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Global Production Sharing:
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Abstract: Global production sharing — cross-border dispersion of production processes within vertically integrated global industries — has been an increasingly important structural feature of economic globalization in the recent decades. This paper examines patterns and determinants of global production sharing with an emphasis on how Australian manufacturing fits into global production networks (GPNs). Though Australia is a minor player in GPNs, there is evidence that Australian manufacturing has a distinct competitive edge in specialized, skill-intensive tasks in several industries such as aircrafts, medical devices, machine tools, measuring and scientific equipment, and photographic equipment. Specialization in high-value-to-weight components and final goods within GPNs, which are suitable for air transport, helps Australian manufacturing to overcome the 'tyranny of distance' in world trade. Being predominantly 'relationship-specific', Australian GPN exports are not significantly susceptible to real exchange rate appreciation

Key words: Australian manufacturing, global production sharing, global production networks, gravity model

JEL Codes: F11, F14, F23, M16

Global Production Sharing: Exploring Australia's Competitive Edge[1]

1. Introduction

Cross-border dispersion of production processes within vertically integrated global industries, which we label 'global production sharing' in this study[2], has been an increasingly important structural feature of economic globalization in recent decades. This process of international division of labour opens up opportunities for countries to specialize in different slices (tasks) of the production process in line with their relative cost advantages. As the production processes are finely sliced across a wide range of industries, new opportunities for specialisation within global production networks (GPNs) are created. Given this structural shift in global production, the conventional approach to analyzing 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. With the rapid expansion of global production sharing, parts and components (middle products), technical and managerial knowhow, and capital have become increasingly mobile across national boundaries, making trade patterns increasingly sensitive to inter-country differences in trade and investment policies (Jones and Kierzkowski 2004).

The 787 Dreamliner 'produced' by the Boeing Corporation, USA has become an eye-catching illustrative case of how countries are engaging in an intricate web of production-sharing arrangements (Gapper 2007). Offshore production accounts for 70% of the many thousands of parts used in assembling the jet. Boeing itself is responsible for only about 10% by value of the aircraft, tail fin and final assembly, but holds rights to the 787 technology. There are 43 parts and component suppliers spread over 135 production sites around the world.

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[1] This paper draws on Athukorala and Talgaswatta (2016). We are grateful to Jagath Dissanayaka, Hal Hill, Abrie Swanepoel, Russell Thomson, Glenn Withers and Nobuaki Yamashita for comments on the draft of the original report.

[2] The alternative terms used in the recent international trade literature include global production sharing, international production fragmentation, intra-process trade, vertical specialization, slicing the value chain, and offshoring.

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. Some parts are produced in foreign affiliates of the Boeing Corporation, while others are supplied under subcontracting arrangements. This pattern of 'outsourced production' around the world is in sharp contrast to the Boeing's parochial emphasis on procuring components domestically: only about 1% of the Boeing 707 was built outside the US in the 1950s. Boeing is now focussing on its own specific 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 has 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 Boeing 787.

The purpose of this paper is to examine the patterns and determinants of global production sharing with an emphasis on the implications for the performance and structural change in Australian manufacturing. The study is motivated by the growing emphasis in the contemporary policy debate in Australia on the country's industrial future in the aftermaths of the cessation of the commodity boom (ACOLA 2015, PC 2014, Withers et al 2015, CEDA 2014 & 2015, Government of Australia 2012). Notwithstanding this policy emphasis, 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 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 *Annual Survey of Business Characteristics* conducted by the Australian Bureau of Statistics (ABS)[3] are consistent with this findings: Only 1.8% of all manufacturing firms on average were engaged in integrated supply chains over the period from 2005-06 to 2013-14.

[3] http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/8167.02013-14?OpenDocument.

The paper is structured as follows: Section 2 provides a stage-setting analytical overview of the process of global production sharing and emerging opportunities for countries to specialize in line with their relative cost advantage. Section 3 discusses the methodology, the procedure followed in delineating trade based on global production sharing (henceforth referred to as 'GPN trade'[4]) from total manufacturing trade flows using data extracted from the United Nations (UN) trade database (*UN Comtrade*). Section 4 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 5 using the standard gravity modelling framework to examine the determinants of inter-country differences in the degree of involvement in GPN trade. Section 6 summarizes the key findings and draws policy inferences.

2. Global production sharing

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 the 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 affiliates of US MNEs 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 from the early 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

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[4] Trade in parts and components and final assembly within production networks arising from global production sharing

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. [5]

Until about the early 1970s, production sharing was basically a two-way exchange between the home and host countries undertaken by multinational enterprise (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 have begun 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, have begun to undertake final assembly by procuring components globally through arm's-length trade, benefitting from the ongoing process of standardization of parts and components.

These developments suggest that an increase in production-sharing based trade in a given country may or may not be associated with an increase in the 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

[5] In recent years, the popular press has begun to pay attention to the phenomenon of 'reshoring' (also termed 'reverse offshoring' or 'onshoring'), shifting back by MNEs of manufacturing facilities from overseas locations to the home country. However, whether this is a new structural phenomenon or simply media hype of some isolated cases against the backdrop of the political rhetoric in the USA of 'bringing back manufacturing home' is yet to be seen (Gray et al 2013).

of new cluster-related activities and specialised support services (Dunning 2009, Ruwane and Gorg 2001, Wells and Wint 2000).

The expansion of global production sharing has been driven by three mutually reinforcing developments (Helpman 2010, Jones 2000, Jones and Kierzkowski 2004, Yi 2003). First, rapid advancements in production technology have enabled the industry to slice up the value chain into finer, 'portable' components. 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, liberalization 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, in a slice/task of the production chain operates with a smaller price-cost margin, the profitability could be erased by even a small tariff.

There is an important two-way link between improvement in technological innovations in communication and transportation, 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.

Policy issues

Global production sharing opens up opportunities for countries to participate in a finer international division of labour. Factor intensities of the given tasks/segments of the production process and the prices of the required 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. 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. By contrast, product design, manufacturing of key components (such as LCDs and memory chips) and establishment of brand names come with high entry barriers because such activities requires large capital and high level of manufacturing capabilities.

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* (Spencer 2005, Helpman 2011).

Why should policy makers pay particular attention to global production sharing as part of 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 (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 for domestic manufacturing. The very nature of the process of global production sharing is the continuous shaking-up of the 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 joining GPNs has the potential to yield growth externalities (spillover effects) through the transfer of technology and managerial know-how and skill development.

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. When production is fully integrated (that is, when a given product is produced in a single location), achieving scale economies is natural limited by the demand for the end product in the given country.

Third, specialisation in parts and components within production networks has the potential to help overcome ‘tyranny of distance’, trade cost disadvantage arising from the geographic distance to the major markets. The process global production sharing opens up opportunities to specialise in high-value-to-weight components and specialised final assembly in the value chain for which air shipment is the major mode of transport (Hummels 2009)

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 cost (Gregory 1993, Krause 1984, McLean 2013, Hutchinson 2014).

