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# 人才、创新与产业链韧性报告

# TALENT, INNOVATION AND RESILIENCE OF INDUSTRIAL CHAINS REPORT 2023

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CCG 全球化智库
CENTER FOR CHINA & GLOBALIZATION

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# 引　言

全球产业链是经济全球化过程中，世界各国企业在细化分工合作过程中按照生产要素高效自由流动、资源优化配置等市场经济原则形成的有效运行形态，符合经济社会发展规律。当前，世界百年未有之大变局加速演进，世纪疫情影响深远，多重挑战和危机交织叠加，经济全球化遭遇逆流，全球产业链安全稳定面临风险和挑战。维护全球产业链韧性是推动世界经济发展的重要保障，符合世界各国人民共同利益。

中国政府高度重视产业链供应链安全稳定。党的二十大报告明确提出，要“着力提升产业链供应链韧性和安全水平”。确保产业链稳定和安全，提升产业链现代化水平，有助于降低“卡链”“断链”风险，为产业迈向全球价值链中高端夯实基础。2022 年中央经济工作会议进一步强调要“着力补强产业链薄弱环节”“产业政策要发展和安全并举”。2023 年 5 月，习近平在二十届中央财经委员会第一次会议上强调指出，要用好我超大规模市场优势，把扩大内需战略和创新驱动发展战略有机结合起来，加强产业链供应链开放合作。

产业链的形成是国际贸易投资与经济合作长期发展、国际劳动分工不断深化的结果。在全球化背景下，链条中一个“断点”的出现可能导致整个链条低效甚至瘫痪，不仅影响本国经济，也会引起全球经济发展不稳定。[①]在“百年未有之大变局”中，世界经济发展的不稳定性、不确定性日益突出，全球产业链体系面临重构。如何维护、保障产业链的安全稳定，提升其韧性，已成为各国面对的共同挑战和重大课题[②]。

国家的产业链韧性与该国产业部门的健全程度、进出口渠道的多元性、适配性等多种 因素相关，其中，人才资本、创新资源对增强产业链韧性至关重要。党的二十大报告提出要推动创新链产业链资金链人才链深度融合，习近平总书记

① 中国政府网, https://www.gov.cn/xinwen/2021-11/11/content_5650246.htm.
② 中国政府网, https://www.gov.cn/xinwen/2022-09/21/content_5710853.htm.

也多次强调围绕产业链部署创新链、围绕创新链完善资金链、部署并完善人才发展机制的重要性[①]。本报告试图通过数据分析，深入探索人才与创新对增强产业链韧性的作用。

本报告选取了人才资本、创新资源、产业总体情况、制造业表现和企业活力等 5 个一级指标和 22 个二级指标，构建国家产业链韧性指数。基于国家产业链韧性指数，报告分析了中国、美国、加拿大、英国、法国、德国、澳大利亚、新西兰、日本、韩国、新加坡、印度等 38 个国家的产业链韧性的国际定位，以及人才资本、创新资源、产业总体情况、制造业表现、企业活力五个方面对产业链韧性贡献的国际比较。报告重点对中国在 5 项指标上的表现进行了分析，并以新能源汽车产业链和半导体产业链为案例，分析人才与创新对相关产业链韧性的影响。基于国际比较与案例研究，报告就产业链韧性提升提出相关建议，以期为共同构筑安全稳定、畅通高效、开放包容、互利共赢的全球产业链体系提供参考。主要建议包括：其一，秉持合作开放的原则，推动有利于全球产业共御风险的规则体系进一步完善；其二，搭建产业链韧性交流平台，形成常态化沟通机制；其三，推动创新链、产业链、人才链和资金链四链融合，最大限度发挥我国市场规模化优势，完善我国在战略产业上的生态系统；其四，加强数字化转型，提升产业链的可预见性与适应性；其五，以有效的宏观政策改善市场环境，以强化我国在关键产业上的薄弱环节。

① 国家发展和改革委员会，
https://www.ndrc.gov.cn/xwdt/ztzl/srxxgcxjpjjsx/xjpjjsxjyqk/202304/t20230410_1353461.html.

# 第一章 国家产业链韧性指数

本章按简约、可预测和国际可比的原则，建立主要国家产业链韧性评价指标体系，对相关国家的产业链韧性进行评价。

## 一、国家产业链韧性评价指标体系构建

### （一）国家产业链韧性内涵

国家产业链韧性是以国家作为主体单位，表示在面临外部破坏性事件或链条内部出现问题时，产业链仍能保持动态平衡、对破坏性事件做出积极反应，并最终恢复常规运转的一种复杂的适应性能力。在突发性公共卫生事件席卷全球的2020 年，以及在世界经济形势下行、国际地缘政治风险加剧的如今，国家产业链韧性反映了各国企业、行业和国家在面临或在将要面临不确定性和风险时，保持经济稳定和持续发展的能力。

本评价选择包括中国在内的世界上 38 个国家，包括二十国集团（G20）国家（“欧盟”虽为 G20 成员，但作为欧洲经济、政治共同体，其成员国与 G20 成员国家有重叠，故未单独作为一个经济体纳入评价），大多数人口超过 1000 万且人均 GDP 超过 1 万美元的国家（亦包含人均 GDP 不足 1 万美元的少数 G20 国家）；少量人口不足 1000 万人但超过或接近 500 万人且人均 GDP 为 4 万美元以上的发达国家（高收入国家）。本评价体系选择的 38 个国家 2022 年的人口和 GDP 之和分别占当年全世界的 62.16%和 87.92%[①]。

### （二）国家产业链韧性指标体系

本指标体系资料来源主要包括：世界银行（WB）WDI 数据库、世界银行 Doing Business Data 数据库、联合国国际劳工组织（ILO）数据库、联合国教科文组织

① 数据源自世界银行数据库 2022 年数据。

（UNESCO）数据库、《胡润》世界独角兽榜单、2020 年 QS 世界大学排名 1000 强榜单、欧盟数据库（Eurostat）、经合组织（OECD）数据库、联合国贸易和发展会议（UNTCAD）数据库。

报告选用反映 2020 年情况的数据，主要数据指标覆盖年度为 2019 年至 2021 年。数据选用标准主要考虑以下主要因素：首先是数据需要能反映出近年最新的产业链供应链体系韧性变化。众所周知，2020 年新冠肺炎疫情在全球暴发，严重扰乱了全球产业链供应链的运行。同期，国际地缘政治剧烈变化增加了不确定性，气候变化推动新能源产业迅速发展，使传统产业发生重大调整，全球产业链面临重塑。2019 年至 2021 年三年的数据较大程度上反映出了这些变化对产业链供应链的影响。

其次，数据需要具有获得性、一致性和完整性。相对而言，本报告应用的数据库所提供的绝大部分数据更新至 2020 年，少量数据更新至 2021 年和 2022 年。部分数据库缺失个别国家的个别数据，所缺失数据主要通过该国相应统计部门的数据、伊比利亚-美洲科技指标网络 RICYT[①]数据库补齐。2021 年、2022 年的数据因其完整性不足，加上乌克兰危机带来更加复杂的影响，故课题组对这一年的数据不予整体纳入统计。

本研究建立的“国家产业链韧性指标体系”涵盖了人才资本、创新资源、产业总体情况、制造业表现和企业活力等 5 项一级指标以及 22 项二级指标。

## 1. 人才资本指标

人才资本指标是衡量不同国家人才储备实力、人才培养能力、人才吸引能力、人才创造性等方面情况的主要指标。该指标包括“劳动生产率”、“劳动人口数量”、“受过高等教育的劳动年龄人口比重”、“国际学生流入数”、“公共教育经费支出占本国国内生产总值比重”等 5 项二级指标。

“劳动生产率”这一指标来自世界银行世界 WDI 数据库中的“就业人员人均国内生产总值”，反映就业人员对经济增长的贡献。“劳动人口数量”是对国家劳动力资源及人口红利的反映，充足的劳动力资源是产业稳定发展的基础，有

① 全称为 The Ibero-American Network of Science and Technology Indicators。

竞争力的劳动力资源对外商投资也有较强的吸引力。“受过高等教育的劳动年龄人口比重”这一指标由国际劳工组织数据库中“受过高等教育的劳动年龄人口数量”、“劳动年龄人口数量”两个指标计算得到，是高素质人才储备实力的直接反映。“国际学生流入数”这一指标是指该国高等教育机构接收的国际学生数量，反映了该国对国际人才的吸引力。“公共教育经费支出占本国国内生产总值比重”指标反映了政府在基础教育、中等教育及高等教育的重视程度和支持力度，反映了该国人才培养的投入力度以及劳动生产率提升的潜力。

### 2. 创新资源指标

创新资源指标是衡量不同国家创新投入、创新产出的主要指标。该指标包括“专利授权总数”、“科技期刊论文数”、“每百万居民中研发人员全时当量”、“研究与开发经费支出占本国国内生产总值比重”、“世界大学 1000 强评分”等 5 项指标。

“专利授权总数”与“科技期刊论文数”是创新成果的直接反映。“专利授权总数”即直接授权和 PCT 国家阶段授权的专利授权总数之和。“科技期刊论文数”指在物理学、生物学、化学、数学、临床医学、生物医学研究、工程与技术以及地球和空间科学领域发表的科学和工程文章数量。“每百万居民中研发人员全时当量”指在某一年度内 100 万人口中从事研发工作的专业人员数量，是创新人员投入的直接反映。“研究与开发经费支出占国内生产总值的比重”反映了政府与企业在创新上的投入。“世界大学 1000 强评分”指标主要反映该国大学的创新潜力和创新人才储备能力。

### 3. 产业总体情况指标

产业总体情况指标是衡量不同国家产业发展总体情况的主要指标。该指标包括“国内生产总值”、“货物与服务总出口值”、“外国直接投资流量”、“2020 年外国直接投资流量增长率”、“对外直接投资流量”、“2020 年对外直接投资流量增长率”等 6 项二级指标。

“国内生产总值”与“货物与服务总出口值”两项指标直接反映国家的产业发展成果及对外贸易的情况。“外国直接投资流量”反映了该国可利用外资规模

以及对国际投资的吸引力，“对外直接投资流量”则反映了该国的国际竞争力及融入全球产业链的情况。“2020 年外国直接投资流量增长率”指 2020 年外商直接投资相较于 2019 年的同比增长情况。“2020 年对外直接投资流量增长率”指 2020 年对外直接投资流量相较于 2019 年的同比增长情况。这两项指标反映了在受到新冠疫情冲击后，该国吸引外资、对外投资的变化情况。

### 4. 制造业表现指标

考虑到产业链更多体现在制造业领域，本指标体系把制造业表现作为一项一级指标。制造业表现指标主要衡量不同国家制造业的表现情况。该指标包括“制造业增加值”、“中高技术制造业增加值占制造业增加价值的比重”、“中高端制造业出口占制造业总出口的比重”等 3 项二级指标。“制造业增加值”是制造业发展情况的直接反映，“中高技术制造业增加值占制造业增加价值的比重”反映制造业的核心竞争力，“中高端制造业出口占制造业总出口的比重”反映制造业在国际市场的竞争力水平。

### 5. 企业活力指标

企业活力指标是从企业发展成效、新创企业创办情况、企业成长环境等方面衡量不同国家企业发展活力的指标。该指标包括“独角兽企业数量”、“每年新注册公司数量”、“营商环境得分”等 3 项二级指标。

“独角兽企业数量”主要反映了某国企业发展潜力。“每年新注册公司”反映了某国新创企业的情况，直接反映了市场创新活力，“营商环境得分”指标反映了该国在维护产业链稳定、支持产业链上企业发展等方面的制度保障情况。

本报告对基于上述指标构建的“国家产业链韧性评价指标体系”，采用层次分析法（AHP），确定了各二级指标的权重，见表 1.1。

**表 1.1 国家产业链韧性评价指标体系**

| 一级指标 | 一级指标权重 | 二级指标 | 平均权重 | 数据来源 |
|---|---|---|---|---|
| 人才资本 | 0.230 | 劳动生产率（美元/人） | 0.043 | WDI |
| | | 劳动人口数量（人） | 0.041 | WDI |
| | | 受过高等教育的劳动年龄人口比重（%） | 0.046 | ILO |
| | | 国际学生流入数（人） | 0.031 | UNESCO |
| | | 公共教育经费支出占本国国内生产总值比重（%） | 0.041 | WDI, WIPO GII Report |
| 创新资源 | 0.179 | 专利授权总数（件） | 0.048 | WIPO |
| | | 科技期刊论文数（篇） | 0.035 | WDI |
| | | 每百万居民中研发人员全时当量（人/年） | 0.045 | UNESCO |
| | | 研究与开发经费支出占本国国内生产总值比重（%） | 0.054 | WDI, WIPO GII Report |
| | | 世界大学 1000 强评分（分） | 0.033 | QS |
| 产业总体情况 | 0.272 | 国内生产总值（以现价美元衡量，百万美元） | 0.051 | WDI |
| | | 货物与服务总出口值（以现价美元衡量，美元） | 0.048 | WDI |
| | | 外国直接投资流量（百万美元） | 0.052 | UNTCAD |
| | | 2020 年外国直接投资流量增长率（%） | 0.050 | 通过 UNTCAD 数据计算得到 |
| | | 对外直接投资流量（百万美元） | 0.038 | UNTCAD |
| | | 2020 年对外直接投资流量增长率（%） | 0.034 | 通过 UNTCAD 数据计算得到 |
| 制造业表现 | 0.180 | 制造业增加值（亿美元） | 0.061 | WDI |
| | | 中高技术制造业增加值占制造业增加价值的比重（%） | 0.063 | WDI |
| | | 中高端制造业出口占制造业总出口的比重（%） | 0.055 | WDI |
| 企业活力 | 0.139 | 独角兽企业数量（家） | 0.053 | 《2020 全球独角兽榜》 |
| | | 每年新注册公司数量（家） | 0.033 | WDI |
| | | 营商环境得分（分） | 0.045 | World Bank Doing Business Data |

注：“WDI”即世界银行 WDI 数据库,“WIPO”即世界知识产权组织数据库，《2020 全球独角兽榜》即胡润研究院发布的《2020 全球独角兽榜》，“QS”即 2020 年 QS 世界大学排名 1000 强榜单。

## 二、世界主要国家产业链韧性评价

依据相关数据进行测算，得到上述 38 个国家 2020 年的产业链韧性的国际定位，以及在人才资本、创新资源、产业总体情况、制造业表现、企业活力五个方面对产业链韧性的贡献的国际比较结果。

从总体情况来看，38 个国家产业链韧性根据得分可分为若干梯队。第一梯队是排名前十的国家。美国大幅度领先，与第二名中国拉开差距，美国得分为中国 1.2 倍。德国、日本、新加坡分列第三至第五，得分在 0.35-0.38 之间；三国表现旗鼓相当，但与美国的差距更明显，得分仅为美国的一半出头。第六至第十名的韩国、英国、瑞典、以色列、法国的指数分值在 0.3-0.35 之间。前十名中，欧美国家 5 个，亚洲国家 5 个，数量上平分秋色。可以看到，亚洲国家的产业发展也具有较强韧性。

排名第 11～17 的加拿大、比利时、丹麦、瑞士、爱尔兰、芬兰、奥地利等 7 个欧美国家处于同一档次，属第二梯队，分值在 0.25-0.3 之间。排名第 18～24 的澳大利亚、西班牙、挪威、捷克、印度、墨西哥、葡萄牙等 7 国处于同一档次，属第三梯队，分值在 0.23-0.24 之间。排名第 25～30 的马来西亚、波兰、俄罗斯、意大利、沙特阿拉伯、荷兰等 6 国处于第四梯队，分值在 0.2-0.22 之间。排名第 31～38 的土耳其、巴西、新西兰、希腊、南非、印度尼西亚、阿根廷、智利为后 8 名，竞争力指数在 0.13-0.2 之间。后三个梯队各国的产业链韧性指数得分相差不大。但是，排名首位的美国的产业链韧性指数是排在末位的智利的 5.4 倍。详见图 1.1。

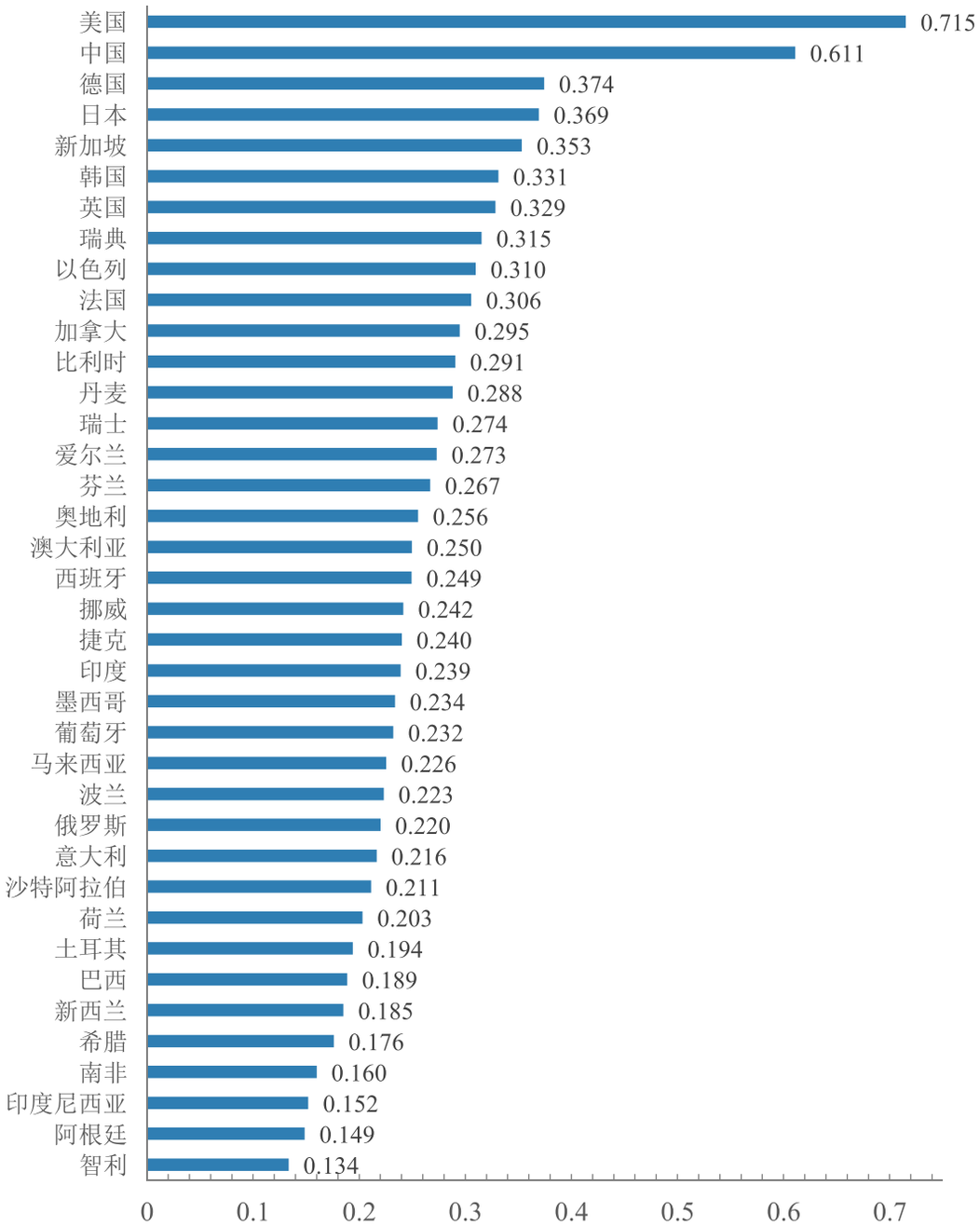


**图 1.1　38 国产业链韧性指数（总体情况）的国际排序**

在人才资本方面，美国排名第一，优势突出；加拿大、澳大利亚、英国分列第二至第四。爱尔兰在“劳动生产率”这一指标方面排名第一，主要原因是该国的税收政策吸引了大量高附加值企业，尤其是 ICT 企业和研发机构前来投资；新加坡紧随爱尔兰排名第二也有这方面的因素。沙特阿拉伯在“公共教育经费支出占本国国内生产总值比重”这一指标上排名第一，瑞典、以色列紧随其后。正因为个别二级指标表现突出，综合结果显示爱尔兰和沙特阿拉伯两国在人才资本方

面整体表现较好。详见图 1.2。

在“劳动人口数量”这一指标方面，中国、印度分列第一和第二，远高于其他各国。在“受过高等教育的劳动年龄人口比重”这一指标上，加拿大排名第一，新加坡、韩国、俄罗斯紧随其后。在“国际学生流入数”这一指标上，美国遥遥领先，与排名第二的英国、排名第三的澳大利亚拉开较大距离。

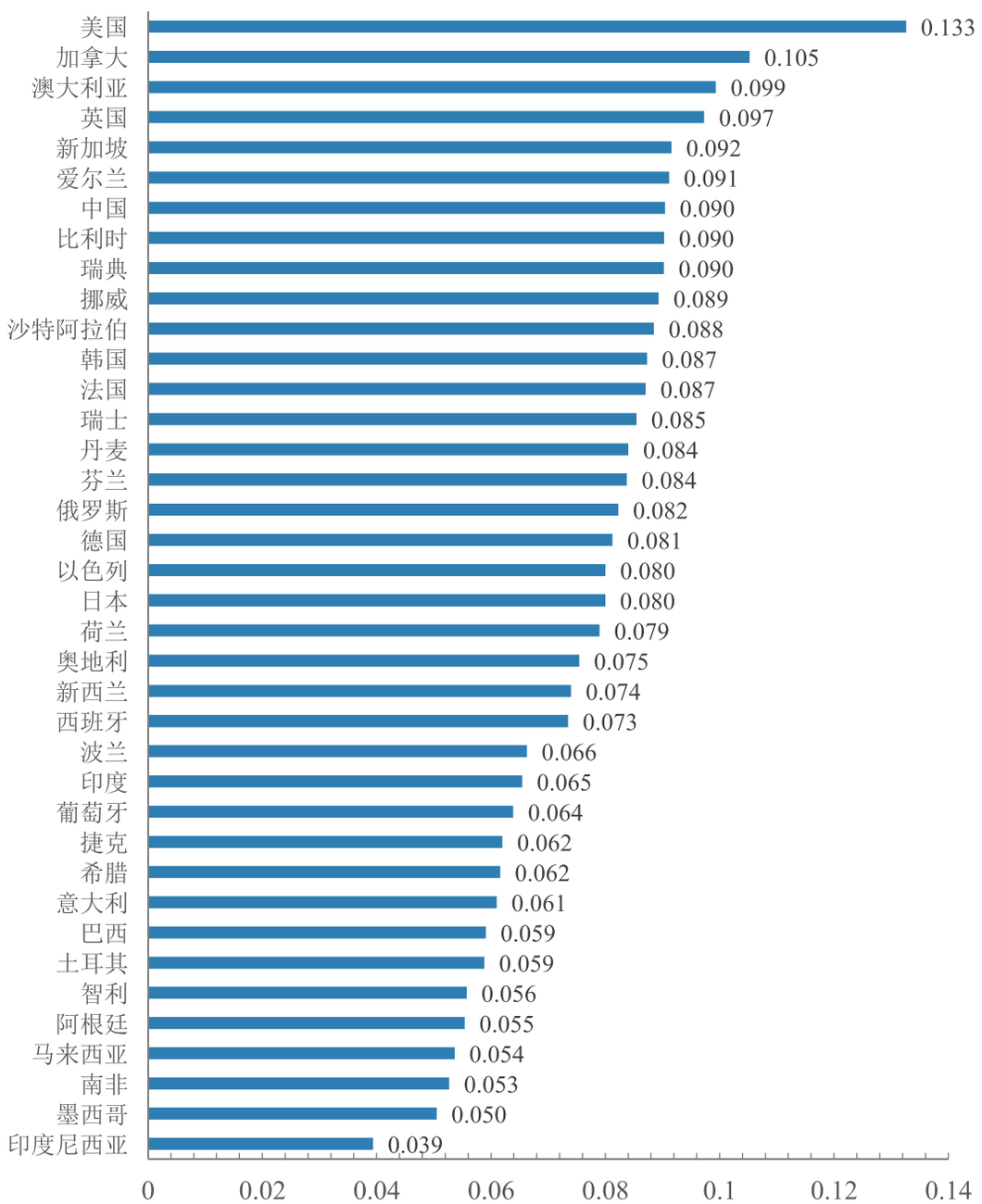


**图 1.2　38 国人才资本指数的国际排序**

在创新资源方面，美国和中国位列前二，美国得分为中国的 1.2 倍；日本、韩国、以色列三国得分差距小，排在第三至第五。与其余各国相比，美国和中国有明显优势，美国得分为排名第三的日本的得分的 1.93 倍。详见图 1.3。

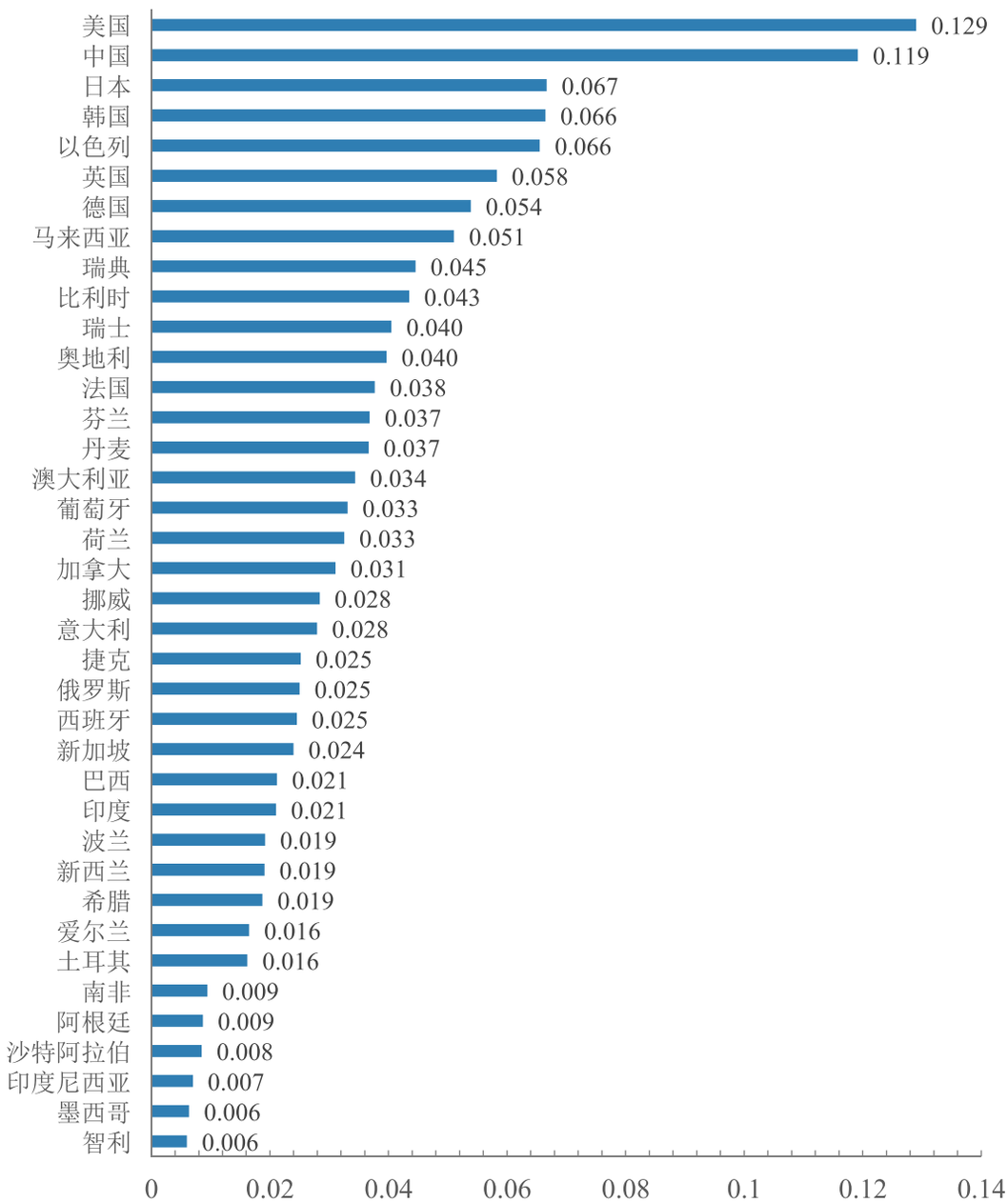


**图 1.3　38 国创新资源指数的国际排序**

在“专利授权总数”方面，中国得分最高，美国其次。中美两国得分远高于其余各国，日本、葡萄牙位列第二和第三。在“科技期刊论文数”方面，中国、美国依然排名前二，且优势明显，印度位列第三。在“每百万居民中研发人员全

时当量”这一指标方面，以色列排名第一，葡萄牙紧随其后。在“研究与开发经费占本国国内生产总值”这一指标上，以色列排名第一，韩国与马来西亚分列第二和第三。在“世界大学 1000 强评分”这一指标上，美国遥遥领先，英国排名第二。

在产业总体情况方面，美国、中国依然排在第一与第二的位置，且两国得分远高于排名第三的德国，中国得分为德国得分的 2.5 倍。爱尔兰产业总体情况得分排名靠前，为第 12 名，因其 2020 年外国直接投资流量为 765.7 亿美元，在“外国直接投资流量”指标方面排名第三。新西兰、瑞士和荷兰的产业总体情况得分排在第 36 至 38 名，相对靠后。具体而言，新西兰在“国内生产总值”、“货物与服务总出口”、“2020 年对外直接投资流量增长率”等三项指标上表现较差，分别排在 37 名、38 名和 36 名；荷兰虽然在“2020 年外国直接投资流量增长率”指标方面排名第一，但在“对外直接投资流量”、“2020 年对外直接投资流量增长率”等两项指标方面排在 38 名。荷兰、新西兰存在对国际贸易依赖程度较高、产业相对单一等问题，2020 年其产业发展状况受全球疫情、物流中断等影响严重。此外，瑞士则在“外国直接投资流量”、“对外直接投资流量”两项指标方面排名分别为 37 名、35 名，主要原因是瑞士金融业发达，在全球投资受疫情冲击之际资本流动性发生异常变化，影响了资本的流入和流出。详见图 1.4。

