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Zoning in on urban manufacturing: industry location and change among low-tech, high-touch industries in Melbourne, Australia

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ABSTRACT

Contemporary policy attention to manufacturing revolves around a narrative of advanced, innovation-driven production. Often overlooked are “low-tech,” “high-touch” manufacturing, which engage in specialized and often urbanized labor-intensive production. These firms represent a missed economic development opportunity yet may be displaced due to major urban industrial re-zonings. We respond to this policy challenge by providing a detailed analysis of the growth, concentration and clustering patterns of cultural manufacturing and food and beverage manufacturing in Melbourne, Australia. These forms of low-tech, high-touch manufacturing are more likely to concentrate in central industrial zones while manufacturing at large is predominately in the outer suburbs. Our findings demonstrate the need for a more nuanced understanding of manufacturing geographies and suggest that a key yet overlooked feature of industrial agglomeration is zoning. We argue that industrial decline is not solely due to outsourcing, but also land use policies geared toward maximizing land values over other benefits.

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The urban manufacturing revival: industrial policy in the post-industrial city

In recent years there has been an almost paradoxical urban policy shift in Western economies. After decades of gearing urban economic development to meet the needs of a “post-industrial” city (i.e. promoting advanced business services, tourism, and tech-driven development), manufacturing is back on the urban agenda. Predictably, the new manufacturing policy vision concentrates on growing “advanced manufacturing” (Livesey, 2015; Grodach & Gibson, 2019) and developing an Industry 4.0 agenda, which emphasizes technological innovations in production through robotics, automation, and data analytics (Schwab, 2017). This has aligned with national governments’ science and innovation programs aimed at developing competitive advantage through technological leadership (Hansen & Winther, 2015). Alongside this, many cities continue to target outer-suburban industrial areas working under the assumption that central city industrial space is outmoded in the post-industrial, knowledge economy era (Grodach & Gibson, 2019).

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This approach toward manufacturing-based economic development is problematic. By emphasizing the Industry 4.0 agenda, many cities overlook what some have termed “low-tech” (Hansen & Winther, 2014, 2015) and “high-touch” manufacturing (Friedman & Byron, 2012), yet these activities offer opportunities for developing quality employment and meeting local consumer demand. This type of manufacturing tends to be low in R&D expenditures and typically employs labor-intensive production processes in the manufacture of high-value, design-driven products (Rosenfeld, 2018). Low-tech, high-touch manufacturing predominately includes craft and cultural manufacturing industries that deliver specialized products and services to apparel designers, architecture firms, and home furnishings industries as well as firms focused on specific products- ceramics, food, furniture, and jewelry to name a few.

A small but growing body of research argues that such activity exhibits highly urbanized and localized location preferences due to their distinct production needs defined by tightly-knit and specialized supply, service, and labor networks (Fox Miller, 2017; Grodach, O'Connor, & Gibson, 2017). As such, they offer potential to diversify urban labor markets and demonstrate the productive use of established industrial districts under threat from rezoning for mixed-use residential and office space as witnessed in London (Ferm & Jones, 2016), Melbourne (Shaw, 2015), Montreal (Sprague & Rantisi, 2018), New York (Curran, 2010), and Sydney (Gibson, Grodach, Lyons, Crosby, & Brennan-Horley, 2017). However, advanced manufacturing policy tends to be aspatial and therefore deflects attention from urban industrial land use conflicts, deferring to the market to determine the highest and best use of land. This is ultimately part of a larger and well-known process of gentrification through land redevelopment (Scott, 2019; Smith, 1987). The ongoing loss of urban industrial zones displaces urban manufacturers by increasing rents or allowing incompatible residential uses (Curran & Hanson, 2005), and, subsequently, the employment and business opportunities that industrial zones provide (Chapple, 2014; Leigh & Hoelzel, 2012).

We respond to this policy challenge by providing a detailed analysis of the growth, concentration and clustering patterns of low-tech, high-touch manufacturing in Melbourne, Australia. Like many cities, Melbourne targets advanced manufacturing among its knowledge-based industries and continues to plan for industrial land uses predominately in the outer suburbs while removing central city industrial zones (State of Victoria, 2017, 2018b). Using Australian Bureau of Statistics (ABS) employment data, we focus on two forms of low-tech, high-touch manufacturing- Cultural Manufacturing (CM) and Food and Beverage Manufacturing (FBM).

We demonstrate that while all manufacturing is heavily reliant on industrial lands, these forms of manufacturing exhibit location patterns distinct from manufacturing at large. Employment is not only dispersed in outer-suburban industrial zones like other manufacturing industries, but also is more likely to cluster in the few remaining pockets of industrial land in the central city. Our findings point toward the importance of a more nuanced understanding of manufacturing geographies and suggest that a key yet overlooked feature of industrial agglomeration and dispersal is zoning. As a consequence, we argue that industrial decline is not solely due to outsourcing, but also a product of land use policies geared toward maximizing land values over other benefits. These findings have important implications for urban policy in “post-industrial” cities and open further research questions around how some low-tech, high-touch manufacturers adapt to adverse land use regulations and property market dynamics.

Low-tech, high-touch manufacturing: between agglomeration benefits and land use competition

A common assumption is that contemporary manufacturing has been almost entirely outsourced to lower-cost countries in the global south. What manufacturing remains in Western cities is spatially dispersed in outer-suburban sites on comparatively lower cost, large lot land with good access to transport and logistics hubs. Therefore, industrial zoned land in central locations is unnecessary; it is also seen as counterproductive given other uses that demand central city land will produce a greater return. This logic reframes deindustrialization as part of a process of “creative destruction” reshaping the built environment to facilitate capital accumulation (Harvey, 1989). Indeed, studies have documented the rezoning of industrial land in urban areas to higher value uses (Chapple, 2014; Ferm & Jones, 2017; Lester, Kaza, & Kirk, 2013; Wolf-Powers, 2005). This assumption continues to drive urban industrial policy even where policymakers have latched on to the promotion of innovation-driven advanced manufacturing (Grodach & Gibson, 2019).

Of course, in reality manufacturing is not a monolithic industry exhibiting a singular set of needs, but a diverse group of subsectors with varying functional and organizational characteristics (Buciuni & Pisano, 2018). Consequently, not all manufacturing firms will benefit from an outer-suburban location. In particular, smaller manufacturing firms that do not require large lot facilities and that tend to be highly specialized may benefit more from a central location near local clients and skilled pools of labor. In Australia, where this study takes place, just over 90% of all manufacturing firms possess fewer than 20 employees (Australian Bureau of Statistics, 2019a).

Further, not all specialized manufacturers rely solely on advanced manufacturing processes. Many are “low-tech,” meaning that they possess low research and development intensity and are more likely to incrementally innovate products and processes (Hansen & Winther, 2014, 2015). This contrasts to “high-tech,” advanced manufacturing, which relies more heavily on R&D expenditures and break-through innovations (e.g. computer equipment, pharmaceuticals, and aerospace manufacturing) (Australian Bureau of Statistics, 2015a; OECD, 2015). Many are also “high-touch” forms of manufacturing, meaning that they rely on skilled, labor-intensive processes and add value through design innovations over digital technologies and automation (Friedman & Byron, 2012; Rosenfeld, 2018).

