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Article

Urban Revitalisation Between Artisanal Craft and Green Manufacturing: The Case of Brisbane’s Northgate Industrial Precinct

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Abstract

As Brisbane prepares for the 2032 climate-positive Olympics, traditional industrial precincts in the city are rapidly transforming. With a population of 2.5 M Brisbane has grown by 20% every decade since 1950, and sustainability-driven urbanism is an imperative. Here we document the history and future of Holland Street in Northgate, an inner-city industrial suburb, in the context of local, state, and national urban revitalisation and policymaking. Two globally distinctive tenants, (a) the Advanced Robotics for Manufacturing Hub and (b) bespoke public art manufacturer and foundry Urban Art Projects, face the twin challenges of embracing green manufacturing and the re-invention of blue-collar work. Digital transformations such as an energy-efficient automated foundry and the integration of cobots in custom manufacturing are advancing the goals of green manufacturing, blue-collar upskilling, and reshoring. An open innovation network creates knowledge spillovers to other industrial precincts in the city. The article discusses local urban planning innovation that is informed by publicly and privately funded R&D, underwritten by state-level government, and a consortium of universities and industry partners. The overall goal is to sketch the nascent planning elements for a locale that is tailored to accommodate the reinvention of urban manufacturing.

Keywords

advanced manufacturing; blue-collar work; Brisbane; brownfield sites; Industry 4.0; intangible capital; public art; social capital; urban revitalisation

Issue

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1. Introduction

Australia’s manufacturing sector contributes close to AU\$100 B (6% of GDP) and employs around 900,000 workers (Australian Department of Industry, Science and Resources, 2020). It has regained some policy relevance since Covid-19 exposed both gaps in and the fragility of Australia’s manufacturing supply chains (Free & Hecimovic, 2021). However, it remains a potent example of deindustrialisation which has been occurring over the past 25 years (Worrall et al., 2021). Share of GDP, export/import ratios for manufactured goods, manufacturing self-sufficiency, and economic complexity (in terms

of diverse high-value exports) are among the lowest in OECD countries (Worrall et al., 2021). Indeed, Australia no longer has “manufacturing cities.” However, many of the 99.5% of Australian manufacturing businesses classified as small and medium-sized businesses are based in or near urban agglomerations. In addition to supply chain resilience, advocates for the re-industrialisation of Australia point to national resource advantages in green energy, critical minerals required for net-zero carbon technologies, and niche advantages in high-value, high-complexity goods and services (Australian Industrial Transformation Institute, 2021). This is consonant with Dierwechter and Pendras (2020, p. 3), who suggest that:

As we challenge outdated assumptions and stereotypes about how manufacturing looks (big and dirty), operates (slow and conservative), and fits with the modern economy (at odds with visions for urban sustainability), the task is to find ways to weave spaces of production into the visions that already animate planning imaginaries.

Australia's story of deindustrialisation is similar to that seen around the world. Globally, urban manufacturing today is more an exception than a widespread practice. Urban industrial areas have been declining since the 1980s (Douglas, 2013). Productive areas in city centres predate modern urban planning zoning logics. They aimed to take advantage of the proximity to transportation nodes, and resources, and have easy transport access to markets. The logic of premodern productive areas was characterised by a strong image of the factory, which was an integral part of the brand of a company. The factory, as a building type, embedded the values of a company and displayed wealth, reliability, and a sense of stability through architecture. Architecture was intended to display the status of a company (Iglesias & Bernardo, 2022). As an example of conspicuous production, these buildings were meant to achieve a symbolic purpose rather than just house manufacturing operations (Goffman, 1999). Changes in the economic systems, the need of expanding or renovating premises, and especially the need for accessible and fast transportation of goods and raw materials, have in time pushed manufacturing outside city centres. This relocation was contextual to the adoption of Euclidean zoning principles in urban planning, which dictate the isolation of manufacturing activities so as to reduce the impact of noxious activities on the urban fabric. Factories, hence, moved to areas close to main railway lines, motorways, or airports, where land was affordable and larger premises could be established. The proximity to transport was also fundamental to provide access to the new premises to workers; in some instances, workers' suburbs were also established.

The premises abandoned within the city context, in time, were rediscovered but not just for their central location (Westbury, 2015). Building on their architectural value and their heritage flavour, since the 1980s many urban productive areas have been converted into residential and mixed-use precincts (Klaebe et al., 2009), often unlocking access to amenities, such as waterways, previously reserved as transportation routes for goods (Zukin, 2009). The result of urban renewal in industrial areas, over the past 40 years, had mixed results. In Europe generally, this has provided an opportunity for ambitious urban projects to equip cities with new facilities, a broader range of dwelling options, welcome social housing within central areas, the creation of new parks and public gardens, and the establishment of walkable affordable suburbs. In Australia, this process was mainly characterised by a focus on high-end residential development

