THE UNIVERSITY OF MELBOURNE

Melbourne Institute Working Paper Series

Working Paper No. 11/07

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MELBOURNE INSTITUTE
of Applied Economic and Social Research

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Melbourne Institute Working Paper No. 11/07

ISSN 1328-4991 (Print)
ISSN 1447-5863 (Online)
ISBN 978-0-7340-3241-6

March 2007

* This paper is an outcome of research funded through ARC Linkage Grant LP0348635. We are grateful for the financial and in-kind supports from Linkage partners the IBISWorld, Australian Bureau of Statistics, Productivity Commission, Austrade and Victorian Department of Treasury and Finance.

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Abstract

This paper investigates the geographic agglomeration of establishments in the Australian manufacturing industries during the period of 1994–1997. We find that although the agglomeration of Australian manufacturing has doubled during the period, it is still not as agglomerated as those in other developed economies such as the United States, the United Kingdom, France and Ireland. We also find that industries which receive higher assistance tend to be more agglomerated. However, there is no statistically significant evidence that the extent of the reduction in assistance due to trade liberalisation between 1994 and 1997 was associated with a further decrease in agglomeration. In terms of establishment dynamics, we find a significant increase in agglomeration but no evidence that establishment entry-exit patterns are correlated with agglomeration.

JEL Classification: R11; R12

Keywords: Agglomeration; Australian Manufacturing; Industry assistance; Trade liberalisation; Entry and exit.

1 Introduction

This paper examines the geographic agglomeration of establishments among Australian manufacturing industries and investigates the link between agglomeration, industry assistance and entry and exit rates of these establishments. We employ the methodologies developed by Ellison and Glaeser (1997) and, for comparison, Maurel and Sédillot (1999) to measure the extent of geographical agglomeration among Australian manufacturing establishments during the period of 1994–97. These measures are then linked with measures of industry assistance and establishment entry and exit rates.

By agglomeration, we mean the geographical co-location of firms or establishments. The terms cluster and network are also used in the literature, but often they carry slightly different meanings. Clusters normally refer to groups of independent firms in a geographical location which are linked to each other in a production chain. For example, a biotech cluster refers not simply to biotech firms, but also to their upstream suppliers and downstream customers. Networks differ from clusters in that a network can involve firms in different geographical locations, for example, a global network. Like clusters, firms in an agglomeration share a common geographical location, but importantly, they may or may not have any link to each other—the empirical measures of agglomeration defined in this paper make no attempt to measure the upstream-downstream linkages across the chain of production activities.

There are many reasons why firms or establishments agglomerate in certain geographical regions. There may be cost-reducing externalities from co-locating with suppliers and/or customers, geographically bounded knowledge spillovers, or benefits from being close to a localised pool of specialist labour and/or other resources. The spillover effects are especially important for high-tech, knowledge intensive industries engaging in innovative activities. However, to realise these spillover effects firms may need to be given incentives to coordinate their location choices—a free market may not provide the mechanism for the emergence of a successful agglomeration when externalities are present. In this respect, government intervention can be critical in overcoming the coordination problem. Firms' location choices can be induced by various policy measures such as those affecting the availability of skilled labour, research activities, financing, training facilities, land use and so on. However, for any policy initiative to be effective, an understanding of the existing pattern of agglomeration is a critical first step.

To our knowledge there has been no previous study examining the extent of agglomeration of Australian industries. Previous quantitative research in this area has been confined mainly to industrial concentration, for example, Bhattacharya and Block (2000), whose study on industry concentration was based on aggregated four-digit industry-level data. Other recent studies were concerned with the phenomena of clustering (for example, Marceau, 1999) and are closer to management case studies. As a result, it is not known how agglomeration in the Australian manufacturing industry compares with the situation in other countries. Given the evidence of substantial variation internationally in the level and dynamics of agglomeration, we believe it is valuable to extend the current knowledge in relation to Australian manufacturing industries. Our detailed data also allow us to contribute to a related literature that investigates how agglomeration is related to industry assistance (such as tariffs and non-tariff barriers, and local content schemes) and establishment dynamics. The results will add to an understanding of how geographical agglomeration in Australia has changed over time.

An extensive international literature has developed which measures the extent of agglomeration and evaluates its possible sources. Ellison and Glaeser (1997), for example, develop a measure of agglomeration and apply it to US manufacturing industries. Ellison and Glaeser (1999) further investigate the sources of agglomeration and find that, broadly measured, natural advantages can explain more than half of the observed geographic concentration level. Maurel and Sédillot (1999) propose a similar measure to that of Ellison and Glaeser (1997) and apply it to French manufacturing. Devereux et al. (2004) compare the level of geographic agglomeration in UK manufacturing with that of the United States and France. They find that, relative to these countries, UK agglomeration is lower. In addition, they also find that high-tech industries in the United Kingdom are relatively more dispersed than non-high-tech industries.

Recent literature also examines how agglomeration is linked to industry dynamics (entry and exit patterns) and attempts to explain the dynamics of agglomeration itself. Devereux et al. (2004), for example, find that agglomerated industries exhibit less churning and higher rates of survival and that entry tends to increase agglomeration. In contrast, Dumais et al. (2002) find that the location of new firms reduces agglomeration in the United States; they also find a declining level of agglomeration in US manufacturing industries. This variation across countries is further confirmed by Barrios et al. (2005), who study the dynamics of agglomeration in Ireland and Portugal.