Cultural manufacturers (CM)¹ and Food and Beverage Manufacturers (FBM) are emblematic of the low-tech, high-touch designation. CM firms tend to be small in size and produce high value-added and design-intensive products in small batch runs in response to changing consumer taste and contractor demands (Fox Miller, 2017; Hatch, 2014; Gibson et al., 2017; Hatuka, Ben-Joseph, & Peterson, 2017; Scott, 2004) as do their FBM counterparts (Donald, 2009; Manniche & Testa, 2010; Schrock, Doussard, Wolf-Powers, Marotta, & Eisenburger, 2019). This type of production requires a diversity of labor (e.g. machining, fabricating, designing, marketing, retailing) that generally extends beyond the limited internal capacities of a small business, thus requiring flexibility in production and institutional structures (Scott, 1988). As such, they tend to cluster in the inner-city in close proximity to other businesses, to meet their varied labor demands through external transactions (Gibson et al., 2017; Scott, 1988, 2004). In the face of volatile consumer demand and high product turnover, spatial proximity across the chain of production facilitates low inventories, fast turnarounds, and rapid responses to

changing market trends (Buciuni & Finotto, 2016; Scott, 2004). In addition to these functional considerations, spatial clustering also plays a significant role in building trust and facilitating tacit knowledge exchange (Leslie & Rantisi, 2017; Maskell, 1998). Close ties to local material suppliers, product designers, and specialized labor persist in concert with global “pipelines” of knowledge, taste, and materials (Bathelt, Malmberg, & Maskell, 2004). This also means that they tend to depend on the colocation of design and production functions (Buciuni & Pisano, 2018; Warren & Gibson, 2013). In some cases, single producers come together in “maker spaces” where they gain access to shared workspace, tools, skills, and information (Wolf-Powers et al., 2017). In short, unlike traditional manufacturing, CM and FBM firms are more likely to rely on the advantages of urban agglomeration that enable them to tap into dense business and labor networks and large consumer markets predominately found in central city locations much like- and in association with- their cultural industry counterparts (Lazzeretti, Capone, & Boix, 2012; Scott, 2004).

However, to assume industrial clustering occurs based on functional and organizational characteristics alone ignores the importance of land use planning in enabling or restricting certain uses. Much more so than other post-industrial activity, low-tech, high-touch manufacturing comes up against the realities of real estate market competition and zoning restrictions. As a consequence, they tend to seek out urban industrial zones, which not only allow nuisance activities and provide flexible work spaces, but also temper market rents based on permitted land uses and height restrictions (Gibson et al., 2017). However, as noted above, the overall decline in manufacturing has been accompanied by the loss of industrial land in many cities without account for the diversity of manufacturing needs and contributions to local economies.

Many have pointed to the role of powerful interest groups in securing the up-zoning of industrial land through local policy maneuvers (Curran & Hanson, 2005; Shaw, 2015; Wolf-Powers, 2005). Property developers have largely pursued the rezoning of urban industrial lands to higher return residential mixed-uses to maximize returns on the potential rent gap (Scott, 2019; Smith, 1987). This in turn may displace urban manufacturing firms- and the quality jobs they provide- to more far flung industrial zones, assuming they do not move to other regions or go out of business entirely (Curran, 2010; Curran & Hanson, 2005; Shaw, 2015; Sprague & Rantisi, 2018). The loss of increasingly scarce urban industrial land is compounded by the extant bias within industrial land use policy described above. This is particularly problematic in high-cost, service-oriented economies where job opportunities are increasingly polarized across high and low wage options and where industrial policy may be a route toward working-class jobs and stimulating consumption of locally made products.

However, the extent to which low-tech, high-touch manufacturing, including CM and FBM, actually concentrates in urban areas and depends on centrally zoned industrial land is largely undocumented. Existing case studies do not document the locational variation across different types of manufacturing and their association with industrial zones in different parts of the city. While researchers have mapped the regional location patterns of the cultural industries (Boix, Capone, De Propriis, Lazzeretti, & Sanchez, 2014; Currid & Williams, 2010; Graif, 2018; Kiroff, 2017; Markusen & Schrock, 2006; Grodach, Currid-Halkett, Foster, & Murdoch, 2014; Qian & Liu, 2018), none have specifically studied cultural manufacturing or related low-tech, high-touch industries. This activity is

likely to have specific needs and land use sensitivities that are overlooked in the current focus, which frames manufacturing largely through a post-industrial, “high-tech” lens. Do low-tech, high-touch manufacturing employment patterns resemble manufacturing overall or do they exhibit a different trajectory? Do they concentrate in central locations as proposed in the literature or do they locate in outer areas like other forms of manufacturing? To what extent do low-tech, high-touch manufacturing location patterns correspond with industrial zoning?

Data and methodology

In this study, we focus on two representative sets of low-tech, high-touch manufacturing- Cultural Manufacturing (CM) and Food and Beverage Manufacturing (FBM)- and compare them to all other manufacturing industries in Melbourne, Australia. We examine manufacturing in Melbourne for several reasons. Melbourne was Australia’s center of manufacturing through the 19th century and remained an important site for motor vehicle and textile manufacture through most of the 20th century. However, this manufacturing legacy has eroded since the 1970s under post-industrial forms of redevelopment and gentrification (Dingle & O’ Hanlon, 2009). Melbourne’s increasing gentrification is facilitated in part by central city industrial re-zoning (Shaw & Davies, 2014) and planning for industrial land uses predominately in the outer suburbs (State of Victoria, 2017). Many also consider Melbourne Australia’s creative capital, possessing a robust concentration of cultural industries and local food production. This, combined with the city’s population of five million, mean that CM and FBM have access to a substantial client and consumer base, yet policy does not recognize these manufacturing subsectors.

