Facing Forward: Trends and Challenges in the Development of Industry in Cities

TALI HATUKA, ERAN BEN-JOSEPH and SUNNY MENOZZI PETERSON

The paper outlines some of the developments and trends associated with the 'Fourth Industrial Revolution' with a focus on three main themes: technology, manufacturing, and cities. Mapping these trends, three interlinked dimensions are perceived as crucial to the future development of industrial areas in cities: geographical proximity, localism, and planning regulations. These issues require further research and study, including mapping the existing industrial typologies and their influence on socio-economic urban dynamics and city residents' daily lives.

In a time of dramatic shifts in the manufacturing sector – from mass production to just-in-time and make-to-order modes of production, from the limited use of expensive robotics to the widespread use of inexpensive robots, from centralized to distributed logistics systems, from polluting and consumptive production to a cleaner and more sustainable process, and from a demand for unskilled, inexpensive labour to a growing need for a more educated and specialized workforce – cities may see new investment and increased employment opportunities. However, garnering benefits from these shifts will require us to change how we think about industrial development and city planning. What are the spatial needs of manufacturing today? What might they be in the next 30 to 50 years? Should advanced manufacturing be subject to the same rules and zoning regulations as traditional manufacturing? How can cities benefit from retaining and attracting manufacturing activity? Is it possible to design an industrial city that is liveable and offers its inhabitants a high quality of life?

The answers to these questions are important given the role of manufacturing in determining countries' economic robustness and technological progress. Reports have shown that countries' manufacturing sectors produce most of their exports, are responsible for almost all their commercial investment in research and development, and propel their productivity growth and, in turn, per capita income growth (Manyika *et al*., 2012; De Backer *et al*., 2015, pp. 16, 17). Furthermore, recent studies strongly support the assertion that city planning and industrial policy go hand in hand. For example, 80 per cent of all manufacturing jobs in the United States are found within metropolitan areas, and 95 per cent of the manufacturing jobs that are categorized as 'very high tech' are also found within metropolitan areas in the US (Helper *et al*., 2012).[1]

This dynamic relationship between cities and industry was the overarching topic of a panel discussion during a symposium entitled *Industrial Urbanism*, which was held at the Massachusetts Institute of Technology (MIT) in October 2014.[2] The following text outlines some of the developments and trends that the panellists identified and their predictions for the future, with a focus on three

main themes: technology, manufacturing, and cities. While the discussion that follows is based on studies and reports conducted mainly in the US, its insights should not be viewed as confined to this context. Many cities around the world are poised to reassess their relationships with industry, and they will benefit from doing so. More specifically, the paper focuses on three interlinked dimensions of manufacturing and city planning – proximity, localism, and planning regulations – and recommends their critical assessment to address the needs of *industrial urbanism* in the future.

Changing Technology: The Role of Proximity in Developing Industrial Ecosystems

Technological change is altering manufacturing's physical footprint, manufacturing spaces, distribution processes and networks, access to transportation, and preferred geographical locations. In particular, this change is modifying the conflict between the competitive advantage of low-wage labour and the competitive advantage of proximity – to centres of research and development, markets, and highly skilled labour – and, in turn, is altering the conceptualization of industry as a whole.

Proximity is becoming an important criterion in manufacturers' site selection decisions. As Marty Schmidt (2014) suggests:

> To quickly innovate – to design, develop, and scale up the production of new products – manufacturers need physically-close, collaborative relationships. When vertical integration was common, proximity to academia or suppliers, for example, was less important because manufacturers employed workers engaged in every stage of the supply chain. To become more competitive in today's market, manufacturers are choosing locations that best support the early stages of production.

Describing proximate relationships in Shenzhen, China, Schmidt remarks:

> [S]tart-ups … can go across the street to about ten blocks of markets that sell all sorts of electronic parts and there are vendors in small booths [who] can take apart ball grid array chips and put [them] back together … the ecosystem of people who have production capability, even in a 10 foot by 10 foot booth, is incredibly enabling. (*Ibid*.)

The view that firms derive an advantage from choosing to be near other firms in the same or related industries and from the diversity of industries located nearby is gaining traction (Helper *et al*., 2012, p. 2). The underlying premise of this approach is that proximity to firms in the same or related industries improves firms' access to 'specialized workers, suppliers, and customers' as well as the institutions that support their work (e.g. universities and research centres) (*Ibid*.). It further presumes that the diversity of a region's industries makes it possible for firms to access and choose between administrative service providers (e.g. financial services and construction services) (*Ibid*.). Relationships and intersections, or crossovers, create an ecosystem.