The role of industry assistance in successful agglomeration deserves a closer look. In the trade liberalisation literature, there are two conflicting views on the removal of trade barriers (which lowers the extent of industry assistance). Krugman and Elizondo (1996) suggest that trade liberalisation decreases agglomeration because it reduces the importance of the local market and hence the incentive to agglomerate, from the perspective of the producers. Paluzie (2001), however, shows that with mobile labour the relationship might be reversed. The evidence is mixed and mostly based on indirect analysis. We contribute to this literature by linking agglomeration to a direct measure of industry assistance, known as the effective rate of assistance (*ERA*), which gives a quantitative measure of the degree by which industries are protected in the form of tariff and non-tariff barriers, quantitative restrictions, tax concessions and so on.

The rest of the paper is structured as follows. Section 2 outlines the methodology for measuring agglomeration, Section 3 gives a brief description of the data used, while Section 4 presents the main findings about the extent of agglomeration in Australian manufacturing. Section 5 tracks the changes in agglomeration of Australian manufacturing industries during the period 1994–97, while Section 6 attempts to link agglomeration to a measure of industry assistance and measures of industry dynamics in the form of entry and exit rates. Section 7 concludes.

2 Measures of agglomeration

The empirical work discussed below makes use of two measures of agglomeration developed in the late 1990s—the indices proposed by Ellison and Glaeser (1997) and Maurel and Sédillot (1999). Henceforth we refer to these indices as the *EG* and *MS* measures. Both measures make use of employment share as the size measure for industries and plants. In essence, they measure agglomeration as geographic concentration over and above that which could be expected given the existing industry concentration (measured by the Herfindahl index) in terms of employment shares.

Let x_a denote area a's share of overall (nationwide) manufacturing employment, where $a \in A$ and A is the set of all areas nationwide. Let there be N manufacturing industries, with each industry i consisting of K^i plants (or establishments). Let s_{ai} be industry i's

share of employment in area a, that is,

$$s_{ai} = \sum_{k=1}^{K^i} z_{ki} I_{ka},$$

where z_{ki} is the employment share of plant k in industry i and I_{ka} is an indicator variable equal to one if plant k is located in area a.

Suppose area a presents no particular advantages for industry i, then one could expect s_{ai} to be approximately the same as x_a. Thus a raw measure of geographic concentration of industry i is

$$G_i = \sum_{a \in A} (s_{ai} - x_a)^2. \tag{1}$$

Note that G_i varies between zero (not concentrated) and one (very concentrated). The G_i measure, however, is sensitive to the concentration of production within an industry. For example, if the employment of an industry is concentrated in a few plants located in a single area, the G_i measure will produce a high value even if the plants' location decisions have nothing to do with each other. Thus, for a measure of agglomeration to be useful, one must also take into account the industry size distribution as measured by the Herfindahl index in terms of employment:

$$H_i = \sum_{k=1}^{K^i} z_{ki}^2. \tag{2}$$

Ellison and Glaeser (1997) show that, in a location choice model in which plants in an industry sequentially choose location to maximize profit, an index of geographic concentration can be constructed based on G_i and H_i as follows:

$$EG_i = \frac{G_i - \left(1 - \sum_{a \in A} x_a^2\right) H_i}{\left(1 - \sum_{a \in A} x_a^2\right)(1 - H_i)}, \tag{3}$$

which is the EG index. Ellison and Glaeser show that the expected value of the EG index is zero ($E(EG_i) = 0$) if plants' location choices are independent of each other. Thus a value of $EG_i > 0$ in one industry can be interpreted as a geographic concentration in excess of that which would prevail if there were no spillovers or natural advantages in location choices. After examining the EG index for US manufacturing industries, Ellison and Glaeser regard an industry i as highly agglomerated if $EG_i > 0.05$, not very agglomerated if $EG_i < 0.02$ and somewhat agglomerated if $0.02 \leq EG_i \leq 0.05$.

Building on the work of Ellison and Glaeser, Maurel and Sédillot (1999) derive the *MS* measure from a probability model of location. The *MS* index takes the form:

$$MS_i = \frac{\left(\sum_{a\in A} s_{ai}^2 - \sum_{a\in A} x_a^2\right) - H_i}{1 - H_i}. \tag{4}$$

Define a measure of raw geographic concentration:

$$\hat{G}_i = \frac{\sum_{a\in A} s_{ai}^2 - \sum_{a\in A} x_a^2}{1 - \sum_{a\in A} x_a^2}.$$

We can then re-write the *MS* index (4) as

$$MS_i = \frac{\hat{G}_i - H_i}{1 - H_i},$$

which is similar to the *EG* index if we write the latter as

$$EG_i = \frac{\tilde{G}_i - H_i}{1 - H_i},$$

where

$$\tilde{G} = \frac{\sum_{a\in A}(s_{ai} - x_a)^2}{1 - \sum_{a\in A} x_a^2}.$$

Maurel and Sédillot further show that, as with the *EG* index, the expected value of the *MS* is zero ($E(MS_i) = 0$) if plants' location choices are independent of each other. They interpret the *MS* index as measuring the excess of the geographic concentration $\hat{G}_i$ on productive concentration H_i. The same convention of classifying industries as highly, somewhat and not very agglomerated is also used, with the same cutoff values as in the *EG* index. We will make use of both the *EG* and *MS* indices to measure the degree of agglomeration of Australian manufacturing.