在“国内生产总值”这一指标上，美国、中国分列第一、第二，得分远高于其余各国；在“货物与服务总出口”这一指标上，中国、美国、德国排名前三，与其余各国得分拉开较大距离；在“外国直接投资流量”这一指标上，中国排名第一，美国、爱尔兰分列第二、第三；在“2020 年外国直接投资流量增长率”这指标上，荷兰排名第一。如前所述，因为特殊的政策和在资本市场当中的独特地位，爱尔兰和荷兰在资本流动在相关指标上表现突出。其排名也体现出疫情导致全球资本出现异于往常的流动变化。在“对外直接投资流量”这一指标上，美国和中国排名前二。在“2020 年对外直接投资流量增长率”这一指标上，美国排名第一，遥遥领先。

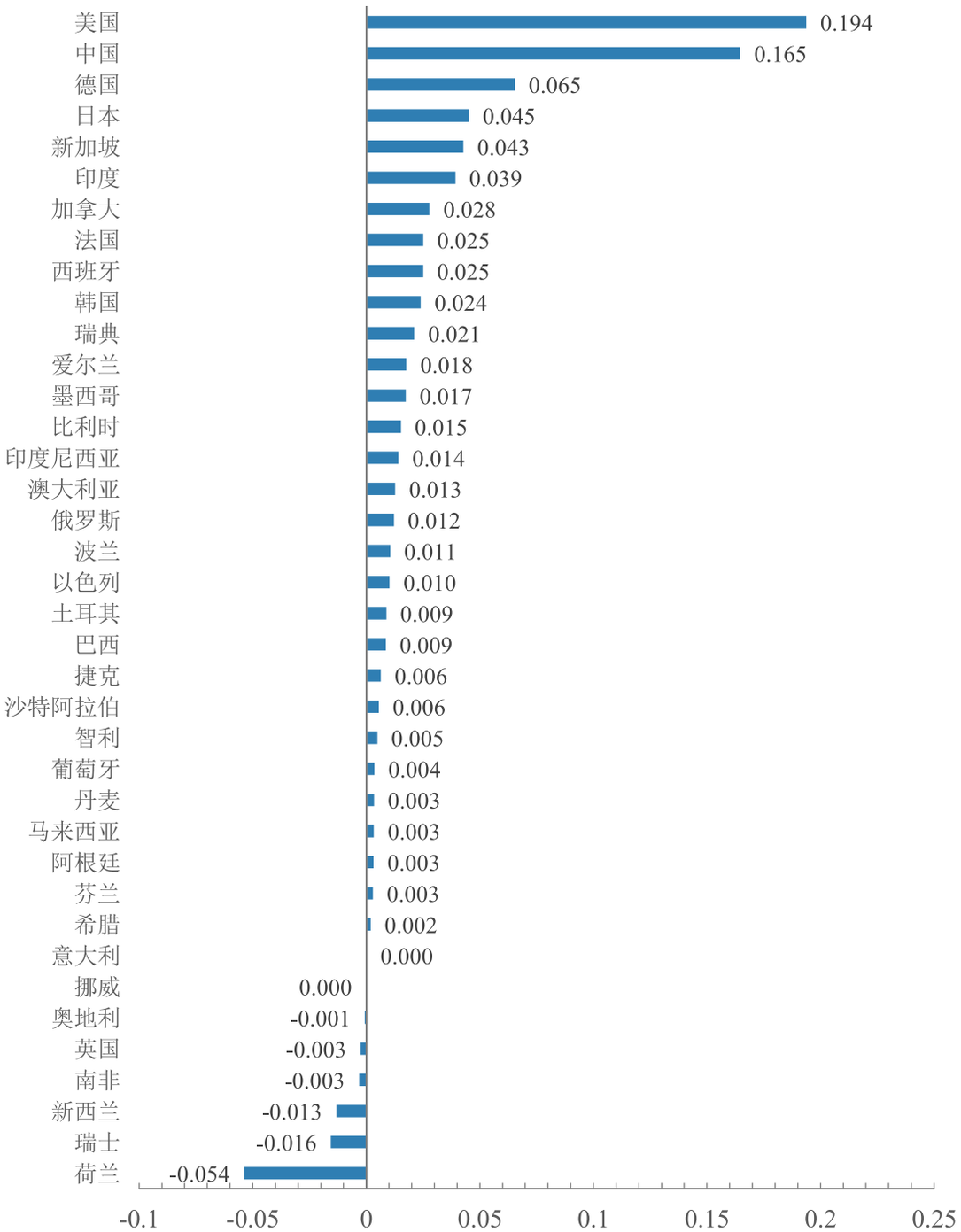


**图 1.4　38 国产业总体情况的国际排序**

在制造业表现方面，中国排名第一，排名第二的新加坡与中国的差距不大；美国、日本和德国分列第三至第五。详见图 1.5。

在“制造业增加值”这一指标上，中国遥遥领先，美国、日本、德国分列第二至第四；在“中高技术制造业增加值占制造业增加价值的比重”这一指标上，新加坡排名第一，瑞士、韩国、德国、丹麦分列第二至第五；在“中高端制造业

出口占制造业总出口的比重”这一指标上，日本排名第一，墨西哥、韩国、新加坡、德国紧随其后。

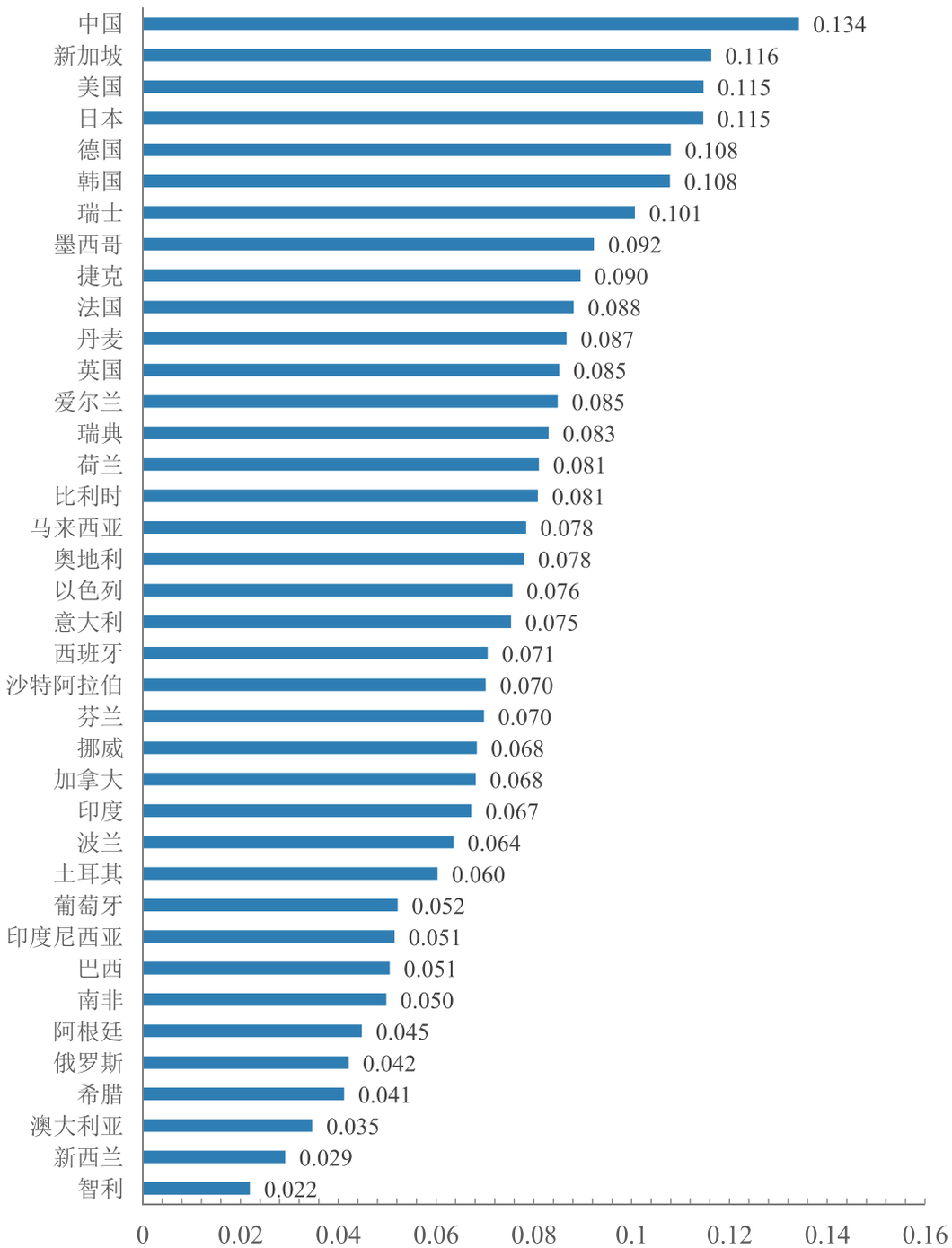


**图 1.5　38 国制造业表现指数的国际排序**

在企业活力方面，美国遥遥领先，得分为排名第二的中国的 1.3 倍；英国位列第三，与中国有一定差距，中国得分为英国的 1.36 倍。详见图 1.6。

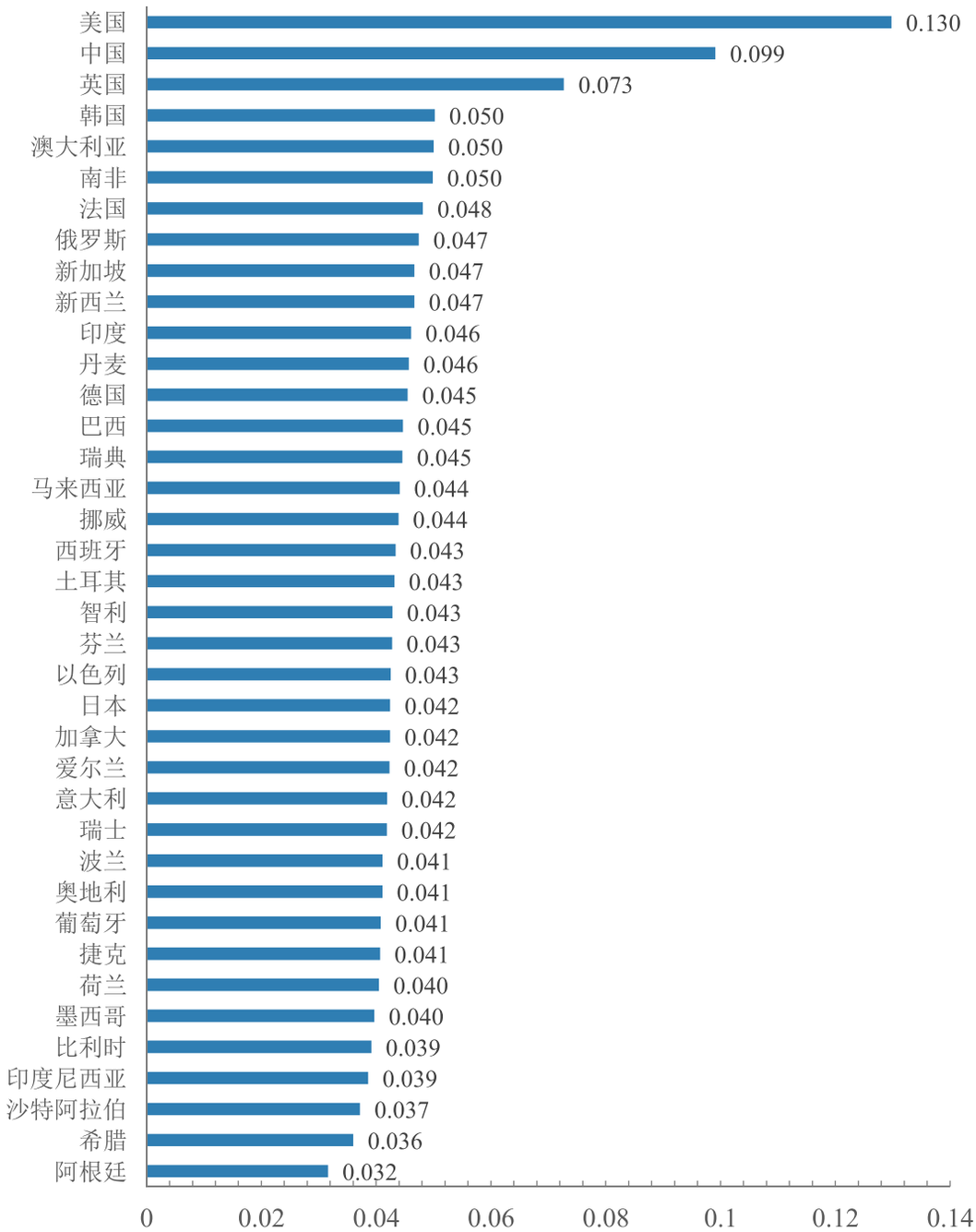


**图 1.6　38 国企业活力指数的国际排序**

在“独角兽企业数量”这一指标方面，美国和中国优势突出，美、中两国得分为排名第三至第三十八的所有国家得分总和的 4 倍。在“每年新注册公司数量”这一指标上，美国排名第一，英国、南非分列第二和第三；南非的突出表现体现了新兴市场国家的创业活力与发展潜力。在“营商环境得分”这一指标上，新西兰排名第一，新加坡、丹麦紧随其后。南非在相应指标上排名靠前与其作为

新兴经济体、市场处于成长变化中、为创业提供了有效竞争空间有一定关系。

此外，人才和创新作为推动产业链转型升级、维持产业链韧性的关键要素，能在技术日新月异、国际局势动荡的背景下，促进产业链各环节应用新兴技术，提升产业链韧性水平。从人才和创新对于维持产业链韧性的表现来看，表现最优的是美国，优势明显，得分为排名第二的中国的 1.3 倍；以色列、英国、日本分列第三、第四和第五，见图 1.7。

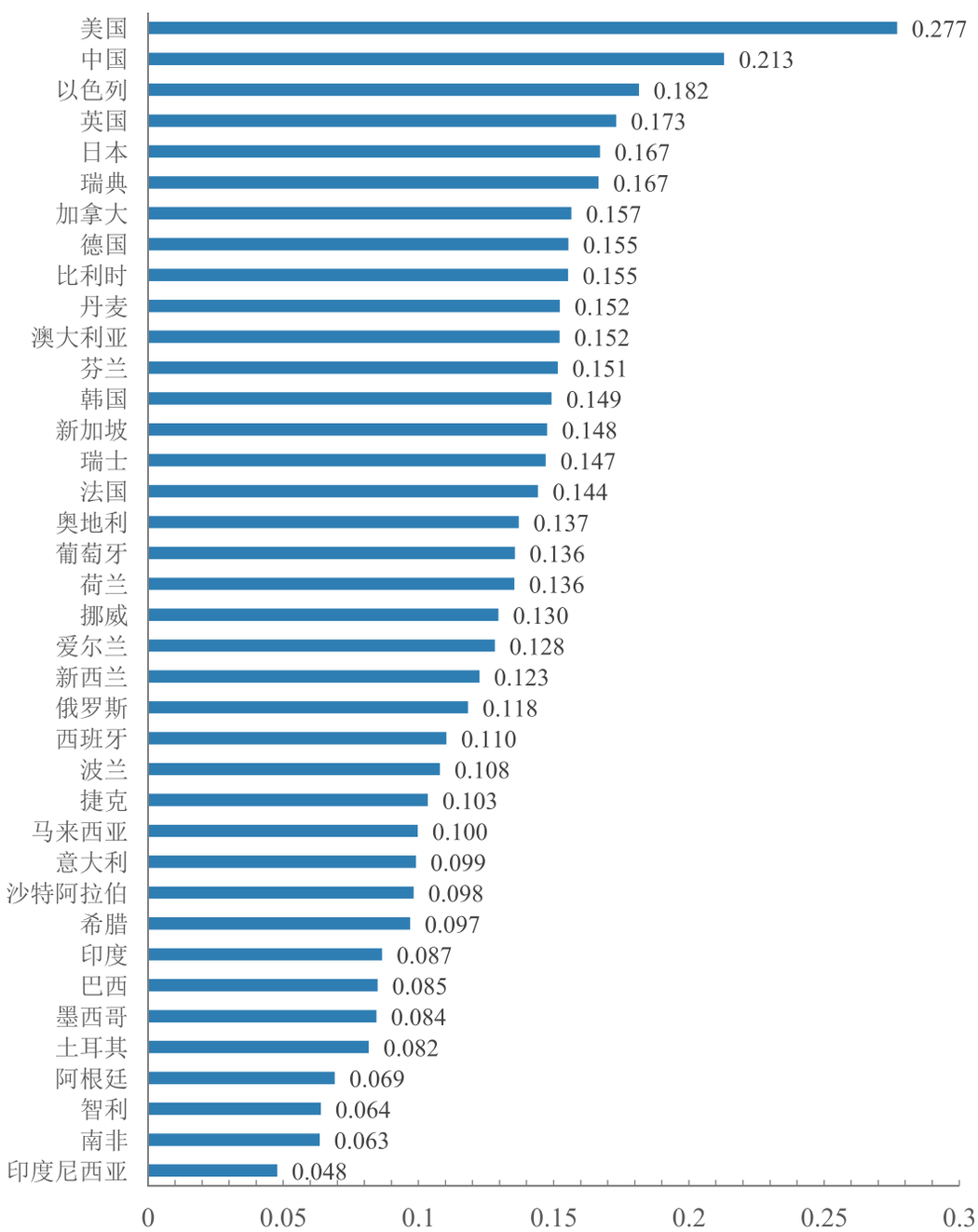


**图 1.7　38 国人才资本和创新资源指标的国际排序**

## 三、中国产业链韧性指数分析

从各个指标得分来看，以单项满分为 1 计算，中国在企业活力表现方面得分最高，得分为 0.76；其次为制造业表现，得分为 0.75，然后是产业总体情况（0.60）、创新资源（0.57）、人才资本（0.45）。

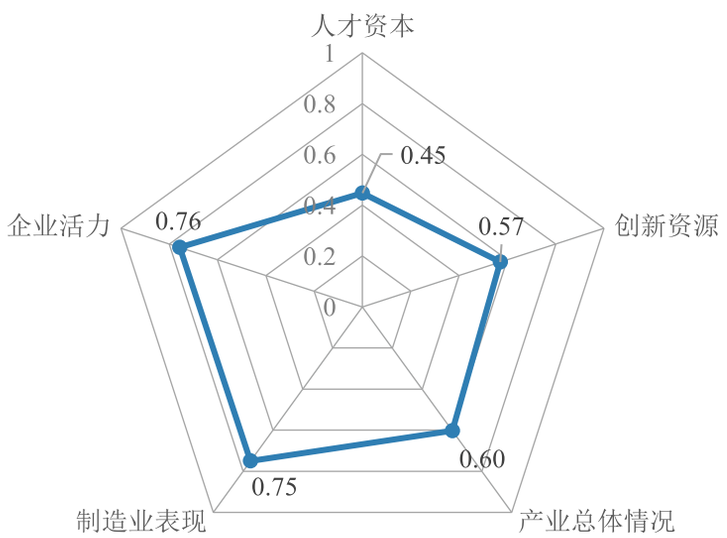


**图 1.8 中国产业链韧性指数各一级指数分值**

从世界产业链韧性指数总体排序看，中国排名第二，在美国之后，与中国的经济体量在世界上的位置相当。

在人才资本方面，中国位居第七，处于暂时弱势。一方面，这与中国公共教育经费投入不足有关，中国“公共教育经费支出占本国国内生产总值比重”这一指标的排名为第 33。另一方面，这也和中国劳动力人口基数较大相关。具体而言，中国在“劳动生产率”、“受过高等教育的劳动年龄人口比重”两项分别涉及人均比重的指标上排名分别为第 36 名、第 28 名，仍有较大的提升空间。

在创新资源方面，中国名列第二，仅次于美国。其中“专利授权总数”、“科技期刊论文数”等两项指标均排名第一，表明中国在科技产出方面具有数量优势。另外，“每百万居民中研发人员全时当量”、“研究与开发经费支出占本国国内生产总值比重”两项指标排名较低，分别为第 29 名、第 14 名，创新投入仍需持续加强；“世界大学 1000 强评分”这一指标排名为第五。

在产业总体情况方面，中国排名第二，仅次于美国。其中，“国内生产总值”、“货物与服务总出口值”两项指标的排名分别为第二和第一，体现了中国全产业链的优势。“外国直接投资流量”、“对外直接投资流量”两项指标排名分别为第一、第二，表明 2020 年疫情对全球产生严重冲击之际，相对稳定的国内环境让中国在吸引外资和对外投资方面优势明显。“2020 年外国直接投资流量增长率”、“2020 年对外直接投资流量增长率”两项指标数值均为正数，表明中国在 2020 年保持外国直接投资流量和对外直接投资流量的正增长，两项指标排名分别为第九和第七，体现了中国产业发展具有较好的稳定性。

在制造业表现方面，中国排名第一。其中“制造业增加值”指标优势明显，排名第一，“中高技术制造业增加值占制造业增加价值的比重”和“中高端制造业出口占制造业总出口的比重”两项指标排名分别为第 22 名、第 15 名，表明中国制造业发展在产业链中下游的优势明显，在产业链上游仍有发展空间。目前，我国制造业门类、品种齐全，应当在保持既有全产业链优势的情况下，努力发展高端制造业，推动中国制造业加速向高端迈进。

在企业活力方面，中国排名第二，仅次于美国。其中“独角兽企业”指标表现突出，排名第二，且中国该项得分为排名第三至第 38 的所有国家得分总和的 2 倍；“每年新注册公司数量”指标排名第五，反映了中国较强的市场活力；“营商环境得分”指标排名为 19 名，中国在优化营商环境方面仍有提升空间。

总体而言，中国产业链韧性在全球排名领先，主要原因在于中国拥有全球最大的市场与最全的产业链门类和产能，以及近些年大力支持产业高质量发展，通过补全短板产业链、升级传统产业链、建立新兴产业链，增强了产业发展的稳定性和竞争力。例如，在传统产业链升级方面，通过供给侧结构性改革，加快整合落后产能，推动传统产业改造，促进其高端化、智能化、数字化和绿色化发展，大幅降低了生产成本，提升了生产效率。在新兴产业链建立方面，结合资源禀赋和市场优势，优化了新能源汽车、新一代信息技术等新兴产业布局，推动了相关领域的稳定发展。在强大的存量支持下，中国产业链基础牢固，实力雄厚，面对整体的国际环境变化表现出了较强的韧性。

但产业链的上游关键环节，如前沿技术研发、高端基础制造工艺提升、高端装备及高端基础材料制造等环节，以及人工智能、量子计算、生物技术等新兴产业发展，还需要长期持续的基础研究投入以实现突破性创新，这也是目前中国产业链韧性指数中表现较为薄弱的方面。这对产业链带来的影响主要体现在产业升级换代存在后续发展动力供应不足，应对迅速变化的外界环境和挑战相对缓慢。

在人才链创新链国际合作受限的情况下，中国产业链韧性仍面临挑战。应对措施包括一方面加大开放交流力度，建立完善有效的国际交流、沟通平台及更高效的供应网络，另一方面需要完善人才和创新机制建设，加速推动科技、教育、产业和资金链的“四链融合”，在强化基础研究、增强自主创新能力，加强人才培养力度的同时，提升创新和人才向产业赋能的效率，进而增进产业链供应链的韧性。

# 第二章 人才与创新对中国产业链地位的影响分析

## 一、人才、创新、产业链相关概念

### （一）人力资源与人才资源

19 世纪，部分学者把人力资本归为国家竞争力的重要组成部分。德国经济学家弗里德里希·李斯特（Freidrich Liszt）在国家生产力三个层次的精神力量层次阐释中强调了激励机制和智力开发，即“人才资本”的重要性。1954 年，彼得·德鲁克（Peter F. Drucker）在其《管理实践》中首次提出“人力资源”概念，认为企业真正的资源只有人力资源，企业走下坡路的第一个信号是对那些合格的、能干的、有志向的人才失去吸引力。[①]人力资源是指能推动国民经济和社会发展、具有智力劳动和体力劳动能力的人们的总和，包括数量和质量两个方面。[②]

中国《国家中长期人才发展规划纲要（2010-2020 年）》将“人才”定义为“具有一定的专业知识或专门技能，进行创造性劳动并对社会做出贡献，为社会创造价值的人，是人力资源中素质较高的劳动者。”[③]在中国《现代汉语词典》中，“人才”意为“德才兼备的人；有某种特长的人”。人才概念的内涵体现在四个方面：一是专业性，具有一定的专业知识或专门技能，是专业化人力资本的载体；二是价值性，能够进行创造性劳动，产生新的价值，或使价值增值，对社会发展和人类进步作出贡献；三是层次性，是人力资源中能力素质较高的劳动者，体现了人才的杰出性甚至是不可替代性；四是时代性，是经济社会发展的第一要素，是科学发展的第一动力，体现了人才在社会和经济发展中的地位和作用，对“人才资源是第一资源”的重要思想作了进一步丰富，突出了时代性特征。

人才资源概念是建立在人力资源质量概念的基础之上的。人才资源指的是人力资源中素质层次较高的那一部分人。如以创造性高过社会平均水平表示，人才

① 王辉耀. 国际人才竞争战略[M]. 北京: 党建读物出版社, 2014:5.
② 余凯成、程文文、陈维政.人力资源管理[M]，大连：大连理工大学出版社，1999：5～6.
③ 中共中央、国务院.国家中长期人才发展规划纲要（2010—2020 年）.人民日报[N].2010-6-6(1).

资源是一个边界模糊的概念。目前没有形成规范的人才统计标准，参考专门人才的界定方法可包括以下三类人之和：第一，具有大专或大专以上规定学历者；第二，拥有技术员或相当于技术员以上专业技术职务者；第三，虽无大专及大专以上规定学历，无专业技术职务，但现在专业技术职位上工作着的人。

## （二）人力资本与人才资本

**人力资本。**美国著名经济学家、诺贝尔经济学奖获得者西奥多·W·舒尔茨（Theodore W. Schultz）自从在美国经济学会 1960 年年会上以“人力资本投资”为题发表演说以来，就一直在执着地要求把“人”视为“资本”，以得到一个完整的资本概念，使“人力资本”的研究成为西方经济学的一个热门的新兴领域。舒尔茨的著名论点是：“经济发展主要取决于人的质量而不是自然资源的丰瘠或资本存量的多寡”，而人力资本是“人为的投资的产物”。

**人才资本。**“人才资本（Talent capital）”是“体现在人才本身和社会经济效益上，以人才的数量、质量和知识水平、创新能力特别是创造性的劳动成果及对人类的较大贡献所表现出来的价值”[①]。人才资本概念是在继承了舒尔茨、加里·贝克尔（Gary Becker）等人创立的人力资本概念的基本内涵，吸收了保罗·罗默（Paul M.Romer）、罗伯特·卢卡斯（Robert E. Lucas, Jr.）等人的“特殊的知识和专业化的人力资本”概念的核心要素，且融合了中国特有的“人才”概念而建立起来的。现有人力资本存量的测度方法有从产出角度的度量方法和从投入角度的度量方法两种。受教育年限法是估算人力资本存量的有代表性的方法[②]。

## （三）创新能力

**创新。**约瑟夫·熊彼特（Joseph Schumpeter）在其《经济发展理论》中提出创新就是建立一种新的生产函数，或者是实现一种生产手段的新组合。具体而言，创新可包括引入一种新产品或提高原有产品质量，引进一种新的生产工艺，打开

① 桂昭明.人才资源经济学[M].北京：蓝天出版社.2005：1；中国人才[J] .2009（23）：1.
② Mulligan,C.B., Sala-l-Martin,X.. A Labor-income-based Measure of TL Value of Human Capital: An Application to TL States of TL United States[J]. Japan and TL World Economy. 1997（9）：159-191.
蔡昉、王德文.中国经济增长可持续性与劳动贡献[J].北京：经济研究. 1999（10）：62-67.

新的市场，开辟一种新的原材料或半成品的供应来源，实现一种新的行业组织，例如形成垄断局面或打断垄断局面。[①]英国技术创新研究专家弗里曼（C. Freeman）将技术创新定义为新产品、新工艺、新系统或新装置从实验室开始到成功的商业性应用为止的整个活动过程，强调技术的商业化过程。[②]1973 年德鲁克在《管理：任务、责任、实践》中首次提出“社会创新”概念，并在 1985 年的《创新与创业精神》中集中地探讨了社会创新问题，强调“教育、保健、政府以及政治等方面的创新，远比商业与经济领域的创新具有更广阔的天地”。[③]总体而言，创新是指在科学、技术、经济、社会等方面，通过引入新的思想、观念、方法、产品或服务等，从而创造价值，带来更高的效益、更好的性能和更优秀的品质。2014 年，习近平在中央财经领导小组第七次会议上强调，创新始终是推动一个国家、一个民族向前发展的重要力量。从本质上来看，“创新驱动实质上是人才驱动”[④]。

**创新能力。**创新能力的特征指标主要包括创新素质（创新人格、战略思维、市场意识等）、创新理论、创新氛围（组织结构、创新文化、任务特征等）、创新成果、创新技能（信息获取与处理、团队协作能力、学习能力等）。其中，可以量化的指标主要有创新素质和创新成果，如研究人员数量、有效授权专利数量、全球创新指数等。创新能力具有新颖性、多向性、多元性、开放性等特点。新颖性即思维的目标、方法、过程等都比较新颖，多向性即思考问题从纵、横、逆等多三方面思考问题，多元性即善于从事物的多侧、多环节、多因素、多层次、多角度来思考，开放性即善于大量、广泛地吸收外界信息，在与外界的信息交换和反馈中不断吸收新东西，建立自身思维模式，调整自身思维方法，整合自身思维成果。

## （四）产业链及产业链韧性

**产业链。**产业链是指一个产品或服务从原材料采购、生产制造、加工组装、

① Swedberg, Richard（1991），Joseph A. Schumpeter: His Life and Work,Cambridge:Polity,p34.
② 克利斯·弗里曼，罗克·苏特. 工业创新经济学（第 3 版）[M]. 华宏勋，华宏慈等译. 北京：北京大学出版社，2004.
③ 纪光欣.国外社会创新理论研究述评[J].理论月刊,2017(05):132-13。+181.
④ 中国中共党史学会编. 中国共产党历史系列辞典[M]. 北京：中共党史出版社、党建读物出版社.2019：

销售分销、售后服务等各个环节所形成的一种关联性、互补性和互动性的产业组织形态。产业链中的各个环节相互依赖、相互配合，共同完成整个产品或服务的生命周期。产业链可以包括一个或多个产业，涉及到多个行业和企业之间的合作与竞争。本报告重点研究制造业产业链。[①]

**产业链韧性。**产业链韧性是指在面临外部破坏性事件或链条内部出现问题时，产业链仍能保持动态平衡，对破坏性事件做出积极反应，并最终恢复正常运转的一种复杂的适应性能力；提升产业链韧性，有助于企业、行业和国家在面临不确定性和风险时，保持经济稳定和持续发展。[②]

# 二、人才与创新对中国产业影响的理论分析

## （一）人才对中国经济增长的影响分析

人才优先发展是后发国家实现经济起飞的成功经验，其重要表征就是人才资本的优先积累。从世界各国的振兴史中可以发现：一个国家的发达无不得益于人力与人才资本的积累与有效使用。每一次成功的经济追赶，都同时伴随着人力与人才资本的先行追赶，人力与人才资本追赶是经济追赶的先导。

改革开放以来，特别是第一次全国人才工作会议以来，我国一些地区的社会经济得到了率先发展。研究发现，人才优先发展的东部沿海省份，其经济实力也遥遥领先。这些地区的经济总量（GDP）与该地区的“受过高等教育的劳动力总量”、“R&D 人员总量”和“人才资本存量”三个人才总量指标具有高度的相关性和同向性，其中广东、江苏、浙江、山东等省具有代表性。这些地区抢占了人才发展的先机，掌握了社会经济欲得到发展必优先发展人才的规律，使得本地区出现了人才—经济同向互驱的科学发展局面。

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① 郎咸平,产业链阴谋：一场没有硝烟的战争 [M]. 东方出版社，2009.
田坤,产业链整合战略研究 [D]. 东华大学，2011.
陈晓红，张继红,产业链竞争优势的生成机理及其对我国产业发展的启示 [J]. 经济管理，2012, 34(8): 102-109.

