828	5450	13278
2014 <sup>2</sup>					5277437	1328776	1161294	2490070	27623	7671	5654	13325

Notes: (1) 25 'old' member countries (2) Data for world exports are incomplete

Source: UN Comtrade database and data CD from Council from Economic Planning and Development, Taiwan

### Table A.4: Export price indices

	Total manufacturing	Parts & components	Final assembly	Total GPN products
1992	102	145	111	120
1993	103	148	111	121
1994	104	150	112	123
1995	109	149	115	125
1996	108	139	116	123
1997	104	125	114	117
1998	100	115	109	111
1999	98	112	107	108
2000	98	110	106	107
2001	96	108	104	105
2002	96	105	102	103
2003	96	104	101	102
2004	98	102	100	101
2005	100	100	100	100
2006	101	99	99	99
2007	104	98	100	99
2008	109	96	102	101
2009	104	95	102	100
2010	107	94	102	99
2011	111	93	103	100
2012	112	92	104	100
2013	110	91	103	100
2014	110	91	102	99
2015	107	94	99	98

Notes: Average for the first three months

Source: Constructed by applying world trade shares to four-digit import price indices from the US Bureau of Labour database

#### Table A.5: World Manufacturing Exports at Constant (2005) prices (U\$ bn)

Year	Total manufacturing	Parts and components	Final assembly	Total GPN products
1988	1478	267	318	617
1989	1985	396	407	855
1990	2256	457	464	982
1991	2322	482	481	1026
1992	2624	545	533	1146
1993	2575	542	513	1130
1994	2923	641	567	1301
1995	3367	796	622	1526
1996	3526	906	660	1654
1997	3847	1089	721	1865
1998	4091	1205	790	2026
1999	4311	1319	839	2189
2000	4722	1531	915	2475
2001	4608	1424	915	2363
2002	4885	1510	999	2535
2003	5623	1739	1154	2923
2004	6605	2130	1383	3528
2005	7168	2380	1521	3902
2006	8034	2739	1762	4502
2007	8972	2694	2059	4726
2008	9364	2915	2162	4987
2009	7699	2287	1703	3910
2010	9008	2830	2111	4828
2011	10026	3211	2339	5393
2012	9923	3222	2326	5362
2013	10380	3381	2379	5555

Source: Derived by applying the price indices in Table A4 to export values in Table A3

SITC Code	Product description	1990/91	2000/01	2012/13
7843	Motor vehicle parts other than bodies	12.9	10.7	15.5
7725	Electrical apparatus for switching or protecting electrical circuits	2.3	2.5	3.3
7132	Engines for propelling vehicles	2.7	2.5	3.2
7139	Parts for internal combustion engines	2.3	1.9	3.1
7929	Aircraft parts (excluding tyres, engines and electrical parts)	3.8	2.8	3.1
7149	Parts of the engines and motors of reaction engines	2.2	2.5	3.0
7239	Parts of earth moving machines	1.4	1.2	2.2
7478	Taps/cocks/valves	1.3	1.0	2.1
7599	Parts/accessories of data processing/storage machines	6.6	6.5	2.0
7285	Parts of specialised industrial machinery	1.2	1.2	2.0
7726	Boards and panels for electrical control	0.8	0.7	1.9
7763	Diodes, transistors and similar semiconductor devices	0.8	1.3	1.9
7144	Reaction engines	1.0	1.5	1.6
7643	Transmission apparatus for radio-telephony/telegraphy/television	0.9	3.9	1.6
7783	Vehicle electric lights and parts	1.1	1.0	1.6
6956	Plates, sticks and tips for tools	1.1	0.9	1.6
7728	Switchgear parts	0.9	0.9	1.4
7649	Parts of sound recording equipment	2.2	2.2	1.2
7731	Insulated wire, cable electric conductors	1.8	1.9	1.2
7523	Digital processing units	3.0	2.8	1.1
5829	Non-cellular plastic sheet	0.7	0.6	1.1
7163	Parts of AC generators	0.7	0.6	1.0
7527	Data storage units	1.9	2.0	1.0
7788	Parts of electrical machinery	0.9	0.8	1.0
7781	Elec accumulator parts	0.6	0.7	1.0
7484	Gears and gearing	0.5	0.4	1.0
7449	Lifting equip parts	0.8	0.6	1.0
6299	Hard robber parts	0.5	0.6	1.0
7138	Diesel engines	0.5	0.5	1.0
7415	Air-conditioner parts	0.8	0.7	0.8
7438	Parts for fans/gas pumps	0.4	0.4	0.8
7429	Parts of pumps and liquid elevators	0.5	0.4	0.8
7169	Parts of motors/generators	0.4	0.4	0.8
8211	Parts of chairs/seats	0.5	0.7	0.8
7148	Gas turbines	0.6	0.6	0.7