3 Data

We make use of establishment-level data obtained from two Australian Bureau of Statistics (ABS) censuses of manufacturing establishments, conducted in 1994 and 1997. These censuses collected production activity statistics at the establishment level and business operation statistics at the management unit and enterprise group levels. According to the ABS, an establishment is 'the smallest accounting unit of a business ... controlling its productive activities and maintaining a specified range of detailed data enabling

value added to be calculated.' (ABS, 1997, p.8.) In practice, establishment-level statistics are the closest to plant-level statistics, although in some cases an establishment may own several plants in the same location. The management unit, in contrast, is the 'highest-level unit within a business ... for which accounts are maintained; in nearly all cases, it coincides with the legal entity owning the business ....' (ABS, 1997, p.8.) A management unit may incorporate several establishments.

For our purposes the most important fields in the data are the five-digit statistical local area (SLA) codes, the number of employees and the four-digit standard industrial classification code (ANZSIC) for each establishment. Table 1 provides the distribution of establishments and total employment over 28 manufacturing industries for each of the two periods.

After eliminating observations with missing information, there were 52,608 establishments in 1994 and 71,757 establishments in 1997 in our 'cleaned' sample. Table 1 shows the distribution of establishment and employment shares over the 28 manufacturing industries in the data. In 1994, half of the manufacturing establishments belonged to just five of the 28 listed industries and 75 per cent of establishments belonged to just ten of these manufacturing industries. The picture changed only slightly by 1997—52 per cent of establishments belonged to just five industries and 77 per cent of establishments were accounted for by ten of the 28 manufacturing industries listed. In terms of the number of establishments, the three most important industries in both years are metal products, printing and furniture industries.

The distribution across industries varies slightly in terms of employment. As shown in Table 1, just under half (48 per cent) of total manufacturing employment was in five industries in 1994 and 68 per cent was across ten industries. These percentages fell slightly by about two percentage points, to 46 per cent and 66 per cent, respectively, by 1997. The top three industries by employment in both years were food and tobacco, printing and the metal products industries. These three industries accounted for 35 per cent of total employment in manufacturing in both years.

Table 1: Distribution of establishments and total employment by sector (%)

Industry	% Establishments		% Employment	
	1994	1997	1994	1997
Food and tobacco	7.6	6.7	16.4	17.4
Beverages	0.9	0.8	2.0	2.3
Textiles	3.1	3.0	3.8	3.0
Apparel	6.6	9.4	3.3	2.9
Leather products	0.5	0.5	0.4	0.3
Footwear	0.5	0.4	0.8	0.4
Wood products	7.8	7.8	4.6	4.2
Furniture	8.8	9.6	3.9	3.1
Paper	0.8	0.6	1.9	2.4
Printing	11.6	11.5	9.6	8.9
Basic chemicals	0.9	0.9	1.7	2.2
Other chemicals product	1.9	1.7	3.3	4.1
Petroleum refining/product & coal product	0.2	0.1	0.5	0.8
Rubber products	0.6	0.5	0.8	1.0
Plastics	3.0	2.8	3.5	3.3
Ceramics	1.0	0.8	1.1	0.9
Glass	0.6	0.7	0.6	0.7
Nonmetallic minerals	2.6	2.6	2.6	3.1
Iron and steel	1.4	1.5	3.7	4.5
Nonferrous metals	0.6	0.5	2.9	2.8
Metal products	15.0	14.4	9.3	8.6
Motor vehicle and part	3.0	2.8	6.1	6.9
Other transport equipment	2.1	2.2	3.1	2.6
Professional equipment	2.3	2.1	1.2	1.2
Electronic equipment	1.8	1.6	1.9	1.8
Electrical equipment	3.1	2.9	4.4	4.5
Industrial machinery	7.1	6.7	4.9	4.6
Other	4.9	4.9	1.6	1.4
Total Manufacturing	100	100	100	100

4 Agglomeration of Australian manufacturing

Using the establishment data, we compute the *EG* and *MS* indices for each of the four-digit ANZSIC manufacturing industries; the results are summarised in Table 2. With average *EG* and *MS* values of respectively 0.007 and 0.014 in 1994, and 0.014 and 0.021 in 1997, the mean agglomeration of Australian manufacturing is relatively low compared with other countries. The mean *EG* index was 0.033 for UK manufacturing in 1992 (Devereaux et al), 0.051 for US manufacturing in 1997 (Ellison and Glaeser), and 0.079 and 0.027 for Portugal and Ireland respectively in 1994 (Barrios et al, 2005), while the mean *MS* index was 0.06 for French manufacturing (Maurel and Sédillot, 1999), all of which are higher than the corresponding figures for Australian manufacturing.

Comparing the Australian manufacturing *EG* and *MS* indices for 1994 and 1997, we find a significant increase in the average agglomeration of Australian manufacturing industries. Both indices suggest that the average level of agglomeration has doubled during the period.