3 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 network trade. There has been a remarkable expansion of production sharing 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 the 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 the 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.

Parts and components are delineated from the reported trade data using a list compiled by mapping parts and components in the UN Broad Economic Classification (BEC) with the Standard International Trade Classification (SITC) at the five-digit level of commodity disaggregation. The product list of the Word Trade Organization (WTO) Information Technology Agreement Information was used to fill gaps in the BEC list of parts and components. The part and component list is given in Athukorala and Talgaswatta 2016, Appendix A-1.

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 the 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 parts and components 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 the standard intermediate goods historically account for a large share of total manufactured exports.

There is no hard and fast rule for distinguishing in international trade data between products assembled within global production networks and other traded goods that are produced from beginning to the end in a given country. 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, which are directly identified based on our list, and the total trade of these product categories.

Guided by the available literature on production sharing,[6] we identified seven product categories: 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

[6] See Krugman (2008) and the works cited therein.

that these product categories contain virtually no products produced from start to finish in a given country (Krugman 2008). The difference between the value of total trade of these catteries and the value of total parts and components falling under these categories was treaded as the value of final assembly. 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 (Productivity Commission 2014, Koopman et al. 2013, Johnson and Noguera 2012). The underlying rationale for using value added trade data is that, in a 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[7] and the geographic profile of its global trade linkages. In other words, value added trade data are useful only for the accurate measurement of bilateral trade imbalances and measure the impact of economic shocks stemming from final export destination countries on a given trading nation.

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 the industry policy point of view, what is important for understanding a country's engagement in global production sharing is gross trade, separated into parts and components (rather than intermediate goods in the conventional sense) and trade in final assembly. Under global production sharing, a country specializes 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

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[7] 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 value added trade analysis (Lamy 2013).

chain. Domestic value addition evolves over time as the country becomes well integrated into the value chain.[8]

4. Australian manufacturing in global production networks

Trends

Data on manufacturing exports from Australia, disaggregated into components, final assembly and total GPN exports, are plotted in Figure 1. 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% to 23.1%. During the ensuing years exports slowed, with greater degree of volatility. By 2013/14 the share of manufacturing in total merchandise export had declined to 12.4%. Interestingly exports of GPN products, however, 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% to 47.5% 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 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 that trade within production networks, in particular parts and components trade, has some structural peculiarities that could weaken the impact of real exchange rate (relative price) changes.

There are reasons to expect the impact of real exchange rate appreciation to be much weaker (or even zero for) in GPN trade for the following reasons (Jones and Kierzkowski 2004; 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 specialize in specific tasks. Therefore, the substitutability of parts and components sourced from various sources is

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

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 production process, its export profitability depends not only on external demand and the domestic cost of production, but also on supply conditions in the countries supplying parts and components, the bilateral exchange rates between them, and magnitude of the share of import content in exported goods. Changes in exchange rates also 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.

Australia is a small player in world manufacturing trade (Table 1). Its share in total world manufacturing remained around 0.28% during the period under study without showing any trend. However, Australia's share in world exports of GPN products increased from 0.22% to 0.25% between 1990/01 and 2012/13, underpinned by an increase in the share of parts and components, from 0.24% to 0.28%. Australia's share of total manufacturing exports of OECD countries increased from 0.35% to 0.54% between these years, with the share of GPN exports increasing from 0.27% to 0.36%.

The share of parts and components in total manufacturing exports from Australia, varied in the rage of 23-30% during 1988-2014, showing a clear upward trend from about 2006 (Figure 2). 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 trend in the past three years. On the import side we see the 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%) with a mild upward trend (Figure 7 in Athukorala and Talgaswatta 2016). These contrasting patterns are consistent with the general factor proportion characteristic of parts and components production 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.

Commodity profile

The data on the commodity profile of parts and components, and final assembly exports from Australian manufacturing exports are summarised in Tables 2 and 3, in terms of three indicators: percentage composition, share in world trade and the reveal comparative advantage index (RCA). The RCA index measures Australia's export performance in a given product compared to its category's overall performance in world trade. It is simply the ratio of the word market share of a given product exported from Australia to Australia's share in total world manufacturing exports.[9]

Among the parts and component exports, the product class of aircraft parts and components (SITC 7929) stands out for its impressive growth performance. Its share in Australia's total parts and components exports increased from 8.2% in 2000/01 to 13.4% in 2012/13 (Table 2). In 2012/13, Australia accounted for 1.7% of total world exports of aircraft components, compared to 0.6% in 2000/01. As measured by the RCA index, in 2012/13 Australia's share of world exports of aircraft parts and components was almost 6 times of the Australian share in world manufacturing exports, compared to 2.1 times in 1990/91.

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 (See Appendix).

The other products that have indicated notable increases in exports shares are parts of earth moving machines (SITC 7239), transmission apparatus for radio-telephony (SITC 7643), mineral processing machines (SITC83) and various machine tool (SITC 7429). Automobile parts (SITC 7843) accounts for the second largest share in exports after aircraft parts, but this share has declined from 10.8% to 8.8% between 2000/01 and 20012/13.

Overall, there has been an increase in the degree of concentration of parts and component exports in the more dynamic products listed above. Their share in total parts and

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[9] 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. When the value of RCA exceeds (is below) unity, country *i* is said to have a revealed comparative advantage (comparative disadvantage) in commodity *j* (Balassa 1965). This measure must be used with some caution because domestic policy measures such as production subsidies, or foreign trade barriers 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 Australian manufacturing trade during the period under study, with the notable exception of the automobile industry.

component exports increased from 79.1% in 1990/91 to 92.7% in 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) (with the notable exception of automotive parts) and miscellaneous manufacturing (SITC 8).

Among the final assembly exports, Motor vehicles (SITC 7821: goods transport vehicles and 7812: passenger cars) still account for over a half of the total assembly exports, but their share has declined in recent years. Also the RCA index of automobile is less than unity (Table 3). This evidence 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.[10] However, 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), engine parts (SITC 7189) and valves (SITC 7429).

The most notable export share gains are associated with medical equipment and measuring instruments. Between 1990/01 and 2012/13, the shares of mechanotherapy exports increased from 0.3% to 7.3%, and that of medical and surgical instruments increased from 2.5% to 5.6%. In 2012/13 Australia accounted for 5.5% of the total world exports of mechanotherapy appliances, up from 0.3% in 1990/91. The share of light aircraft (<2000kg) accounted for 3.6% of total final goods exports, compared to 1.2% in in 1990/91. Australia's share in world light aircrafts exports increased from 1.1% to 3.6% between 1990/91 and 2012/13.

Various categories of measuring, scientific, and medical/surgical equipment have recorded increases in their shares in total GPN final exports from Australia as well as in total world exports. As in the case with component exports, a comparison across all GPN final products show 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 commodity concentration of final assembly exports. The share of unclassified products in Table 3 declined from 24.5% in 1990/01 to 15.9% in 2012/13.

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[10] Automobile industry has also been the largest beneficiary of various industry assistance programs of the Australian government (PC 2014).