## Table A.6: Commodity composition of parts & components exports of OECD countries<sup>1</sup> (per cent)

SITC Code	Product description	1990/91	2000/01	2012/13
7439	Parts of centrifuges and purifying machines	0.4	0.4	0.7
7529	Data-processing equipment	0.8	1.3	0.7
7479	Parts of valves, taps and cocks	0.3	0.3	0.6
6572	Non-woven fabrics	0.4	0.3	0.6
7165	Generators with piston engines	0.3	0.3	0.6
8746	Parts of automatic regulating or controlling instruments	0.4	0.4	0.6
7359	Parts for agricultural machinery	0.6	0.5	0.6
7461	Ball bearings	0.6	0.4	0.6
7219	Parts of agricultural machinery	0.4	0.2	0.6
7768	Electronic components (other)	0.5	0.8	0.6
7786	Electrical capacitor part	0.6	0.9	0.6
7472	Pneumatic/hydraulic valves	0.2	0.2	0.6
7919	Railway or tramway track fixtures and fittings	0.3	0.3	0.6
7722	Printed circuits	1.0	0.8	0.5
7742	X-ray equipment parts and accessories	0.3	0.3	0.5
7711	Parts of electronic transmitters	0.4	0.3	0.5
7119	Parts of broilers	0.5	0.4	0.5
7712	Parts of electrical power machinery.	0.4	0.5	0.5
7782	Parts of lamps	0.6	0.5	0.5
7422	Pistons for internal combustion machines	0.4	0.4	0.5
7526	Input or output units for automatic data-processing machines	2.7	2.1	0.5
7499	Machinery parts, not containing electrical connectors	0.4	0.4	0.5
8843	Mounted optical elements	0.2	0.3	0.5
8218	Furniture parts	0.3	0.3	0.5
7724	Electrical apparatus for switching or protecting electrical circuits	0.4	0.3	0.5
7481	Transmission shafts	0.3	0.3	0.5
	Other <sup>2</sup>	25.7	26.9	17.1
	Total	100	100	100
	US\$ billion	545	1,040	1,383

Notes: (1) Products are listed by ascending order based on export shares for 2012/13. Figures are two-year average (2) Twenty eight Nine 3-digit items, each of which accounts for less than 0.5 per cent of the total

Source: Compiled from the UN Comtrade database using the procedure discussed in Section 2

