China's Manufacturing amid New Industrialization in the 14th Five-Year Plan Period*

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Abstract: *Driven by a new round of technological and industrial revolution, China's manufacturing industry is heading towards green, intelligent, service-based and customized development. In light of the new technological revolution and evolving industrial development model, we need to revise and breathe new life into the traditional industrialization theory. When assessing a country's industrial development, we should use the level of industrial technology, instead of the proportion of primary, secondary and tertiary industries, as the key criterion. In addition, the level of modern industrial development should be determined according to the degree of digital, network-based, and smart features. The new industrialization theory should employ knowledge-intensive complex labor to replace simple labor as the labor factor input in the production function, and include data as a new factor of production in the analytical framework. We should also define natural resources and the environment and greenhouse gas emissions as hard constraints of the production function. In the comparison of smart, service-based and green development levels of China's, the US' and Japan's manufacturing sectors, our results suggest that China lags far behind developed countries in terms of the level of industrial development. During the 14th Five-Year Plan period, China's manufacturing industry should shift from quantitative expansion to digital and smart innovations and applications, modernize the industrial system, promote industrial integration, and broaden its horizon from domestic regional planning to the global value chain.*

Keywords: *new industrialization, new technology revolution, manufacturing outlook*
JEL classification code: O14, O21, O38
DOI: 10.19602/j .chinaeconomist.2020.07.02

In modern world history, industrialization has played a decisive role in economic development. Since the late 1930s, international economists have investigated the goals, pathways and policy approaches for industrial development in less developed countries. Among them, the industrialization theory based on a structuralist view has held sway (Syrquin & Chenery, 1989). It argues that most developing countries face barriers to their economic development such as a dual economy and structural inflation and that structural rigidity prevents the market from allocating resources effectively. Thus, the government should intervene to overcome the structural barriers and spur the economy (Chenery, 1975). In order to put this theory into practice, economists like Kuznets (1971) and Chenery *et al*. (1986) have

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新工业化与“十四五”时期中国制造业发展方向选择*

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摘 要： *在新一轮科技革命和产业变革的推动下，制造业发展的绿色化、智能化、服务化和定制化趋势不断凸显。为顺应新技术革命及工业发展模式变化趋势，需要对传统工业化理论进行修正和创新。其中，对工业化水平的判断标准从三次产业比重标准为主回归到工业技术水平本身，并且要把数字化、网络化、智能化作为判别现代化工业水平的关键标准。新工业化理论要用知识密集型复杂劳动取代简单劳动成为生产函数中的劳动要素投入，并把数据作为新的重要生产要素纳入分析框架，同时还要把资源与环境、温室气体减排作为生产函数的硬约束。比较中国、美国、日本制造业智能化、服务化、绿色化发展水平，结果显示，与发达国家相比，中国工业化水平差距较大。“十四五”期间，中国制造业的发展要由规模扩张转向增强数字化和智能化技术创新及应用、产业升级要指向现代产业体系构建、结构调整重点是促进产业融合发展、发展空间优化要转向全球价值链构建。*

关键词： *新工业化；新技术革命；制造业发展方向*
JEL 分类号：O14, O21, O38

从世界近现代发展历程看，工业化在各国经济发展中发挥着决定性作用。从20世纪30年代末开始，国外经济学家对落后国家的工业化目标、路径和政策设计做了大量研究。其中，结构主义视角的工业化理论影响最为深远(Syrquin & Chenery，1989)，其强调发展中国家普遍存在二元经济、结构性通胀等妨碍经济起飞的障碍，并且认为结构刚性(structural rigidity)使得市场和价格机制难以有效发挥其资源配置作用，因此需要政府采取措施来克服结构性障碍，从而促进经济发展(Chenery，1975)。为了将这些理论付诸实践，Kuznets(1971)、Chenery等(1986)等经济学家通过历史统计分析与比较分析，提出了划分工业化阶段的标准，指出人均收入水平的变动、三次产业产值结构和就业结构的变动、工业内部机构的变动是衡量工业化阶段演进的三个最主要指标。尽管20世纪80年代以来，新发展经济学(Stiglitz，1986)以及基于新古典范式的新制度经济学(North，1981)、新政治经济学(Storm，2017)、新结构经济学(林毅夫，2010)等理论流派，均对结构主义视角的传统工业化理论有所批判和超越，但到目前为止，尚未提出不同于传统的基于结构主义视角的工业化阶段判别标准。

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identified the three primary indicators - changes in per capita income, the output value and employment ratios of primary, secondary and tertiary industries, and industrial institutions, for determining the stage of industrial development. Since the 1980s, new developmental economics (Stiglitz, 1986), new institutional economics based on the neoclassical paradigm (North, 1981), new political economics (Storm, 2017), and new structural economics (Justin Yifu Lin, 2010) have all criticized and transcended the traditional industrialization theory based on structuralism, but are yet to put forward any non-traditional approach for assessing the stage of industrial development.

Since 1978, China has experienced rapid industrial development through industrial restructuring based on the valid elements of the traditional industrialization theory. Yet today's external environment and goals for China's industrial development are very different from those of the 1950s-1980s with which the traditional industrialization theory is concerned. After World War II, less developed countries experienced rapid industrial development thanks to stable technology frontiers and advancing globalization. In today's world, a new round of technological and industrial revolution is reshaping the pattern of globalization. Traditional industrialization theory has focused on how less developed countries may catch up with industrialized nations in terms of "the home country's growing material, human and technological inputs that contribute to manufacturing sophistication" (Lall, 1991). With developed countries vowing to "re-industrialize," China as a developing country should not be satisfied with its industrial success. As China embarks upon a new journey of industrial development, the case for a new industrialization theory becomes stronger than ever. By analyzing the implications of the new technology revolution and the weaknesses of the traditional industrialization theory, this paper elaborates on the new industrialization theory's innovations, creates indicators for measuring the level of the new industrialization, and discusses China's industrial policy outlook in the 14th Five-Year Plan period (2021-2025).

1. New Technological Revolution: Implications for Industrial Development

Recent years have seen the rise of a new round of technological and industrial revolution led by groundbreaking innovations in sectors such as new-generation information technology (IT), new materials, new energy, and life science. Green, smart, service-based and customized manufacturing marks the beginning of a new industrial revolution that upends the traditional industrial mode, format, and organizational pattern. These trends have prompted reflection on the traditional pattern of industrial development.

First, green development sets the new industrialization apart from the traditional approach. Green manufacturing refers to a transition towards better energy and resource efficiency, environmental performance, and emissions abatement. It stems from innovation-driven production and business models. While energy-intensive, polluting and resource-based sectors strive to become cleaner and more efficient, all manufacturing sectors throughout the supply chain have adopted greener equipment, processes, and practices. With green concepts taking hold, countries have raised their environmental standards from raw materials to manufacturing processes and final products. On the flip side, green development also adds to the manufacturing cost. Manufacturing firms without a knack for green technology are likely to see their cost advantage whittled away (Shi, 2018).

Second, smart features are the key variable for the new industrialization. New-generation IT has enabled data-driven, real-time online, and intelligent manufacturing activities. Artificial intelligence (AI) is opening possibilities for self-sensing, self-learning, decision-making, self-execution, and self-adaptation capabilities. Smart manufacturing is reshaping the mode of production and the value chain, catalyzing more efficient R&D and production, allowing a faster market response, and creating better user services. Smart features are giving rise to strategic emerging industries based on software, digital, and data analysis solutions. Digitalization is breathing life into traditional industries, too. In this context,

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应当说，改革开放以来，中国借鉴传统工业化理论的合理成分，并结合中国国情，通过促进产业结构调整等方式，有力推动了工业化进程。但是，时移世换，与传统的工业化阶段判别标准所分析的20世纪50~80年代相比，当前及未来一段时期，中国工业化面临的环境及所要实现的目标都大不相同。就外部环境而言，“二战”以来欠发达国家的工业化面临的是技术前沿相对稳定、全球化逐步推进的国际环境，而在当前，新一轮科技和产业革命扑面而来，过往的全球化模式又面临深度调整；从工业化目标看，传统工业化理论研究的基本上都是欠发达国家的追赶过程，并把“以日益增长的本国物质、人力和技术投入不断使制造业活动复杂化和深化”作为工业化成功的衡量标准（Lall，1991），然而，在发达国家竞相“再工业化”的背景下，中国作为发展中国家丝毫不能沉醉于表面的“成功”工业化之中。面向未来的中国工业化新征程，迫切需要工业化新理论的指导。本文拟在分析新技术革命对工业发展模式的影响、阐述传统工业化理论不足的基础上，论述新工业化理论的创新点，探索构建用于判别新工业化水平的指标体系，并提出“十四五”时期中国制造业发展的新方向及支撑措施。

一、新技术革命对工业发展模式的影响

近年来，以新一代信息技术、新材料、新能源、生命科学等领域的科技爆发为主要特点的新一轮科技革命和产业变革正在全球兴起。制造业发展呈现出绿色化、智能化、服务化和定制化的趋势，这四个趋势性变化标志着新工业革命的开始，并从根本上改变着传统工业的生产模式、产业形态和组织方式，同时也包括对传统工业化的反思和修正。

第一，绿色化是新工业化区别于传统工业化的价值观。制造业发展的绿色化是指制造业向能源和资源节约、环境友好和低温室气体排放方向的转变。绿色化的趋势，一方面源于技术创新引发生产方式、商业模式等变革，这不但提高了高耗能、高污染、资源型行业能源转化效率和资源利用效率，而且将促使各个制造业部门、制造业产业链的全流程和全生命周期的每个环节普遍采用更加绿色的生产设备、生产工艺和发展方式。另一方面，世界各国对制造业的原材料、生产工艺、最终产品、环境影响、回收循环等提出更高的环境标准，绿色发展越来越成为共识。绿色化的趋势既会促进节能环保产业成为主导产业，也会使制造业的环境成本有所增加。对于那些缺乏绿色制造技术的企业来说，环境成本的增长可能会抵消已有成本优势（史丹，2018）。

第二，智能化是迈向新工业化阶段的关键变量。新一代信息技术的发展使制造业向数据驱动、实时在线、智能主导的智能化方向发展。在人工智能技术的赋能下，生产设备和产品将具有自感知、自学习、自决策、自执行、自适应的能力。制造业的智能化将会重构制造业的生产方式、价值流程，使制造业提高研发与生产效率、加强市场反应、改善用户服务。智能化还将使制造业结构发生根本性的变化，形成一批以软件和数字传输、集成分析为主的新兴战略性产业，同时一些传统产业因数字赋能而焕发生机。制造业的竞争优势因此向人力资本和知识密集方向转变（李晓华，2019）。例如，食品制造业，印刷业和记录媒介的复制，家具制造业和纺织服装、鞋、帽制造业等这些劳动密集型行业，在高度自动化生产范式下正演变为对劳动力依赖度较低的资本密集型行业。

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human capital and knowledge-intensive applications will become new advantages in manufacturing (Li, 2019). For instance, labor-intensive sectors such as food production, printing, recording media reproduction, furniture manufacturing, textiles, apparel, shoemaking and hat production are evolving into less labor-dependent capital-intensive sectors under the highly automated production paradigm.

