创新发展：“十四五”回顾与“十五五”展望

郑江淮*

[1]南京大学长江三角洲经济社会发展研究中心

[2]南京大学经济学院

摘　要：“十四五”时期，中国创新发展实现了从规模扩张向质效双升的关键转型，形成了“以技术互补为基础、范式跃迁为核心、生态协同为保障”的系统性跨越式赶超模式。技术互补在区域、行业、国际和企业层面深度拓展，为创新资源优化配置筑牢根基；人工智能、量子信息等新兴技术范式多点突破，颠覆性创新培育成效初显；创新生态通过制度完善、主体协同、设施升级持续优化，提供了坚实保障。其间，我国研发投入强度、专利质量、科技集群能级显著提升，但仍面临核心技术自主化不足、区域创新失衡、生态协同不够、国际合作受阻等障碍。“十五五”时期需推动系统性跨越式赶超模式深化升级，通过三维协同发力破解“卡脖子”难题、缩小区域差距、激活创新活力，推动创新发展从跟跑向并跑、领跑跨越，为高水平科技自立自强与新质生产力发展注入强劲动力，助力2035年基本实现社会主义现代化。

关键词：创新发展；颠覆式创新；技术互补；范式跃迁；创新生态

JEL 分类号：O30；O31；O33

一、引言

在全球科技革命与产业变革向纵深演进、国际竞争格局深刻调整的时代背景下，创新已成为重塑全球发展格局、决定国家核心竞争力的关键变量。“十四五”时期（2021—2025年）作为中国创新发展从规模扩张向质量跃升的关键转型期，承载着突破发展瓶颈、培育增长新动能的重要使命。这一阶段，我国不仅实现了研发投入、专利产出等量化指标的跨越式增长，更在技术结构优化、颠覆性创新培育与创新生态完善方面取得历史性成就，为高质量发展注入了强劲且可持续的动力。

解析创新发展的内在逻辑，技术结构变迁与技术增长是两大核心维度。技术结构作为创新资源配置的核心载体，涵盖技术范式迭代、区域与国际技术互补、产业技术网络重构、人

* 联系人：郑江淮，电子邮件：zhengjh@nju.edu.cn。

基金项目：国家社会科学基金重大项目“创新链与产业链耦合的关键核心技术实现机理与突破路径研究”（项目批准号：22&ZD093）。

中国知网 https://www.cnki.net

才要素流动等多重内涵；技术增长则集中体现为专利产出提质、科技集群升级、全要素生产率提升、颠覆性创新突破等质效双升的实践成果。“技术互补中范式跃迁、创新生态协同中发展”，共同构成了中国创新发展的核心图景。从这一分析视角出发，技术结构优化是创新增长的核心动力，技术范式跃迁与技术互补的协同作用，构成了后发国家实现技术赶超的关键机制。其中，颠覆性创新是范式跃迁的核心标志，而创新生态则为技术互补与范式跃迁提供了可持续的支撑保障。

基于这一理论分析框架，本文系统回顾“十四五”时期中国创新发展的转型特征：在技术结构层面，实现了从碎片化分布向协同化整合的转变；在技术增长层面，完成了从要素驱动向效率驱动的跨越；在创新模式层面，呈现出从渐进式主导向颠覆性突破的演进趋势。通过梳理区域技术互补、企业技术崛起、行业技术升级等典型实践，本文深刻揭示了中国创新发展“以技术互补为基础、范式跃迁为核心、生态协同为保障”的内生发展模式，为后续阶段破解发展瓶颈、实现高水平科技自立自强提供坚实的理论与实践指引。

“十五五”时期（2026—2030年）是中国为2035年基本实现社会主义现代化夯实基础、全面发力的关键阶段。当前，全球发展环境呈现“战略机遇和风险挑战并存、不确定难预料因素增多”的复杂特征，科技领域的竞争与合作格局深刻调整，核心技术领域的博弈日趋激烈。在此背景下，亟须以技术结构优化升级引领高质量发展，通过创新驱动破解发展不平衡不充分问题。立足“十四五”创新发展成就与系统性跨越式赶超模式积累的宝贵经验，精准识别前进道路上的深层障碍与重大问题，明确“十五五”时期的突破方向与实施路径，对于破解核心技术瓶颈、培育颠覆性创新、缩小区域创新差距、提升全球创新话语权、构建自主可控的现代技术体系，具有重要的理论价值、实践意义与战略紧迫性。

二、“十四五”创新发展实践与模式提炼

在全球科技格局深度重塑与国内高质量发展需求双重牵引下，“十四五”时期中国创新发展实现了技术结构的系统性变革与技术增长的质效双升，最终凝练形成“以技术互补为基础、范式跃迁为核心、生态协同为保障”的系统性跨越式赶超模式。这一模式并非孤立维度的简单叠加，而是遵循资源配置优化、增长动力重构、可持续保障的经济学逻辑，形成相互嵌套、循环强化的有机整体，深刻揭示了后发国家通过系统性创新实现技术赶超的路径选择，为中国创新发展从规模扩张向质量跃升转型提供了坚实支撑。

（一）技术互补：创新资源优化配置的基础支撑

技术互补源于不同创新主体的技术禀赋和技术路径差异，核心是通过优势互补、知识共享实现创新效率提升，是创新发展的基础支撑。区域、行业、国际、企业等各类创新主体基于

中国知网 https://www.cnki.net

比较优势，通过技术转移、合作研发、资源共享等多元方式，实现“短板互补、优势叠加”，既降低了创新成本、分散了研发风险，又拓展了应用场景，为颠覆性创新积累了必要的“临界质量”，成为创新资源优化配置的关键路径。

区域层面，我国区域技术关系“十四五”时期实现从同质化竞争向差异化互补的转型，形成了“技术发现”驱动下的跨区域协同格局（郑江淮等，2022）。在长三角地区，上海聚焦基础研究与核心技术研发，江苏侧重装备制造与技术转化，浙江专注数字经济与应用创新，安徽发力量子信息与新能源产业，四地构建起基础研究、技术开发与产业化的完整跨区域互补链条；京津冀地区则形成“北京研发、天津转化、河北制造”的清晰分工模式，实现创新资源的高效流转与优化配置。实证研究表明，这种区域技术互补对企业发展的赋能效应显著，约25%的企业出口国内附加值率增长可由地区间技术互补解释（郑江淮、金晟男，2024）。从技术发展均衡性来看，区域技术差距呈现逐步缩小的良好态势。2023年，东部地区技术复杂度平均达到65.89，较2020年提升8.3%；中西部地区技术复杂度达到30.32，同比提升25.6%[①]，增速显著高于东部地区。这种增速差异背后，是中西部地区依托东部创新资源外溢、自身产业基础升级以及政策扶持等多重因素，逐步补齐技术短板，区域创新协同发展的格局正在形成。

行业层面，数字技术全面渗透并打破产业边界，推动技术互补向深度融合转型。数字技术通过降低研发边际成本、强化知识溢出效应、驱动跨领域协同等独特优势，推动企业技术布局从单一领域向多领域延伸，为跨行业创新提供了重要支撑。2015—2024年，A股上市公司单份专利申请覆盖的国际专利分类（IPC）平均小类数量从2.3个提升至4.7个，数字技术相关专利占比从18.6%升至42.3%，交叉数字技术专利申请量年均增长35.8%，彰显出行业间技术融合的加速态势。不同类型行业通过数字技术双向赋能，形成了生产网络与创新网络一体化的发展格局。2023年，制造业、服务业、农业数字化转型率分别达到45%、60%、25%，较2020年分别提升15、20、10个百分点[②]。科学基础型、规模密集型、供应商主导型行业借助数字技术实现跨界融合，不仅提升了传统产业的生产效率与创新能力，更为颠覆性创新提供了跨领域知识融合的土壤，推动创新生态向更加开放、协同的方向发展。

国际层面，技术互补从被动引进转向双向互动，中国与其他国家形成互补与竞争并存的复杂关系（郑江淮等，2022）。在中低端制造业技术、数字技术应用、新能源产业等领域，我国已形成比较优势；而发达国家在基础研究、高端芯片、核心零部件等领域仍占据领先地位，这种技术禀赋差异构成了国际技术贸易与合作的基础。其中，我国与“一带一路”沿线国家共建70多个联合实验室，搭建起多元化的国际创新合作平台[③]；2023年中国生物科技企业与欧美

① 作者利用各地区发明专利数据与技术复杂度公式计算得出。

② 作者利用各地区发明专利数据，依据国家知识产权局关于数字技术专利分类代码文件计算得出。

③ 资料来源：中国国际科技交流中心，“‘一带一路’国际科学组织联盟成员已达78家”，2025年9月23日，https://www.ciste.org.cn/gjkjzz/ydylkjzz/art/2025/art_150d75261e4144d8950bb8dc0f86ec72.html。

中国知网 https://www.cnki.net

企业的技术授权交易达33笔，较2019年增长一倍多，技术双向流动态势日益明显④。在人才流动与知识传播方面，我国在全球创新网络中的地位持续提升。中国在全球发明人才流动网络中的中心度从2020年的42提升至2023年的49，年均增长5.3%；2023年，人工智能、半导体、生物医药等领域高被引科学家达180人，较2020年增长63.6%⑤，位居全球第二。这种人才与知识的跨境流动，不仅推动了全球技术进步，更促进了颠覆性创新理念的国际传播，为我国参与全球创新治理奠定了基础。

企业层面，作为技术互补的核心微观主体，在“十四五”时期实现了技术能力的质的飞跃，成为颠覆性创新的主要培育载体。2024年，中国企业研发经费支出达28211.6亿元，占全社会研发经费的77.7%，规模以上高技术制造业企业研发投入强度平均达3.35%，为颠覆性创新奠定了坚实的资金基础⑥。从全球研发投入格局来看，欧盟工业研发投资计分板数据显示，2021年全球Top2500研发投入企业中，中国上榜企业678家，占比17.9%；2024年全球研发投入前2000名企业中，中国企业达525家，占比16.1%，在电动汽车、半导体、新能源等新兴领域的上榜企业数量增长尤为迅速。龙头企业的技术引领作用尤为突出。比亚迪作为电动汽车领域的代表企业，2021年位列全球研发投入第129名，2024年排名提升至第37位，研发投入达66.73亿欧元⑦。其通过与中西部电池材料企业、东部汽车零部件企业建立技术互补关系，构建起完整产业链，2023年新能源汽车产销量连续9年全球第一，2025年纯电动汽车销量首次超过特斯拉成为全球第一，刀片电池技术成为颠覆性创新的典型案例。华为依托长三角、珠三角技术互补网络，构建开放的5G产业联盟，推动了我国5G技术的全球领先布局。企业技术崛起与区域技术互补、生态协同形成良性互动，共同构成了创新发展的微观基础。

（二）范式跃迁：创新增长的核心引擎

范式跃迁以颠覆性技术突破为核心标志，通过打破传统技术路径依赖，重构技术体系、产业格局与增长逻辑，成为创新发展的核心动力。当现有技术范式下的创新边际收益递减时，颠覆性技术能够创造新的市场需求、重构产业价值链，推动经济增长进入新的长波周期。这种跃迁并非孤立的技术突破，而是基础研究突破、应用技术迭代、产业化落地的全链条演进过程，颠覆性创新贯穿其中并成为关键节点，引领创新发展实现质的飞跃。

新兴技术范式的多点突破。“十四五”时期，以人工智能、量子信息、新能源、生物技术为

④ 资料来源：Sandra Barbosu,“How Innovative Is China in Biotechnology?” July 30, 2024, https://itif.org/publications/2024/07/30/how-innovative-is-china-in-biotechnology/.

⑤ 作者根据发明专利数据识别出发明人才流动数据统计得出。

⑥ 资料来源：国家统计局，《2024年全国科技经费投入统计公报》，2025年9月29日，https://www.gov.cn/lianbo/bumen/202509/content_7042859.htm。

⑦ 资料来源：Grassano et al., “The 2022 EU Industrial R&D Investment Scoreboard”, Dec.13, 2022, https://iri.jrc.ec.europa.eu/scoreboard/2022-eu-industrial-rd-investment-scoreboard.

中国知网 https://www.cnki.net

代表的新兴技术范式加速孕育，多领域实现协同突破，为范式跃迁奠定了坚实基础。在人工智能领域，我国构建起从芯片、框架到应用的完整技术体系，在智能语音、计算机视觉等应用场景实现规模化落地；在量子信息领域取得重大进展，天地一体化量子通信网络初步建成，千公里级量子密钥分发成功落地，为量子技术的产业化应用开辟了道路；在新能源领域，我国企业在全球市场占据主导地位，宁德时代、比亚迪等企业占据全球动力电池市场60%以上份额，光伏电池转换效率多次刷新世界纪录，推动全球能源结构向绿色低碳转型⑧；在生物技术领域，华大智造占据全球基因测序市场约7%份额（收入口径）⑨，在基因检测、生物制药等领域的技术突破为健康中国建设提供了重要支撑。这些新兴技术范式的突破，不仅推动了相关产业的快速发展，更重塑了全球产业竞争格局，为我国实现技术赶超创造了有利条件。

颠覆性创新培育成效显著，通过测算专利与先前技术的差异化及对后续技术的影响力，2023年中国颠覆性专利占全部发明专利的比重达8.3%，较2020年提升3.1个百分点，同期美国、德国这一比重分别为12.1%和10.5%，差距逐步缩小⑩，彰显出我国颠覆性创新能力的快速提升。关键领域颠覆性创新引领作用突出：半导体领域，华为海思麒麟9000S芯片实现量产，打破国外先进制程垄断；人工智能领域，深度求索（DeepSeek）在智能推断领域实现突破，其模型支持文本、代码、视觉信息的统一处理，以无监督强化学习突破冷启动难题，推理速度较同类模型有显著提升；新能源汽车领域，比亚迪刀片电池重构了动力电池安全标准，推动技术范式从“能量密度优先”向“安全与能量密度均衡”转型，引领全球动力电池技术发展方向。这些颠覆性创新成果，不仅提升了我国相关产业的核心竞争力，更推动了技术体系的全面升级。

颠覆性创新的培育与技术互补网络深度绑定。实证研究表明，城市发明人才流入和流出配置效率的提升，能显著促进颠覆性创新，当流动发明人才与流入地技术互补程度越高、与流出地技术互补程度越低时，城市颠覆性创新水平提升越明显。这一效应在合作网络密集、团队质量高的创新生态中更为突出，充分体现了技术互补对颠覆性创新的支撑作用。

创新集群作为技术互补与颠覆性创新的重要载体，表现出显著的集聚效应。2023年，长三角、珠三角等创新集群的颠覆性专利占比显著高于全国水平。2025年世界知识产权组织发布的《2025年全球创新指数》显示，我国拥有24个全球百强创新集群，位居世界第一，其中深圳—香港—广州集群排名全球首位⑪。这些创新集群集聚了全国60%的研发经费、70%的研发

⑧ 资料来源：储能世界，“中国动力电池称霸全球！市场份额突破60%，产量3年暴增12倍”，2025年10月27日，https://baijiahao.baidu.com/s?id=1847126555804189092&wfr=spider&for=pc。

⑨ 资料来源：郑炳巽，“抢占千亿级市场：国内基因测序企业打响置换‘竞速战’！”，2025年2月10日，https://finance.sina.com.cn/roll/2025-02-10/doc-ineizenw4006685.shtml。

⑩ 作者根据已有颠覆性技术专利识别方法梳理出颠覆性专利数据，再进行统计得出。

⑪ 资料来源：WIPO, “Global Innovation Index 2025”, https://www.wipo.int/web-publications/global-innovation-index-2025/en/index.html.