with minimal attention to the benefit to the broader community, starting from the established residents of the surrounding areas. First, the redevelopment of urban industrial areas has generally facilitated gentrification, increasing problems in housing affordability and challenging the communities that were deeply rooted in these areas. Second, it accelerated the loss of artisanal values and amplified the segregation of manufacturing to specific compounds in peri-urban and suburban areas. This resulted also in making production invisible and detached from the rest of the urban social and physical fabric. The new manufacturing precincts, developed following modernist paradigms, generated anonymous precincts characterised by big anonymous boxes, where production is concealed. The value of architecture as a key signifier for manufacturing surrendered to functionalism and efficiency. Third, the rise of the creative industries emphasised digital means of production in a knowledge economy. While there is growing evidence of this trend not being limited to just inner-city areas—as first proclaimed by Florida's (2003) "creative class" argument—catering for creative/digital economic activities within urban schemes has seen variegated approaches. In some cases, precincts have been created; in others, the range of activities admitted in residential or mixed-use areas expanded. What is clear is that these types of economic activities do not have the same level of visibility and raise the same level of awareness on the urban scene, often not relying on the same signifiers that traditional hard industry adopt, such as the factory as a recognisable building type (Adkins et al., 2007; Collis et al., 2013; R. Florida, 2017). Finally, the neoliberal post-industrial paradigm depends on the continuing growth of consumption and mass manufacturing, which both undergird the long-term destruction of the ecological environment of the planet (Monbiot, 2007; Moore, 2017).

For many, the building fabric of inner cities is a key point of departure in the reimagining of urban manufacturing. This comprises not only zonings of different precincts but also the actual built form and what kind of activities its features allow. Advocates of urban manufacturing have at times emphasised the possibility of small-scale local manufacturing where labour, consumers, and suppliers are all close by (Grodach & Martin, 2021; Manzini, 2009). Ferm et al. (2021) point out that small-scale manufacturers, startups, or incubation-dependent companies are often connected to other local businesses in their supply chains, and more dependent on local labour than capital compared to larger manufacturers. This disconnection from global supply chains arguably has benefits for the planet. Moreover, the emphasis on low-tech artisanal craft instead of high-tech Industry 4.0 is also a vote against the dominant paradigm. Hence there is an emphasis on saving industrial land in inner cities as a way of exemplifying a countervailing set of possibilities to the global post-industrial paradigm with its spiralling inequality and environmental degradation.

However, there are a number of tensions in this debate, none the least of which is the tension between environmental sustainability and employment as evidenced by the political tensions between the Green parties and Labour parties around the world. The development of conspicuous urban manufacturing streets and redevelopments have often focused on traditional industrial districts in relatively central areas, but these have often also been caught up in processes of gentrification. Consumers of artisan products and artefacts tend to be wealthy enough to afford them compared to “cheap” mass-produced goods. Furthermore, it can be argued that localisation of supply chains is a limited ecological strategy because transportation costs are only a small element of the total environmental impact of manufacturing. Tsui et al. (2020) suggest that small urban manufacturers can reduce transport emissions but these are far less than production emissions as a whole. As well, the size of urban manufacturers may be too small to make an impact on the carbon footprint of the whole city. Grodach and Guerra-Tao (2022) show that in Melbourne the *diversity* of employment in industrial areas and equality between categories of occupation is better in industrial districts than in Central Business Districts (CBDs) or professional services precincts. However, small-scale manufacturers do not make a big impact on total city employment outcomes and, as a result, on income inequality. This focus on inner urban manufacturing at the smaller scale still leaves the issue of larger scale manufacturing on the urban fringe, with its large employment footprint but sometimes questionable ecological credentials, as a problem yet to be solved.

In response to these tensions discussed above, our approach in this article is to ask what is the mix of different kinds of capabilities and capital that are needed in order to reinstate manufacturing in cities. Traditionally, formal considerations of productivity have focused on human capital and tangible assets, namely equipment, factories, and land. The culmination of decades of the “post-industrial society” is that for the first time in history, since around 2000, the amount of investment in *intangible capital* in some countries has exceeded investment in these traditional forms of capital (Haskel & Westlake, 2018). The primary forms of intangible capital are patents and other forms of intellectual property including brands and marketing collateral such as customer data, R&D knowledge, business or other methodologies, and creative and cultural material protected by copyright or other means (Haskel & Westlake, 2018). These forms of capital investments can be owned by either companies, governments, or other entities. In some sectors (e.g., film, knowledge intensive business services), these forms of intangible capital are the principal factors of production; in others, they are a significant factor (e.g., pharmaceuticals). In manufacturing, companies that utilise intangible capital to add value to their products have the opportunity to compete on terms besides the unit cost of labour per output unit. Examples

of high-value manufacturing include superior functionality through advanced R&D, superior aesthetic appeal, add-on services, and brand features such as artisanal or green attributes.

The rise of intangible capital cannot be denied but comes with a significant risk of income inequalities (Hearn & McCutcheon, 2020). Another key aspect therefore is the distinction made by Bowman and Swart (2007) between *separable* intangible capital and *embodied* intangible capital. This refers to whether the use of that capital can be separated from the human—their body or mind—who has this capital. High-level artisanal skills are a good example of embodied, tacit human capital, as is the detailed understanding of a particular factory’s engineering systems, or an artist’s unique aesthetic sensibilities (Foth et al., 2007; Francisco, 2007). Much general trade work is embodied, requiring high cognitive as well as psychomotor capabilities, gained through long practice in order to produce valuable outcomes. This tacit knowledge (Polanyi, 1966) is also key to understanding how manufacturers pass down ways of working that are not codified in any explicit form but are essential to the operation of a manufacturing business.