Third, services are the main business format of the new industrialization. IT networks allow manufacturers to reach their customers. Manufacturing is becoming less product-centric and more customer-centric, less focused on processing and assembly and more focused on service integration; instead of offering mere products, manufacturers compete in delivering long-term services, and derive value from a combination of products and services; product-based integrated and bespoke services increasingly underpin manufacturing competitiveness (Liu, Li, 2019). In the context of service-based manufacturing, such criteria as the structure of primary, secondary and tertiary industries have become less relevant in determining the stages of industrial development.

Fourth, customization represents a key value proposition for the new industrialization. Unlike traditional industrialization that relies on standardization and mass manufacturing to raise efficiency, the new industrial revolution has enabled low-cost bespoke manufacturing. By offering bespoke products, manufacturers may boost their profit margin by catering to individual customer needs and receiving more orders. After the waves of emulative consumption, the consumer market is becoming more diverse than ever, presenting opportunities for bespoke manufacturing.

2. Traditional Industrialization Theory: Drawbacks and Corrections

In the era of new industrialization, the relevance of the traditional industrialization theory is diminishing. Theoretical innovations lag behind industrial progress in the following ways:

First, traditional criteria cannot help determine the level of the integrated industrial development. Traditional studies on industrial structure assume that the boundary between industries is explicit, and that change in the proportion of industrial sectors is a salient feature of industrial upgrade. With increasing product sophistication, technological revolution propels industrial development not only in terms of progress in individual technologies, but more importantly, in a combination of innovations. New industrial sectors are emerging in the fringes and integrated areas of traditional industries. Industry integration is taking place both between industrial segments, such as between IT and traditional industry, and between primary, secondary and tertiary industries, as manifest in service-based manufacturing and agricultural industrialization. Industrial integration poses challenges to the traditional theory of industrialization, which cannot explain the re-industrialization of developed countries. Criteria for the structure of primary, secondary and tertiary industries cannot serve as benchmarks for analyzing the stage of integrated industrial development.

Second, the traditional theory on industrial division of labor cannot explain the network- and platform-based organization of production. During the Second Industrial Revolution starting in the late 19th century, modern enterprises emerged as the primary organizational form of production with separate ownership and control. New-generation information technologies such as cloud computing, big data, the internet of things (IoT), mobile internet, artificial intelligence and the block chain have slashed transaction costs. Without providing commodities and services, internet platforms bring together public and private resources. The boundary between firms is becoming blurred. With horizontal and technological product and business interconnections, former rivals and firms from different industries have forged new networks of competition and coordination. Enabled by internet platforms and open-source communities, numerous medium-sized, small and micro enterprises (MSMEs) and individuals have taken part in R&D and manufacturing, prompting a shift towards self-organized and decentralized production.

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第三，服务化是新工业化的主要业态。信息网络技术为制造企业在生产分工的基础上向客户端延伸创造了条件。制造业正在由以产品为中心向以客户为中心、由加工组装为主向以产品服务包集成、由一次性交易产品向长期提供服务、由以产品为价值来源向以“产品+服务”的组合为价值来源的方向转变，基于产品的集成化、定制化服务日益成为制造企业竞争力的重要来源（刘尚文、李晓华，2019）。在制造业服务化背景下，三次产业结构等用以衡量工业化阶段演进的指标的有效性大为降低。

第四，定制化是新工业化重要的价值创造。标准化、批量化生产是传统工业化提高效率的主要途径，新工业革命使得企业同时具备低成本、大规模和极端个性化的定制化制造的两个条件。向特定客户精确提供高度定制化的产品使得制造企业能够扩展个性化的市场需求，获得更多订单和提高效益。个性化定制市场是在传统的排浪式消费需求之后制造业扩展市场规模、形成竞争新优势的“金矿”。

二、传统工业化理论的不足与修正

建立在传统工业技术基础之上的工业化理论，对新工业化呈现出的新的发展特征及其演进水平缺乏理论解释，工业化理论创新明显滞后于新工业化发展，主要表现在以下几个方面：

一是传统工业化水平判定标准不能合理地确定产业融合趋势下的工业化水平。传统的产业结构研究有一个前提假设，产业间的界限是清晰的，不同产业部门之间比重关系的变化是产业结构升级的显著特征。随着产品复杂程度的不断提高，科技革命对产业的影响不仅表现在单项技术的突破，更多体现为多项技术的组合创新，在传统产业分类的边缘地带和多个产业交融地带滋生、壮大，并逐渐形成新的产业门类。产业的融合不仅体现在细分产业间（如信息技术产业与传统产业的融合），而且体现在三次产业之间，如制造业的服务化、农业的工业化。产业融合发展的现状对基于清晰的产业边界、根据三次产业结构划分工业化阶段的传统工业化理论形成挑战。传统工业化理论也无法解释发达国家再工业化现象，同时也难以用三次产业结构标准来分析产业融合发展条件下工业化水平和发展阶段。

二是传统工业化分工理论难以解释生产组织网络化与平台化。在19世纪下半叶兴起的第二次工业革命中，所有权与经营权分离的现代企业出现，成为社会生产的最主要组织形态。云计算、大数据、物联网、移动互联网、人工智能、区块链等新一代信息技术大幅度降低了市场交易成本，本身不直接提供商品和服务但聚合社会资源的互联网平台大量涌现，企业的边界日益模糊化，原有的竞争对手或者不同产业的企业因为技术、产品或业务的横向联系形成了新型竞争协同的网络关系。依托互联网平台、开源社区，大量分散化的小微企业、个人参与到产品和服务的研发和生产过程中，社会生产由原来企业进行决策、组织的科层制、中心化转向自组织、扁平化、分布式协同。

三是传统产业布局理论无法解释产业布局虚拟化。传统工业化理论认为，企业在特定地理范围的高度集聚或产业集群能够降低运输成本和交易成本，深化分工、促进创新，成为竞争优势的重要来源。新一代信息技术发展所形成的新型通信手段、互联网平台极大地降低了物流和运输成本、交易成本、信息匹配和选择成本、集聚的拥塞效应，集聚的知识溢出不再依赖于地理邻近性，进而使产业集聚的范围、内容和形式发生重大改

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Third, the traditional theory on industrial layout cannot explain the virtualization of the industrial layout. According to the traditional theory of industrialization, a high concentration of firms or industrial clustering in a specific region may reduce the transportation and transaction costs, induce the division of labor and innovation, and foster competitive advantages. New methods of communication based on new-generation IT and internet platforms have slashed the logistics, transportation, and transaction costs, as well as the congestion effect of agglomeration, while at the same time improving access to information. Knowledge spillover no longer depends on geographical proximity, catalyzing changes in the scope, content and form of industrial clustering; amid the diminishing relevance of geographical clustering, we have seen a rising trend towards integration between new-generation IT and the real economy, i.e. "virtual clustering" (Wang *et al*., 2018). Virtual clustering may influence the pattern of industrial relocation by attracting talent and technology to developed regions, thus depriving less developed regions of the opportunity to participate in the industrial division of labor and develop their industries. It may lead to premature "de-industrialization" in low-income countries and give rise to new development gaps.

Fourth, the traditional theory on production and distribution cannot reflect data contribution. Amid industrial development, labor, capital, land, knowledge, technology and management have become key production factors. With the development of new-generation information technologies led by big data and AI, the real-time collection, mining and efficient use of data may conserve resources, raise efficiency, cut costs, and broaden services. Data has become a key source of value and a vital factor in competitiveness. Having entered the production function as a critical production factor, data also serves as a key source of value creation and generates market-based value and return.

We should revise and breathe new life into the traditional industrialization theory. Only in this way will the theory properly guide the direction of industrial development.

(i) The level of the industrial technology has replaced the ratio of primary, secondary and tertiary industries as the criterion for assessing the stage of industrial development. According to the traditional industrialization theory, a key indicator of mid- and late-stage industrialization is a decrease in industrial value-added as a share of the GDP, which shows an inverted U-shaped curve. At the same time, value-added in services makes up a rising share. Yet the share of services is not a perfect indicator of the level of industrial development. The traditional industrialization theory offers little guidance for countries in mid- and late-stage industrialization. Despite having created a complete industrial system, China ranks globally in the third and fourth tiers in terms of industrial strength, and still has a long way to go before completing industrialization. Hence, we should reference the level of industrial technology, including fundamental, applied and frontier technologies, in determining the stage of industrial development. Compared with industrial structure, it is much more complex to assess the level of the technology, which involves economics, engineering, and fundamental sciences. The stage of industrial development is therefore not merely a concept of economics. Judging by the new trend of industrial development, economic analyses of industrial development stages are subject to a great number of limitations.

