Industrial Spatial Organization through the Evolution of Production Systems: Fordism, Toyotism, Wintelism, and Distributed Manufacturing

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Abstract: This study combines theoretical and case analysis to examine the spatial logic of Fordist, Toyotist, Wintelist, and distributed production systems and to anticipate how distributed manufacturing may transform industrial space in the digital-intelligent era. Production systems evolve from centralization through polycentric organization toward decentralization. Digital technology reorganizes information flows and supply chains, contributing to partial dissolution of cluster- and chain-based formations and to production networks operating across larger regions. At micro scale, industrial space becomes smaller and more modular, with agglomerated manufacturing-service units and dispersed automated manufacturing units. Planning should reconsider conventional industry-city integration and provide flexible spaces that support rainforest-like industrial ecologies and rapid response.

Keywords: industrial production system; industrial space; Fordism; Wintelism; distributed manufacturing

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Industrial production systems integrate raw materials, equipment, labor, technology, and management to organize design, manufacturing, quality control, and logistics. Since the Second Industrial Revolution, Fordism, Toyotism, and Wintelism have represented major organizational paradigms [1]. Artificial intelligence, industrial internet technologies, mass customization, and service-oriented manufacturing are now supporting more distributed systems [2]. These changes affect location, spatial organization, morphology, and the underlying relationship between industry and cities [3-7].

1 Characteristics of Typical Industrial Production Systems

1.1 Fordism: Single-center Organization under Mass Standardized Production

Fordism combines standardized products, assembly lines, specialized labor, and vertically integrated large firms. Production is centralized in large factories, suppliers are organized around the core plant, and economies of scale favor extensive industrial districts [8]. Spatial organization is hierarchical, relatively stable, and strongly linked to mass labor and transport infrastructure.

1.2 Toyotism: Lean Production, Flexible Manufacturing, and Local Networks

The Toyota system replaces large inventories with just-in-time delivery, continuous improvement, flexible production, and long-term supplier relations [10-13]. Core plants remain important, but specialized suppliers form a multilayer local network. Geographic proximity reduces uncertainty and supports frequent coordination, producing polycentric industrial regions and clustered supplier systems.

1.3 Wintelism: Modular Production and Global Production Networks

Wintelism separates product architecture into modules governed by interface standards. Lead firms control design, operating systems, and brands, while specialized producers manufacture components across global networks [9,14-17]. Industrial organization shifts from vertical integration toward platform control and international outsourcing. Production islands may be geographically distant yet tightly linked through information and logistics.

1.4 Distributed Manufacturing: Digital Coordination and Decentralized Units

Distributed manufacturing uses digital models, cloud platforms, additive manufacturing, intelligent equipment, and networked coordination to place production closer to demand. Producers and consumers interact more directly, small batches become viable, and manufacturing units can be modular, mobile, and partially autonomous [2,18]. Physical flows and digital flows form a combined production space.

2 Typical Industrial Spaces under Different Systems

2.1 Fordist and Toyotist Industrial Space

Fordist space is dominated by large plants, worker settlements, transport corridors, and supplier belts. Toyotist space retains a central assembler but develops a denser local network of suppliers and logistics facilities. Both systems support concentrated industrial parks, although Toyotism produces more differentiated nodes and stronger interfirm circulation.

