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Urban Transformation Under Technological Disruption: A Literature Review

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Abstract: Most contemporary urban theories highlight the role of global capitalism. In difference, this article argues that technological development has the potential to transform the urban. This article examines the urban transformation in the Industry 4.0 era due to the technological disruption generated by the Internet of Things, blockchain, 3D printing, robotics, drones, and artificial intelligence. Through a semi-systematic literature review method, this article draws on the fact that the utilisation of those cutting-edge technologies in manufacturing leads to a back-shoring industry. Production activities are becoming more localised in multilayer urban factories. In contrast to the traditional notion of the megalopolis agglomeration model, this study finds that the future urban transformation will undermine the established regional networks and even draw back economic networks into the intra-urban scale.

Keywords: urban; region; transformation; industry 4.0

1. Introduction

Urban development is a dependency process wherein several factors, such as historical trajectory, technological advancements, institutional frameworks, labour capabilities, and industrial growth, interact and support one another[1,2]. The cumulative nature of productive activities in the urban space determines economic upsides, downsides, and geographical advantages for regional and national prosperities. The urban area and its diverse socio-economic aspects undergo perpetual and ongoing transformation. During the period known as the agrarian revolution, the utilisation of both animal power and human labour facilitated the emergence of extensive agricultural output, leading to the concentration of communities in the agricultural regions. Craft manufacturing has emerged as a means of supporting daily activities, with experienced artisans utilising relatively simple tools to produce essential items for everyday use [3].

During the mid-18th century, a notable shift took place in the process of manufacture. The utilisation of advanced technology facilitates large-scale production in industries. The Industrial Revolution 1.0, spanning from 1760 to 1840, was initiated by the advent of the steam engine, which facilitated the mechanisation of industrial processes and fostered the growth of a farming village into monocentric industrial cities. In the mid-19th century, a significant shift in the methods employed to produce goods emerged. Manufacturing activities associated with various adverse effects, including heightened levels of air pollution, compromised quality of freshwater due to wastewater discharge, a significant increase in population due to the influx of labour migrants, and the chimneys seen in urban areas symbolise the manifestation of urbanisation in modern history[4].

The Revolution of Industry 2.0, which occurred towards the end of the 19th century, was primarily propelled by significant advancements in electricity and assembly systems. Mechanics hold significant importance in the displacement of industrial workers with machines (early robotics). This technology allows industries to be relocated to the city outskirts, away from the population (city centre), and creating a metropolitan belt. Novel technologies also mitigate air emissions and water pollution by including filters in industrial production [3]. It facilitates the feasibility of ecological response and environmental concerns. The emergence of ideal city notions and city rehabilitation initiatives has been foundational in modern urban thought. Notable examples include the Garden City concept proposed by Howard, the City Beautiful movement led by Burnham, and the Haussman-led rebuilding of Paris [5]. The Revolution of Industry 3.0, which occurred in the 1960s, was primarily propelled by significant advancements in the invention of semiconductors, computers, and internet-based advances. This advancement facilitates long-distance industrial communication and administration to remote areas, achieving land-rent cost savings. The global expansion of industrial capital investment has accompanied the industry shift from western to eastern regions or developing countries. This phenomenon has significantly altered global economic, social, and political structural configurations[6]. With the support of global capitalists, industrialisation and metropolitan are progressing more massively into large metropolitan belts. The white-collar class predominantly influenced the transformation of deserted industrial cities into service cities, such as offices, banks, museums, restaurants, and new urban social structures [7].

Recently, significant technical developments have propelled the advent of the Fourth Industrial Revolution. Robotic, Artificial Intelligence (AI), and Internet of Things (IoT) based operating systems have caused significant disruptions to conventional industrial operating systems [8–10]. The recent advancement of technology resulted in a greater degree of disruption compared to the preceding industrial revolution, primarily influenced by three key determinants. Firstly, there is a notable increase in the speed at which events occur compared to previous times. Secondly, these changes are extensive and profound, affecting multiple areas concurrently. Lastly, the changes are transformative, altering the system[11]. Regarding the preceding Industrial Revolution, this article aims to examine whether the contemporary Industrial Revolution will similarly bring about a significant transformation for the urban.