#### Table A.7: Commodity composition of final assembly exports from OECD<sup>1</sup> (per cent)

SITC Code	Product description	1990/91	2000/01	2012/13
7821	Motor vehicles for the transport of goods	30.8	31.5	32.8
7812	Passenger motor vehicles	26.0	27.2	28.9
7921–2	Aircrafts (SITC 7921 and 7922)	7.8	6.5	5.8
8722	Medical, surgical or veterinary science instruments	1.4	1.9	3.2
8744	Instruments and apparatus for physical or chemical analysis	1.0	1.1	1.7
7832	Semi-trailer tractors	1.0	1.4	1.7
7932	Ships, boats and other vessels	2.6	1.8	1.7
7522	Digital automatic data-processing machines	1.2	1.7	1.3
8742	Drawing, marking-out or mathematical calculating instruments	1.0	1.0	1.3
7712	Discharge tube ballasts	0.6	0.9	1.2
7638	Sound-recording/reproducing apparatus	1.9	1.4	1.1
8854	Pocket watches	0.7	0.5	1.1
7788	Electrical machinery and equipment	1.0	1.3	1.0
7741	Ultra-v/infra-red apparatus	0.6	0.7	0.9
8746	Automatic regulating or controlling instruments	0.5	0.7	0.8
7758	Non-carbon elements	0.9	0.7	0.7
8743	Lenses, prisms, mirrors and other optical elements	0.4	0.4	0.7
8853	Wrist-watches, pocket watches and other watches	0.4	0.2	0.7
8719	Optical instruments	0.2	0.5	0.7
8747	Oscilloscopes, spectrum analysers and other instruments	0.8	1.1	0.7
7742	X-ray generators	0.4	0.4	0.6
7822	Special motor vehicles	0.6	0.4	0.6
7612	Monochrome receivers	1.7	1.2	0.6
7851	Motorcycles	0.7	0.9	0.6
7648	Telecommunications equipment	1.5	0.4	0.6
7784	Hand electrical machine tools	0.7	0.6	0.6
8741	hydrological, meteorological or geophysical instruments	0.6	0.5	0.6
7931	Yachts and other vessels for pleasure or sports	0.5	0.5	0.5
	Other <sup>2</sup>	12.5	12.6	7.3
	Total	100	100	100
	US\$ billion	570	957	1,667

Notes: (1) Products are listed by ascending order based on export shares for 2012/13. Figures are two-year average; (2) Four-digit products, each of which accounts for less than 0.5 per cent of the total

Source: Compiled from the UN Comtrade database using the procedure discussed in Section 2

ISIC code	Product category	Value added (\$m)	Employment (number)	Labour Productivity (\$)	Real wage (\$)	R&D/Sale ratio <sup>1</sup>	Unit labour cost (\$)	Wage/value- added ratio (per cent)	Export/sales per cent	Import/sales per cent	Import penetration (per cent)
1723	Cordage, rope, twine and netting	35	469	74665	39520	0.0	0.64	54.0	3.4	41.7	30.2
1810	Wearing apparel, except fur apparel	1100	22610	50205	27711	0.2	0.66	55.5	8.2	380.1	79.4
1912	Luggage, handbags, etc	144	2328	62163	33164	0.0	0.64	54.3	0.3	18.6	15.7
2109	Other articles of paper and paperboard	942	7833	120878	63565	0.0	0.63	53.6	0.8	1.0	1.0
2222	Service activities related to printing	113	2057	54886	32910	0.0	0.72	60.8	0.9	6.8	6.4
2429	Other chemical products n.e.c.	2112	15480	136428	68100	0.8	0.60	50.9	0.1	0.2	0.2
2519	Other rubber products	536	4918	109041	58317	0.2	0.64	54.5	6.4	35.0	27.2
2520	Plastic products	2868	31640	90546	49113	0.8	0.65	55.2	0.3	2.6	2.5
2610	Glass and glass products	2246	19011	118100	61580	0.2	0.63	53.1	1.0	3.0	3.0
2691	Pottery, china and earthenware	151	2210	68430	38584	0.6	0.68	57.4	0.1	3.5	3.4
2699	Other non-metallic mineral products n.e.c.	480	5673	84626	43846	0.0	0.62	52.8	0.4	0.9	0.9
2812	Tanks, reservoirs and containers of metal	384	5352	71868	40916	0.2	0.69	58.1	0.1	0.4	0.4
2813	Steam generators	601	7110	84608	49803	1.7	0.71	60.0	0.1	0.9	0.9
2893	Cutlery, hand tools and general hardware	1596	19956	80019	46937	0.7	0.71	59.8	3.4	10.2	9.6
2899	Other fabricated metal products n.e.c.	2482	29151	85161	47671	0.6	0.67	57.1	0.4	1.4	1.4
2914	Ovens, furnaces and furnace burners	1526	17331	88264	55343	1.4	0.76	64.0	0.4	0.5	0.5
2919	Other general purpose machinery	1040	11938	87390	51377	2.2	0.71	60.0	6.3	44.1	32.0
2923	Machinery for metallurgy	388	5775	67170	41305	1.5	0.74	62.7	0.6	1.9	1.8