② 李晓兵. 产业链韧性研究 [D]. 上海交通大学，2016.
张继红，陈晓红. 产业链竞争优势的生成机理及其对我国产业发展的启示 [J]. 经济管理，2012, 34(8): 102-109.

为什么人才优先发展能驱动经济的快速发展？这个问题涉及人才对经济增长的贡献问题。人才资本对经济增长的贡献率（简称“人才贡献率”），是《国家中长期人才发展规划纲要（2010-2020）》的六个“国家人才发展主要指标”之一[①]。人才贡献率是人才资本作为经济运行中的核心投入要素,通过其自身形成的递增收益和产生的外部溢出效应,从而对经济增长所作出的贡献份额。

2009 年中央人才工作领导小组测算了我国 2008 年的人才贡献率为 18.9%，预测了 2015 年、2020 年我国的人才贡献率分别为 32%和 35%。在其后的跟踪测算中，我国 2010 年、2015 年、2020 年按照受过高等教育的劳动力认定为“人才”的人才贡献率分别为 16.19%、25.00%和 27.81%，总人力资本贡献率分别为 24.39%、31.50%和 33.77%。

根据 2020 年中国人才贡献率为 27.81%这一数据，可计算得 2020 年中国人才所创造的 GDP 为 40943.83 亿美元。此值多于 OECD1961 年 20 个创始成员国中冰岛、卢森堡、希腊、葡萄牙、丹麦、挪威、爱尔兰、奥地利、比利时、瑞典、土耳其 11 个欧洲国家当年的 GDP 总和（38675 亿美元），是除美国、加拿大两个美洲国家之外的所有 OECD 创始成员国中的 18 个欧洲国家 GDP 总和（178859 亿美元）的约四分之一。由此可见，我国人才资源丰富，对经济发展贡献巨大。

中国虽然是人才大国，但还不算人才强国。从第一章的产业链韧性评价来看，人才资本对产业链韧性的贡献方面，中国位居 7 名，落后于美国等国。而人才资本的大部分指标，如“公共教育经费支出占本国国内生产总值比重”“劳动生产率”“劳动年龄人口中受过高等教育的人口比重”等，均不是短时间可以快速提升的指标，对产业链韧性而言属于慢变量，需要持续关注并投入。

## （二）科技创新对中国产业发展的影响分析

党的二十大报告指出，高质量发展是全面建设社会主义现代化国家的首要任务。“经济高质量发展取得新突破，科技自立自强能力显著提升，构建新发展格局和建设现代化经济体系取得重大进展”[②]是未来 5 年我国全面建设社会主义现

①中共中央、国务院.国家中长期人才发展规划纲要（2010—2020 年）.人民日报，2010-6-6（1）。
②习近平.高举中国特色社会主义伟大旗帜 为全面建设社会主义现代化国家而团结奋斗——在中国共产党

代化国家开局起步的关键时期的主要目标任务之一。以科技创新赋能产业高质量发展，是在新的历史节点全面实现社会主义现代化目标的重要抓手。

从国内经济发展现状来看，经过改革开放以来数量追赶、规模扩张、要素驱动的四十余年，我国产业走过了高速发展阶段。中国不仅成为世界第一制造业大国，还是当今全世界唯一拥有联合国产业分类中所列全部工业门类的国家。但在如此巨大成就的背后，中国的产品质量和附加值水平仍亟待提升，中国大部分产业在全球产业体系与价值链中仍处在中低端。当前，我国产业发展的生产函数已然发生变化，依靠劳动等生产要素推动的经济增长模式已难以为继，中国经济迫切需要缩小全要素生产率与国际先进水平的差距。同时，资源环境的硬约束持续强化，已经不可能像过去那样主要依靠要素投入驱动产业高质量发展。因此，产业发展模式转变已是箭在弦上不得不发，而完成“华丽转身”则关键要靠科技创新来驱动。

从全球范围的国际竞争态势来看，国际政治经济局势风云变幻，争夺科技制高点的竞争也逐渐走向“白热化”。中国必须通过自主技术创新，在关键核心技术解决“卡脖子”问题，推动中国经济向全球价值链中高端迈进，增强中国在全球产业链与供应链的韧性，保障中国的经济安全与发展利益。

在过去 40 年经济全球化过程中，中国比较充分地发挥了自身丰富劳动力资源的比较优势，并通过“引进—消化—吸收—再创新”的方式提升中国企业的技术水平和竞争力。如何构建支撑高质量发展的创新体系体制机制，最现实的办法就是向我国自身的先进成功经验学习。中国最大的优点是具有统一的大市场，这决定中国科技体制机制改革可以自下而上推进。改革开放以来中国的高科技产业发展最快，科技创新也取得了不少成功经验，在全球科技创新领域具备了不少优势。在本报告研究的 38 个国家中，中国的全球创新指数名次也在逐年上升，从 2018 年排名第 15 提升到 2020 年的第 13 位，2023 年则进一步提升到第 12 位。

从第一章产业链韧性评价来看，创新资源对产业链韧性的贡献方面，中国排在第二位，这也说明科技创新驱动着中国的主导产业特别是制造业的飞速发展，带动中国从“世界工厂”的外延发展，逐步走向“专精特新”的内涵发展之路。

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第二十次全国代表大会上的报告. 人民日报[N].2022-10-26（1）。

# 三、人才与创新对中国产业影响的案例分析

## （一）新能源汽车产业

### 1．中国新能源汽车产业呈现稳健发展态势，具有良好韧性

近年来，我国新能源汽车产业规模不断扩大，国际市场份额逐步上升，吸引了资本市场越来越多的关注。在“双碳”目标大背景下，中国汽车产业加速转型，逐渐形成了横跨上中下游、庞大且成熟的新能源汽车产业链。

中国作为全球最大的新能源汽车市场，其销量和出口量都呈现出强劲增长。综合多种数据源可知，2021 年中国新能源汽车的出口量大致在 31 万辆到 59.7 万辆之间，同比增长 1.7 倍以上；[①]销量方面，2021 年中国的新能源汽车销量达到了约 350 万辆，比前一年增加了 1.6 倍，而新能源汽车在新客车销量中的份额也从年初的 8.4%增加到年底的 20.6%。[②] 2022 年，中国的新能源汽车销量达到 688.7 万辆，已拥有约 35%的全球市场份额。[③]2023 年 1-7 月，根据中国汽车工业协会（CAAM）发布的数据，中国新能源汽车国内销量 389 万辆，同比增长 32.5%；同期出口量达到 63.6 万辆，同比增长 1.5 倍。[④]根据国际相关信息服务供应商预测，到 2025 年中国有望成为全球新能源汽车销量的第一大市场，预计占领全球总销量的 40%。[⑤]

### 2．新能源汽车产业链主要环节与发展现状

新能源汽车产业链大致可分为三个关键环节：上游的原材料与核心部件，中游的设备制造及应用，以及下游的终端产品。

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① 国家发展和改革委员会 (2018). 《关于进一步优化新能源汽车产业发展环境的通知》.
② 《关于修改<新能源汽车生产企业及产品准入管理规定>的决定》，工业和信息化部, 2020.
③ 中国汽车工业协会. (2022). 《中国汽车工业年鉴 2022》. 北京: 机械工业出版社.
北极星储能网. 中汽协：2022 年新能源汽车销量 688.7 万辆 同比增长 93.4%.
④ 中国汽车工业协会（2023）。中国汽车出口年度报告。
⑤ IHS Markit (2023). Global Electric Vehicle Outlook.

表 2.1 新能源汽车产业链主要环节分析

| 产业链主要环节 | 产业链细分环节 |
| --- | --- |
| 上游：原材料与核心部件 | 电池 |
| | 电机 |
| | 电控及其他核心部件 |
| 中游：设备制造及应用 | 电池单体制造与模组集成 |
| | 电机生产与集成 |
| | 电控硬件与软件开发 |
| | 车辆总装：结合车身、底盘与新能源系统 |
| | 车载软件开发：车载操作系统、驾驶辅助系统、车载娱乐系统等 |
| 下游：终端产品 | 纯电动汽车 (BEV) |
| | 插电式混合动力汽车 (PHEV) |

得益于行业的技术持续创新，我国新能源汽车全产业链均取得了阶段性成就。在上游环节中，中国在电池、电机和电控等关键组件的研发上有所突破，在锂电池技术方面的表现突出；中游环节中，中国在电池单体制造与模组集成领域已取得了显著的市场地位；下游环节的终端汽车产品在国内外市场上取得出色表现，彰显出新能源汽车产业的巨大市场潜力和竞争优势。

### 3．近三年新能源汽车核心技术领域投资持续增加

随着全球范围内对气候变化的担忧加深，新能源汽车逐渐受到了各国政府、企业和消费者的广泛关注。随着过去几年中新能源汽车的市场渗透率在全球范围内逐步提高，该领域的投融资活动热度显著增长。这种趋势在中国大陆、欧洲与美国尤其显著。

中国在新能源汽车领域保持领先地位，投资者对此保持较大信心。仅 2021 年一年，中国新能源汽车及动力电池行业的投资总额就达到 1172.5 亿元人民币，投资案例数达 170 起。[①]这从近年的投资案例也可以窥见一斑。2018 年，特斯拉在上海投资了 50 亿美元，建立了其首个海外超级工厂（Gigafactory），为特斯拉在中国市场的大规模拓展奠定了基础。[②]在 2021-2022 年期间，欧洲主要汽车制

① 清科研究中心. (2022). 2022 中国新能源汽车及动力电池行业投融资分析报告.
② South China Morning Post. (2018). Tesla helps Shanghai record increase in foreign investment for 2018.

造商均大幅增加了在华投资。据报道，2021 年欧洲汽车制造商在中国汽车领域的直接投资达到了 62 亿欧元，而所有其他领域的投资总额为 15 亿欧元。[①]中国已成为欧洲汽车的第三大市场，仅在 2022 年，欧洲向中国出口的乘用车价值就超过了 240 亿欧元。[②]尤其在电动汽车(EV)领域，中国的市场潜力巨大。2022 年，电动汽车的销量占中国汽车总销量的四分之一，预计这一比例在未来三年内将增至 50%。此外，根据多方预测，中国新能源汽车市场的规模在 2023 年到 2028 年将维持显著增长，显示出积极的投资前景。德国汽车制造商也计划在 2030 年前向中国消费者提供超过 30 种不同品牌的电动汽车型号，德国大众“为中国而在中国”战略也体现出中国市场的重要性。[③]

欧洲，尤其是北欧国家和德国，一直在推动绿色出行。强有力的政策支持和消费者对新能源汽车的持续需求推动了欧洲的投融资活动。2019 年，欧洲在新能源汽车和电池生产方面的投资额达到了 600 亿欧元，是 2018 年的 19 倍。相关投资的增加也受到欧盟汽车二氧化碳排放目标的推动，工业界和政府为欧洲的新能源汽车和电池生产的资金投入量达到了中国的 3.5 倍。[④]

美国的新能源汽车市场也非常活跃，特斯拉等大型企业都在积极推广新能源汽车。自 2021 年初以来，美国的新能源汽车投资总额超过 1500 亿美元，新立法为此提供了 830 亿美元的贷款、补助和税收抵免支持。2022 年，美国新能源汽车销量增长 40%，进一步刺激了相关投资。[⑤]2021 年，美国新能源汽车市场规模估值为 175.4 亿美元，预计 2022 年至 2029 年的增长率为 37.1%。[⑥]

截至 2019 年底，全球电动汽车的市场渗透率达到 2.5%，并在 2020 年第一季度进一步增加到 2.8% 。[⑦]中国的新能源汽车市场也呈现出高速增长的趋势。尽管与传统的燃油汽车相比，我国新能源汽车的市场份额仍然较小，但其增长势头明显。未来，新能源汽车可能会在全球更大范围内，特别是在中国与欧洲地区取得更高的市场渗透率。大量该领域的创业公司在近年如雨后春笋般涌现，带来了

① Financial Times. (2021). European carmakers play catch-up in China with record investment.
② Statista. (2022). Value of car exports from the EU to China.
③ Autovista24. (2022). China’s impact on the European automotive industry.
④ Transport & Environment website, Fitch Ratings. (n.d.). European Autos Maintain EV Investments Amid Supply-Chain Issues.
⑤ Kennedy, R. (2023, January 17). Inside the $455 billion U.S. investment in electric vehicles. PV Tech.
⑥ Maximize Market Research. (2021). US Electric Vehicle Market: Industry Analysis and Forecast (2022-2029).
⑦ Seeking Alpha. (2021). Analysis Of The Global New Energy Automobile Industry In 2021.

创新的技术和商业模式，也进一步吸引了资本的注入。

当前，全球新能源汽车行业的重点投融资方向为有以下几个核心技术领域。

第一，纯电动汽车领域。2019-2021 年，戴姆勒 AG、福特、雷诺集团等知名的行业参与者显著增加了对新能源汽车制造的投资，并且增长趋势将持续到 2030 年。[①]此外，全球汽车制造商计划在 2030 年之前在新能源汽车、电池和相关材料上投资近 1.2 万亿美元，显示了这个领域强劲的投资轨迹。[②]

第二，燃料电池技术。尽管燃料电池技术的市场推广面临挑战，但其长续航和快速加氢的优势仍吸引了大量投资。2022 年全球燃料电池市场规模估计为 63 亿美元[③]，相比 2021 年的 58 亿美元有显著的增长。[④]根据市场预测，从 2021 年到 2026 年，燃料电池市场预计将以 16.47%的复合年增长率增长，到 2026 年市场规模将从 2019 年的 25.28 亿美元增长到 73.50 亿美元[⑤]。

第三，先进电池技术。随着对电池性能和安全性的需求增加，先进电池技术，如固态电池和高密度电池，成为了投资的热点。在 2019 年至 2021 年期间，先进电池技术领域的投融资活动显著增加。具体来说，2019 年，全球先进电池储能系统市场规模达到 1519.6 亿美元，并预计在未来几年将以每年 4.8%的增长率增长，到 2027 年将达到 2211.2 亿美元。[⑥]2019-2020 年年间，电池储能、智能电网和能效企业的全球风险投资从 23 亿美元增加到 26 亿美元，增长了 12%。[⑦]特别是在 2020 年，电池储能领域的企业融资增长了 136%，达到 66 亿美元。[⑧]

## 4．高度重视人才培养和技术创新，成为新能源汽车产业发展的核心动力

（1）中国各大学与研究机构加强新能源汽车领域的人才培养。近年来，新能源汽车及相关技术领域人才需求渐增，中国作为全球最大的新能源汽车市场对

① Fortune Business Insights. (2021). Electric Vehicle Market Size Share & Growth - Update 2023 - Industry.
② Reuters. (2022,10). Automakers electric vehicle investment plans.
③ Grand View Research. Fuel Cell Market Size, Share & Trends Analysis Report, 2030.
④ Fortune Business Insights. Fuel Cell Market Size, Share | Growth Analysis Report [2022-2030].
⑤ Knowledge Sourcing Intelligence LLP. (2021). Fuel Cells Market - Forecasts from 2021 to 2026.
⑥ GlobeNewswire. (n.d.). Advanced Battery Energy Storage System Market Size, Share & Trends Analysis Report By Technology, By Application, Regional Outlook, And Segment Forecasts, 2021 - 2027.
⑦ Mercom Capital Group. (2021, January 19). Funding For Battery Technology Companies Exploded In 2020.
⑧ 新能源汽车教育与研究发展报告 (2022), 中国汽车工程学会.

相关人才的需求尤为旺盛。在我国，每年约有 20 万的相关工作岗位需求在市场上出现，中国的高等教育机构和研究院所也根据需求把新能源汽车技术和相关领域设立为重点发展方向。据 2021 年的数据显示，超过 50 所大学开设了新能源汽车及其相关技术的专业或研究方向，为新能源汽车领域储备了大量年轻人才。

**（2）大量研发投入推动新能源汽车技术创新，促进领域快速发展。**2022 年，全球对新能源汽车相关创新技术的投资超过了 1000 亿美元，其中，中国占据了 30%的比例。得益于完整的产业链生态和持续增加的研发投入，中国新能源汽车技术水平不断提升，在新能源汽车关键部件已取得重要地位。近三年来，新能源汽车领域的专利申请数量快速增长。据 WIPO 数据，2019 年全球有约 12 万件与新能源汽车相关的专利申请，到 2021 年这一数字增长至 18 万件，增长了 50%。[①]从专利的领域分布来看，主要分布在固态电池技术、无人驾驶与 AI 技术、车载操作系统与 V2X 通信技术等领域。

**（3）资金链、人才链、创新链融合发展促进新能源汽车产业链韧性提升。**过去三年中，资金链、人才链、创新链成为新能源汽车产业稳步发展的主要驱动力，其间的相互作用和关联形塑了该产业的发展。首先，投融资加速了人才创新集聚，大量资金的注入使得新技术研发得到了积极推进，同时技术进步反过来吸引了更多的投资者，形成了正向的发展循环；其次，人才、创新互为促进成为产业发展的关键。中国各大学、研究机构及企业加强了对新能源汽车领域的人才培养，不仅加速了先进技术的研发和管理模式的创新，也加快了技术的商业化进程，使得技术创新与政策及投资形成了一种相互促进的关系。当譬如固态电池等某项技术取得突破，它会获得更多的资金和政策支持，使这项技术得到进一步的发展。反过来，这种技术进步也会刺激资本市场为其提供更多的资源和支持。

总之，资金链、人才链、创新链三链融合发展，有效提升新能源汽车产业链的韧性，促进产业的稳定发展。

① World Intellectual Property Indicators (2022). World Intellectual Property Organization (WIPO).

## （二）半导体产业

### 1. 中国半导体产业链框架与发展现状

2017 年以来，随着数字经济的发展，作为重要基础设施之一的半导体产业成为全球经济发展的焦点。我国半导体产业底子薄，韧性较为脆弱，整体市场对外依赖性较高。特别是 2018 年中美贸易战、科技战以及 2020 年新冠疫情暴发以来，我国半导体产业链面临的不确定性增加。这些外部变化一方面推动了提高国产替代程度的热潮，刺激了对半导体产业人才与创新的需求，另一方面也暴露了我国当前半导体人才供应仍不足以满足市场需求、创新以及研发则仍受外部条件制约的痛点。不确定因素的增加也在客观上对产业人才供给与创新造成了负面影响。在此背景下，提升半导体市场发展韧性和供应链稳定性，并打通人才链、创新链与产业链十分必要。

**（1）中国半导体产业链框架**

半导体产业上游支撑产业包括半导体材料、半导体设备，中游制造业包括集成电路、分立元器件，下游主要包括智能手机、新能源汽车等终端应用。就位于产业中游的半导体产品而言，主要分为集成电路（IC 设计）和分立元器件两个部分。其中，集成电路占据半导体产业总量的 80%以上，分为数字电路和模拟电路两个部分；分立元器件下又细分为分立器件、光电子元器件和感应器。其具体构成如下图：

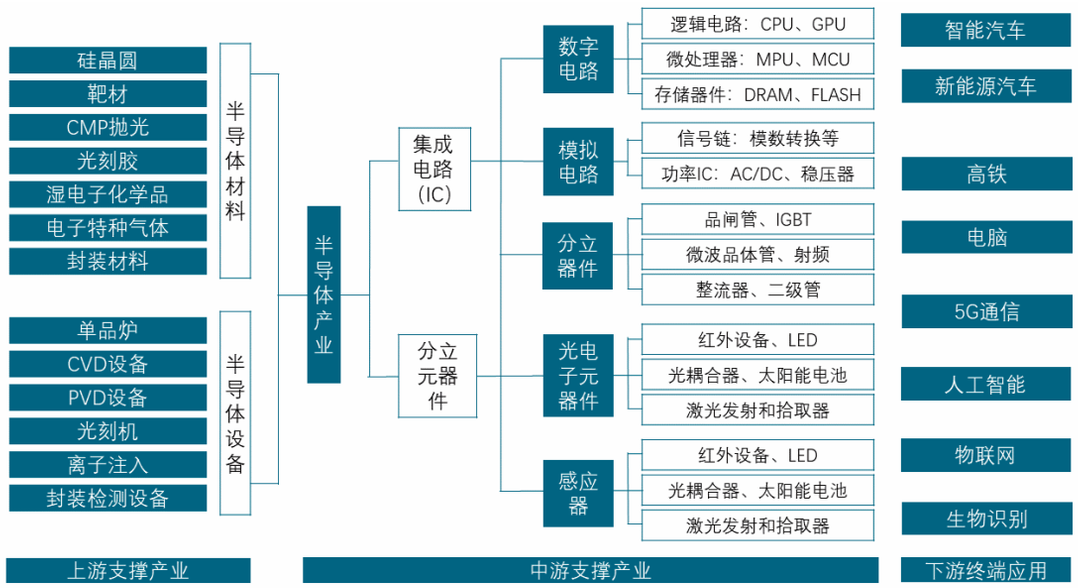


**图 2.1 半导体产业链主要环节**

**（2）中国半导体产业发展现状**

中国是世界上最大的半导体市场，长期占全球半导体市场份额的 30%以上。但由于受到国内产业短板的影响，中国半导体市场对外依赖性较强，供应链稳定性不足。据市场研究机构 IC Insights 预测，中国半导体自给率到 2025 年可能仅有 19.4%，与相关产业政策提出的 70%的目标相去甚远。

在 2019 年前中国半导体的产业链分工中，IC 设计从研发体量到商业化程度上对其余分工形成了绝对优势，并出现了一批优秀的 IC 设计企业。但在其余分工领域，中国市场均严重依赖国外产品进口以及软件专利授权。中国半导体产业链所面临的结构性问题在于，半导体产业是资本密集和技术密集产业，即境外厂商在足够高的技术壁垒和成本优势加持下实现“赢者通吃”，对后来者形成了压倒性优势。而中国厂商在进入相关赛道时往往面临先期较大的投资成本及竞争压力，相关投资产出结果也难以在商业领域维持持续竞争优势。故而在半导体产业的全球分工当中，尽管中国有全球第一大市场，却长期处于产业链中低端。

近年来，中国半导体市场供应链受到了多重冲击。一是，在中高端半导体产品当中，受到美国“长臂管辖”等贸易保护主义措施限制，无法获得足够先进的半导体设备、产品、专利授权和生态支持；二是，受行业变化和新冠疫情的影响，半导体行业出现了周期性下行，供应链出现不畅，全球需求下降、库存上升，中

国部分半导体产品对外贸易受阻；三是，受新能源汽车产销迅速上升以及人工智能发展技术快速发展的影响，市场对车载半导体产品及人工智能应用芯片的需求上升，与半导体整体产业进入下行周期形成对冲，加剧了半导体市场的复杂程度。

## 2. 2019-2021 年中国半导体产业韧性表现

### （1）市场投资状况

受到中美贸易战、科技战及其他因素带来的市场变化及供应链影响，中国国内半导体市场出现了较为明显的国产替代趋势。国产替代为国内企业大幅增加投融资、扩大产能提供了有效的市场空间，一定程度上助力产业实现稳定。

2019 年到 2021 年国内半导体市场投资规模大幅增加。但在 2021 年相关投融资达到高潮后，行业周期下行使 2022 年中国半导体市场投融资出现了下降，投融资次数与投融资总金额均下降。

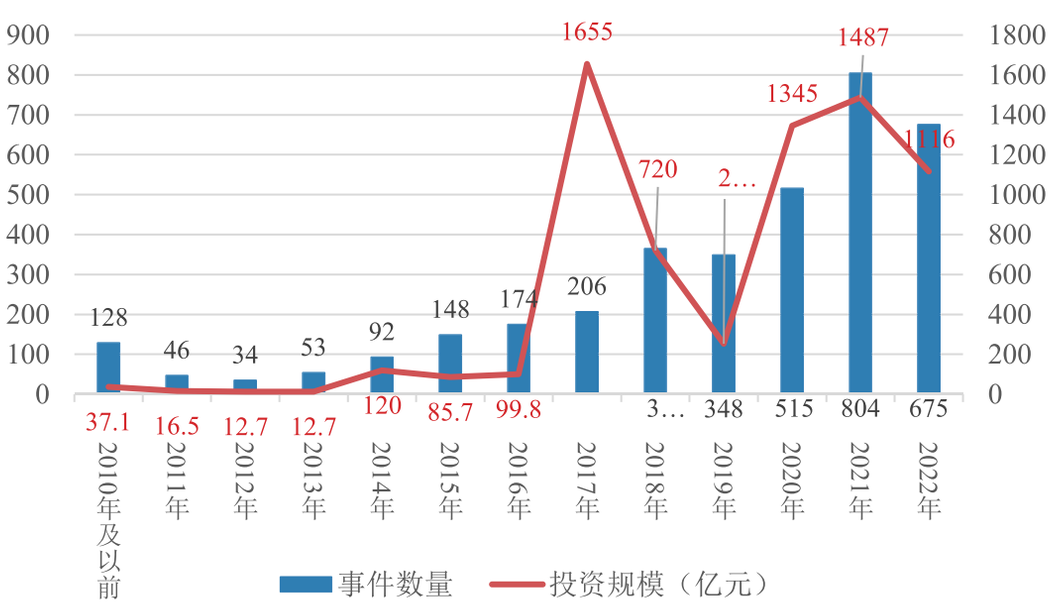


**图 2.2 中国芯片半导体行业历年投融资数量及规模**

数据来源：桔子水晶

表 2.2 中国半导体行业一级市场投融资统计（2019-2022 年）

| 年份 | 一级市场投融资规模（亿元） |
|---|---|
| 2019 | 693.38 |
| 2020 | 1693.53 |
| 2021 | 1563.41 |
| 2022 | 1114 |

数据来源：云岫资本

而从投资的产业链细分环节来看，国内半导体投资主要集中在 IC 设计上，其在全球市场的占比从 2004 年的不到 5%提升到 2022 年的 13.7%，年均复合增长率达到了 20.6%；投资保持较快增速则是在电子设计自动化（EDA）赛道上。两者在总投资占比未受到 2022 年周期的明显冲击。中国企业在封测领域有较强的竞争力，但在 EDA/IP 以及制造方面是弱项。而 EDA 领域被认为是“卡脖子”领域的关键之处。

表 2.3 各投融资领域在全球市场的占比

| 投融资领域 | IC 设计 | 材料和设备 | IDM | 封测 | EDA/IP | 制造 |
|---|---|---|---|---|---|---|
| 2020 | 67.22% | 19.17% | 6.94% | 2.78% | 2.22% | 1.67% |
| 2021 | 69.44% | 20.00% | 1.94% | 3.06% | 4.73% | 0.83% |
| 2022 | 80.00% | 6.72% | 6.11% | 0.28% | 4.16% | 2.73% |

数据来源：前瞻产业研究院

### （2）企业营收状况

企业营收情况能够较为明显地体现出与外部环境变化的相关性。

根据 Wind 统计信息显示，2022 年 A 股半导体产业中 96 家企业披露的营收总收入增速为 11.43%，超六成企业实现营收增长，但净利润率同比下降 12.95%。半导体设备是唯一一个同时实现毛利润均值和净利润均值双增长的细分领域。而在此之前，2021 年 Wind 统计的 96 家半导体上市企业营收增速为 60.3%，净利润总额同比增速为 86.41%；2020 年对 75 家半导体上市企业的营收增速统计则显示为 35.45%，净利润增速更是达到了 164.39%。

尽管相关不完全统计可能存在一定数据一致性问题，但仍然从整体趋势上反映出：在 2020 年到 2021 年间，在 A 股上市的半导体企业营收均出现了大幅增

长，净利润率也出现了大幅上扬，中国半导体市场仍处于扩张区间；但在 2022 年营收增速出现了明显下降，上市企业的平均净利润率则出现负增长。

## 3. 我国半导体产业发展中的人才与创新要素

### （1）半导体产业高端人才不足给产业链稳定发展带来隐忧

一般而言，高科技行业离职率变化的原因与产业活跃程度正相关，即产业越活跃，对人才的需求就越大，职位升迁和调整就越多，离职率就越高。通过对比 2020 年到 2022 年三年行业离职率，可看到 2020 年到 2022 年半导体产业经过了一个发展的高峰，但 2022 年半导体企业离职率有所降低，在行业周期性性下行期间，相对于整体的高科技行业和制造业行业而言保持了稳定的趋势。

**表 2.4 高科技行业、制造业、半导体行业离职率（%）**

| 年份 | 高科技行业离职率 | 制造业离职率 | 半导体行业离职率 |
|---|---|---|---|
| 2020 | 15.50 | 17.80 | 20.30 |
| 2021 | 20.90 | 20.60 | 20.70 |
| 2022 | 19.20 | 19.00 | 18.80 |