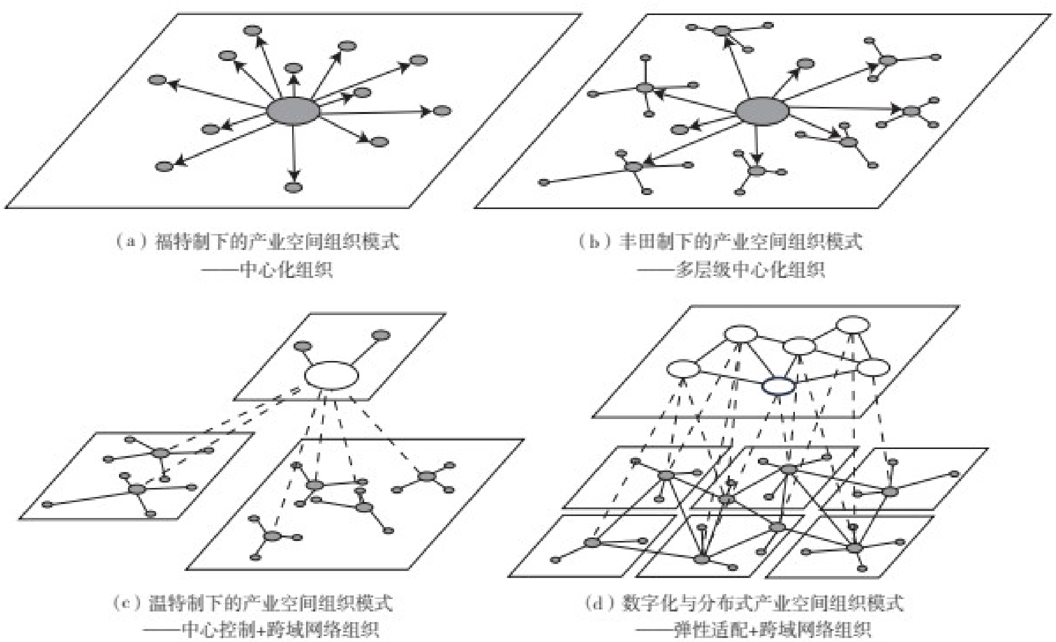

Fig. 1 Spatial organization under different industrial production systems

2.2 Wintelist Industrial Space

Wintelist firms distribute design, components, assembly, and markets internationally. Shenzhen electronics firms, for example, can relocate manufacturing while retaining innovation and management functions in the city [19]. Individual factories may become isolated production islands embedded in a global network. Their local linkages are weaker than those of the Toyota supplier system, while connectivity through standards, information, and logistics is stronger.

工厂案例	台积电(南京)	三星(西安)	富士康(郑州)
空间边界	有实体围网 无制度围网	有实体围网 有制度围网(西安高新综合保税区)	有实体围网 有制度围网(郑州新郑综保区)
产业关联	与周边产业弱关联,仅有小部分供应链在本地,产品直接空运发往全球	与周边产业无关联,部分供应链在本地但分布在围网内部,产品直接空运发往全球	与周边产业无关联,供应链不在本地,产品直接空运发往全球
空间区位	城市远郊区的新城	城市远郊区,周边为城乡接合部	远离城市,紧靠机场枢纽
空间形态			

Table 1 Examples of island-like layouts among Wintelist firms

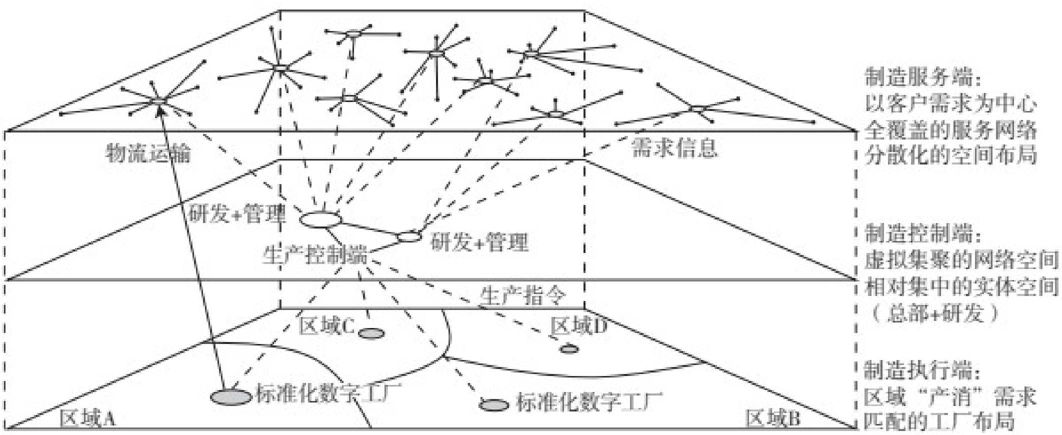

Fig. 2 Physical and digital spaces of distributed production

生产系统	核心逻辑	优势	局限性	典型行业/场景
福特制	标准化流水线、规模经济	低成本、高效率	无法应对需求波动	基础工业品(标准件)
丰田制	精益生产、有限外包	灵活性较高、减少库存浪费	依赖供应链稳定性	汽车、机械装备
温特制	模块化分工、全球价值链整合	快速创新迭代、优化资源配置	产业在地性不足	半导体、电子消费品
分布式	分散化网络、数字技术、人工智能驱动	定制化、服务化、灵活度极高	协同难度大,对研发和服务的要求高	家具建材、服装、医疗器械等