## Table A.8: Key performance indicators of non-RCA industries<sup>1</sup>, 2010–13, annual averages

ISIC code	Product category	Value added (\$m)	Employment (number)	Labour Productivity (\$)	Real wage (\$)	R&D/Sale ratio <sup>1</sup>	Unit Iabour cost (\$)	Wage/value- added ratio (per cent)	Export/sales per cent	Import/sales per cent	Import penetration (per cent)
2926	Machinery for textile, apparel and leather	735	8276	88869	50658	1.5	0.69	58.1	0.3	0.9	0.8
3000	Office, accounting and computing machinery	180	2320	77830	44844	5.3	0.70	58.8	10.2	49.7	35.6
3313	Industrial process control equipment	706	7259	97318	61796	5.2	0.77	64.8	1.5	79.4	44.7
3410	Motor vehicles	1560	16352	95145	61267	2.5	0.77	65.3	2.0	216.5	68.8
3420	Automobile bodies, trailers & semi- trailers	1086	14116	77020	42833	0.9	0.67	56.8	0.9	7.2	6.7
3591	Motorcycles	72	994	72606	40344	1.2	0.67	56.6	17.1	219.5	72.5
3610	Furniture	2768	39419	70161	38380	0.6	0.66	55.7	0.2	3.7	3.6
3692	Musical instruments	440	6540	67149	35433	1.9	0.64	53.6	0.2	1.5	1.4
3694	Games and toys	313	4697	66750	37818	0.1	0.68	57.7	0.0	45.0	31.1
3699	Other manufacturing n.e.c.	658	10386	62916	31461	0.8	0.60	50.9	0.1	0.2	0.2

Notes: (1) Industries of which parts and components and/or final assembly exports had an RCA index of above unity (RCA> 1) in 2012–13 (2) The data are annual average for 2010–12

Source: Compiled from ABS, Australian Industry Statistics (Cat. 8155.0) and Research and Developmental Statistics (Cat. 8104.0)

## References

ACOLA (Australian Council for Learned Academies (2015), Securing Australia's Future: The Role of Science, Research and Technology in Lifting Australia's Productivity, Canberra: ACOLA (www.acola.org.au).

ACTSE (Australian Academy of Technological Sciences and Engineering) (1988), *The Technology in Australia, 1788–1988*, Melbourne: ACTSE.

Arndt, Seven W. and A. Huemer (2007), 'Trade, Production Networks and Exchange Rate', Journal of Economic Asymmetries, 4(1), 11–39.

Arvis, Jean Francois, Mustra, M.A., Panzer, J., Ojala, L. and Naula, T. (2007), Connecting to Compete: *Trade Logistics in the Global Economy: The Logistic Performance Index and Its Indicators*, Washington DC: World Bank.

Athukorala Prema-chandra (2014) 'Global Production Sharing and Trade Patterns in East Asia', in Inderjit Kaur and Nirvikar Sing (Eds.), *The Oxford Handbook of the Economics of the Pacific Rim*, Oxford: Oxford University Press, 65–95.

Athukorala, Prema-chandra (2009) 'The Rise of China and East Asian Export Performance: Is the Crowding-out Fear Warranted?', *World Economy*, 32(2), 234–66.

Athukorala, Prema-chandra and Fahad Khan (2015) 'Global Production Sharing and the Measurement of Price Elasticity in International Trade', *Economics Letters* (forthcoming).