数据来源：《2023 年中国大陆集成电路产业人才供需报告》

就人才供求状况而言，中国半导体人才长期处于不足状态。中国半导体产业市场规模从 2015 年的 986 亿美元增长至 2022 年的 1803 亿美元，复合增长率达到 9.00%，而现有人才供给无法满足全国半导体市场快速发展需求。例如，2020 年我国直接从事集成电路产业的人员约 54.1 万人，同比增速 5.7%，而同期集成电路产业总销售额达到 8848 亿元人民币，同比增长 17%。综合不同方面的统计数据，中国半导体从业人才的长期缺口可能在 20 万到 35 万人之间。从从业人员薪酬现状看，集成电路行业 2022 年度整体薪酬涨幅明显，相关研究显示其自然涨幅和跳槽涨幅均超 30%。

纵览我国集成电路行业的薪酬变化、人才缺口现状以及离职率情况，可以推断，尽管 2022 年中国半导体产业受大环境影响出现周期性下行，但这一行业的人才需求始终保持增长，供不应求的情况一直存在，未体现出受到行业周期变化的影响。与此同时，尽管相关领域人才培养力度增加，但人才缺口从整体上未能

获得足够补充，这为半导体产业的稳定发展带来隐忧。

**（2）半导体产业研发强度持续增加但研发总额仍有差距**

从专利数量来看，我国半导体产业研发近年保持上升状态。2021 年，中国半导体产业的专利申请数量和有效发明专利数量比 2020 年有较大幅度增长；2022 年虽有增加，但增幅降低，一定程度上受到行业周期性变化的影响以及新冠疫情的冲击。

**表 2.5 中国规模以上工业企业（高科技产业）半导体专利申请及有效专利统计**

| | 分立器件制造 | | | 集成电路制造 | | |
|---|---|---|---|---|---|---|
| 年份 | 专利申请数 | 专利申请数：发明专利 | 有效发明专利数 | 专利申请数 | 专利申请数：发明专利 | 有效发明专利数 |
| 2020 | 2118 | 645 | 2833 | 16728 | 12112 | 27809 |
| 2021 | 3285 | 1645 | 3515 | 21595 | 15317 | 32099 |
| 2022 | 3539 | 1705 | 3686 | 22232 | 15989 | 35025 |

数据来源：国家统计局

从研发投入强度来看，受产业政策鼓励及市场需求影响，行业对半导体产业的研发投入强度近年持续增加。2019 年到 2022 年间，规模以上工业企业研究与试验发展（R&D）经费投入中，计算机、通信和其他电子设备制造业始终在所有领域分类中保持投入总额第一，且 R&D 经费投入强度（经费投入与营收之比）逐年上升。

**表 2.6 计算机、通信及其他电子设备制造业研发经费投入统计（2019-2022 年）**

| 年份 | R&D 经费（亿元） | R&D 经费投入强度（%） |
|---|---|---|
| 2019 | 2448.1 | 2.15 |
| 2020 | 2915.2 | 2.35 |
| 2021 | 3577.8 | 2.43 |
| 2022 | 4099.9 | 2.63 |

数据来源：科技部

从企业研发角度看，我国半导体企业可能存在研发费用分布不均、平均研发金额偏低的问题。以集微网[①]统计数据来看，2020 年到 2022 年间我国 A 股有统

① http://jiweidev.jiweinet.com

计的上市半导体企业研发与营收之间占比（即研发费用率）分别为 14.6%（75 家）、10.4%（50 家）以及 20.5%（62 家）。2021 年 A 股研发实力排名前 50 的半导体企业合计研发支出为 409.23 亿元，2022 年 191 家 A 股半导体上市公司研发支出仅有 686.15 亿元，研发费用率为 9.1%。另外，中国在半导体领域研发总费用相对于国外企业存在着较大差距。譬如，仅英特尔一家企业，在 2022 财年营收下滑 20.2%的情况下，研发费用依旧达到 175.3 亿美元，超过 191 家 A 股半导体上市公司研发总支出。尽管这一数据并不具有广泛的代表性（因 A 股上市的半导体企业在规模和业务成熟程度上与国际大型半导体巨头存在较大差异），但我国投入的研发经费相对美国等发达国家有所不足的事实较为明显。尽管投入逐年增长，一定程度上为产业发展和稳定提供了支撑。但这一支撑作用可能有限，遇到行业周期变化，即出现研发产出增速下滑的情况，对产业稳定的支撑作用有所降低。

## 4. 人才和创新对产业链发展的影响

我国在集成电路产业政策与人才政策上的倾斜在一定程度上加大了产业人才供应。自进入新世纪以来的历年五年计划中，均提出“大力发展新一代信息技术……重点发展集成电路等高端服务”，《中国制造 2025》当中列出了集成电路发展专项。在人才培养方面，相关部委先后在 2016 年和 2020 年印发了《教育部等七部门关于加强集成电路人才培养的意见》和《新时期促进集成电路产业和软件产业高质量发展的若干政策》，以促进高校设置集成电路一级学科，与集成电路企业合作优先建设培育集成电路产教融合型企业，鼓励地方表彰和奖励相关领域高端人才。在政策引导下，集成电路人才供给呈现上升趋势。根据近年来发布的《中国集成电路产业人才白皮书》数据，中国集成电路产业从业人员规模从 2017 年的 40 万人上升至 2020 年的 54.1 万人，人才缺口从 26 万人下降到 20 万人左右。

在外部环境变化不确定性增加的情况下，我国半导体产业国产替代取得一定的成果。近年来我国从境外引进半导体高端人才的途径受阻，通过常规路径获取技术授权和引入专利设备的成本急剧增加，与国际高端半导体研发领域的交流不

畅，在一定程度上加剧了我国在半导体领域人才不足和创新力量薄弱的情况。但是，中国半导体企业仍在努力发挥优势，以确保供应链稳定和产业链的持续发展。近几年来，国内半导体人才供给和创新投入逐年增加，推动国内半导体产业供应链的国产替代率逐年上升。以国产集成电路为例，以价值计算，国内产品及服务在国内半导体市场总额的比例从 2013 年的 13.5%提升到了 2021 年的 41.4%。国内半导体人才供给未受全球半导体产业大幅调整的影响，对国内半导体产业供应链稳定提供了一定程度的支撑。2019 至 2022 年，集成电路产品出口稳定提升，从 2019 年的 1016 亿美元增长到 2022 年的 1539 亿美元，进口也从 2019 年的 3055 亿美元持续增长至 2021 年的 4326 亿美元，2022 年稍有回落，见图 3.3。

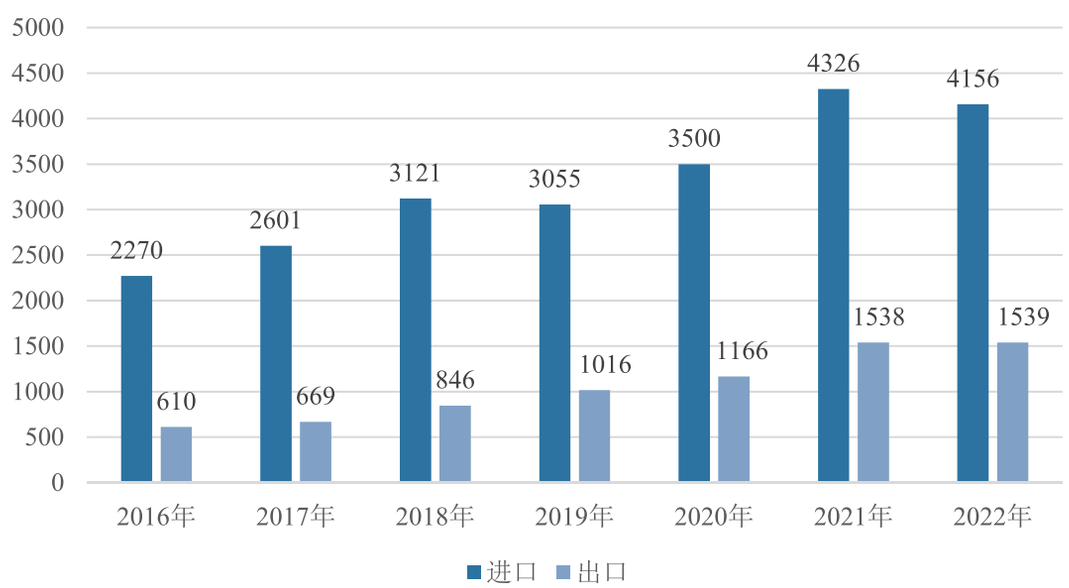


**图 2.3 中国（大陆）集成电路进出口（单位：亿美元）**

数据来源：海关总署

从宏观上看，中国半导体产业在经历了严峻的考验后，其产业韧性得到了一定程度的提升。这一韧性的可持续程度，在未来有赖于投融资的增加程度，以及人才缺口是否能够迅速得以填补；研发和创新能否进一步加强，也有赖于我国半导体产业能否重新打通与全球主要半导体产业和市场的连接。从根本而言，半导体产业是一个高度资本和知识密集、高度全球化的领域，中国在半导体领域的人才供给和创新支撑是否足以推动产业发展形成正反馈，仍是有待深入研究的话题。

# 第三章 相关建议

参考全球各经济体当前提升产业链供应链韧性的一些措施，课题组认为，当前我国在这一方向上的具体做法可考虑从以下方面入手：其一，秉持合作开放的原则，推动有利于全球产业共御风险的规则体系进一步完善；其二，搭建产业链韧性交流平台，形成常态化沟通机制；其三，推动创新链、产业链、人才链和资金链四链融合，最大限度发挥我国市场规模化优势，完善我国在战略产业上的生态系统；其四，加强数字化转型，提升产业链的可预见性与适应性；其五，以有效的宏观政策改善市场环境，以强化我国在关键产业上的薄弱环节。

## 一、坚持开放合作，共同维护全球产业链韧性

通过提升开放合作以提升全球产业链供应链应对风险的能力，近年来一直是我国经济交往和对外合作的主要路径与目的，也是提升我国产业链供应链韧性的可行方案。近年来，中国领导人一再强调，要充分利用中国庞大的市场优势，将扩大内需战略与创新驱动发展战略有机结合，加强产业链和供应链的开放合作。在 2023 年 10 月举行的第三届“一带一路”国际合作高峰论坛开幕式上，中国领导人提出，中国将“全面取消制造业领域外资准入限制措施。主动对照国际高标准经贸规则，深入推进跨境服务贸易和投资高水平开放，扩大数字产品等市场准入。”[①]这进一步显示了中国扩大开放、建设开放型世界经济的决心。

在产业发展发展过程中，由于国际分工不同，全球产业链的各个环节分布在不同的经济体中，从而分散风险，优化效率。相互开放与合作，促进资源、技术和市场的有效衔接，这是产业链全球发展不可或缺的前提。扩大开放合作程度，有助于促进产业链的健康发展，也有助于全球经济的互利共赢。

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①《习近平在第三届“一带一路”国际合作高峰论坛开幕式上的主旨演讲》，新华社, 2023 年 10 月 18 日, http://www.news.cn/politics/leaders/2023-10/18/c_1129922670.htm.

当前，全球供应链出现了“碎片化”的趋势，对全球产业链和生产分工体系构成了挑战。对此，中国需要倡议更加开放、更加平等的国际合作，确保各经济体在全球产业链供应链中享有平等的机会。具体而言，充分利用或创建合作平台与机制深化国际合作，促进知识、技术、人才等各方面的资源共享，消弭信息和技术鸿沟，降低共享成本，提高合作效率；打造共识并将共识具体化到行动与规则之上，应对市场波动和不确定性，从而降低全球产业链供应链面临的不确定。

开放平等的合作，有助于扩展市场接触面，提供更多的经贸选择，从而降低市场风险，确保产业链的稳定和韧性。而所谓“近岸外包”“友岸外包”等所谓去风险提韧性的做法，实际上是打着“减轻对单一市场的依赖”旗号的贸易保护主义行为，对降低市场风险，确保产业链的稳定和韧性并无益处。全球化在数十年的进程中建立了一整套完整的国际合作和全球治理体制。近年来，中国提出了“一带一路”倡议，与众多新兴发展中国家建立了金砖国家合作机制等多层次的合作平台。发达国家也提出了一些类似的合作倡议。应以开放而非排他的态度对待大部分合作倡议与机制，寻找彼此利益的最大公约数。

## 二、搭建产业链韧性交流平台，形成常态化沟通机制

近年来，中国举办了系列博览会，以“博览会战略”促进产业沟通和交流，取得了很大的成效。数博会、服贸会、消博会、进博会都形成了品牌效应。2023年 11 月底还将举办首届中国国际供应链促进博览会（链博会）。这些博览会传承着中国的开放理念，探索了中国对外开放的崭新途径，并凸显出中国愈发广阔的开放大门，为全球自由贸易注入新的活力。

其中，中国国际进口博览会（进博会）是展示与交流产业链不同环节产品的标志性活动。经过六年发展，进博会的国际公共产品属性不断增强，已经成为国际采购、投资促进、人文交流和开放合作的重要公共平台。进博会虹桥论坛也发展为思想碰撞、共识凝聚、多边合作的国际高端平台。未来，可以考虑把“提升产业链供应链韧性分论坛”等论坛机制化，以建立常态化全球产业链供应链韧性交流对话合作机制，促进不同环节的产业链参与者之间的信息共享，推动资源和

经验共享，加强技术创新和风险管理，增强互信。这样也有益于增进进博会的国际公共产品属性和提升品牌形象。

建立产业链韧性交流平台的具体要求包括：一是提供开放的沟通渠道。促进信息共享和合作，有助于不同国家和企业及时了解全球市场的变化、政策调整和技术进展。通过该平台分享最佳实践和经验，赋能各国和企业共同应对挑战，提高韧性。二是为技术创新和协同研发提供机会。不同国家和企业可以汇集和整合创新能力，共同研发新技术和解决方案，以满足不断变化的市场需求，从而提高产业链整体水平。三是成为应对共同危机和风险管理的平台。各国和企业可以共同制定应对突发事件的策略，分享危机管理经验，提高应对外部冲击的能力。四是推动全球产业链可持续发展。各方可以共同探讨及分享环保减排等事关可持续发展的技术和商业模式，从而减少资源浪费，降低碳排放，提高全球产业链的可持续性，应对气候变化等全球性挑战。五是建立信任和互信。通过开放的对话和合作，各方可以更好地理解彼此的立场和利益，增进商业往来，达到提高全球产业链韧性的目的。

## 三、推动创新链、人才链、资金链和产业链融合发展

中国是全球最大贸易国和最主要的消费市场、外国投资目的地和对外投资来源国。这一切源自于中国具有市场规模庞大，人力、土地、资金等要素全面的独特优势，多年工业化进程也使中国成为全世界唯一拥有联合国产业分类中所列全部工业门类的国家。但同时，因为后发原因，中国的创新和人才资源积累不足，长期处于价值链的中低端，在产业链、价值链上游存在短板，在部分战略产业生态上韧性不足，易受外部因素影响。这一问题在过去几年中已经表现无遗。

因此，党的二十大报告提出，“教育、科技、人才是全面建设社会主义现代化国家的基础性、战略性支撑”。要更好统筹教育、科技、人才“三位一体”融合发展，通过协同配合、系统集成，塑造科技创新优势。二十大报告中还强调，“推动创新链产业链资金链人才链深度融合”。其中，创新链本质上是一种创新组织模式，在满足市场需求导向下，将参与创新的主体进行对接，以推动知识创新转化为经济社会效益。资金链是为企业正常运转提供资金支持的各类金融机构

主体或融资渠道构成的资金网络。人才链是通过培育或引进集聚与产业链发展相适应的人才梯队。产业发展离不开创新、资金、人才等生产要素的协同投入，产业链韧性的提升必然依赖于创新链、资金链和人才链的共同作用。推动“四链”深度融合，对于提升产业链韧性具有基础性、战略性意义。

需要指出的是，“四链融合”并不单指某一单一产业或者行业实现融合，而是在统一的国内大市场上的融合，意在构建一个完善的、要素充分流动的生态体系，以包容的方式维护战略产业的安全和韧性。

如前文所述，“四链”深度融合关键在于打造集创新活动、资金支持和人才保障为一体的生态体系。具体而言，一是优化财政、金融、税收、知识产权保护等创新支持政策，引导企业与社会资本积极投入研发和创新活动，提高研发投入强度；二是加强人才培育与流动。提升教育水平，加强 STEM 领域的教育，加强人才培养力度；开展技能培训和职业教育，提升人才的技术水平；鼓励人才集聚，畅通人才跨区域、跨领域、跨部门流动的通道。三是推动科学技术与产业的双向互动，强化产业实践积累与创造。重视产业为主角的技术创新和发明，提高我国企业的创新含量，争取培育更多科技创新型企业。四是破除体制障碍，更好发挥政府在“三位一体”协同发展中的统筹作用。具体做法包括通过深化改革，进一步打通创新和产业发展之间的通道；针对产业需求，引导市场培育、引进、用好各类高端人才，集中力量做强产业链制高点；围绕产业链部署创新链，围绕创新链完善资金链，消除科技创新中的“孤岛现象”。五是突破“四链”融合过程中的机制障碍，创新协作机制、激励模式和考核评价体系，增强链条主体参与融合的获得感。建立政府、企业、教育机构和社会团体之间的跨部门协作机制，形成合力，推动“四链融合”。

## 四、加强数字化转型，提升产业链的可预见性与适应性

数字化转型在现代产业发展中扮演着至关重要的角色，不仅能够提高效率和生产力，还能提高创新、生产、供应管理的智能化水平，增强产业链的可预见性，应对不断变化的市场环境和突发事件，从而提升产业链的稳定性和韧性。通过加强数字化转型，加强产业链内部各环节之间的紧密联系，帮助产业

链相关主体更好地应对市场变化和外部冲击，提高韧性，在竞争激烈的环境中保持竞争力。加强数字化转型，具体而言要求：一是加强数字基础设施的建设，确保高速互联网连接和数据存储能力，支持数字化转型。二是产业部门建立数据收集、分析和应用的能力，以数据分析助力决策科学化。三是推广物联网等技术应用，加强设备和系统的实时监控，提高生产效率；推动自动化和人工智能技术的应用，提高生产效率和生产质量；加快供应链管理的数字化，实现供应链的实时可视化，提高供应链的灵活性。四是增强网络安全，确保数字化系统和数据的安全性，减少潜在的网络攻击和数据泄露风险。五是在产业链数字化转型过程中，加强人才的数字化培训和技能提升，确保其适应数字化转型环境。

## 五、以有效的宏观政策改善市场环境，强化我国在关键产业上的薄弱环节

我国能够建立全产业链经济体系，与市场规模、充分的市场竞争以及行之有效的宏观经济政策引导息息相关。过去十多年来，我国的宏观经济政策推动相关高新制造业不断升级，我国制造业体系在全球价值链上的地位不断上升。但同时也留下了许多不足之处，如部分政策的效率存在问题、一些行业存在先天不足或存在市场资源配置、供给扭曲等问题。

近年来，为了保护战略产业的发展，我国先后通过设定战略规划，引导国企行动，辅以货币政策和财政政策支持的方式引导相关产业发展。但是，未来在解决“卡脖子”的战略环节问题上，从长远来说，除了通过货币政策和财政政策加以引导外，需要更多从立法方面出发给予引导。

一方面，在一定程度上借鉴欧盟和美国等发达国家的立法案例，加强对战略产业实施有效的法治化保护；另一方面，需要从更长远的角度考虑，通过营造市场化、法治化、国际化一流营商环境，优化民营和外资经济发展环境，依法保护民营企业产权和企业家权益，使各种所有制经济依法平等使用生产要素，公平参与市场竞争，以打通战略产业的研发、商业化、生产和流通相关环节。

在这一方面，2023 年 7 月发布的《中共中央 国务院关于促进民营经济发展壮大的意见》（即“民营经济 31 条”）成为近期宏观政策方面的一个积极案例。

此外，通过政策促进资本市场为人才培养和创新转化提供更多融资便利也是一个重要政策方向。资本市场与一些高新初创企业在短期利益与长期利益上不匹配的情况，应设法通过政策予以协调、引导，为企业提供更多成长空间以及竞争缓冲余地。

# 附件 1 国家产业链韧性相关指数及评价体系构建方法

## 一、国家产业链韧性相关指数综述

作为市场经济发展到一定历史阶段的必然产物，产业链是以企业活动为中心、凝聚多重产业发展、维系区域经济稳定的重要系统。韧性是宏观经济学中衡量经济主体抵抗冲击与恢复更新能力的重要概念。

产业链韧性评价是产业链研究中的重要课题，不仅需要综合运用经济学、管理学、生态学等学科知识考察产业链与韧性的来源、内涵、基本因素及其相互关系等问题，还需要用统计学的方法以数量化的指标对产业链韧性状况加以展示，从而相对地反映出国家在产业竞争力、自主创新能力、治理经营水平等方面的真实状况，并做出切合实际的评价和分析。

国家产业链韧性的评价指标大体可以分为两大类：效能指标与归因指标。前者反映的是一国产业链容纳、抵御冲击的能力，即受到一定冲击后的震荡水平；后者反映的是产业链韧性形成的原因或决定因素。

考虑到产业链所涉及主体层次的复杂性，本报告参考了制造业竞争力指数（CPI, Competitive Industrial Performance Index）、全球创新指数（GII, Global Innovation Index）、营商环境指数（Ease of Doing Business Index）三个广受国际认可的综合性指数。这些指数从不同角度对不同国家的产业链韧性进行了评估。

### （一）全球制造业竞争力指数

由联合国工业发展组织(UNIDO)发布的全球制造业竞争力指数(Competitive Industrial Performance Index)[①]是一项衡量世界主要国家在国内外市场上生产与出

① 全球制造业竞争力指数数据：https://stat.unido.org/cip/

口制造业产品能力的综合性指数。自 1996 年发布以来，该指数通过建立统一的制造业竞争力衡量标准，以图表形式对共 152 个国家在制造业竞争力上的表现进行展示与排名，为评估与比较该国家近期表现及其在全球制造业中的相对地位提供了可能。

CIP Index 一直不断改进，其最新指标体系在联合国工业组织政策、研究与统计部于 2021 年 5 月发布的《包容性与可持续的制造业竞争力指数》报告(The Inclusive and Sustainable Competitive Industrial Performance Index)[①]中得以确认，由制造业能力、国际影响力与结构性变动三个核心维度共 8 个二级指标组成。

**表 4.1 全球制造业竞争力指数体系构成**

| 一级指标 | 二级指标 |
|---|---|
| 制造业能力 | 国家人均制造业增加值 |
| | 国家人均制造业出口 |
| 国际影响力 | 单一国家全球制造业增加值占比 |
| | 单一国家全球制造业出口值占比 |
| 结构性变动 | 国家制造业增加值在 GDP 中占比 |
| | 国家制造业出口在整体出口中占比 |
| | 中高端制造业增加值在总制造业增加值中占比 |
| | 中高端制造业出口在总制造业出口中占比 |

全球制造业竞争力指数体系囊括了产业链中最重要的产业主体——制造业的核心衡量指标，为国家产业链韧性评价体系衡量产业链的增值功能与结构完整提供了宝贵参考。

## （二）全球创新指数

全球创新指数(GII, Global Innovation Index)[②]由世界知识产权组织(World Intellectual Property Organization)自 2007 年起每年发布，以统一的绩效衡量标准对世界上 132 个经济体的创新生态系统进行排名，并就各国创新的优劣势进行

①全球制造业竞争力指数构成说明：https://unido-gc.org/Publications/The%20extended%20inclusive%20and%20sustainable%20index.pdf#:~:text=The%20CIP%20index%20is%20a%20composite%20index%20that,sub-indicators%20encompass%20domestic%20production%20as%20well%20as%20exports

② https://www.wipo.int/global_innovation_index/en/

研究与分析。该指数以丰富的数据集为基础，包含了从公共和私人来源收集 的共 81 个指标。自 2007 年启动以来，全球创新指数不断塑造着全球创新评价议程，并为越来越多的政府提供经济决策的基石。

本报告所参考的 2022 年全球创新指数以“创新驱动增长的未来(the future of innovation-driven growth)”为主题，从 7 个维度、采用 81 个指标对每个经济体的政治环境、教育、基础设施和知识创造等方面的表现进行了评估与比较。

**表 4.2 全球创新指数体系构成**

| 一级指标 | 二级指标 | 三级指标 |
|---|---|---|
| 制度 | 政治环境 | 政治与运行稳定性（指数） |
| | | 政府效力（指数） |
| | 监管环境 | 监管质量（指数） |
| | | 法治（指数） |
| | | 裁员费用 |
| | 营商环境 | 经商政策 |
| | | 创业政策与文化（指数） |
| 人力资本与研究 | 教育 | 教育支出在 GDP 中占比 |
| | | 政府对每名中学生的资助占人均 GDP 的比重 |
| | | 基础教育阶段预期在校时长 |
| | | PISA 测试阅读、数学与和科学三科平均得分 |
| | | 中学师生数量比 |
| | 高等教育 | 高等教育毛入学率 |
| | | 科技工程专业毕业生在所有毕业生中占比 |
| | | 海外留学生流入率 |
| | 研究与开发 | 每百万人口中研究者与全职同等人员数量 |
| | | 研究与开发费用在 GDP 中占比 |
| | | 全国前三跨国公司的平均科研投入 |
| | | QS 排名中全国前三高校平均得分 |
| 基础设施 | 信息与通信技术 | ICT 接入（指数） |
| | | ICT 使用（指数） |
| | | 政府线上服务（指数） |
| | | 电子参与（指数） |
| | 一般基础设施 | 每百万人口的电力产出 |
| | | 物流表现（指数） |
| | | 集资总额占 GDP 的比重 |
| | 生态可持续性 | 花费每单位能源所产出的 GDP |
| | | 自然环境表现（指数） |
| | | 每产出十亿 GDP 所得 ISO 14001 环境证书数 |

| 一级指标 | 二级指标 | 三级指标 |
| --- | --- | --- |
| 市场成熟度 | 信贷 | 初创与规模企业投资 |
| | | 私营部门所用信贷占 GDP 的比重 |
| | | 小型信贷机构提供的贷款占 GDP 的比重 |
| | 投资 | 上市公司市值占 GDP 的比重 |
| | | 风险投资投资额占 GDP 的比重 |
| | | 风险投资成交额占 GDP 的比重 |
| | | 风险投资收入额占 GDP 的比重 |
| | 贸易、多元化与市场规模 | 平均关税税率 |
| | | 国内产业多样性 |
| | | 国内市场规模 |
| 商业成熟度 | 知识工作者 | 知识密集型产业从业人数占比 |
| | | 提供正式培训的公司占比 |
| | | 商业企业执行的研发支出总额占 GDP 的比重 |
| | | 商业企业提供的研发支出占比 |
| | | 具有高等学历的女性在总从业人口占比 |
| | 创新联结 | 企教间科创合作程度 |
| | | 企业集群的发展状况与深度 |
| | | 海外研发融资在总研发支出中占比 |
| | | 合资企业与战略联盟交易数 |
| | | 专利系列数 |
| | 知识转化 | 知识产权的使用费用占 GDP 的比重 |
| | | 高科技进口在总贸易额中占比 |
| | | 电信、计算机及信息服务进口在总贸易额中占比 |
| | | 国外直接投资占 GDP 的比重 |
| | | 商业企业从业者中研究人员比重 |
| 知识与科技产出 | 知识创造 | 居民专利申请数 |
| | | PCT 专利申请数 |
| | | 居民实用新型专利申请数 |
| | | 科技领域期刊论文数 |
| | | 可引用文档 H 指数 |
| | 知识影响 | 劳动生产率 |
| | | 新注册公司密度 |
| | | 计算机软件支出在 GDP 中占比 |
| | | ISO 9001 质量管理体系颁发的证书数 |
| | | 高科技制造业产出在总制造业产出中占比 |
| | 知识扩散 | 知识产权收入在总贸易额中占比 |
| | | 生产与出口复杂性（指数） |
| | | 高科技出口在总贸易额中占比 |

| 一级指标 | 二级指标 | 三级指标 |
| --- | --- | --- |
| | | 电信、计算机与信息服务出口在总贸易额中占比 |
| 创意输出 | 无形资产 | 全国前 15%公司的无形资产在其总值中占比 |
| | | 居民申请商标种类数 |
| | | 入围全球前 5000 名的品牌其价值在 GDP 中占比 |
| | | 居民工业设计提交数 |
| | 创意产品与服务 | 文创产品出口在贸易总额中占比 |
| | | 每百万人口中正片数量 |
| | | 娱乐和媒体市场 |
| | | 印刷等媒体产出在制造业总产出中占比 |
| | | 创意产品出口在贸易总额中占比 |
| | 在线创造力 | 通用顶级域名数 |
| | | 每千人人口中国家代码顶级域名数 |
| | | 每百万人口中 GitHub 接受修改数 |
| | | 移动应用全球下载量 |

自主创新能力是国家保证其经济自主可控的基础，对产业链的完整度与更新调控能力具有决定性作用。全球创新指数在多年发展中不断突破传统“创新”概念，拓展了国家制造业韧性评价体系的构建视野。

## （三）营商环境指数

营商环境指数(Ease of Doing Business Index)[①]由世界银行每年通过《营商环境报告》(World Bank’s Doing Business)发布，是对营商便利度得分和营商便利度排名两个综合指标的结果展示。该指数涵盖的 10 个主题共 41 个指标，对 190 个经济体进行了排名。营商环境指数一方面展示了经济体的营商便利度随时间推移发生的变化，另一方面反映了不同经济体在营商监管上的表现差异。

**表 4.3 营商环境指数体系构成**

| 一级指标 | 二级指标 |
| --- | --- |
| 创业 | 规程数量 |
| | 时间（天数） |

① https://databank.worldbank.org/metadataglossary/jobs/series/IC.BUS.EASE.XQ

| 一级指标 | 二级指标 |
| --- | --- |
| | 花费（占人均收入百分比） |
| | 最低花费（占人均收入百分比） |
| 处理基建许可 | 规程数量 |
| | 时间（天数） |
| | 花费（占仓库价值比重） |
| | 建筑质量控制指数（0－15） |
| 通电 | 规程数量 |
| | 时间（天数） |
| | 花费（占人均收入百分比） |
| | 供应稳定性与关税透明度指数（0－8） |
| 注册地产 | 规程数量 |
| | 时间（天数） |
| | 花费（占财产价值比重） |
| | 土地管理质量指数（0－30） |
| 获取信贷 | 法定权利强度指数（0-12） |
| | 信用信息深度指数（0-8） |
| 保护小股东 | 披露范围指数（0－10） |
| | 董事责任指数（0－10） |
| | 股东诉讼方便度指数（0－10） |
| | 股东权力范围指数（0－6） |
| | 所有权与控制范围指数（0－7） |
| | 企业透明度范围指数（0－7） |
| 缴税 | 缴款（每年） |
| | 时长（小时每年） |
| | 总税收及出资率 |
| | 信息公开指数（0-100） |
| | 处理增值税退税所需时间（小时） |
| | 获得增值税退税所需时间（星期） |
| | 处理调整企业所得税所需时间（小时） |
| | 完成企业所得税调整所需时间（星期） |
| 跨境贸易 | 出口时间（小时） |
| | 出口花费（美元） |
| | 进口时间（小时） |
| | 进口花费（美元） |
| 合同执行 | 时间（天数） |
| | 花费（占索赔的比重） |
| | 司法程序质量指数（0－18） |
| 破产解决 | 回收率（价格） |
| | 破产框架强度指数（0－16） |