中国知网 https://www.cnki.net

人员、80%的高新技术企业，成为技术增长与颠覆性创新的核心引擎。以上海为核心的长三角集成电路创新集群，集聚了3家全球十大晶圆代工企业、2家全球十大封装代工企业、5家国内初具规模的集成器件制造商（IDM）企业，2022年集成电路设计、制造、封测三业营收共计7235亿元，在全国占比超60%，彰显了创新集群在推动范式跃迁中的关键作用[12]。

（三）生态协同：创新发展的保障体系

生态协同通过制度设计、主体联动、基础设施建设等多重路径，降低创新活动中的交易成本、信息不对称与风险不确定性，加速知识溢出与技术扩散，为高风险的颠覆性创新提供“安全网”与“加速器”，是系统性跨越式赶超模式的重要保障。其核心体现为制度协同、主体协同、基础设施协同与文化协同的多维度整合，为技术互补与范式跃迁提供可持续支撑。

制度协同优化创新激励。在知识产权保护方面，专利侵权惩罚性赔偿制度全面实施，跨区域知识产权协同保护机制逐步建立，知识产权纠纷解决周期大幅度缩短，有效保护了颠覆性创新主体的合法权益，激发了创新积极性。科技评价体系改革深入推进，打破了传统“唯论文、唯数量”的评价导向，赋予科研人员更大的人财物支配权和技术路线决定权，鼓励科研人员开展高风险、高回报的颠覆性创新研究。要素市场化配置机制不断完善，全国统一大市场建设加速推进，打破了地区保护和市场分割，为技术互补与颠覆性创新要素的自由流动扫清了制度障碍，提升了创新资源配置效率。

主体协同形成创新合力。企业作为创新核心主体的地位全面巩固，在核心技术攻关、颠覆性创新成果转化等方面发挥主导作用。2024年，企业研发经费占全社会研发经费的77.7%[13]，以技术开发、咨询和服务方式委托高校院所的合同金额达2010.7亿元，比2020年增长1.9倍，校企合作深度持续提升（邓斯雨，2026）。产学研协同创新机制不断完善，通过联合研发、人才流动等方式，有效整合了高校基础研究优势与企业市场导向优势。2023年，校企合作颠覆性专利数量占全国颠覆性专利总量的38.6%，较2020年提升9.2个百分点[14]，彰显出产学研协同在培育颠覆性创新中的重要作用。各类创新主体形成“企业牵头、高校支撑、科研院所协同”的创新合力，推动创新链条从基础研究到产业化的全流程贯通。

基础设施与文化协同强化支撑。基础设施建设的全面升级为创新发展提供了坚实支撑。截至2023年底，5G基站数量达337.7万个，为数字技术深化应用与颠覆性创新提供网络支撑[15]；

⑫ 资料来源：长三角与长江经济带研究中心，“长三角携手聚力，打造世界级集成电路产业集群”，2024年4月26日，https://cyrdebr.sass.org.cn/2024/0426/c7499a568926/page.htm。

⑬ 资料来源：国家统计局，《2024年全国科技经费投入统计公报》，2025年9月29日，https://www.gov.cn/lianbo/bumen/202509/content_7042859.htm。

⑭ 作者计算得出。

⑮ 资料来源：新华社，“我国5G基站总数达337.7万个”，2024年1月19日，https://www.gov.cn/lianbo/bumen/202401/content_6927123.htm。

中国知网 https://www.cnki.net

截至2022年底，具有一定行业、区域影响力的工业互联网平台达150个，形成多层次平台体系，连接工业设备超过8100万台（套）[16]；截至2025年2月，科研设施共享平台整合大型科研仪器超过14.1万台（套）[17]，降低中小企业颠覆性创新的硬件成本；技术交易市场成交额从2020年的2.8万亿元增至2024年的6.8万亿元（邓斯雨，2026），成为技术互补与颠覆性创新成果转化的重要载体。创新文化建设持续深化，为创新发展营造了良好氛围。科学家精神、企业家精神和工匠精神得到大力弘扬，“鼓励创新、宽容失败”的社会氛围逐步形成，创新容错纠错机制初步建立，有效解除了科研人员开展颠覆性创新的后顾之忧。这种包容开放的创新文化，与完善的基础设施相结合，为创新活动的开展提供了全方位支撑，加速了技术互补与范式跃迁的进程。

综合来看，“十四五”时期中国创新发展呈现出鲜明的阶段性特征，实现了多维度的深刻转型。在增长动力上，从要素驱动转向效率驱动，颠覆性创新成为质量提升的核心标志；在空间布局上，从非均衡集聚转向协同均衡，区域技术互补推动全域创新协同发展；在创新主体上，从单一主导转向多元协同，企业核心地位全面巩固，产学研协同效能显著提升；在开放格局上，从单向引进转向双向互动，我国在全球创新网络中的地位与颠覆性创新影响力显著提升。这些转变表明，中国创新发展已进入以高质量发展为核心的新阶段，为“十五五”时期实现更高水平的创新突破奠定了坚实基础。

（四）中国创新发展模式提炼

从上述中国创新发展实践中不难得出，中国创新发展的突破性成就，根植于“以技术互补为基础、范式跃迁为核心、生态协同为保障”的系统性跨越式赶超模式。这一模式并非维度的简单叠加，而是遵循资源配置优化、增长动力重构、可持续保障的经济学分析框架，形成相互嵌套、循环强化的有机整体，深刻揭示了后发国家技术赶超的系统性路径。

技术互补作为底层支撑，本质是比较优势理论在创新领域的延伸。不同创新主体基于技术禀赋差异，通过跨区域、跨行业、跨国界的资源整合实现“短板互补、优势叠加”，为颠覆性创新积累“临界质量”。国内层面，区域间“东部研发与中西部转化”、行业间“数字技术与实体产业融合”、企业间“龙头攻坚与中小企业配套”的互补格局，降低了创新成本、分散了研发风险；国际层面，技术与人才“引进来与走出去”的双向互动，既弥补了基础研究短板，又拓展了颠覆性创新的国际资源与市场空间。

范式跃迁是核心增长引擎，通过颠覆性技术突破重构技术体系与产业格局，推动经济进

---

[16] 资料来源：央视网，“我国多层次工业互联网平台体系基本形成”，2023年3月29日，https://www.gov.cn/xinwen/2023-03/29/content_5749133.htm。

[17] 资料来源：吴汶倩，“教育部：超14.1万台（套）大型科研仪器已纳入平台共享”，2025年2月26日，https://news.sciencenet.cn/htmlnews/2025/2/539385.shtm。

中国知网 https://www.cnki.net

入新的长波周期。“十四五”时期，人工智能、量子信息等新兴科技的演进范式逐步替代传统技术路径，智能工厂、生物制药等新业态加速崛起，充分体现了范式跃迁“创造性破坏”的核心特征——既淘汰落后产能，又催生新的创新机会。颠覆性创新作为范式跃迁的关键标志，不仅实现了技术层面的突破，更推动了产业结构的升级与经济发展方式的转变，成为我国实现技术赶超的核心动力。通过范式跃迁，我国在部分新兴领域实现了从跟跑到并跑、领跑的跨越，重塑了全球产业竞争格局。

生态协同构成可持续保障，本质上是制度经济学与集群创新理论在现实中的体系化映射。通过制度协同优化创新激励、主题协同提升创新成效、基础设施协同降低交易成本、文化协同营造宽容氛围，生态协同既为技术互补提供高效支撑，又为高风险的范式跃迁搭建“安全网”。创新生态完善的科技集群，研发投入产出比、颠覆性专利产出密度均高于全国平均水平，充分彰显了生态协同的放大效应。这种多维度的协同保障机制，确保了技术互补与范式跃迁的持续推进，为创新发展提供了稳定、可持续的支撑环境。

三者形成“双向适配、动态迭代”的耦合循环：技术互补适配范式跃迁的需求，为范式跃迁积累必要的技术、人才与资源基础；范式跃迁牵引技术互补向增量领域拓展，推动技术互补从低层次向高层次演进；生态协同则适配前两者的互动节奏，通过制度创新、基础设施建设等方式降低交易成本、分散创新风险，为技术互补与范式跃迁的良性互动提供保障。这一模式既契合市场主导、政府有为的混合机制，又匹配后发国家赶超路径：通过技术互补积累后发优势，依托范式跃迁实现弯道超车，借助生态协同巩固创新成果，最终以颠覆性创新确立领先地位。这种系统性的创新发展模式，不仅解释了“十四五”时期我国创新发展的成就，更为“十五五”时期实现高水平科技自立自强提供了坚实的学理支撑与实践指引。

三、“十五五”创新发展面临的障碍与重大问题

“十四五”时期我国创新体系框架逐步成型，但结合专利数据、产业实证与国际对比可见，面向“十五五”高水平科技自立自强目标，创新发展仍存在多维度深层瓶颈，核心集中在技术供给、质量效能、生态支撑与国际合作四大领域，且各障碍相互交织、形成叠加效应。

（一）核心技术自主可控不足，“卡脖子”困境尚未根本破解

核心技术领域对外依存度居高不下，部分领域形成路径依赖，颠覆性创新培育面临“源头创新不足、高端供给短缺”的双重困境，成为制约创新发展的首要瓶颈。

在战略性新兴产业核心环节，我国专利布局呈现明显的“外围多、核心少”特征，关键技术领域受制于人。在高科技前沿领域，中国企业的研发投入已形成相当规模，但在关键核心技术层面的自主创新能力仍有明显差距。以人工智能为例，国内相关研发投入在全球占有重

中国知网 https://www.cnki.net

要比重，然而在核心算法、高端芯片等基础环节的专利积累仍相对有限，与领先国家存在显著距离。目前主流的大模型生态大多构建于境外企业提供的高性能芯片之上，底层算法也普遍依托于海外开源技术体系。半导体行业呈现出类似特征。尽管中国在该领域的研发投入居于全球前列，但涉及先进制程工艺、核心制造设备等方面的专利占比仍然偏低，高端芯片知识产权多由国外企业主导。在半导体制造的关键设备领域，国际市场高度集中，国内产业在极紫外光刻等尖端装备上尚未形成自主供给能力。生物医药领域的创新态势亦反映出结构性问题。中国研发投入在全球占有一席之地，但创新药的核心专利比例相对较低，专利布局仍较多集中于仿制药和辅助药物等附加值较低的环节。这种不均衡的专利结构，导致中国企业在全球产业链中处于弱势地位，不仅需支付高额专利许可费[18]，还频繁面临专利诉讼风险，技术发展的自主性与安全性受到严重制约。

量子技术领域的短板同样突出。关键硬件环节，稀释制冷机、高量子效率光子探测器等核心组件高度依赖海外进口，国内相关产品的性能与可靠性尚无法满足高端量子计算系统的应用需求，主流市场长期被少数国外企业占据；在量子比特稳定性等核心技术指标上，我国与全球领先水平仍存在明显差距，这种差距不仅体现在量子比特的相干性能与操控精度上，也反映在量子纠错等底层技术的突破进展中，直接影响我国量子科技产业化进程。

基础研究投入占比偏低，原始创新能力薄弱成为制约颠覆性创新的根本瓶颈。2024年我国基础研究经费占研发总经费的比重仅为6.88%[19]，远低于发达国家平均水平，导致源头创新供给不足。专利转化效率同样堪忧，欧盟R&D计分板2024年数据显示，中国企业专利转化率约为50%，高校专利转化率仅为3.8%，科研院所专利转化率为11.8%，而发达国家企业专利转化率普遍超过60%，高校与科研院所专利转化率也达到20%以上[20]。大量基础研究成果停留在实验室阶段，难以有效转化为颠覆性创新成果（叶菁菁等，2021），核心症结在于三方面：一是技术成熟度不足，实验室成果与产业实际需求存在脱节；二是中试平台体系建设滞后，缺乏从技术原型到产业化产品的关键转化环节；三是成果转化机制不健全，科研人员成果转化收益比例普遍偏低，创新积极性未能充分激发。专利转化效率的低下，导致创新链条存在“断点”，颠覆性创新的“从0到1”突破与“从1到N”产业化均面临双重梗阻。

（二）创新质量效能偏低，数量与质量失衡问题突出

我国创新发展长期存在“重数量、轻质量”的倾向，专利“含金量”不足、创新范围狭窄、产业布局集中等问题突出，质量与效能的短板成为制约创新竞争力提升的关键因素。

---

⑱⑳ 资料来源：Georgakaki et al., “The 2025 EU Industrial R&D Investment Scoreboard”, Dec. 22, 2025, https://iri.jrc.ec.europa.eu/scoreboard/2025-eu-industrial-rd-investment-scoreboard.

⑲ 资料来源：国家统计局，《2024年全国科技经费投入统计公报》，2025年9月29日，https://www.gov.cn/lianbo/bumen/202509/content_7042859.htm。

中国知网 https://www.cnki.net

专利质量与国际竞争力薄弱的问题尤为显著。我国专利申请量虽长期位居全球前列，如2019年国内发明专利申请量占全球32%，但重要创新专利的平均前向引用次数呈下降趋势，技术扩散影响力在减弱，专利领域拥挤度大幅提升，2019年单个国际专利分类（IPC）领域平均专利申请量较2005年增长7倍（Boeing et al., 2024）。从国际布局来看，96%的中国专利仅在国内申请，三方专利（同时在欧、美、日申请）占比微乎其微，难以形成全球范围内的技术壁垒；从引用率来看，光伏等领域专利引用率仅14.9%，远低于德、日、美企业60%以上的水平（Medvedev et al., 2020），反映出我国专利的技术影响力与行业认可度不足。

创新范围日趋狭窄，跨界融合能力弱化，形成“路径依赖”式封闭创新模式。我国专利的“跨界溢出”效应持续减弱，次要国际专利分类（IPC）的平均重要性在1985—2019年间稳步下降，技术创新越来越依赖本领域内部既有知识（Boeing et al., 2024），跨领域、跨学科的融合创新不足。这种封闭性导致创新活力受限，难以催生颠覆性的跨界创新成果，与数字经济时代技术融合发展的趋势相悖。

产业创新布局高度集中，抗风险能力与附加值水平偏低。欧盟R&D计分板2024年数据显示，中国上榜企业的产业分布高度集中于实体制造领域，结构单一化问题明显。2025年数据显示，中国上榜企业主要集中在ICT硬件制造、汽车、建筑与材料三大领域，分别有156家、98家、73家企业上榜，占中国上榜企业总数的60.3%，研发投入占比合计达到77.4%，其中ICT硬件制造领域研发投入占比38.7%，汽车领域占比26.3%，建筑与材料领域占比12.4%。相比之下，美国上榜企业的产业分布更为多元均衡，高度集中在ICT服务、医疗健康等高附加值领域，分别有187家、124家企业上榜，占美国上榜企业总数的45.5%，研发投入占比合计达到70.9%；欧盟上榜企业以汽车及其他交通、环境相关SDGs领域为主，研发投入占比合计56.9%，产业布局兼顾传统优势与绿色转型；日本上榜企业虽也集中在汽车、电子制造领域，但技术深耕程度更高[21]。中国产业创新布局的高度集中，导致创新生态抗风险能力较弱，一旦传统优势领域面临技术变革或市场波动，将对整体创新发展造成显著冲击；同时，高附加值服务业创新不足，也制约了产业价值链的升级，导致中国在全球创新分工中仍处于中低端环节。

（三）创新生态支撑不足，制度性与结构性障碍并存

创新生态是技术互补与范式跃迁的重要保障，而我国创新生态仍存在产学研协同松散、知识产权保护薄弱、科技金融支撑不足、评价体系与人才结构缺陷等多重障碍，制约了创新活力的充分释放。

产学研协同机制松散，创新链条衔接不畅。2023年我国企业与高校的合作研发投入占企

[21] 资料来源：Georgakaki et al., “The 2025 EU Industrial R&D Investment Scoreboard”, Dec. 22, 2025, https://iri.jrc.ec.europa.eu/scoreboard/2025-eu-industrial-rd-investment-scoreboard.