Interdependencies, exchanges, and overlaps within an ecosystem might be between upstream suppliers and downstream producers; manufacturers, academia, and the public sector; the industrial sector and the service sector; and large and small firms. Interactions of this sort empower suppliers and, in doing so, make the most of their expertise (Gallagher, 2013). Moreover, the ecosystem concept is especially important in the context of intersections between the manufacturing and service sectors. Categorizing a firm as either a manufacturer or a service provider reflects an antiquated way of thinking about economies and classifying firms, especially in countries that are members of the Organisation for Economic Development and Co-operation (OECD) (De Backer *et al*., 2015, p. 29). The production processes of some service-sector firms are capital- and energy-intensive because they depend on infrastructure in a fixed, physical location (*Ibid*., pp. 19–20). In addition, manufacturing firms have diversified their operations by offering service options with their products (*Ibid*., p. 29). Thus, some service-sector firms look a lot like manufacturers, and *vice versa*. Hence, the more developed a city's ecosystem is,

the less meaningful its loss of traditional manufacturing will be because there should be ample opportunities to establish hybrid manufacturing-service firms, especially in cities in OECD countries. Furthermore, changes in technology reinforce the logic of the ecosystem concept. Patrick Gallagher, Acting Deputy Secretary of the US Department of Commerce, observes that 'technology itself has gone from being discrete to being systems' (Gallagher, 2013). The redefinition of the relationship between technology and proximity, services, manufacturing, and logistics seems destined to evolve further in the future as, for example, the peer-to-peer logistics model pioneered by Uber becomes more common. Sanjay Sarma (2014) argues:

> If you look at the industries around us, they … have been fragmented irreversibly almost … the music industry, [the] auto rental [industry], hotels, software… We were used to getting all of our software, even ten years ago, from one company, Microsoft, maybe Adobe [too], two companies … and now you have [applications] on your phone [made by] thousands of companies.

This splintering of firms will change how people receive deliveries and buy products. Moreover, this splintering and new transit technology (e.g. driver-less cars and drones) may necessitate an entirely new infrastructure (e.g. 'special byways for driver-less cars', 'skyways for drones') (*Ibid*.).

Competitiveness and proximity are becoming interdependent. Gary Pisano and Willy C. Shih suggest that industrial ecosystems, their 'industrial commons' or communal resources for innovation, and firms' and countries' competitiveness are tightly linked (Pisano and Shih, 2009). They further argue that outsourcing erodes the 'industrial commons' (i.e. place-specific networks or systems of suppliers; research and development resources, including universities, government or corporate research centres; and specialized workers); it degrades firms' internal process-engineering and design capabilities by severing the feedback loop between manufacturers, engineers, and designers; and, by reducing the number of jobs in an industry in a location, it encourages specialized workers to move away and discourages students from pursuing coursework in related fields (*Ibid*.; De Backer *et al*., 2015, p. 4).

The severing of the feedback loop between manufacturers, engineers, and designers hinders firms from developing new products (innovating) because face-to-face interactions are necessary to imagine new products. This situation is perilous for firms because, when a firm outsources high-value-added work (e.g. design), 'there is little to prevent [a downstream supplier] from launching its own brand and becoming a competitor… When it comes to knowledge, distance does matter … proximity is crucial' (*Ibid*.). Indeed, 'technical knowledge, even in the hard sciences, is highly tacit and therefore far more effectively transmitted face-to-face' (*Ibid*.). The central role of face-to-face interactions in knowledge transfer anchors industrial commons to particular places. Moreover, a cyclical interaction exists between commons and firms; the magnetism of the commons attracts additional firms and industry experts, and this pull grows the commons (Pisano and Shih, 2009). The implications here are significant given the relationship between innovation, on the one hand, and productivity growth and economic robustness and technological progress, on the other (De Backer *et al*., 2015, p. 12).

This position has been further supported by Susanne Berger, who presented three key lessons from the MIT Taskforce on Innovation and Production's analysis of industrial development in Germany and China: (1) strong manufacturing does not require low-wage labour; (2) dense ecosystems preserve jobs by dissuading companies from relocating or shifting jobs elsewhere; and (3) real innovation occurs in scaling up firms and rebuilding the capabilities of the industrial ecosystem (Berger, 2013). Clearly, no single national model is going to work across the economy, but policy-makers need to acknowledge that proximity enables knowledge development.