1.1 Salient discourse of urban theories

The field of urban studies is diverse and characterised by its multidisciplinary character. Certain schools or theoretical frameworks often exert significant influence on urban studies. These include the Chicago School, Neo-Marxist, Cultural Analysis, Post-Colonial, Assemblage Theory, and Planetary Urbanization Theory[12–15]. Scholars affiliated with the Chicago School tend to focus on specific parts of social structure within the urban environment [16]. They tend to perceive the city as a means to enhance the intricacy of social relations. Scholars in Political Economy aim to critically examine and question the conventional practices of the Chicago School. Their focus lies in establishing connections between urban centres and broader societal phenomena, particularly to the capitalist system[17,18]. Within this framework, urban areas transform into entities that serve as conduits for capital accumulation and mechanisms for exerting control. Alternatively, they can be viewed as spaces where social dynamics become localised, aligning with the economic goals of capital[19].

Cultural analysts provide an alternative perspective by considering cities not merely capitalist economic goods or entities driven by capital accumulation but also cultural amenities and sites of consumption patterns[20,21]. From a cultural standpoint, the interaction of specific amalgamations of local and global processes generates city creation. Nonetheless, an overemphasis on consumption without considering socio-political factors is a limitation in comprehending urban processes[22]. Assemblage and Post-Colonial theories acknowledge cities' immense size, complexity, and diversity, emphasising identifying shared and distinct characteristics within each urban context. Each urban centre is a distinct occurrence or undertaking that transpires inside a designated geographical location and temporal framework[23,24]. Hence, using a relational standpoint, it can be argued that any typical urban area transforms into a confluence of diverse elements, serving as a hub for various entities and fostering interconnectedness[13,23]. The concept of Planetary Urbanisation posits that we are currently transitioning towards an era characterised by the widespread urbanisation of our globe. Consequently, it argues that no domain exists beyond urban regions[25,26]. As Brenner and Schmid wrote[25], "Today, cities represent increasingly global conditions in which political-economic relations exist." The comprehensive examination of cities necessitates significant theoretical and conceptual advancements and the development of novel epistemologies centring on urbanisation.

Despite the prevailing divergences regarding the extent of the capital industry's influence on urban development, it is evident that cities embody a distinct level of economic and social interaction resulting from agglomeration. This phenomenon emphasises the importance of proximity structures that address the challenges posed by density and the effects of proximity[13]. Simultaneously, the city is situated inside a geographic, economic expansion that sustains it while preserving its integrity as a conventional social phenomenon[27]. Cities worldwide exhibit a phenomenon known as agglomeration, which entails attracting individuals, economic endeavours, and various other interests toward interconnected, densely populated, and centralised areas of land usage[14]. The organic division of labour has arisen as a complex system in which various aspects of economic and social life, encompassing the goods and services production and religious, cultural, and governmental pursuits, are structured and rearranged inside a network of specialised yet interdependent human activity units. The aforementioned organisational structure highlights the need for geographic proximity or agglomeration of various entities. Without such proximity, the expenses associated with time and distance in their interactions would hinder their operational efficiency. The enduring influence of urban theory has been seen throughout history, playing a pivotal role in the fundamental dynamics of urban agglomeration.[13,14,27)]

characterising spatial dispersion. Thirdly, the expansion of metropolitan commuters resulted in the physical merging of previously isolated regions. Fourthly, there is an emergence or reorganisation of remote areas. The central metropolitan core is restructuring and rejuvenating at a higher level.

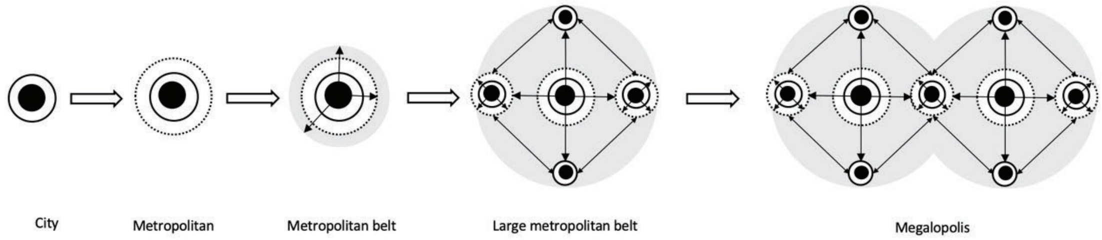

Fig 1: Expansion model of urban agglomeration[33)]

1.2 Urban agglomeration and industrialisation

The cumulative nature of productive activities in the urban space determines the geographical advantages. Several factors that influence production include endowment variables, the geographical accessibility of a specific location, and the expenses associated with production and transportation.[28)]