Australia-OECD export similarity/difference

How does the commodity composition of GPN exports from Australia compare with that of OECD countries? The Finger-Kreinin export-similarity index is a useful summary measure of for addressing this issue (Finger-Kreinin 1972).[11] The index calculated for Australian and OECD exports of total manufacturing, parts and components and final assembly are plotted in Figure 3. 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 have continuously widened since then. The prime driver behind the growing dissimilarities has been the emerging patterns of Australia's parts and components exports.

A comparison of the data on the commodity composition of Australian manufacturing exports (Tables 2 and 3) with that of OECD countries (Tables A-6 and A-7 in Athukorala and Talgaswatta 2016) help understand the sources of widening divergence of the Australian GPN exports patterns from the OECD patterns. Auto parts (SITC 7843) is the single most important item on the parts and components export list of OECD countries. This item accounted for 15.5% of total parts and components exports from these countries, up from 12.9% in 1990/01. Auto 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 the changes in the product mix noted earlier, resource-based manufacturing industries (products belonging to SITC 6) and heavy machinery industries (roughly SITC codes 71 to 75) still account for a larger share of Australian's GPN final assembly exports. Products in which GPN trade has been heavy concentrated in OECD countries such as

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[11] The index is defined by the formula

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

where 'a' and 'b' denote two countries (or country group) 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 (that is, for each are identical *Xi*(*ac*) > 0, *Xi*(*bc*) = 0, and vice versa) the index will take on a value 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.

telecommunication and sound recording equipment (SITC 76), electrical machinery (SITC 77), professional and scientific equipment (SITC 87), and photographic equipment (SITC 88) do not still figure prominently in the Australian export product mix. Medical and surgical equipment accounts for a relatively larger share of GPN final assembly exports from Australia compared to the OECD average patterns.

Direction of exports

There has been a notable shift in the source-country composition of GPN trade from advanced industrial countries to countries in East Asia (Athukorala 2014). Has this structural shift reflected in the geographic profile of Australian exports? This issue is central to the contemporary Australian policy focus on reaping gains from the East Asian economic dynamism.

OECD countries still account for over half of total GPN exports, with the US continuing to remain the largest single destination (Figure 4), The East Asian share of total GPN exports from Australia is significantly larger (27.7% in 2012-13), compared to the OECD average (16.2%). However, there is no evidence of a notable East Asian bias in GPN exports from Australia, given its proximity to the region. The East Asian share of Australian GPN exports has varied in the range of 27% to 33% over the period 2000-14 without showing any clear upward trend in line with East Asia's growing importance in global production sharing. The share of exports to China has varied in the narrow range of 4% to 5.3% over the past 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. 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).

A notable feature of final assembly exports is the significant share (24.4%) 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 to these countries too have 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).

5 Determinants of Exports

In this section we undertake an econometric analysis of the determinants of manufacturing exports, distinguishing among parts and components, final assembly and conventional (horizontal) products. The analysis is undertaken within the standard gravity modelling framework, which has now become the 'workhorse' for modelling bilateral trade flows.[12] We estimate the export equation separately for total manufacturing and the three product categories by including intercept and slope dummy variables to examine how Austrian performance differ 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.

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,

$$lnEXP_{ijt} = \alpha + \beta_1 lnSBV_{it} + \beta_2 lnDBV_{jt} + \beta_3 DST_{ijt} + \beta_4 lnPGDP_{it} + \beta_5 lnRER_{ijt} + \beta_6 lnTECH_{it} + \beta_7 FTA_{ij} + \beta_8 INST_{it} + + \beta_9 lnLPI_{ijt} + \beta_{10} ADJ_{ij} + \beta_{11} CML_{ij} + \beta_{12} CLK_{ij} + \beta_{13} EUD_{ij} + \beta_{14} EAD_{ij} + \beta_{15} AFC_{ij} + \beta_{16} GFC_{ij} + \eta_t + \epsilon_{ijt}$$

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 (+)

[12] 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) provides and extensive survey of the relevant literature.

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

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 unity 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

η_t A set of time dummy variables to capture year-specific 'fixed' effects

ε A stochastic error term, representing the omitted influences on bilateral trade

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 the 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 2004, Grossman and Rossi-Hansberg 2013). 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 for 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 including 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-crossing 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 (RPGDP) 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. More developed countries also have better ports and communication systems that facilitate production sharing by reducing the cost of maintaining 'services links' (Golub *et al*. 2007).

Real exchange rate *(RER)*, measured as the 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 modelling, this variable is expected to have a positive impact on bilateral trade flows. However, as discussed (Section 3) we hypothesize this impact to be weaker (or even zero) for GPN trade.

Technological capabilities (*TECH*) is a key determinant of a country's ability to move from low-value assembly activities to high-value upstream and down-street 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). 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 the 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.

Data and the estimation method

The model is estimated using annual data compiled from the exporter records in the UN trade data system (*Comtrade* database) during the period 1996-2013. The data set covers export trade of 44 countries each of which accounted for 0.01% or more of total world manufacturing exports in 2005. These countries account for over 98% of total world manufacturing exports. The trade data in nominal US$ 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 4.

Of the three standard panel data estimation methods (pooled OLS, random-effects, and fixed-effects estimators), the fixed effect estimator is not appropriate for estimating the model because it contains a number of time-invariant explanatory variables, which are central to our analysis. In experimental runs, we used both pooled OLS estimator and random-effects estimator (REE). The Breusch-Pagan Lagrange Multiplier test favoured the use of RE over the OLS counterpart. However RE 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 (Brun et al 2005; Baier and Bergstrand 2007). Given these concerns, we re-estimated the model by 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 inside the model to capture various dimensions of the data. Its superiority of HTE over REE in generating consistent coefficient estimates of the gravity model has been demonstrated by a number of recent studies.[13]

General inferences

The preferred Hausman and Tayler Estimator estimates of the trade equation are reported in Table 5. The coefficient estimates for Australia derived from the overall regression are given in Table 6. 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. The alternative RE estimates are reported in Appendix Table A-1 for comparison.

[13] See Egger (2005) and Serlenga and Shin (2007), and the works cited therein.

The coefficients of the standard gravity variables (SBV, DBV 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).

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 components 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 weaken 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 the perverse 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 generally more technology intensive compared to final assembly.

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*)[14] 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 GNP 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 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.[15] 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, with the exception of parts and components, after controlling for the other explanatory variables, in particular the *FTA* dummy.

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[14] 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.

[15] 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.

Australia-Specific inferences

The coefficients of most of the dummy interaction variables are not statistically significant (Table 6). 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 '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% 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% 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.

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. The coefficient of the parts and comments 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[16] 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 a mere 0.04.

6 Concluding remarks

Global production sharing has become an integral part of the global economic landscape over the past few decades. Australia is still a minor player in global production sharing, but at the disaggregated levels we can observe a number of promising signs. There are early signs of Australian manufacturing reaping gains from joining the 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.