The constraints on manufacturing that can take place in an urban setting are highly dependent on the kinds of capital that forms the basis of production and the form of manufacturing itself (e.g., bespoke artisanal vs. large-scale replicative via automation). Investment models, public funding, access to skills, energy costs, and political will are all important to the future of urban manufacturing. Simply changing land use or urban planning zoning does not necessarily change the complex mix of capital that is required for an urban manufacturing precinct to be successful and provide employment to blue-collar workers. In light of all these factors, the case study that we present is an illustrative experiment that tries to speak to one path of the viability of manufacturing in urban environments. It illustrates a model that (a) involves artists and artisanal values, (b) is not antithetical to advanced manufacturing, (c) features job growth in a range of both trades and professional workers, and (d) demonstrates the importance of public and private investment and partnerships (Foth & Adkins, 2006). Northgate is a brownfield industrial area in the city of Brisbane, Australia, where public-private collaboration between a publicly funded innovation hub (the Advanced Robotics for Manufacturing [ARM] Hub) and a private large-scale public art manufacturing company (Urban Art Projects [UAP]) is demonstrating new visions for manufacturing in urban centres. Our account is not Panglossian, but replete with challenges and shortcomings not yet addressed. Nevertheless, something innovative is happening that not only can animate new urban imaginaries (Estrada-Grajales et al., 2018) but also offers insight into some of the tensions in the urban manufacturing debates discussed above.

2. The Case of Northgate

The case study presented here is centred on Holland Street, Northgate, a brownfield industrial area located 14 km north of the Brisbane city centre. The case focuses on the collaboration between the ARM Hub and UAP. The case approach is “theory oriented” for the purpose of “theory extension or refinement” (Ebneyamini & Sadeghi Moghadam, 2018, p. 8), offering a focus on the *mix* of different kinds of capital as determinants of different kinds of sustainable urban manufacturing. Three of the authors have a long engagement as researchers (2017–2023) with the ARM Hub and UAP; Queensland University of Technology (QUT) is a founding partner of the ARM Hub. The case primarily uses secondary data sources including historical documents of the area, local government planning reports, company reports, published research papers that describe the operation of the companies, and information provided by the companies for this article. A key informant interview with the CEO of UAP was conducted and both UAP and ARM Hub verified the information pertaining to them in this article.

Although the collaboration between ARM Hub and UAP is central here, it is relevant to the urban planning aims of the article to provide some context of the whole of Northgate and surrounding suburbs. The history of the Northgate Industrial District (Brisbane City Council, 2008; Fisher, 2016) can be traced back to the late 1800s when a north-bound railway line was built from central Brisbane diagonally through the Northgate locale sepa-

rating the western higher land suitable for housing, from the flood-prone eastern side of the line. The industrial district began life as a railway workshop when McKenzie and Holland, an Australian offshoot of the British rail equipment manufacturer, opened the first factory on the eastern side of the Northgate railway station (and siding), which is in the same place as it was in the late 1800s (Figure 1). Employment in the district grew with the development of a pineapple cannery in the nearby suburb of Banyo, in close proximity to pineapple plantations in Nundah. In the 1960s the current sites of the ARM Hub and UAP housed National Nails Pty Ltd, a manufacturer of fencing and galvanised products (Agribusiness, 2015). These buildings are adjacent to the rail station on Holland Street in the same vicinity as the very first factory (Figure 2). This transport link to the CBD remains a potent conduit for labour and knowledge workers coming from centrally located universities.

On the western side of the railway line, significantly more residential activity can still be found today, including the transit adjacent development of Nundah (Figure 3). Together, Northgate and Nundah currently have a combined population of around 20,000 people. The industrial district spanning Northgate, Virginia, and Banyo, is currently promoted by the local government as a valuable asset for the city. Brisbane City Council, in its 2019 Banyo-Northgate Neighbourhood Plan, aims to create two employment districts catering for more than 5,000 jobs (Brisbane City Council, 2019). At the same time, the plan aims to protect pre-1911 buildings



Figure 1. Site of Northgate station and current Holland Street, 1916. Source: State Library of Queensland (2011).



Figure 2. ARM Hub and UAP in Holland Street. Source: Google Imagery date: 12/11/2020.

to enhance the traditional character of the area and also allow redevelopment to cater for a broader range of dwelling solutions. Industrial tenants of Northgate in the present day are a wide variety of manufacturing, warehousing, industrial services, some boutique brewers, a salvage yard, mechanical services, and industrial cleaners. Virginia also has a variety of different activities, ranging from large retailers, workshops, food processing and production, and services to the construction industry. The Northgate Industrial Estate is located within several hundred metres of a motorway with connections to Brisbane Airport and the major tourist destinations of the Gold Coast and Sunshine Coast. The greater area is in fact served by four railway stations and two different lines.