Athukorala, Prema-chandra and Archanun Kohpaiboon (2013), 'Australian-Thai Trade: Has the Free Trade Agreement Made a Difference?', *Australian Economic Review*, 44(4), 355–65.

Baier, Scott L., and Jeffrey H. Bergstrand (2007) 'Do free trade agreements actually increase members' international trade?', *Journal of International Economics*, 71(1), 72–95.

Balassa, Bela (1965), 'Trade Liberalisation and Revealed Comparative Advantage', *The Manchester School*, 33 (1), 99–123.

Baldwin, Richard, and Daria Taglioni (2011), 'Gravity chains: Estimating bilateral trade flows when parts and components trade is important', National Bureau of Economic Research (NBER) Working Paper, 16672, Cambridge: MAS: NBER

Bergeijk, Van Peter, and Steven Brakman (eds.) (2010), *The gravity model in international trade: Advances and applications*, Cambridge: Cambridge University Press.

Bhagwati, Jagdish N. (1984), "Splintering and Disembodiment of Services and Developing Nations". World Economy. 7:2. pp. 133–43.

Brash, Donald T (1966), *American investment in Australian industry*, Canberra: Australian National University Press,

Bremer Company (2015), *Australian Capabilities in Material Science and Technology: Intelligence Report* (study undertaken for Austrade), Canberra: Austrade.

Brown, Clair, and Greg Linden (2005), 'Offshoring in the Semiconductor Industry: A Historical Perspective', *in Lael Brainard and Susan M. Collins* (eds.), *The Brookings Trade Forum 2005: Offshoring White-Collar Work: The Issues and Implications,* Washington DC: Brooking Institution Press, 270–333.

Brun, Jean-Francois, C. Carr`ere, P. Guillaumont and J. de Melo (2005), "Has distance died? Evidence from a panel gravity model," *The World Bank Economic Review*, 19(1), 99–120.

Bryson, J. R. and Daniels, P. W. (2010), "Service worlds: the "Services Duality" and the rise of the "Manuservice" economy", in Maglio, P., Kieliszewski, C. & Spohrer, J. C. Eds. (2010), The Handbook of Service Science, Springer. Berlin. pp. 79–106.

Burstein, Ariel, Chrostopher Kurz and Linda Tesar, (2008), 'Trade, Production Sharing, and International Transmission of Business Cycles', *Journal of Monetary Economics*, 55:4, 775–795.

Butlin, S.J. (1955), The War Economy 1939–1942, Canberra: Australian War Memorial.

Butlin, S.J. and C.B. Schdvin (1977), The War Economy, 1942–1945, Canberra: Australian War Memorial.

Cairncross, Frances (2001), *The death of distance: How the communications revolution is changing our lives*, Cambridge, MAS: Harvard Business Press.

CEDA (The Committee for Economic Development of Australia) (2014), *Advanced Manufacturing beyond the Production Line*, Melbourne: CEDA, <u>http://www.ceda.com.au/</u>.

CEDA (The Committee for Economic Development of Australia) (2015), *Global Networks: Transforming how Australia does Business*, Melbourne: CEDA, www.ceda.com.au.=

Constantinescu, Cristina, Aaditya Matto and Michele Ruta (2014), 'Slow Down', *Finance & Development*, 51(4), 38–41.

Dean, Judith, Kwok Chiu Fung, and Zhi Wang (2011), 'Measuring Vertical Specialization: The Case of China', *Review of International Economics*, 19(4), 609–625.

Dornbusch, Rudigar (1992), 'The Case for Trade Liberalization in Developing Countries', *Journal of Economic Perspective*, 6(1), 69–85.

Dunning, John H. (2009), 'Location and the Multinational Enterprise: A Neglected Factor?', *Journal of International Business Studies*, 40(1), 5–19.