(ii) Digitalization, IT network and intelligence have become key features of modern industry. After the Industrial Revolution, Britain experienced the three stages of industrial development - mechanization, electrification, and automation. Driven by new-generation information technology, the new industrial revolution has unleashed great potential for cloud computing, big data, IoT, artificial intelligence, and the block chain. Digitalization, IT network and intelligence represent the trends of the manufacturing transition. In assessing a country's or region's industrial clout, we should focus on its level of digital and smart applications. Modern industry is the cornerstone of a modern economy. The global financial crisis brought the real economy into the spotlight, prompting the developed world to "re-industrialize." By deploying new technology, countries compete for industrial dominance. Some developing countries have seen their economy falter as a result of their failure to move forward after mid- and late-stage industrialization.

(iii) Knowledge-intensive labor is replacing simple labor as essential input in the production

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变，传统的地理空间集聚的重要性下降，基于互联网的新一代信息技术与实体经济深度融合的“虚拟集聚”的影响力不断凸显（王如玉等，2018）。虚拟集聚的出现可能会影响到产业梯度转移规律，人才、技术等高端要素资源将进一步向发达地区聚集，使欠发达地区失去发挥低要素价格优势参与产业分工、推进工业化的机会，有可能在低收入国家出现过早“去工业化”，形成新的发展鸿沟。

四是传统生产理论、分配理论未能体现数据的贡献。在人类工业化进程中，劳动、资本、土地、知识、技术、管理等先后成为重要的生产要素。随着新一代信息技术特别是大数据、人工智能技术的发展，对数据的实时采集、深度挖掘、高效使用能够节约资源、提高效率、降低成本、拓展服务，数据成为价值的重要来源和竞争力的重要决定因素。数据一方面进入生产函数，成为关键生产要素，另一方面作为价值创造的重要来源，也参与到“由市场评价、按贡献决定报酬”的分配之中。

为了适应工业发展新趋势，需要对传统工业化理论进行修正和创新。只有这样，才能对工业化发展方向形成正确的引领：

第一，对工业化水平的判断标准从三次产业比重标准为主回归到工业技术水平本身。按传统工业化理论，工业化进入中后期的重要标准之一是工业增加值在GDP中占比逐步下降，在一个完整的工业化过程中，工业增加值在GDP中的占比呈现倒U形变化。随着工业增加值占比的下降，服务业的增加值占比上升，这一趋势是客观的。但是，服务业占比的高低并不能完全反映工业化水平的高低。另外，对于已进入工业化中后期、完成传统工业化的国家如何发展工业，传统工业化理论并没有给出方向。我国目前已经建成了一个门类比较齐全的工业体系，但是从工业技术水平来看，我国仍处于全球工业化水平的第三、四方阵。中国工业化进程仍然任重道远。因此，判断工业化发展阶段要回归到工业技术本身。技术水平包括基础技术、应用技术和前沿技术。技术水平的判别远比产业结构分析复杂，需要运用经济学、工程技术学和基础科学等方法综合分析。因此，工业化发展阶段不应只是一个经济学的概念，从工业发展新趋势来看，经济学家们借助产业结构的演变分析工业化发展阶段具有很大局限性和片面性。

第二，数字化、网络化、智能化成为判别现代化工业水平的核心技术。英国工业革命以来，随着技术的发展，工业生产先后经历了机械化、电气化、自动化三个阶段，其关键技术分别是机械加工技术、能量转换技术、计算机技术。新一代信息技术是新工业革命最重要的主导技术，云计算、大数据、物联网、人工智能、区块链等新技术在制造业的应用场景被不断挖掘，制造业整体上沿着数字化、网络化和智能化的方向转型升级。因此，判断一个国家和地区工业现代化水平，需要更多地考察其数字化和智能化的程度。数字化、智能化和网络化技术业已成为工业现代化的关键技术。工业现代化是经济现代化的基础。国际金融危机以后，发达国家重新聚焦实体经济，纷纷实施“再工业化”战略，加强运用新技术的前瞻性布局，谋求占领全球产业竞争的战略制高点。反观一些发展中国家，在工业化中后期由于未能坚持发展制造业，推动制造业的转型升级，经济现代化进程严重受阻。

第三，知识密集型复杂劳动逐步取代简单劳动成为生产函数中的劳动要素投入，并且数据成为新的重要生产要素。劳动力是经济系统最基本的投入要素之一，传统的工业化理论中将劳动力要素认定为是无差异的。在新工业革命条件下，机器人、人工智能将会取代重复性的体力和脑力劳动，大量的简单劳动岗位将消

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function, and data has become a new vital factor of production. As a basic factor in an economic system, labor is treated in the traditional industrialization theory as undifferentiated. Amid the new industrial revolution, robots and AI will replace repetitive physical and mental work. As jobs requiring simple skills disappear, knowledge-intensive and creative work will play a bigger role in our economy. Amid the new industrial revolution, talent is in short supply. The quality, rather than the size, of the workforce is a key determinant of industrial development. With omnipresent IT applications, data has become a new factor of production. Access to data and the ability to turn data into a factor of production has become a key aspect of corporate and national competitiveness. Yet data needs to be created, processed, and sent to users to generate value. Unlike the traditional industrialization theory, the new industrialization theory is preoccupied with how to promote data's participation in value creation and distribution.

(iv) Natural resources, the environment, and greenhouse gas emissions have become hard constraints in the production function in addition to the technical constraints in the traditional theory on production function. In the absence of ecological constraints, the traditional theory on economic development has led to excessive development and use of energy resources. Climate change has led people around the world to reflect upon and repudiate the traditional industrialization theory. With the adoption of the United Nations Framework Convention on Climate Change (UNFCCC), countries have come to realize that under their emissions reduction responsibilities and obligations, economic development should no longer serve economic rationality, but is instead subject to the survival rationality of sustainability for humankind. Economic development has allowed humankind to expand their sphere of activity at an unprecedented speed. Yet Nature's retributions in the form of natural disasters and infectious diseases force humankind to pay a price of either economic or population losses. In the era of ecological civilization, industrial development relies on the following three pillars: (1) a shift from fossil fuels to clean and renewable energies with fewer emissions; (2) the recyclability and reusability of industrial goods processed with natural resources; (3) the disruptions of industrial production to the natural environment should be remediable. For instance, vegetation damage from mining activities should be remediated within the shortest time possible. The green and low-carbon energy industry, resource recycling, and the environmental protection industry are important sectors for industrial modernization. The level of development in these sectors is also a key criterion for assessing the level of modern industrial development.

3. Indicators for Evaluating the Level of the New Industrialization

To provide an integrated evaluation of the smart, service-based, green and customized performance of the new industrialization, this section creates a system of indicators for evaluating the level of the new industrialization. Specifically, this system includes 18 secondary indicators under four primary indicators, as shown in Table 1.

Smart manufacturing relies on the extensive application of information and communication technologies (ICT) and AI in manufacturing. Therefore, we select the seven secondary indicators for smart performance - ICT investment as a share of non-housing fixed asset formation, ICT intermediate input as a share of output, ICT intermediate service input as a share of output, ICT as a share of manufacturing intermediate input, robot stock per 100 employees, as well as the number of AI PCT patent applications in the industrial sectors.

The service-based manufacturing level is manifest not only in the efficiency of the manufacturing service, but also in the importance of product-related external services to users. From the aspects of both factors and output, service-based manufacturing can be divided into service-based inputs and outputs, respectively. For China as a major trading nation, value-added in service input for manufacturing output can be seen as an indicator of the service-based manufacturing level. Hence, we identify the three secondary indicators - service factor as a share of manufacturing input, service output as a share of

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失，但知识密集型和创造性工作对经济发展的推动作用将越发突出，适应新工业革命时代的高端人才存在巨大缺口。劳动力的质量而不是简单的人口数量和劳动力规模成为决定工业化水平的关键投入。此外，随着信息技术深入发展和深度应用，数据已经成为生产经营活动必不可少的新生产要素。能否掌握数据资源并将其有效转化为生产要素，已经成为衡量一个企业甚至一个国家竞争力水平高低的重要因素。但数据创造价值的功能并不能直接实现，数据要素也不能直接参与价值分配，而是要经过数据创造、加工并传输给数据要素使用者后，才能创造价值、参与价值分配。由此可见，如何促进数据要素有效参与价值创造和分配，是新工业化理论区别于传统工业化理论的重要内容。

第四，工业文明与生态文明相融合，除了传统生产函数理论的技术约束外，资源与环境、温室气体减排成为生产函数的硬约束。传统经济发展理论认为，缺乏生态约束条件将造成能源资源的过度开发和使用。气候变化引发人们对传统工业化理论的深刻反思和批判，《联合国气候变化框架公约》的出台与各国面临减排责任与义务使得经济发展不再完全是经济理性的，而是要服从于人类可持续发展的生存理性。经济发展使得人类以前所未有的速度扩展人类活动的领域，大自然则以自然灾害、传染性疾病“报复”人类，使人类付出经济损失或人口减少的代价。建立在生态文明下的工业发展，非常重要的三点是：①工业生产的能量由化石能源为主向清洁可再生能源为主转变，污染物排放要尽可能降低；②由自然资源加工而成的工业产品能够回收与再利用；③工业生产对自然界的扰动要可修复，例如，开采地下资源对地表植被的破坏要在最短的时间内修复。绿色低碳能源产业、资源回收利用产业、生态环保产业是工业现代化的重要组成部门，这三个产业的发育程度也是判别现代工业化水平的重要标准。

三、新工业化水平的评价指标体系

为了对新工业化进程的智能化、服务化、绿色化、定制化特征进行综合评价，在遵循科学性、合理性、代表性等原则的基础上，本文构建用于评价新工业化水平的综合指标体系。具体而言，该指标体系包含18项基础指标，各子指标数量分布情况见表1。

从智能化的维度看，信息和通信技术（ICT）、人工智能技术在制造业的广泛应用是制造业实现智能化发展的主要基础。由此，选取ICT投资占非住宅固定资产形成额的比重、软件和数据库投资占非住宅固定资产形成额的比重、ICT中间品投入占产出的比重、ICT中间服务投入占产出的比重、制造业中间投入品中ICT的占比、每百人员工拥有的机器人存量、工业领域人工智能PCT专利申请量7项指标作为衡量智能化水平的二级指标。

就服务化而言，制造业服务化水平不仅体现在内部服务的效率水平，还包含了与产品相关的外部服务对用户的重要程度。因此，从要素使用与产出提供两个方面讲，制造业服务化直观上可分为投入服务化与产出服务化。此外，中国作为贸易大国，基于制造业出口的服务投入增值率可视为反映制造业服务化水平的一个指标。所以，选取服务要素在制造业投入中的比重、服务产出在制造业产出中的比重、基于制造业出口的服务投入增值率3项指标作为衡量服务化水平的二级指标。

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manufacturing output, as well as the ratio of service value-added in manufacturing export.