The urban structure of the area is characterised by a manufacturing axis, centred on Toombul Road and connecting the productive area of Virginia to the motorway through Northgate, and a residential neighbourhood developed following an “urban village” approach (Garcia et al., 2010), with services and retails clustered around a main street, often directly connected to the railway. This clustering affects the urban form as well as the way people navigate and use the different precincts, with a polarising focus on each suburb village centre more than cross-suburb connections. This situation is also heightened by

the presence of the railway and major roads stressing further the boundary of the contemporary neighbourhood, which follows the boundary of the older villages. This means that the connections in population terms between the more densely populated accommodation area of Nundah compared to the industrial Northgate are hard to navigate for most people. In fact, the only reason that the young urban professionals living in Nundah would visit the east side of the railway line is to visit the two popular craft brewing businesses: Aether Brewing and Fick Brewing. In addition, those renovating older housing stock could be attracted to the popular salvage yard called Grand Ideas and a popular local coffee shop built in a container.

Northgate station is a 15-minute train journey into the densely populated entertainment district of Fortitude Valley. Nundah experienced a planning-driven accommodation boom in the early 2000s creating dense, medium-rise accommodation options and leading to a revival of the high street including a number of popular hotels and eateries. Nundah is today a self-sufficient suburb, which provides a range of services and amenities to its residents. Recent redevelopments have also created new commercial precincts that provide a mix of white- and blue-collar jobs. Nundah is rapidly gentrifying;

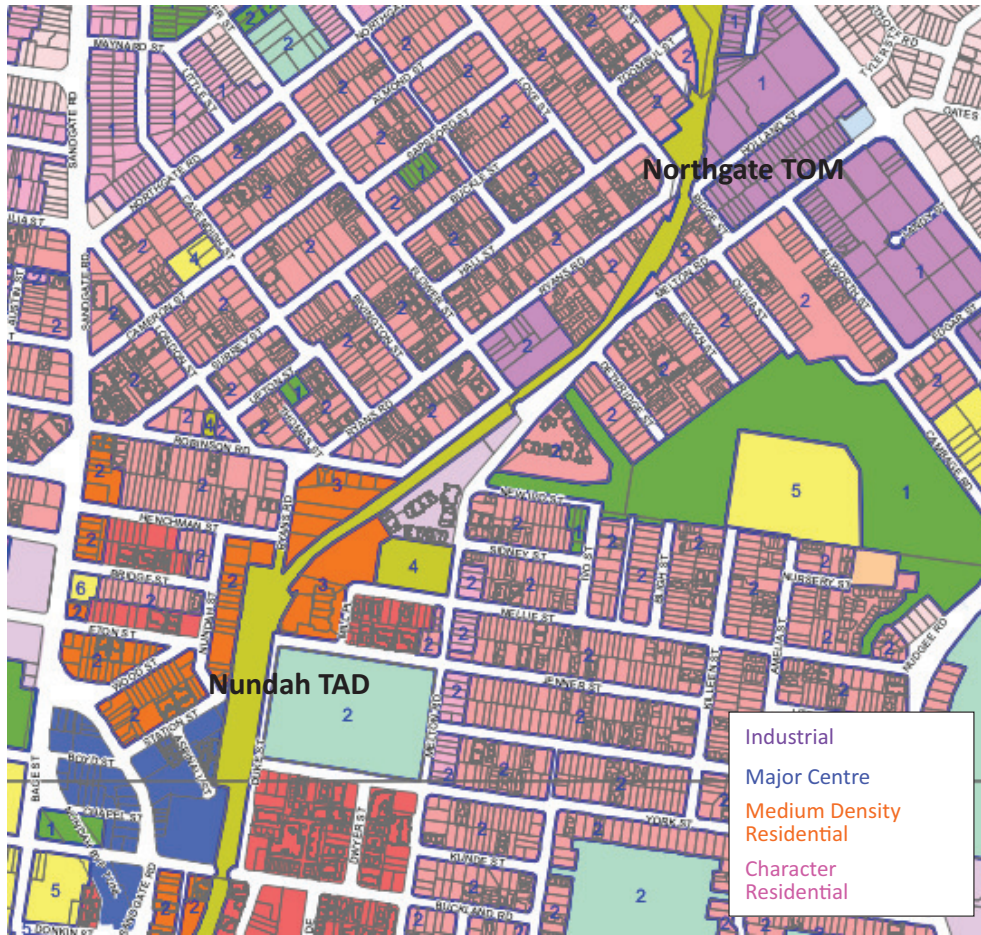


Figure 3. Contrasting transit adjacent development and transit oriented manufacturing. Source: Adapted from Brisbane City Planning Scheme Zoning Map (Brisbane City Council, 2016).

housing affordability, which traditionally was better than other inner-city suburbs, has more recently been challenged by the heightened demand for dwellings in this area (Brisbane City Council, 2020). Many residents still prefer to commute rather than work in the local area. Nundah is a high residential development area that has a privileged direct access to the CBD through a tunnel. The possibility of driving into the city in less than 15 minutes makes the use of cars the most popular option for locals. Nundah has a disjointed bus network, and permeability with the east, as described, is difficult. As a result, cycling is not easy.