In 1997, approximately 74 percent of the 153 industries were not very agglomerated, 20 per cent were somewhat agglomerated and only 6 per cent were highly agglomerated. For comparisons, the corresponding US and UK figures are 10 per cent, 65 per cent, and 25 per cent (Ellison and Glaeser, 1997) and 65 per cent, 19 per cent, and 16 per cent (Devereux et al, 2004), respectively. Figure 1 further shows that the increase in average agglomeration between 1994 and 1997 is due to a shift in the 0–0.05 range of the values, indicating that more industries in the upper-middle part of the distribution became more agglomerated.

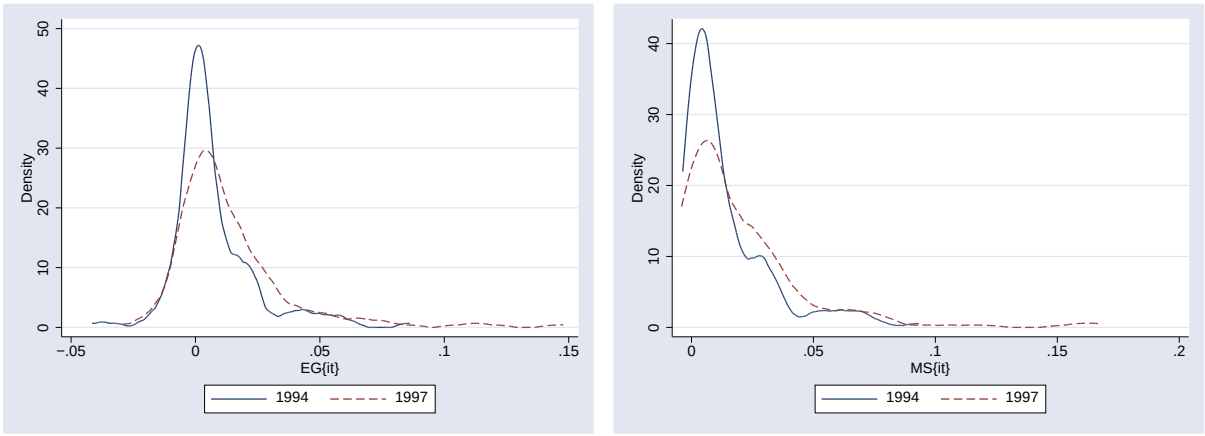
After examining the empirical distribution of the agglomeration indices, Maurel and Sédillot (1999) found that the distribution can be quite skewed. This feature is also borne out in our data. Figure 1 presents the density plots of the two indices, both the distributions of *EG* and *MS* indices are skewed. However, *MS* index's distribution is substantially more skewed (to the right) than that of the *EG* index. We also note that the skewness of the distributions is similar to that observed in the United Kingdom, the United States and France (see Devereux et al, 2004).

We next examine the 20 most and least agglomerated industries in 1994 and 1997. Table 3 presents four concentration measures at the four-digit ANZSIC industry clas-

Table 2: Average agglomeration at the four-digit ANZSIC level

	Mean	Std dev	Min	Max
1994				
Ellison-Glaeser (EG_i)	0.007	0.017	-0.042	0.086
Maurel-Sédillot (MS_i)	0.014	0.018	-0.004	0.093
Raw geographical concentration (G_i)	0.081	0.119	0.004	0.986
Herfindahl (H_i)	0.075	0.121	0.002	1.000
1997				
Ellison-Glaeser (EG_i)	0.014	0.024	-0.029	0.148
Maurel-Sédillot (MS_i)	0.021	0.027	-0.004	0.167
Raw geographical concentration (G_i)	0.078	0.064	0.004	0.322
Herfindahl (H_i)	0.066	0.059	0.001	0.303

Figure 1: Establishment agglomeration at four-digit ANZSIC, 1994 & 1997



(a) EG_i (b) MS_i

sification level for the top 20 industries, sorted in terms of the EG index in 1994 and 1997 respectively. The most highly agglomerated manufacturing industry in 1994 was the synthetic resin industry, followed by wood chipping, basic iron and steel and ceramic products. This pattern perhaps reflect the importance of proximity to the raw materials used in these industries—petroleum and chemicals in the case of the resin industry, trees and timber supply in the case of wood chipping, and coal and iron ore in the case of iron and steel. A similar high degree of agglomeration in these industries has also been observed in the United Kingdom and France. Proximity to raw materials may also explain the high degree of agglomeration for some other industries listed in Table 3, such as alumina, non-ferrous metals, pesticides and explosive manufacturing. However, industries such as books and book publishing, recorded media manufacturing

and publishing, and textiles might show higher agglomeration because of market driven forces rather than any desire to locate close to suppliers.

Among the 20 most agglomerated four-digit manufacturing industries in 1997, ceramic product manufacturing topped the list, moving from fourth place in 1994. Next are tobacco products, textile floor coverings and the corrugated paperboard container industries. One notable change between 1994 and 1997 is the increase in the number of machinery and equipment industries, from two in 1994 to five industries in 1997. It is notable that, among the top 20 industries in 1994, only five industries (book and other publishing, ceramic products, commercial space heating and cooling equipment, professional and scientific equipment, and textile floor covering) remained in the top 20 list in 1997. Among the new entries to the list of highly agglomerated industries in 1997 are shipbuilding, automotive electrical instruments and motor vehicles. It thus appears that significant changes in the degree of agglomeration occurred among manufacturing industries between 1994 and 1997.