The monocentric model was developed by Alonso and other scholars, who drew upon the neo-classical demand and substitution theory and enlarged upon the 'von Thünen' agricultural land rent theory. The proposed model suggests that production is localised solely inside a geographically connected zone[29)]. The Von Thünen model illustrates the spatial organisation of a self-contained network controlled by a central entity or attractor. The process of urban expansion will afterwards occur according to the hierarchical agglomeration pattern as concentric rings extending from the city centre to the periphery. Nevertheless, the model disaggregates, revealing geographical variations identifying distinct centres regarding land use, transportation costs, and land rent factors. Initially, these centres are recognised, but eventually, they emerge as influential entities that regulate the local economy. The urban land model serves as an illustrative framework for depicting the spatial organisation and how socioeconomic dynamics strive to achieve equilibrium in the allocation of agricultural resources, hence fostering the emergence of novel urban configurations that are not reliant on agriculture[30)].

Following the Second Industrial Revolution, urban spatial structures evolved non-concentrically, driven by the desire to capitalise on location and infrastructure. This driver led to progressively developing more intricate and complicated spatial expansion. Morrill[31)] stated that the phenomenon encompasses several distinct processes. Firstly, there is a period of modest economic and demographic growth. Secondly, there is a suburbanisation

The formation of urban agglomeration resulted from integrating metropolitan areas, cities, and neighbouring cities by establishing transportation infrastructure such as expressways, high-speed trains, and railroads[30)]. An urban agglomeration is intricately linked to the ongoing progression, alteration, and enhancement of industrial activities, creating additional value. In addition to the impact of industrial transformation on spatial configuration and organisation, alterations in production space are also influenced by the concentration of economic activities and industries[32)]. These factors subsequently affect the spatial development of urban agglomerations in conjunction with physical attributes. Figure 1 illustrates the course of urban agglomeration, driven by economic globalisation and advancements in transportation and communication technology that mitigate distance and time limitations. It can be understood as a continuum from clusters of cities to metropolitan areas, subsequently evolving into metropolitan area belts, then progressing to metropolitan belts, large metropolitan belts, and ultimately culminating in the formation of megalopolis[33)].

According to Scott and Storper[14)], industrial agglomeration significantly impacts the established cities' expansion and contraction and configures the concentration of metropolitan areas. Marshallian and Jacobian externalities elucidate the explanatory framework for change effects resulting from typical industrial processes[34)]. The authors highlight facilitating knowledge and technology exchange across enterprises through informal market processes by promoting sharing, matching, and learning. Sharing encompasses the interconnections within production systems at a local level, as well as the allocation of public assets. Matching entails developing correlations between corporations and individuals residing in the vicinity. The process of acquiring knowledge involves formal and informal information dissemination channels[14,35,36]. Marshallian externalities facilitate more innovation and the diffusion of knowledge from enterprises that produce similar commodities. While Jacobian externalities drive transformative innovation and product development across diverse sectors, creating novel markets and employment opportunities[34,37].

The trajectory of the industrial revolution plays a crucial role in shaping spatial patterns and urban agglomeration. The ongoing discourse on urban theory is facing growing challenges, primarily due to the worldwide expansion of capital and the adoption of advanced technologies in the emerging Industry 4.0. This article addresses these challenges by formulating a conceptual model of future urban agglomeration.

2. Method

Instead of a systematic literature review, this article applies a semi-systematic literature review because the topic evolves in a broad scope. The discussion about Industry 4.0 comes from various fields, i.e., industrial manufacturing, information and communication, economics, transportation, and urban studies. This semi-systematic literature review technique implements a qualitative search approach that is less thorough or detailed, identifies themes and develops conceptual models[38,39].

The semi-systematic literature review involves synthesising knowledge and evidence from a wide range of research. The study conducts four steps[38]. The initial step is preparation, which entails establishing the requirements for the review and formulating protocols. These protocols establish the overarching strategy, keywords, and their interrelationships in searching relevant articles. In the context of this social science, the vocabulary utilised exhibits a lesser degree of convergence. Several authors have introduced distinct terminology to describe and elucidate the same situation. Therefore, brainstorming was conducted on identified keywords related to the issue, drawing upon the study topic. The proposed approach involves incorporating a diverse range of terms and their corresponding synonyms, with the keywords: "industry 4.0", "urban" (alternatively referred to as "city" or "cities"), and "transform" (alternatively denoted as "change" or "disrupt"). The second step focuses on carefully selecting articles subjected to synthesis. The third step involves the dissemination of research findings, which entails establishing connections between these discoveries and the continuing urban agglomeration discourses. The last step is writing the review.