The industrial estate, on the other hand, is an example of a “transit-oriented manufacturing” hub (Dierwechter & Pendras, 2020) where most of the people who work in the ARM Hub or UAP often use the rail network (Figure 3). The connections between the ARM Hub and UAP with the rest of the local industrial district are relatively weak compared with the network ties and relationships with other R&D partners, clients, or in the case of UAP, upstream and downstream fabricators. UAP does use a range of subcontractors, however, most of them are not part of the local industrial estate.

Brisbane City Council has developed a new neighbourhood plan for the Northgate-Banyo area; the pro-

cess, started in 2016 and informed by several community consultations, promotes the idea of railway stations as hubs for the local communities (Brisbane City Council, 2019). Northgate station, in particular, is proposed as an ideal location for a new mixed industry and business zone precinct tailored to advanced manufacturing, creative industries, low-impact manufacturing, commercial uses, retail, and hospitality. This location is meant to become the new centre of the neighbourhood guided by an “urban village” structure (Winger, 1999). The proximity to the Australia Trade Coast, a complex of freight businesses and transport facilities that includes the international airport, major roads, and logistics, as well as a network of manufacturing precincts, makes this site particularly strategic for advanced manufacturing. The plan also stresses the need to preserve heritage and character housing around Northgate station, improving the permeability of the railway station with public space design, supporting existing industrial activities, and also, promoting a diverse offering of dwelling solutions (Collis et al., 2013; Houghton et al., 2015). Holland Street is planned to be redeveloped through active frontage and the creation of new arcades to connect it with surrounding character areas.

3. Engineering Science Meets Artisan Crafts

The development of the ARM Hub began in 2017 as a collaboration between UAP and the QUT (Brophy et al., 2020). UAP facilitates, co-designs, and fabricates major public artworks and architectural elements (Caldwell et al., 2019). Inside UAP, a wide variety of art projects have been imagined and designed. The company has developed innovative projects and installed major artistic works in countries such as Australia, USA, Canada, China, and Saudi Arabia. Most relevant to this article, UAP have formally specified digital, environmental, and workforce goals and partnered with QUT to address their need for incorporating robotics and other technology enhancements into their traditional foundry and craft-based processes. This was driven by a business need and a desire to reshore work from their manufacturing operation in Shanghai. Labour costs and supply chain reliability were also key issues. Specialising in facilitating large-scale bespoke public art and architectural features, they wished to retain their strong artisanal and artistic values, whilst at the same time integrating advancements in digital capabilities that enable them to stay commercially viable and maintain exceptional levels of quality.

Following a series of grant-funded research partnerships between UAP and QUT, the ARM Hub was established in January 2020 via an investment by the Queensland State Government, along with substantial investments by QUT and UAP. Despite the difficult impacts of Covid-19, the ARM Hub has since expanded to operate as an innovation hub not just for local manufacturing small and medium-sized businesses but also those in other cities, including regional Queensland. The ARM Hub functions as a demonstrator space, outreach and education hub, provides commercial R&D and design services, supports the development of industry and uni-

versity grants, and co-develops original R&D initiatives consistent with Industry 5.0 (Figure 4). The ARM Hub is collocated with UAP in a 2,000-square-metre 1960s industrial building. In addition to the ARM Hub, the factory space is occupied by tenants who range from startups to established robotic manufacturers and other tenants with an interest in industry verticals such as energy, digital, autonomous systems, and steel processing. The ARM Hub and UAP both seek to champion circular green manufacturing and the upskilling of blue-collar workers. Central to both the ARM Hub and UAP is the role of embodied knowledge in R&D. The importance of knowledge access in new forms of conspicuous manufacturing is a factor well-known in the literature of economic geography with regards to precinct development, knowledge spillovers, and social networks (Adkins et al., 2007; Hearn, 2020).

In terms of workforce matters, UAP is distinctive in its combined artisanal and high-tech manufacturing approach (National Gallery of Australia, 2023). Their blue-collar workforce is a key aspect of their success, underpinning their approach to artisanal traditions and craft practices (e.g., pattern makers and foundry trades) that are essential to the fabrication of artworks. The constraints on manufacturing that can take place in an urban setting are highly dependent on the kinds of capital that form the basis of production. Simply changing land use or planning zones does not necessarily change the complex mix of capital that is required for an urban manufacturing precinct to be successful and provide employment to blue-collar workers.