Table 2 Comparison of the core characteristics of four production systems

3 Industrial-space Change as Distributed Systems Penetrate Existing Production

3.1 Coexistence, Hybridization, and Gradual Penetration

Production systems do not replace one another in a simple sequence. Fordist scale, Toyotist supplier relations, Wintelist modular networks, and distributed technologies coexist and hybridize across sectors and regions. Digital tools penetrate existing systems unevenly, according to product characteristics, regional development, and firm capability. The result is a mixed technical-social system rather than a single universal model [18-22].

3.2 Macro Scale: Partial Dissolution and Regional Recombination of Clusters and Chains

Digital coordination reduces the need for every production link to be geographically adjacent. Some cluster and chain formations partially dissolve, and production stages are recombined across a larger regional range. Lead firms, service nodes, flexible suppliers, and automated plants form cross-regional networks. Agglomeration remains important for knowledge, talent, infrastructure, and policy, but supply-chain control increasingly operates through digital platforms and standards.

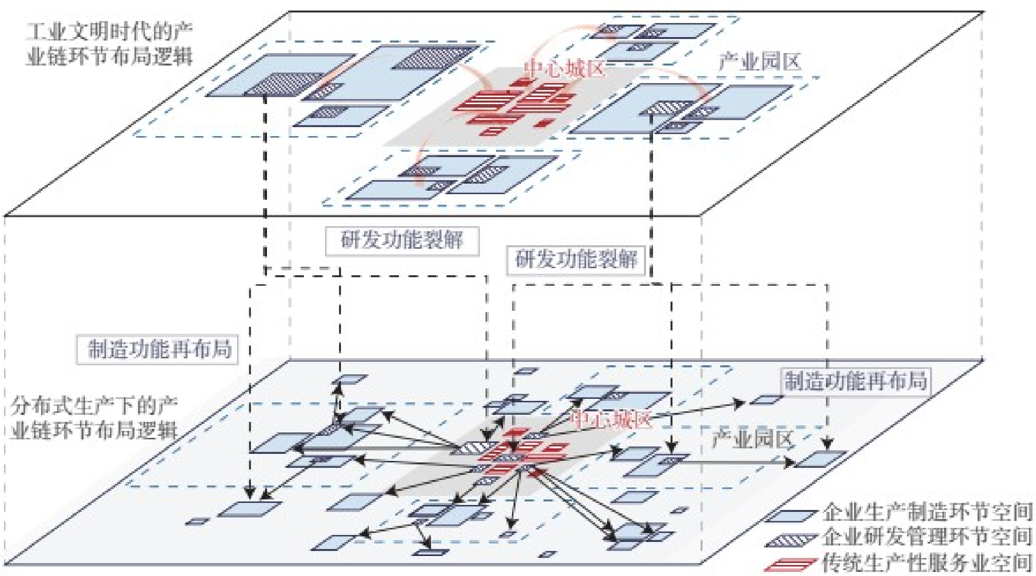

Fig. 3 Industrial-chain and regional-network organization under distributed production

3.3 Meso and Micro Scales: Modular Units, Agglomerated Services, and Dispersed Automation

Industrial parks increasingly contain small modular units that can be recombined as firms and technologies change. Manufacturing-service units prefer agglomeration because research, finance, testing, design, talent, and interaction benefit from proximity [20-21]. Automated execution units can be more dispersed because labor and commuting needs decline. Compact unmanned plants, shared factories, urban manufacturing buildings, and flexible standard units become important types.

Fig. 4 Scale and morphological characteristics of industrial-space units

3.4 Technical-social Change and New Industry-city Relations

Technology and social organization jointly shape space [22]. As management and research become more labor- and knowledge-intensive while manufacturing execution becomes automated, the two ends of production can separate spatially. The conventional idea that every industrial park should balance jobs and housing requires re-examination. The discussion concerns greater flexibility in locating different production links; it does not deny the continuing economies of infrastructure, services, and policy within industrial parks.