Regarding green development, we should measure not only indicators such as energy intensity by energy factor input and renewable energy consumption, but also carbon emissions, resource recycling, and green innovations. Thus, we have identified the five secondary indicators for green development - energy consumption per unit of industrial value-added, renewable energy consumption as a share of final energy consumption, CO_2 emissions per unit of industrial value-added, the resource recycling industry as a share of manufacturing output, and green patents as a share of patent authorizations.

Regarding customization, consumption upgrade in the context of the new industrialization - in particular, individual demand that can be processed and digitalized by the manufacturing industry - has induced a transition from mass production to customization in many manufacturing sectors. Apart from rapid production, mass customization also requires firms to stay nimble and responsive to market demand, capture consumer requirements, and shorten the product design and production cycle. We have identified the three secondary indicators of customization - customized orders as a share of total orders,

Table 1: Indicators of the Level of the New Industrialization

Primary indicators	Secondary indicators	Unit of measurement	Attribute
Smart performance	ICT investment as a share of non-housing fixed asset investment	%	Positive indicator
	Software and database investment as a share of non-housing fixed asset investment	%	Positive indicator
	ICT intermediate input as a share of output	%	Negative indicator
	ICT intermediate service input as a share of output	%	Positive indicator
	ICT as a share of manufacturing intermediate input	Pcs./100 persons	Positive indicator
	Stock of robots per 100 employees	%	Positive indicator
	Number of industrial AI PCT patents	Pcs.	Positive indicator
Services	Service factor as a share of manufacturing input	%	Positive indicator
	Service output as a share of manufacturing output	%	Positive indicator
	Ratio of service input value-added in manufacturing export	%	Positive indicator
Green performance	Energy consumption per unit of industrial value-added	tce/10,000 yuan	Negative indicator
	CO_2 emissions per unit of industrial value-added	Ton/10,000 yuan	Negative indicator
	Renewable energy consumption as a share of final energy consumption	%	Positive indicator
	Resource recycling as a share of manufacturing output	%	Positive indicator
	Green patents as a share of all patent authorizations	%	Positive indicator
Customization	Share of customized orders	%	Positive indicator
	Number of mass customization standards	个?	Positive indicator
	Number of customized service platforms	个?	Positive indicator

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关于绿色化发展，不但要从能源要素投入的角度考察能源强度、可再生能源消费量占比等指标，还要考虑碳排放、资源回收利用及绿色技术创新等方面的情况。因此，以单位工业增加值能源消耗量、可再生能源消费占终端能源消费总量的比重、单位工业增加值CO_2排放量、资源回收利用产业在制造业产值中所占比重、绿色专利在专利授权中的比重5个二级指标来衡量绿色化发展水平。

从定制化看，新工业化背景下的消费升级尤其是可被制造业感知和数字化的个性化需求促使许多制造行业的生产模式由规模化向定制化转型。要实现大规模定制，除了要求企业自身的快速生产能力外，也需要企业具备对市场需求快速灵活的反应能力，及时捕捉消费者需求，缩短产品设计和生产周期。因此，选取用户定制订单占总订单的比重、大规模个性化定制标准数量、客户定制服务平台数量3个指标来衡量定制化水平。

表1：评价新工业化水平的指标体系

二级指标	基础指标	单位	属性
智能化	ICT投资占非住宅固定资产形成额的比重	%	正指标
	软件和数据库投资占非住宅固定资产形成额的比重	%	正指标
	ICT中间品投入占产出的比重	%	负指标
	ICT中间服务投入占产出的比重	%	正指标
	制造业中间投入品中ICT的占比	个/百人	正指标
	每百人员工拥有的机器人存量	%	正指标
	工业领域人工智能PCT专利申请量	件	正指标
服务化	服务要素在制造业投入中的比重	%	正指标
	服务产出在制造业产出中的比重	%	正指标
	基于制造业出口的服务投入增值率	%	正指标
绿色化	单位工业增加值能源消耗量	吨标准煤/万元	负指标
	单位工业增加值CO_2排放量	吨/万元	负指标
	可再生能源消费占终端能源消费总量的比重	%	正指标
	资源回收利用产业在制造业产值中所占比重	%	正指标
	绿色专利在专利授权中的比重	%	正指标
定制化	用户定制订单占总订单的比重	%	正指标
	大规模个性化定制标准数量	个	正指标
	客户定制服务平台数量	个	正指标

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the number of mass customized orders, and the number of customized service platforms.

After identifying the 18 secondary indicators, we need to adopt a reasonable method for an integrated evaluation. Currently, there are two common categories of methods for indicator synthesis: (i) subjective evaluation, i.e. indicators are scored based on expert experience; (ii) objective evaluation, i.e. weight is determined according to the attributes of change in variables. Compared with the former, the latter category of methods offers a better reflection of change in indicators based on data attributes, and mainly includes the factor analysis method, principal component analysis (PCA), and the entropy method. Yet all these methods have inadequacies when employed to conduct multi-index inter-temporal comparison. Hence, we adopt the vertical and horizontal scatter-degree method developed by Guo (2002) for an objective evaluation. This method can effectively compensate for the drawbacks of traditional cross-section evaluation methods, and is specifically realized as follows:

Before evaluation, we need to non-dimensionalize various indicators to remove any significant errors due to the difference of indicator dimensions. We make $p_{ij}(t_k)$ denote indicator j of evaluation subject i at time t_k; $\max_j$ and $\min_j$ respectively denote the minimum and maximum values of indicator j. We employ the range method to treat the positive and negative indicators as follows:

$$p_{ij}^{'}(t_k)=\begin{cases}(p_{ij}(t_k)-\min_j)/(\max_j-\min_j), & p_{ij}(t_k) \text{ is a positive indicator}\\ (\max_j-\min_j)/(\max_j-p_{ij}(t_k)), & p_{ij}(t_k) \text{ is a negative indicator}\end{cases} \tag{1}$$

Suppose that m indicators that contain n subjects of evaluation are to be systematically evaluated, and the time sequence is T. Then, the integrated linear evaluation function based on the vertical and horizontal scatter-degree method can be expressed as:

$$q_i(t_k)=\sum_{j=1}^{m}s_j p_{ij}(t_k) \quad (i=1,2,...,n;\ j=1,2,...,m;k=1,2,...,T) \tag{2}$$

Where, $q_i(t_k)$ is the value of evaluation unit i during period t_k, and S_j is the weight of the indicators. The principle for determining weight S_j is to reflect the differences of the indicators as much as possible, so as to maximize the sum of the squares of deviations $\sigma^2=\sum_{k=1}^{T}\sum_{i=1}^{n}(p_i(t_k)-\overline{p})^2$ of the integrated assessment value $q_i(t_k)$.

According to Guo (2002), original data can be standardized as $\overline{p}=\frac{1}{T}\sum_{k=1}^{T}\left[\frac{1}{n}\sum_{i=1}^{n}\sum_{j=1}^{m}s_j p_{ij}(t_k)\right]=0$.

Hence, $\sigma^2=\sum_{k=1}^{T}\sum_{i=1}^{n}p_i(t_k)^2=\sum_{k=1}^{T}S^T H_k S=S^T\sum_{k=1}^{T}H_k S$. Where, $S^T=[s_1,s_2,...,s_m]^T$ is the weight matrix. $H=\sum_{k=1}^{T}H_k$ denotes the m-order symetrical matrix. Further, H can be expressed as $H=P_k^T P_k$, and P_k is the $n\times m$ order matrix.

$$P_k=\begin{pmatrix}q_{11}(t_k) & \cdots & q_{1m}(t_k)\\ \vdots & \ddots & \vdots\\ q_{n1}(t_k) & \cdots & q_{nm}(t_k)\end{pmatrix},\ k=1,2,...,T \tag{3}$$

Last, we limit the feature vector S of the weight matrix under the condition of obtaining the maximum value of the sum of the squares of deviations: $S\times S^T=s_1^2+s_2^2+\cdots+s_m^2=\|S\|=1$. The feature

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在确定18项基础评价指标后，需要采用合理的方法进行综合评价。目前，常用的指标合成方法主要有两类：一是基于专家经验对各指标进行打分赋权的主观评价法，二是根据变量变动的特征来确定权重的客观评价法。相较于前者，后者能更好地根据数据的自身特征来客观反映指标的变动状况，主要包括因子分析法、主成分分析法、熵值法等。然而，这些方法在进行多指标跨期比较时，均存在不足。为此，采用郭亚军(2002)提出的“纵横向”拉开档次法予以客观评价。该方法能够有效弥补传统截面评价方法在实现跨期比较中的不足，其具体评价过程如下。