Egger, Peter (2005), "Alternative techniques for estimation of cross-section gravity models", Review of International Economics, 13(5), 881–91.

Evans, Carolyn L., and James Harrigan (2005). Distance, Time, and Specialization: Lean retailing in general equilibrium. American Economic Review, 95(1), 292–313

Finger, J. Michael and M. E. Kreinin (1979), 'A measure of "export similarity" and its possible uses', Economic Journal 89 (356): 905–12.

Golub, Stephen S., Ronald W. Jones and Henrik Kierzkwski (2007), 'Globalisation and Country Specific Service Links', *Journal of Economic Policy Reforms*, 10(2), 63–88.

Government of Australia (2012), Australia in the Asian Century White paper, Canberra: Prime Minister's Department.

Grapper, John A. (2007), 'A Clever Way to Build a Boeing', *Financial Ti*mes, 9 July.

Gray, John, Keith Skowrosky, Gokce Esenduran and M. Johnny Rungtusanatham (2013), 'The Reshoring Phenomenon: What Supply Chain Academic Ought to Know and Should Do', *Journal of Supply Chain management*,49(2), 27–33.

Gregory, Robert G. (1993), 'The Australian Innovation System', in R. R. Nelson (ed.) National Innovation Systems: A Comparative Analysis, New York: Oxford University Press, 324–352.

Grossman, Gene M. and Elhanan Helpman (1993), *Innovation and Growth in the Global Environment*, Cambridge, MAS: MIT press, 1993.

Grossman, Gene M. and Esteban Rossi-Hansberg (2013), 'Task trade between similar countries.' *Econometrica*, 80(2), 593–629.

Grunwald, Joseph, and Kenneth Flamm (1985), *The global factory: Foreign assembly in international trade*, Washington DC: Brookings Institution Press.

Hanson, Gordon H., Raymond J. Mataloni Jr, and Matthew J. Slaughter (2001), 'The Expansion Strategies of U.S. Multinational Firms', in Dani Rodrik and Susan Collins (eds.) Brookings Trade Forum 2001, Washington DC: Brookings Institution, 245–282.

Hanson, Gordon H., Raymond J. Mataloni Jr, and Matthew J. Slaughter (2005), "Vertical production networks in multinational firms", *Review of Economics and statistics*, 87(4), 664–678.

Hausman, Jerry A., and William E. Taylor (1981), 'Panel data and unobservable individual effects', Econometrica, 49(6), 1377–1398.

Head, Keith, and Thierry Mayer (2014), 'Gravity equations: Workhorse, toolkit, and cookbook' (2014) in Gopinath, Gita, Elhanan Helpman, and Kenneth Rogoff (eds.) *Handbook of international economics*. Vol. 4: Amsterdam: Elsevier, 131–193.

Helleiner, Gerald K. (1973), 'Manufactured Exports from Less-Developed Countries and Multinational Firms', *Economic Journal*, 83 (329), 21–47.

Helpman, Elhanan (1987), 'Imperfect Competition and International Trade: Evidence from Fourteen Industrial Countries', *Journal of the Japanese and International Economies*, 1(1), 62–81.

Helpman, Elhanan (2006), "Trade, FDI, and the Organization of Firms." *Journal of Economic Literature* 44(3), 589–630.

Helpman, Elhanan (2011), *Understanding Global Trade*, Cambridge, Mass: Harvard University Press.

Hill, Hal and Bruce McKern (1993), 'Australia', in John H. Dunning (ed.), Governments, Globalisation, and International Business, Oxford: Oxford University Press, 202–243.

Hoekman, Bernard (ed.) (2015), The Global Trade Slowdown: A New Normal?, A VoxEU. Org eBook.

Hughes, Helen (1977), 'Technology Transfer: The Australian Experience', in Tamir Agmon and Charles P. Kindleberger (eds.), *Multinationals from Small Countries*, Cambridge, MAS: MIT Press, 101–127.