Australia seems to have a distinct competitive edge in parts and components specialisation in several product categories: aircrafts and associated equipment, parts of earth moving and mineral processing machines, and specialised automotive parts. Among final assembly products, Australia seems to have a competitive edge in medical and surgical equipment, light aircrafts, measuring and scientific equipment, and instruments for chemical analysis. In summary, the findings of the commodity-level analysis suggests that the ongoing process of global production sharing has opened up opportunities for Australia to specialise in high-value-to-weight 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. 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 domestic technological capabilities is relatively more important compared to the average global experience in determining components exports from Australia.

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[16] 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).

The econometric analysis and the analytical narrative of export patterns suggest that 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 ‘relation-specific’ and are based on long-term supplier-producer relationship. This evidence suggests that reaping gains from Australia’s comparative advantage in primary commodity (resource-based) trade and from specialisation in knowledge-intensive tasks within global production networks are not conflicting policy goals for Australia. We also find that the FTA membership has so far not helped expansion of manufacturing exports from Australia.

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.

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 industry’s struggle to attract and retain talent while potential customers and policy makers continue to sidestep the potential opportunities. The government industry bodies should improve the perception of manufacturing, by highlighting the achievement 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 2 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, as extensively discussed in these studies there are still many unresolved problems relating to the overall investment climate. Given the importance of 'service link' cost, 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.

Finally, 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 specialization 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.

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Table 1: Summary data of manufacturing exports: Australia - OECD Comparison

	Total manufacturing	Parts & components	Final assembly	GPN products	Other manufacturing
OECD share in world exports (%)					
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 (%)					
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					
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 (%)					
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 (%)					
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

Note: 1. Countries which became OECD member before 1990.

Source: Compiled from UN Comtrade database in current US$

Table 2: Parts and components exports from Australia: Composition, world market share and revealed comparative advantage (RCA)[1] (%)

SITC code	Product description	Composition (%)			Share of world exports (%)			RCA index		
		1990/91	2000/01	2012/13	1990/91	2000/01	2012/13	1990/91	2000/01	2012/13
7929	Aircraft parts (excluding tyres and electrical parts)	8.2	7.6	13.3	0.6	1.0	1.7	2.1	2.9	5.8
7843	Motor vehicle parts other than bodies	10.2	10.8	8.8	0.2	0.4	0.2	0.8	1.0	0.7
7239	Parts of earth moving machines	3.1	2.8	8.6	0.6	0.8	1.4	2.1	2.4	4.7
7599	Parts/accessories of data processing/storage machines	9.2	13.5	7.1	0.3	0.4	0.6	1.2	1.3	2.2
7643	Transmission apparatus for radio-telephony	1.4	2.0	3.7	0.4	0.1	0.2	1.4	0.4	0.6
7283	Parts of machines for mineral processing	0.9	1.3	2.9	1.1	2.7	3.0	3.8	7.8	10.3
7132	Engines for propelling vehicles	9.8	4.6	2.4	1.0	0.6	0.3	3.4	1.8	1.0
7429	Parts of pumps and liquid elevators	1.0	0.8	2.2	0.6	0.7	1.1	2.0	2.1	3.9
7725	Electrical apparatus for switching/protecting electrical circuits	2.2	3.8	2.0	0.3	0.5	0.2	0.9	1.3	0.7
6956	Plates, sticks and tips for tools	0.7	0.9	1.8	0.2	0.3	0.4	0.6	0.9	1.5
7285	Parts of specialised industrial machinery	0.9	2.0	1.8	0.2	0.6	0.4	0.7	1.8	1.3
7726	Boards and panels for electrical control	0.5	0.5	1.7	0.2	0.2	0.3	0.6	0.6	1.0
7139	Parts for internal combustion engines	3.6	1.9	1.6	0.4	0.3	0.2	1.5	1.0	0.7
7724	Reciprocating positive displacement pumps	1.2	1.0	1.6	0.8	1.3	1.3	2.7	3.7	4.6
7478	Taps/cocks/valves	0.5	0.5	1.6	0.1	0.2	0.3	0.3	0.5	0.9
7919	Railway or tramway track fixtures and fittings	0.4	0.3	1.3	0.4	0.3	0.9	1.5	1.0	2.9
7523	Digital processing units	2.1	1.3	1.2	0.2	0.2	0.2	0.7	0.5	0.6
7783	Accessories of motor vehicles except bodies	0.8	0.6	1.2	0.2	0.2	0.2	0.7	0.6	0.8
7449	Parts for lifting, handling and loading machinery	0.9	0.8	1.2	0.3	0.5	0.5	1.1	1.3	1.7
7529	Data-processing equipment	0.8	1.2	1.0	0.2	0.3	0.4	0.9	0.9	1.2
7649	Parts of sound recording equipment	1.0	2.7	0.9	0.1	0.3	0.1	0.3	0.8	0.5
6299	Hard rubber parts	0.5	0.3	0.9	0.3	0.2	0.3	0.9	0.5	1.1
7763	Diodes, transistors and similar semiconductor devices	0.3	0.6	0.9	0.1	0.1	0.1	0.3	0.3	0.3
7788	Parts of electrical machinery	1.0	1.3	0.9	0.3	0.5	0.2	1.0	1.4	0.8
7731	Insulated wire, cable electric conductors	3.1	2.2	0.9	0.4	0.3	0.1	1.5	0.8	0.4

7484	Gears and gearing and other speed changer	0.6	0.1	0.9	0.4	0.1	0.4	1.3	0.2	1.3
7189	Engines and motors for electric rotary converters	0.2	0.1	0.8	0.4	0.5	1.0	1.4	1.5	3.5
6648	Vehicle rear-view mirror	1.0	0.9	0.8	4.5	4.2	2.1	16.1	12.3	7.2
7728	Parts suitable for electrical apparatus	0.7	0.6	0.8	0.2	0.2	0.2	0.8	0.6	0.7
7489	Parts of Gear/flywheel/clutches	0.4	0.3	0.7	0.5	0.5	0.6	1.6	1.6	2.2
7526	Input or output units for automatic data-processing machines	0.7	0.6	0.7	0.1	0.1	0.2	0.2	0.2	0.8
7439	Parts of centrifuges and purifying machines	0.3	0.3	0.7	0.2	0.3	0.4	0.8	0.9	1.4
8741	Parts of surveying and navigating instruments	0.3	0.3	0.7	0.4	0.8	1.0	1.3	2.5	3.4
7479	Parts of valves, taps and cocks	0.5	0.4	0.7	0.5	0.4	0.4	1.8	1.3	1.2
7527	Data storage units	0.1	0.3	0.7	0.0	0.0	0.1	0.0	0.1	0.3
8912	Parts of military equipment	0.2	0.0	0.7	0.1	0.1	1.5	0.5	0.2	5.1
8749	Parts and accessories for other machines and appliance	1.6	1.3	0.7	4.0	3.6	1.5	14.1	10.5	5.0
7149	Parts of the engines and motors of reaction engines	1.5	0.2	0.6	0.2	0.0	0.1	0.7	0.1	0.3
7499	Machinery parts, not containing electrical connectors	0.5	0.7	0.6	0.3	0.6	0.5	1.1	1.8	1.8
7415	Air-conditioner parts	0.8	1.0	0.6	0.3	0.4	0.2	1.0	1.3	0.7
7853	Parts and accessories of cycles	0.0	0.3	0.6	0.0	0.2	0.3	0.0	0.6	1.0
7148	Gas turbines	0.3	0.3	0.5	0.2	0.2	0.3	0.6	0.6	1.1
7219	Parts of agricultural machinery	0.8	0.5	0.5	0.6	0.7	0.4	2.2	1.9	1.2
7787	Parts of electrical machines and apparatus	0.2	0.6	0.5	0.4	0.7	0.4	1.3	1.9	1.3
	Other[2]	24.5	25.6	15.9	0.2	0.2	0.2	1.1	0.7	0.3
	Total	100	100	100	0.26	0.28	0.3	0.89	0.82	1.02
	Total $ million	1,628	4,325	8,032						