3. Results

3.1 Technologies that generate disruption

The events that transpired today manifest the inherent progression of society and technology[40]. In Europe, the contemporary phenomenon is called the Fourth Industrial Revolution, sometimes known as "Industry 4.0." In North America, it is often labelled as the Industrial Internet, both denoting the underlying technological advancements of the Internet. When novel concepts collide with pre-existing frameworks, a phenomenon known as "Creative Destruction" occurs[41,42]. Substantial technological disruptions could disrupt established workflows that fail to adapt. As discussed, this concept draws on Schumpeter's fundamental concepts to elucidate Western firms' need to adjust during "technological disruption." A critical observation is that technological disruption alters information processing, leading to a reduction in customer uncertainty and an enhancement of customer experience with a particular service. By achieving this, organisations shift economic power within the existing Value Chain. This phenomenon is observable in the successful cases of companies like Netflix, Uber, and Airbnb[40]. Achieving success through technological disruption would generate additional value for the enterprise and contribute to the community's overall prosperity[43]

Derived from the existing body of research, it is evident that five cutting-edge technologies have significantly impacted industrial and company operational frameworks. These technologies include the Internet of Things (IoT), blockchain, 3D printing, robotics, drones, and artificial intelligence (AI). The Internet of Things (IoT) denotes a network of interconnected objects, such as sensors, that can communicate and engage with individuals via the Internet. This system enables remote monitoring and control of the devices[44]. According to recent research, the adoption of Internet technology has experienced significant growth due to the simultaneous decrease in costs, increased processing speed of sensors, and advancements in measurement and communication technology[45]. Blockchain is the system's distributed nature and ability to be authorised and accessed by other entities, perhaps with authorisation storage over a peer-to-peer network[46]. The prospective implications of blockchain technology on Supply Chain operations have garnered significant recognition in academic discourse[47]. This technology can revolutionise the industry by facilitating the integration of electronic "proof of delivery" and enabling efficient tracking of supplier payments across the whole supply network, ensuring timely payments from all parties involved[40,48]. Additive manufacturing (3D printing), also known as 3D printing, is a technological process that uses a digital three-dimensional representation of an object to fabricate physical objects. Additive manufacturing has the potential to expedite the development of prototypes and personalised items such as hearing aids, knee replacements, and toys. This technology offers advantages in terms of speed, cost-effectiveness, and quality improvement[49–54]. Advanced Robotics created from the integration of communication technologies, enhanced sensor capabilities, and artificial intelligence has facilitated significant progress in the intelligence of robots, enabling them to collaborate with human workers while ensuring safety effectively[55–57]. Drones, more commonly called Unmanned Aerial Vehicles (UAVs) or Remotely Piloted Aircraft Systems (RPAS), may be operated from a distant location without an onboard human pilot. These UAVs can transport various sensors capable of capturing visual and aural data and are employed in search, rescue, monitoring and transportation endeavours[43,58]. Artificial Intelligence (AI) is a complex computer system that simulates human-like natural intelligence to analyse external data, extract information from said data, and apply this obtained knowledge to conduct descriptive, predictive, or prescriptive analyses. The organisation has created machine learning and deep learning algorithms to implement preventive maintenance strategies to mitigate future damages[43].

3.2 Emerging new industrial organisation

The advancement of industrialisation minimises the expenses associated with non-differentiating functionalities, such as supplementary expenditures, throughout its range of products and services. Porter's seminal work on the "Value Chain"[59] delineates two primary areas of emphasis: (i) The main value-contributing activities encompass incoming logistics, operations, outbound logistics, sales, and marketing; and (ii) Furthermore, there are secondary supporting activities such as corporate infrastructure, human resource management, corporate IT, and procurement. The nexus encompasses advanced technologies that intersect with various segments of the value chain [60]. Providing a comprehensive analysis of the impact of each technology would be challenging to articulate within this context[61].