While agglomeration in shipbuilding is perhaps driven mostly by the need for access to sea ports, the increased agglomeration in automotive instruments and motor vehicle production can be explained by changes in government policy relating to industry and plant closures. Another noteworthy feature of the list in 1997 when compared to the list in 1994 is the general increase in the proportion of more 'high-tech' industries amongst the 20 most agglomerated industries. Typically high-tech industries tend to be less agglomerated than other industries by virtue of their 'newness' (see Devereaux et al, 2004). However, given the emphasis in the literature on knowledge spillovers as an important source of agglomeration externalities, increased agglomeration in these technology intensive industries are hardly surprising.

We next examine the bottom end of the agglomeration list. Table 4 presents the 20 least agglomerated industries, in 1994 and 1997, at the four-digit ANZSIC level in terms of the degree of agglomeration according to the *EG* index. Tobacco products was the least agglomerated manufacturing industry in 1994, followed by battery manufacturing, telecommunications, and the oil and fat industry. Compared to the situation with the most agglomerated industries, the list of least agglomerated appeared to be more stable over time—nine of the 20 least agglomerated industries in 1994 again appeared in the 1997 least agglomerated list. These nine industries are batteries, biscuits, hosiery, industrial gas, milk and cream processing, oil and fat, plaster product, rope, cordage and

Table 3: 20 most agglomerated industries 1994 & 1997, four-digit ANZSIC level

1994		EG_i	MS_i	G_i	H_i
2533	Synthetic resin	0.086	0.093	0.129	0.048
2312	Wood chipping	0.062	0.065	0.203	0.150
2711	Basic iron & steel	0.059	0.072	0.193	0.144
2622	Ceramic products	0.055	0.077	0.145	0.096
2852	Electric cable & wire	0.053	0.069	0.130	0.082
2544	Pesticide	0.049	0.066	0.185	0.143
2423	Book & other publishing	0.046	0.050	0.086	0.042
2867	Commercial space heating/cooling equip.	0.044	0.056	0.096	0.055
2332	Solid paperboard container	0.042	0.057	0.111	0.072
2732	Non-ferrous metal rolling, etc nec	0.040	0.063	0.192	0.071
2839	Professional & scientific equipment	0.038	0.054	0.127	0.158
2430	Recorded media mfg/publishing	0.034	0.048	0.103	0.093
2242	Women's and girls wear	0.031	0.037	0.038	0.008
2232	Cardigan and pullover mfg	0.026	0.033	0.050	0.024
2721	Alumina production	0.026	0.034	0.327	0.309
2184	Spirit mfg	0.025	0.031	0.264	0.245
2215	Textile finishing	0.023	0.032	0.068	0.046
2861	Agricultural machinery	0.022	0.022	0.039	0.018
2541	Explosive mfg	0.022	0.030	0.124	0.105
2222	Textile floor covering	0.021	0.033	0.126	0.107
1997		EG_i	MS_i	G_i	H_i
2622	Ceramic product	0.148	0.167	0.290	0.168
2190	Tobacco product	0.118	0.158	0.282	0.186
2222	Textile floor covering	0.107	0.116	0.205	0.110
2333	Corrugated paperboard container	0.083	0.095	0.229	0.160
2313	Timber re-sawing & dressing	0.072	0.071	0.131	0.063
2821	Shipbuilding	0.069	0.077	0.163	0.101
2423	Book & other publishing	0.067	0.073	0.124	0.063
2813	Automotive electrical & instrument	0.060	0.074	0.147	0.093
2243	Sleepwear, u/wear, infant clothing	0.056	0.072	0.145	0.095
2839	Professional & scientific equipment	0.050	0.056	0.172	0.130
2422	Other periodical publishing	0.050	0.052	0.105	0.059
2711	Basic iron and steel	0.048	0.057	0.142	0.100
2811	Motor vehicle	0.047	0.063	0.133	0.091
2334	Paper bag and sacks	0.044	0.069	0.146	0.107
2547	Ink	0.040	0.056	0.151	0.116
2174	Prepared animal and bird feed	0.038	0.038	0.103	0.068
2765	Non-ferrous pipe fitting	0.036	0.050	0.093	0.059
2761	Hand tool & general hardware	0.036	0.036	0.080	0.046
2867	Commercial space heating/cooling equip.	0.033	0.044	0.091	0.061
2534	Organic industrial chemical nec	0.032	0.044	0.110	0.081

twine, telecommunications, broadcasting and transceiving equipment. We further note with interest that, as shown in Table 3, the tobacco industry had the second highest degree of agglomeration 1997. In other words, for some reason this industry went from being among the least agglomerated in 1994 to be among the most agglomerated by 1997. Two other industries—the shipbuilding and automotive industries—also appeared on the list of 20 least agglomerated industries in 1994 but featured amongst the 20 most agglomerated in 1997.

5 Agglomeration over time

This section examines the changes in the degree of manufacturing agglomeration between 1994 and 1997. The question of interest is the extent of movement, up or down, in agglomeration of manufacturing industries during this period. For this purpose we construct transition tables which measure changes in the number of agglomerated industries at the four-digit level, the number of establishments and the share of total manufacturing employment over the period. We make use of the *EG* index in constructing the transition tables.[1]

Table 5 presents the transition of four-digit manufacturing industries between 1994 and 1997. Most industries (104 out of 153 four-digit industries) were not very agglomerated in either years. More industries moved from not very agglomerated to somewhat (18 industries) and very agglomerated (six industries), compared to the number of industries moving in the opposite direction, from very agglomerated to somewhat agglomerated (three industries) and not very agglomerated (one industry). Table 5 also shows that industries were becoming more agglomerated in 1997 when compared to 1994—the number of four-digit industries in the somewhat agglomerated and very agglomerated categories rose from 25 in 1994 to 40 in 1997.