在进行评价前需对各指标进行无量纲化处理，以消除由于指标量级不同而造成的较大误差。设$p_{ij}(t_k)$表示位于时间t_k的第i个评价对象的第j个指标，$\max_j$和$\min_j$分别表示第j个指标的最大值和最小值，对正向指标和逆向指标使用极差法分别进行如下处理：

$$p_{ij}^{'}(t_k)=\begin{cases}(p_{ij}(t_k)-\min_j)/(\max_j-\min_j), & p_{ij}(t_k)\text{ is a positive indicator}\\(\max_j-\min_j)/(\max_j-p_{ij}(t_k)), & p_{ij}(t_k)\text{ is a negative indicator}\end{cases} \tag{1}$$

假定对包含n个评价对象的m个评价指标进行系统综合评价，时序设为T。则基于“纵横向”拉开档次法的线性综合评价函数可表示为：

$$q_i(t_k)=\sum_{j=1}^{m}s_j p_{ij}(t_k)\quad (i=1,2,...,n;\ j=1,2,...,m;k=1,2,...,T) \tag{2}$$

其中，$q_i(t_k)$为第i个评价单元在时期t_k的综合评价值，S_j为各指标权重。确定S_j的权重的具体原则是尽可能反映出各评价指标的差异，即使得综合评价值$q_i(t_k)$的离差平方和$\sigma^2=\sum_{k=1}^{T}\sum_{i=1}^{n}(p_i(t_k)-\overline{p})^2$达到最大。

根据郭亚军(2002)，对原始数据标准化后有：$\overline{p}=\frac{1}{T}\sum_{k=1}^{T}\left[\frac{1}{n}\sum_{i=1}^{n}\sum_{j=1}^{m}s_j p_{ij}(t_k)\right]=0$。因而，$\sigma^2=\sum_{k=1}^{T}\sum_{i=1}^{n}p_i(t_k)^2=\sum_{k=1}^{T}S^T H_k S=S^T\sum_{k=1}^{T}H_k S$。其中，$S^T=[s_1,s_2,...,s_m]^T$为权重矩阵。$H=\sum_{k=1}^{T}H_k$表示$m$阶实对称矩阵。进一步地，$H$可表示为$H=P_k^T P_k$，$P_k$为$n\times m$阶矩阵。

$$P_k=\begin{pmatrix}q_{11}(t_k) & \cdots & q_{1m}(t_k)\\ \vdots & \ddots & \vdots\\ q_{n1}(t_k) & \cdots & q_{nm}(t_k)\end{pmatrix},\ k=1,2,...,T \tag{3}$$

最后，以综合评价值总离差和取最大值为条件，将权重矩阵的特征向量S限定为：$S\times S^T=s_1^2+s_2^2+\cdots+s_m^2=\|S\|=1$。由此得到的特征向量$S$即为权重系数。

限于数据的可获取性，本文不对上述指标体系进行综合评价和指数合成，只选取部分二级指标进行国别层面的比较，以期在一定程度上反映当前中国的新工业化水平。具体而言，是用数字经济占GDP比重、中国制造业中间投入品中信息业的占比这两个指标从智能化视角来衡量新工业化水平，用制造业中间投入的服务

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vector *S* thus obtained is the weight coefficient.

Due to limited data availability, this section does not conduct any integrated assessment and indicator synthesis of the above indicator system. Instead, we only select some secondary indicators for country-level comparison to reflect the current level of China's new industrialization in terms of smart performance, i.e. digital economy as a share of the GDP and information as a share of China's manufacturing intermediate input. In addition, we further employ the indicators of energy intensity and renewable energy consumption to measure the level of the new industrialization in terms of green development.

First, China is outranked by the US and Japan in the level of new industrialization in terms of smart performance. Based on the estimation results of China's input-output tables of 2012-2017, Xu and Zhang (2020) find that despite its rapid development in recent years, the digital economy only accounted for 6.46% of China's GDP in 2017, and was about 58% the size of the US digital economy. In particular, China is outperformed by developed countries in terms of the level of information-based and digitalized manufacturing. According to the results calculated with the input-output tables, information only accounted for 0.36% of China's manufacturing intermediate input. This figure was 0.56% for the US in the same year and 0.6% for Japan in 2015. In the 14th Five-Year Plan period, we should step up new infrastructure construction and propel smart manufacturing to narrow this gap.

Second, China's level of new industrialization is significantly below that of the US and Japan from a service-based perspective. As manufacturing becomes increasingly service-based, services as a share of manufacturing intermediate input have become an important criterion for measuring the level of the new industrialization. According to the results calculated with the input-output tables, services accounted for 16.5% of China's manufacturing input in 2017, 0.69 and 2.11 percentage points lower than that of the US and Japan, respectively (see Figure 1).

Third, China outperformed the US, Germany and Japan in some green development indicators, and underperformed in some others. Recent years have seen remarkable progress in China's energy efficiency

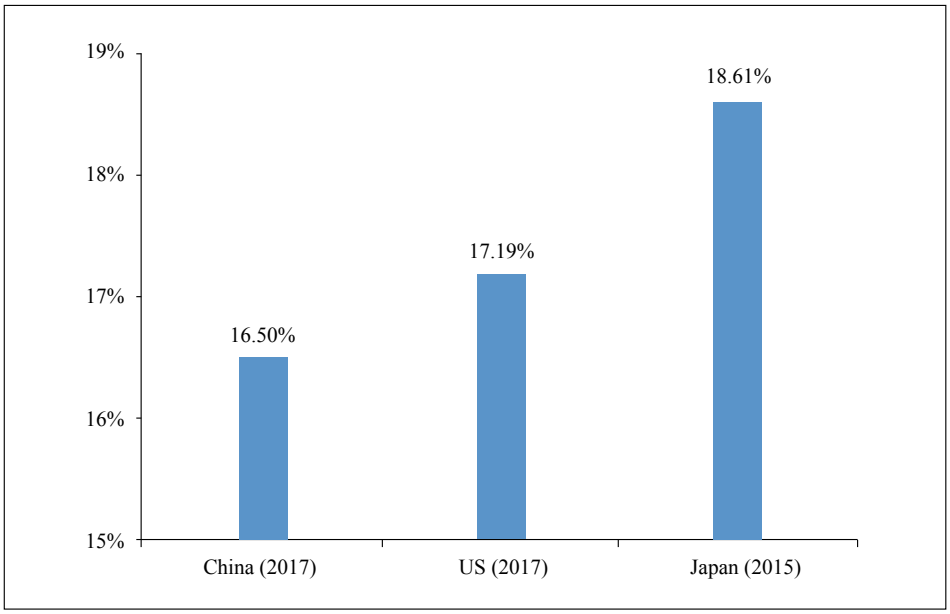

Figure 1: Services as a Share of Manufacturing Intermediate Input in China, the US and Japan

Source: China's 2017 Input-Output Tables from the National Bureau of Statistics (NBS), US 2017 Input-Output Tables from the US Bureau of Economic Analysis (BEA), and Japan's 2015 Input-Output Tables from the Ministry of Internal Affairs and Communications

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占比来衡量服务化趋势下的新工业化水平，并用能源强度、可再生能源消费占比这两个指标从绿色化视角来衡量新工业化水平。

首先，从智能化的角度衡量，中国的新工业化水平低于美国、日本。许宪春和张美慧（2020）利用2012~2017年中国投入产出表的测算结果发现，虽然近年来中国数字经济发展较快，2017年中国数字经济占GDP的比重为6.46%，但与美国仍然存在一定差距，仅为美国数字经济规模的58%左右。特别是，中国的制造业信息化、数字化程度低于发达国家。利用投入产出表数据计算的结果显示，2017年中国制造业中间投入品中信息业的占比仅为0.36%，而同年美国这一指标的值为0.56%，日本在2015年就已达到0.6%。因此，“十四五”时期，要加大新基建的建设力度，更有效推动智能制造。

其次，从服务化的视角衡量，中国的新工业化水平显著低于美国和日本。在服务化发展背景下，制造业中间投入品中服务的占比是衡量新工业化水平的重要标准。以投入产出表为基础计算的结果显示，2017年中国制造业的中间品投入中有16.50%来自服务业，分别低于美国0.69个百分点和日本2.11个百分点（见图1）。

最后，从绿色化的角度衡量，中国的新工业化水平与美国、德国、日本互有高低。近些年来，中国积极推进能源生产和消费革命与生态文明建设，节能减排工作取得了显著成效，绿色发展水平大幅提升。然而，从国别比较的结果看，中国的能源强度仍然显著高于发达国家。根据世界银行数据，2015年，中国能源强度为6.69兆焦耳/按2011年不变美元价格计算的购买力平价GDP，比德国、日本、美国分别高86%、79%、24%（见图2）。另外，在可再生能源消费占终端能源消费总量的比重这个指标上，中国仅稍落后于德国，但大幅领先美国、日本（见图3）。