As set out above, CM and FBM are classified as “low-tech” because they tend not to engage in tech-oriented R&D and employ “high-touch” or labor-intensive production methods. We define CM and FBM based on the Australia New Zealand Standard Industrial Classification (ANZSIC) system at the four-digit level to provide the finest granularity of industry activity (Appendix Tables A1–A3).² CM encompasses a variety of industries that manufacture consumer products that convey signs of social distinction and self-affirmation (e.g. furniture, clothing, jewelry), as well as industries that produce specialized material components for cultural industries (e.g. specialized printing for media, advertising and visual arts). Unfortunately, CM is not a designated class within the ANZSIC. As such, we developed a composite taxonomy based on ABS industry definitions (Trewin & Pink, 2006). We selected industries that combined practical and symbolic knowledge in low-technology, labor-intensive processes. Though there are variations between the industries selected, we reasoned that similar production processes were likely to translate to similar locational preferences. FBM is clearly distinguished within ANZSIC and we include all four-digit industries within this category. All manufacturing industries not designated as CM or FBM are included as All Other Manufacturing (AOM) industries.³

We obtained 2011 and 2016 manufacturing employment data from the Australian Bureau of Statistics (ABS) Census of Population and Housing (Census) based on place of work at the Destination Zone (DZN) level (Australian Bureau of Statistics, 2019b). DZNs are the smallest available Census geography and thereby enable the identification of employment concentrations closest to their actual locations. This mitigates the scale effects associated with modifiable areal unit problem (MAUP) by maintaining variability in the data that is generally

moderated when aggregating to larger areal units (Altaweel, 2018; Wong, 2009). Although some geostatistical studies use firm-based data (Boix, Hervás-Oliver, & De Miguel-Molina, 2015; Currid & Williams, 2010), we elected to use employment data because it allows us to capture the high incidence of small firms, micro-enterprises, and self-employed persons that may not be counted in the ABS Business Register (Australian Bureau of Statistics, 2015b). A limitation to using employment rather than firm data is that large single employers may accentuate certain geographical areas over others (Sunley & Martin, 2003). However, over 90% of manufacturing firms in Australia possess less than 20 employees (ABS, 2019a).

The first part of the analysis examines 2011–2016 employment change and 2016 employment concentration for CM, FBM, and AOM for “Inner Melbourne” and “Greater Melbourne.” We used location quotients to measure industry concentration for Inner and Greater Melbourne using national employment as a benchmark. Inner Melbourne is based on the ABS’s Statistical Area 4 (SA4), which comprises the Central Business District (CBD) and immediately surrounding suburbs or neighborhoods. Greater Melbourne represents the entire metropolitan area and is defined by the ABS’s Greater Capital City Statistical Area (GCCSA) designation. Inner Melbourne contains 34% of the jobs in Greater Melbourne (ABS, 2019b). In fact, the CBD alone contains nearly 11% of Greater Melbourne jobs, followed by Dandenong, an area in southeast Melbourne with just over 3% of employment (ABS, 2019b). This is indicative of Melbourne’s highly centralized job market and the importance of inner-city locations compared to other polycentric cities with multi-nodal job centers.

The second part of the analysis used GIS to perform a “hotspot analysis” on employment across Greater Melbourne for CM, FBM and AOM. Employment hotspots were ascertained using the Getis Ord G_i^* statistic, a common approach used to identify areas with clusters of high employment that are unlikely to have occurred randomly (Currid & Williams, 2010; ESRI, n.d.). The G_i^* statistic compares the local sum of employment for a Destination Zone and its neighbors to the expected local sum for the study area (Mitchell, 2009). If the local sum was significantly higher than the expected sum for Greater Melbourne, the Destination Zone was deemed to be part of an employment hotspot. The 90% confidence level was used to determine statistical significance.

While there is little consensus on the appropriate threshold distance for cluster analysis (Carroll, Reid, & Smith, 2008; Reid, Carroll, Smith, & Frizado, 2009; Sunley & Martin, 2003), in this instance a band of 500 meters was used, corresponding with a large body of literature highlighting the intensity of local clustering in the cultural sector (Bell & Jayne, 2004; Currid & Williams, 2010; Wood & Dovey, 2015; Grodach, Currid-Halkett, Foster, & Murdoch, 2014; Scott, 2004), as well as emerging studies on cultural manufacturing more specifically (Comunian & England, 2019; Lazzeretti & Oliva, 2018; Pollard, 2004; Gibson et al., 2017; Sprague & Rantisi, 2018). In addition to its theoretical grounding, a small distance band was used for pragmatic reasons relating to the industrial geography of Greater Melbourne. The outer metropolitan region contains Victoria’s State Significant Industrial Precincts (SSIPs), comprising large, continuous areas of industrially-zoned land strategically located in the regional freight transport network (State of Victoria, 2018b). By contrast, Inner Melbourne contains small industrial pockets dispersed amongst a mix of residential and green spaces that do not contain employment. As a result, a large distance band presents a generalized picture of employment patterns (i.e. large hotspots of manufacturing employment in the peripheral SSIPs) not particularly useful in answering questions around fine-grain location patterns. However, a smaller distance band is more adept

at distinguishing areas in the SSIPs with the highest concentrations of employment, as well as detecting small clusters of comparably high employment in the urban core. Whilst small distance bands are used cautiously in hotspot analysis, a parameter was specified in the spatial weights matrix to ensure all Destination Zones had at least one neighbor to uphold the validity of computed z-scores (Basu, 2015; ESRI, n.d.).

Manufacturing industry concentration and change in Melbourne, Australia

In this section, we employ location quotient analysis and examine change over time to compare the relative strength of the CM and FBM industries with other manufacturing activity in Inner Melbourne and Greater Melbourne.⁴ Overall, we find that manufacturing has experienced pronounced decline particularly in the central city, which coincides with a dramatic loss of industrial zoned land. However, not all manufacturing is going offshore. Important concentrations within CM and FBM persist primarily at the metropolitan level.

Inner Melbourne

None of the three manufacturing subsets are concentrated in Inner Melbourne (Table 1). This is not a surprise given that manufacturing has been on the decline nationally since the 1970s and local and state government have focused on strategies to make central Melbourne appealing to middle-class consumption, including the re-zoning of industrial land (Shaw & Davies, 2014; Shaw & Montana, 2016). In fact, between 2000 and 2016–17, Greater Melbourne lost 2,221 hectares (about 8.6 square miles) of industrial land. Most of this was in the form of smaller industrial zones (< 5 hectares) in the inner and middle suburbs where 34% of the land was re-zoned to residential and 18% was designated mixed-use (State of Victoria, 2018b).

As Table 1 shows, while Inner Melbourne does not specialize in CM employment ($LQ = 0.71$), it is considerably more concentrated than other manufacturing activity here ($FB = 0.52$ and $AOM = 0.45$). So, while CM employment is comparatively weak in Inner Melbourne, it is notably more concentrated here than other forms of manufacturing. However, employment loss in Inner Melbourne is sizable over the 2011–2016 study period. CM employment declined by nearly 25%, compared to a loss of 21% in All Other Manufacturing (AOM). FBM shows slight growth (1.4%).

Still, a few specific industries within each manufacturing group holdout strong concentrations in Inner Melbourne. Notably, these are CM industries tied to the cultural economy in media (Reproduction of Recorded Media, Printing Support) and fashion (Clothing, Jewelry). FBM concentrations are in local specialty food production, particularly Beer, but also Cheese and Confections (Figures 1 and 2). These specialized industries may indicate the presence of firms that require highly centralized locations near the firms and customers that they service and supply. They also may be legacy firms that have been able to maintain long-term locations. Determining these characteristics is an important area for future research.