Both UAP and the ARM Hub are committed to manufacturing trade work as well as attracting talent in the field of robotics, new digital occupations, and other manufacturing-related industries (Tables 1 and 2). Attraction of knowledge workers is a significant issue in conspicuous manufacturing. Key issues for both UAP

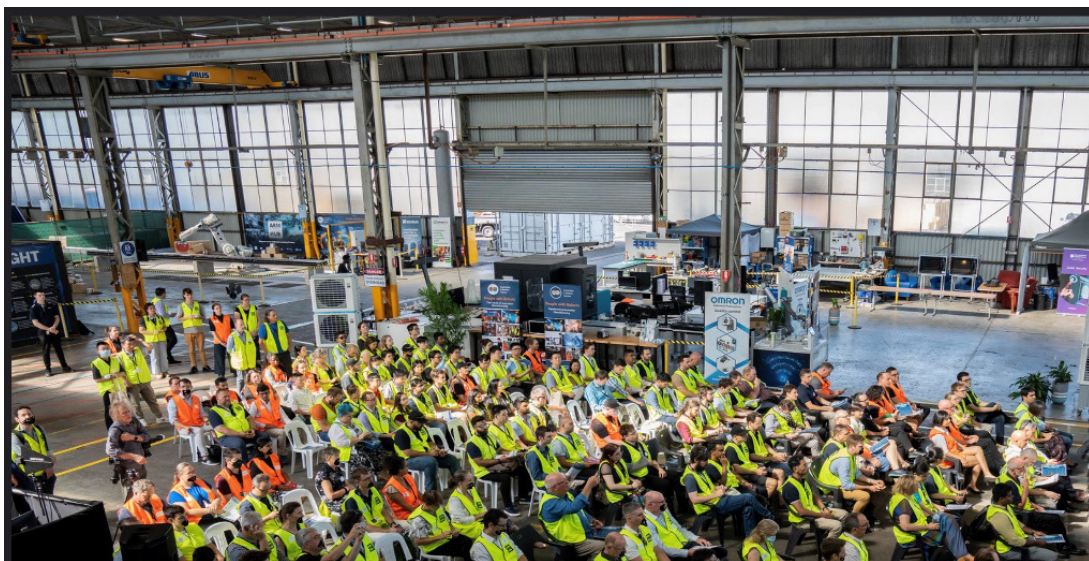


Figure 4. ARM Hub outreach event. Photo courtesy of the ARM Hub.

Table 1. ARM Hub tenant company exemplars (2020–2023).

Company	Innovation	Sectors
Australian Cobotics Centre	Cobotics R&D	Research and education
Verton	Remote controlled load management systems	Mining Construction Offshore turbines
Clean and Recover	Electrochemical wastewater recycling	Mining
Omron	Collaborative robots	Industrial automation
Valiant Space	Bipropellant thruster	Small satellites
Macrobotix	Robotics	Manufacturing
Blue Lens Group	Innovation management	Multi sector
Southern Green Gas	Solar powered CO ₂ capture	Multi sector
Bondi Labs	Augmented Intelligence through AR	Multi sector
Wisk Aero	Autonomous air taxis	Transport
Lyro Robotics	Robotic packing	Robotics/food

Note: Information courtesy of the ARM Hub.

and the ARM Hub are access to advanced levels of Industry 5.0 expertise, for example in AI, mechatronics, design, AR/VR, and digital twins. It is this knowledge that is the primary attractor for increasing interest in Northgate (Figure 5). Most visitors to the area are there to learn and observe cutting-edge manufacturing practices (Bilandzic & Foth, 2016). This exemplifies the role of knowledge in conspicuous manufacturing and access to talent in the creative class incorporating scientific, engineering, artistic, and design capabilities at a very high-level (Figure 6). In parallel, because of the significant trade workforce of UAP and the manufacturing workforce mission of the ARM Hub, both entities are committed to upskilling trade workers, particularly patent makers, metal workers, fitters, spray painters, and foundry workers. One of the rationales for the ARM Hub was uplifting smaller metal fabrication and other subcontracting manufacturers into global export markets. Seen through the lens of knowledge flows, an average day

at the ARM Hub and in UAP is an example of global knowledge transfers. UAP's contracts may often require detailed knowledge of a particular geometric algorithm for robotic polishing, and workers from UAP frequently visit the ARM Hub to seek specific technical advice. Some of this knowledge is internationally known, yet UAP staff cannot easily locate it. Due to the tacit nature of current and new industry practices, it is difficult to codify and document them (Rust, 2004).

The ARM Hub–UAP nexus is also noteworthy for the international character of the quotidian day-to-day networks of knowledge. For example, UAP operates not only in Brisbane but in New York and Shanghai, with the principals of the company visiting each site reasonably regularly. The ARM Hub also hosts the Australian Centre for Cobotics bringing together researchers from Australia, Denmark, Germany, and Pakistan. While these knowledge exchanges have become common, they represent a new process that rapidly links university R&D

Table 2. Occupational breakdown in 2023 for UAP Brisbane Operations.

Occupation	Approximate % of workforce in 2023	Status
Trades	26	Increasing
Design or art	12	Stable
Technology professional	19	Increasing
Other professions	16	Stable
Admin and management	12	Stable
Other	15	n/a
Total employment in Brisbane	93	—

Note: Information courtesy of UAP.