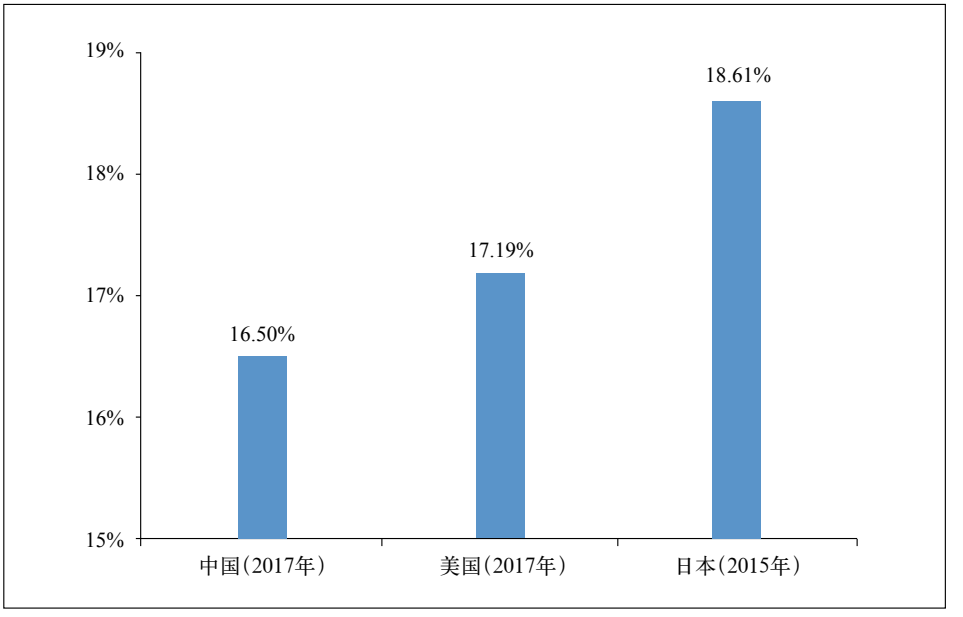

图1：中国、美国和日本制造业中间投入的服务占比

资料来源：中国国家统计局《中国2017年投入产出表》，美国经济分析局《美国2017年投入产出表》，日本总务省《日本2015年投入产出表》。

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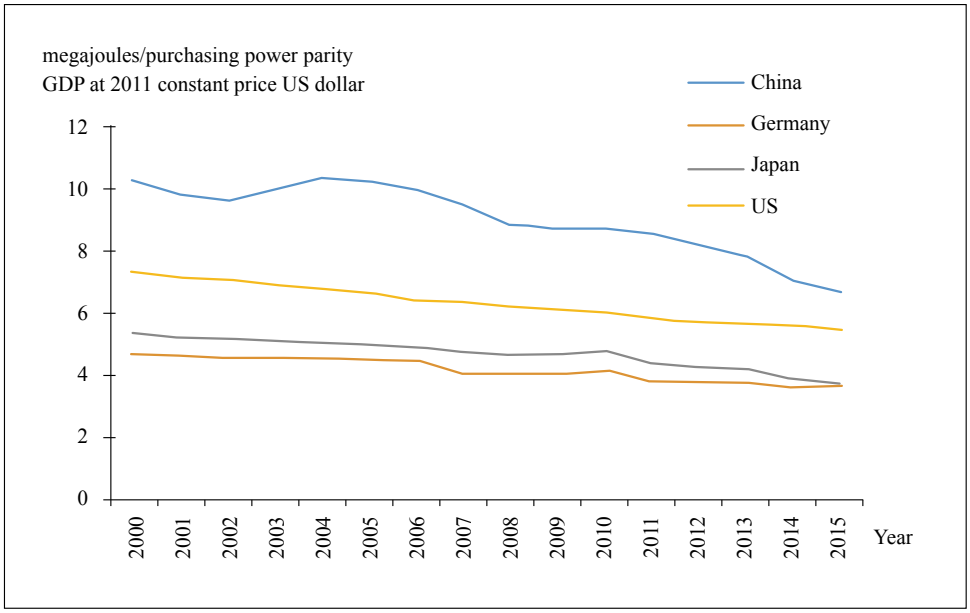

Figure 2: Energy Intensity of China, Germany, Japan and the US

Source: the World Bank World Development Indicators (WDI) Database.

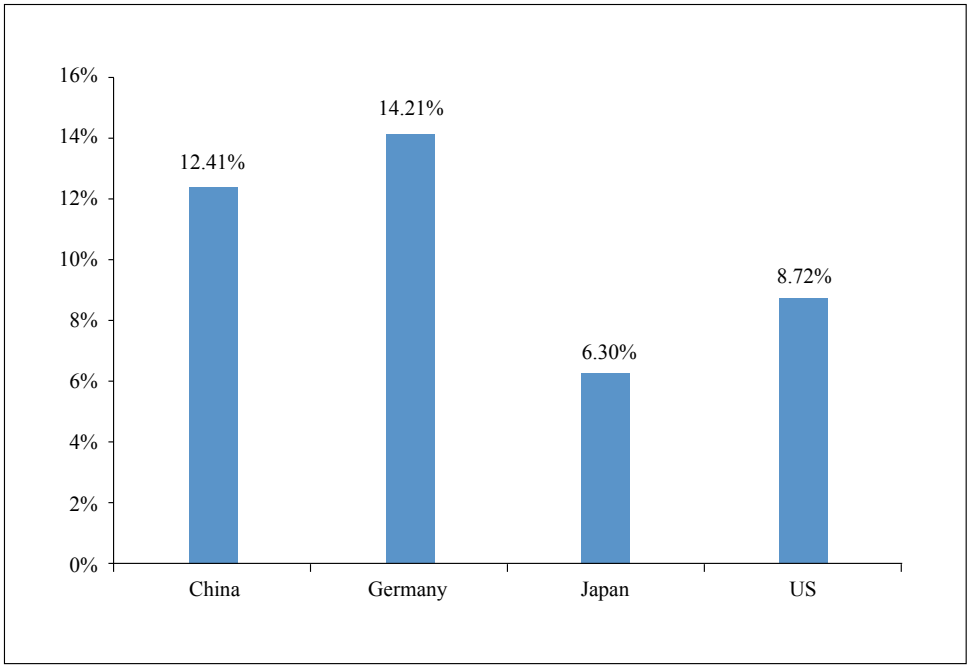

Figure 3: Renewable Energy Consumption as a Share of Final Energy Consumption for China, Germany, Japan and the US

Source: the World Bank World Development Indicators (WDI) Database.

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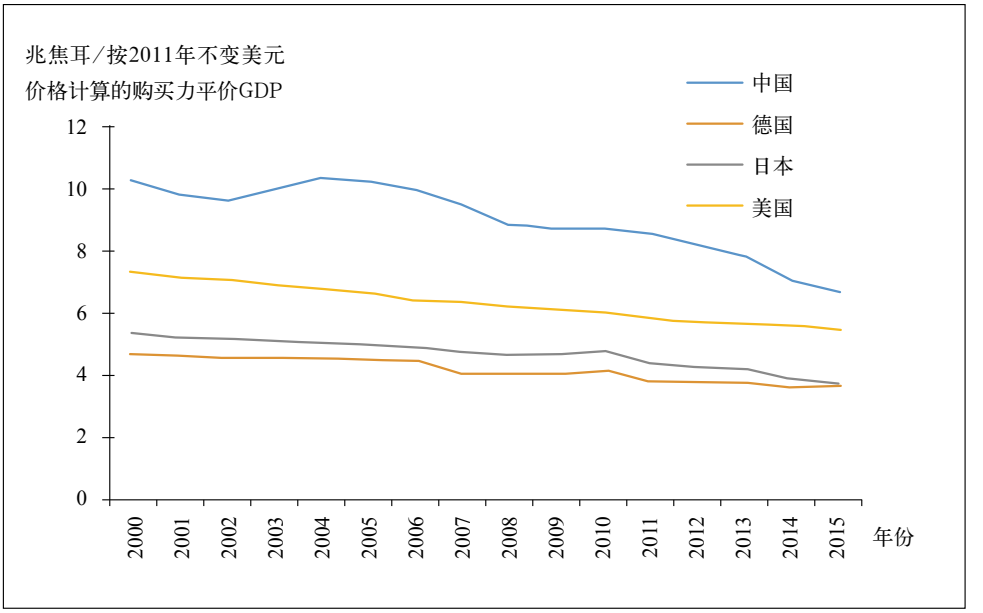

图2:2000~2015年中国、美国、德国、日本能源强度比较

资料来源:世界银行世界发展指标数据库。

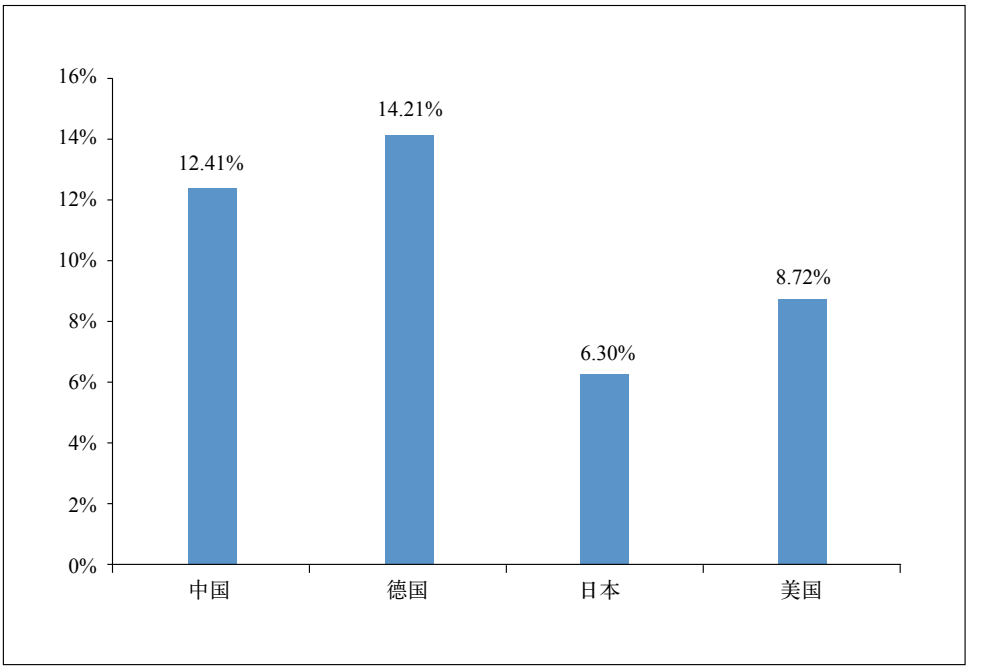

图3:中、美、德、日可再生能源消费占终端能源消费总量的比重比较

资料来源:世界银行世界发展指标数据库。

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and emissions abatement as a result of energy revolution and commitment to ecological civilization. Yet China's energy intensity is still way above that of developed countries. According to the World Bank's data, China's energy intensity was 6.69 megajoules/purchasing power parity GDP at the 2011 constant price of the US dollar, which was 86%, 79% and 24% higher than that of Germany, Japan and the US, respectively (see Figure 2). On the other hand, China's renewable energy consumption as a share of final energy consumption was slightly smaller than Germany's, but way above that of the US and Japan (see Figure 3).