产业链的形成与升级既离不开企业的内部管理和市场经济的作用，也离不开政府的宏观调控。国家产业链韧性评价体系中对营商环境指数相关指标的参考良好地平衡了“无形之手”与“有形之手”在提升国家产业链韧性中的影响，提升了评价体系的科学性。

## 二、国家产业链韧性评价指标体系构建

### （一）评价体系构建的指导思想

提升产业链韧性是推进产业链现代化的重要内容，也是增强经济韧性的关键环节。

一方面，不断提高国家产业链水平、强化产业在全球价值链各环节的增值能力、实现在全球价值链的地位升级，对促进产业、人才、创新、资金等要素协同以及国家经济发展具有重要意义；另一方面，保证产业链供应链的稳定性、增强产业链在完整性、协同性、强韧性三方面的协调统一是身处百年未有之大变局，应对后疫情时代贸易保护主义、逆全球化及全球经济下行风险的必然选择。

从国家的角度看，产业链的抵御风险能力与恢复更新能力是产业链韧性的根本；从事物发展的角度看，事物发展同时受到“内因”和“外因”的作用。

因此，在构建评价体系的过程中，本报告形成了以企业与产业为主体、以人才、创新、资金等重要要素为参考的评价体系；同时，本报告引入市场与政府双重视角，以反映各国在新冠疫情爆发当年产业链的变化，评估产业链韧性的表现与潜力。

### （二）评价体系设计的基本原则

#### 1. 科学性原则

本报告在构建“国家产业链韧性评价体系”时，运用产业链相关研究的最新成果，充分结合已有的评价体系，设置与产业链特征密切相关的指标，使得评价体系科学地、完整地反映产业链韧性的本质。

### 2. 可量化原则

尽管体制、机制、制度环境等社会因素直接影响国家产业链，但对此类因素的评价具有很大的主观性，会受到评价人的主观意识、认知能力乃至个性、好恶的左右，难以客观、公正。因此，本报告在评价体系设计中不采用通过问卷调查等方法得到的定性评价结果，所有指标均为世界银行等机构发布的统计数据以及根据这些数据计算得到的定量结果。

### 3. 可比较原则

鉴于产业链韧性是一个差别性概念，本报告将对国家产业链韧性的不同指标进行指数化处理，使得研究的对象具有可比性。

## （三）评价体系的结构

根据以上原则，设计出专门用于国家产业链韧性的评价体系结构。此评价体系将国家产业链韧性分为人才资本、创新资源、产业总体情况、制造业表现和企业活力 5 个一级指标。其中，人才资本指标衡量不同国家人才资本、人才储备、人才培养能力，创新能力指标衡量不同国家创新投入、创新产出，企业活力指标从营商环境、企业经营成果等方面衡量不同国家企业发展活力。这几个一级指标主要属于归因指标。产业总体情况指标衡量不同国家产业发展总体情况，制造业表现指标衡量不同国家制造业表现，这两个指标表征国家制造业韧性现状，反映了国家的人才、创新、企业、政策投入对产业的影响情况。

## （四）国家产业链韧性评价模型

### 1. 模型的选择

根据国家产业链韧性评价体系的结构，可以构建一般意义上的国家产业链韧性评价模型，即：

$$J_i = \sum B_k * Q_k$$

其中，$J_i$为不同国家的产业链韧性，$B_k$为一、二层级等各项指标（指数），$Q_k$为分别对应一、二级指标（指数）的权重。k 分别为第一、二层级的指标数。与国家产业链韧性评价体系的结构对应，本报告第一层级指标数 k 为 5，第二层级的指标数则根据不同一级指标的不同特征确定。

## 2. 权重的确定

国家产业链韧性评价体系中各指标在评价某国的产业链韧性时发挥的作用各不相同。为体现不同指标在评价指标体系中的重要程度，应给每个指标赋予不同的权重系数。指标的权重是各指标相对重要程度的一种主观与客观度量的反映，合理的权重系数对国家产业链韧性评价具有重要的意义。

目前，评价指标权重的确定方法主要采用主客观相结合的专家集体决策方法，如德尔菲法、层次分析法、灰色关联分析法等。

层次分析法（AHP）是美国学者 T.L.Satty 等人在 20 世纪 70 年代提出的一种定性分析与定量分析相结合的多准则决策方法。该方法对各指标的重要程度的分析逻辑严密，且进行周密的数学处理，可信度较大，体现了主观分析与客观计算相结合的特点，因而被广泛应用到指标权重的确定上。

本研究报告在明确指标体系层级结构后，即采用层次分析法对国家产业链韧性评价指标体系中的指数权重加以确定。本研究组共邀请 9 位专家分别对一、二层次的指标（指数）进行两两比较与判断，并采用 1-9 的比例标度，将专家的定性判断定量化，由此构造出若干个两两比较判断矩阵。再对这些比较判断矩阵进行层次单排序，计算各自的权重系数（精确到小数点后两位数），并对之进行一致性检验。由于计算过程繁琐，占用篇幅过多，本研究报告计算权重的过程均不一一列出。

## 3. 数据处理的原则、方法

由于产业链韧性各项指标数据的量纲不同，因此，需要对这些指标进行综合集成，并且对指标数据进行无量纲处理。本研究报告主要采取指数化方法。

指数法的计算公式为：

$$X_i = \frac{x_i}{x_{0i}}$$

$X_i$ 为指数，$x_i$ 为原始值，$x_{0i}$ 为最大值。

# 附件 2 关于全球化智库（CCG）及课题组

## 全球化智库介绍

全球化智库（Center for China and Globalization，CCG）是中国领先的国际化社会智库，成立于 2008 年，是唯一获得联合国特别咨商地位的中国智库，也是首个进入世界百强的中国社会智库，在国内外多个权威智库排行榜单均被评为中国社会智库第一。

CCG 被人社部授予博士后科研工作站，并拥有独立招收博士后资质，是中联部“一带一路”智库联盟理事单位，中央人才工作协调小组全国人才理论研究基地，人社部中国人才研究会国际人才专业委员会所在地，财政部“美国研究智库联盟”创始理事单位，中国公共关系协会副会长单位，是“国际青年领袖对话（GYLD）”项目的秘书处所在地。2021 年，CCG 发起的“国际青年领袖对话（GYLD）”项目获得了习近平主席回信。

CCG 总部位于北京，在国内外有多个分支机构和海外代表，拥有全职智库研究和专业人员百余人。CCG 秉承“国际化、影响力、建设性”的专业定位，坚持“以全球视野为中国建言，以中国智慧为全球献策”，致力于全球化、全球治理、国际关系、国际经贸与投资、国际人才与企业全球化、一带一路、华人华侨及智库发展等领域的深入研究。

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全球化智库（CCG）研究员于蔚蔚、政府项目合作部副总监赵占杰、助理研究员何航宇、助理研究员彭智涵、美编曹茜，研究助理王越、田馨玥、马政洋、贺景一等对本报告的资料收集、讨论、翻译、编辑、设计做出了贡献。

本报告得到虹桥国际经济论坛秘书处及中国汽车技术研究中心中国汽车战略与政策研究中心前瞻战略与国际化研究部部长宋瑞等领域专家的支持，在此特别感谢。由于撰写和编辑匆促，报告中难免出现纰漏。欢迎社会各界批评指正，以便我们在未来的研究工作中获得进益。

2023

# TALENT, INNOVATION AND RESILIENCE OF INDUSTRIAL CHAINS REPORT 2023

## (ENGLISH VERSION)

November 2023

CCG 全球化智库
CENTER FOR CHINA & GLOBALIZATION

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# Introduction

The global industrial chain has emerged during the process of economic globalization, in which enterprises from various countries cooperate in a specialized division of labor according to the market economy principles of efficient and free movement of production factors and optimizing resource allocation. This is in line with the trends of economic and social development. Currently, the world is undergoing “the significant transformation that has not been seen in a century”, with the profound impact of the pandemic and the convergence of multiple challenges and crises. Economic globalization is facing headwinds, and the security and stability of the global industrial chain are at risk. Maintaining the resilience and stability of the global industrial chain is essential for driving global economic development and is in the common interest of people around the world.

The Chinese government places a high priority on the resilience of industrial and supply chains. The 20th National Congress of the Communist Party of China explicitly stated the need to “focus on enhancing the resilience and security of industrial and supply chains”. Ensuring the stability and security of industrial chains while improving their modernization is aimed at reducing the risks of “chain blockages” and “chain disruptions” and laying a solid foundation for industries to move towards the high end of the global value chain. At the Central Economic Work Conference 2022, it was further emphasized the importance of “strengthening weak links in the industrial chain” and that “industrial policies should prioritize both development and security.” In May 2023, during the first meeting of the 20th Central Committee of Financial and Economic Affairs, President Xi Jinping emphasized that it is necessary to leverage China's vast market advantages, integrate the strategies of expanding domestic demand and driving innovation-led development, and strengthen open cooperation in industrial and supply chains.

Industrial chains are the result of long-term development in international trade, investment, and economic cooperation, as well as the continuous deepening of the international labor division. In the context of globalization, the occurrence of a “breakpoint” within a chain can lead to inefficiency or even paralysis of the entire chain. This not only affects the domestic economy but also triggers instability in global

economic development.[①]

Under the context of a significant transformation that has not been seen in a century, the stability of global economic development is becoming increasingly prominent, and the global industrial chain system is facing restructuring. How to maintain and ensure the safety and stability of industrial and supply chains and enhance their resilience has become a common challenge and a significant topic for all countries[②].

The resilience of a country's industrial chain is related to several factors, including the soundness of its industrial sectors, the diversity of import and export channels, and adaptability. Among these factors, human capital and innovation resources are especially crucial for enhancing the resilience of the supply chain. The 20th Party Congress report has proposed the promotion of deep integration among the innovation chain, industrial chain, capital chain, and talent chain. President Xi Jinping has also emphasized the importance of deploying the innovation chain around the industrial chain, improving the capital chain around the innovation chain, and deploying and perfecting the mechanism for talent development[③]. This report attempts to explore the role of talent and innovation in enhancing the resilience of the industrial chain through data analysis.

This report constructs a National Industrial Chain Resilience Index using five primary indicators (talent capital, innovation resources, overall industry situation, manufacturing performance, and corporate vitality) and 22 secondary indicators. Based on the index, the report analyzes the international positioning of the industrial chain resilience of 38 countries, including China, the United States, Canada, the United Kingdom, France, Germany, Australia, New Zealand, Japan, South Korea, Singapore and India. It also compares the contributions of talent capital, innovation resources, overall industry situation, manufacturing performance, and enterprise vitality to the industrial chain resilience of each country. Besides, the report focuses on China's performance in the five aspects and analyzes the impact of talent and innovation on industrial chains, with a focus on the new energy vehicle and semiconductor industries. Through comparisons and case studies, the report provides recommendations for improving industrial chain resilience. These recommendations aim to contribute to the construction of a global industrial chain system that is safe, stable, efficient, open,

① 中国政府网, https://www.gov.cn/xinwen/2021-11/11/content_5650246.htm.
② 中国政府网, https://www.gov.cn/xinwen/2022-09/21/content_5710853.htm.
③ 国家发展和改革委员会, https://www.ndrc.gov.cn/xwdt/ztzl/srxxgcxjpjjsx/xjpjjsxjyqk/202304/t20230410_1353461.html.

inclusive, and mutually beneficial. The key recommendations include: (1) uphold the principle of cooperation and openness to further enhance the rule-based system that benefits global industrial risk management; (2) establish a platform for the exchange of industrial chain resilience and creating a routine communication mechanism; (3) promote the integration of innovation, industry, talent, and financial chains to maximize China's advantages in market scale and improve the ecosystem in strategic industries; (4) enhance digital transformation to improve the predictability and adaptability of the industrial chain; (5) improve the market environment with effective macro policies and strengthening China's weaknesses in key industries.

# Chapter 1: National Industrial Chain Resilience Index

In this chapter, following the principles of simplicity, predictability, and international comparability, we establish a primary national industrial chain resilience assessment index system and evaluate the resilience of relevant national industrial chains.

## I. Construction of the National Industrial Chain Resilience Assessment Index System

### 1. The Connotation of National Industrial Chain Resilience

National industrial chain resilience, with the nation as the primary unit, signifies a complex adaptive capability where, when faced with external disruptive events or internal issues within the chain, the industrial chain can maintain dynamic equilibrium, respond positively to disruptive events, and ultimately return to normal operation. In the year 2020, as the world was swept by a sudden global public health crisis and at a time when the global economic situation deteriorates and international geopolitical risks intensify, national industrial chain resilience reflects the ability of businesses, industries, and nations to maintain economic stability and sustainable development when facing or about to face uncertainty and risks.

This evaluation includes 38 countries from around the world, including Group of Twenty (G20) countries[①], most countries with a population of over 10 million and per capita GDP of over $10,000, and a few developed countries with populations of less than 10 million but exceed or approach 5 million and per capita GDP above $40,000 (high-income countries). The combined population and GDP of these 38 selected countries in 2022 accounted for 62.16% and 87.92%[②] of the world's total, respectively.

① The European Union (EU), while a member of the G20, was not included in the assessment due to overlaps between its member countries and those in the G20.
② The data is from World Bank.

## 2. National Industrial Chain Resilience Index System

The data sources for this index system primarily include the World Bank's World Development Indicators (WDI) database, the World Bank's Doing Business Data database, the United Nations International Labor Organization (ILO) database, the United Nations Educational, Scientific, and Cultural Organization (UNESCO) database, *Hurun Global Unicorn Index 2020*, the 2020 QS World University Rankings Top 1000 list, the European Union's Eurostat database, the Organization for Economic Cooperation and Development (OECD) database, and the United Nations Conference on Trade and Development (UNCTAD) database.

The report used data reflecting the situation in 2020, with the main data indicators covering the years from 2019 to 2021. The criteria for data selection mainly considered the following key factors:

(1) The data should be capable of reflecting the most recent changes in the resilience of industrial and supply chain systems. It is well-known that the COVID-19 pandemic erupted globally in 2020, severely disrupting global supply chains. Simultaneously, the continued escalation of geopolitical risks and uncertainties, as well as the rapid development of the new energy industry, driven by the urgency of climate change, have led to a profound transformation in global industrial chains. The data from 2019 to 2021 largely reflects the impact of these changes on industrial and supply chains

(2) The data should be accessible, consistent, and comprehensive. In general, the majority of the data used in this report was updated to 2020, with a small portion updated to 2021 and 2022. Some databases lacked specific data for certain countries, and these missing data were mostly supplemented using data from the corresponding statistical departments of those countries or the Ibero-American Science and Technology Indicators Network (RICYT) database. Data for 2021 and 2022 were not included in the statistics due to their lack of completeness, compounded by the complex impacts of the Ukrainian crisis.

The National Industrial Chain Resilience Index System established in this study includes five primary indicators: talent capital, innovation resources, overall industry situation, manufacturing performance, and enterprise vitality, as well as 22 secondary indicators.

**i. Talent Capital Indicator**

The *Talent Capital* indicator is a primary indicator that measures various aspects

of a country's talent reserve strength, talent development capability, talent attraction capacity, and talent creativity. This indicator includes five secondary indicators: *Labor Productivity, Labor Force Size, Proportion of Labor Force with Higher Education, Inbound International Students* and *Share of Public Education Expenditure in GDP*.

The indicator *Labor Productivity* is derived from the *GDP per person employed, constant 2017 PPP $* in the World Bank's World WDI database, and portrays the contribution of employed individuals to economic growth. *Labor Force Size* is a reflection of a country's labor resources and demographic dividend. Abundant labor resources are the foundation for stable industrial development, while a competitive labor force is also attractive to foreign investment. The indicator *Proportion of Labor Force with Higher Education* is calculated using two indicators in the International Labor Organization database: *Working-age population by sex, gender, and education* and *Working-age population by sex and gender*. It directly showcases the strength of the advanced talents. *Inbound International Students*" refers to the number of international students received by a country's higher education institutions, which signifies the country's attractiveness to international talent. The indicator *Share of Public Education Expenditure in GDP* reflects the government's emphasis on and support for basic education, secondary education, and higher education. It also shows a country's investment in talent development and the potential for increasing labor productivity.

**ii. Innovation Resource Indicator**

The *Innovation Resources Indicator* is a primary indicator assessing the input and output of innovation in different countries. This indicator consists of five components: *Total Granted Patents*, *Number of Scientific and Journal Articles*, *Researchers per million inhabitants (FTE)*, *Share of Research and Development Expenditure in GDP*, *Top 1000 World University Score.*

*Total Granted Patents* and *Number of Scientific and Journal Articles* are both direct measurement of innovation output. *Total Number of Granted Patents* includes both direct grants and PCT national phase patents. *Number of Scientific and Journal Articles* represents the quantity of scientific research articles published in fields such as physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology, as well as earth and space sciences. *Researchers per million inhabitants (FTE)* indicates the number of professional researchers engaged in research and development (R&D) work per one million inhabitants within a given year,

providing a direct reflection of the input of innovation personnel. *Share of Research and Development Expenditure in GDP* demonstrates the level of investment in innovation by both the government and businesses. *Top 1000 World University Score* primarily reflects the potential for innovation of universities of a country and its reserve of innovative talent.

**iii. Overall Industry Situation Indicator**

The *Overall Industry Situation* indicator is a key indicator for assessing the overall situation of industrial development in different countries. This indicator includes six secondary indicators: *Gross Domestic Product* (or GDP), *Total Value of Goods and Services Exports*, *Foreign Direct Investment Inflow* (or FDI inflow), *Growth Rate of FDI Inflow in 2020*, *Foreign Direct Investment Outflow* (FDI outflow), and *Growth Rate of FDI outflow in 2020*.

The *Gross Domestic Product* and *Total Value of Goods and Services Exports* directly reflect a country's industrial development performance and its export trade situation. *FDI Inflow* reflects the size of foreign capital available in the country and its attractiveness to international investments while *FDI Outflow* reflects the country's international competitiveness and its integration into the global industry chain. *Growth Rate of FDI Inflow in 2020* indicates the year-over-year growth of inward FDI in 2020 compared to 2019. *Growth Rate of FDI outflow in 2020* indicates the year-over-year growth of outward FDI in 2020 compared to 2019. These two indicators demonstrate the changes in a country's foreign investment attraction and outward investment following the impact of the COVID-19 pandemic.

**iv. Manufacturing Performance**

Given that the industrial chain is more prominently represented in the manufacturing sector, this report takes manufacturing performance as a primary indicator. Assessing the performance of the manufacturing industry in different countries, the *Manufacturing Performance* indicator comprises three secondary indicators: *Value Added in Manufacturing*, *Proportion of Value Added in Medium and High-Tech Manufacturing to Total Manufacturing Value Added*, and *Proportion of High-End Manufacturing Exports to Total Manufacturing Exports*.

*Value Added in Manufacturing* serves as a direct demonstration of manufacturing industry development. *Proportion of Value Added in Medium and High-Tech Manufacturing to Total Manufacturing Value Added* reflects the core competitiveness of the manufacturing industry. *Proportion of High-End Manufacturing Exports to Total*

*Manufacturing Exports* measures the competitiveness of the manufacturing industry in international markets.

**v. Enterprise Vitality**

The Enterprise Vitality is an indicator used to measure the vitality of business development in different countries from diverse aspects such as the effectiveness of enterprise development, the situation of new startup companies, and the business environment. This indicator includes three secondary indicators: *Number of Unicorn Enterprises*, *Number of New Registered Companies Annually*, and *Ease of Doing Business Score*.

**Table 1.1 National Industrial Chain Resilience Evaluation Index System**

| Primary Indicator | Primary Indicator Weighting | Secondary Indicator | Secondary Indicator Weighting | Data Source |
|---|---|---|---|---|
| **Talent Capital** | 0.230 | Labor Productivity (USD per person) | 0.043 | WDI |
| | | Labor Force Size (number) | 0.041 | WDI |
| | | Proportion of Labor Force with Higher Education (%) | 0.046 | ILO |
| | | Inbound International Student (number) | 0.031 | UNESCO |
| | | Share of Public Education Expenditure in GDP (%) | 0.041 | WDI, WIPO GII Report |
| **Innovation Resource** | 0.179 | Total Granted Patents (number) | 0.048 | WIPO |
| | | Number of Scientific and Journal Articles (number) | 0.035 | WDI |
| | | Researchers per Million Inhabitants, Full-Time Equivalent (per person per year) | 0.045 | UNESCO |
| | | Share of Research and Development Expenditure in GDP (%) | 0.054 | WDI, WIPO GII Report |
| | | Top 1000 World University Score (points) | 0.033 | QS |
| **Overall Industry Situation** | 0.272 | Gross Domestic Product (measured in current US dollars, millions) | 0.051 | WDI |

| Primary Indicator | Primary Indicator Weighting | Secondary Indicator | Secondary Indicator Weighting | Data Source |
|---|---|---|---|---|
| | | Total Value of Goods and Services Exports (measured in current US dollars, dollars) | 0.048 | WDI |
| | | Foreign Direct Investment Inflow (millions of US dollars) | 0.052 | UNTCAD |
| | | Growth Rate of FDI Inflow in 2020 (%) | 0.050 | Calculated using UNTCAD data |
| | | Foreign Direct Investment Outflow (millions of US dollars) | 0.038 | UNTCAD |
| | | Growth Rate of FDI Outflow in 2020 (%) | 0.034 | Calculated using UNTCAD data |
| **Manufacturing Performance** | 0.180 | Value Added in Manufacturing (billion US dollars) | 0.061 | WDI |
| | | Proportion of Value Added in Medium and High-Tech Manufacturing to Total Manufacturing Value Added (%) | 0.063 | WDI |
| | | Proportion of High-End Manufacturing Exports to Total Manufacturing Exports (%) | 0.055 | WDI |
| **Enterprise Performance** | 0.139 | Number of Unicorn Enterprises (number) | 0.053 | Global Unicorn Index 2020 |
| | | Number of New Registered Companies Annually (number) | 0.033 | WDI |
| | | Ease of Doing Business Score (points) | 0.045 | World Bank Doing Business Data |

Note: "WDI" refers to the World Bank World Development Indicators database, "WIPO" stands for the World Intellectual Property Organization database, "2020 Global Unicorn Index" refers to the *Hurun Global Unicorn Index 2020* published by the Hurun, and "QS" refers to the 2020 QS World University Rankings Top 1000 list.

The *Number of Unicorn Enterprises* mainly reflects the potential for business development in a given country. *Number of New Registered Companies Annually* reflects the situation of new startup companies and directly indicates market innovation vitality. The business environment is a critical institutional guarantee for business development and industrial stability, and the *Ease of Doing Business Score* indicator portrays the country's institutional support in maintaining industrial chain stability and supporting the development of enterprises in the industrial chain.

Based on the National Industrial Chain Resilience Assessment Indicator System and using the aforementioned indicators, this report employs the Analytic Hierarchy Process (AHP) to determine the weights of each secondary indicator, as shown in Table 1.1.

## II. Assessment of Industrial Chain Resilience in Major Countries Worldwide

Using above data and indicators, this report calculates the international ranking of industrial chain resilience of 38 countries in 2020, as well as their performance in the following aspects: talent capital, innovation resources, overall industry situation, manufacturing performance and enterprise vitality.

Final results shows that the 38 countries can be categorized into several tiers based on their scores in industrial chain resilience. The first tier comprises the top ten ranking countries. The United States leads significantly, opening up a considerable gap with the second-ranked country, China, with a score 1.2 times higher. Germany, Japan, and Singapore rank third to fifth, with scores ranging from 0.35 to 0.38; these three countries perform similar but have a more distinct gap when compared to the United States, with scores just over half that of the United States. The sixth to tenth positions are held by South Korea, the United Kingdom, Sweden, Israel, and France, with scores between 0.3 and 0.35.

In the top ten, there are five European and five Asian countries, demonstrating a balanced representation in terms of quantity. It can be observed that Asian countries also possess robust industrial resilience.

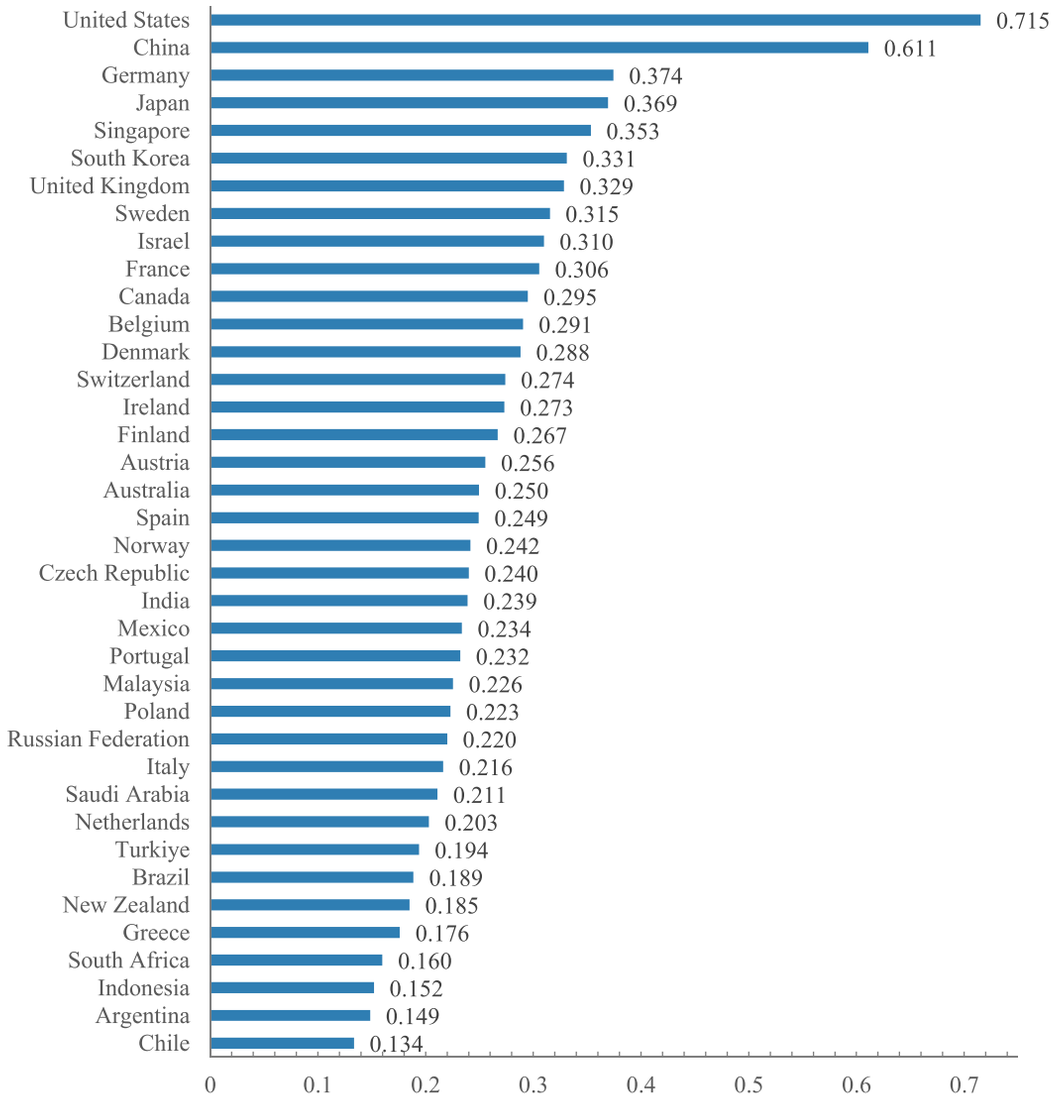


**Figure 1.1 Industrial Chain Resilience Rankings for 38 Countries**

The second tier consists of countries ranked from 11 to 17, including Canada, Belgium, Denmark, Switzerland, Ireland, Finland, and Austria, with scores ranging from 0.25 to 0.3. The third tier encompasses countries ranked from 18 to 24, which include Australia, Spain, Norway, Czech Republic, India, Mexico, and Portugal, with scores ranging from 0.23 to 0.24. Countries ranked from 25 to 30, including Malaysia, Poland, the Russian Federation, Italy, Saudi Arabia, and the Netherlands, make up the fourth tier, with scores ranging from 0.2 to 0.22. The last 8 countries, ranked from 31 to 38, which are Turkiye, Brazil, New Zealand, Greece, South Africa, Indonesia, Argentina, and Chile, have resilience indices ranging from 0.13 to 0.2.

The differences in Industrial Chain Resilience Index between countries in the last three tiers are not significant. However, the score of the top-ranking United States is

5.4 times that of the last-ranking Chile. Refer to Figure 1.1 for details.

In terms of *Talent Capital*, the United States ranks first with a significant lead, while Canada, Australia, and the United Kingdom take the second to fourth positions. Ireland holds the first position in the *Labor Productivity* indicator, primarily due to its tax policies that attract a substantial number of high-value-added businesses, especially in the ICT sector and research organizations. Singapore closely follows Ireland in the second position with similar contributing factors. Saudi Arabia secures the top spot in the *Share of Public Education Expenditure in GDP* indicator, with Sweden and Israel following closely. The comprehensive results indicate that both Ireland and Saudi Arabia perform well in the overall aspect of talent capital. See Figure 1.2 for more details.