In any case, these subsectors are outliers compared to manufacturing as a whole in Inner Melbourne. With the lone exception of Recorded Media manufacturing, all CM industries lost employment 2011–2016, including Clothing (–45.3%) and Jewelry (–33.2%) (Figure 1). Confectionary Manufacturing is the only FBM industry with both a positive LQ (1.16) and growth rate (230.2%) (Figure 2).

Table 1. Employment concentration (LQ) and change 2011–2016, by industry and geography.

	Cultural Manufacturing			Food and Beverage Manufacturing			All Other Manufacturing		
	LQ 2016	Employment 2016	% Change	LQ 2016	Employment 2016	% Change	LQ 2016	Employment 2016	% Change
Inner City	0.71	3,966	-24.8	0.52	6,037	1.4	0.45	9,113	-20.7
Greater Melbourne	1.55	25,667	-16.6	0.93	32,335	4.8	1.29	77,716	-25.8
Australia	-	86,447	-22.3	-	182,249	-0.2	-	314,462	-31.5

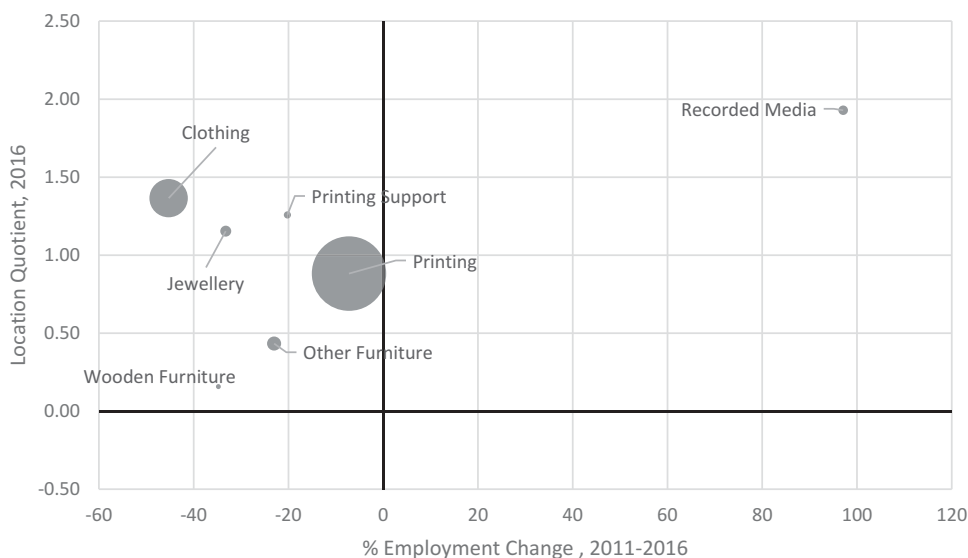


Figure 1. Cultural manufacturing employment size, concentration and change, Inner Melbourne.

Note: Figure shows representative Cultural Manufacturing industries with 100 or more employment.

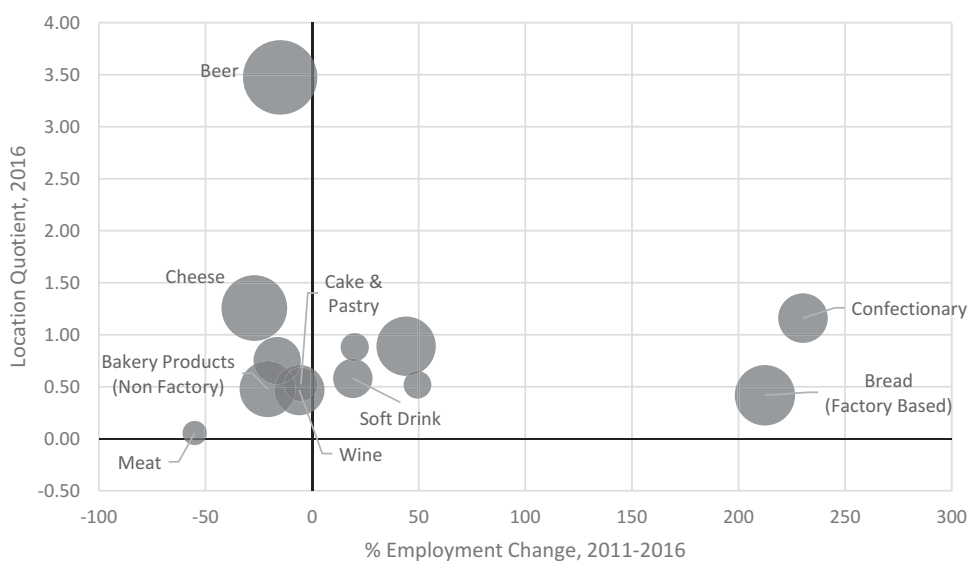


Figure 2. Food and beverage manufacturing employment size, concentration and change, Inner Melbourne.

Note: Figure shows representative Food and Beverage Manufacturing industries with 100 or more employment.

Greater Melbourne

Greater Melbourne exhibits stronger manufacturing employment concentrations and softer employment declines than Inner Melbourne. This coincides with a net increase of 4,084 hectares in industrial land primarily through expansion of the outer-suburban State

Sponsored Industrial Precincts (SSIP) as directed by the State's strategic plan, Plan Melbourne (State of Victoria, 2017,2018b). The preservation and addition of outer-suburban industrial land likely plays a role in slowing regional employment decline despite the overall loss of industrial land due to Inner Melbourne re-zonings, also a strategic component of Plan Melbourne.

While FBM sits below the national average (0.93), AOM (1.29) and, in particular, CM (1.55) exhibit strong concentrations at the metropolitan level. CM Employment decline is less pronounced than in Inner Melbourne, but it is still substantial (16.6%). However, this compares to an employment loss in AOM industries of nearly –26% in Greater Melbourne and a massive –31.5% Australia-wide. In contrast to the national trend of manufacturing employment loss, FBM grew by 4.8% in Greater Melbourne. Metropolitan level growth may be due to demand for specialized, locally-made food products (Schrock et al., 2019) or is simply tied to population increase and the highly localized nature of much food production.

Some CM industries exceeded the CM LQ of 1.55 including multiple apparel manufacturing and printing industries, Reproduction of Recorded Media, and Other Furniture Manufacturing (Figure 3). However, these concentrations are waning as many of the industries lost employment between 2011 and 2016. Apparel manufacture declined across the board alongside some furniture manufacturing, Ceramics (–43.3%), and Jewelry (–25.7%). However, Wooden Furniture manufacturing actually gained employment (3.8%) alongside Reproduction of Recorded Media (13.3%), and Printing (0.7%). In FBM, Confections, Ice Cream, Cigarette, Beer, and Cheese Manufacturing are highly concentrated, yet few of these industries added jobs (Figure 4).

Overall, the analysis of industry concentration and change paints a picture of manufacturing in contraction, particularly in Inner Melbourne. However, this does not appear to be simply a product of a shifting post-industrial economy. Rather, it may be an outcome of urban planning and policy priorities. In the next section, we focus on the specific “hotspots” of manufacturing activity and confirm the crucial role of central city industrial land for low-tech, high-touch manufacturing.