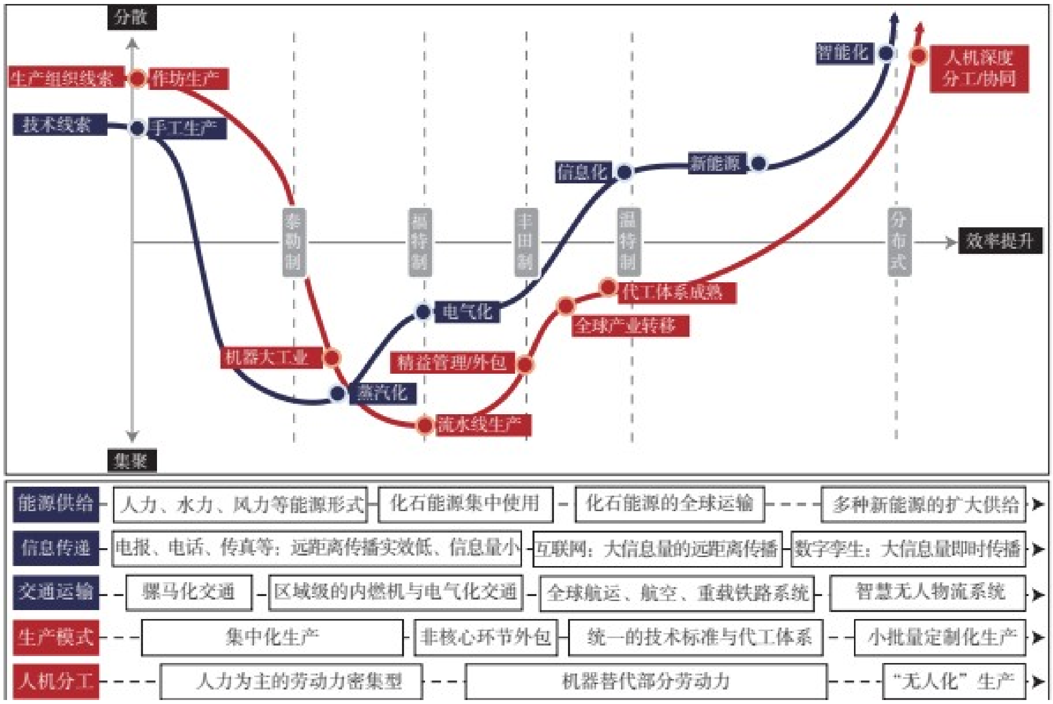

Fig. 5 Evolution of industrial space from a technical-social systems perspective

4 Adaptive Strategies for Industrial-space Planning

First, planning should reconsider the simultaneous operation of integration and dispersion. Manufacturing-service functions may remain embedded in cities, while automated execution spaces can separate from dense urban environments. Population forecasts, industry-city balance, and land matching should reflect falling labor intensity in some sectors.

Second, industrial layout should move from rigid chain-cluster models toward flexible unit models. Geographic proximity increasingly supports tacit knowledge, labor mobility, creative interaction, and co-creation, while direct upstream-downstream control may be weaker. Operators should be allowed to configure space across units, parcels, and buildings and to support firms occupying different ecological niches.

Third, space supply should shift from long-term fixed guarantees toward rapid response. Small firms often need compatible office-production space instead of whole parcels, and lead firms change products and processes rapidly. Control indicators should emphasize universality, compatibility, divisibility, and expandability, with flexible tenure and conversion mechanisms.

5 Conclusions and Discussion

Distributed production, supported by big data, the Internet of Things, and artificial intelligence, will penetrate existing systems and restructure chain-based industrial space. Industrial networks will operate at larger regional scales, production links will be more spatially dispersed, and land use will become more intensive and flexible. Planning should update conventional industry-city integration, concentrated layouts, and rigid land supply.

The relationship between production systems and spatial patterns remains complex. Sectoral differences, regional development, and overlapping concepts such as flexible, agile, and distributed manufacturing prevent a simple technological periodization. Longitudinal firm studies and sector-specific comparisons are needed to test these forward-looking propositions.

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