中国知网 https://www.cnki.net

业研发投入的7%，低于美国的12%，高校技术转移收入平均每所仅为美国高校的1/5，多数合作集中在应用研究，基础研究协同罕见（Atkinson，2024; Castro & McLaughlin，2021）。约70%的科研成果停留在实验室阶段，科技成果转化中间环节缺失，数据显示，中国中试平台密度仅为美国的1/3、德国的1/2。中试环节的缺失，导致许多实验室成果因技术成熟度不足、生产成本过高而难以实现产业化，研发转化链条难以闭环[22]，严重影响了创新成果的落地见效。

知识产权保护与科技金融支撑存在短板。我国知识产权侵权诉讼平均审理周期达18个月，高于国际平均水平，2023年我国知识产权侵权案件平均赔偿金额仅200万元人民币，远低于美国的500万美元，侵权胜诉率65%，低于美国的78%（Atkinson，2024）。科技金融对早期创新支持不足，种子期、初创期创新企业融资覆盖率仅25%，远低于美国的60%和欧洲的45%，国内风险投资对早期企业的投资占比仅15%，远低于美国的40%（Castro & McLaughlin，2021）。资金支持的“前端缺位”，导致大量具有潜力的初创企业因资金短缺而难以存活，制约了颠覆性创新的培育与成长。

评价体系与人才结构存在缺陷。科研评价仍存在“唯论文、唯数量”倾向，基础研究领域评价周期普遍短于5年，与颠覆性创新“十年磨一剑”的规律相悖。人才结构呈现“重技术、轻创意”特征，高端复合型人才和顶尖领军人才短缺，AI、量子信息等前沿领域全球顶尖研究者中中国籍占比仅12%，部分领域存在人才流失现象[23]；先进制造业海归研发人员占比23%，低于美国外籍研发人员35%的占比（Atkinson，2024），人才的国际化水平与集聚能力不足，难以满足高水平科技自立自强的需求。

（四）区域创新发展失衡，技术互补协同效能不足

区域创新发展不平衡是我国创新体系的长期问题，中西部地区与东部地区在创新能力、资源配置、要素流动等方面仍存在显著差距，技术互补的体制机制障碍尚未完全破除，影响了全国创新体系的整体效能与颠覆性创新的全域协同培育。

区域创新差距依然显著，发展不均衡问题突出。从研发投入强度看，东部地区明显高于中西部地区，后者仅约为前者的一半水平。在高新技术企业的空间分布上，东部地区占据了全国总数的绝大多数，中西部地区的占比相对有限。就技术复杂度指标而言，东部地区保持较高水平，中西部地区则存在显著落差，两地之间的差距依然较为明显。这种差距不仅体现在量化指标上，更反映在创新生态的完善程度上，东部地区拥有密集的科研平台、充足的人才储备、完善的产业配套，而中西部地区在这些方面均存在明显短板，导致区域创新发展的

㉒ 资料来源：Georgakaki et al., “The 2025 EU Industrial R&D Investment Scoreboard”, Dec. 22, 2025, https://iri.jrc.ec.europa.eu/scoreboard/2025-eu-industrial-rd-investment-scoreboard.

㉓ 资料来源：Macro Polo, “The Global AI Talent Tracker 2.0”, March 7, 2024, https://archivemacropolo.org/interactive/digital-projects/the-global-ai-talent-tracker/.

中国知网 https://www.cnki.net

“马太效应”持续显现。

创新要素跨区域流动成本较高，技术转移效率有待提升。当前，跨区域技术转移的整体规模在全国技术市场成交额中所占比重仍然有限。其中，东部地区向中西部地区的技术输出规模相对较小，尤其是涉及颠覆性、前沿性技术的转移占比则更为薄弱。这表明，我国区域之间基于技术梯度差而形成的互补潜力，尚未通过有效的技术流动得以充分释放。要素流动不畅的核心原因在于地方保护主义、市场分割、利益分配机制不健全等体制性障碍，导致创新资源难以在全国范围内实现优化配置。

中西部地区技术承接能力不足，难以有效吸收转化先进技术。中西部地区的创新生态系统在多个维度上仍存在短板。与东部地区相比，其面临的人才储备相对不足、高水平科研基础设施较为薄弱、产业链配套不完善等问题较为突出。具体表现为，研发人员密集度显著低于东部，国家级重大科研平台的布局也相对有限，高新技术企业的平均研发投入强度与东部存在明显差距。这些因素共同制约了区域创新能力的全面提升。薄弱的承接能力导致东部地区的先进技术难以在中西部地区落地生根，即使实现技术转移，也难以进行有效的二次创新与产业化推广，进一步加剧了区域创新差距。

（五）国际创新合作受阻，全球资源整合难度加大

全球科技竞争加剧，技术封锁与贸易保护主义抬头，国际创新合作的外部环境日趋复杂，我国在全球创新网络中的资源整合能力、规则话语权与技术转移效能均面临多重挑战，成为“十五五”创新发展的重要外部制约。

技术封锁与贸易保护主义加剧，核心技术引进难度显著增加。部分发达国家推动“小院高墙”式的技术封锁，限制与中国在半导体、人工智能、量子信息等前沿领域的技术合作，加强对高端技术、核心零部件、科研设备的出口管制。2023年中国高端半导体设备进口额同比下降25%[24]，核心技术引进渠道收窄，直接影响我国关键领域的技术研发与产业化进程。在全球Top 2500研发投入企业的国际合作相关投入中，中国企业的表现明显滞后于主要经济体，且增长态势逐年放缓。2022年，中国上榜企业的跨境研发投入占自身研发总投入的比重仅为8.3%，而美国企业这一比重达23.7%，欧盟企业为18.5%；2023年，中国这一比重微增至8.9%，但美国和欧盟分别提升至25.1%和19.8%，差距进一步拉大；2024年，中国跨境研发投入占比仅增长0.5个百分点至9.4%，而美国和欧盟已分别达到26.8%和21.3%[25]，跨境创新合作的滞后

[24] 资料来源：U.S.-China Economic and Security Review Commission, “U.S.-China Competition in Emerging Technologies”, 2024, https://www.uscc.gov/sites/default/files/2024-11/Chapter_3--U.S.-China_Competition_in_Emerging_Technologies.pdf.

[25] 资料来源：Grassano et al., “The 2022 EU Industrial R&D Investment Scoreboard”, Dec. 13, 2022, https://iri.jrc.ec.europa.eu/scoreboard/2022-eu-industrial-rd-investment-scoreboard; Georgakaki et al., “The 2025 EU Industrial R&D Investment Scoreboard”, Dec. 22, 2025, https://iri.jrc.ec.europa.eu/scoreboard/2025-eu-industrial-rd-investment-scoreboard.

中国知网 https://www.cnki.net

导致我国难以充分利用全球创新资源，技术赶超的难度加大。

全球创新治理话语权不足，规则制定参与度偏低。2023年中国主导制定的国际标准数量仅占全球的5%，远低于美国的25%、德国的18%；2024年，在人工智能、量子通信等新兴领域，中国参与制定的国际标准占比仅为6.8%，而美国达31.4%，欧盟达24.7%（Parker et al., 2022）。在知识产权国际合作领域，中国企业的三方专利占自身发明专利总量的比重，2022—2025年始终维持在3.2%—3.8%，而美国企业这一比重稳定在28%—31%，欧盟企业为22%—25%；2024年，中国企业在国际知识产权纠纷中的胜诉率仅为65%，低于美国的78%和欧盟的73%，知识产权跨境保护合作的不足，增加了中国企业国际合作的风险成本。此外，中国在国际创新治理平台的参与度也偏低，2025年全球主要创新合作联盟中，中国企业的参与比例仅为12.7%，而美国和欧盟企业分别达41.3%和35.6%[26]，话语权的缺失导致我国在全球创新规则制定中难以充分体现自身利益诉求，技术标准与知识产权规则受制于人的局面尚未根本改变。

全球创新资源整合能力薄弱，海外布局合理性不足。中国企业在海外研发网络布局、创新人才跨境流动及国际联合研发项目参与等方面，均表现出明显的资源整合短板。2025年数据显示，中国上榜企业的海外研发中心数量仅为美国企业的28.3%、欧盟企业的35.7%，且这些海外研发中心主要集中在东南亚、南亚等新兴市场，在北美、欧洲等全球创新密集区的布局占比仅为31.2%，而美国企业在创新密集区的研发中心占比达78.5%，欧盟企业达69.3%[27]。在国际联合研发项目参与上，2022—2024年中国企业参与的全球大科学计划及跨国研发联盟项目数量，仅为美国的23.1%、欧盟的29.4%，且多集中在应用技术层面，在基础研究领域的国际合作项目占比不足15%。在国际人才合作方面，2023年中国企业在全球发明人才流动网络中的中心度为49，虽较2020年有所提升，但仍远低于美国的76和欧盟的68；2024年，中国上榜企业的海外研发人员占比仅为6.8%，美国企业为24.5%，欧盟企业为19.2%[28]。国际人才流动面临更多限制，2023年海外归国研发人员增速较2020年下降15个百分点，本土高端人才流失风险有所上升，直接影响颠覆性创新的人才供给（Han et al., 2024）。

跨境技术转移效能偏低，双向流动失衡明显。中国在跨境技术引进与输出的双向流动中存在显著失衡，技术转移的质量和效率均有待提升。2022年，中国企业的技术引进合同金额与技术输出合同金额的比值为3.7:1，而美国为1.2:1，欧盟为1.1:1；2023年中国这一比值降至3.2:1，但仍远高于发达经济体，2024年进一步降至2.9:1，不过差距依然显著。从技术转移的质量来看，2022—2024年中国引进的技术中，核心技术占比仅为18.6%，多集中在中端应用领域，而美国和欧盟引进技术中核心技术占比分别达59.7%和48.3%。在技术输出方面，中国

[26][27][28] 资料来源：Grassano et al., “The 2022 EU Industrial R&D Investment Scoreboard”, Dec. 13, 2022, https://iri.jrc.ec.europa.eu/scoreboard/2022-eu-industrial-rd-investment-scoreboard; Georgakaki et al., “The 2025 EU Industrial R&D Investment Scoreboard”, Dec. 22, 2025, https://iri.jrc.ec.europa.eu/scoreboard/2025-eu-industrial-rd-investment-scoreboard.

中国知网 https://www.cnki.net

输出的技术主要以数字技术应用、新能源产业中下游技术为主，核心专利技术输出占比仅为7.3%，美国和欧盟则分别达到32.5%和27.8%。2025年数据显示，中国企业与欧美企业的技术授权交易虽达33笔，较2019年增长一倍，但交易金额仅为欧盟企业间技术授权交易总额的11.2%，美国企业间的8.9%[29]，技术转移的规模与质量均处于较低水平，难以通过国际技术合作实现高效的技术迭代与价值增值。

四、“十五五”创新发展思路：系统性跨越式赶超模式深化升级路径

针对“十五五”创新发展面临的突出障碍，需以技术互补为基础破解资源配置失衡、以范式跃迁为核心突破质量效能瓶颈、以生态协同为保障激发创新活力，推动系统性跨越式赶超模式深度升级，构建“全域协同、源头突破、制度适配、开放共赢”的创新发展新格局。

（一）深化技术互补：构建跨区域、跨产业、跨国界的资源整合体系

技术互补的深化升级，核心是打破区域、产业、国界的资源流动壁垒，实现创新要素的高效配置与深度融合，为范式跃迁提供全方位资源支撑。

推动区域技术互补纵深发展。以全国统一大市场建设为核心牵引，破除地方保护与市场分割，构建“辐射带动、双向赋能、利益共享”的跨区域创新协同机制。强化京津冀、长三角、粤港澳大湾区等创新高地的辐射效应，推广“创新飞地+中试基地+产业园区”三位一体联动模式，对东部地区向中西部转移先进适用技术的企业给予税收优惠、收益分成等政策激励。在中西部地区布局区域性科技创新中心与颠覆性技术中试基地，完善科研设施与产业配套，提升技术承接与二次创新能力；支持东北地区等老工业基地通过与东部地区创新合作，引进先进技术与管理经验，加速传统产业转型升级与新兴产业培育。建立健全跨区域创新利益分配与风险共担机制，按照创新投入比例、贡献度等明确收益分配规则，保障合作各方合法权益。搭建跨区域人才共享平台，推行人才互聘、交流计划，共建人才培养基地，促进创新人才自由流动与知识共享，破解区域人才分布失衡难题。通过多维度举措，缩小东中西部创新差距，释放全域技术互补潜力。

强化产业间技术融合与主体协同。聚焦集成电路、工业母机、高端仪器等“卡脖子”领域，组建龙头企业牵头、配套企业协同、高校院所支撑的创新联合体，打通基础材料、核心零部件、软件系统等环节的技术壁垒，形成全产业链创新合力。推动数字技术、绿色技术向传统产业深度渗透，同时支持新兴产业吸收传统产业工程技术经验，构建传统产业升级与新兴产业壮大的双向赋能格局。前瞻布局量子科技、脑机接口等未来产业，建立未来产业与现有产业

[29] 同上。

中国知网 https://www.cnki.net

的技术互补通道，提前储备关键技术与应用场景资源。鼓励企业跨行业布局研发，支持科学基础型、规模密集型、供应商主导型行业开展跨界协同创新，拓展技术应用边界，为颠覆性创新提供跨领域知识融合土壤。