Such recognition will serve as the starting point for policy development. Learning is an ongoing process that takes place when engineers and technicians on the factory floor bring their problems to the design engineers and struggle with them to find solutions; learning takes place when users return with problems (MIT Taskforce on Innovation and Production, 2013, p. 12). Moreover, technological change is making proximity – the minimization of distance – a vital factor in structuring logistical networks and regulatory regimes.

Changing Manufacturing: The Power of Localism

Industry has often been perceived in an economic or political context divorced from geographic, locational, or spatial considerations. However, this detachment from *geography* and *community* is becoming increasingly unsustainable. Technological change and subsequent changes in manufacturing processes and strategies are likely to reverse the trend towards the globalization of manufacturing. In the future, manufacturing will be more localized, increasing the importance of community and place for manufacturers. Economies of scale, which favour large manufacturers with global reach, will be less important because manufacturers' primary costs will be for machine tools (e.g. a 3D printer) (Markillie, 2012). '[W]hether it makes one thing [or more] … it will keep going, at about the same cost for each item' (*Ibid*.). Additive manufacturing (i.e. 3D printing) will dramatically reduce the cost of traditional manufacturing, which involves making moulds, pouring the material, and finishing the product (*Ibid*.). In addition, it will be cheaper to make prototypes. Because workers will be more likely to use a computer than any traditional tool, fewer workers will be required, decreasing manufacturers' labour costs (*Ibid*.). Thus, future manufacturing 'will empower small and medium-sized firms and individual entrepreneurs' (*Ibid*.). Community-based manufacturing cooperatives ('social manufacturing') will also have a role in incubating and prototyping new products. While this trend towards localism means that smaller firms will be more competitive, it does not mean that large multinational firms will relocate their operations to their countries of origin (Pisano and Shih, 2009). Instead, for large multinational firms, expanding markets, especially in emerging economies, will be more attractive than low labour costs (De Backer *et al*., 2015, p. 13). Thus, Asian firms will want to build factories in Europe and the US to be closer to their consumers, and *vice versa* (Pisano and Shih, 2009). Therefore, China, Brazil, India and other countries with expanding middle classes will need to plan cities and industrial sites in tandem. In some ways, for countries that are planning and building entirely new cities (as China is), in seizing the opportunity that this trend towards localism presents, it is important that the design of those cities supports the ecosystem concept.

In addition, technological change is altering manufacturers' understanding of the trade-off between the costs and benefits of low-wage labour and the costs and benefits of proximity in novel ways. Technological change is thereby creating new geo-spatial relationships. This phenomenon is not exclusive to the world's largest manufacturing economies. Instead, new geo-spatial relationships are emerging worldwide because of technological change in industry. Calestous Juma (2014) observes that these changes are giving African countries a 'unique opportunity to … reimagine [cities] in light of emerging technological opportunities and [to] be able to leapfrog'. To take advantage of the opportunities created by technological change, Juma argues:

> a large part of that [will] be driven … by … visionary leaders … even more important than the leaders, there will have to be major reforms in legislation [e.g. housing codes] to really … reinvent the governance system so that it [aligns] with the technological advances. (*Ibid*)

Changes in manufacturing are reshaping not only community dynamics but also areas and regions, with cities becoming increas-

ingly specialized in particular products and industries. For example, a study examining US metropolitan areas found that cities became more specialized (e.g. in primary metals, furniture, and computer and electronic products) between 1980 and 2010 (148 in 1980 vs. 163 in 2010) (Helper *et al*., 2012, pp. 12–13).[3] Furthermore, the study found that industries cluster around 'anchor' industries (e.g. chemicals or machinery) in about two-thirds of US metropolitan areas (*Ibid*., p. 16). In addition to the attractive power of anchor industries, clusters can be found in one city or region (e.g. software in Silicon Valley, biopharmaceuticals in Boston, robotics in Pittsburgh), in part, because today's innovative companies are at the intersection of software, on the one hand, and hardware and fabrication, on the other. For example, Artaic, a company that manufactures bespoke mosaics using internally developed software, demonstrates the influence that agglomeration can have on manufacturers' choice of location. Founder and chief executive officer Ted Acworth chose to locate his factory in Boston because '[the city] … has the 3rd largest market for architecture services in the [U.S]'. Recalling making this decision, Acworth said that he asked himself, 'Why not put the factory right in the middle of [its] customer base?' (Acworth, 2014).