Table 6 presents the transition of agglomeration in terms of the number of manufacturing establishments in both 1994 and 1997.[2] As shown in the table, most manufacturing establishments belonged to not very agglomerated industries in both 1994 and 1997—39,279 out of 46,693 establishments, or 84 per cent. Meanwhile, Table 6 shows that

[1]The transition tables using the *MS* index show similar patterns and is omitted for brevity.

[2]Note that the number of establishments in 1997 were different from that in 1994. For brevity, we construct Table 6 based on the number of establishments that existed in both years.

Table 4: 20 least agglomerated industries 1994 & 1997, four-digit ANZSIC level

1994		EG_i	MS_i	G_i	H_i
2190	Tobacco product	-0.042	0.000	0.269	0.299
2853	Battery	-0.033	-0.002	0.208	0.234
2842	Telecom., broadcasting & transceiving equip.	-0.020	-0.001	0.083	0.101
2140	Oil and fat	-0.018	0.004	0.136	0.151
2520	Petroleum & coal product	-0.014	-0.002	0.070	0.083
2532	Industrial gas	-0.013	-0.001	0.115	0.127
2813	Automotive electrical & instrument	-0.012	0.001	0.066	0.077
2634	Concrete pipe & box culvert	-0.011	-0.001	0.050	0.061
2121	Milk and cream processing	-0.009	-0.001	0.051	0.059
2223	Rope, cordage and twine	-0.009	0.005	0.271	0.278
2163	Biscuit	-0.009	0.001	0.088	0.096
2713	Steel pipe & tube	-0.009	0.004	0.103	0.111
2213	Cotton textile	-0.008	0.001	0.076	0.084
2829	Transport equipment mfg nec	-0.008	0.002	0.101	0.108
2564	Plastic product, rigid fibre reinforced	-0.007	0.000	0.029	0.036
2172	Confectionary	-0.007	0.001	0.061	0.068
2632	Plaster product	-0.007	0.002	0.021	0.028
2821	Shipbuilding	-0.006	0.003	0.147	0.152
2733	Non-ferrous metal casting	-0.006	0.002	0.061	0.066
2231	Hosiery	-0.005	0.013	0.170	0.175
1997		EG_i	MS_i	G_i	H_i
2853	Battery	-0.029	-0.001	0.277	0.298
2223	Rope, cordage and twine	-0.019	0.000	0.257	0.271
2532	Industrial gas	-0.016	-0.001	0.116	0.130
2184	Spirit	-0.014	0.000	0.275	0.286
2831	Photographic & optical good	-0.014	-0.002	0.183	0.196
2823	Railway equipment	-0.014	0.000	0.135	0.147
2140	Oil and fat	-0.011	0.002	0.083	0.093
2842	Telecomm., broadcasting & transceiving equip.	-0.010	0.003	0.072	0.082
2121	Milk and cream processing	-0.010	-0.001	0.075	0.084
2634	Concrete pipe & box culvert	-0.009	0.000	0.049	0.057
2632	Plaster product	-0.007	0.000	0.042	0.049
2163	Biscuit	-0.007	0.000	0.162	0.168
2562	Plastic extruded product	-0.007	0.007	0.047	0.054
2531	Fertiliser	-0.007	0.000	0.097	0.104
2122	Ice cream	-0.006	-0.001	0.168	0.173
2321	Plywood & veneer	-0.006	-0.001	0.065	0.070
2231	Hosiery	-0.004	0.008	0.151	0.154
2722	Aluminium smelting	-0.003	0.000	0.154	0.157
2161	Bread manufacturing	-0.003	0.001	0.029	0.033
2546	Cosmetic & toiletry prep	-0.003	0.008	0.044	0.047

the number of establishments moving from not very agglomerated in 1994 to somewhat and very agglomerated in 1997 was 3,005 and 423 establishments respectively. At the opposite end of the scale, the number of establishments that were in very agglomerated industries in 1994 but belonged to somewhat and not very agglomerated industries by 1997 was 644 and 60 respectively. The transition pattern shows that the number of establishments moving up in terms of agglomeration was significantly higher than the number moving down. As a result, there were 6,820 establishments in somewhat or very agglomerated industries in 1997, compared to 3,986 establishments in the corresponding categories in 1994, a net increase of 2,834 establishments or approximately 71 per cent.

We next examine the transition of agglomeration in terms of manufacturing employment. Table 7 shows that 88 per cent of manufacturing workers were employed in not very agglomerated industries in 1994. Of these workers, 73.9 percentage points remained employed in not very agglomerated industries in 1997, 10.9 and 3.5 percentage points respectively had moved into somewhat agglomerated and very agglomerated industries by 1997. In contrast, of the 3.8 per cent employed in very agglomerated industries in 1994, 3.2 and 0.5 percentage points of those respectively were employed in somewhat agglomerated and not very agglomerated industries in 1997. The transition pattern again suggests that there was an upward movement in agglomeration in terms of manufacturing employment.