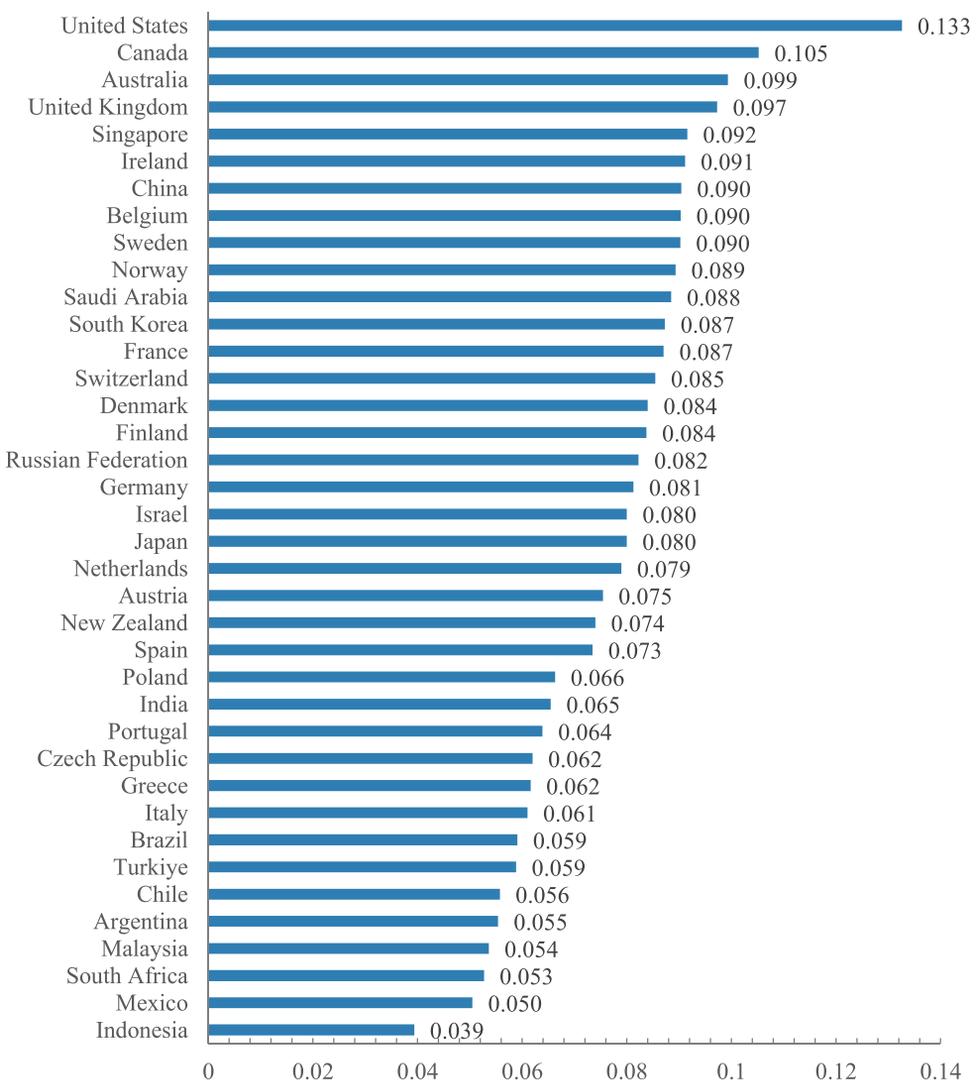


**Figure 1.2 Talent Capital Rankings for 38 Countries**

Regarding the *Labor Force Size* indicator, China and India are ranked first and second, significantly ahead of other countries. Canada takes the first position in the *Proportion of Labor Force with Higher Education* indicator, with Singapore, South Korea, and Russia following closely. In the *Inbound International Student* indicator, the United States leads by a considerable margin, with a significant gap from the second-ranked United Kingdom and the third-ranked Australia.

In terms of *Innovation Resources*, the United States and China secure the top two positions, with the United States having a score 1.2 times that of China. Japan, South Korea, and Israel follow closely, ranking third to fifth. When compared to other countries, the United States and China exhibit significant advantages, with the United States having a score 1.93 times that of Japan, the third-ranked country. For more details, please refer to Figure 1.3.

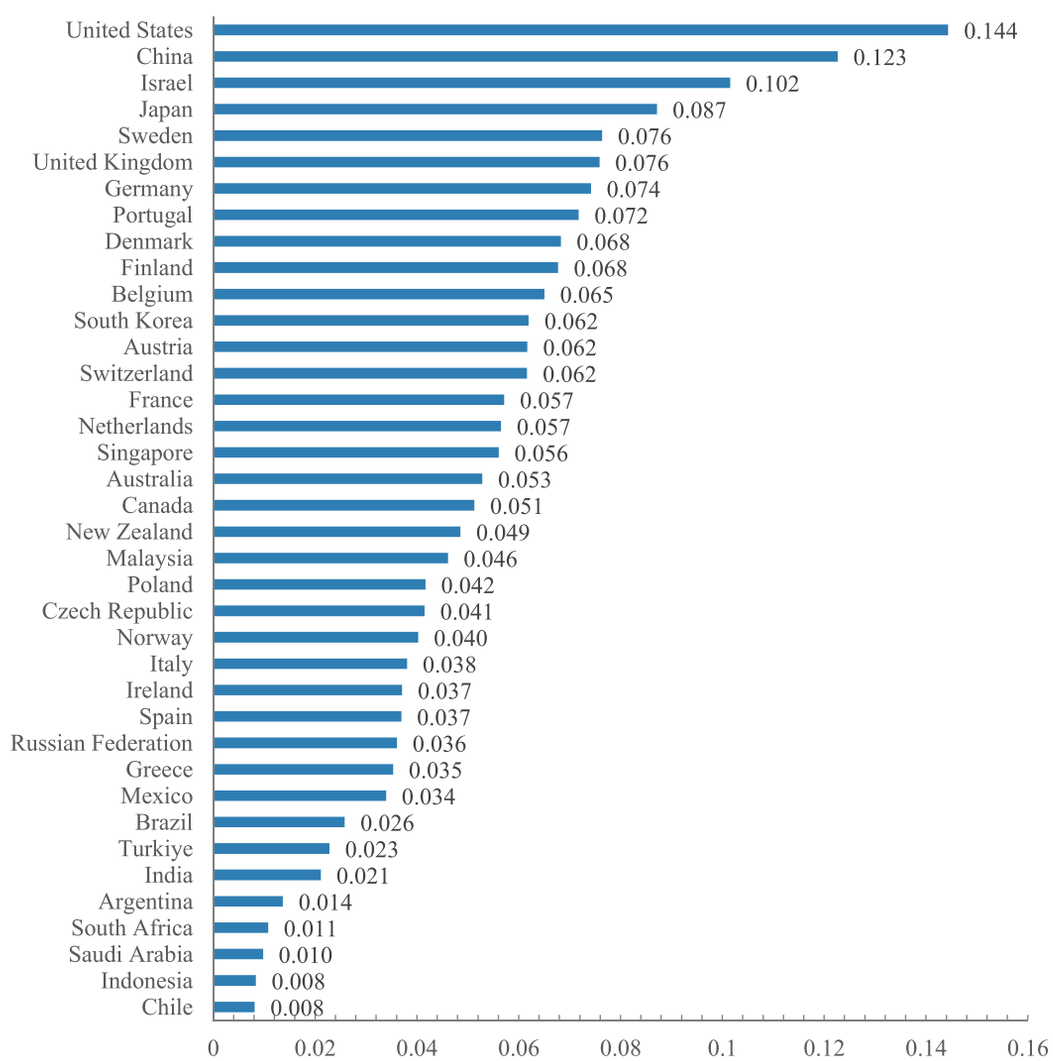


**Figure 1.3 Innovation Resource Rankings for 38 Countries**

In the *Total Patents Granted* indicator, China claims the highest score, with the United States in the second position. China's continuous ranking as the global leader in the number of patent applications, along with its achievement of having the highest number of valid patents in 2021, surpassing the United States, have significantly contributed to China's top-ranking position. The scores of China and the United States differ significantly from those of other countries, with Japan and Portugal taking the second and third positions.

In the *Number of Scientific Journal Papers* indicator, China and the United States remain at the forefront with a clear advantage, and India ranks third. Regarding the *Researchers per Million Inhabitants, Full-Time Equivalent* indicator, Israel leads, with Portugal closely following. In the *Research and Development Expenditure as a Percentage of GDP* indicator, Israel is the leader, while South Korea and Malaysia secure the second and third positions. In the *Top 1000 World University Score* indicator, the United States is notably ahead, with the United Kingdom in the second place.

In the *Overall Industry Situation* indicator, the United States and China maintain their top two positions. Both countries have a considerable lead over Germany, which ranks third, with China's score being 2.5 times that of Germany. See Figure 1.4 for more details. Ireland has a strong overall industrial situation, ranking 12$^{th}$, mainly due to its 2020 FDI inflow of $76.57 billion, placing it third in the *Foreign Direct Investment Inflow* indicator. New Zealand, Switzerland, and the Netherlands have lower scores in the overall industrial situation, ranking from 36$^{th}$ to 38$^{th}$. Specifically, New Zealand performs poorly in three indicators: *Gross Domestic Product*, *Total Value of Goods and Services Exports* and *2020 FDI Outflow Growth Rate*, ranking 37$^{th}$, 38$^{th}$, and 36$^{th}$, respectively. The Netherlands, while ranking first in the *2020 FDI Inflow Growth Rate* indicator, ranks 38$^{th}$ in the *Foreign Direct Investment outflow* and *2020 FDI Outflow Growth Rate* indicators. The relatively single-industry structure and high dependence on international trade have severely impacted the industrial development in the Netherlands, under the impact of the global pandemic and logistics interruptions in 2020. Furthermore, Switzerland ranks 37$^{th}$ in *Foreign Direct Investment Inflow* and 35$^{th}$ in *Foreign Direct Investment Outflow*, mainly because of the well-developed financial sectors, leading to unusual changes in capital flows during the global pandemic, affecting both capital inflow and outflow.

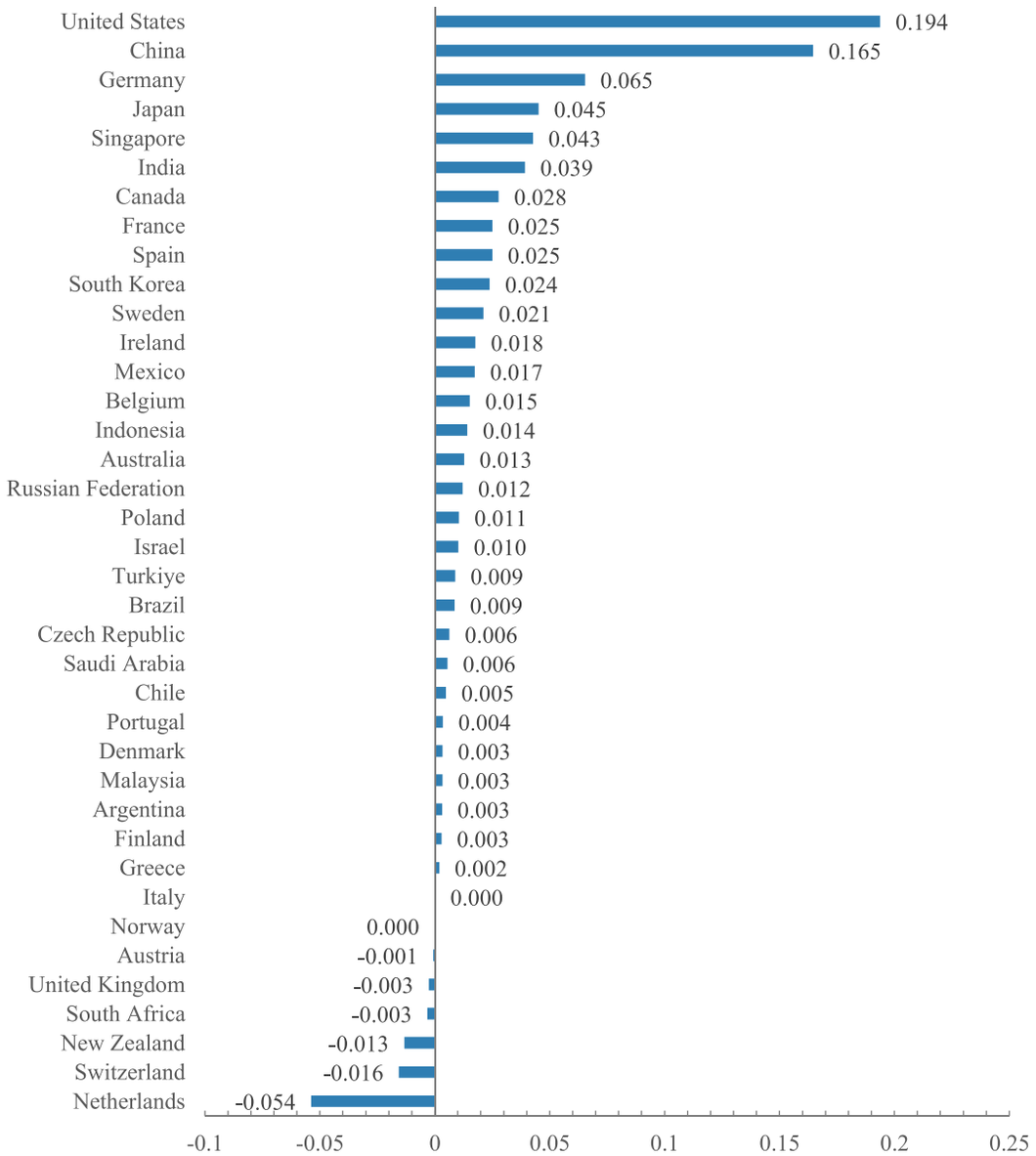


**Figure 1.4 Overall Industry Situation Rankings for 38 Countries**

In the *Gross Domestic Product* indicator, the United States and China rank first and second, with a significant gap from the rest of the countries. In the *Total Value of Goods and Services Exports* indicator, China, the United States, and Germany are the top 3, with a considerable gap from other countries. In the *Foreign Direct Investment Inflow* indicator, China ranks first, while the United States and Ireland are second and third, respectively. In the *2020 FDI Inflow Growth Rate* indicator, the Netherlands is ranked first. As previously mentioned, due to special policies and their unique positions in the capital market, Ireland and the Netherlands perform exceptionally well in relevant indicators of capital flow. Their rankings also reflect the unusual changes in global

capital flow caused by the pandemic. In the *Foreign Direct Investment Outflow* indicator, the United States and China are the top two. In the *2020 FDI Outflow Growth Rate* indicator, the United States ranks first, significantly ahead of others. In terms of the *Manufacturing Performance* indicator, China ranks first, but the gap with second-ranked Singapore is not significant. The United States, Japan, and Germany are third to fifth. See Figure 1.5 for more details.

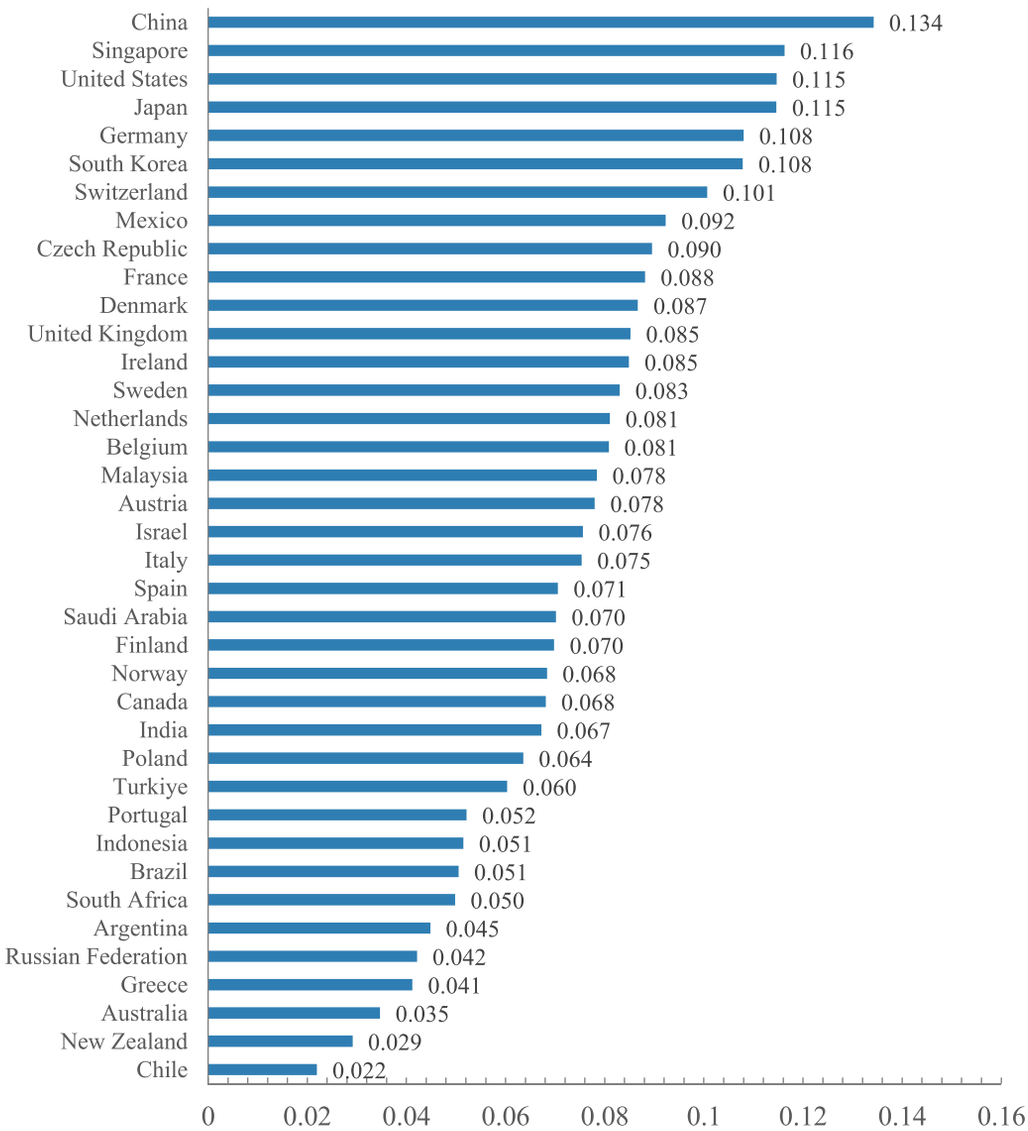


**Figure 1.5 Manufacturing Performance Rankings for 38 Countries**

In the *Manufacturing Value Added* indicator, China leads by a large margin, with the United States, Japan, and Germany ranking second to fourth. In the *Share of Medium-High Technology Manufacturing Value Added in Total Manufacturing Value*

*Added* indicator, Singapore takes the top spot, followed by Switzerland, South Korea, Germany, and Denmark. In the *Share of High-End Manufacturing Exports in Total Manufacturing Exports* indicator, Japan ranks first, followed closely by Mexico, South Korea, Singapore, and Germany.

In terms of *Enterprise Vitality*, the United States leads by a significant margin, with a score 1.3 times that of second-ranked China. The United Kingdom comes in third but has a noticeable gap compared to China, with China's score being 1.36 times that of the UK. See Figure 1.6 for more details.

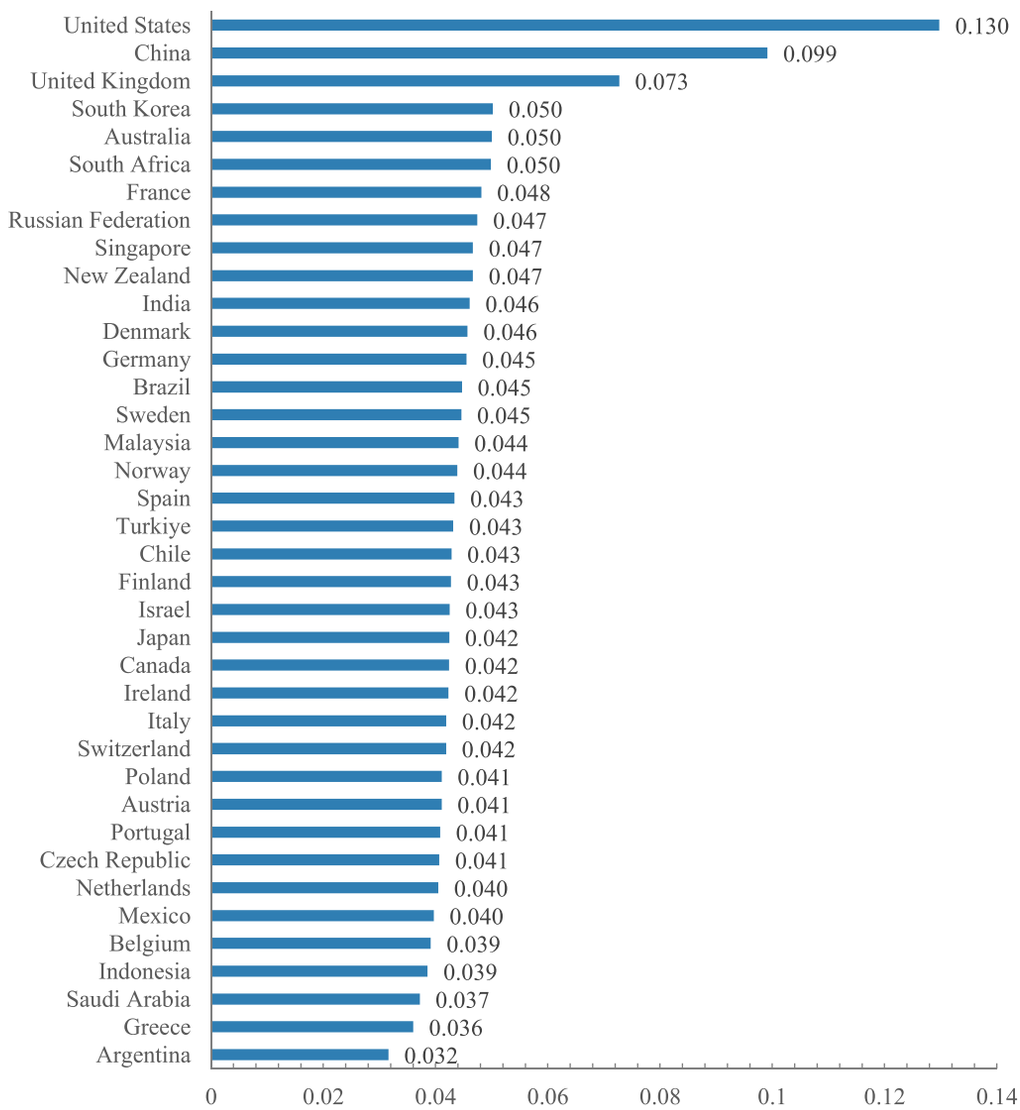


**Figure 1.6 Enterprise Vitality Rankings for 38 Countries**

In the *Number of Unicorn Enterprises* indicator, the United States and China stand out, with the combined scores of the two countries being four times that of all the

countries ranked from third to thirty-eighth. In the *Number of New Registered Companies Annually* indicator, the United States is in the top spot, with the United Kingdom and South Africa coming second and third, respectively. South Africa's impressive performance reflects the entrepreneurial vitality and potential in developing countries. In the *Ease of Doing Business Score* indicator, New Zealand takes the lead, with Singapore and Denmark closely following. South Africa's high rankings in the respective indicators are related to their status as emerging economies, which often have less mature and developed markets and can provide significant competition space for entrepreneurship.

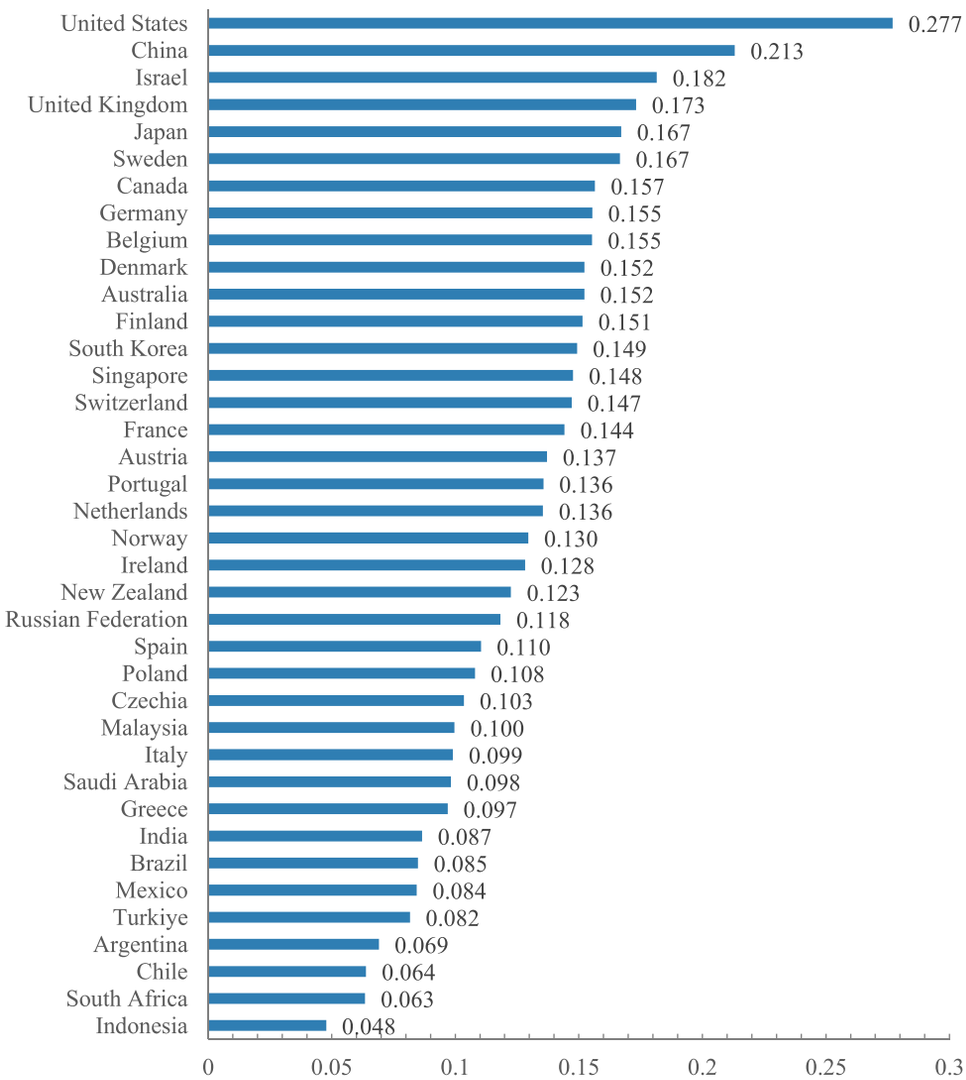


**Figure 1.7 Rankings for Talent Capital and Innovation Resource for 38 Countries**

In addition, talent and innovation, as key factors driving industrial chain

transformation and upgrading, are crucial for maintaining industrial resilience. They can promote the application of emerging technologies across various segments of the industrial chain and enhance its resilience, especially in a context of rapidly evolving technology and global turbulence. The part focuses on the performance of talent and innovation in maintaining industrial resilience. Figure 1.7 illustrates the overall performance of the 38 countries in terms of talent and innovation.

The United States stands out as the top performer in talent and innovation, with a significant advantage. Its score is 1.3 times that of China, which is ranked second. Israel, the United Kingdom, Japan, and other countries follow closely, ranking third, fourth, and fifth, respectively.

## III. Analysis of China's Industrial Chain Resilience

Based on the scores of each indicator, China demonstrates the highest performance in terms of “Enterprise Vitality”, achieving a score of 0.76 out of a maximum of 1. Following closely is “Manufacturing Performance”, with a score of 0.75. The subsequent rankings are as follows: Overall Industrial Performance (0.60), Innovation Resources (0.57), and Talent Capital (0.45).

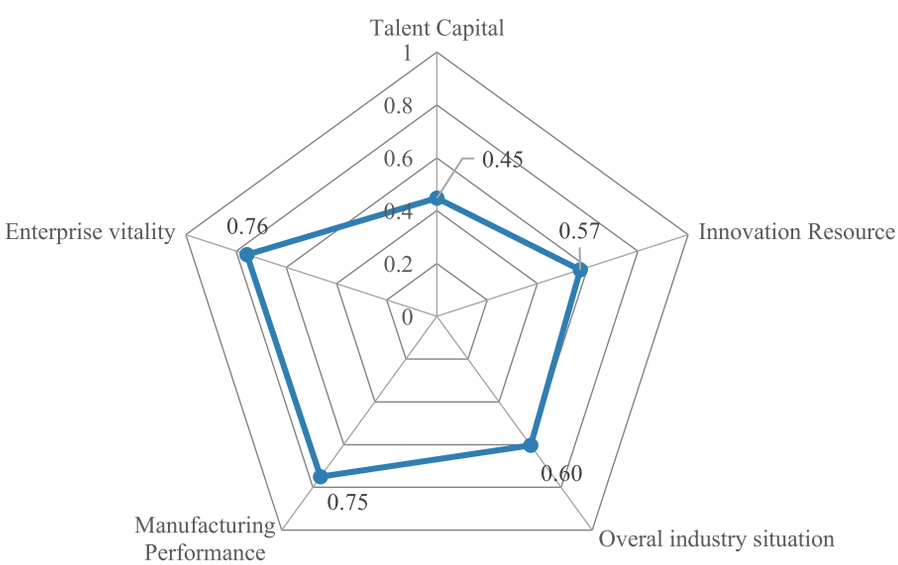


**Figure 1.8 China’s Industrial Chain Resilience Index Performance on Primary Indicators**

Overall, China is ranked second on the Industrial Chain Resilience Index,

following the United States, which is equal to the rankings of its economic volume in the world.

In terms of *Talent Capital*, China is ranked seventh and going through a temporary period of vulnerability. On one hand, this is related to China's relatively low investment in public education, with a rank of 33 in the indicator *Public Education Expenditure as a Percentage of GDP*. On the other hand, it is also associated with China's large population base of labor force. Specifically, China's performance is not strong in indicators related to per capita proportion, such as *Labor Productivity* and *Proportion of the Labor Force with Higher Education*, with rankings of 36$^{th}$ and 28$^{th}$ respectively.

In terms of Innovation Resources, China ranks second, just behind the United States. China excels in the *Total Patent Grants* and *Number of Scientific and Technical Journal Papers* indicators, where it is ranked first, indicating China's quantitative advantage in technology output. However, China's rankings are relatively lower in the indicators of *Researchers Per Million Inhabitant, FTE* (29$^{th}$) and *R&D Expenditure as A percentage of GDP* (14$^{th}$), and *Top 1000 University Rankings* (5$^{th}$).