This shift towards localism raises the question of the role of educational institutions: what sort of relationship should academia have with industry? Fiona Murray argues that the clustering of universities, start-ups, and manufacturers capable of making prototypes and producing small volumes can expedite the innovation process by creating opportunities for knowledge transfer amongst skilled labour (Murray, 2014). Moreover, as she argues, institutional-industrial clustering gives innovators the ability to scale up their production incrementally. However, for clusters to develop, cities must allow some industrial uses in areas where these uses have been hitherto prohibited. Murray observes that universities are in a unique regulatory position as the property owners of large campuses, remarking, 'We need to think about the kinds of spaces for scale-up, and we have an opportunity because of the property ownership [of universities] and so on to really, actually space the urban environment' (*Ibid*.).

Localization is thus not only an opportunity but also a major challenge. Seizing this opportunity has important implications for cities which stand to benefit from new investment, tax revenues, and increased employment opportunities. However, reports and policy recommendations on clustering – the trend towards industry specialization and geographic concentration – and manufacturing fail to consider urban spatial and social realities. Furthermore, the role of community and geography in the development of industry raises new macroeconomic challenges, which need to be translated into updated regional economic development strategies and updated planning regulations.

Changing Cities: Rethinking Industry Planning Regulations

Turning to the question of space, we see a troubling trend in the practices of post-industrial planning that has led to the abandonment of urban industrial land in cities with large but shrinking manufacturing sectors and expanding service sectors. In some cities, vacant or underutilized factories and warehouses are being converted into non-industrial uses, such as loft apartments or living/working spaces for artists; in others, former manufacturing sites are razed to make way for new residential and commercial districts. Leigh and Hoelzel observe that 'the view of urban industrial areas as unproductive and unattractive dominated the discourse in the [Smart Growth] publications [that they examined]. This narrow view, in turn, provides little incentive to consider local industrial policies' (Leigh, and Hoelzel, 2012, p. 91). The irregular industrial spaces that remain as a result of these two processes are often insufficient to accommodate large or unique building footprints. Furthermore, they argue

that cities' public works departments need urban industrial land, especially to execute environmental initiatives, including recycling programmes. They contend that '[t]hese services and products depend on industrial land, facilities, and workers, and represent lost economic development potential if they are not locally sited' (*Ibid*.).

However, the detachment of cities from the *physicality* of industry is becoming increasingly unsustainable. In the coming decades, the question will not be *whether* growth in manufacturing is going to occur but *where*. A major factor in manufacturers' site selection decisions is the speed of delivery to customers; manufacturers are increasingly choosing locations based on labour availability and transportation access, which influence the speed of delivery, rather than on land costs. This shift suggests that manufacturers are willing to compete to purchase land in mixed-use zones that permit industrial uses. In fact, Klatskin (2014) states:

> Industrial and manufacturing land [has] always [been] the [kind of] bottom-feeder of land use, but right now [manufacturers] are paying more per acre than retail, … office … [and] hospitality; the only people who can still beat [manufacturers] is multi-family residential.

Furthermore, while the storage and distribution practices and regulations, e.g. freight transport via truck and plane, the use of tractor-trailer trucks, containerization, and the deregulation of the trucking industry, which 'minimize[s] [costs] when goods [are] shipped from a national location that [minimizes] distance to all customers', often make exurban sites more attractive, cities cannot exile industry to the hinterland (Leigh and Hoelzel, 2012, p. 88). The need for 'warehouse space that supports the efficient distribution of products specifically created for inner city markets' and 'firms that produce products more easily transported on smaller trucks (due to small size or small volumes) and can also use inner-city warehouse space' remains (*Ibid*.). Nonetheless, land-use and zoning regulations and building codes continue to prevent manufacturers of various types of products (from pharmaceuticals to foodstuffs) from building factories in cities.

Changes in technologies and manufacturing are not yet affecting planning regulations. However, their factories are still required to comply with outdated, one-size-fits-all regulations. Alex Klatskin (2014) argues:

> there's a massive amount of regulation which keeps [manufacturers of furniture and upholstered goods, technology, biotechnology, and pharmaceuticals] as well as *cookies*, the mundane [products], out of mixed use areas.