Hummels, David (2002), 'Review of Fragmentation: New production pattern in the world economy by S.W. Arndt and H. Kierzkowskei', Journal of Economic Geography 2, 368–369.

Hummels, David (2007), 'Transport Costs and International Trade in the Second Era of Globalisation', *Journal of Economic Perspectives*, 21(2), 131–154.

Hummels, David (2009), 'Trends in Asian Trade: Implications for Transport Infrastructure and Trade Cost', in Douglas H. Brooks and David Hummels (eds.), *Infrastructures Role in Lowering Asia's Trade Costs: Building for Trade*, Cheltenham: Edward Elgar, 17–36.

Hummels, David, J. Ishii and Kei-Mu Yi (2001). 'The Nature and Growth of Vertical Specialization in World Trade', *Journal of International Economics*, 54(1), 75–96.

Hutchinson, Diane (2014), 'Manufacturing' in Simon Ville and Glen Withers (eds.), *The Cambridge Economic History of Australia*, Cambridge: Cambridge University Press, 287–308.

Johnson, Robert C., and Guillermo Noguera (2012), 'Accounting for Intermediates: Production Sharing and Trade in Value Added', *Journal of International Economics*, 86(2), 224–236.

Jones, Ronald W. (2000), *Globalisation and the Theory of Input Trade*, Cambridge, Mass.: MIT Press.

Jones, Ronald W. and Henryk Kierzkowski (2001), 'A Framework for Fragmentation' in Seven Arndt and henryk Kierzkowski (eds.), Fragmentation: New Production Patterns in the World Economy, Oxford: Oxford University Press, 17–34.

Jones, Ronald W. and Henryk Kierzkowski (2004). 'Globalisation and the consequences of international fragmentation' in R. Dornbusch, G. Calvo& M.

Obstfeld (eds.), *Money, Factor Mobility and Trade: Essays in in Honor of Robert A. Mundell*, Cambridge, Mass.: MIT Press, 365–381.

Kindleberger, Charles (1967), *Europe's Postwar Growth: The Role of Labour Supply*, Cambridge, Mass: Harvard University Press.

Koopman, Robert, Zhi Wang and Shang-Jin Wei (2014), 'Tracing Value-Added and Double Counting in Gross Exports', *American Economic Review*, vol. 102, no. 2, pp. 459–494.

Krause, Lawrence B. (1984), 'Australia's Comparative Advantage in International Trade', in *Richard E. Caves and Lawrence B. Krause (eds.), The Australian Economy: A View from The North, Sydney: George Allen & Unwin, 275–312.* 

Krugman, Paul R. (1995), Growing World Trade: Causes and Consequences', *Brooking Papers on Economic Activity*, 25th Anniversary Issue, 27–77.

Krugman, Paul R. (2008). Trade and Wages, Reconsidered. *Brookings Papers* on *Economic Activity 1: Macroeconomics*. pp. 103–138.

Li, Hui-Hong JK, and Kim Hua Tan (2004), 'SMEs' business growth model: a medium to big effort.', International Journal of Management and Enterprise Development 1(3), 195–207.

Lodefalk, M. (2012). "Servicification of Manufacturing — Evidence from Sweden". International Journal of Economics & Business Research.

Majeed, Omer (2015) 'Global Production Sharing: Patterns and Determinants', paper presented at the Academy of International Business Conference, October, Milan.

Mattoo, Aditya, Zhi Wang and Shang-Jin Wei (eds.) (2013), *Trade in Value Added: Developing New Measures of Cross-Border Trade*, Washington DC: World Bank.

McLean, Ian W. (2013), *Why Australia Prospered: Shifting Sources of Economic Growth*, Princeton, NJ: Princeton University Press.

Neely, Andy (2008), 'Exploring the financial consequences of the servitization of manufacturing', *Operations Management Research* 1 (2), 103–118.

Ng, Francis and Alexander Yeats (2003), 'Major Trade Trends in Asia: What are the Implications for Regional Cooperation and Growth?', Policy Research Working Paper 3084, Washington DC: World Bank.