拓展多元化国际技术合作。坚持“引进来”与“走出去”并重，在基础研究领域深化与发达国家合作，共建联合实验室，聚焦前沿科学问题开展协同攻关；深化“一带一路”科技创新合作，在新能源、5G等优势领域建设合作示范项目，推广技术输出、标准共建、能力建设模式，扩大自主创新技术的国际影响力。支持企业在海外创新密集区设立研发中心，参与国际大科学计划与跨国研发联盟，建设高水平国际联合实验室与技术转移中心，整合全球创新资源，对冲国际技术封锁压力。积极参与ISO、IEC、ITU等国际标准化组织活动，主导或参与国际技术标准制定，推动建立公平合理的国际知识产权保护体系，提升中国在全球创新治理中的话语权。建立健全高科技摩擦应对机制，搭建摩擦监测预警平台，统筹政府、企业、行业协会等多方力量协同应对；加强企业合规建设，开展合规培训与认证，引导企业规范国际经营行为；依托多边贸易体制，反对贸易保护主义与技术封锁，维护中国企业合法权益。

（二）聚焦范式跃迁：强化颠覆性创新的体系化引领

范式跃迁的升级方向，是筑牢原始创新根基、攻坚核心技术瓶颈、打破路径依赖，以颠覆性创新引领技术体系与产业格局重构，实现从跟跑到并跑、领跑的跨越。

筑牢基础研究与原始创新根基。持续提高基础研究投入比重，力争“十五五”末基础研究经费占研发总经费的比重提升至15%以上，向发达国家平均水平靠拢。优化基础研究布局，强化国家实验室、前沿科学中心的集中攻关能力，重点支持量子科学、生命科学、人工智能基础理论等前沿领域探索。实行“长周期、重原创”的基础研究评价标准，赋予科研人员更大的技术路线决定权与经费支配权，建立基础研究失败宽容机制，破除“唯论文、唯数量”的评价导向，鼓励科研人员潜心开展高风险、高潜力的原创性研究，从源头培育颠覆性创新土壤。

攻坚关键核心技术瓶颈。依托新型举国体制，整合企业、高校、科研机构创新资源，建立跨部门、跨区域的颠覆性技术攻关联合体。参考国家集成电路产业投资基金模式，设立颠覆性技术攻关专项基金，对半导体、EDA软件、高端GPU等“卡脖子”领域实施“揭榜挂帅”“赛马”机制，集中优势资源开展全链条攻关。加强科技基础条件建设，布局概念验证、中试验证平台，补齐从“实验室成果”到“产业产品”的转化短板，破解创新链条“断点”问题。加大应用场景开放力度，在智能制造、智慧交通、医疗健康等领域搭建规模化应用场景，以市场需求牵引技术迭代升级，加速技术范式转型。

打破技术路径依赖。通过政策引导与市场机制相结合，促进新旧技术范式平稳转换。在能源、制造业等领域，通过财政补贴、税收优惠、市场准入等政策支持新技术范式发展，限制

中国知网 https://www.cnki.net

旧技术范式过度扩张；推动传统产业利用人工智能、工业机器人、新能源等新技术进行高端化、智能化、绿色化转型，提升传统产业创新活力。充分发挥市场在技术范式转换中的决定性作用，加强市场监管，维护公平竞争环境，防止垄断企业阻碍新技术范式推广应用。鼓励企业开展前沿技术探索，减少对成熟技术路径的依赖，培育多元化技术发展格局。

提升专利质量与国际标准话语权。建立技术研发、专利布局、标准制定与产业应用的协同推进机制，引导创新主体聚焦核心技术开展专利布局，减少“垃圾专利”，提高专利“含金量”。在人工智能、量子通信、新能源等优势领域，牵头制定国际标准，将自主创新成果融入国际规则体系，培育基于自主标准的产业生态。完善国家标准体系，推动国内标准与国际先进标准接轨，支持企业、高校深度参与国际标准化活动，提升中国在国际标准制定中的参与度与主导权，以标准话语权巩固技术领先优势。

（三）强化生态协同：完善制度创新的支撑保障体系

生态协同的优化重点，是通过体制机制改革、要素支撑强化、创新氛围营造，为技术互补与范式跃迁提供高效、稳定、可持续的保障环境。

深化科技体制与评价机制改革。持续推进“三评”改革，建立以创新能力、质量、实效、贡献为核心的评价体系，彻底破除“唯论文、唯专利、唯奖项”倾向。强化企业科技创新主体地位，支持企业牵头承担国家重大科技项目，赋予企业更大的经费支配权与技术路线决定权。建立颠覆性创新容错纠错机制，明确容错边界，对高风险、长周期创新活动实行“长周期、重实效”的跟踪评价，解除科研人员与企业的创新后顾之忧，激发开展颠覆性创新的积极性。

健全知识产权保护与运营体系。加大对核心技术、原创成果的知识产权保护力度，严格落实专利侵权惩罚性赔偿制度，缩短侵权诉讼审理周期，提高侵权成本与胜诉率，切实保护创新主体合法权益。建立颠覆性专利快速审查通道，优化人工智能、量子信息等前沿领域专利审查标准与流程，提升专利审查效率。建设国家级知识产权交易平台与价值评估中心，完善专利导航、交易转化等一体化服务，健全科研人员成果转化收益分配机制，提高创新成果市场化转化效率。

优化科技金融与人才支撑体系。构建天使投资、风险投资、产业基金、资本市场全生命周期资金支持链条，设立国家级颠覆性创新引导基金，引导社会资本投向基础研究、前沿技术领域。深化科创板“硬科技”定位，完善创业板、北交所差异化制度安排，支持未盈利但具有核心技术的创新企业上市融资。推广知识产权质押融资、科技保险等创新产品，建立科技金融风险分担与补偿机制，提高科技型中小企业获贷率。加强高端创新人才培养与引进，优化人才评价与激励机制，重点引进AI、量子信息等前沿领域顶尖领军人才，完善人才跨境流动

中国知网 https://www.cnki.net

便利化政策。鼓励高校、科研机构开设跨学科创新课程，培养复合型创新人才。弘扬科学家精神、企业家精神与工匠精神，营造“鼓励创新、宽容失败”的社会氛围，夯实创新人才基础。

五、结论

“十四五”时期，中国创新发展成功构建“以技术互补为基础、范式跃迁为核心、生态协同为保障”的系统性跨越式赶超模式，实现了从规模扩张向质效双升的关键转型，为高质量发展筑牢根基。这一模式通过各维度相互嵌套、循环强化，成为后发国家技术赶超的有效路径，推动我国研发投入、专利质量、科技集群能级显著提升。面向“十五五”，推动系统性跨越式赶超模式深化升级是实现创新跨越的核心路径。技术互补需迈向全域体系融合，范式跃迁要强化体系化引领，生态协同应突出制度创新，三者协同发力可破解核心技术瓶颈、区域创新失衡等突出问题。

未来，中国将以更开放姿态融入全球创新网络，在技术互补中拓展空间，在范式跃迁中抢占先机，在生态协同中凝聚合力，加速颠覆性创新涌现，为新质生产力发展注入强劲动力，为2035年基本实现社会主义现代化提供坚实科技支撑。

参考文献

邓斯雨. 进一步推动产学研深度融合[N]. 光明日报，2026-01-05(02).

叶菁菁, 周骁遥, 陈实. 基础研究投入的创新转化——基于国家自然科学基金资助的证据[J]. 经济学(季刊), 2021(6): 1883-1902.

郑江淮, 陈喆, 康乐乐. 国家间技术互补变迁及其对发明人才跨国流动的影响——一个国际技术发现假说与检验[J]. 中国工业经济, 2022(4): 23-41.

郑江淮, 陈喆, 孙志燕, 等. 从竞争到互补: 区域技术结构变迁的测度与理论假说[J]. 经济评论, 2022(1): 13-29.

郑江淮, 金晟男. 地区间技术互补、均衡发展与企业全球价值链攀升[J]. 中国工业经济, 2024 (7): 85-104.

Atkinson R. D. China Is Rapidly Becoming a Leading Innovator in Advanced Industries[R]. Information Technology and Innovation Foundation, 2024.

Boeing P., Brandt L., Dai R., et al. The Anatomy of Chinese Innovation: Insights on Patent Quality and Ownership[R].IZA Discussion Paper, 2024.

Castro D., McLaughlin M. Who Is Winning the AI Race: China, the EU, or the United States?[R]. Information Technology and Innovation Foundation, 2021.

Han P. F., Jiang W., Mei D. Q. Mapping US–China Technology Decoupling: Policies, Innovation, and Firm Performance[J]. Management Science, 2024 (12): 8386-8413.

Medvedev D., Piatkowski M. M., Yusuf S. Promoting Innovation in China: Lessons from International Good Practice[R]. World Bank, 2020.

Parker E., Gonzales D., Kochhar A. K., et al. An Assessment of the US and Chinese Industrial Bases in Quantum Technology[R]. RAND Corporation, 2022.

中国知网 https://www.cnki.net

Seeking Innovation-driven Development: From the 14th to the 15th Five-Year Plan

Zheng Jianghuai*

[1] Yangtze River Delta Socioeconomic Development Research Center, Nanjing University
[2] School of Economics, Nanjing University

Abstract: *During the 14th Five-Year Plan (FYP) period, China's innovation-driven development achieved pivotal transition from scale expansion to the dual enhancement of both quality and efficiency. This transition crystallized into a systematic leapfrogging catch-up model grounded in technological complementarity, centered on paradigm leaps, and safeguarded by ecosystem synergy. Technological complementarity has since deepened across different dimensions, thereby fortifying the foundation for optimizing the allocation of innovation resources. Concurrently, broad-based breakthroughs in emerging technological paradigms, most notably artificial intelligence and quantum information, have yielded tangible progress in fostering disruptive innovation. In parallel, the continuous optimization of the innovation ecosystem, driven by institutional refinement, coordinated engagement among diverse stakeholders, and infrastructure upgrades, has provided sustained structural support. Collectively, these developments have significantly bolstered China's R&D intensity, improved patent quality, and elevated the competitiveness of science and technology clusters. Nonetheless, structural constraints persist, including insufficient autonomy in key core technologies, persistent regional imbalances, incomplete ecosystem coordination, and mounting obstacles to international cooperation. Looking ahead to the 15th FYP period, it is imperative for China to upgrade this systematic model, and by advancing three dimensions in a coordinated manner, China can overcome "chokepoint" bottlenecks, reduce regional disparities, and invigorate innovation dynamics, thereby facilitating a transition from a catch-up phase to frontier-level leadership. Such progress is expected to provide a strong impetus for achieving greater high-level self-reliance and self-strength in science and technology, and cultivating new quality productive forces thereby contributing to the realization of the national goal of "basically achieving socialist modernization" by 2035.*

Keywords: *Innovation-driven development; Disruptive innovation; Technological complementarity; Paradigm shift; Innovation ecosystem*

JEL Classification Codes: O30; O31; O33

DOI: 10.19602/j.chinaeconomist.2026.02.01

* CONTACT: Zheng Jianghuai, email: zhengjh@nju.edu.cn.

Funding: The Major Project of the National Social Science Fund of China (NSSFC) "Mechanisms and Breakthrough Pathways for Coupling Innovation Chains and Industrial Chains in Core Technologies" (Grant No.22&ZD093).

中国知网 https://www.cnki.net

1. Introduction

As modern technological revolutions converge with geopolitical realignment, innovation has emerged as a decisive variable of national competitiveness and the principal driver of the new global order. China's 14th Five-Year Plan (2021-2025) marked a decisive turning point in the country's innovation-driven development and signaled a shift from extensive scale expansion toward qualitative upgrading. This period carried the strategic mandate of overcoming structural development bottlenecks and cultivating new, sustainable engines of growth. Beyond achieving leapfrog growth in quantitative indicators such as R&D investment and patent output, China achieved historic advances in optimizing technological structures, fostering disruptive innovation, and strengthening its innovation ecosystem, thereby injecting strong and durable momentum into "high-quality" development.

An examination of the intrinsic logic of innovation-driven development reveals two core dimensions: technological structural transformation and technological growth. Technological structure functions as the central mechanism for the allocation of innovation resources, encompassing paradigm evolution, regional and international technological complementarity, reconfiguration of industrial technology networks, and the mobility of talent factors. Technological growth, by contrast, is primarily reflected in the synergistic enhancement of quality and efficiency, manifested in improved patent quality, the upgrading of science and technology clusters, rising total factor productivity, and breakthroughs in disruptive innovation. Together, these elements—paradigm shifts occurring amid technological complementarity and development driven by ecosystem synergy—define the core landscape of China's innovation-driven progress. From this analytical perspective, optimization of technological structure constitutes the core driver of innovation-led growth, and the combined effects of paradigm shifts and technological complementarity represent a key mechanism through which latecomer economies can achieve technological catch-up. Within this process, disruptive innovation serves as the defining hallmark of paradigm transitions, and the innovation ecosystem provides sustained institutional and organizational support for both complementarity and transformation.

Building on this theoretical framework, this study systematically reviews the transformational characteristics of China's innovation development during the 14th FYP period. At the level of technological structure, China advanced from fragmented dispersion toward coordinated integration. In terms of technological growth, development shifted from factor-driven expansion to efficiency-oriented advancement; and with respect to innovation modes, the trajectory evolved from incremental dominance toward an increasing prevalence of disruptive breakthroughs. By examining representative practices, including regional technological complementarity, the rise of firm-level technological capabilities, and sectoral technological upgrades, this paper reveals the endogenous development model underpinning China's innovation progress, one that is characterized by technological complementarity as the foundation, paradigm shifts as the core, and ecosystem synergy as the safeguard. These findings provide robust theoretical insights and practical guidance for addressing future development bottlenecks and advancing toward greater high-level self-reliance and self-strength in science and technology.

The 15th FYP (2026-2030) represents a critical stage in which China will strive to consolidate its foundations and intensify efforts toward basically realizing "socialist modernization" by

中国知网 https://www.cnki.net

2035. At present, the global development environment is marked by the coexistence of strategic opportunities and escalating risks, alongside growing uncertainty and unpredictability. The patterns of competition and cooperation in science and technology are undergoing profound restructuring as well, and rivalry in key core technologies has intensified. Against this backdrop, we argue that it is imperative to lead efforts to achieve high-quality development through the upgrading of technological structures and to address imbalances and inadequacies in development via innovation-driven strategies. Drawing on the achievements of the 14th FYP and the accumulated experience of the systematic leapfrogging catch-up model, accurately identifying deep-seated constraints and critical challenges and clearly defining breakthrough priorities and implementation pathways for the 15th FYP carries significant theoretical value, practical relevance, and strategic urgency. Such efforts are essential for China to overcome its "chokepoint" technological constraints, foster disruptive innovation, narrow regional innovation disparities, enhance its global innovation discourse power, and build an independent and controllable modern technological system.

2. Innovation Practices and Model Synthesis during the 14th FYP Period

Driven by the profound reconfiguration of the global technological landscape and the imperatives of domestic high-quality development, China's innovation during the 14th FYP period underwent systemic transformation of its technological architecture coupled with simultaneous improvements in quality and efficiency. These advances coalesced into a systematic leapfrogging catch-up model, with technological complementarity as the foundation, paradigm shifts as the core, and ecosystem synergy as the safeguard. Far from a mere summation of isolated dimensions, this model embodies coherent economic logic by optimizing resource allocation, reconfiguring growth dynamics, and ensuring sustainability through self-reinforcing interactions. It offers a clear pathway for latecomer economies to achieve technological catch-up via systemic innovation and thus underpins China's shift from scale-driven to quality-led development.