Klatskin also notes that the use of standardized pallets and stocking/stacking systems in shipping and storage means that the multi-storey factory is more practical then the single-storey factory. The American City Coalition's Newmarket and Upham's Corner project in the Lower Roxbury and Dorchester neighbourhoods of Boston propose a 'Walk-to-Work Community' for an industrial district that is vital to the provision of services in the City of Boston (McCullagh, 2014). Neil McCullagh predicts that less community opposition to the mixing of industrial uses with other uses will exist in the future; he contends that communities will be more concerned with the benefits that will accrue to the community because of a given industrial project (*Ibid*.). In other words, opposition to the integration of industrial uses could be overcome through good-faith negotiations between communities, industry, and the government.

Bridging this gap between needs and regulations requires conceptualizing the city in a way that situates it within its broader regional economy by viewing the centre and the periphery, or the metropolitan area, as an innovation-production ecosystem that cultivates production along an 'advanced manufacturing continuum' through a regional advanced manufacturing strategy (Reynolds, 2014). As Liz Reynolds argues:

> Planning and policy has [*sic*] to figure what to do at [the] maker stage, at the start-up stage, at the scale-up stage, at the [small and medium-sized

enterprise] stage, and at the [original equipment manufacturer] stage, and [at] each of those [stages] there [is] a policy response that speaks to the urban landscape. (*Ibid*.)

Identifying and developing sites that are appropriate for manufacturers at various stages (e.g. the maker stage, the start-up stage, the scale-up stage, the small and medium-sized enterprise stage – Reynold's 'advanced manufacturing continuum') based on regional strategic objectives (e.g. the growth of a particular sector) could encourage the return of industry to the city. However, first, cities must update their regulatory regimes, which currently encourage the conversion of industrial land into other uses (Leigh and Hoelzel, 2012, p. 90). Planners are well poised to change this paradigm.

Economic development strategies and updated planning regulations might evolve with planners' and administrators' recognition of the importance of industrial land to cities' economic robustness and their understanding that some standards and policies have quickened the re-zoning of vital, central industrial land for other uses (e.g. hotels and mixed-use developments). Smart growth refers to a set of urban design and planning standards and policies that support the building of compact, mixed-use neighbourhoods that are connected to the wider region via different types of transportation systems, that aim to improve residents' quality of life (e.g. by making communities more affordable and/or diversifying residents' transportation choices), that support and diversify local economies, and that conserve natural resources and farmland. Although smart growth standards and policies aim to support and diversify local economies, these standards and policies fail to protect industrial land from encroachment and do not call for urban land to be reserved for industry (*Ibid*., p. 87).

However, cities should not have to choose between strategies that either support compact, mixed-use development or 'urban industrial development'; instead, they need 'approaches that *explicitly* safeguard productive urban industrial land and discourage industrial sprawl' (*Ibid*.). To build liveable cities with robust economies, policy-makers must integrate their economic development, industrial policies, and environmental policies (Mistry and Byron, 2011, p. 6). Moreover, policy-makers should 'develop a new narrative about manufacturing and metropolitan economies', and:

> urban, industrial land use strategies should be linked to wider economic development and workforce objectives and should minimize mismatches among workforce, community revitalization, and city-wide economic development goal. (*Ibid*., p. 4)

Additionally, public administrators should collect, analyse, and share data related to urban production (e.g. 'supply-chain mapping') (*Ibid*., p. 5).

Further, regulations and codes related to multi-storey industrial buildings are especially in need of re-examination to consider the advances in building technology (*Ibid*., p. 88; Klatskin, 2014). Multi-storey factories will maximize the supply of urban land zoned for industry, and, as a building typology, multi-storey factories will fit into cities' existing urban fabric better than single-storey factories. Furthermore, in anticipation of small and medium-sized advanced manufacturers' needs, policy-makers should seek to encourage and support the renovation and partition of old urban factories originally designed for a single large manufacturer's use (Mistry and Byron, 2011, p. 7). Cities need to develop 'metropolitan export strategies' to '[help] local firms market their goods, services, and expertise, including newly fashioned advanced manufacturing products, beyond regional borders' (*Ibid*., pp. 5–6), which might require building, redesigning, or updating transportation systems.