Crowdsensing is the inception of People-Centric Sensing and Computing[62,63]. This paradigm integrates wireless communication and sensor networks with the many activities of individuals in their daily lives. Whether willingly or not, people and their smart devices are potential sensing devices dispersed throughout physical space[64,65]. Cellular devices can function as sophisticated sensors using their camera as a video and image sensor, microphone as an auditory sensor, GPS receiver for location information sensing, and other features. Embedded sensors, such as gyroscopes, accelerometers, and proximity sensors, can extract significant contextual information, such as discerning the locomotion mode of persons, such as walking or cycling. The vast number of mobile devices equipped with location-aware capabilities makes it possible to perceive the physical world without relying on a sensor network. This approach enables the collection of real-world observations through billions of users' mobile devices[62]. Crowdsensing is employed to gauge user experience and perceive the tangible environment, transmitting sensory data to the digital realm. This data is then utilised to construct virtual renditions of actual entities, enabling enhanced user services business.

Fast-Moving Consumer Goods (FMCG) refer to a category of durable retail products[66]. These products encompass a wide range of commodities, such as food, beverages, personal care products, furniture, textiles, domestic care products, and packaging materials[67]. FMCG items are frequently purchased, inexpensive, and typically have a shorter lifespan than durable goods [68]. Reusable packaging has supplanted disposable packaging in diverse settings, encompassing business-to-business commerce, transportation, and consumer-oriented scenarios effectively. The packaging has been intentionally designed to facilitate reuse by customers or recycling by-product producers and retailers for future utilisation. The progress in material technology has resulted in pallets composed of non-toxic materials, which are recyclable within metropolitan systems. From the user's standpoint, packaging continues simultaneously. However, a thorough system for collection and processing is employed to transform the material into fresh packaging. The urban retail sector has transformed in response to global societal shifts during the past decade. The previous unidirectional movement of goods from sellers to buyers has evolved into a bidirectional association. As an illustration, the waste generated by consumers is either returned to the store directly by the customers themselves or facilitated through service innovation spearheaded by the retail industry.

Circular Economy (CE) represents a novel framework for the interplay between producers and customers, propelled by the advancement of People-Centric technology—inadequate prioritisation of user experience, encompassing servitisation, customisation, and localisation[69,70]. The subsequent subsection will go into the two primary factors that have contributed to the rise of Re-distributed Manufacturing. Baines et al.[71] present servitisation as "... customers pay to use assets, not own them, and therefore benefit from the risk cover (warranty), responsibilities and costs traditionally associated with ownership." This mechanism implies that the distinction between goods and services can become blurred, resulting in a service-product system that enables producers to enhance their competitiveness, optimise the value chain, and supply products and services that are rich in knowledge[71]. This principle includes tracking the sourcing of raw materials from suppliers, their transformation by producers, distribution by distributors, and sale by retailers to end consumers. This approach can also be applied to the examination of the reverse flow of the supply chain, wherein the reusable product serves as an input to launch another cycle inside a closed-loop supply chain system[72].

Re-distributed manufacturing (RdM) works around the augmentation of digitalisation within the manufacturing sector to bolster industrial flexibility and facilitate product customisation through the implementation of automation and the exchange of data[73]. The manufacturing model aims to enhance competitiveness by adapting its location and production scale, minimising supply chain expenses, promoting sustainability, and delivering tailored products that align closely with individual customers' preferences[73]. This transformation entails transitioning from a centralised approach to a decentralised, demand-driven, localised, and customisable manufacturing model. The concept is commonly known as Re-distributed Manufacturing (RdM) in the United Kingdom, but in the United States, it is commonly referred to as 'Smart Manufacture[74]. The implementation of the RdM application can be accomplished by employing three alternative strategies: There are three primary methods of manufacturing: small-scale production, in-house manufacturing, and outsourcing to external manufacturers.[74]

Backshoring is an organisational strategy to offset labour costs incurred at outsourcing sites, hence facilitating the relocation of production to enhance flexibility and minimise waiting periods, utilising advanced robotics[75]. The primary factors driving the decision to backshore manufacturing activities include quality issues, less flexibility and extended tool delivery times, reputational consequences stemming from product quality assurance, diminishing labour cost differentials, and excessive total procurement costs, encompassing logistical expenses[76–78]. A positive correlation exists between the level of investment in advanced production technology and the necessity for achieving high-capacity utilisation. This correlation is crucial to enhance the ownership advantage associated with the investment. Hence, the preference lies in integrating this manufacturing process into a specialised facility using advanced technology in a backshoring system instead of engaging in offshoring activities[79].