Figure 5. Using AR to sculpt forms for casting. Photo courtesy of the ARM Hub.

to a “glocal” arts-led manufacturing industry (Robertson, 1995). The need to maintain both digital and physical global access raises the question of whether the traditional focus on local urban manufacturing has underestimated this “glocal” nature of viability and visibility. As Ferm et al. (2021, p. 353) suggest: “Despite this growing knowledge about the importance of locale for small urban manufacturers, and place specific social economic ties, there is little understanding of how the urban fabric can be shaped to accommodate such an ecology.”

We argue the daily knowledge exchange processes, though taken for granted in Holland Street, are of rare quality, mixing research scientists, artists, and trade

workers to achieve artistic, academic, and commercial objectives. These knowledge exchanges are also essential for green manufacturing.

Green manufacturing was not an immediate driver of the development of the ARM Hub nor UAP in 2017. However, in 2023, the circular economy and green manufacturing combined is now one of the four pillars of the ARM Hub, and UAP has embarked on an in-house, well-resourced green manufacturing strategy in the last two years. This reflects the turning of the tide in political, community, and consumer discourse. Green manufacturing has become important to many of the clients of the ARM Hub/UAP simply because it is now considered to



Figure 6. Stephanie Hutchison performs Cobotic Improvisations dance work “Fling it”, part of an Australian Network of Art and Technology’s Synapse Residency at Australian Cobotics Centre and ARM Hub. Photo courtesy of the ARM Hub.

be non-negotiable. And with the coming of the climate-positive Olympic Games to Brisbane in 2032 (Foth et al., 2022), interest is likely to increase further.

Significant impetus, expertise, and capital investment by UAP have been evident in the last two years, driven primarily by UAP's corporate values but also by recognition of consumer sentiment. For example, UAP is developing a carbon calculator to measure and improve carbon reduction in the supply chain of new projects. UAP is seeking to calculate the carbon footprint of each project as well as for the whole manufacturing operation. The installation of an induction furnace will be more energy-efficient than the current gas system. Another UAP priority is to follow circular lifecycle parameters by using sustainable raw materials. This concern is moving UAP to create artworks that will last a long time and that are created by using green and recycled materials such as recycled aluminium that is available locally. Besides using sustainable raw material alternatives in artworks, UAP is working on reducing other environmental impacts such as water, waste, and the transport packaging's carbon footprint. For example, UAP has decommissioned the use of water jet cutting. As the majority of production waste is produced in casting (e.g., sand-resin blocks or polystyrene), UAP is trying to replace the conventional scale of the blocks by using blocks supplemented with green materials such as potato starch. UAP are now also using additive manufacturing processes when it suits a project, such as PMMA prints for patterns, as an alternative to polystyrene milling. The prints use much less material overall as they are hollow and have a relatively thin wall thickness, which is a big deviation from solid polystyrene patterns. In addition, they are investigating longer-term solutions to the use and recycling of sand resin.

4. Conclusions

As Baker (2017, p. 125) suggests: "In imagining contemporary re-industrialization based on high-tech manufacturing, distributed digital fabrication and the revival of craft, there are various ways in which these activities might be made publicly visible."

Since then, research has identified various models of attempting greater connection between consumers and the costs of that consumption in the pursuit of green, just, and productive cities, as per the New Leipzig Charter (Godson, 2020). Grodach and Martin (2021) juxtapose Industry 4.0 manufacturing with low-tech, high-touch manufacturing in an examination of cultural and food and beverage manufacturing in Melbourne. Such manufacturers as exemplified in inner city Melbourne are often ignored in government policy but offer a diversity of labour and relationships with other kinds of retail consumption activities, which provide for greater visibility of manufacturing as a craft-based activity where consumers and manufacturers interact on a daily basis. Symbolically, this case is relevant to Northgate because it is one potential example of an amelioration of inequal-

ities evident in typical post-industrial cities. In a contrasting example, Suwala et al. (2021) analysed case studies in Berlin that were premised on scientific knowledge as primary factors of production. They consider Adlershof as a successful example, eventually achieving the quadruple helix of academic, business, government and civil society, which were brought together to formulate its planning strategy. Similar to Foth (2003), they also argue that spatial proximity is necessary but not sufficient to stimulate the required successful execution of the strategy, but rather mobilisation of social capital through things such as technology transfer, brokering of relationships between industry and research, and formulation of various combined research and development projects have been key features of the success of Adlershof.

Part of what makes Holland Street notable is that the ARM Hub/UAP collaboration could be considered to be a high-tech, high-touch model that relies heavily not only on access to local labour markets but also on local advanced scientific knowledge resources. In addition, because of a strong emphasis on export, there is a possibility that this model can develop at a greater scale, and is therefore important for Australian manufacturing nationally. UAP's customer base is largely not local, but rather global. ARM Hub serves manufacturers of different scales with markets ranging from national to export. This is not to say that local relationships, trust, and local knowledge are not important because subcontracting firms and connections between labourers, artists, and researchers are important to Holland Street's operation. Put another way, UAP and the ARM Hub are a good example of different kinds of capital and capital flow because the mix of knowledge include blue-collar, arts and design, and scientific knowledge coming together to produce value. This is a good example of embodied intangible capital (Bowman & Swart, 2007) at work to produce high-value manufacturing.