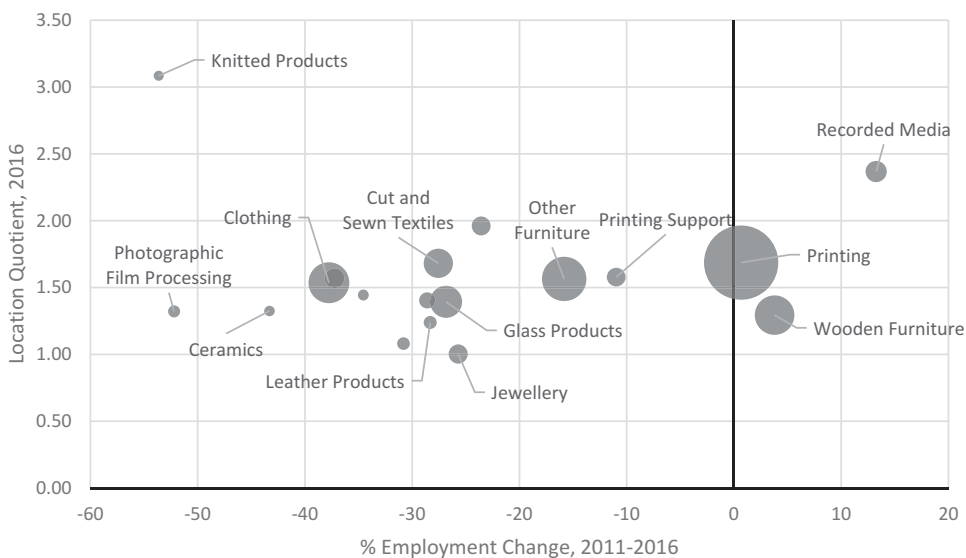


Figure 3. Cultural manufacturing employment size, concentration and change, Greater Melbourne.

Note: Figure shows representative Cultural Manufacturing industries with 100 or more employment.

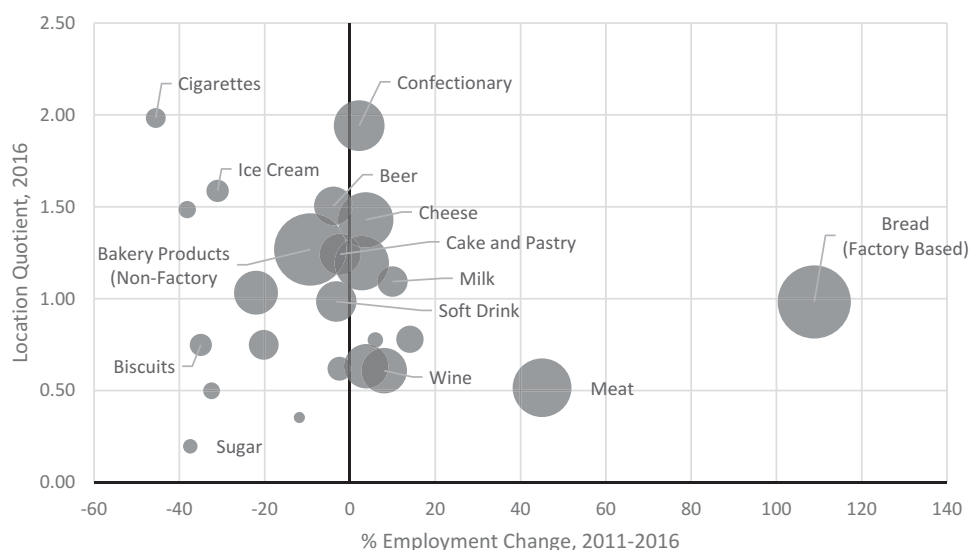


Figure 4. Food and beverage manufacturing employment size, concentration and change, Greater Melbourne.

Note: Figure shows representative Food and Beverage Manufacturing industries with 100 or more employment.

Melbourne's manufacturing geography

In this section, we examine the geography of manufacturing in Melbourne more closely, zoning in on “hotspots” of manufacturing activity and their location in relationship to industrial lands. While the LQ provides a broad measure of concentration, “hotspot” analysis gives a more detailed picture of where industries cluster. We not only find that low-tech, high-touch manufacturers exhibit location patterns distinct from manufacturing at large, but also that variation exists between CM and FBM. Confirming the urbanized production characteristics of some CM, we observe significant clusters of activity throughout Inner Melbourne, though likely not to the extent of their cultural industry counterparts. We surmise this is due to their dependence on industrial zoned land, which hardly exists in Inner Melbourne, rather than their functional characteristics. In fact, with a zero percent vacancy rate, industrial zoned land in Inner Melbourne is clearly a precious commodity (State of Victoria, 2018b). This speaks to the importance of industrial zoned land for existing low-tech, high-touch manufacturers and the extant tensions between re-zoning and industrial agglomeration patterns.

Overall, we observe hotspots of all manufacturing groups scattered across Greater Melbourne's industrial zones. As Figures 5–7 show, a ring of large manufacturing hotspots exists in the outer suburbs particularly in the massive State Significant Industrial Precincts (SSIP) in the North, Southeast and West of the metro area. Here, AOM maintains stronger concentrations at higher confidence levels than CM and particularly FBM (Figures 5–7). This fits with general descriptions of manufacturing as more cost-focused and less design-oriented.

This makes sense too when we consider variations between the low-tech, high-touch manufacturing groups from manufacturing overall. CM in particular possesses notable

clusters of employment closer to the city center in middle ring suburban zones, particularly in the city's east (Figure 5). These tend to align with existing industrial zones and, in many instances, may spread beyond their boundaries to surrounding areas. This suggests a manufacturing legacy around prior industrial zoning but requires further research to confirm.

Despite employment loss, low-tech, high-touch manufacturing continues to cling to industrial land in Inner Melbourne. Each type of manufacturing clusters in distinct locations and CM and FBM clearly cluster more strongly here than AOM activity (Figures 8–10). As in Greater Melbourne, employment clusters center on and tend to expand beyond the bounds of the few remaining industrial zoned areas. CM exhibits the largest and strongest hotspots across the north, east, and west portions of Inner Melbourne and take up a much larger portion of this area expanding into adjacent industrial zones as well as in weaker clusters scattered throughout the entire Inner Melbourne area. FBM clusters are predominately located along the southern end of the Inner area running through rapidly gentrifying Yarraville to the west, through South Bank adjacent to the CBD, and the converted industrial buildings of gentrified Richmond. This could indicate a new mix of hybrid manufacturing-design-retail outfits adapted to post-industrial land use patterns. In contrast, AOM is clustered around just four industrial zones. Its primary concentration remains near Port Melbourne and in the Fisherman's Bend urban renewal project. At 215 hectares, the latter comprises the largest single re-zoning of industrial land in Greater Melbourne. Once crucial to Australia's aerospace and auto manufacturing industries, it is now slated for redevelopment to expand the CBD by "drawing on its industrial heritage and building on its proximity to a thriving knowledge sector" (State of Victoria, 2018a, p. 15).