Urban Factories departed from the understanding that urban areas are conducive environments for leveraging the opportunities presented by co-creation and co-design, primarily due to their high population density, which provides a substantial consumer market, and their proximity to a diverse range of activities and supporting infrastructure offered by the Internet of Things (IoT). Within this context, it is plausible for customers, manufacturers, and service providers to actively participate in various stages of the product manufacturing process, product utilisation, or customer experience. The generation of value is highly probable to occur inside an urban environment, where collaborative efforts that are more decentralised and interconnected play a significant role in the future. This collaborative approach involves the active participation of citizens throughout all phases of the product life cycle[80]. When examining the economic dimensions of urban settings, the proximity of space emerges as a valuable asset for generating value. This attribute holds exceptional potential for implementing urban factories instead of factories in a broader context [3].

Multi-Floor Manufacturing. The growing necessity for enhanced production adaptability and the utilisation of advanced technologies[81] has resulted in a significant demand for consumer goods that align with customer preferences. Consequently, manufacturing facilities have been established in residential neighbourhoods within large cities strategically located close to consumers[82]. The expansion of small and medium-sized firms has played a significant role in the formation of Multi-Floor Manufacturing (MFM) city clusters. One notable characteristic of the MFM cluster in the city is the existence of a collection of MFMs and multi-story non-story structures. This logistics node is situated within a designated central urban area region and is interconnected through diverse communication infrastructure. These facilities cater to the demands of the population residing in a large city and its surrounding agglomeration[83]. The MFM cluster in the city predominantly exists within small and medium firms (SMEs) that exhibit diverse production orientations, including those involved in supply chain activities. The MFM city cluster feature enables enterprises to effectively leverage diverse manufacturing structures, such as network manufacturing organisations, to meet consumer demands—a real-time network construction system utilising a client/server architecture.

Zero Warehousing Smart Manufacturing (ZWSM) is a novel manufacturing paradigm that seeks to eliminate non-value-added activities like put away and order picking in typical warehouse operations. It also intends to minimise the storage space required for metropolitan factory operations, particularly in areas with limited land availability[84]. The transportation of goods within metropolitan areas is a significant concern due to the escalating logistical demands of globalisation and the growth of the Internet market. The industry should explore strategies to mitigate the financial burden of manufacturing goods in developing countries. The advancement of logistics services has been a significant catalyst for the growth in product sales, particularly within the fashion industry[85]. Dispatchers frequently traverse urban regions, where congestion frequently results in prolonged waiting periods lasting many hours. These various circumstances will result in a significant time delay in the construction process at the warehouse, thereby leading to a financial burden of around 30% of the production expenses[86].

Open-Workshop. The primary tendencies observed in the development of the modern information society include the acceleration of urbanisation within agglomerations, the presence of high population densities in large cities, the widespread utilisation of information and communication technology, and the prevalence of intensive urban traffic[27,82,87]. One potential strategy for addressing the issue of talent shortages among small and medium-sized enterprises (SMEs) is the implementation of internal training programs. The Open-Workshop is a facility where various production technologies, including good laboratories, 3D printing, screen printing, traditional crafts, and bicycle repair shops, can be employed, examined, and included within prototype endeavours[88]. Open Workshops offer a platform for addressing social and intellectual needs related to the repair, reassembly, or development of prototypes, depending on the relevance of the subject matter concerned. The authors suggest a strong correlation between knowledge about technology, materials, physical labour, and social innovation[89].

4. Discussion

Over 50% of the global population resides in urban areas and cities. This specific component is projected to experience a growth rate of approximately 70% by the year 2050. Urban areas exhibit distinct characteristics due to their complex and dynamic nature, as they function as central nodes for various urban activities. They have a crucial role in promoting and maintaining the community's economic, social, and environmental balance. The rise in environmental issues has sparked daily discussions on how to address and mitigate these issues[90–94]. The manufacturing sector is vital in upholding stability, primarily within the economic sphere, while also exerting indirect influence on the other two dimensions. The production of goods and the provision of related services influence the economy's performance. The emergence of urbanisation during the onset of the ongoing Industry 4.0, along with the growing inclination towards customised products and localised production, has fuelled great interest in urban factories. As industrial areas expand, numerous embryos are likely to develop in newly constructed neighbourhoods designed to workshop and house workers[92,95]

The previous section has elucidated the paradigm of Re-distributing Manufacturing and Backshoring, highlighting the advantages of urban locations regarding value creation, market proximity, and the supportive ecosystems for manufacturing output in Industry 4.0[76,79]. Similarly, implementing the Urban Factory and Multi-Floor Manufacturing mode and the Open-Workshop approach for producing customised products appears to bring us back to the craft production paradigm of the 17th century [3] or further back to the 13th century in Java[95]. However, it is essential to note that this contemporary approach utilises distinct technology and operates at different scales.