Note: (1) Products are listed by ascending order based on export shares for 2012/13. Figures are two-year averages.

(2) Four-digit items, each of which accounts for less than 0.5% of the total value.

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

Table 3: Final assembly exports from Australia: Composition, world market share and revealed comparative advantage (RCA)[1] (%)

SITC code	Product description	Composition (%)			World export share (%)			RCA index		
		1990/01	2000/01	2012/13	1990/01	2000/01	2012/13	1990/01	2000/01	2012/13
7821	Motor vehicles for the transport of goods	25.7	29.2	28.9	0.2	0.4	0.3	0.6	1.2	0.9
7812	Passenger motor vehicles	24.5	28.3	25.3	0.2	0.5	0.3	0.7	1.4	0.9
8723	Mechanotherapy appliances[2]	0.3	0.8	7.3	0.3	1.4	5.5	1.0	4.1	18.7
8722	Medical, surgical or veterinary science instruments	2.5	3.4	5.6	0.4	0.8	0.6	1.3	2.3	1.9
7921-22	Aircrafts <2000kg	1.2	1.4	3.6	0.7	1.2	2.4	2.5	3.6	8.0
8744	Instruments/apparatus for physical or chemical analysis	2.7	2.1	3.1	0.6	1.0	0.6	2.2	2.8	2.2
7522	Digital automatic data-processing machines	3.5	0.6	2.1	0.4	0.1	0.1	1.5	0.3	0.3
7788	Electrical machinery and equipment	0.9	1.3	2.0	0.2	0.4	0.3	0.6	1.2	1.1
8742	Drawing, marking-out or mathematical calculating instruments	0.5	0.6	1.6	0.1	0.3	0.4	0.4	0.8	1.3
8741	hydrological, meteorological or geophysical instruments	0.3	0.8	1.6	0.1	0.8	1.0	0.4	2.2	3.4
7931	Yachts and other vessels for pleasure or sports	5.0	1.7	1.4	2.0	1.6	0.9	6.9	4.8	3.1
7638	Sound-recording/reproducing apparatus	0.3	0.4	1.1	0.0	0.1	0.2	0.1	0.2	0.5
7648	Telecommunications equipment	0.6	0.3	0.9	0.1	0.3	0.4	0.3	1.0	1.3
8745	Measuring, controlling and scientific instruments	0.2	0.2	0.9	0.1	0.3	0.7	0.5	0.9	2.5
8746	Automatic regulating or controlling instruments	0.1	0.3	0.8	0.1	0.2	0.3	0.2	0.5	0.9
8842	Drawing, marking-out or mathematical calculating instruments	0.3	0.2	0.8	0.2	0.3	0.5	0.6	0.9	1.8
7932	Ships, boats and other vessels	6.1	4.0	0.8	0.4	0.7	0.1	1.5	1.9	0.2
7758	Electro-thermic appliances	0.9	0.4	0.8	0.2	0.2	0.2	0.6	0.5	0.5
7741	Electro-diagnostic (other than radiological) apparatus	0.5	0.4	0.7	0.2	0.3	0.3	0.6	0.8	0.9
7712	Microphones and stands therefor	1.2	0.4	0.7	0.4	0.1	0.1	1.3	0.4	0.4
7642	Wrist-watches, pocket watches and other watches	0.2	0.3	0.7	0.0	0.2	0.2	0.2	0.4	0.7
7832	Semi-trailer tractors	0.1	0.4	0.6	0.0	0.1	0.1	0.1	0.4	0.3
8743	Lenses, prisms, mirrors and other optical elements	0.2	0.2	0.6	0.1	0.2	0.3	0.4	0.7	1.0

8747	Oscilloscopes, spectrum analysers and other instruments	0.9	1.2	0.6	0.3	0.6	0.3	0.9	1.7	0.9
7822	Special-purpose motor vehicles	0.6	0.3	0.5	0.2	0.4	0.3	0.8	1.1	0.9
	Other[3]	21.9	20.6	7.3	0.3	0.6	0.2	1.1	1.6	0.8
	Total	100	100	100	0.2	0.4	0.3	0.7	1.2	0.0
	US$ million	1,331	5,096	7,193						

Note: (1) Products are listed by ascending order based on export shares for 2012/13. Figures are two-year averages.

(2) Appliances used for exercise prescribed for heel-drop exercises for Achilles tendon injury.

(3) Four-digit items, each of which accounts for less than 0.5% of the total value.

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

Table 4: 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, 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 (at CIF price, US$): compiled from UN COMTRADE database 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 2000 price).	World Development Indicator database, The World Bank.
DST	Weighted distance measure of 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: $RER_{ij} = NER_{ij} * \frac{P_j^D}{P_i^W}$ 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_{ij} indicates improvement (deterioration) in country's international competitiveness relative to country j.	Constructed using data from World Bank, World development Indicators database. The mean-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 performance).	World Governance Indicators database, World Bank http://data.worldbank.org/data-catalog/worldwide-governance-indicators
LPI	World Bank logistic performance index. 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).	LPI database, World Bank 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

Table 5: Determinants of manufacturing exports[1]