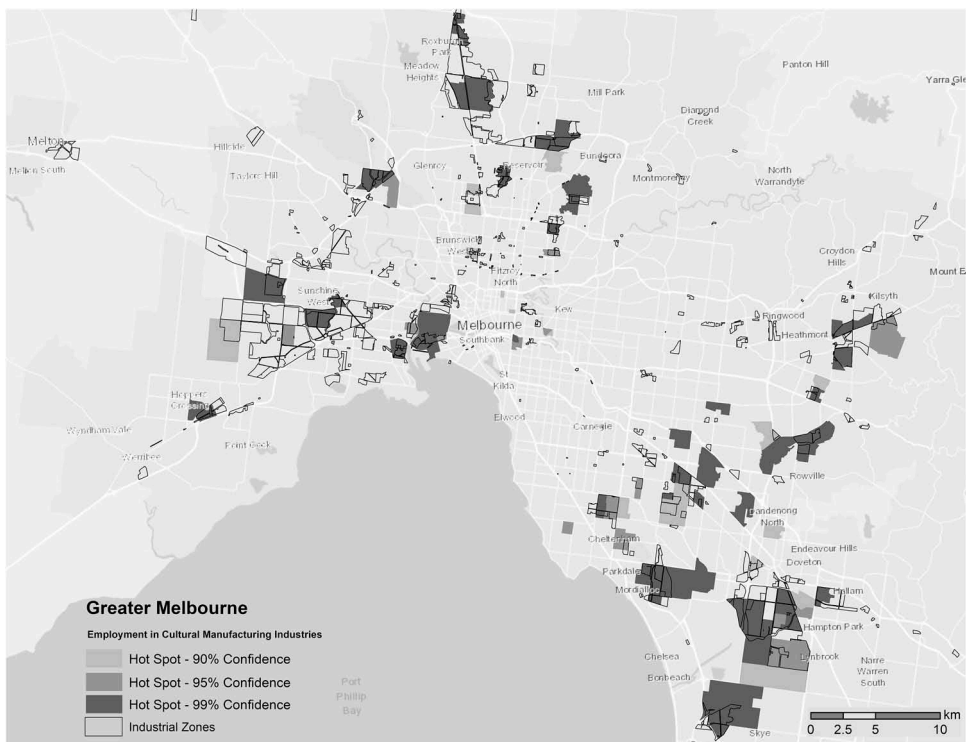


Figure 5. Employment hotspots for Cultural Manufacturing (CM), Greater Melbourne.

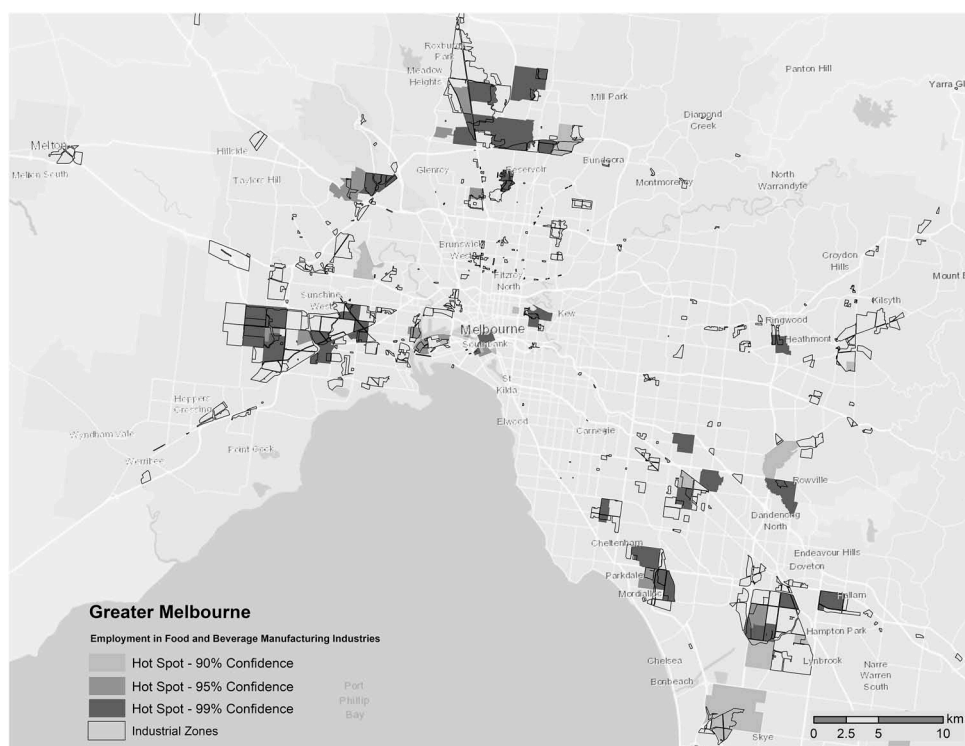


Figure 6. Employment hotspots for Food and Beverage Manufacturing (FBM), Greater Melbourne.

Rethinking manufacturing in post-industrial cities

Manufacturing in “post-industrial” cities is increasingly framed around a narrative of advanced, innovation-driven production. This policy directive tends to concentrate on the preservation and even expansion of outer-suburban industrial zones for larger, cost-competitive firms while ignoring the re-zoning of central industrial land for higher-dollar uses and the resultant loss of small manufacturers (Grodach & Gibson, 2019). Speculative redevelopment through the creative destruction of devalued land uses is of course not new (Harvey, 1989), but the current situation is reinforced by an aspatial, post-industrial vision of manufacturing that fails to differentiate between the locational needs of particular subsectors.

Contemporary manufacturing policy exhibits a particular policy gap and lack of knowledge around forms of manufacturing that we label low-tech and high-touch due to their low reliance on production innovations and emphasis on specialized, labor-intensive processes. As this study shows, low-tech, high-touch manufacturing exhibits distinct patterns of employment concentration, change, and clustering compared to other manufacturing industries. Drilling down, we also see significant differences within the low-tech, high-touch designation. While Cultural Manufacturing (CM) has been hit by substantial employment loss, particularly in Inner Melbourne, it is nonetheless the most highly concentrated form of manufacturing in the greater metropolitan area. Conversely, while Food and Beverage Manufacturing (FBM) is weakly concentrated, the sector stands out for its employment growth over the study period.