In terms of *Overall Industry Situation*, China ranks second, just behind the United States. Among them, China ranks second and first in the indicators of *Gross Domestic Product* and *Total Value of Goods and Services Exports* respectively, reflecting China's overall advantage in the entire industrial chain. In addition, China's performance in indicators related to foreign investment is notable. China ranks first in both *Foreign Direct Investment Inflows* and *Foreign Direct Investment Outflows*, which shows that despite the serious impact of the COVID-19 global pandemic in 2020, China's relatively stable domestic environment has provided significant advantages in attracting foreign investment and outward investment. Moreover, the indicators *Growth Rate of FDI Inflow in 2020* and *Growth Rate of FDI Outflow in 2020* are both positive, suggesting that China maintained positive growth in both FDI inward and outward in 2020. These two indicators rank ninth and seventh, respectively, underscoring the stability of China's industrial development.

In terms of *Manufacturing Performance*, China holds the top position. This is particularly evident in the *Added in Manufacturing* indicator, where it ranks first. Additionally, the indicators *Proportion of Value Added in Medium and High-Tech Manufacturing to Total Manufacturing Value Added* and *Proportion of High-End Manufacturing Exports to Total Manufacturing Exports* rank 22$^{nd}$ and 15$^{th}$, respectively, indicating that China's manufacturing sector exhibits significant advantages in the

midstream of the industrial chain. However, there is still room for development in the upstream of the industrial chain. At present, China's manufacturing sector encompasses a wide array of industries and offers a diverse range of products. While maintaining its existing strengths, China should focus on developing high-end manufacturing to accelerate its transition to higher value-added manufacturing.

In terms of Enterprise Vitality, China is ranked second, just behind the United States. China performs particularly well in the *Number of Unicorn Enterprises* indicator, where it ranks second, and its score in this category is twice that of all countries ranked third to thirty-eighth. What's more, China ranks fifth in the *Number of New Registered Companies Annually* indicator, reflecting its strong market dynamism. However, there's room for improvement in China's *Ease of Doing Business Score* indicator, where it ranks 19$^{th}$. This indicates that China can further optimize its business environment.

Overall, China's industrial chain resilience ranks at the forefront globally, primarily due to China's possession of the world's largest market and the most comprehensive industrial chain structure. In recent years, China has vigorously supported the high-quality development of its industries by filling gaps in the industrial chain, upgrading traditional industries, and establishing emerging industrial chains. This has enhanced the stability and competitiveness of industrial development. For instance, to upgrade traditional industry chains, China has accelerated the integration of outdated production capacity, driven the transformation of traditional industries, and promoted their advancement towards high-end, intelligent, digital, and green development. This has significantly reduced production costs and improved production efficiency. Regarding the establishment of new industrial chains, China has leveraged its resource endowments and market advantages to optimize the layout of emerging industries such as new energy vehicles and next-generation information technology, thereby fostering stable development in these sectors. Supported by a robust existing infrastructure, China's industrial chain is solid and robust, demonstrating considerable resilience in the face of changing international circumstances.

However, the upstream key links of the industrial chain, such as cutting-edge technology research and development, high-end basic manufacturing process improvement, advanced equipment, and high-end basic material production, along with the development of emerging industries like artificial intelligence, quantum computing, and biotechnology, all require long-term and sustained investment in basic research to achieve breakthrough innovations. This is currently a relatively weak aspect in China's

Industrial Chain Resilience Index. The impacts on the industrial chain are evident in the inadequate supply of subsequent development drivers for industrial upgrading and transformation, as well as the relatively slow response to rapidly changing external environments and challenges.

In the context of limited international cooperation in talent and innovation chains, the resilience of China's industrial chain still faces challenges. Response measures include, on one hand, increasing openness and exchange, establishing comprehensive and effective international communication platforms, and more efficient supply networks. On the other hand, there is a need to enhance the construction of talent and innovation mechanisms, accelerate the integration of the 'four chains' of technology, education, industry, and finance, strengthen basic research, enhance independent innovation capabilities, and intensify efforts in talent development. Simultaneously, improving the efficiency of innovation and talent empowering industries to enhance the resilience of industrial and supply chains.

# Chapter 2: Analysis of the Impact of Talent and Innovation on China's Industrial Chain Status

## I. Conceptualizing Talent, Innovation, and the Industrial Chain

### 1. Human Resources and Talent Resources

In the 19th century, partial scholars regarded human capital as a crucial component of a nation's competitiveness. German economist Friedrich List, explaining the spiritual power level within the three levels of national productivity, emphasized the importance of incentive mechanisms and intellectual development, which is essentially the importance of "human capital." In 1954, Peter F. Drucker, in his book "The Practice of Management," introduced the concept of "human resources" for the first time. He believed that a company's true resource is its human resources, and the first sign of a company's decline is the loss of appeal for qualified, capable, and ambitious talents. ① Human resources refer to the collective sum of individuals with intellectual and physical labor capabilities that can drive the national economy and social development, including both quantity and quality aspects. ②

The "National Medium and Long-Term Talent Development Plan Outline (2010-2020)" in China defines "talent" as individuals with a certain level of professional knowledge or specialized skills, engaging in creative work, making contributions to society, and creating value for society. They are high-quality laborers within the human resources category. ③ In the Modern Chinese Dictionary, "talent" is described as someone with both moral and intellectual qualities or possessing certain special skills. The core of talent embodies four key aspects: (1) Professionalism: Certain people who possess a certain level of professional knowledge or specialized skills, serve as carriers of specialized human capital. (2) Value: Certain people who are capable of engaging in

① 王辉耀. 国际人才竞争战略[M]. 北京: 党建读物出版社, 2014:5.
② 余凯成、程文文、陈维政.人力资源管理[M]，大连：大连理工大学出版社，1999：5～6.
③ 中共中央、国务院.国家中长期人才发展规划纲要（2010—2020 年）.人民日报[N].2010-6-6(1).

creative labor, generating new value, or enhancing existing value, thereby contributing to societal development and human progress (3) Hierarchy: Representing individuals with higher quality and capabilities within the realm of human resources, emphasizing excellence and even indispensability. (4) Timeliness: Serving as the foremost element in economic and social development, acting as the primary driving force for scientific progress, highlighting the role and status of talent in social and economic development. This further enriches the idea that human resources are the foremost resource and underscores the temporal characteristics of talent.

The concept of talent resources is built upon the foundation of the quality of human resources. Talent resources refer to the group of human resources with a higher level of quality. If talent is defined as the term of exceeding the creativity of the societal average, the concept would be blurred at the boundaries. Currently, there are no standardized statistical criteria for defining talent. The method for defining specialized talent can include three categories: (1) people with a college degree or higher, (2) individuals holding the position of technician or an equivalent professional and technical position, (3) people working in professional and technical positions, even if they do not possess a college degree or a position requiring professional and technical qualifications.

## 2. Human Capital and Talent Capital

**Human Capital**. Since delivering a speech titled Investment in Human Capital at the American Economic Association's annual meeting in 1960, Theodore W. Schultz, a renowned American economist and Nobel laureate, has been persistently advocating for considering Humans as Capital to obtain a comprehensive concept of capital. This has made the study of human capital a popular emerging field in Western economics. Schultz's notable argument is, economic development depends primarily on the quality of people rather than the fertility of natural resources or the quantity of capital stock, and human capital is the product of human-made investments.

**Talent Capital**. Talent capital is the value expressed in both the talents individually and their socio-economic contributions. It is reflected in the quantity, quality, knowledge level, and innovation capacity, especially in the creative labor results and significant contributions to humanity made by talented individuals. [①] The concept of talent capital is built upon the fundamental principles of the concept of

① 桂昭明.人才资源经济学[M].北京：蓝天出版社.2005：1；中国人才[J] .2009（23）：1.

human capital established by Theodore Schultz and Gary Becker. It incorporates core elements from the concepts of "specialized knowledge and specialized human capital" as put forth by scholars like Paul M. Romer and Robert E. Lucas, Jr. It also integrates China's unique concept of talent. Existing methods for measuring human capital stock include output-based and input-based measurement. The education years method is a representative approach for estimating the stock of human capital. ①

## 3. Innovative Capability

**Innovation.** Joseph Schumpeter, in his Theory of Economic Development, proposed that innovation is the establishment of a new production function or the realization of a new portfolio of production methods. Specifically, innovation can include introducing a new product or improving the quality of existing products, introducing a new production process, opening new markets, exploring new sources of raw materials or semi-finished products, and reshaping the organization of industries, such as forming or disrupting monopolies.② C. Freeman, a British expert in technology innovation research, defines technological innovation as the entire process from the inception of new products, processes, systems, or devices in the laboratory to their successful commercial application, emphasizing the commercialization of technology. ③ In 1973, Peter Drucker introduced the concept of social innovation for the first time in Management: Tasks, Responsibilities, Practices, and in Innovation and Entrepreneurship (1985), he extensively explored the issue of social innovation. He emphasized that innovation in areas such as education, healthcare, government, and politics offers a broader scope than innovation in the business and economic sectors. ④In general, innovation refers to creating value in various fields, including science, technology, economics, and society, by introducing new ideas, concepts, methods, products, or services. This results in higher benefits, improved performance, and superior quality. In 2014, during the seventh meeting of the Central Leading Group for Financial and Economic Affairs Xi Jinping emphasized that innovation is always a

① Mulligan,C.B., Sala-l-Martin,X.. A Labor-income-based Measure of TL Value of Human Capital: An Application to TL States of TL United States[J]. Japan and TL World Economy. 1997（9）：159-191.
蔡昉、王德文.中国经济增长可持续性与劳动贡献[J].北京：经济研究. 1999（10）：62-67.
② Swedberg, Richard（1991）, Joseph A. Schumpeter: His Life and Work, Cambridge: Polity, p34.
③ 克利斯·弗里曼，罗克·苏特. 工业创新经济学（第 3 版）[M]. 华宏勋，华宏慈等译. 北京：北京大学出版社，2004.
④ 纪光欣.国外社会创新理论研究述评[J].理论月刊,2017(05):132-13。+181.

significant force driving the progress of a country and its people. Fundamentally, innovation-driven is essentially talent-driven.

**Innovation Capability**. Key indicators of innovation capability include characteristics such as innovation qualities (innovative personality, strategic thinking, market awareness, etc.), innovation theory, innovation environment (organizational structure, innovation culture, task characteristics, etc.), innovation outcomes, and innovation skills (information acquisition and processing, teamwork, learning abilities, etc.). Among these, quantifiable indicators primarily include innovation qualities and innovation outcomes, such as the number of researchers, the quantity of granted patents, and global innovation indices, among others. Innovation capability is characterized by novelty, multidimensionality, diversity, and openness. Novelty implies that the goals, methods, and processes of thinking are relatively fresh and original. Multidimensionality involves considering issues from multiple perspectives, including vertical, horizontal, and reverse angles. Diversity means the ability to approach problems from various sides, across multiple stages, involving multiple factors, layers, and perspectives. Openness indicates a propensity to extensively absorb external information, continually incorporate new elements through information exchange and feedback from the external environment, establish one's thinking patterns, adjust one's thinking methods, and integrate one's thinking outcomes.

## 4. Industrial Chains and Industrial Chain Resilience

**Industrial chain.** Industrial chain refers to a connected, complementary, and interactive form of industrial organization that encompasses various stages in the production and lifecycle of a product or service, including raw material procurement, manufacturing, processing and assembly, sales and distribution, and after-sales services. The various links in an industrial chain depend on and cooperate with each other to collectively complete the entire lifecycle of a product or service. An industrial chain can involve one or multiple industries, encompassing cooperation and competition among various sectors and businesses. This report primarily focuses on the manufacturing industry's industrial chain. [①]

① 郎咸平,产业链阴谋：一场没有硝烟的战争 [M]. 东方出版社，2009.
田坤,产业链整合战略研究 [D]. 东华大学，2011.
陈晓红，张继红,产业链竞争优势的生成机理及其对我国产业发展的启示 [J]. 经济管理，2012, 34(8): 102-109.

**Industrial chain resilience.** Industrial chain resilience refers to the complex adaptive capacity of an industrial chain to maintain dynamic equilibrium, respond proactively to disruptive external events or internal issues, and ultimately return to normal operation when faced with destructive incidents. Enhancing industrial chain resilience is beneficial for enterprises, industries, and nations to maintain economic stability and sustainable development in the face of uncertainty and risks. ①

## II. The Theoretical Analysis of the Impact of Talent and Innovation on Chinese Industries

### 1. Analysis of the Impact of Talent on China's Economic Growth

The prioritized development of talent is a successful experience for late-developing countries to achieve economic takeoff, with a key characteristic being the prioritized accumulation of human capital. From the histories of rejuvenation in various countries around the world, it can be observed that the development of a nation is always linked to the accumulation and effective utilization of human resources and human capital. Every successful economic catch-up is accompanied by an earlier pursuit of human resources and human capital. The pursuit of human resources and human capital serves as a precursor to economic catch-up.

Since reform and opening-up, particularly since the First National Talent Work Conference, some regions in China have taken the lead in the development of their socio-economic sectors. Research reveals that the eastern coastal provinces, which prioritize talent development, have demonstrated significant economic strength. These regions exhibit a strong and positive correlation between their total economic output (GDP) and three key talent-related indicators: the total number of individuals with higher education, the total number of R&D personnel, and the stock of human capital." Representative provinces in this regard include Guangdong, Jiangsu, Zhejiang, and Shandong. These regions seized the opportunity for talent development, understanding

① 李晓兵. 产业链韧性研究 [D]. 上海交通大学，2016.
张继红，陈晓红. 产业链竞争优势的生成机理及其对我国产业发展的启示 [J]. 经济管理，2012, 34(8): 102-109.

the principle that prioritizing talent is essential for driving socio-economic growth so as to achieve a situation of mutual promotion between talent and economic development.

Why does prioritizing talent development drive rapid economic growth? This problem relates to the issue of the contribution of talent to economic growth. The contribution rate of human capital to economic growth, known as talent contribution rate, is one of the six main indicators of national talent development in the National Medium and Long-Term Talent Development Plan Outline (2010-2020). [①] The talent contribution rate represents the share of the contribution made by human capital to economic growth as a core input factor in the economic operation, through its self-generated incremental benefits and external spillover effects.

In 2009, the Central Leading Group for Talent Work calculated that China's talent contribution rate for the year 2008 was 18.9% and forecasted that in the year of 2015 and 2020, China's talent contribution rates would be 32% and 35%, respectively. According to the following tracking calculations, China's talent contribution rates in 2010, 2015, and 2020, based on the definition of talent as individuals with higher education, were 16.19%, 25.00%, and 27.81%, respectively. The total human capital contribution rates were 24.39%, 31.50%, and 33.77%, respectively.

Based on the data that China's talent contribution rate in 2020 was 27.81%, it can be calculated that the GDP created by Chinese talent in 2020 was $4,094.83 billion. This value exceeds the combined GDP ($3,867.5 billion) of 11 European countries - Iceland, Luxembourg, Greece, Portugal, Denmark, Norway, Ireland, Austria, Belgium, Sweden, and Turkey - among the 20 founding member countries of the OECD in 1961. It also accounts for approximately one-fourth of the combined GDP ($17,885.9 billion) of 18 European countries among the founding member countries of the OECD, excluding the United States and Canada, in the American Continent. This demonstrates that China possesses abundant talent resources and makes a significant contribution to economic development.

Although China is known as a talent-rich country, it does not yet hold the status of a talent powerhouse. From the perspective of the assessment of industrial chain resilience in Chapter 1, regarding the contribution of human capital to industrial chain resilience, China ranks 7th, significantly falling behind countries like the United States.

① 中共中央、国务院.国家中长期人才发展规划纲要（2010—2020 年）.人民日报，2010-6-6（1）.

Most indicators of human capital, such as the proportion of public education expenditure to the national GDP, labor productivity, and the proportion of the population of working age with higher education, are not measurements that can be rapidly improved in the short term. In the context of industrial chain resilience, they are considered slow variables that require continuous attention and investment.

## 2. Analysis of the Impact of Science and Technological Innovation on China's Industrial Development

Report to the 20th National Congress of the Communist Party of China emphasizes that high-quality development is the primary task for the comprehensive construction of a modern socialist country. Making new breakthroughs in high-quality economic development, significantly enhancing self-reliance and self-improvement capabilities in science and technology, and making significant progress in building a new development pattern and a modern economic system[①] is one of the key objectives and tasks for the initial stage of comprehensive construction of a modern socialist country in the next five years. Empowering industrial high-quality development with technological innovation is an important lever to comprehensively achieve the goal of socialist modernization at this new historical juncture.

From the status quo of domestic economic development, it can be seen that after over four decades of pursuing quantity, expanding scale, and driving factors through the process of reform and opening up, China's industries have passed through a period of rapid growth. China has not only become the world's largest manufacturing nation but is also the only country globally that possesses all industrial categories listed in the United Nations Industrial Classification. However, behind these significant achievements, there remains an urgent need to improve product quality and value-added levels, as China's industries still operate in the lower end of the global industrial system and value chain. Currently, the production function for China's industrial development has undergone a transformation. The economic growth model driven mainly by factors such as labor is becoming unsustainable. China's economy urgently requires a smaller gap between total factor productivity and international advanced levels. At the same

① 习近平.高举中国特色社会主义伟大旗帜 为全面建设社会主义现代化国家而团结奋斗——在中国共产党第二十次全国代表大会上的报告. 人民日报[N].2022-10-26（1）.

time, the hard constraints of resource and environmental issues are growing stronger. It is no longer possible to rely primarily on factor inputs to drive high-quality industrial development as was done in the past. Hence, the transformation of the industrial development model is essential and must be driven by technological innovation to complete this dramatic turnabout.

From the perspective of global competition, the international political and economic landscape is unpredictable, and the competition for technological supremacy is gradually heating up. China must achieve independent technological innovation to address critical core technological challenges and propel the Chinese economy into the higher-end segments of the global value chain. This will enhance China's resilience within the global industrial and supply chains, safeguarding China's economic security and development interests.

During the past 40 years of economic globalization, China has effectively leveraged its comparative advantage in abundant labor resources. It has improved the technological capabilities and competitiveness of Chinese companies through the process of "importing, analyzing, absorbing, and innovating." To establish an innovative system and institutional mechanism that supports high-quality development, the most practical approach is to learn from China's own advanced and successful experiences. China's primary advantage is its unified and vast domestic market, which allows for the potential for bottom-up progress in reforming the technological and institutional mechanisms. Since reform and opening up, China's high-tech industries have developed rapidly, and technological innovation has achieved significant success, giving China a competitive edge in the global technological innovation landscape. Among the 38 countries studied in this report, China's Global Innovation Index ranking has steadily risen, up from 15th in 2018 to 13th in 2020 and 12th in 2023.

From the evaluation of industrial chain resilience in the first chapter, China ranks second in terms of the contribution of innovative resources to industrial chain resilience. This also indicates that technological innovation is driving the rapid development of China's dominant industries, especially in manufacturing. China is transitioning from the extensive development of World's Factory to a path of intensive development focusing on Specialization, Expertise, and Innovation.

# III. Case Studies of the Impact of Talent and Innovation on Chinese Industry

## 1. Electric Vehicle Industry

**i. China's New Energy Vehicle Industry Showing Steady Development and Good Resilience**

In recent years, the scale of China's electric vehicle (EV) industry has been expanding continuously, and its share in the international market is gradually escalating with more active performance in attracting domestic and foreign capital. Under the broader context of the “dual carbon” goals, the automotive industry in China is accelerating its transformation, gradually forming a vast and mature EV industry chain that spans from upstream, to downstream, and midstream.

China, as the largest EV market in the world, has seen strong growth in both sales and exports. A comprehensive analysis from various data sources reveals that the export volume of new energy vehicles in China ranged from approximately 310,000 to 597,000 units in 2021, a year-over-year increase of more than 1.7 times. [①]Regarding the sales, about 3.5 million new EVs were sold in China in 2021, which is 1.6 times more than the previous year, and the share of EVs in the sales of new passenger vehicles increased from 8.4% at the beginning of the year to 20.6% .[②] In 2022, China's new energy vehicle sales reach 6.887 million, owning about 35% of the global market share. [③]From January to July 2023, according to data released by the China Association of Automobile Manufacturers (CAAM), the domestic sales of EVs in China reached 3.89 million units, a year-over-year increase of 32.5%; the export volume reached 636,000 units during the same period, a year-over-year increase of 1.5 times.[④] According to forecasts by international information service providers, China is expected to become the largest global market for EVs by 2025, accounting for an estimated 40% of the total global sales. [⑤]

① 国家发展和改革委员会 (2018). 《关于进一步优化新能源汽车产业发展环境的通知》.
② 《关于修改<新能源汽车生产企业及产品准入管理规定>的决定》，工业和信息化部, 2020.
③ 中国汽车工业协会. (2022). 《中国汽车工业年鉴 2022》. 北京: 机械工业出版社.
北极星储能网. 中汽协：2022 年新能源汽车销量 688.7 万辆 同比增长 93.4%.
④ 中国汽车工业协会（2023）。中国汽车出口年度报告。
⑤ IHS Markit (2023). Global Electric Vehicle Outlook.

**ii. Key Links and Development Status of the EV Industry Chain**

The EV industry chain can be roughly divided into three key links: upstream raw materials and core components, midstream equipment manufacturing and application, and downstream end products.

**Table2.1 Analysis of Main Links in EV Industry Chain**

| Main Link of Industry Chain | Sub-link of Industry Chain |
|---|---|
| **Upstream: Raw Materials and Core Components** | Battery |
| | Motor |
| | Electronic Control and Other Core Components |
| **Midstream: Equipment Manufacturing and Application** | Cell Manufacturing and Module Integration |
| | Motor Production and Integration |
| | Hardware and Software Development for Electronic Control |
| | Vehicle Assembly: Integration of Body, Chassis, and New Energy System |
| | Onboard Software Development: Onboard Operating Systems, Driver Assistance Systems, Onboard Entertainment Systems, etc. |
| **Downstream: End Products** | Battery Electric Vehicles (BEV) |
| | Plug-in Hybrid Electric Vehicles (PHEV) |

Benefiting by continuous technological innovation in the industry, China's EV industry chain has harvested some achievements on early stage. In the upstream, China has made breakthroughs in the research and development of key components such as batteries, motors, and electronic controls, with outstanding performance in lithium battery technology; in the midstream, China has already achieved a significant market position in the field of cell manufacturing and module integration; and in the downstream, the end automotive products have achieved excellent performance in both domestic and international markets, demonstrating the immense market potential and competitive advantages of the EV industry.

**iii. Continuous Increase in Investment in Core Technology Areas of EVs over the Past Three Years**

With growing concerns about climate change globally, EVs have gradually received extensive attention from governments, enterprises, and consumers worldwide. As the market penetration rate of EVs has steadily increased globally over the past few

years, the heat of investment and financing activities in this field has significantly grown. This trend is particularly pronounced in mainland China, Europe, and the United States.

China maintains a leading position in the field of EVs, which keeps investors highly confident. As of 2021, the total investment in China's EV and power battery industry reached ￥117.25 billion, with 170 investment cases. [①] This can also be glimpsed from recent investment cases. In 2018, Tesla invested US$5 billion in Shanghai to establish its first overseas Gigafactory, laying the foundation for Tesla's expansion in the Chinese market. [②]During the period of 2021-2022, major European car manufacturers significantly increased their investments in China. It is reported that in 2021, European car manufacturers' direct investment in China's automotive field reached €6.2 billion, while the total investment in all other fields amounted to €1.5 billion. [③] China has become the third-largest market for European cars, with the value of passenger cars exported from Europe to China exceeding €24 billion in 2022 alone. [④]Especially in the electric vehicle (EV) sector, China's market potential is enormous. In 2022, the sales of EVs accounted for a quarter of China's total vehicle sales, and this proportion is expected to increase to 50% within the next three years. Additionally, according to various forecasts, the size of China's EV market will notably grow from 2023 to 2028, demonstrating abundant market potential to its investors. German automobile manufacturers also plan to offer over 30 different brands of EVs to Chinese consumers before 2030, Volkswagen's "China for China" strategy also reflects the importance of the Chinese market. [⑤]

Europe, particularly Nordic countries and Germany, has been an enthusiastic advocate of green transportation. Strong policy support and continuous consumer demand for EVs have driven investment and financing activities in Europe. In 2019, Europe's investment in EVs and battery production reached €60 billion, 19 times that of 2018. The EU's carbon dioxide emission targets also help motivate relevant investments in the EV industry, with the industrial sector and government funding for EVs and battery production in Europe reaching 3.5 times that of China.[⑥]

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① 清科研究中心. (2022). 2022 中国新能源汽车及动力电池行业投融资分析报告.
② South China Morning Post. (2018). Tesla helps Shanghai record increase in foreign investment for 2018.
③ Financial Times. (2021). European carmakers play catch-up in China with record investment.
④ Statista. (2022). Value of car exports from the EU to China.
⑤ Autovista24. (2022). China’s impact on the European automotive industry.
⑥ Transport & Environment website, Fitch Ratings. (n.d.). European Autos Maintain EV Investments Amid Supply-Chain Issues.
Automotive News Europe. (n.d.). The next electric-car battery champion could be European.

The EV market in the United States is also very active, with large enterprises like Tesla keenly promoting its EVs under the courage of the U.S. EV industry policy. Since the beginning of 2021, the total investment in EVs in the United States has exceeded $150 billion, with new legislation providing $83 billion to boost the industry. In 2022, the sales of EVs in the United States increased by 40%, further stimulating related investments. ① In 2021, the valuation of the US EV market was estimated at $17.54 billion, with a projected overall growth rate of 37.1% from 2022 to 2029. ②

As of the end of 2019, the global market penetration rate of EVs reached 2.5%, and further increased to 2.8% in the first quarter of 2020. ③ The EV market in China is also showing a trend of rapid growth. These data reveal the fact that China's new energy vehicle market has been undergoing rapid expanding. Although the market share of EVs in China is still small compared to traditional internal combustion engine (ICE) vehicles, the growth momentum is obvious. In the future, the market penetration rates of EVs is expected to go higher given a larger global market is coming into being, especially in the China and Europe regions. A large number of startups of EVs have swarmed to the market in recent years, bringing numerous technologies and business innovations, thus further attracting more inflow of capital.

Currently, the global EV investors generally focus on the following core technology areas.

First, battery EV sector. From 2019 to 2021, notable industry participants like Daimler AG, Ford, and Renault Group significantly increased their investments in EV manufacturing, and this growth trend is expected to continue until 2030. ④ Furthermore, global automakers plan to invest nearly $1.2 trillion US dollars in EVs, EV batteries, and relevant raw materials before 2030, showcasing a robust investment trajectory in this sector. ⑤

Second, fuel cell technology. Although the commercialization of fuel cell technology faces challenges, given the advantage of refueling and its effective power range over the battery, fuel cell continuously attracts investment. The global fuel cell market size is estimated to be $6.3 billion in 2022, ⑥ a significant increase from 5.8

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CleanTechnica. (n.d.). 19× More Invested In EVs & EV Batteries In Europe Last Year Than In..
① Kennedy, R. (2023, January 17). Inside the $455 billion U.S. investment in electric vehicles. PV Tech.
② Maximize Market Research. (2021). US Electric Vehicle Market: Industry Analysis and Forecast (2022-2029).
③ Seeking Alpha. (2021). Analysis Of The Global New Energy Automobile Industry In 2021.
④ Fortune Business Insights. (2021). Electric Vehicle Market Size Share & Growth - Update 2023 - Industry.
⑤ Reuters. (2022,10). Automakers electric vehicle investment plans.
⑥ Grand View Research. Fuel Cell Market Size, Share & Trends Analysis Report, 2030.

billion US dollars in 2021. [①] According to market forecasts, from 2021 to 2026, the fuel cell market is expected to grow with a CAGR of 16.47%, with the market size increasing from $2.528 billion in 2019 to $7.350 billion by 2026. [②]

Third, advanced battery technology. With the rising demand for battery performance and safety, advanced battery technologies like solid-state batteries and high-density batteries have become investment hotspots. From 2019 to 2021, the investment and financing activities in the field of advanced battery technology remarkably increased. Specifically, in 2019, the global advanced battery energy storage system market size reached $151.96 billion and is expected to grow at an annual rate of 4.8% in the coming years, reaching $221.12 billion by 2027. [③] Between 2019 and 2020, global venture investment in battery storage, smart grid and energy efficiency technology increased from $2.3 billion to $2.6 billion, a growth of 12%.[④] Particularly in 2020, corporate financing in the battery storage sector grew by 136%, reaching $6.6 billion. [⑤]

**iv. Prioritizing Talent Development and Technological Innovation: The Core Driving Forces of EV Industry Development**

**Chinese universities and research institutions are reinforcing talent education regarding the EV sector.** In recent years, there has been a gradual increase in talent demand in the field of new energy vehicles and related technology. China, as the largest new energy vehicle market globally, has a particularly strong demand for relevant talents. In China, about 200,000 related jobs are in demand in the market every year. Chinese higher education institutions and research institutes have set new energy vehicle technology and related fields as key development directions based on the demand. According to data from 2021, over 50 universities have established majors or research directions in new energy vehicles and related technology, reserving a large number of young talents for the field of new energy vehicles.

**A substantial amount of R&D investment is driving technological innovation in EV industry, creating rapid development in the field.** In 2022, global investment in innovative technologies related to new energy vehicles exceeded $100 billion, of which China accounted for 30%. Thanks to the complete industrial chain ecology and

① Fortune Business Insights. Fuel Cell Market Size, Share | Growth Analysis Report [2022-2030].
② Knowledge Sourcing Intelligence LLP. (2021). Fuel Cells Market - Forecasts from 2021 to 2026.
③ GlobeNewswire. (n.d.). Advanced Battery Energy Storage System Market Size, Share & Trends Analysis. Report By Technology, By Application, Regional Outlook, And Segment Forecasts, 2021 - 2027.
④ Mercom Capital Group. (2021, January 19). Funding For Battery Technology Companies Exploded In 2020.
⑤ 新能源汽车教育与研究发展报告 (2022), 中国汽车工程学会.

continuously increased R&D investment, the technological level of EVs in China keeps improving and achieving influential position in key components of EV market. Over the past three years, the number of patent applications in the field of EVs has rapidly increased. According to WIPO data, there were about 120,000 patent applications related to new energy vehicles globally in 2019, and this number increased 50% to 180,000 by 2021. ① The new patents are mainly concerned with solid-state battery technology, autonomous driving and AI technology, vehicular operating systems, and V2X communication technology, among others.