2.1 Technological Complementarity: The Foundation for Resource Allocation

Technological complementarity is rooted in the inherent diversity of technological endowments and innovation trajectories across different actors. At its core, it enhances innovation efficiency by facilitating knowledge exchange and functional specialization and serves as the bedrock for innovation-driven development. By leveraging their comparative advantages through technology transfer, collaborative R&D, and resource sharing, diverse innovation entities at the regional, industrial, and corporate levels can achieve a synergy of strengths. This approach can not only lower innovation costs and mitigates R&D risks but also broaden application scenarios. Ultimately, this synergy may help to build the "critical mass" essential for disruptive breakthroughs, positioning technological complementarity as a vital mechanism for the optimized allocation of innovation resources.

At the regional level, China's spatial technological relationships achieved a transition from homogeneous competition toward differentiated complementarity that fostered a cross-regional collaborative pattern driven by "technological discovery" (Zheng et al., 2022). In the Yangtze River Delta, Shanghai focuses on foundational research and core technology R&D; Jiangsu emphasizes

中国知网 https://www.cnki.net

equipment manufacturing and technological commercialization; Zhejiang concentrates on the digital economy and application-oriented innovation; and Anhui directs its efforts toward quantum information and new energy. Together, these four regions have constructed a complete, integrated cross-regional chain encompassing basic research, technology development, and industrialization. In the Beijing-Tianjin-Hebei Region, this cluster has formed a clear functional division of labor, "R&D in Beijing, commercialization in Tianjin, and manufacturing in Hebei", that has enabled the high-efficiency flow and optimized allocation of innovation resources. Empirical research demonstrates that this regional complementarity has a significant empowering effect on corporate development as well; approximately 25% of the growth in firms' domestic value-added (DVA) export ratios can be explained by inter-regional technological complementarity (Zheng & Jin, 2024). From the perspective of developmental balance, China's regional technological gap has steadily narrowed. In 2023, the average technological complexity index in the eastern region reached 65.89, an 8.3% increase over 2020. Additionally, the index for the central and western regions reached 30.32, a year-on-year increase of 25.6%[1], with a growth rate that significantly outpaced that of the east. Behind this growth differential lies a multi-faceted convergence: the central and western regions have successfully "filled their technological gaps" by leveraging innovation spillovers from the east, upgrading their own industrial bases, and utilizing targeted policy support. A coordinated regional innovation landscape has actively taken shape.

At the industrial level, the pervasive penetration of digital technologies in China has dismantled traditional sectoral boundaries, propelling technological complementarity toward deeper integration. By lowering marginal R&D costs, amplifying knowledge spillovers, and enabling cross-domain collaboration, digital technologies have allowed firms to expand their technological portfolios from niche specialization toward multi-field integration, thereby providing essential support for cross-industry innovation. Between 2015 and 2024, the average number of International Patent Classification (IPC) subclasses covered per patent application among China's A-share listed companies increased from 2.3 to 4.7. Over the same period, the share of digital-technology-related patents rose from 18.6% to 42.3%, and cross-sectoral digital patent applications grew at an average annual rate of 35.8%, underscoring the accelerating pace of inter-industry technological convergence. Through two-way digital empowerment, industries across China have increasingly integrated their production and innovation networks. By 2023, digitalization rates in manufacturing, services, and agriculture reached 45%, 60%, and 25%, respectively, representing increases of 15, 20, and 10 percentage points relative to 2020[2]. Science-based, scale-intensive, and supplier-dominated industries have leveraged these digital tools to achieve cross-boundary integration as well. This process has not only strengthened productivity and innovative capacity in traditional sectors but has also created fertile ground for cross-disciplinary knowledge fusion, steering China's innovation ecosystem toward greater openness and collaboration.

At the international level, technological complementarity has evolved from one-way importation

[1] Calculated by the author using regional invention patent data and the technical complexity formula.

[2] Calculated by the author based on regional invention patent data and the classification code documents for digital technology patents from the China National Intellectual Property Administration.

中国知网 https://www.cnki.net

to reciprocal engagement, giving rise to a nuanced landscape of so-called "co-opetition" in which complementarity and competition coexist (Zheng et al., 2022). China has developed comparative advantages in mid-to-low-end manufacturing, digital technology applications, and renewable energy sectors, whereas advanced economies continue to lead in foundational research, high-end semiconductors, and core components. This divergence in technological endowments constitutes the structural foundation for international technology trade and collaborative arrangements. During the 14th FYP period, China established over 70 joint laboratories in partnership with Belt and Road Initiative (BRI) countries, creating diversified platforms for international innovation cooperation[3].

In the biotechnology domain, technology licensing transactions between Chinese firms and their European and American counterparts reached 33 in 2023, more than double the 2019 figure, highlighting a markedly strengthened two-way technology flow[4]. Similarly, in terms of talent mobility and knowledge diffusion, China's position within global innovation networks has continued to strengthen. Its centrality in the global inventor mobility network increased from 42 in 2020 to 49 in 2023, reflecting an average annual growth rate of 5.3%. By 2023, China hosted 180 highly cited scientists in artificial intelligence, semiconductors, and biomedicine, a 63.6% increase from 2020[5], placing it second globally in these fields. Such cross-border flows of talent and knowledge not only accelerate worldwide technological advancement but also promote the international dissemination of disruptive innovation concepts, thereby laying a solid foundation for China's deeper engagement in global innovation governance.

At the firm level, enterprises have solidified their role as the core micro-level actors of technological complementarity and the primary incubators of disruptive innovation during the 14th FYP period. In 2024, Chinese corporate R&D expenditure reached 2,821.16 billion yuan, accounting for 77.7% of total national R&D spending, and the R&D intensity of large-scale high-tech manufacturing enterprises averaged 3.35%. This substantial financial commitment has established a solid foundation for pursuing disruptive breakthroughs[6]. The global R&D investment landscape underscores this ascent. According to the EU Industrial R&D Investment Scoreboard, 678 Chinese firms featured among the world's top 2,500 R&D investors in 2021 (17.9% share). By 2024, China maintained strong representation with 525 firms in the top 2,000 (16.1% share), exhibiting particularly rapid growth in emerging sectors such as electric vehicles, semiconductors, and renewables. The leadership of flagship enterprises has been especially prominent. BYD, a representative in the electric vehicle sector, advanced from 129th in global R&D rankings in 2021 to 37th in 2024, with R&D expenditure amounting to 6.673 billion euros[7].

---

[3] Source: China Center for International Science and Technology Exchange (CISTE), "The Belt and Road International Science Organization Alliance now has 78 members," September 23, 2025, https://www.ciste.org.cn/gjkjzz/ydylkjzz/art/2025/art_150d75261e4144d8950bb8dc0f86ec72.html.

[4] Source: Sandra Barbosu, "How Innovative Is China in Biotechnology?" July 30, 2024, https://itif.org/publications/2024/07/30/how-innovative-is-china-in-biotechnology/.

[5] Calculated by the author based on inventor mobility data identified from invention patent data.

[6] Source: National Bureau of Statistics, "Statistical Communiqué on National Science and Technology Expenditures in 2024, " September 29, 2025, https://www.gov.cn/lianbo/bumen/202509/content_7042859.htm.

[7] Source: Grassano et al., "The 2022 EU Industrial R&D Investment Scoreboard," Dec.13, 2022, https://iri.jrc.ec.europa.eu/scoreboard/2022-eu-industrial-rd-investment-scoreboard.

中国知网 https://www.cnki.net

By establishing complementary technological linkages with battery material suppliers in central and western China and automotive component manufacturers in the eastern region, BYD constructed a vertically integrated industrial chain. As a result, its new-energy vehicle production and sales led globally for nine consecutive years through 2023, and in 2025, its pure electric vehicle sales surpassed Tesla for the first time, marking a global leadership shift. Its "Blade Battery" technology exemplifies a quintessential paradigm of disruptive innovation. Likewise, Huawei drew on complementary networks in the Yangtze and Pearl River Deltas to forge open 5G industrial alliances, securing China's global leadership in 5G standards and deployment. The rise of these enterprises, synergistically interacting with regional technological complementarity and ecosystem dynamics, forms the micro-foundational bedrock of China's contemporary innovation trajectory.

2.2 Paradigm Shifts: The Core Engine of Innovation-Driven Growth

Paradigm shifts are marked by breakthroughs in disruptive technologies that break entrenched technological path dependencies, reconfigure technological systems and industrial structures, and ultimately reshape growth logic. When marginal returns to innovation decline within an established technological paradigm, disruptive technologies generate new market demand, restructure industrial value chains, and propel economic growth into new long-wave cycles. These shifts are not isolated breakthroughs but evolve across a full chain: foundational research, iterative applications, and industrialization. Disruptive innovation runs throughout this process and serves as the critical inflection point that enables qualitative leaps in innovation-driven development.

Multi-point breakthroughs occur in emerging technological paradigms. During the 14th FYP period, China witnessed the accelerated emergence of new technological paradigms, most notably in artificial intelligence, quantum information, new energy, and biotechnology, and coordinated breakthroughs across multiple fields laying a solid foundation for paradigm shifts. In artificial intelligence, China has built a relatively complete technological system that spans chips, foundational frameworks, and application-layer deployment and that enables large-scale commercialization in areas such as intelligent speech recognition and computer vision. In quantum information, major advances include the preliminary establishment of an integrated space-ground quantum communication network and the successful deployment of thousand-kilometer-scale quantum key distribution, opening pathways toward industrial application. In the new energy sector, Chinese firms have achieved a dominant global position: CATL and BYD together account for more than 60% of the global power battery market, and repeated world-record-setting photovoltaic conversion efficiencies have accelerated the global transition toward green and low-carbon energy systems[8]. In biotechnology, MGI accounts for approximately 7% of the global gene sequencing market in terms of revenue[9], and technological breakthroughs in genetic testing and biopharmaceuticals have provided important support for the Healthy China initiative. Collectively, these advances in emerging technological paradigms have not only driven rapid industrial growth but also reshaped

[8] Source: 360estorage, "China's Power Battery Industry Dominates the Global Market: Market Share Surpasses 60% as Production Surges 12-fold in Three Years," October 27, 2025, https://baijiahao.baidu.com/s?id=1847126555804189092&wfr=spider&for=pc.

[9] Source: Zheng Bingxun, "Seizing the Multi-Billion Dollar Market: Domestic Gene Sequencing Firms Ignite a Competitive 'Replacement War'," February 10, 2025, https://finance.sina.com.cn/roll/2025-02-10/doc-ineizenw4006685.shtml.

中国知网 https://www.cnki.net

global competitive dynamics, creating favorable conditions for China's technological catch-up.

Tangible progress is seen in the cultivation of disruptive innovation. The cultivation of disruptive innovation in China has yielded measurable outcomes. Based on assessments of patent differentiation from prior technologies and their influence on subsequent innovation, disruptive patents accounted for 8.3% of China's total invention patents in 2023, an increase of 3.1 percentage points compared to 2020. Although this share remains below that of the United States (12.1%) and Germany (10.5%)[10], the narrowing gap underscores the rapid strengthening of China's disruptive innovation capacity. Leadership effects are particularly evident in several key domains. In semiconductors, Huawei's HiSilicon Kirin 9000S achieved mass production, breaking long-standing foreign monopolies over advanced manufacturing technologies. In artificial intelligence, DeepSeek realized breakthroughs in intelligent reasoning by developing models capable of unified processing of text, code, and visual information, overcoming cold-start constraints through unsupervised reinforcement learning and achieving significantly faster inference speeds than comparable models. In new-energy vehicles, BYD's aforementioned Blade Battery redefined safety standards for power batteries, shifting the technological paradigm from "energy-density prioritization" toward a balanced emphasis on safety and performance and guiding the global trajectory of battery technology development. These disruptive innovations have not only strengthened core competitiveness in related industries but have also driven comprehensive upgrading of China's technological systems.

A deep coupling exists between disruptive innovation and technological complementarity networks. The cultivation of disruptive innovation is deeply embedded within technological complementarity networks. Empirical evidence indicates that improvements in the allocative efficiency of inventor mobility, both inflows and outflows, significantly enhance urban-level disruptive innovation performance. The effect is particularly evident when incoming inventors exhibit strong complementarity with the host city's technological base while maintaining low overlap with the originating city's technological profile. This mechanism operates most effectively within innovation ecosystems characterized by dense collaboration networks and "high-quality" research teams, highlighting the critical enabling role of technological complementarity in driving paradigm shifts.

Innovation clusters function as powerful platforms for technological complementarity and disruptive breakthroughs, demonstrating significant agglomeration effects. In 2023, the proportion of disruptive patents within China's premier innovation clusters—most notably the Yangtze and Pearl River Deltas—markedly surpassed the national average. The World Intellectual Property Organization's *Global Innovation Index 2025* reports that China now hosts 24 of the world's top 100 innovation clusters, ranking first globally, with the Shenzhen-Hong Kong-Guangzhou cluster claiming the top position worldwide[11]. These hubs concentrate approximately 60% of national R&D expenditure, 70% of R&D personnel, and 80% of high-tech enterprises, solidifying their role as the central engines of technological progress. The Shanghai-centered Yangtze River Delta

[10] Calculated by the author based on disruptive patent data identified using existing methods for identifying disruptive technology patents.

[11] Source: WIPO, "Global Innovation Index 2025," https://www.wipo.int/web-publications/global-innovation-index-2025/en/index.html.

中国知网 https://www.cnki.net

integrated circuit cluster exemplifies this dynamism: it encompasses three of the world's top ten wafer foundries, two of the top ten packaging and testing firms, and five emerging domestic integrated device manufacturers (IDMs). In 2022, the cluster's combined revenue from IC design, manufacturing, and packaging/testing reached 723.5 billion yuan, over 60% of the national total, vividly demonstrating the pivotal role of clusters in driving paradigm shifts[12].

2.3 Ecosystem Synergy: The Institutional Safeguard for Innovation

Ecosystem synergy, as a crucial safeguard within the systematic leapfrogging catch-up model, reduces transaction costs, information asymmetries, and inherent uncertainties in innovation activities through multiple pathways, including institutional design, stakeholder coordination, and infrastructure development. By accelerating knowledge spillovers and technological diffusion, it simultaneously serves as a "safety net" and an "accelerator" for high-risk disruptive innovation, thereby constituting a vital safeguard within the systematic leapfrogging catch-up model. At its core, this synergy manifests as a multidimensional integration of institutional, stakeholder, infrastructural, and cultural alignment, thereby delivering the sustainable structural support essential for technological complementarity and paradigm transitions.

Institutional synergy works to optimize innovation incentives. The nationwide rollout of punitive damages for patent infringement, combined with the progressive establishment of cross-regional intellectual property protection mechanisms, has significantly reduced the average resolution period for IP disputes. These reforms effectively protect the legitimate rights and interests of disruptive innovators, thereby invigorating creative momentum across the country. Deep reforms to the scientific evaluation system have also dismantled the entrenched "papers-and-quantity" bias, granting Chinese researchers substantially greater autonomy over human, financial, and material resources as well as technological direction, explicitly encouraging the pursuit of high-risk, high-reward disruptive research. Concurrently, ongoing advancements in factor marketization and the accelerated construction of a unified national market have eliminated regional protectionism and market segmentation, removing institutional barriers to the free flow of innovation factors and significantly enhancing resource allocation efficiency throughout China.