Table 5: Industry EG_i transition at four-digit ANZSIC, 1994 to 1997

1994 degree of agglomeration	1997 degree of agglomeration			
	Not very	Somewhat	Very	Total
Not very	104	18	6	128
Somewhat	8	10	2	20
Very	1	3	1	5
Total	113	31	9	153

Note: figures are number of four-digit industries
Not very: $EG_i < 0.02$
Somewhat: $0.02 \leq EG_i < 0.05$
Very: $EG_i \geq 0.05$

Despite the increased degree of agglomeration in manufacturing as indicated by the number of four-digit industries, the number of establishments and the share of employment, it is clear from Tables 5–7 that most manufacturing industries remained in the not very agglomerated category. This finding is consistent with the earlier finding that Australian manufacturing has the lowest degree of agglomeration compared to other

Table 6: EG_i transition of manufacturing establishments, 1994 to 1997

1994 degree of agglomeration	1997 degree of agglomeration			
	Not very	Somewhat	Very	Total
Not very	39,279	3,005	423	42,707
Somewhat	534	2,306	387	3,227
Very	60	644	55	759
Total	39,873	5,955	865	46,693

Note: figures are number of establishments in both 1994 and 1997

Not very: $EG_i < 0.02$
Somewhat: $0.02 \leq EG_i < 0.05$
Very: $EG_i \geq 0.05$

Table 7: EG_i transition of manufacturing employment (%), 1994 to 1997

1994 degree of agglomeration	1997 degree of agglomeration			
	Not very	Somewhat	Very	Total
Not very	73.9	10.9	3.5	88.3
Somewhat	1.9	4.7	1.2	7.8
Very	0.5	3.2	0.1	3.8
Total	76.3	18.8	4.8	100.0

Note: figures are per cent of total manufacturing employment in 1997

Not very: $EG_i < 0.02$
Somewhat: $0.02 \leq EG_i < 0.05$
Very: $EG_i \geq 0.05$

developed economies documented elsewhere. We next investigate whether the degree of agglomeration in Australian manufacturing is affected by policy measures that provide industry assistance and/or protection.

6 Agglomeration, industry assistance and industry dynamics

The previous section shows that there were significant changes in the agglomeration tendency of Australian manufacturing between 1994 and 1997. In terms of the *EG* index, the average across 153 four-digit industries doubled from 0.007 to 0.014 and the number of industries that were somewhat or highly agglomerated increased from 25 to 40. The reasons for the increased agglomeration in manufacturing during the period are likely to be complex and industry specific. The 1990s was a period during which the Australian economy experienced strong productivity growth. It is widely accepted that the application of new information and communication technologies contributed significantly to the productivity growth, as did widespread structural reforms in the economy. These factors have had differing impacts on different industries. For example, deregulation in the 1990s which subjected domestic industries to more intense foreign competition are thought to have led to the hollowing out of core elements of many Australian clusters (McPherson, 2002). This section investigates whether industry assistance, in the form of trade and other protection measures, and related industry entry-exit patterns, are linked to the extent of agglomeration in Australian manufacturing.

One possibly significant source of increased agglomeration is the change in industry assistance resulting from trade liberalisation. Some authors argue that trade liberalisation, which reduces industry assistance, leads to increased agglomeration in certain geographic locations from a global perspective.[3] However, from a national perspective, the effect of trade liberalisation is not certain. On the one hand, trade liberalisation could reduce agglomeration if imports were to substantially weaken, or even completely replace, a domestic agglomerated industry; but on the other hand liberalisation could also increase agglomeration if imports were to force the least competitive and least agglomerated domestic producers out of the market.

[3]See Wacziarg and Wallack (2004), citing Krugman (1991) and the references therein, for examples.

We examine, in the case of Australian manufacturing, whether industry assistance leads to more or less agglomeration, by regressing the *EG* index on the effective rate of industry assistance. The latter is a measure documented in the report by the Industry Commission (1995), which computed the effective rate of assistance (*ERA*) faced by Australian industries by taking into account tariffs, quantitative import restrictions, production subsidies, input subsidies, export subsidies, tax concessions, local content schemes and so on. Roughly, the *ERA* is defined as the difference between value added measured in assisted and unassisted prices, expressed as a percentage of value added measured in unassisted prices.[4] The reported *ERA* figures show a significant decline in the simple average of *ERA*s across four-digit industries by about six percentage points, or about 40 per cent from the base period, due perhaps to trade liberalisation during the period 1994 to 1997. However, there were significant inter-industry variations, textile industries, for example, experienced a more than 20 percentage point reduction in *ERA*s, while printing and publishing industries experienced a substantially smaller decrease in assistance. These differences in *ERA*s can also be measured in relative terms. Thus, Table 8 reports regression results based on absolute as well as relative changes in *ERA*s.

The regression results are summarised in Table 8. The *ERA* coefficient estimate suggest that, on average, industries with a one percentage point higher *ERA* have a roughly two per cent higher level of agglomeration, and this marginal effect is statistically significant at the 10% level. The regression results in the second column also confirms the significantly higher level of agglomeration in 1997, as indicated by the statistically significant coefficient for the year dummy variable D_{1997}. The same regression also shows that the change in the link between industry assistance and agglomeration (the time interaction effect) over time is positive, but not statistically significant. On the whole, these results imply that industries with higher protection were more likely to be agglomerated. These results imply that trade liberalisation which leads to lower *ERA*s in some industries would also lead to a lesser degree of agglomeration in these industries, all else being equal.