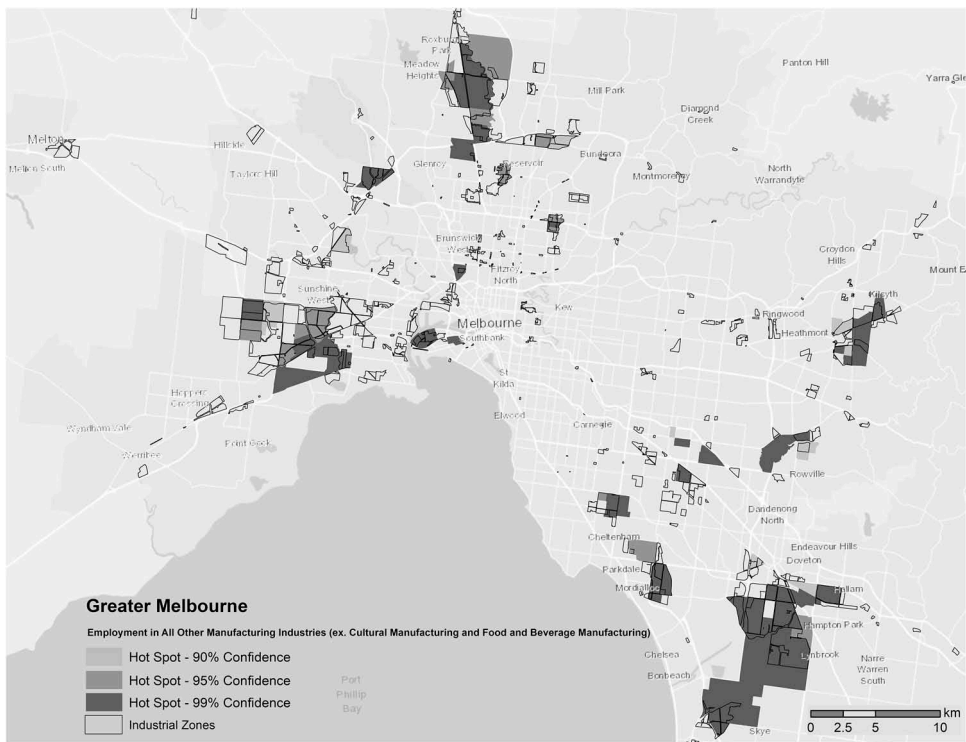


Figure 7. Employment hotspots for All Other Manufacturing (AOM), Greater Melbourne.

Moreover, although all manufacturing hotspots strongly correspond with industrial zoning designations, different types of manufacturing tend to occupy different areas, particularly in Inner Melbourne. Here, CM exhibits the strongest presence among the three types of manufacturing, hanging onto the few remnants of industrial zoning. Indeed, while the SSIPs provide important space for manufacturing on the urban fringe, they are not necessarily suitable for all types of manufacturing. This is particularly the case for CM firms, which tend to be smaller and more urbanized, likely due to their diverse labor needs and close association with other centralized firms in the cultural industries. They therefore rely on central city and middle suburban industrial zones perhaps more than any other manufacturing subsector and may in rare instances survive in formerly zoned industrial areas.

Consequently, the employment loss within CM is likely not only a product of employment outsourcing to lower-cost regions. As others have demonstrated, the loss of urban manufacturing is also due to the re-zoning of industrial land in suitable locations, particularly in high-cost cities (Curran & Hanson, 2005; Ferm & Jones, 2017; Wolf-Powers, 2005). Ultimately, the loss of central city industrial land is a direct consequence of post-industrial land use policies that prioritize market return over diversifying business and employment opportunity. The strategic decision to develop outer-suburban industrial areas and remove central city industrial land not only contributes to the shifting geography of manufacturing. It also paradoxically reduces land use and job diversity in the central city as former industrial areas are re-zoned to house upmarket residential buildings. Behind the scenes of gentrified



Figure 8. Employment hotspots for Cultural Manufacturing (CM), Inner Melbourne.



Figure 9. Employment hotspots for Food and Beverage Manufacturing (FBM), Inner Melbourne.



Figure 10. Employment hotspots for All Other Manufacturing (AOM), Inner Melbourne.

cityscapes and the celebration of a maker movement, are pressures on potentially important manufacturing employers and suppliers to key post-industrial industries.

Urban policy needs to broaden its understanding of manufacturing to recognize the importance of different locations and types of industrial land to the survival of a manufacturing economy. This includes rethinking the value and uses of remnant inner-city industrial zones. Preserving “industrial sanctuaries” and tightening existing industrial zones to restrict residential uses is one basic yet challenging step toward providing tenure security to small urban manufacturing enterprises. It also requires experimenting with new forms of mixed-use that permit manufacturing. A handful of US cities are selectively introducing programs that require higher-dollar uses to subsidize new manufacturing space, but this has yet to be implemented widely (Grodach & Gibson, 2019).

While this study has uncovered variations in locational clustering patterns between manufacturing subsets, more research is needed to understand the precise organizational and social dynamics behind locational decisions. Clearly, central city industrial districts continue to be important spaces for some manufacturers. However, few studies have looked at how specific manufacturers have negotiated the cost and land pressures associated with post-industrial restructuring (Evans & Smith, 2006). Beyond this, while the re-integration of urban manufacturing has the potential to ameliorate growing inequality in post-industrial cities, a greater understanding of the labor market characteristics of low-tech, high-touch manufacturers is required to assess the extent to which they actually contribute living wage jobs for socially and economically marginalized groups.

Notes

1. CM produce material goods (e.g. furniture, clothing, jewelry) and specialized production services (e.g. printing, recorded media) strongly infused with cultural or semiotic meaning (2017).
2. We exclude employment that could not be coded to the four-digit level (i.e. where Census respondents provided incomplete, nonspecific, or imprecise details of their employment activities) (ABS, 2016). As a consequence, the study undercounts manufacturing employment across the three categories. Nationally, a total of 105,641 employees or 13.5% of manufacturing employment could not be classified at the four-digit level (ABS, 2019b).
3. The latter category may incorporate some activity that qualifies as low-tech and high-touch but does not fall into either CM or FBM categories. AOM tends to encompass more heavy industrial activity (see Appendix Table A3).
4. A complete list of location quotients and employment change 2011–2016 for all industries is available from the authors.

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Appendix

Table A1. Cultural manufacturing industries (CM).

3 ANZSIC (4 Digit)	Cultural Manufacturing Industries (CM)
1320	Leather Tanning, Fur Dressing and Leather Product Manufacturing
1331	Textile Floor Covering Manufacturing
1333	Cut and Sewn Textile Product Manufacturing
1340	Knitted Product Manufacturing
1351	Clothing Manufacturing
1352	Footwear Manufacturing
1611	Printing
1612	Printing Support Services
1620	Reproduction of Recorded Media
2010	Glass and Glass Product Manufacturing
2029	Other Ceramic Product Manufacturing
2511	Wooden Furniture and Upholstered Seat Manufacturing
2512	Metal Furniture Manufacturing
2519	Other Furniture Manufacturing
2591	Jewelry and Silverware Manufacturing
2592	Toy, Sporting and Recreational Product Manufacturing
2599	Other Manufacturing nec
9532	Photographic Film Processing

Table A2. Food and beverage manufacturing industries (FBM).