The digitalisation of production will be the primary catalyst for transforming the global value chain in the coming years. The proliferation of Industry 4.0 technology can significantly impact global manufacturing sites and organisational structures. Automation facilitates enhanced productivity and improved interactions between humans and machines, enabling superior product customisation and personalisation. The industrial sector that engages in on-site manufacturing activities or operates from home tends to perceive a higher level of automation and digitalisation in their production processes than other enterprises[96].

The current state of backshoring trends can potentially alter the structure of the global capital industry. However, it is essential to note that this technology is still in its early stages of development, resulting in minimal impact thus far. When the economic advantages of engaging in industrial activities in low-wage or developing nations cease to be financially viable, the appeal of offshore and global capital investment diminishes. The anticipated planetary urbanisation initiative will be directly negated by this condition, impeding the operation of the planetary capital industry. McKinsey[97] asserts that they have extensively studied the global impact of manufacturing automation technology. The phenomenon under consideration has caused significant disruption to almost half of the global economy. This disruption has resulted in the displacement of 1.2 billion workers and the loss of earnings amounting to USD14.6 trillion, primarily due to backshoring decisions. The combined contributions of China, India, Japan, and the United States account for precisely 50% of the sum mentioned[40].

An increasing number of urban development initiatives actively seek to incorporate manufacturing and production processes. This process aligns with the viewpoint that increasing funding for research is evident, as exemplified by the European Cities of Making (CoM) program. This initiative seeks to foster collaboration among Brussels, Rotterdam, and London to investigate the prospective developments in urban manufacturing in terms of resources, technology, spaces, and applications. Similar projects for productive cities exist in urban areas such as New York and Hamburg [3]. In the context of New York, notably the Brooklyn Navy Yard (BNY). BNY is an exemplar of urban manufacturing, showcasing the viability and beneficial outcomes of advancing contemporary urban industries[98]. A flexible working pattern enables professionals to effectively manage several enterprises through outsourcing, resulting in various advantages. The re-skilling process in non-IT professions is essential to align with the evolving demands of the labour market, which is increasingly influenced by the prevalence of e-business and digital technologies. Individuals can attain the Jacobian externality, which involves securing new employment positions indirectly generated through backshoring production capacity. The recruitment of highly skilled personnel and professionals is a significant determinant in this scenario. The geographical disparities between workers and firms will thus exacerbate the issue of scarcity of trained labour.

In general, the augmentation of digital integration within the manufacturing process appears to foster a shift towards a localised value chain that exhibits greater resilience and cohesion than the global industrial network. In contrast to the preceding era, whereby agglomeration was contingent upon the concentration of industrial capital[13], future agglomeration prediction was based upon the concentration of prospective consumer products and potential labour force. This similar trend is also starting to be applied on a country-wide scale in India, where India