Table 8 also includes regression models that attempt to capture the effects of absolute and relative changes in industry assistance. The third and fourth columns show the estimated effect of respectively absolute and relative changes in the *ERA*s. Given earlier results showing that *ERA*s are positively related to agglomeration, we would ex-

[4]For details, see Industry Commission (1995), Chapter 2. The *ERA* figures for 1997 were based on projected changes in tariffs and other assistance measures.

pect that a decline in *ERA*s will be negatively associated with agglomeration, all else being equal. The results affirm this belief although not completely—the coefficient estimates are negative but not statistically significant. Therefore we conclude that, while industry assistance may increase agglomeration, the extent to which it does so is not captured in a straightforward relationship to agglomeration. This finding may reflect the countervailing effects of trade liberalisation. On one hand trade liberalisation encourages imports and results in the replacement of existing industries, some of which were agglomerated. On the other hand, trade liberalisation may also facilitate knowledge spillovers, the effects of which may encourage agglomeration, especially in knowledge intensive industries.[5]

Closely related to industry assistance are the entry and exit rates of industries. We next examine how the entry to and exit from an industry, and by implication the survival rates of establishments, vary with the extent of agglomeration in manufacturing industries. Following Devereux et al. (2004), we estimate several simple regression models between 1994 and 1997 with entry and exit rates as the dependent variable and the level of agglomeration in the initial period ($EG_{i,1994}$ and $MS_{i,1994}$) as the main explanatory variable, with two-digit industry dummy variables to control for the aggregate variation in establishment dynamics. The entry rate for an industry k is defined as the number of 'new' establishments in industry k in 1997 divided by the total number of existing establishments in industry k in 1997, where a new establishment is one that existed in the 1997 census but not in the 1994 census. The exit rate is similarly defined, with new establishments replaced by 'failed' establishments, which are establishments that existed in 1994 but not in 1997.[6]

The regression results are summarised in Table 9, which shows no significant relationship between agglomeration and establishment dynamics in each industry. Thus, unlike in the UK manufacturing as reported in Devereux et al. (2004), Australian establishment entry and exit rates are not statistically significantly higher in more agglomerated industries.

[5]However, our regression results should be interpreted with caution. Ideally we would like to estimate a richer model with more explanatory variables as in Rosenthal and Strange (2001), but data limitations preclude this possibility.

[6]Note that the survival rate of an industry is simply (1 − exit rate).

Table 8: Agglomeration and effective rates of assistance (*ERA*s), 1994–97

Explanatory variable	Dependent variable		
	$\ln EG_i$	$\ln EG_{i,1997}$	
ERA_i	0.018†	--	--
	(0.009)		
$ERA_{i,1994}$		0.023	0.024†
	(0.009)	(0.015)	(0.013)
D_{1997} (=1 for 1997)	0.668**	--	--
	(0.232)		
$ERA_i \times D_{1997}$	0.005	--	--
	(0.013)		
$ERA_{i,1997} - ERA_{i,1994}$	--	-0.012	--
		(0.036)	
$(ERA_{i,1997} - ERA_{i,1994})/ERA_{i,1994}$	--	--	-0.243
			(0.215)
No. obs.	106	117	116
R^2	0.142	0.099	0.115

Note: Standard errors in parantheses.
Significance levels: †: 10% *: 5% **: 1%
All regressions include two-digit industry dummy variables.

Table 9: Industry dynamics and agglomeration, 1994–97

Explanatory variable	Dependent variable	
	Entry rate	Exit rate
$EG_{i,1994}$	1.239	-0.314
(Standard error)	(2.697)	(0.400)
R^2	0.050	0.194
No. obs.	153	153
$ms_{i,1994}$	-0.120	0.021
(Standard error)	(2.510)	(0.373)
R^2	0.050	0.190
No. obs.	153	153

Note: All regressions include two-digit industry dummy variables.

7 Conclusion

This paper examines the extent of agglomeration within the Australian manufacturing industry, using establishment level data. We also investigate the link between agglomeration and industry assistance, as well as between agglomeration and industry dynamics. Compared to the United Kingdom, the United States, France and several other developed economies, the degree of agglomeration in Australian manufacturing is low, although the types of industries at the upper and lower end of the agglomeration scale are broadly similar. Furthermore, unlike in these countries, manufacturing agglomeration in Australia shows no statistically significant relationship with industry dynamics. It is also worth noting that, although low, the degree of agglomeration of Australian manufacturing about doubled between 1994 and 1997.

We also investigate the relationship between agglomeration and the extent of assistance received by industries using the effective rate of assistance measures compiled by the Industry Commission (1995). We find that industry assistance did contribute to increased agglomeration during the period studied. We further find that industries that enjoyed less assistance due to trade liberalisation and other industry reforms did not necessarily become less agglomerated. In fact, the sign of our coefficient estimates seems to indicate otherwise, although they are not statistically significant. We conjecture that trade liberalisation may have countervailing effects on agglomeration—on one hand it encourages imports which may have replaced existing industries, some of which were agglomerated; but on the other hand it may also facilitate knowledge spillovers, the effects of which may encourage agglomeration.

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