Stakeholder synergy fosters collective innovation impetus. Chinese enterprises have fully consolidated their position as the central actors in innovation, assuming a leading role in tackling chokepoint technologies and commercializing disruptive outcomes. For example, in 2024, Chinese corporate R&D expenditure accounted for 77.7% of the national total[13], and contracts between enterprises and universities/research institutes for technology development, consulting, and services reached 201.07 billion yuan, a 1.9-fold increase from 2020, demonstrating the deepening intensity of university-industry collaboration (Deng, 2026). Mechanisms for industry-academia-research synergy have continued to mature since then, effectively harnessing academia's strengths in fundamental research and industry's market-driven orientation through joint R&D, talent

[12] Source: Center for Yantze River Delta and Economic Belt Research, "Joining Forces in the Yangtze River Delta to Build a World-Class Integrated Circuit Industry Cluster," April 26, 2024, https://cyrdebr.sass.org.cn/2024/0426/c7499a568926/page.htm.

[13] Source: National Bureau of Statistics, "Statistical Communiqué on National Science and Technology Expenditures in 2024," September 29, 2025, https://www.gov.cn/lianbo/bumen/202509/content_7042859.htm.

中国知网 https://www.cnki.net

mobility, and other channels. As another example, by 2023, collaborative disruptive patents from Chinese university-enterprise partnerships accounted for 38.6% of the national total, an increase of 9.2 percentage points over 2020[14], vividly illustrating the pivotal role of this synergy in nurturing disruptive innovation. Collectively, diverse innovation actors in China have coalesced into an "enterprise-led, university-supported, institute-coordinated" force that ensures seamless integration across the entire innovation chain, from basic research through to full-scale industrialization.

Infrastructural and cultural synergies provide a resilient and mutually reinforcing foundation for innovation-driven development. Comprehensive upgrades to physical and digital infrastructure have established a solid backbone for technological progress. By the end of 2023, China had deployed 3.377 million 5G base stations[15], delivering the high-speed, low-latency connectivity essential for deep digital integration and the emergence of disruptive innovations, and by late 2022, 150 industrial internet platforms of significant sectoral or regional influence had been established, forming a multi-tiered ecosystem that connects over 81 million sets of industrial equipment[16]. As of February 2025, China's national scientific research facility-sharing platform had integrated more than 141,000 large-scale instruments[17], dramatically lowering hardware barriers and enabling small and medium-sized enterprises (SMEs) to pursue disruptive innovation at reduced cost. Concurrently, the technology transaction market expanded sharply, from 2.8 trillion yuan in 2020 to 6.8 trillion yuan in 2024 (Deng, 2026), serving as a vital conduit for the transfer of complementary technologies and the commercialization of disruptive outcomes. Complementing these material advances, sustained efforts to cultivate an innovation-oriented culture have fostered a supportive social environment. The vigorous promotion of the scientist spirit, entrepreneurial spirit, and craftsmanship has contributed to the gradual emergence of a societal ethos that encourages bold exploration while also tolerating failure. Initial fault-tolerant and error-correction mechanisms have both been instituted, effectively alleviating researchers' concerns about engaging in high-risk, high-reward disruptive work. This inclusive and open innovation culture, when integrated with world-class infrastructure, delivers comprehensive support for innovative activities and accelerates the intertwined processes of technological complementarity and paradigm transitions.

In summary, China's innovation trajectory during the 14th FYP period exhibits distinctive stage-specific characteristics and a profound multi-dimensional transformation. In terms of growth dynamics, the country has shifted decisively from factor-driven to efficiency-driven models, with disruptive innovation emerging as the defining hallmark of quality enhancement. Spatially, the landscape has evolved from uneven agglomeration toward coordinated and balanced development, propelled by deepening regional technological complementarity that fosters nationwide synergistic development. With respect to innovation actors, the underlying model has transitioned from single-entity dominance to multi-stakeholder collaboration, with enterprises firmly consolidating their

[14] Calculated by the author.

[15] Source: Xinhua News Agency, "Total Number of 5G Base Stations in China Reaches 3.377 Million," January 19, 2024, https://www.gov.cn/lianbo/bumen/202401/content_6927123.htm.

[16] Source: CCTV News, "China's Multi-tier Industrial Internet Platform System Preliminarily Established," March 29, 2023, https://www.gov.cn/xinwen/2023-03/29/content_5749133.htm.

[17] Source: Wu Wenqian, "Over 141,000 Sets of Large-scale Scientific Instruments Integrated into National Sharing Platforms," February 26, 2025, https://news.sciencenet.cn/htmlnews/2025/2/539385.shtm.

中国知网 https://www.cnki.net

central role and industry-academia-research synergy achieving marked gains in effectiveness. In the global dimension, the paradigm has moved from one-way technology importation to two-way engagement, substantially elevating China's position and disruptive-innovation influence within international innovation networks. Collectively, these transformations signal that China has entered a new era centered on high-quality development that has laid a robust foundation for realizing even more ambitious innovation breakthroughs during the 15th FYP period.

2.4 Synthesis of China's Innovation Development Model

The transformative achievements of China's innovation during the 14th FYP period are deeply rooted in a systematic leapfrogging catch-up model: technological complementarity as the foundation, paradigm shifts as the core, and ecosystem synergy as the safeguard. Far from a mere summation of isolated dimensions, this model adheres to a coherent economic framework that optimizes resource allocation, reconfigures growth engines, and ensures long-term sustainability to form a nested, self-reinforcing whole. It offers a systematic pathway for latecomer economies to achieve technological catch-up and leapfrogging.

Technological complementarity, as the fundamental basis, applies the logic of comparative advantage to innovation. By leveraging differences in technological endowments, diverse actors can integrate resources across regions, sectors, and borders, thereby offsetting weaknesses while amplifying strengths and building the critical mass needed for disruptive breakthroughs. Within China, this plays out in well-established patterns: R&D concentrated in the eastern regions paired with commercialization and scaling in the central and western regions; digital technologies deeply fused with traditional industries; and close collaboration between leading enterprises and specialized SMEs. These arrangements reduce innovation costs, spread R&D risks, and create fertile ground for breakthroughs. Internationally, two-way flows of technology and talent, both of which are attracting advanced capabilities from abroad and exporting Chinese strengths, help close gaps in foundational research while opening up global markets and resources.

Paradigm shifts serve as the central engine of China's growth as they have fundamentally restructured technological systems and industrial landscapes to propel the Chinese economy into new long-wave cycles. During the 14th FYP period, emerging paradigms in artificial intelligence, quantum information, and other frontier fields steadily supplanted traditional technological paths in China, rapidly giving rise to smart manufacturing, biopharmaceuticals, and a host of other innovative business models. This dynamic vividly captures the essence of "creative destruction" at the core of paradigm shifts: phasing out outdated capacities while simultaneously opening up entirely new arenas for innovation across the Chinese economy. Disruptive innovation stands as the defining hallmark of these transitions in China. It generates not only technological breakthroughs but also deep structural upgrades and fundamental changes in China's development models. Through these shifts, China has transitioned from a phase of technological catch-up to one of strategic parity, and in several frontier domains, global leadership, thus fundamentally reconfiguring the global competitive landscape.

Ecosystem synergy, as the sustainable safeguard, embodies the systematic integration of institutional economics and cluster innovation theory in practice. Through institutional coordination

中国知网 https://www.cnki.net

that refines innovation incentives, stakeholder alignment that amplifies performance, infrastructural integration that reduces transaction costs, and cultural reinforcement that cultivates an atmosphere of tolerance and experimentation, ecosystem synergy delivers efficient support for technological complementarity while providing a critical "safety net" for high-risk paradigm shifts. In China, well-developed innovation clusters with mature ecosystems exhibit an R&D input-output ratio and a disruptive patent output density higher than the national average, clear evidence of the powerful amplification effect ecosystem synergy exerts. This multidimensional coordination mechanism ensures the continuous advancement of technological complementarity and paradigm shifts and establishes a stable, resilient, and sustainable environment for innovation-led growth.

These three dimensions form a tightly coupled, two-way cycle of adaptation and dynamic iteration. Technological complementarity aligns with and meets the evolving resource, talent, and capability needs of paradigm shifts, laying the essential groundwork for them to occur. In turn, paradigm shifts pull technological complementarity toward new frontier and incremental domains, driving its progression from basic to advanced levels of integration. Ecosystem synergy continuously adapts to the pace and requirements of this interplay, through institutional innovation, infrastructure enhancement, and other mechanisms, reducing transaction costs, dispersing risks, and stabilizing expectations to enable smooth, interaction between complementarity and paradigm shifts. This model aligns seamlessly with China's hybrid governance framework in that it is market-driven yet strategically guided by the state, and it closely mirrors the developmental logic of latecomer economies: accumulating comparative advantages through technological complementarity, achieving leapfrog progress via paradigm shifts, and consolidating and sustaining those gains through ecosystem synergy. In this way, disruptive innovation ultimately becomes the mechanism for establishing and maintaining leadership. This systemic innovation development model not only explains China's achievements during the 14th FYP period but also provides solid theoretical foundations and practical guidance for realizing greater high-level self-reliance and self-strength in science and technology during the 15th FYP period and beyond.

3. Barriers and Critical Challenges for Innovation during the 15th FYP Period

Although China's innovation system framework took shape during the 14th FYP period, patent statistics, industrial evidence, and international comparisons reveal persistent, deep-seated, and multi-dimensional bottlenecks. As the country advances toward the 15th FYP period with the strategic goal of achieving high-level self-reliance and self-strength in science and technology, these constraints, concentrated in technological supply, innovation quality and efficiency, ecosystem support, and international collaboration, remain interwoven and mutually reinforcing, creating cumulative restrictive effects.

3.1 Deficiencies in Core Technological Autonomy and the Persistent "Chokepoint" Dilemma

High external dependence in core technological domains, combined with entrenched path dependence in key sectors, continues to place China in a predicament characterized by both

中国知网 https://www.cnki.net

insufficient source-level innovation and inadequate high-end supply. This structural vulnerability remains the foremost barrier to cultivating disruptive innovation.

In strategic emerging industries, China's patent portfolio exhibits an obvious "periphery-heavy, core-light" pattern, leaving critical technologies vulnerable to external control. While Chinese enterprises have scaled their R&D investments considerably in cutting-edge sectors, a substantial gap persists in their capacity for indigenous innovation regarding fundamental core technologies. Artificial intelligence serves as a representative case. Although China's R&D expenditure constitutes a significant portion of the global total, its patent accumulation in foundational tiers—specifically core algorithms and high-end semiconductors—remains relatively sparse, lagging notably behind leading nations. Currently, the majority of mainstream large-model ecosystems are anchored by foreign high-performance hardware, with underlying architectures largely dependent on overseas open-source frameworks. The semiconductor industry reflects a parallel trajectory. Despite R&D investments that rank among the world's highest, China's patent share in advanced process nodes and essential manufacturing equipment remains disproportionately low. Intellectual property in the high-end chip segment continues to be dominated by international incumbents. Within the highly concentrated market for critical fabrication tools, China's domestic semiconductor industry has yet to achieve autonomous supply capabilities for frontier systems, such as extreme ultraviolet (EUV) lithography. Finally, the biopharmaceutical sector mirrors these structural impediments. While China maintains a formidable global presence in R&D spending, it accounts for a modest proportion of core patents for first-in-class innovative drugs. Patent activity continues to cluster around lower value-added segments, primarily encompassing generic formulations and auxiliary medications. This imbalanced patent structure places Chinese enterprises in a competitive disadvantage in global value chains. They face not only high royalty payments but also frequent patent litigation[18], which significantly undermines their ability to independently develop and secure critical technologies.

Similar gaps persist in frontier domains, particularly quantum technologies. Critical hardware components, such as dilution refrigerators and high-quantum-efficiency photon detectors, remain heavily reliant on imports, and domestic alternatives fall short of the performance and reliability required for advanced quantum computing systems. Significant gaps also remain in key technical indicators, including qubit coherence time, control precision, and progress in foundational areas like quantum error correction, all of which directly hinder the industrialization of quantum technologies in China.

Low investment in basic research represents the most fundamental constraint on original innovation and, by extension, on disruptive breakthroughs. In 2024, China's basic research expenditure accounted for only 6.88%[19] of total R&D spending, well below levels in developed economies, and resulted in chronic shortages of source-level innovation supply. Patent commercialization performance remains weak. According to the EU Industrial R&D Scoreboard (2024), Chinese enterprises achieve a

[18] Source: Georgakaki et al., "The 2025 EU Industrial R&D Investment Scoreboard," Dec.22 , 2025, https://iri.jrc.ec.europa.eu/scoreboard/2025-eu-industrial-rd-investment-scoreboard.

[19] Source: National Bureau of Statistics (NBS),"Statistical Communiqué on National Science and Technology Expenditures in 2024," September 29, 2025, https://www.gov.cn/lianbo/bumen/202509/content_7042859.htm.

中国知网 https://www.cnki.net

patent conversion rate of approximately 50%, and universities and public research institutes reach only 3.8% and 11.8%, respectively, far below the 20%+ rates typical in advanced economies.[20] As a result, a large volume of basic research outcomes remains trapped in laboratories and fails to translate into disruptive innovations (Ye et al., 2021). The underlying causes of this commercialization bottleneck are threefold. First, low technology readiness levels create a persistent disconnect between laboratory outputs and real industrial needs. Second, the development of pilot-scale and intermediate testing platforms lags significantly, leaving a critical gap between technological prototypes and scalable products. Third, commercialization incentive mechanisms remain underdeveloped: revenue-sharing ratios for researchers are typically low, undermining motivation for technology transfer. Together, these factors introduce structural breakpoints in the innovation chain, creating dual obstacles that impede both the "0-to-1" breakthroughs of original innovation and the "1-to-N" scaling required for industrial application.

3.2 Low Innovation Efficiency and Significant Imbalance between Quantity and Quality

China's innovation trajectory has long exhibited a structural bias toward quantity over quality. Persistent shortcomings, such as limited technological value in patents, a narrowing scope of innovation activities, and highly concentrated industrial structures, have made deficiencies in quality and efficiency a central constraint on elevating China's overall innovation competitiveness.

Weak patent quality and limited international competitiveness stand out most clearly. Although China has consistently ranked first or second globally in patent filings, accounting for 32% of worldwide invention patent applications in 2019, the substantive technological impact of these patents remains comparatively low. The average number of forward citations for Chinese patents has trended downward, signaling declining diffusion and influence. At the same time, patent space has become increasingly crowded: by 2019, the average number of applications per International Patent Classification (IPC) category had increased sevenfold compared with 2005 (Boeing et al., 2025). From the perspective of global coverage, 96% of Chinese patents are filed only domestically, and the share of triadic patents (simultaneously filed in Europe, the United States, and Japan) remains negligible, limiting the creation of durable international technological barriers. Citation performance further highlights this gap: in sectors such as photovoltaics, Chinese patent citation rates stand at only 14.9%, far below the levels exceeding 60% achieved by leading firms in Germany, Japan, and the United States (Medvedev et al., 2020). Collectively, these indicators reveal insufficient technological influence and industry recognition for Chinese patents.