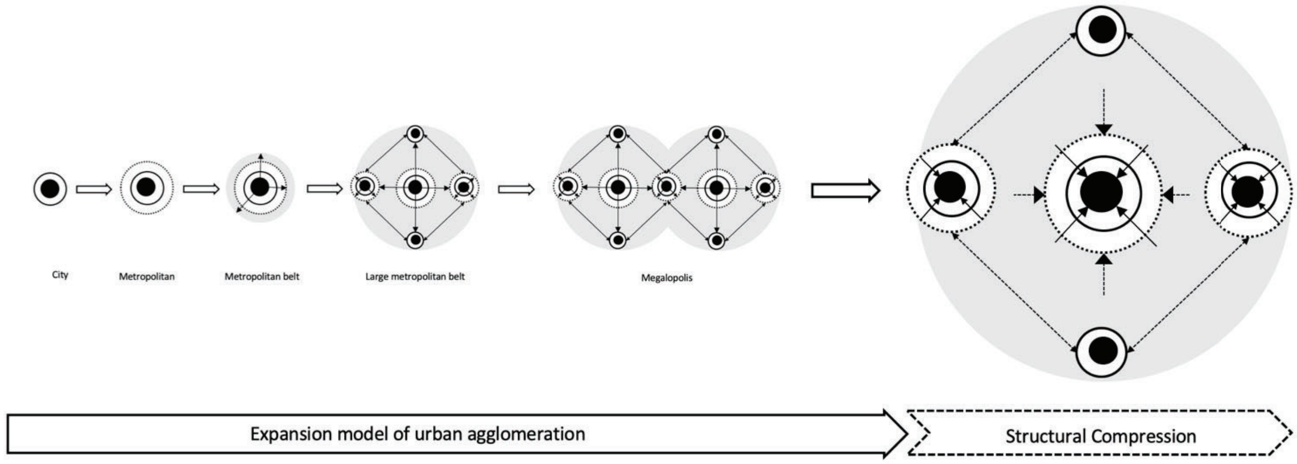

Fig 2: Conceptual model of future urban agglomeration due to industry 4.0

decided to pull out of The Regional Comprehensive Economic Partnership to focus more on local manufacturing development[99]. At the village scale, IoT allows remote areas to reach the global market without relying on the capital city's networks[90,100,101]. Simultaneously, Industry 4.0 technologies potentially lead to a reconfiguration of the urban network. Following the assertions made by Storper[13] and Capello[28], the activation of IoT technology within industrial production processes, coupled with its integration with other information technology advancements like Big Data and Artificial Intelligence (AI), elicits spillover effects within the social structure. Urbanisation has led to the emergence of novel skill sets, resulting in the digital displacement of certain conventional occupations, such as cost-estimating tasks, which can now be automated. However, this shift has also given rise to new employment opportunities, exemplified by the emergence of professions like Data Construction Science. Marshallian externalities manifest within information technology (IT), where IT departments assume a crucial role within organisations as intermediaries between investment and value generation.

Referring to the discussion above, we summarise three future urban transformation assumptions. First, backshoring manufacturing diminishes the global capital network while concurrently bolstering regional-scale economic networks. Therefore, the urban agglomeration process might revert to the concept of large metropolitan belts, even pulled back into the intra-urban network. Second, urban economic development is shaped by its unique potential and is influenced by the interactions within the community. The urban and suburban poles collaborate to generate value inside their respective domains and cooperate on a regional level. Third, in the context of market and consumer integration, manufacturers have achieved a high level of proximity to consumers, eliminating the spatial divide between business/office premises and residential areas. Both merging operations use an identical physical area, specifically a multi-level urban industry setting.

In this particular scenario, when production is more integrated and close to consumers, the spatial structure is determined by the urban population level. Manufacturing is becoming more localised in urban areas. In addition, the traditional demarcation between business/office areas and residential regions has been eliminated. These entities use an identical physical area, specifically a multilayer urban factory. Those growing phenomena potentially undermine the agglomeration trend of megalopolis regions and even draw back economic activity networks into the intra-urban scale. This model of structural compressing is illustrated in Fig. 2. Presumably, urban spaces will be filled by the city centre, which serves as the administrative hub for urban infrastructure. The urban factory in question is a complex structure that spans multiple floors and incorporates both residential and urban settlements. It also includes industries that are situated in suburban and sector-based settlements. These various components are integrated with urban areas through a compressing network of supply chains and suburban regions.

5. Conclusion

Industry 4.0 has prompted significant technological advancements in IoT, blockchain, 3D printing, robotics, drones, and AI. They require restructuring and reconfiguration of production processes, enabling more manufacturing activities inside urban areas. Integrating the factory production site aligns with the concept of "urban production" in a manner conducive to urban environments. The revival of manufacturing in cities requires aligning production sites with the urban environment, incorporating production processes with resource conservation and pollution and noise emissions mitigation[102]. This concept has been comprehended for the past three centuries [4]. This approach entails a shift in urban production dynamics, wherein a symbiotic relationship between firms and urban inhabitants. Urban production potentially shifts the traditional reliance on capital-intensive industries in special industrial zones with urban manufacturing. The assumptions are depicted as the conceptual model of urban transformation throughout Industry 4.0, as presented in Fig. 2. In contrast to the traditional notion of the megalopolis agglomeration model, this study proposes a structural compression model, a new model for the future urban transformation, where urban structure tends to undermine established regional networks and even draw back economic networks into the intra-urban scale. This model is a preposition and needs empirical proof from further research. In addition, the findings strengthen the argument on the relevance of the integrated and compact intra-city model, first initiated by Danzig and Saaty[103)], in the coming urban studies and policy development.

However, the emergence of Industry 4.0 is still two decades away. Technological developments and other patterns of transformation are still very much possible. Therefore, discussions from other perspectives (consumption and residential mobility[91,92)]) need to be further developed to reveal and anticipate the uncertain situation in the future.

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