4. China's Manufacturing Path in the 14th Five-Year Plan Period

By the traditional industrialization theory and criteria of industrial development, one may conclude that China has entered mid-and-late stage industrialization. This will mislead people to believe in the inevitability and rationality of manufacturing's declining position, which is clearly a misperception. Without recognizing the important role of manufacturing, a nation may experience a premature sophistication in its industrial structure and disoriented manufacturing development (Shi, Bai, 2019). Unlike previous rounds of industrial development, the new round of technological revolution has ushered in a new chapter of industrial development featuring new energies, factors, production modes, and development concepts. With the new industrial revolution poised to transform the existing industrial layout and competitive strengths, countries in both the developing and developed world have started to map out their industrial strategies. According to the new theory of industrialization, China is at the same starting point as the developed countries in some aspects of new industrialization, but still lags behind with respect to integration, green performance, and digitalization. During the 14th Five-Year Plan period, China's manufacturing industry should strive to develop strengths in high-end manufacturing, focusing on industrial integration, digitalization, intelligence, and green performance.

First, manufacturing growth should be driven by smart innovations. During the 14th Five-Year Plan period, China's manufacturing development must rely on innovations, especially digital and smart innovations, to offset the impact of slowing growth. Structurally, China should improve manufacturing quality in terms of both process and result. Process improvement refers to factor input optimization to minimize adverse environmental and social impacts. The manufacturing industry should consume less primary energy and adopt greener equipment and practices to curb emissions; increase R&D intensity, apply digital and smart features, and innovate. Vocational training and lifelong learning must be enhanced to boost labor productivity. Result quality means higher value-added and technology sophistication in products and services.

Second, we must modernize our industrial system amid industrial transition. By the traditional statistical standard, the manufacturing industry should account for a certain share of China's economy. The real economy should hold its ground in the face of a growing virtual economy. During the 14th Five-Year Plan period, manufacturing should account for over 27% of China's GDP. This percentage includes upgraded traditional industries and emerging industries. In most sectors, China's manufacturing industry has developed homegrown capabilities, but is yet to reach internationally advanced levels of technology, product performance, stability, reliability, and durability. The lack of manufacturing heritage and core technology has held back China's manufacturing sophistication, leaving China at a disadvantage in trade conflicts. Manufacturing prowess requires fundamental capabilities with respect to core components, critical materials, advanced processes, industrial technologies, and industrial software. We should build reputable manufacturing brands, bolster manufacturing weaknesses, and modernize our industrial system.

Third, structural adjustment should focus on industrial integration. The goal of traditional industrial policy and planning is to adjust the proportions of industries, which becomes elusive given the vague

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四、“十四五”时期中国制造业发展的新方向

按照传统工业化理论和工业化水平判别方法，会得出中国工业化水平进入中后期阶段的结论。这会使人认为，制造业发展地位下降具有其必然性和合理性。如果这成为社会共识，会使产业结构加速早熟，同时也会让制造业发展失去方向（史丹、白骏骄，2019）。要深刻认识到，本轮新技术革命使全球进入了全然不同以往的工业化过程，其主要特征是能源基础不同、生产要素不同、生产方式不同、发展理念不同。基于新技术革命的新工业革命将改变已有的工业格局和竞争优势，因此世界各国包括发达国家都在部署本国的工业发展战略。按照新工业化理论，新一轮工业化中，中国与发达国家在某些方面都处于起步阶段，但中国在产业融合、绿色化、数字化方面落后发达国家，因此，“十四五”时期中国制造业应顺应新工业革命的趋势，瞄准以下四个重大方向，在产业融合、数字化、智能化、绿色化等方面加紧抢跑，力争占领新兴制造业的产业链高端。

第一，由规模扩张转向增强智能化创新技术应用。“十四五”期间，制造业的发展要依靠技术创新特别是数字化、智能化技术创新的带动，以发展质量提升弥补发展速度减缓的负面影响。从结构的角度看，制造业实现“高质量”发展的重点包括过程质量提升和结果质量提升。其中，过程质量提升是指制造业的运营过程中减少和优化要素投入，降低对环境社会的不良影响。在资源和能源投入方面，降低一次能源消耗的比重，采用更环保的生产装备和工艺，减少污染物的排放；在资本和技术投入方面，不断提高制造业研发投入强度，重点推进制造业数字化、智能化改造，实现创新驱动制造业的发展；在劳动力投入方面，加强职业培训和终身学习，实现制造业劳动生产率的明显提升和制造业人力资本的明显增加。结果质量提升是制造产品和服务的附加值和科技含量明显提升，先进制造业的比重明显提高。

第二，产业升级指向现代产业体系构建。从整个国民经济的层面看，按照传统的统计口径，作为主要物质产品生产部门的制造业在中国经济由大变强的过程中需要保持与经济发展水平相适应的比重，扭转和抑制“脱实向虚”的趋势。通过传统产业转型升级、新兴产业培育壮大，制造业占GDP的比重在“十四五”期间应保持在27%以上。我国制造业在大多数细分领域都实现了从0到1的突破，但高精尖产品的技术水平、产品性能、稳定性、可靠性和使用寿命等方面整体上与世界领先水平存在性能差距。基础不牢、缺乏核心技术成为制约我国制造业高质量发展的瓶颈，也使我国在国际经贸冲突中处于被动地位。推动制造业高质量发展，需要找准关键“痛点”下功夫，加强在核心基础零部件、关键基础材料、先进基础工艺、产业技术基础以及工业软件等方面的产业基础能力建设，打响中国品牌，补齐我国制造业的短板，构建现代化产业体系。

第三，结构调整重点在产业融合发展。传统的产业政策和规划的目标是调整优化产业间的比重关系，但所谓“高技术产业”“新兴产业”或者“数字经济”本身难以划定边界，目标的制定和实现标准模糊不清。在新工业革命背景下，“十四五”时期的制造业结构调整应当更加注重制造业与其他产业的融合发展，而不是一些特定制造业部门产值比重的提高。一是推进制造业与数字经济深度融合。积极推动数字技术在制造业的应用场景创新、试点，将制造业和互联网产业各自的竞争优势进行融合，大力发展智能制造、工业物联网系统、工业大数据，成为全球领先的“智能+制造”应用国。二是推进制造业与服务业深度融合。将先进制造业和现代服务业作为制造业与服务业深度融合创新实践的触发点，重点支持高端装备制造、电子信息制造、新能源汽车、生

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boundary between high-tech industries, emerging industries, and the digital economy. Amid the new industrial revolution, China's manufacturing industry should strive to integrate with other industries, such as the digital economy, during the 14th Five-Year Plan period, and not just raise the share of specific sectors. We should apply digital and internet-based solutions, industrial IoT systems, and industrial big data to lead the world in smart manufacturing. Moreover, we should integrate services in manufacturing. Priority should be given to embedding software and information services, financial services, and R&D services in equipment, IT, new energy vehicle, and biopharmaceutical manufacturing.

Fourth, we should broaden our horizon from domestic regional planning to the global value chain. In recent years, China's central and western regions have seen their cost advantage, not least labor cost advantage, diminish, and have struggled to attract investment. Despite land grants and tax breaks, the central and western regions have fared poorly in raising fiscal revenues and improving livelihoods. Now it's time for China's manufacturing industry to seek opportunities from global markets. While improving the domestic layout of industrial sectors, we should also enhance the global presence of Chinese manufacturing companies through international capacity cooperation and outbound direct investment with the intention of creating a new framework of international division of labor for win-win or multi-win results in contrast to the exploitation of cheap local labor by developed countries.

5. China's Manufacturing Policy Outlook

First, we should raise public awareness and foster a Chinese "manufacturing culture." Manufacturing underpins a nation's strength and wealth, and lays the groundwork for innovations in science and technology. Manufacturing plays a vital role in people's livelihoods, and is a fountain of cultural creativity. Amid the waves of new technology and industrial revolution, manufacturing transition holds the key to China's ambition to join the ranks of leading nations. During the 14th Five-year Plan period, manufacturing should be given a strategic position in national strategies and industrial policies. In planning for industrial development, local governments should transform traditional manufacturing and foster emerging industries. We should raise public awareness of manufacturing, and attract capital, technology, and human resources to the manufacturing industry.

Second, we should implement an innovation-driven strategy and build a strong manufacturing nation. Specifically, efforts should be made to: enhance fundamental research, innovations, and design capabilities; create national manufacturing innovation centers, focusing on strategic, pioneering, and generic technologies; ramp up research on applied technology and implement key national S&T projects; break ground in critical technologies, and apply R&D results in practical use; and cultivate a squadron of innovative world-class companies. We should continue to strengthen our industry and create long-term mechanisms to overcome key technological limitations.

Third, we should enhance our human capital through educational reform. Our educational system should churn out brighter minds, not only well-versed in theoretical knowledge, but also equipped with hands-on skills. We should prepare our younger generation for an AI-based society, where creativity matters more than rote learning and repetitive work is replaced by machines. We should refocus education from classroom teaching to vocational training. Myriad manufacturing processes require a full spectrum of skills.