Nunn, Nathan (2007), 'Relationship-Specificity, Incomplete Contracts, and the Patterns of Trade', *Quarterly Journal of Economics*, 122(2), 569–600.

Pilat, D. & Wölfl, A. (2005), "Measuring the Interaction Between Manufacturing and Services". OECD Science, Technology and Industry Working Papers. 2005–5. OECD.

Productivity Commission (2014), *Trade and Assistance Review 2012–13*, Canberra: Productivity Commission.

Roos, Goran (2014), 'The Constantly Changing Manufacturing Context' in The Committee for Economic Development in Australia (CEDA), *Advanced Manufacturing: Beyond the Production Line*, Melbourne: CEDA, 31–52.

Roos, G. & Murrie, R. (2012), "South Australia's Manufacturing Strategy — succeeding in a high cost environment". Australian Manufacturing Technology — AMT. November. 2012. pp. 18–19.

Ruwane, Frances and Holger Gorg (2001), 'Globalisation and Fragmentation: Evidence for the Electronics Industry in Ireland', in Seven Arndt and Henryk Kierzkowksi (eds.), *Fragmentation: New Production Patterns in the World Economy*, Oxford: Oxford University Press, 17–34.

Serlenga, Laura, and Yongcheol Shin (2007), 'Gravity Models of Intra-EU Trade: Application of the CCEP-HT Estimation in Heterogeneous Panels with Unobserved Common Time-Specific Factors', *Journal of Applied Econometrics*, 22 (3), 361–381.

Shih, Stan (1996), *Me-too is not my Style: Challenge Difficulties*, Taipei: Acer Foundation.

Spenser, Barbara J. (2005), International Outsourcing and Incomplete Contracts', *Canadian Journal of Economics*, 38(4), 1107–1135.

Srinivasan, T.N. (1999), 'Trade Orientaion, Trade Liberalization, and Economic growth', in Garry Saxphouse and T.N. Srinivasan (eds,), *Development, Duality and International economic Regime: Essay in Honor of Gustav ranis,* Ann Arbor: University of Michigan Press, 155–196.

Tinbergen, Jan (1962), 'Appendix VI: An Analysis of World Trade Flows', in Jan Tinbergen, *Shaping the World Economy: Suggestions for International Economic Policy*, New York: Twentieth Century Fund.

Wells, Louis T. and Alvin G. Wint (2000), *Marketing a Country: Promotion as a Tool for Attracting Foreign Investment*, Washington DC: World Bank/International Finance Corporation.

Wilkins, Mira (1970), *The emergence of multinational enterprise: American business abroad from the colonial era to 1914*. Vol. 34. Cambridge, Mass: Harvard University Press, 1970.

Withers, Glenn, Nitin Gupta, L. Curtis and N. Larkins (2015), *Australia's Comparative Advantage*, Report for the Australian Council for Learned Academics, (www.acola.org.au).

WTO (2015), World Trade Report 2015, Geneva: WTO.

Yeats, Alexander (2001), 'Just how Big is Global Production Sharing?', in *Fragmentation: New Production Patterns in the World Economy*, SW Arndt and H Kierzkowski (eds), pp. 108–43. New York: Oxford University Press.

Yi, Kei-Mu (2003), 'Can vertical specialization explain the growth of world trade', *Journal of Political Economy*, 111 (1), 52–102.

Young, Allyn (1928), Increasing Returns and Economic Progress. *Economic Journal*. 38. pp. 527–542.

Yuskavage, Robert E. (2013), 'Integrating Value Added Trade Statistics into the System of National Accounts: Perspectives from the US Bureau of Economic Analysis' in Mattoo, Aditya, Zhi Wang and Shang-Jin Wei (eds.) (2013), *Trade in Value Added: Developing New Measures of Cross-Border Trade*, Washington DC: World Bank, 331–335.