Variables	Total manufacturing	Parts & components	Final assembly	Conventional (horizontal) exports
Ln Real GDP (RGDP), reporter[2]	1.23*** (0.03)		1.81*** (0.06)	1.03*** (0.03)
Ln Real GDP (RGDP), partner[3]	1.38*** (0.03)		2.14*** (0.06)	1.19*** (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*** (0.06)	-0.81*** (0.10)	-1.09*** (0.10)	-0.95*** (0.05)
Ln Relative per capital GDP (RPGDP)	-0.00** (0.00)	-0.01*** (0.00)	0.01*** (0.00)	-0.01*** (0.00)
Ln Bilateral real exchange rate (RER)	0.01*** (0.00)	-0.01 (0.00)	-0.01* (0.01)	0.01*** (0.00)
Ln Technology base, reporter (TECH)	0.07*** (0.01)	0.22*** (0.01)	0.05*** (0.02)	0.09*** (0.01)
FTA membership dummy (FTA)	0.34*** (0.02)	0.47*** (0.04)	0.69*** (0.05)	0.22*** (0.02)
Institutional quality (INST), reporter	-0.06*** (0.01)	0.04** (0.02)	-0.05** (0.02)	-0.05*** (0.01)
Ln Logistic quality (LPI), reporter	0.93*** (0.12)	1.02*** (0.18)	1.16*** (0.24)	0.79*** (0.13)
Contiguity dummy (ADJ)	-0.03 (0.21)	-0.44 (0.35)	-0.60* (0.36)	0.11 (0.18)
Common language dummy (CML)	0.38*** (0.13)	0.70*** (0.23)	0.15 (0.22)	0.48*** (0.11)
Colony dummy (CLK)	-0.32 (0.22)	0.12 (0.37)	-0.93** (0.39)	0.01 (0.20)
European Union dummy (EU)	-0.13 (0.15)	0.40 (0.24)	-0.30 (0.27)	-0.17 (0.14)
East Asia dummy (EAS)	1.68*** (0.18)	1.97*** (0.31)	1.79*** (0.32)	1.37*** (0.16)
Constant	-51.47*** (1.18)	-47.06*** (1.31)	-87.70*** (2.23)	-40.77*** (1.17)
Australia dummy (AD) variables				
AD*RGDP, Australia	-0.03 (0.32)		-1.22** (0.62)	0.14 (0.33)
AD*RGDP, partner	-0.22 (0.24)		-1.24*** (0.47)	0.09 (0.25)
AD*RMF, reporter		1.09 (1.48)		
AD*RMF partner		-0.23 (0.21)		
AD*RPGDP	-0.00 (0.01)	0.04*** (0.01)	0.00 (0.02)	-0.01 (0.01)
AD*RER	0.05* (0.03)	0.09** (0.04)	0.06 (0.05)	0.07*** (0.03)
AD*TECH	0.17 (0.26)	0.67 (0.50)	1.27** (0.50)	0.40 (0.27)
AD*FTA	-0.56*** (0.15)	-0.53*** (0.20)	-0.97*** (0.29)	-0.53*** (0.15)

AD**INST*	0.27 (0.18)	0.94*** (0.28)	0.32 (0.35)	0.14 (0.19)
AD*LPI	1.29 (3.23)	-2.78 (5.12)	7.36 (6.36)	3.45 (3.40)
AD*CML	0.26 (0.60)	0.41 (1.03)	0.88 (1.05)	0.08 (0.53)
AD*CLK	0.70 (1.74)	0.90 (2.72)	1.41 (3.06)	0.36 (1.56)
AD	26.91*** (10.42)	-14.42 (33.24)	53.94*** (19.63)	16.80* (10.30)
Observations	30,570	24,546	30,100	30,060
Number of country pairs	1,845	1,672	1,843	1,838

Notes:

1. 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

2. Real manufacturing output (RMF) for parts and components and GDP for final assembly and total exports of country *i*

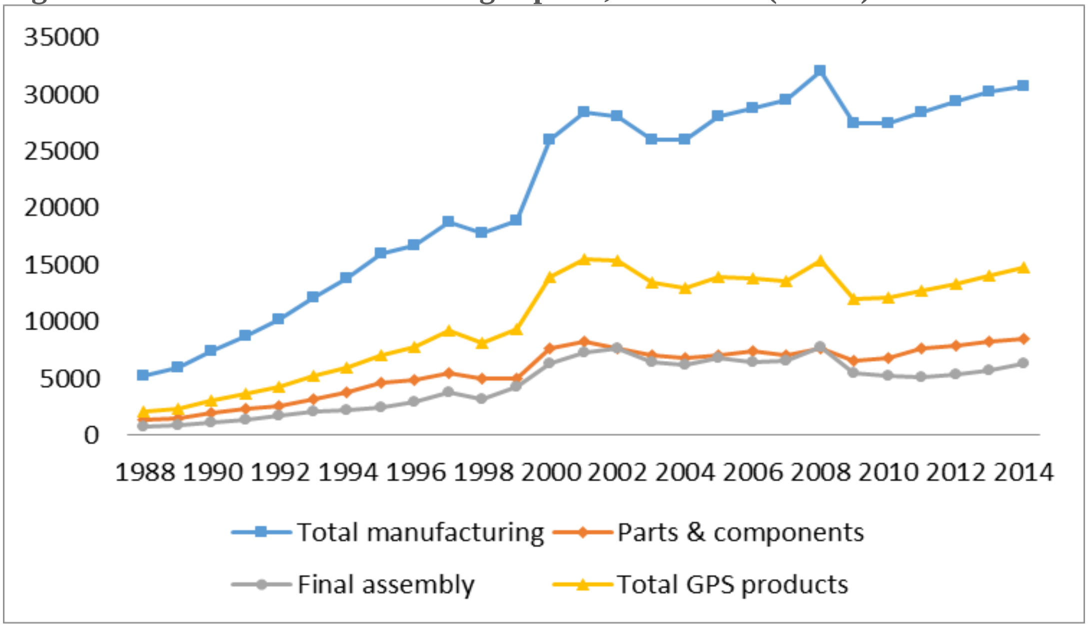
3. Real manufacturing output (RMF) for parts and components and GDP for final assembly and total exports of country *j*

Table 6: Determinants of manufacturing exports: Australia specific results[1]

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*** (0.73)	-1.94 (1.17)	-2.05* (1.29)	-4.30*** (0.66)
Ln Relative per capital GDP (*RPGDP*)	-0.01 (0.01)	0.03*** (0.01)	0.01 (0.02)	-0.02 (0.01)
Ln Bilateral real exchange rate (*RER*)	0.06*** (0.02)	0.07* (0.04)	0.04 (0.05)	0.08*** (0.03)
Ln Technology base, reporter (*TECH*)	0.14*** (0.02)	0.43*** (0.03)	0.10*** (0.04)	0.18*** (0.01)
FTA membership dummy (*FTA*)	-0.22 (0.15)	-0.06 (0.20)	-0.28 (0.29)	-0.30* (0.15)
Institutional quality (*INST*), Australia	0.22 (0.18)	0.98*** (0.28)	0.27 (0.35)	0.09 (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 (1.73)	1.03 (2.70)	0.48 (3.04)	0.37 (1.55)