ANZSIC (4 Digit)	Food and Beverage Manufacturing Industries
1111	Meat Processing
1112	Poultry Processing
1113	Cured Meat and Smallgoods Manufacturing
1120	Seafood Processing
1131	Milk and Cream Processing
1132	Ice Cream Manufacturing
1133	Cheese and Other Dairy Product Manufacturing
1140	Fruit and Vegetable Processing
1150	Oil and Fat Manufacturing
1161	Grain Mill Product Manufacturing
1162	Cereal, Pasta and Baking Mix Manufacturing
1171	Bread Manufacturing (Factory based)
1172	Cake and Pastry Manufacturing (Factory based)
1173	Biscuit Manufacturing (Factory based)
1174	Bakery Product Manufacturing (Non-factory based)
1181	Sugar Manufacturing
1182	Confectionery Manufacturing
1191	Potato, Corn and Other Crisp Manufacturing
1192	Prepared Animal and Bird Feed Manufacturing
1199	Other Food Product Manufacturing nec
1211	Soft Drink, Cordial and Syrup Manufacturing
1212	Beer Manufacturing
1213	Spirit Manufacturing
1214	Wine and Other Alcoholic Beverage Manufacturing
1220	Cigarette and Tobacco Product Manufacturing

Table A3. All other manufacturing industries (ex. Cultural & Food and Beverage Manufacturing).

ANZSIC (4 Digit)	All Other Manufacturing Industries (<i>ex. Cultural & Food and Beverage Manufacturing</i>)
1311	Wool Scouring
1312	Natural Textile Manufacturing
1313	Synthetic Textile Manufacturing
1332	Rope, Cordage and Twine Manufacturing
1334	Textile Finishing and Other Textile Product Manufacturing
1411	Log Sawmilling
1412	Wood Chipping
1413	Timber Resawing and Dressing
1491	Prefabricated Wooden Building Manufacturing
1492	Wooden Structural Fitting and Component Manufacturing
1493	Veneer and Plywood Manufacturing
1494	Reconstituted Wood Product Manufacturing
1499	Other Wood Product Manufacturing nec
1510	Pulp, Paper and Paperboard Manufacturing
1521	Corrugated Paperboard and Paperboard Container Manufacturing
1522	Paper Bag Manufacturing
1523	Paper Stationery Manufacturing
1524	Sanitary Paper Product Manufacturing
1529	Other Converted Paper Product Manufacturing
1701	Petroleum Refining and Petroleum Fuel Manufacturing
1709	Other Petroleum and Coal Product Manufacturing
1811	Industrial Gas Manufacturing
1812	Basic Organic Chemical Manufacturing
1813	Basic Inorganic Chemical Manufacturing
1821	Synthetic Resin and Synthetic Rubber Manufacturing
1829	Other Basic Polymer Manufacturing
1831	Fertilizer Manufacturing
1832	Pesticide Manufacturing
1841	Human Pharmaceutical and Medicinal Product Manufacturing
1842	Veterinary Pharmaceutical and Medicinal Product Manufacturing
1851	Cleaning Compound Manufacturing
1852	Cosmetic and Toiletry Preparation Manufacturing
1891	Photographic Chemical Product Manufacturing
1892	Explosive Manufacturing
1899	Other Basic Chemical Product Manufacturing nec
1911	Polymer Film and Sheet Packaging Material Manufacturing
1912	Rigid and Semi-Rigid Polymer Product Manufacturing
1913	Polymer Foam Product Manufacturing
1914	Tyre Manufacturing
1915	Adhesive Manufacturing
1916	Paint and Coatings Manufacturing
1919	Other Polymer Product Manufacturing
1920	Natural Rubber Product Manufacturing
2021	Clay Brick Manufacturing
2031	Cement and Lime Manufacturing
2032	Plaster Product Manufacturing
2033	Ready-Mixed Concrete Manufacturing
2034	Concrete Product Manufacturing
2090	Other Nonmetallic Mineral Product Manufacturing
2110	Iron Smelting and Steel Manufacturing
2121	Iron and Steel Casting
2122	Steel Pipe and Tube Manufacturing
2131	Alumina Production
2132	Aluminum Smelting
2133	Copper, Silver, Lead and Zinc Smelting and Refining
2139	Other Basic Non-Ferrous Metal Manufacturing
2141	Non-Ferrous Metal Casting
2142	Aluminum Rolling, Drawing, Extruding
2149	Other Basic Non-Ferrous Metal Product Manufacturing
2210	Iron and Steel Forging
2221	Structural Steel Fabricating

(Continued)

Table A3. (Continued).

ANZSIC (4 Digit)	All Other Manufacturing Industries (<i>ex. Cultural & Food and Beverage Manufacturing</i>)
2222	Prefabricated Metal Building Manufacturing
2223	Architectural Aluminum Product Manufacturing
2224	Metal Roof and Guttering Manufacturing (except Aluminum)
2229	Other Structural Metal Product Manufacturing
2231	Boiler, Tank and Other Heavy Gauge Metal Container Manufacturing
2239	Other Metal Container Manufacturing
2240	Sheet Metal Product Manufacturing (except Metal Structural and Container Products)
2291	Spring and Wire Product Manufacturing
2292	Nut, Bolt, Screw and Rivet Manufacturing
2293	Metal Coating and Finishing
2299	Other Fabricated Metal Product Manufacturing nec
2311	Motor Vehicle Manufacturing
2312	Motor Vehicle Body and Trailer Manufacturing
2313	Automotive Electrical Component Manufacturing
2319	Other Motor Vehicle Parts Manufacturing
2391	Shipbuilding and Repair Services
2392	Boatbuilding and Repair Services
2393	Railway Rolling Stock Manufacturing and Repair Services
2394	Aircraft Manufacturing and Repair Services
2399	Other Transport Equipment Manufacturing nec
2411	Photographic, Optical and Ophthalmic Equipment Manufacturing
2412	Medical and Surgical Equipment Manufacturing
2419	Other Professional and Scientific Equipment Manufacturing
2421	Computer and Electronic Office Equipment Manufacturing
2422	Communication Equipment Manufacturing
2429	Other Electronic Equipment Manufacturing
2431	Electric Cable and Wire Manufacturing
2432	Electric Lighting Equipment Manufacturing
2439	Other Electrical Equipment Manufacturing
2441	Whiteware Appliance Manufacturing
2449	Other Domestic Appliance Manufacturing
2451	Pump and Compressor Manufacturing
2452	Fixed Space Heating, Cooling and Ventilation Equipment Manufacturing
2461	Agricultural Machinery and Equipment Manufacturing
2462	Mining and Construction Machinery Manufacturing
2463	Machine Tool and Parts Manufacturing
2469	Other Specialized Machinery and Equipment Manufacturing
2491	Lifting and Material Handling Equipment Manufacturing
2499	Other Machinery and Equipment Manufacturing nec
2513	Mattress Manufacturing