This approach raises new questions regarding the role of the periphery and living conditions in suburban, ex-urban, and rural areas. As cities change in response to technological changes in manufacturing and cleaner modes of production, what role will those living on the periphery play? Studies suggest that manufacturers will not abandon the peri-

phery in the near future, but forward thinking could mitigate the effects of a shift from the periphery to the core.[4] Amy Glasmeier voices concerns about this trend, but she remarks that some of the advanced manufacturing jobs that might seem closed to low-skilled workers may, in fact, be open to them (Glasmeier, 2014).

Industry and Planning Prospects

Effective policy (or effective design) works on the boundaries between dream and reality, linking deep needs and obscure desires to open experience and test.

Kevin Lynch, *Good City Form*

Manufacturing constitutes a significant share of the world's total economic activity, and industry occupies large areas of our built environment. No single answer can predict what future manufacturing will require, but cities can begin to respond to manufacturers' needs by establishing the right conditions and re-embracing extant urban industry. Four central challenges complicate this response. The first is conceptual: with the rapid growth of biotechnology, internet-related digital media, and digital fabrication, confusion regarding terminology is a pervasive problem. What exactly do we mean when we speak of 'industry', 'manufacturing' or 'production'? (Cohen *et al*., 2007). The second concerns public consciousness – i.e. the public's and political leaders' lack of exposure to modern industry (and, consequentially, their outdated perceptions about industrial activity). The third involves planning – i.e. the lack of local and regional industrial policies that encourage the return of industry to urban sites and the failure of the planning-practice literature and recommendations to advocate for the conservation of urban industrial land and the retention and attraction of manufacturers as an economic development strategy (Leigh and Hoelzel, 2012). The fourth challenge is spatial – i.e. the limited and declining supply of urban land zoned for industry.

As has been discussed, while the economic arguments for urban manufacturing and the policies that support it are maturing, the *planning and spatial* strategies for supporting manufacturing are either scattered or non-existent. How should planners and policy-makers address the challenges facing industry through spatial solutions? What criteria should guide the development of contemporary urban industrial spatial development? What parameters are being used to decide where manufacturing is located? What is manufacturing going to look like in the city of tomorrow? These questions consider the future of urban industrial land: an enormous challenge that the planning profession has barely begun to address. Economic development professionals focus primarily on workforce development and access to financial capital; however, these efforts are often only at the regional level. Physical planners and urban designers are, by and large, not part of the conversation. Left to its own devices, legacy urban industrial land will not be redeveloped in a manner that supports manufacturing jobs; the near-term remediation costs and long-term competition from competing land uses are significant disincentives.

Fundamentally, urban manufacturing matters to the production and job creation in cities that lack economic opportunity. When manufacturers began to move their operations from cities to the suburbs to reduce costs, they separate the factories from the city's workforce, creating what has been termed a 'spatial mismatch' between class and income. The commuting costs of the working class increased, which had a negative impact on access. Bringing manufacturing jobs back to the city core could mitigate the harmful effects of industrial sprawl (i.e. the densification of the existing fabric), and integrate a variety of people into the labour market. In addition, urban manufacturing offers a chance to locate living-wage jobs where people live, something that has been overlooked by smart growth advocates who have concentrated on employment in the 'post-

industrial' economy. Measurable environmental benefits are associated with shortening commutes and reducing the delivery distances between firms. Proximity can also bolster economic clusters' strength due to the positive effects of knowledge spillover and a robust labour market.

Manufacturing also has a multiplier that far exceeds that of service jobs: for every job gained or lost, 2–3 supporting jobs are similarly affected. Promoting urban manufacturing is also good fiscal policy; cities can generate additional revenue by allowing industrial land to be used efficiently. Finally, the quality of urban manufacturing is essential to place-making and civic pride in industrial-core cities, thereby connecting the means of production and tapping into the city's creative and constructive spirit. By implementing recycling models between plants and promoting a multi-dimensional resource management model, cities built on industry are celebrating their past, present, and future as centres of production. In addition, technology can help cities face and tackle factories' many nuisance activities.