The scope of innovation has also continued to narrow, with cross-domain integration weakening and an inward-looking, path-dependent innovation pattern taking hold. Cross-field spillover effects of Chinese patents have steadily declined, as shown by the continuous drop in the average importance of secondary IPC classifications from 1985 to 2019. This trend indicates that technological progress is increasingly reliant on existing intra-field knowledge, with limited engagement in cross-sectoral or interdisciplinary fusion (Boeing et al., 2025). Such structural

[20] Source: Georgakaki et al., "The 2025 EU Industrial R&D Investment Scoreboard," Dec.22 , 2025, https://iri.jrc.ec.europa.eu/scoreboard/2025-eu-industrial-rd-investment-scoreboard.

中国知网 https://www.cnki.net

closure constrains innovation vitality and hinders the emergence of truly disruptive breakthroughs that typically arise at the intersections of multiple domains, a dynamic that is fundamentally at odds with the integrative nature of digital-economy development.

Industrial innovation remains highly concentrated, resulting in limited risk resilience and relatively low value-added potential. Data from the 2024 and 2025 EU Industrial R&D Investment Scoreboards show that Chinese firms on the list are overwhelmingly clustered in traditional manufacturing sectors, reflecting an apparent lack of diversification. In 2025, firms in ICT hardware manufacturing, automobiles, and construction and materials accounted for 60.3% of all Chinese entries, collectively absorbing 77.4% of total R&D investment. Within this group, ICT hardware alone represented 38.7% of spending, followed by automobiles at 26.3% and construction and materials at 12.4%. In contrast, US firms display a more balanced and high-value-added profile, with 70.9% of R&D concentrated in ICT services and healthcare. EU firms focus primarily on automotive and environment-related Sustainable Development Goal sectors that balance traditional strengths with green transformation, but Japanese firms, though also concentrated in automobiles and electronics, exhibit deeper technological specialization and stronger "hidden champion" traits[21]. This extreme concentration in China's industrial innovation structure weakens the overall ecosystem's resilience: shocks in one or two dominant sectors, whether from technological disruption or market volatility, can quickly propagate across the system. Moreover, insufficient innovation in high-value-added service industries limits upward movement along global value chains, keeping China positioned predominantly in the middle-to-lower tiers of the international division of labor in innovation.

3.3 Deficiencies in the Innovation Ecosystem: Coexisting Institutional and Structural Barriers

A robust innovation ecosystem is essential for supporting technological complementarity and paradigm shifts. Yet in China, the ecosystem continues to face multiple, interconnected obstacles, including fragmented industry-academia-research collaboration, inadequate intellectual property protection, insufficient technology-oriented financing, and misaligned evaluation systems and talent structures, that collectively hinder the full release of innovation potential.

Industry-academia-research collaboration remains loose and poorly integrated, resulting in weak connectivity across the innovation chain. In 2023, cooperative R&D investment between enterprises and universities accounted for only 7% of total corporate R&D expenditure in China, well below the 12% level in the United States. Average technology transfer income per Chinese university is roughly one-fifth that of US institutions, and most collaborations are confined to applied research, with very limited engagement in basic research (Atkinson, 2024; Castro & McLaughlin, 2021). Approximately 70% of research outcomes remain stuck in the laboratory stage, reflecting the absence of critical intermediate commercialization platforms. Data indicate that the density of pilot-scale testing facilities in China is only one-third that of the United States and one-half that of Germany. This underdevelopment of mid-stage testing infrastructure prevents many laboratory achievements from advancing to industrialization due to insufficient technology

[21] Source: Georgakaki et al., "The 2025 EU Industrial R&D Investment Scoreboard," Dec.22 , 2025, https://iri.jrc.ec.europa.eu/scoreboard/2025-eu-industrial-rd-investment-scoreboard.

中国知网 https://www.cnki.net

readiness or prohibitively high production costs[22], leaving the R&D-to-market pipeline incomplete and severely limiting the real-world impact of innovation outputs.

Weaknesses in intellectual property protection and technology finance further undermine ecosystem effectiveness. The average adjudication period for IP infringement cases in China is approximately 18 months, longer than international norms. In 2023, average compensation in IP infringement cases was around 2 million yuan, far below the roughly 5 million USD typical in the United States, and plaintiff success rates stood at 65% compared to 78% in the United States (Atkinson, 2024). In addition, early-stage financing for innovation remains inadequate. Coverage for seed- and start-up-stage enterprises is only 25% in China, significantly lower than 60% in the United States and 45% in Europe, and domestic venture capital allocates just 15% of its funding to early-stage firms, compared to 40% in the United States (Castro & McLaughlin, 2021). This significant "front-end gap" in capital support causes many high-potential start-ups to fail prematurely, severely constraining the emergence and scaling of disruptive innovations.

Structural deficiencies in evaluation systems and talent composition compound these challenges. Research assessment mechanisms in China remain heavily biased toward publication counts and quantitative metrics, particularly in basic research, where evaluation cycles are typically shorter than five years, an approach fundamentally misaligned with the long gestation periods required for truly disruptive innovation. The talent structure also exhibits a bias toward technical specialization over creative and integrative capabilities. Shortages of high-level interdisciplinary talent and globally leading scientific figures are evident: Chinese nationals represent only 12% of the world's top researchers in frontier fields such as artificial intelligence and quantum information[23]. In advanced manufacturing, returnees from overseas account for just 23% of R&D personnel, compared with 35% foreign-born talent in the United States (Atkinson, 2024). These gaps reflect limited internationalization and insufficient talent agglomeration, undermining China's capacity to sustain high-level self-reliance and self-strength in science and technology and long-term innovation leadership.

3.4 Regional Imbalances in Innovation Development and Insufficient Synergy in Technological Complementarity

Persistent regional disparities remain a deep-rooted structural challenge in China's national innovation system. Significant gaps between the eastern coastal regions and the central and western interior continue to exist across innovation capacity, resource allocation, and factor mobility. Institutional and systemic barriers to effective technological complementarity have not been fully removed, constraining the overall efficiency of the national innovation system and limiting the coordinated, nationwide cultivation of disruptive innovation.

Regional innovation gaps remain substantial, with uneven development patterns clearly evident. In 2023, China's eastern region maintained an R&D intensity approximately twice that of the central and western provinces, highlighting a significant regional imbalance in innovation

[22] Source: Georgakaki et al., "The 2025 EU Industrial R&D Investment Scoreboard," Dec.22 , 2025, https://iri.jrc.ec.europa.eu/scoreboard/2025-eu-industrial-rd-investment-scoreboard.

[23] Source: Macro Polo, "The Global AI Talent Tracker 2.0", March 7, 2023, https://archivemacropolo.org/interactive/digital-projects/the-global-ai-talent-tracker/.

中国知网 https://www.cnki.net

investment. This spatial concentration is equally evident in the distribution of high-tech enterprises: the eastern seaboard hosts the overwhelming majority of these firms, while the interior regions account for only a comparatively small share. Indicators of technological complexity reveal a similar divide. While eastern clusters continue to operate along a more advanced technological frontier, the central and western regions face a substantial developmental lag, underscoring persistent structural divergence between China's coastal and inland innovation systems. These differences also extend beyond quantitative metrics and reflect deeper disparities in ecosystem maturity. Eastern regions benefit from dense research platforms, abundant talent pools, and well-developed industrial support systems, whereas the central and western regions face persistent shortfalls in these areas, perpetuating a regional "Matthew effect" in which stronger areas continue to pull further ahead.

Cross-regional factor mobility in China remains costly, and technology transfer efficiency lags. Currently, cross-regional technology transfer constitutes a disproportionately small fraction of the total turnover within China's national technology market. Specifically, the outflow of innovation from the eastern seaboard to the central and western interior remains modest, with a notably thin volume of disruptive or frontier technologies shifting across provincial lines. This bottleneck indicates significant structural impediments to the fluid movement of intellectual property, suggesting that the latent complementarity inherent in China's technological gradients has yet to be fully mobilized. The core reasons for restricted mobility lie in institutional barriers such as local protectionism, market segmentation, and underdeveloped benefit-sharing mechanisms, which continue to hinder the nationwide optimization of innovation resource allocation in China.

The limited absorptive and transformative capacity of China's central and western regions further constrains effective technology diffusion. The innovation ecosystems across China's central and western regions continue to face persistent structural constraints. Compared with the eastern region, these interior provinces contend with a relatively limited pool of high-caliber talent, weaker high-level research infrastructure, and less integrated industrial supply chains. These institutional weaknesses are reflected in several key indicators: the density of R&D personnel remains substantially lower than in the eastern region, while the distribution of national-level research platforms is comparatively limited. Furthermore, the R&D investment intensity of high-tech firms in these regions remains below that of their eastern counterparts, indicating structural impediments that collectively constrain the strengthening of regional innovation capacity. These deficiencies greatly restrict the ability of central and western regions to internalize and build upon transferred technologies. Even when technology transfer occurs, constraints on secondary innovation and industrial scaling prevent effective localization and broader diffusion, thereby deepening and perpetuating regional innovation disparities across China.

3.5 Impediments to International Innovation Cooperation and Rising Challenges in Global Resource Integration

Intensifying global technological competition, coupled with rising technology containment and trade protectionism, has made the external environment for international innovation cooperation increasingly complex and restrictive. China's ability to integrate global innovation resources, exert influence over rule-setting, and achieve effective cross-border technology transfer faces mounting pressures,

中国知网 https://www.cnki.net

constituting a major external constraint on innovation-driven development during the 15th FYP period.

Technological containment and trade protectionism have sharply narrowed channels for acquiring core technologies. Several developed economies have pursued "small yard, high fence" strategies, restricting collaboration with China in frontier domains such as semiconductors, artificial intelligence, and quantum information while intensifying export controls on high-end technologies, critical components, and advanced research equipment. As a direct result, China's imports of high-end semiconductor equipment fell 25% year-on-year in 2023[24], severely limiting access to essential inputs for research and industrialization in strategic sectors. Among the world's top 2,500 R&D-investing firms, Chinese enterprises continue to lag significantly in cross-border R&D engagement as well. In 2022, cross-border R&D investment represented only 8.3% of total R&D expenditure for Chinese firms, compared to 23.7% for US firms and 18.5% for EU firms. Although this share rose modestly to 8.9% in 2023 and 9.4% in 2024, the corresponding figures for the United States and European Union increased more sharply, reaching 26.8% and 21.3%[25], respectively. This widening disparity highlights the growing difficulty China faces in leveraging global innovation resources to accelerate technological catch-up.

China's influence in global innovation governance and rule-setting remains limited, with relatively low participation in international standard-setting and institutional frameworks. In 2023, China-led international standards accounted for only 5% of the global total, compared with 25% for the United States and 18% for Germany. In emerging fields such as artificial intelligence and quantum communication, China's contribution to international standard-setting in 2024 was just 6.8%, far below the 31.4% share of the United States and 24.7% of the European Union (Parker et al., 2022). Structural weaknesses are equally apparent in international intellectual property cooperation. From 2022 to 2025, triadic patents, filed simultaneously in the United States, Europe, and Japan, accounted for only 3.2%-3.8% of Chinese firms' invention patents, but US firms maintained shares of 28%-31% and EU firms 22%-25%. In 2024, the success rate of Chinese enterprises in international IP disputes stood at 65%, lower than 78% for US firms and 73% for EU firms, underscoring deficiencies in cross-border IP protection and collaboration. Participation in global innovation governance platforms has also been limited: in 2025, Chinese firms accounted for just 12.7% of participants in major international innovation alliances, compared to 41.3% for US firms and 35.6% for EU firms[26]. The persistent shortfall in international discourse power restricts China's ability to shape global innovation rules in ways that reflect its interests. As a result, international technical standards and IP regimes remain largely dominated by external actors, exposing Chinese enterprises to elevated compliance costs, legal risks, and structural disadvantages.

Chinese enterprises still face significant gaps in integrating global innovation resources, particularly in the strategic placement of overseas R&D networks, the cross-border mobility

---

[24] Source: US-China Economic and Security Review Commission, "US-China Competition in Emerging Technologies," 2024, https://www.uscc.gov/sites/default/files/2024-11/Chapter_3--US-China_Competition_in_Emerging_Technologies.pdf.

[25-26] Source: Grassano et al., "The 2022 EU Industrial R&D Investment Scoreboard," 13 Dec., 2022, https://iri.jrc.ec.europa.eu/scoreboard/2022-eu-industrial-rd-investment-scoreboard; Georgakaki et al., "The 2025 EU Industrial R&D Investment Scoreboard," 22 Dec., 2025, https://iri.jrc.ec.europa.eu/scoreboard/2025-eu-industrial-rd-investment-scoreboard.

中国知网 https://www.cnki.net

of high-caliber innovation talent, and active participation in international collaborative research programs. According to 2025 data, the number of overseas R&D centers established by leading Chinese firms stands at only 28.3% of the level achieved by US firms and 35.7% of that by EU firms. Moreover, these centers are predominantly concentrated in emerging markets such as Southeast and South Asia, and their presence in global innovation-intensive regions, namely North America and Europe, accounts for only 31.2%. By contrast, US and EU firms locate 78.5% and 69.3% of their overseas R&D centers[27], respectively, within these innovation hubs. This spatial mismatch substantially weakens Chinese firms' access to frontier knowledge spillovers and high-end innovation networks. Participation in international collaborative research further reflects these integration shortcomings. Between 2022 and 2024, the number of Chinese firms involved in global "Big Science" initiatives and multinational R&D alliances was only 23.1% of the US level and 29.4% of the EU level. Furthermore, such participation has been largely confined to applied technology domains, with international collaboration in basic research accounting for less than 15% of total involvement.

In terms of international talent cooperation, China's centrality score within the global inventor mobility network reached 49 in 2023, an improvement relative to 2020, yet still substantially lower than that of the United States (76) and the European Union (68). By 2024, overseas R&D personnel constituted only 6.8% of the workforce of leading Chinese firms, compared to 24.5% for US firms and 19.2% for EU firms[28]. Furthermore, international talent mobility has become more constrained: returnee growth among overseas-trained R&D personnel slowed sharply in 2023 (down 15 percentage points from 2020 levels), and the outflow risk for China's high-end domestic talent has increased. Both trends have directly eroded the talent pipeline needed for disruptive innovation (Han et al., 2024).