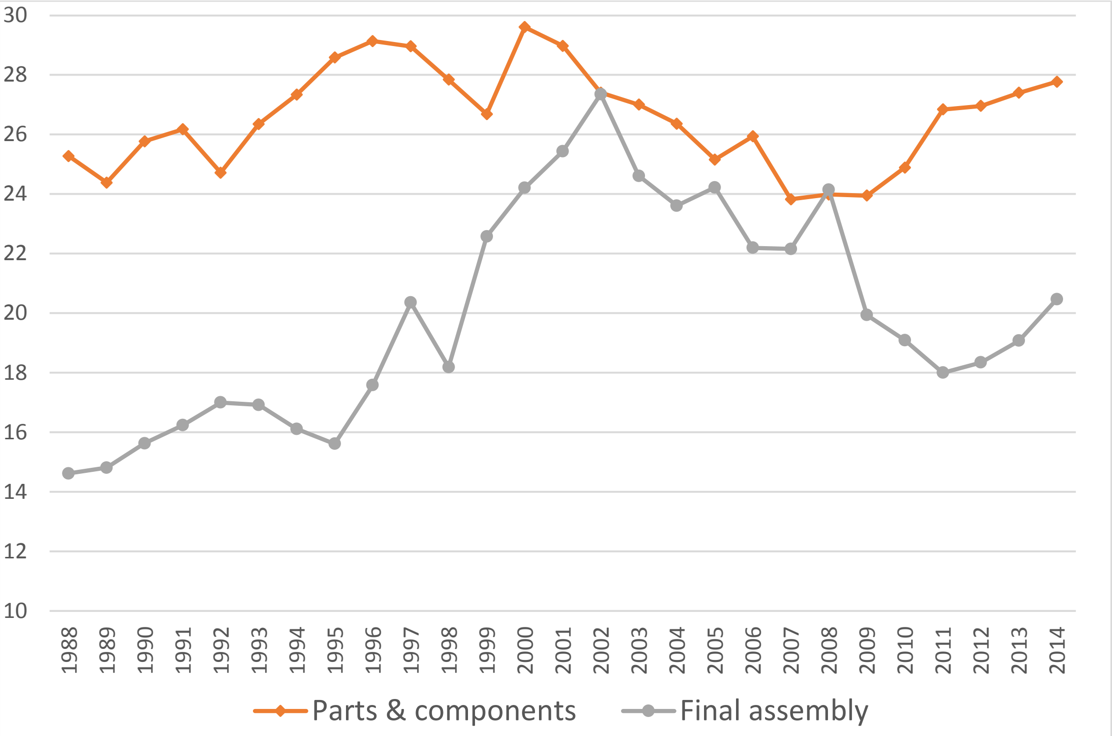
Notes:
1.The results reported in this table are derived from the overall regressions reported in Table 6. The coefficients are the linear combinations of each of the base coefficient and the coefficient of the Australia dummy. The standards errors (derived from the covariance of the two coefficients) are given in brackets. The statistical significance of the regression coefficients is denoted as *** p<0.01, ** p<0.05, * p<0.10.
2. Real manufacturing output (RMF) for parts and components and GDP for final assembly and total exports of country *i*
3. Real manufacturing output (RMF) for parts and components and GDP for final assembly and total exports of country *j*

Figure 1: Australian manufacturing exports, 1988-2013 (A$mn)



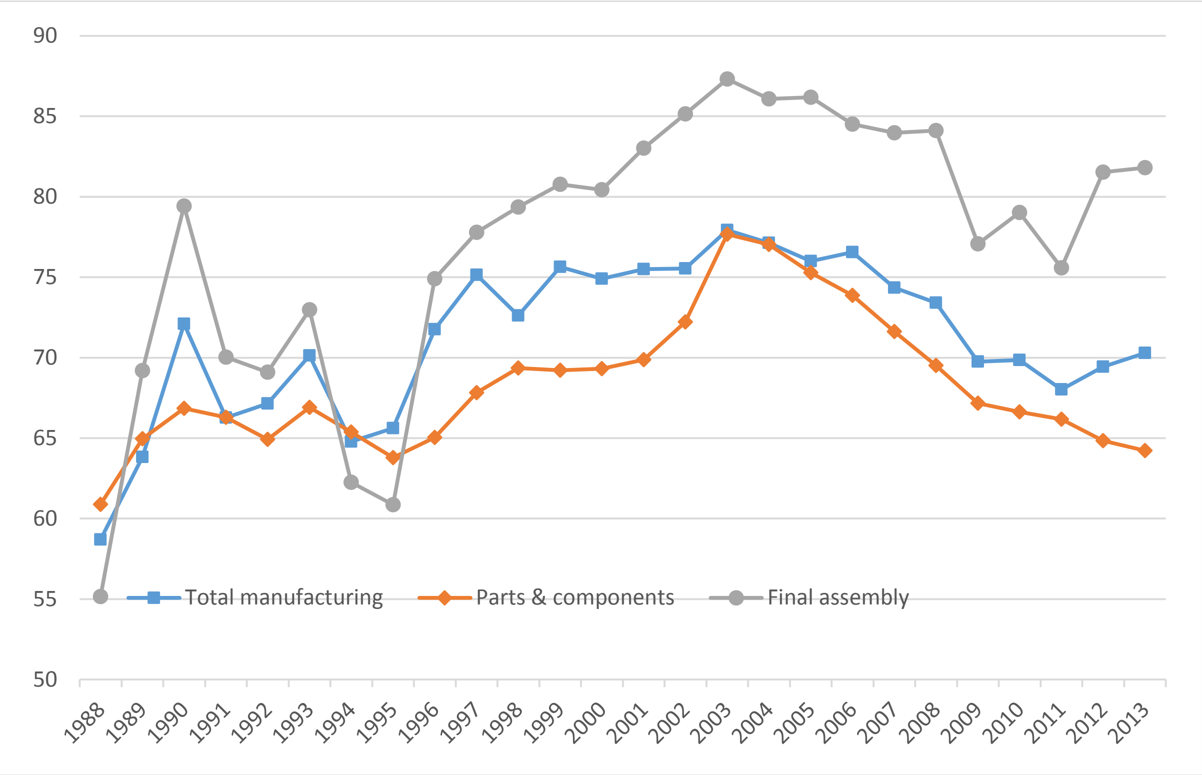
Source: Data compiled from UN Comtrade database.

Figure 2: Parts and components and final assembly in Australian manufacturing exports (%)