Urban manufacturing requires a different approach that recognizes people as a vital factor in the competitive advantage of cities. Instead of single-use industrial parks and stand-alone factories, industrial urbanism encourages the convergence of users and activities to create vibrant economic clusters. The new industrial urbanism should re-introduce human-centred design to manufacturing facilities. Places of production are often defined and controlled by the same regulatory mechanisms that were used almost 100 years ago. Cities continue to reduce the supply of industrial land through re-zoning. As a result, the availability of suitable urban land for the kind of buildings and operations-intensive activities that characterize manufacturing is shrinking. As demand for industrial space increases, planners and policy-makers will need to consider infill sites whenever possible. As an added benefit, by focusing on the *reuse* of existing urban industrial land, outward sprawl can be avoided, as well as the associated drawbacks of longer commutes and diminished natural habitats.

These ideas require further research and study. First, such research should seek to understand and theorize the evolving spatial relationships between cities and industrial environments, thereby mapping the existing industrial typologies and their influence on socio-economic urban dynamics and city residents' daily lives. Manufacturing serves as a lens through which to view and assess the ways that cities adjust to economic competition, demographic growth and rapid urbanization. Second, further research could analyse the changes in contemporary manufacturing areas and the ways that they may influence future urban development, the residential fabric and urban infrastructures. Third, researchers could propose a new spatial model that re-establishes the connection between cities and industry, a prototype that meets the needs of the twenty-first century by promoting technological interfaces and advancing environmental concerns. This challenge to the decline of manufacturing is used as a means of aiming for four interrelated goals: (1) Employment, i.e. integrating a variety of people into the job market and adjusting industrial areas and employment to contemporary lifestyles; (2) Sustainability, i.e. implementing recycling models between plants and promoting a multi-dimensional resource management model; (3) Smart Planning, i.e. densifying the existing fabric in residential and industrial areas; and (4) Knowledge and Technology, i.e. using technological tools to reconsider future urban manufacturing.

Finally, in a society widely perceived as being 'post-industrial', educating the public about manufacturing processes is essential. This general awareness – a true consciousness-raising – is necessary if we are to dispel lingering misconceptions that regard industry as routinely unsafe and polluting and instead present manufacturing as an *appropriate* and even *desirable* activity in cities. When

industrial processes were the most noxious, factories moved outside the city and into windowless boxes; the animosity was mutual: manufacturers were as content to shut out the public as the public was to banish them from downtown areas. This attitude must be altered if industry is to be welcomed back to cities and re-assume its role as a good (and productive) urban citizen. Transparency in industrial spaces has proved successful in enhancing the marketability of cities and factories. Manufacturers who take pride in their work will enable the public to share in that fulfilment.

Manufacturing must be viewed with fresh eyes to recognize that sustaining thriving cities is *vital* and to re-think and re-imagine industrial urbanism. Doing so will be a major task for designers, planners, and policy-makers in the years ahead, but it is one that is sure to bear fruit and lead to better place-making.

NOTES

1. Metropolitan areas are defined as geographic areas with core populations of 50,000 or more; each US metropolitan area includes one or more counties that contain an urban core and adjacent counties that 'have a high degree of social and economic integration (as measured by commuting to work)' (US Census Bureau, 2016).

2. The Industrial Urbanism Symposium was held at MIT on 27 October 2014. The symposium included an exhibition by Tali Hatuka (Tel Aviv University) and Eran Ben-Joseph (MIT) in the Wolk Gallery at MIT. For additional information, please refer to www.industrialurbanism.com. The participants cited in this essay are Marty Schmidt, Provost of the Massachusetts Institute of Technology; Sanjay Sarma, the Director of Digital Learning at MIT; Calestous Juma, Professor of the Practice of International Development at Harvard's Kennedy School and the Martin Luther King Visiting Professor in the Department of Urban Studies and Planning at MIT; Ted Acworth, Founder and CEO of Artaic; Fiona Murray, Associate Dean of Innovation in the Sloan School of Management at MIT; Alex Klatshin, a General Partner at Forsgate Industrial Partners; Neil McCullagh, Executive Director of the American City Coalition; Liz Reynolds, Executive Director of the MIT Industrial Performance Center; and Amy Glasmeier, Professor of Economic Geography and Regional Planning in the Department of Urban Studies and Planning at MIT.

3. Specialization is the number of manufacturing jobs in a given industry in a metropolitan area divided by the number of manufacturing jobs in that industry in that country (location quotient).

4. The study found that, within US metropolitan areas, the county (or counties) with the urban core lost more manufacturing jobs than outlying counties (suburban or rural) between 2000 and 2010 (33.9 per cent vs. 29.3 per cent (Helper *et al.*, 2012).

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