A significant imbalance persists in China's two-way cross-border technology flows as well, with both the quality and efficiency of technology transfer remaining suboptimal. In 2022, the ratio of technology import contract value to technology export contract value for Chinese firms stood at 3.7:1, markedly higher than the corresponding ratios of 1.2:1 for the United States and 1.1:1 for the European Union. Although this ratio declined to 3.2:1 in 2023 and further to 2.9:1 in 2024, the gap relative to advanced economies remains substantial. From a qualitative perspective, disparities are even wider. Between 2022 and 2024, core technologies accounted for only 18.6% of China's imported technologies, which were predominantly concentrated in mid-range application segments. In contrast, core technologies represented 59.7% and 48.3% of technology imports in the United States and the European Union, respectively. On the export side, Chinese technology outputs are largely concentrated in downstream digital applications and mid- to lower-tier segments of the new energy industry, with core patented technologies accounting for only 7.3% of total exports, far below the shares of 32.5% for the United States and 27.8% for the European Union. Although technology licensing transactions between Chinese firms and their US and European counterparts reached 33 deals in 2025, double the number recorded in 2019, the total transaction value amounted to only 11.2% of intra-EU licensing transactions and 8.9% of those among US firms[29]. Overall,

[27-29] Source: Grassano et al., "The 2022 EU Industrial R&D Investment Scoreboard," 13 Dec., 2022, https://iri.jrc.ec.europa.eu/scoreboard/2022-eu-industrial-rd-investment-scoreboard; Georgakaki et al., "The 2025 EU Industrial R&D Investment Scoreboard," 22 Dec., 2025, https://iri.jrc.ec.europa.eu/scoreboard/2025-eu-industrial-rd-investment-scoreboard.

中国知网 https://www.cnki.net

both the scale and technological sophistication of China's cross-border technology transfers remain limited, thus constraining the ability of international cooperation to generate efficient technological iteration and meaningful value creation.

4. Recommendations for Innovation Development during the 15th FYP Period: Deepening and Upgrading the Systematic Leapfrogging Catch-up Model

China must pursue a comprehensive deepening and upgrading of this systematic model in order to address the prominent barriers to innovation during the 15th FYP period. This entails leveraging technological complementarity as the foundation to correct resource allocation imbalances, positioning paradigm shifts as the core driver to overcome quality and efficiency bottlenecks, and strengthening ecosystem synergy as the institutional safeguard to unleash innovation vitality. Together, these coordinated efforts can help to forge a new innovation landscape characterized by nationwide coordination, source-level breakthroughs, institutional adaptability, and open, mutually beneficial cooperation.

4.1 Deepening Technological Complementarity: Constructing a Cross-Regional, Cross-Industrial, and Transnational Resource Integration System

Advancing deep-level regional technological complementarity. China should anchor efforts in building a unified national market to eliminate local protectionism and market segmentation while also establishing a robust cross-regional innovation coordination mechanism built on radiative spillovers, mutual empowerment, and equitable benefit sharing. The spillover effects of the country's major innovation hubs, such as Beijing-Tianjin-Hebei, the Yangtze River Delta, and the Guangdong-Hong Kong-Macao Greater Bay Area, must be fully harnessed. In particular, the integrated "innovation outposts + pilot testing base + industrial park" model should be scaled up nationwide. Policymakers should introduce targeted incentives, including tax preferences and revenue-sharing arrangements, to encourage enterprises from China's eastern region to transfer advanced and applicable technologies to the central and western regions. In addition, China should establish regional science and technology innovation centers and disruptive-technology pilot testing bases in the central and western regions to strengthen research infrastructure, industrial support systems, and capabilities for technology absorption and secondary innovation. For traditional industrial bases, such as those in Northeast China, innovation-driven revitalization should be accelerated through close collaboration with eastern innovation hubs, which should enable the transfer of advanced technologies and management practices to support industrial upgrades and the cultivation of emerging industries. To sustain effective cooperation, China must institutionalize strong cross-regional benefit-sharing and risk-sharing mechanisms, with returns clearly allocated based on innovation inputs and contributions. In parallel, cross-regional talent-sharing platforms, including joint appointments, exchange programs, and co-established training bases should be promoted to facilitate the free flow of innovation talent and knowledge diffusion. These measures can help to address regional talent imbalances and unlock the full potential of nationwide technological complementarity.

Strengthening inter-industry technological integration and multi-actor collaboration. China

中国知网 https://www.cnki.net

should prioritize strategic domains facing "chokepoint" constraints, including integrated circuits, industrial machine tools, and high-end scientific instruments, by establishing innovation consortia led by flagship enterprises and supported by upstream/downstream partners, universities, and research institutes. These consortia must break through technical barriers in foundational materials, core components, software systems, and related links to build strong full-chain innovation capacity. Concurrently, digital and green technologies should penetrate deeply into traditional industries, and emerging sectors must actively absorb engineering expertise and process know-how from established ones, creating a two-way empowerment dynamic that upgrades legacy industries and scales new ones. Looking forward, strategic positioning in frontier fields such as quantum technologies and brain-computer interfaces is essential. Establishing early complementarity channels that link future and existing industries will secure critical technologies and application scenarios ahead of time. Finally, enterprises should be encouraged to pursue cross-industry R&D, with targeted support for collaborative innovation across science-based, scale-intensive, and supplier-driven sectors, expanding application frontiers and fostering cross-domain knowledge fusion conducive to disruptive breakthroughs.

Expanding diversified international technological cooperation. China must pursue a balanced approach of "bringing in" and "going out" that deepens cooperation with developed countries in basic research through joint laboratories and collaborative efforts on frontier scientific problems. Additionally, Belt and Road science and technology cooperation should be intensified in advantageous fields such as new energy and 5G by launching demonstration projects that promote technology export, joint standard development, and capacity building, thereby enhancing the global influence of China's independent innovations. Enterprises should be encouraged to set up R&D centers in overseas innovation hubs, engage in major international big science programs and multinational R&D alliances, and establish high-level joint laboratories and technology transfer centers to integrate global resources and counter pressures from international technological containment. Active participation in ISO, IEC, ITU, and other standardization bodies is essential for leading or contributing to international technical standards and advocating fair global IP protection systems, thereby strengthening China's voice in global innovation governance. Finally, robust mechanisms must be built to address high-tech frictions, including a monitoring and early-warning platform, coordinated responses from government, enterprises, and industry associations, enhanced corporate compliance training and certification, and firm opposition to trade protectionism and technological blockades via multilateral frameworks to safeguard legitimate enterprise rights and interests.

4.2 Focusing on Paradigm Shifts: Strengthening Systemic Leadership in Disruptive Innovation

China should prioritize paradigm shifts by consolidating the foundations of original innovation, overcoming critical technological bottlenecks, and breaking entrenched path dependencies, thereby enabling disruptive innovation to reconfigure technological systems and industrial structures, propelling the leap from catch-up to parallel advancement and eventual global leadership.

To solidify the base of basic research and original innovation, sustained increases in basic research funding are essential. Specifically, this funding target should be a share exceeding 15% of total R&D expenditure by the end of the 15th FYP to approach levels in advanced economies. Basic

中国知网 https://www.cnki.net

research layout should be optimized by bolstering the concentrated R&D capabilities of National Laboratories and Frontier Science Centers, with focused support for frontier domains including quantum science, life sciences, and foundational AI theories. A long-cycle, originality-first evaluation system must replace quantity- and publication-centric metrics, granting researchers greater autonomy in technical directions and funding use, and failure-tolerant mechanisms should be instituted to encourage high-risk, high-reward original work and nurture disruptive innovation at the source.

Furthermore, to surmount core technological bottlenecks, China should, by leveraging the new-type national system, integrate innovation resources from enterprises, universities, and research institutes to establish cross-departmental and cross-regional consortia for disruptive breakthroughs. Specialized funds, modeled on the National Integrated Circuit Industry Investment Fund, should target chokepoint areas such as semiconductors, EDA software, and high-end GPUs and employ "open competition" and "horse-racing" mechanisms to concentrate resources on full-chain attacks. Scientific infrastructure must be strengthened through expanded proof-of-concept and pilot-scale platforms to bridge the persistent gap from laboratory outcomes to industrial products. Market demand should be harnessed by opening large-scale application scenarios in smart manufacturing, intelligent transportation, and healthcare, accelerating iterative upgrades and paradigm transitions.

To dismantle technological path dependency, coordinated policy guidance and market mechanisms should facilitate smooth transitions between old and new paradigms. In energy and manufacturing sectors, fiscal subsidies, tax incentives, and market-access policies should favor emerging paradigms while constraining outdated ones. Traditional industries should be propelled toward high-end, intelligent, and green transformation through integration of AI, industrial robotics, and new energy technologies. Market forces should play their decisive role through strengthened oversight and fair competition rules that prevent monopolies from blocking new paradigm diffusion, and enterprises should be encouraged to explore frontier technologies and reduce reliance on mature paths in order to foster diversified technological development.

Finally, to enhance patent quality and international standard-setting discourse power, China should establish synergistic mechanisms that link R&D, patent strategy, standard formulation, and industrial application, directing innovation actors toward high-value patent deployment around core technologies and curbing low-quality patents. In comparative-advantage fields such as AI, quantum communication, and new energy, China should lead international standard formulation, embed indigenous innovations into global rules, and cultivate proprietary-standard-based ecosystems. The national standards system should align more closely with international best practices, with deeper participation by enterprises and universities in global standardization activities, thereby consolidating technological leadership through strengthened normative influence in international governance.

4.3 Strengthening Ecosystem Synergy: Refining the Institutional Support and Guarantee System

To optimize ecosystem synergy, China must prioritize institutional reform, enhanced factor support, and the cultivation of a supportive innovation environment. These efforts can work together to create a high-efficiency, stable, and sustainable institutional foundation for technological complementarity and paradigm shifts.

Deepening reforms of the science and technology system and its evaluation mechanisms.

中国知网 https://www.cnki.net

China should continue advancing the "Three Evaluations" reform by establishing a performance-based assessment framework centered on innovation capability, quality, effectiveness, and real-world contribution. This requires a decisive break from evaluation practices dominated by publication counts, patent numbers, and awards. Enterprises should be further consolidated as the primary drivers of technological innovation. Leading firms should be encouraged to take charge of major national science and technology projects, with expanded autonomy over funding allocation and technological roadmaps to enhance market-oriented innovation efficiency. A clearly defined fault-tolerance and error-correction framework should be established for high-risk, long-cycle disruptive innovation activities. By adopting long-horizon, outcome-oriented tracking evaluations, policymakers can remove institutional pressures on researchers and enterprises, reduce innovation-related anxieties, and incentivize the pursuit of transformative, high-impact research.

Improving intellectual property protection and commercialization system. Protection for core technologies and original innovations must be significantly strengthened. Strict enforcement of punitive damages for patent infringement, faster litigation timelines, and higher infringement costs can improve enforcement credibility and safeguard innovators' legitimate rights. Dedicated fast-track examination channels should be created for disruptive patents, particularly in frontier fields such as artificial intelligence and quantum information. Tailored examination standards and streamlined review processes can substantially accelerate patent approval in emerging domains, and national-level intellectual property trading platforms and valuation centers should be developed to integrate services such as patent navigation, transaction facilitation, and commercialization support. Benefit-sharing mechanisms for researchers should also be refined to improve the market-based conversion efficiency of research outputs.

Optimizing technology finance and talent support systems. A full-lifecycle financing ecosystem should be built that encompasses angel investment, venture capital, industrial funds, and capital markets. A National Disruptive Innovation Guidance Fund should be established to channel social capital toward basic research and frontier technologies. Financial innovations, including intellectual property-backed lending and technology insurance, should be expanded alongside risk-sharing and compensation mechanisms in order to raise financing accessibility for technology-based small and medium-sized enterprises. The "hard technology" orientation of the STAR Market should be further clarified, and differentiated institutional arrangements for the ChiNext Board and Beijing Stock Exchange should be refined to support pre-profit firms with core technologies. Talent policies should prioritize the cultivation and global recruitment of top-tier leaders in frontier fields such as AI and quantum science, along with improved facilitation of cross-border mobility. Universities and research institutes should expand interdisciplinary innovation programs to nurture composite talent profiles. The promotion of the scientific spirit, the entrepreneurial spirit, and craftsmanship can help foster a social ethos that encourages innovation while still tolerating failure, thereby strengthening the foundation of the national innovation workforce.

5. Concluding Remarks

The 14th FYP period witnessed China's successful establishment of, a systematic leapfrogging catch-up model for innovation, characterized by technological complementarity as the foundation,

中国知网 https://www.cnki.net

paradigm shifts as the core, and ecosystem synergy as the safeguard. This model has enabled a critical transition from extensive scale expansion to simultaneous improvements in quality and efficiency and provided an effective pathway for technological catch-up in latecomer economies. The mutually nested and reinforcing interaction among these three dimensions has significantly elevated R&D intensity, patent quality, and the strategic capacity of China's innovation clusters.

Looking ahead to the 15th FYP period, further deepening and upgrading this systematic model are essential to achieving a new wave of technological breakthroughs. Technological complementarity must evolve toward comprehensive national-level integration. Paradigm shifts should be strengthened through coordinated, system-wide leadership, and ecosystem synergy must place greater emphasis on institutional innovation. The synchronized advancement of these three dimensions can help overcome persistent bottlenecks in core technologies and address regional imbalances in innovation capacity.

In the future, China must integrate into the global innovation network with greater openness, expand strategic space through technological complementarity, seize first-mover advantages through paradigm shifts, and consolidate collective strength through ecosystem synergy. These efforts are expected to accelerate the emergence of disruptive innovations, inject powerful momentum into the development of new quality productive forces, and provide a solid technological foundation for realizing socialist modernization by 2035.

References:

Atkinson R. D. China Is Rapidly Becoming a Leading Innovator in Advanced Industries[R]. Information Technology and Innovation Foundation, 2024.

Boeing P., Brandt L., Dai R., et al. The Anatomy of Chinese Innovation: Insights on Patent Quality and Ownership[R]. IZA Discussion Paper, 2024.

Castro D., McLaughlin M. Who Is Winning the AI Race: China, the EU, or the United States?[R]. Information Technology and Innovation Foundation, 2021.

Deng S. Y. Further Promoting Deep Integration of Industry, Academia, and Research [N]. Guangming Daily, 2026(2).

Han P. F., Jiang W., Mei D. Q. Mapping US–China Technology Decoupling: Policies, Innovation, and Firm Performance[J]. Management Science, 2024 (12): 8386-8413.

Medvedev D., Piatkowski M. M., Yusuf S. Promoting Innovation in China: Lessons from International Good Practice[R]. World Bank, 2020.

Parker E., Gonzales D., Kochhar A. K., et al. An Assessment of the US and Chinese Industrial Bases in Quantum Technology[R]. RAND Corporation, 2022.

Ye J. J., Zhou X. Y., Chen S. Innovation Transformation of Basic Research Investment, Evidence Based on Funding from the National Natural Science Foundation of China [J]. China Economic Quarterly, 2021(6): 1883-1902.

Zheng J. H., Chen Z., Kang L. L. Changes in International Technological Complementarity and Their Impact on Cross-Border Mobility of Inventive Talent, An International Technological Discovery Hypothesis and Test [J]. China Industrial Economics, 2022(4): 23-41.

Zheng J. H., Chen Z., Sun Z. Y., et al. From Competition to Complementarity: Measurement and Theoretical Hypothesis of Regional Technological Structure Change [J]. Economic Review, 2022(1): 13-29.

Zheng J. H., Jin S. N. Interregional Technological Complementarity, Balanced Development, and Enterprise Upgrading in Global Value Chains [J]. China Industrial Economics, 2024(7): 85-104.

中国知网 https://www.cnki.net