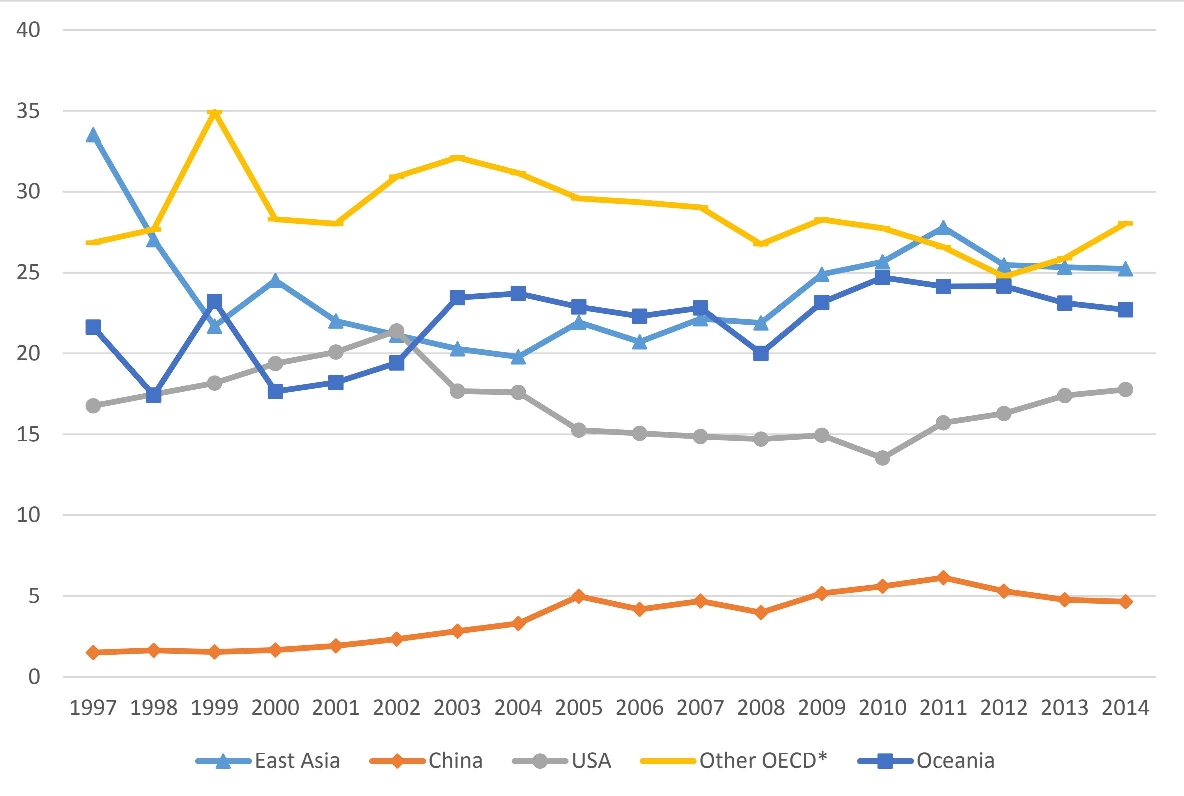
Source: Data compiled from UN Comtrade database.

Figure 3: Finger-Kreinin export similarity index: Australia and OECD, 1988-2013 (%)



Source: Based on data compiled from the UN Comtrade database.

Figure 4: Australia: Direction of GPN exports (%)



Appendix

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 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 hand 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 archive self-sufficiency in the production of aircrafts and to upgrade the RAAF's strike capacity. The US and UK governments supported the Australian initiatives because the location of light aircraft construction in Australia, with service and repair facilities, helped archive 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 thousand 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 post-war 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 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 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 manufacture of ingle 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. Citified 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 Levitt 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.

Table A-1: Determinants of manufacturing exports: Random effects estimates[1]

Explanatory variables	Total manufacturing	Parts & components	Final assembly	Conventional (horizontal) exports
Ln Real SBV, reporter[2]	0.88***	1.06***	0.99***	0.81***
	(0.02)	(0.02)	(0.03)	(0.02)
Ln Real SDB, partner[3]	1.00***	0.96***	1.11***	0.94***
	(0.02)	(0.02)	(0.02)	(0.02)
Ln Distance (DST)	-0.71***	-0.70***	-0.69***	-0.83***
	(0.04)	(0.05)	(0.05)	(0.04)
Ln Relative per capital GDP (RPGDP)	-0.01***	-0.00***	-0.01***	-0.01***
	(0.00)	(0.00)	(0.00)	(0.00)
Ln Bilateral real exchange rate (RER)lrer	0.01***	0.00	-0.00	0.01***
	(0.00)	(0.00)	(0.01)	(0.00)
Ln Technology base, reporter (TECH)	0.11***	0.17***	0.18***	0.11***
	(0.01)	(0.01)	(0.02)	(0.01)
FTA membership dummy (FTA)	0.33***	0.48***	0.74***	0.19***
	(0.02)	(0.04)	(0.05)	(0.03)
Institutional quality (INST), reporter	-0.04***	0.13***	0.04**	-0.05***
	(0.01)	(0.02)	(0.02)	(0.01)
Ln Logistic quality (LPI), reporter	1.45***	2.30***	3.14***	1.18***
	(0.11)	(0.16)	(0.20)	(0.12)
Contiguity dummy (ADJ)	0.32**	-0.03	0.26	0.38***
	(0.14)	(0.18)	(0.19)	(0.14)
Common language dummy (CML)	0.52***	0.72***	0.44***	0.56***
	(0.09)	(0.12)	(0.12)	(0.09)
Colony dummy (CLK)	0.05	0.36*	-0.02	0.24
	(0.15)	(0.19)	(0.20)	(0.15)
European Union dummy (EU)	0.50***	0.91***	1.03***	0.28***
	(0.10)	(0.13)	(0.14)	(0.10)
East Asia dummy (EAS)d_EAS	1.72***	2.09***	1.86***	1.42***
	(0.13)	(0.16)	(0.17)	(0.13)
Constant	-34.11***	-37.75***	-44.77***	-30.01***
	(0.75)	(0.84)	(1.10)	(0.76)
Australia dummy (AD) variables				
AD*SBV, Australia	-0.10	0.52	-1.98***	0.25
	(0.27)	(1.51)	(0.52)	(0.28)
AD*SDB, partner	-0.07	-0.17	-0.22	0.04
	(0.12)	(0.13)	(0.17)	(0.12)
AD*DST	-2.70***	-1.75***	-1.80**	-3.21***
	(0.51)	(0.64)	(0.71)	(0.52)
AD*RER	0.05**	0.09**	0.07	0.07***
	(0.03)	(0.03)	(0.05)	(0.03)
AD*RPGDP	-0.00	0.02**	0.00	-0.01
	(0.01)	(0.01)	(0.01)	(0.01)
AD*LPI	-0.08	-4.82	2.49	2.69
	(3.27)	(5.29)	(6.47)	(3.43)
AD*TECH	0.06	0.45	0.90*	0.34
	(0.26)	(0.51)	(0.51)	(0.27)
AD*FTA	-0.53***	-0.52**	-0.97***	-0.48***
	(0.15)	(0.21)	(0.29)	(0.15)

AD*IST	0.24	0.83***	0.17	0.14
	(0.18)	(0.29)	(0.36)	(0.19)
AD*CLK	0.63	0.73	0.50	0.53
	(1.18)	(1.44)	(1.58)	(1.19)
AD*CML	0.22	0.36	0.55	0.12
	(0.41)	(0.54)	(0.55)	(0.41)
AD	28.12***	8.87	64.95***	15.01
	(9.13)	(32.74)	(16.50)	(9.46)
Observations	30,570	24,546	30,100	30,060
Number of country pairs	1,845	1,672	1,843	1,838

Notes:

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

2. Real manufacturing output (RMF) for parts and components and GDP for final assembly and total exports of country *i*

3. Real manufacturing output (RMF) for parts and components and GDP for final assembly and total exports of country *j*

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