Much of the knowledge of artists is tacit and cannot easily be replicated by other artists. Similarly, very specific artisanal practices of trade workers are equally hard to replicate when these are combined with cutting-edge engineering, and digital or robotic knowledge (Burden et al., 2022). Thus, in addition to labour and buildings, this combination requires a particular kind of social capital to be considered in the future of urban manufacturing. The reliance on tacit knowledge requires experienced intermediaries to build and maintain trusted relationships not only in the operation of a manufacturing business but throughout its supply chain suppliers and through to the ultimate customers (Teli et al., 2022). This accords with Hüttenhain and Kübler (2021), who emphasise soft site factors in urban manufacturing including a range of affordances to encourage collaboration, sharing of resources, exchange of tacit knowledge, and access to knowledge partners such as universities and research hubs.

A key question for urban planning is therefore what are the elements of a locale that actually contribute to the social capital required to sustain urban

manufacturing? A joined-up ecosystem of makers, applicators, facilitators, intermediaries, and spillover adopters seems key to developing, attracting, and retaining talent for the total ecosystem. In general, the biggest attractor of talent is the availability of jobs and, in the case of families, jobs for both adults. This is made more likely by a joined-up local ecosystem such as that emerging in Northgate. Other factors significant for the future of Northgate are jobs that are secure and at the cutting edge of scientific and practical application, housing affordability, cultural amenity, the global brand of companies, and attractive salary/cost of living ratios. The relationship with local universities is another key factor in the recruitment, development, and retention of talent. Hüttenhain and Kübler (2021) also suggest that industrial districts can have symbolic impacts outside of their immediate footprint. This can be achieved not only through collaborative relationships with the wider city but also through the rise of industrial tourism, which is beginning to become evident in the Holland Street precinct. In terms of the implications for the city of Brisbane, Holland Street could play an important role over the next 10 years leading to the Brisbane Olympic Games in terms of its connection through supply chains within the networks of tenants and the ARM Hub to educate a broader group of manufacturing companies and related industries towards both advanced manufacturing, the importance of design to manufacturing as well as circular economy initiatives.

The Queensland Productivity Commission (2017) points out that approximately 75% of Queensland manufacturing employment is located in the rapidly urbanising greater Brisbane and adjacent municipalities. There is a large diversity of manufacturers providing manufacturing employment with food, machinery and equipment, and metal products dominating in that order. Around 90% of manufacturers are non-employing or employ fewer than 20 people. Around 1% employ more than 200. Fox and Alptekin (2018) propose a taxonomy of types of manufacturers and distribution systems, distinguishing between DIY, artisanal, distributed industrial (e.g., parts, kits, and small products), and large centralised manufacturing (e.g., materials conversion, massive goods). Their taxonomy includes third-wave “glocal” DIY manufacturers, Fab Labs or makerspaces, and mobile factories. Distribution systems include evolving transport and internet-based services providing a wide range of opportunities (e.g., web-based artisanal operations, and component makers for large-scale industrial production). Distributed networks of milling machines and autonomous local air transport options are technically possible now. This could mean that process control work, and parts repair, do not necessarily have to occur in the same place as the primary machinery. Furthermore, in the era of chat GPT-4, knowledge work is easily disaggregated from physical space.

These developments are a good match for the size profile and diversity of manufacturing in greater Brisbane. This suggests that a wide range of capital fac-

tors need to be considered in relation to the viability and sustainability of urban manufacturing in greater Brisbane. We agree with Grodach and Martin (2021, p. 473) that “urban policy needs to broaden its understanding of manufacturing...rethinking the value and uses of remnant inner-city industrial zones [and] experimenting with new forms of mixed-use that permit manufacturing.” It is also important to recognise that different constellations of land, equipment, and knowledge resources are evolving in complex ways to produce diverse opportunities in urban manufacturing. Imaginaries for future urban manufacturing and urban planning should not be restricted to “Industry 4.0” or “high-touch, low-tech” types of manufacturing, but rather encompass a much broader set of possibilities for sustainable operations and local employment. Given the future of manufacturing could evolve in a number of different ways, we suggest that future research in urban planning could develop varied models to account for different constellations of land, buildings, transport, and knowledge suitable for urban manufacturing. The case study presented in this article provides only one novel example which hopefully stimulates future research into a broader conception of different possibilities for urban manufacturing. The planning response to take advantage of the local social capital, and of the local peculiar synergies facilitated by transport, is structured through a precinct approach. More than trying to resolve broad dynamics with complex urban plans, the precinct approach allows one to take advantage in a more timely and fluid manner of local potentials and resources, avoiding the challenges of developing a detailed urban or suburban plan. With the urban planning strategies in place for this locale, the next decade of development will constitute a worthwhile experiment in the rebirth of urban manufacturing that we are keen to study, evaluate, and document further.

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Conflict of Interests

Hearn, Caldwell, and Camelo-Herrera have research affiliations with the ARM Hub. QUT and UAP are founding members of the ARM Hub.

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