Fourth, we should foster a pro-manufacturing environment. We should streamline administration, delegate more powers to lower-level governments and society, and improve regulation and public services. We should minimize transaction costs and the burden of taxes and fees for businesses. We should better protect intellectual property rights, inspire innovation and entrepreneurship, and commercialize innovations. We should ensure a stable energy and land supply, and reform our tax system to cut manufacturing costs. We should break through all sorts of industry and regional barriers, form a

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物医药等先进制造业与软件和信息服务业、金融业、科技研发和科技服务业等现代服务业间的深度融合。

第四，发展空间优化转向全球价值链构建。近些年，中西部地区以劳动力为代表的要素价格与东部发达地区的差距不断缩小，中西部地区招商引资形势日益严峻，巨大的政策“透支”招商使得部分中西部城市在产业发展的同时并没有实现财政收入的增加和民生的改善，还浪费了珍贵的土地和资本资源。中国制造业的发展已经到了必须“走出去”实现全球布局的阶段。“十四五”时期，制造业区域结构调整的重点除了继续优化各个产业部门在国内不同发展水平区域间的布局，更要通过国际产能合作、对外直接投资来加强和优化中国制造企业在全球的布局，逐步构架由中国参与的、区别于发达国家过去仅仅利用当地廉价劳动力资源的、最大程度实现双边或多边共赢的国际制造业分工新框架。

五、支撑中国制造业沿着新方向发展的政策措施

一是提高全社会对制造业的重视程度，打造中国特色“制造文化”。制造业是立国之本、强国之基、富国之源，肩负创造物质财富的历史责任，是科技创新和民生发展的坚实基础，也是创造精神财富的实践源泉。新科技革命和产业革命浪潮中，我国要进一步缩小与世界领先水平的差距，其根本还是制造业的发展和升级。“十四五”期间，国家战略设计、产业政策制定和实施都要赋予制造业重要的战略地位，地方主导产业选择和规划中，要根据自身特点和基础重视传统制造业的转型升级和新兴制造业的培育。通过教育和宣传，不断提高制造业部门对人才市场、资本市场的吸引力，通过统筹协调、部门协同和各级联动，推动政策、资金、技术、人才等要素向制造业汇聚。

二是大力实施创新驱动发展战略，建设“制造强国”。加强基础研究和原创型创新，强化制造业正向设计能力，聚焦电子信息、生物医药、新材料、新能源等具有使能作用的基础技术研发，奠定制造业未来竞争力发展技术基础。继续实施国家制造业创新中心等工程，聚焦战略性、引领性、重大基础共性需求，建成一批高水平制造业创新中心。加强应用基础研究，拓展实施国家重大科技项目，加大关键核心技术攻关和成果转化力度，培育一批创新型领军企业。继续实施工业强基工程，构建体系化、长效化推进机制，突破重点领域发展的基础瓶颈。

三是推进教育改革，转变劳动力成本优势为人力资源竞争优势。教育改革既要为制造业技术进步和产业发展提供足够的人才支持，又要树立制造业在国民经济中起基础作用的思想认识。教育的目标由知识的传授转变为能力的培养，技术进步会逐步替代很多传统岗位，仅仅掌握知识不能应对未来人工智能社会的挑战，创造能力、创新能力、创意能力的培养应该成为教育改革的重要方向。教育的重点环节由课堂教育延伸到职业培训，制造业的智能化、融合化、国际化发展需要大量复合型人才，具体到每一种应用场景，课堂教育都难以提供相应的教学和实践，需要专业化、定制化、细分化的职业教育来满足复合型人才培养的需求。

四是优化制造业发展环境。全面推进依法行政，深化“放管服”改革，强化涉企收费目录清单管理，最大限度降低制度性交易成本和企业税费负担。加强知识产权保护，激发创新创业活力，引导技术创新成果在制造业中的产业化。保障能源、土地要素供给，进一步改革优化税收制度，降低制造业发展成本。打破各种行业壁

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national industrial merchandise market, and increase the affordability and free flow of factors.

Fifth, we should upgrade the manufacturing infrastructure. Priority should be given to the transportation infrastructure for intermediate inputs, hazardous chemicals, air freight, cold chain logistics, as well as the Yangtze River and the Pearl River waterways. We should make transportation more efficient, safer, and less energy-consuming by adopting IT solutions. New infrastructure construction should contribute to 5G and IoT applications in smart manufacturing. We should enhance infrastructure connectivity with Belt and Road countries, and construct cross-border highways, railways, pipelines, and optical fibers.

Sixth, financial services should support manufacturing through more competitive and efficient investment and financing. We should create a nationwide credit rating system in line with international practices to curb financial risks. We should increase the manufacturing industry's access to capital. We should nudge the financial sector to assist manufacturing transition, emerging technology commercialization, and international business development for competitive sectors.

Seventh, we should develop smart manufacturing as our comparative advantage. Following digital technology trends, we should adjust IT manufacturing priorities to develop emerging industrial sectors. We should encourage the manufacturing industry to become more efficient by applying smart industrial equipment and software. We should re-organize manufacturing with smart technology to increase workshop flexibility, synchronize manufacturing, R&D and marketing across the value chain, and foster virtual industry clusters. We should supercharge manufacturing innovations with smart technology, and promote digitalized and service-based manufacturing.

Eighth, we should step up international manufacturing cooperation. We should encourage key industries to go global, improve industrial security review and regulation, and create a stable, fair and transparent business climate. We should nudge foreign firms to invest in high-end manufacturing and create global R&D centers in China. We should deepen international technology and capacity cooperation, and create overseas industrial cooperation parks. We should enhance cooperation with neighboring countries, especially South Asia and Southeast Asia, to bring about a supply chain network.

Ninth, we should promote medium-sized, small and micro enterprises (MSMEs) and the role of the private economy. We should create a close and clean government-business relationship, challenging officials to support private firms to develop the real economy and innovate. We should extend equal policy support to state-owned R&D institutions, improve MSME service platforms, facilitate information connectivity among MSMEs, and assist MSME entrepreneurship, innovation, investment, and financing.

Tenth, we should propel industrial relocation across China's eastern, central and western regions. By granting greater reform autonomy to economic development zones, we should assist central and western regions in attracting all factors of production with a desirable business environment, robust industrial momentum, and complete supply chain. We should promote regional coordination based on comparative advantages. Through free trade zones and bonded areas, the western region should develop trade, especially border trade, and create conditions to attract processing trade to relocate from the eastern region. CE

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垒、地区壁垒，形成工业品全国统一市场，实现要素价格的合理化、促进制造业要素的自由流动。

五是升级制造业基础设施。进一步完善交通基础设施，重点改善制造业中间品运输、危化品运输、货运航空、管道运输、冷链运输、长江珠江黄金水道运输的硬件设施和软件系统，运用信息技术大力提升交通设施的使用效率，提高运输安全，大幅降低物流能耗和成本。通过新型基础设施建设，大力推进5G、物联网在智能制造中的应用。加强与周边国家和“一带一路”国家基础设施的接驳，推进跨境公路、跨境铁路、跨境高速铁路、跨境管道、跨境通信光缆的规划建设。

六是进一步引导金融业服务制造业发展。不断增强金融业自身竞争力，提高金融业运营效率，降低制造业投融资成本，建立与国际接轨的国内统一的信用评判体系，降低金融风险。不断增强制造业自身的融资能力，拓宽制造业融资渠道，提高制造业资本效率。根据制造业发展的总体思路，着重引导金融业服务传统制造业的改造升级、新兴技术的产业化项目和优势制造业部门的国际市场开拓。

七是全方位推进实施“智能+制造”，培育制造业的数字化比较优势。根据智能技术发展趋势，调整电子信息制造业发展重点，加快培育具有未来竞争力的新兴产业部门。根据不同制造业特征、发展阶段和现阶段发展需求，推广智能工业装备、智能工业软件，提高制造业生产效率和资本效率，促进制造业高质量发展。利用智能技术再造制造业生产组织方式，在车间层面，提高生产的柔性化程度；在价值链层面，实现制造与研发、营销的同步；在区域层面，形成虚拟的产业集群。利用智能技术推动制造业业态创新，促进制造业的数字化发展和服务化发展。

八是推动国内外制造业协作，开辟制造业对外开放新格局。坚持“引进来”和“走出去”并重，推进重点产业领域国际化布局。健全产业安全审查机制和政策法规体系，营造稳定公平透明可预期的营商环境。积极引导外资投向高端制造领域，鼓励在我国设立全球研发机构。深化技术和产能国际合作，建设一批境外合作园区。以数字经济发展与“智能+制造”为契机，以工业生产贸易推动与周边国家的合作，带动制造业网络的形成，产业链的对接，重点形成与南亚、东南亚的信息网络和制造业供应链体系。

九是大力发展中小微企业，注重民营经济在制造业中的作用。积极推动构建“亲”“清”新型政商关系，将支持民营企业发展实体经济、开展技术创新等工作情况，纳入干部考核内容。对民营企业内部的新型产业技术研发机构，在承担政府科研项目、人才引进、职称评审、建设用地、投融资等方面，实施与国有科研机构同等的支持政策。完善制造业中小微企业公共服务平台网络，建立中小微企业信息互联互通机制，为制造业中小微企业提供创业创新、投融资等专业化服务。

十是促进制造业产业转移，实现东中西实现高水平对接。以深化“放管服”改革、创新园区管理模式和运行机制、健全完善绩效激励机制为重点，通过赋予中西部地区各级经济开发区更大改革自主权，持续改善中西部地区承接产业转移环境，增强中西部地区的内生产业发展动力，以优良的产业发展环境和强大的产业配套能力，吸引聚集各类生产要素，促进东中西部地区良性互动，逐步形成基于互补性区域优势的产业布局体系。依托西部地区沿边重点口岸城镇区位和资源优势，以试点建设自贸区、综合保税区为抓手，更大力度推进西部地区对外开放，改善西部地区的加工贸易配套条件，促进加工贸易在从东部地区向西部地区转移过程中实现转型升级。

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