**The integrated development of the capital chain, talent chain, and innovation chain improves the resilience of the EV industry chain.** In the past three years, the capital chain, talent chain, and innovation chain have become the main driving forces for the steady development of the EV industry, and their interaction and association have shaped the development of the industry. Firstly, investment and financing have accelerated the aggregation of innovative talents. A large influx of funds has actively boosted new technology R&D, and technological progress, in turn, has attracted more investors, forming a positive development cycle. Secondly, talent and innovation promote reinforced mutually and become the key to industry development. Major universities, research institutions, and enterprises in China have strengthened talent cultivation in the field of EVs, not only accelerating the R&D of advanced technologies and innovation in management models but also speeding up the commercialization process of technology, which creates a mutually promoting relationship between technological innovation and policy and investment. When there is a breakthrough in a certain technology, such as solid-state batteries, it will receive more financial and policy support, furthering the development of this technology. In turn, this technological advancement will stimulate the capital market to provide more resources and support.

In conclusion, the integrated development of the capital chain, talent chain, and innovation chain effectively enhances the resilience of the new energy vehicle industry chain, promoting the stable development of the industry.

## 2. Semiconductor industry

### i. The framework and development status of China's semiconductor industry chain

① World Intellectual Property Indicators (2022). World Intellectual Property Organization (WIPO).

Since 2017, with the development of the digital economy, the semiconductor industry, as one of the important infrastructures, has become the focus of global economic development. China's semiconductor industry has a thin base, a more fragile resilience, and a higher overall market dependence on foreign suppliers. Especially since the Sino-US trade and technology war from 2018 and the COVID-19 in 2020, the uncertainty faced by China's semiconductor industry chain has increased. These external changes have, on the one hand, promoted the upsurge of domestic substitution and stimulated the demand for talent and innovation in semiconductor industry. On the other hand, they have also exposed the drawbacks that China's current supply of semiconductor talent is still insufficient to meet the market demand, and that innovation as well as research are still subject to external constraints. The increase in uncertainties has also had a negative impact on the talent supply and industrial innovation. Under this circumstance, it is necessary to reinforce the resilience of the semiconductor market, to maintain the stability of the supply chain, and to integrate the talent supply chain, the innovation chain, and the industrial chain.

**(1) China's Semiconductor Industry Chain Framework**

The upstream industries of the semiconductor industry include semiconductor raw materials and semiconductor equipment, the midstream manufacturing industry includes integrated circuits and discrete components, and the downstream mainly includes terminal applications such as smartphones, new energy vehicles and other electronic devices. The midstream of the industry are mainly divided into two parts: integrated circuits (IC design) and discrete components. Among them, integrated circuits occupy more than 80% of the total semiconductor industry in terms of its market shares and can be further divided into two parts: digital circuits and analog circuits; discrete components are further subdivided into discrete devices, optoelectronic components, and inductors. Its specific composition is shown as follows:

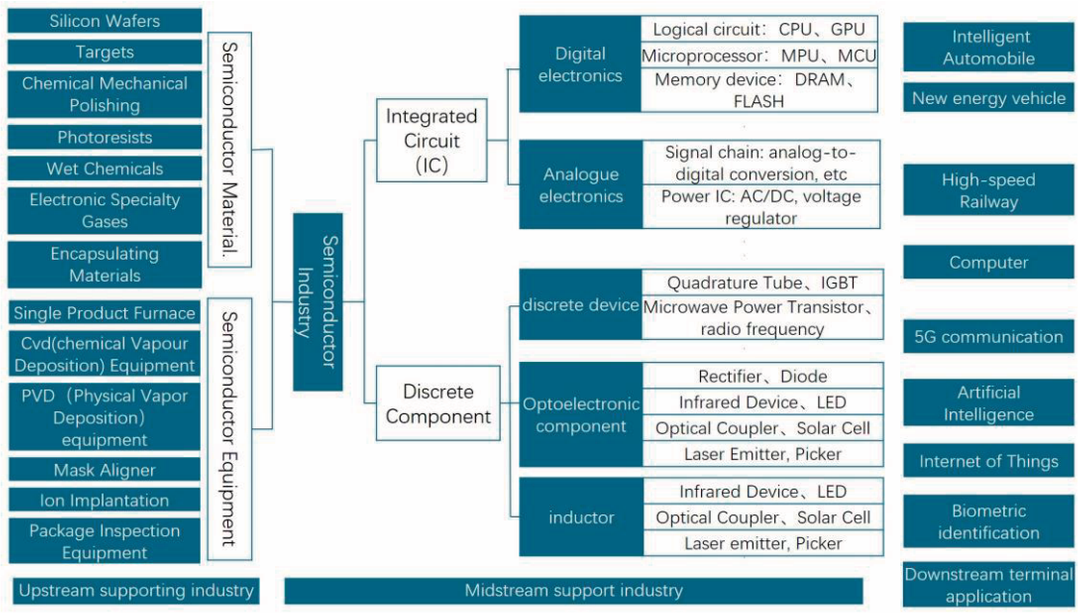


**Figure 2.1 Major links in the semiconductor industry chain**

**(2) Current development status of China's semiconductor industry**

China is the world's largest semiconductor market, accounting for more than 30% of the global semiconductor market share for a long time. However, due to the impact of domestic industrial shortcomings, China's semiconductor market is highly dependent on external sources, and the stability of supply chain is insufficient. According to IC Insights, an information platform for the semiconductor industry, China's semiconductor self-sufficiency rate may reach 19.4% by 2025, which is far from the 70% target set by relevant industrial policies.

In China's semiconductor industry chain before 2019, IC design has overwhelming superiority over the rest of the industry in terms of its R&D volume to commercialization, and some Chinese IC design companies have come to the top at the worldwide level. In spite of this, the Chinese market relies heavily on the import of foreign products and software with franchised patents. The structural problem faced by China's semiconductor industry chain is that the semiconductor industry is both capital and technology-intensive, that is, foreign manufacturers, with sufficiently high technical barriers and cost advantages, have realized "winner-take-all" and formed an overwhelming advantage over the latecomers, while Chinese manufacturers have to face large investment at early strategies as well as and business pressure from its competitors, thus they are difficult to maintain a sustainable competitive advantage in the commercial field. Given these unfavorable conditions, although China has the

world's largest market, it has long been stuck at the middle and low end of the industrial chain.

In recent years, the supply chain of China's semiconductor market has suffered multiple impacts. First, in the high-end semiconductor products, by the U.S. "long arm jurisdiction" and other trade protectionist measures to limit access to sufficiently advanced semiconductor equipment, products, patent licensing and ecological support; Second, by the changes in the industry and the new crown of the epidemic, the semiconductor industry has experienced a cyclical downturn in the supply chain, the supply chain appeared to be poor, the global demand for the decline in inventories rose, China's part of the semiconductor products in the foreign trade is blocked; Second, the COVID-19 pandemic disrupted the supply chains whereas the global demand to semiconductor products has declined and the inventories have increased, hindering the foreign trade of some China's semiconductor products; Third, the sharp increase in production and sales of EVs and the rapid development of artificial intelligence technology lead to increasing demand for in-vehicle semiconductor products and chips applied to AI application as well as the overall semiconductor industry has contributed to a more complex semiconductor market.

**ii. Resilience performance of China’s semiconductor industry from 2019 to 2021**

**(1) Market investment status**

Affected by market changes and supply chains brought with the Sino-US trade war, technology war and other factors, China's semiconductor market has witnessed a noticeable trend of domestic substitution, which has provided domestic enterprises with a significant increase in investment and financing opportunities and the ability to expand their production capacity, thus helps the industry maintain its stability.

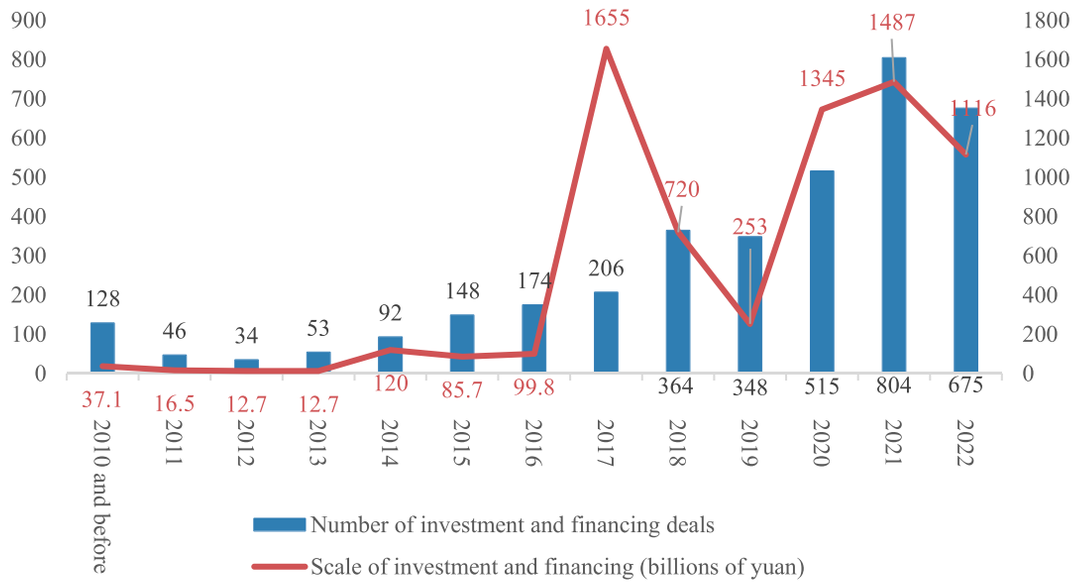


**Figure 2.2 The number and scale of investment and financing in China's chip semiconductor industry over the years**

Data source: ITJUZI

The investment scale in the domestic semiconductor market experienced a significant increase from 2019 to 2021. However, after reaching a peak in 2021, industry cycle exercise 2022 China's semiconductor market investment and financing saw a decline in both the number of investment and financing and the total amount of investment and financing.

**Table 2.2 China's semiconductor industry primary market investment and financing statistics (2019-2022)**

| Year | Scale of investment and financing in the primary market ($ billion) |
|---|---|
| **2019** | 693.38 |
| **2020** | 1693.53 |
| **2021** | 1563.41 |
| **2022** | 1114 |

Data source: Yunxiu Capital

From the perspective of investment industry chain segments, domestic semiconductor investment is mainly concentrated in IC design, and its share of the global market has increased from less than 5% in 2004 to 13.7% in 2022, with an average CAGR of 20.6%; investment maintained a rapid growth rate in electronic

design automation (EDA) on the track. The proportion of them in total investment has not been affected by the clear impact on the periodical downturn of 2022. Chinese companies have strong competitiveness in the field of packaging and testing, but have obvious weakness in the EDA/IP and manufacturing parts, and the EDA area is considered one of the "chokepoints" that needs to be urgently addressed.

**Table 2.3 Proportion of each investment and financing field in the global market**

| Fields | IC Design | Materials and Equipment | IDM | Packaging and Testing | EDA/IP | Manufacturing |
|---|---|---|---|---|---|---|
| **2020** | 67.22% | 19.17% | 6.94% | 2.78% | 2.22% | 1.67% |
| **2021** | 69.44% | 20.00% | 1.94% | 3.06% | 4.73% | 0.83% |
| **2022** | 80.00% | 6.72% | 6.11% | 0.28% | 4.16% | 2.73% |

Data source: Prospect Industry Research Institute

**(2) Enterprise revenue situation**

Enterprise revenue can clearly demonstrate the correlation with changes in the external environment and that in semiconductor industry.

According to statistical information from Wind, in 2022, among the 96 enterprises in the A-share semiconductor, the total revenue growth rate was 11.43%. And more than 60% of these companies experienced revenue growth, although the net profit margin decreased by 12.95%. The semiconductor equipment sector was the only one to achieve growth in both the average gross profit margin and the average net profit margin. In contrast, in the preceding year, in 2021, the 96 listed semiconductor companies in Wind's statistics reported a revenue growth rate of 60.3% and a net profit growth rate of 86.41%. In 2020, the statistics for 75 listed semiconductor companies showed a revenue growth rate of 35.45%, with net profit growth reaching an impressive 164.39%.

Despite some data consistency issues in the incomplete statistics, they still reflect the overall trend: from 2020 to 2021, A-share listed semiconductor companies experienced significant growth in revenue, and the net profit margin also saw substantial increases. This suggests that Chinese semiconductor market was still in an expansion phase during this period. However, there was a notable decrease in revenue growth in 2022, and the average net profit margin of listed companies declined.

**iii. Talent and innovation elements in the development of China's semiconductor industry**

**(1) Insufficient high-end talents in the semiconductor industry brings latent concerns to the stable development of the industry chain**

Generally speaking, the turnover rate in high-tech industries is positively related to the activeness of industry. That is, the more active the industry is, the greater the demand for talents, the more job promotions and adjustments are, and the higher the turnover rate. By comparing the industry turnover rate from 2020 to 2022, it can be seen that the semiconductor industry went through a development peak from 2020 to 2022. In 2022, the turnover rate of semiconductor companies has decreased, which demonstrates a possible trending towards a cyclical trough.

**Table 2.4 Turnover rate in high-tech, manufacturing and semiconductor industry (%)**

| Year | Turnover rate in high-tech industry | Turnover rate in manufacturing industry | Turnover rate in semiconductor industry |
|---|---|---|---|
| **2020** | 15.50 | 17.80 | 20.30 |
| **2021** | 20.90 | 20.60 | 20.70 |
| **2022** | 19.20 | 19.00 | 18.80 |

Data source: 2023 China Mainland Integrated Circuit Industry Talent Supply and Demand Report

In terms of talent supply and demand, China's semiconductor talent has been in shortage for a long time. China's semiconductor industry market size has grown from $98.6 billion in 2015 to $180.3 billion in 2022, with a CAGR of 9.00%. However, the existing talent supply cannot meet the needs of the rapidly expanding semiconductor market. For example, in 2020, there were approximately 541,000 people directly engaged in the integrated circuit industry in China, with a year-on-year growth of 5.7%, while the total sales of the integrated circuit industry during the same period reached 884.8 billion yuan, with a year-on-year growth of 17%. Based on statistics from different sources, the long-term talent gap in China's semiconductor industry is likely running between 200,000 to 350,000. As for the current salary situation of employees, the increase in overall salary in the IC industry in 2022 is obvious, as relevant research shows that the increase in salary and job-hopping both exceed 30%.

Examining the evolution of compensation, talent shortages, and turnover rates within China's IC industry, it can be inferred that, despite the cyclical trough in the semiconductor industry in 2022 due to macroeconomic influences, the demand for talent in this industry has remained on an upward trajectory, but the persistently existing

scenario of demand outstripping supply does not seem to be significantly affected by the cyclical trough. At the same time, despite intensified efforts aimed at augmenting talents in relevant domains, the overall talent deficit has not been comprehensively mitigated, thus posing latent concerns for the stable development of the semiconductor industry.

**(2) The R&D intensity of the semiconductor industry continues to increase but there is still a gap in the total R&D amount**

From the perspective of patent quantity, it is evident that China's semiconductor has been on an upward trajectory in recent years. In 2021, there was a significant increase in both the total number of patent applications and valid invention patents in China's semiconductor industry compared to 2020. In 2022, although there was continued growth, the growth rate decreased, which can be attributed, in part, to the cyclical trough in the industry and the impact of the COVID-19 pandemic.

From the perspective of R&D investment intensity, influenced by industry policies and market demands, the intensity of national R&D investment in the semiconductor industry has continued to increase in recent years. Between 2019 to 2022, the computer, communication, and other electronic equipment manufacturing enterprises above the designated size have consistently maintained the highest total R&D investment in all categorized fields. Furthermore, the R&D investment intensity (the ratio of investment to revenue) within the above three categories has been rising each year.

**Table 2.5 Statistics on semiconductor patent applications and active patents of industrial enterprises above designated size (high-tech industries) in China**

| | Discrete device manufacturing | | | IC manufacturing | | |
|---|---|---|---|---|---|---|
| Year | Number of patent applications | Number of patent applications: Patents for inventions | Number of active patents | Number of patent applications | Number of patent applications: Patents for inventions | Number of active patents |
| 2020 | 2118 | 645 | 2833 | 16728 | 12112 | 27809 |
| 2021 | 3285 | 1645 | 3515 | 21595 | 15317 | 32099 |
| 2022 | 3539 | 1705 | 3686 | 22232 | 15989 | 35025 |

Data source: National Bureau of Statistics

From the perspective of enterprise R&D, there may be issues with uneven distribution of R&D expenses and low average R&D expenditure in China's

semiconductor enterprises. According to data from Jiwei[①], between 2020 and 2022, the ratio of R&D expenses to revenue (i.e., R&D expenditure rate) for A-share listed semiconductor companies in China was 14.6% (75 companies), 10.4% (50enterprises) and 20.5% (62enterprises), respectively. In 2021, the total R&D expenditure of the top 50 semiconductor companies listed on the A-share market amounted to ￥40.923 billion. However, in 2022, 191 A-share listed semiconductor companies have a total R&D expenditures of only￥68.615 billion, with an R&D expense ratio of 9.1%. Moreover, China' enterprises lags far behind foreign companies in total R&D expenditure in the semiconductor field. For example, Intel alone, in the 2022 fiscal year, despite a 20.2% decline in revenue, still had R&D expenses amounting to $17.53 billion dollars, surpassing the total R&D expenditure of 191 A-share listed semiconductor companies listed. Although this data may not be broadly representative (as A-share listed semiconductor companies differ significantly from international semiconductor giants in terms of size and business maturity), the fact that China's R&D spending is relatively lower compared to developed countries like the US is evident. The R&D investment in China has been growing year by year, providing support to industry development and stability to some extent. However, this support may have its limitations. In the face of industry periodical downturn, the R&D output growth rates, the support for industry stability have been suffered inevitably.

**Table 2.6 Statistics on R&D investment in computer, communication, and other electronic equipment manufacturing industries (2019-2022)**

| | R&D investment (billions of yuan) | the intensity of R&D funding input (%) |
|---|---|---|
| **2019** | 2448.1 | 2.15 |
| **2020** | 2915.2 | 2.35 |
| **2021** | 3577.8 | 2.43 |
| **2022** | 4099.9 | 2.63 |

Data source: Ministry of Science and Technology

### (3) Impact of talent and innovation on industrial chain development

China's industry policy to support its IC industry and the talent pool, to a certain extent, increased the supply of industrial talent. Since the beginning of the new century, several Five-Year Plans regarding strategic economic design have proposed to "vigorously develop a new generation of information technology ..... focus on the development of integrated circuits and other high-end services". *Made in China*

*2025* outlines a dedicated program for the development of integrated circuits. In terms of talent cultivation, the relevant government ministries have issued *Opinions of the Ministry of Education and Other Seven Departments on Strengthening the Cultivation of IC Talents* in 2016 and *Several Policies for Promoting the High-quality Development of the IC Industry and Software Industry in the New Period* in 2020. These policies aim to promote the setting up of primary curriculums of IC by colleges and universities and prioritize the integration of IC industry education and training between enterprises and the higher education system while encouraging local recognition and awards for high-end talents in related fields. Under policy guidance, the supply of IC talents has continued to increase. According to the data from *China IC Industry Talent White Paper* published between 2018 to 2021, the scale of employees in China's IC industry has risen from 400,000 in 2017 to 541,000 in 2020, and the talent gap has dropped from 260,000 to about 200,000.

However, recently, China has faced obstacles in the introduction of high-end semiconductor talents from abroad. And the cost of introducing technology authorization and patented equipment through conventional channels has increased sharply. Also, communication with the international high-end semiconductor research and development community has been limited. These factors, to a certain extent, have exacerbated China's shortage of talent and the lack of innovation in the semiconductor field. Nevertheless, Chinese semiconductor companies are still working hard to leverage their advantages to ensure the stability of the supply chain and the sustainable development of the industrial chain. In recent years, domestic semiconductor talent supply and innovation investment have increased driving up the domestic substitution rate. Taking the domestic IC industry as an example, the ratio of made-in-China products and services to the domestic market consumption in terms of value has increased from 13.5% in 2013 to 41.4% in 2021. The supply of domestic semiconductor talent has generally not been affected by the substantial changes in the global semiconductor industry, providing a certain degree of support for the stability of the domestic semiconductor industry supply chain. From 2019 to 2022, the export of IC products has increased steadily, from $101.6 billion in 2019 to $153.9 billion in 2022. The imports have also continued to grow from $305.5 billion in 2019 to $432.6 billion in 2021, while there was a pullback in 2022. The details are shown in Figure 3.3.

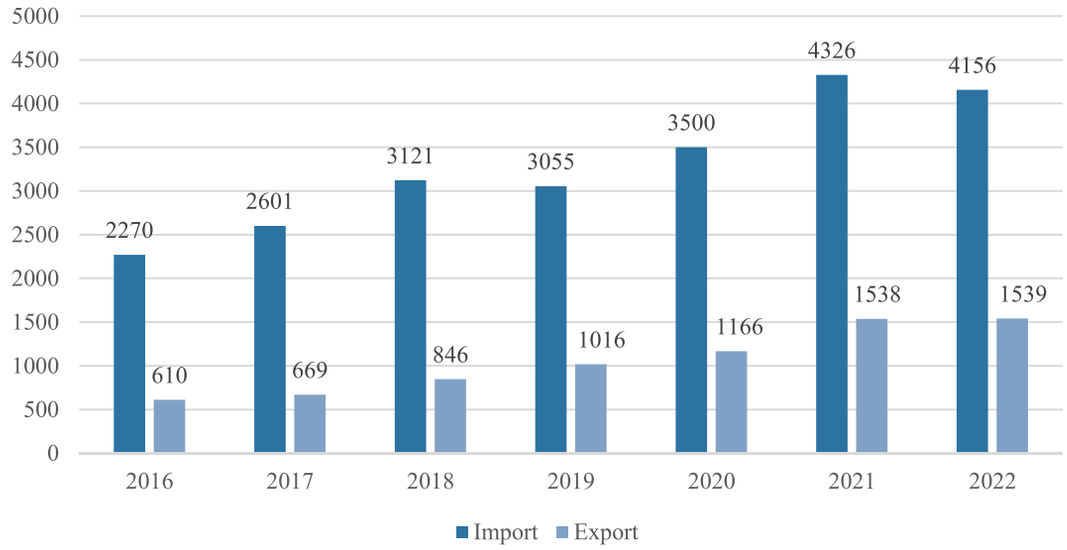


**Figure 2.3 The import and export of integrated circuits in mainland China (in billions of US dollars)**

Source: General Administration of Customs

In conclusion, the resilience of China's semiconductor industry has partially improved during the cyclic trough. The future of resilience depends on the degree to which investment and financing can be maintained, and whether the talent deficit can be filled with satisfactory speed. Whether R&D and innovation can be further strengthened also depends on whether China's semiconductor industry can reconnect with major global semiconductor industries and markets. Fundamentally, the semiconductor industry is highly capital- and knowledge-intensive, highly globalized. Whether China’s talent supply and innovation support in the semiconductor field are sufficient to promote sustainable development is still a question requiring in-depth research.

# Chapter 3: Recommendations

Drawing from the practices of various global economies in enhancing their industrial and supply chain resilience, this report suggests that China could explore targeted measures in the following areas: First, uphold the principle of cooperative openness, further promoting the improvement of global rules that contribute to global industrial risk management; Second, establish a communication platform for industrial resilience and create a regular communication mechanism；Third, foster the integration of the innovation chain, industrial chain, talent chain, and capital chain, thus harnessing China's advantage of a large market scale to enhance the ecosystem in strategic industries; Fourth, accelerate digital transformation to elevate the predictability and adaptability of the industrial chain; Fifth, implement effective macroeconomic policies to improve the market environment and address vulnerabilities in key industries.

## I. Uphold openness and cooperation to jointly safeguard global industrial chain resilience

Enhancing openness and cooperation to improve the capacity of global industrial and supply chains to respond to risks has been a key direction and objective of China's economic engagement and international cooperation. It is also a feasible solution to enhance the resilience of China's industrial and supply chains. Recently, Chinese governments have repeatedly emphasized the need to fully leverage China's vast market advantages by integrating the strategy of expanding domestic demand with innovation-driven development and strengthening openness and cooperation in industrial and supply chains. At the opening ceremony of the Third Belt and Road International Cooperation Summit Forum held in October 2023, Chinese governments stated in his keynote speech that China would “comprehensively remove restrictions on foreign access in the manufacturing sector. Proactively align with international high-standard economic and trade rules, deepen cross-border service trade and high-level openness in investment, and expand market access for digital products and other markets.” [①] This

①《习近平在第三届“一带一路”国际合作高峰论坛开幕式上的主旨演讲》，新华社, 2023 年 10 月 18 日, http://www.news.cn/politics/leaders/2023-10/18/c_1129922670.htm.

further demonstrates China's determination to expand its openness and build an open world economy.

In the process of industrial development, due to the different division of labor in the global economy, various segments of the global industrial chain are distributed across different economies, thereby dispersing risks and improving efficiency. Mutual openness and cooperation, promoting the effective connection of resources, technology, and markets are indispensable prerequisites for the global development of industrial chains. Increasing the degree of openness and cooperation helps promote the sustainable development of industrial chains and also contributes to mutual benefit and win-win outcomes in the global economy.

Currently, there is a trend of “fragmentation” in global supply chains, posing challenges to the global industrial chain and production division of labor. In response, China needs to advocate for more open and equitable international cooperation to ensure that all economies have equal opportunities in global industrial and supply chains. Specifically, by utilizing or creating cooperative platforms and communication mechanisms, we can deepen international cooperation, promote the sharing of resources in various aspects, such as knowledge, technology, and talent, bridge information and technology gaps, reduce costs of communication, and enhance cooperation efficiency. We can also build consensus and concretize consensus into actions and rules to address market fluctuations and uncertainties, reducing the uncertainties of global industrial and supply chains.

Open and equitable cooperation helps expand market access and provide more economic and trade choices thereby reducing market risks, enhancing industrial chain resilience. Practices such as “nearshoring” and “reshoring” that claim to reduce risk and enhance resilience are, in fact, forms of trade protectionism under the guise of “reducing dependence on a single market.” Actually, these practices do not contribute to reducing market risks or enhancing industrial chain resilience. Globalization has established a comprehensive international cooperation and global governance system over the past few decades. For the past few years, China has proposed initiatives like the “Belt and Road” and established multilayered cooperation platforms with emerging developing countries through mechanisms like the BRICS. Developed countries have also introduced similar cooperation initiatives. It is essential to approach these cooperation proposals and mechanisms with an open, rather than exclusionary attitude, seeking common ground that serves mutual interests.

## II. Establish a communication platform for industrial chains resilience and a regularized communication mechanism

In recent years, China has made remarkable strides in facilitating industrial communication and exchange through a series of expos that leverage the “Expo Strategy”. The International Big Data Industry Expo, China Beijing International Fair for Trade in Services (CIFTIS), China International Consumer Products Expo, and China International Import Expo have all effectively established themselves as notable brands. The inaugural China International Supply Chain Expo (CISCE), scheduled for late November 2023, is set to continue this trend. These expos reflect China's philosophy of openness, as they explore innovative approaches to the country's opening-up and underscore its increasingly expansive opportunities for collaboration, thereby energizing global free trade.

Among them, the China International Import Expo (CIIE) is a signature event for showcasing and exchanging products from different parts of the industrial chain. After six years of development, CIIE has continuously strengthened its international public goods attributes and has grown into an important international platform for global procurement, investment promotion, cultural exchanges, and cooperation. The CIIE Hongqiao Forum has also evolved into an international high-end platform for intellectual collision, consensus building, and multilateral cooperation. In the future, it is worth considering institutionalizing the forums such as “Resilient Global Industrial and Supply Chains” to establish a regular global dialogue and cooperation mechanism for enhancing the resilience of industrial chains and supply chains. This dialogue and cooperation mechanism will promote information sharing among participants in different parts of the industrial chain. It will facilitate resource and experience sharing, strengthen technological innovation and risk management and help to build mutual trust. Such efforts will also contribute to enhancing the international public goods attributes and improving the brand image of the CIIE.

Specific requirements for the establishment of an industry chain resilience exchange platform include:

(1) Provide an open communication channel: By facilitating the sharing of information and fostering cooperation, this measure enables diverse countries and enterprises to remain well-informed regarding global market dynamics, policy adjustments, and technological advancements. Through the exchange of best practices and experiences, the platform empowers nations and companies to collectively address challenges and enhance their resilience.

(2) Offer opportunities for technological innovation and collaborative research and development: This measure involves the consolidation and integration of innovative capabilities from different countries and enterprises, enabling them to collaboratively develop novel technologies and solutions that effectively cater to the evolving demands of the market. Consequently, this measure elevates the overall standard of the industrial chain.

(3) Function as a platform for addressing common crises and risk management: By fostering collaboration, countries and enterprises can jointly devise strategies to respond to unforeseen events, exchange experiences in crisis management, and enhance their capacity to withstand external shocks.

(4) Promote the sustainable development of global industrial chains: All participating entities have the opportunity to explore and share environmentally friendly technologies and business models that facilitate emissions reduction and environmental protection. This measure contributes to the long-term viability of global industrial chains and addresses pressing global challenges, such as climate change.

(5) Build trust and mutual confidence: Through the establishment of open dialogues and cooperative frameworks, all parties involved are better equipped to comprehend each other's perspectives and interests, thereby enhancing business exchanges. Ultimately, this measure leads to an improvement in the resilience of global industrial chains.

## III. Drive the integrated development of the innovation chain, talent chain, funding chain, and industry chain

China is the world's largest trading nation and major consumer market, foreign investment destination, and source of outbound investments. All of this stems from China's unique advantages in terms of market size, comprehensive factors such as labor, land, and capital. And its years of industrialization has made it the only country in the

world with all industrial categories listed in the United Nations' industrial classification. However, due to its latecomer status, China lags in innovation and talent resource and has long stuck in the mid-to-low end of industrial chains, and has shortcomings in the upstream of the industrial and value chains. In some strategic industries, it lacks resilience and is susceptible to external factors. This problem has become increasingly evident recently.

Therefore, the 20th National Congress report of the Communist Party of China emphasizes, “Education, science and technology, and talent are the fundamental and strategic elements for building a socialist modernization country in an all-around way.” It is necessary to better coordinate the integrated development of education, science and technology, talent as a “trinity system”, shaping a new advantage in scientific and technological innovation through synergies, systematic integration, and deep integration. The 20th National Congress report also emphasizes, “Promote the deep integration of the innovation chain, the industrial chain, the capital chain, and the talent chain.” Among them, the innovation chain is essentially an innovative organizational model that aligns the entities participating in innovation under the guidance of market-oriented needs, driving the conversion of knowledge innovation into economic and social benefits. The capital chain is a network of various financial institutions or financing channels that provide financial support for the normal operation of businesses. The talent chain is a talent pool of aggregating talents that are compatible with the development of the industrial chain through cultivation or introduction. Industrial development relies on the coordinated input of elements such as innovation, capital, and talent. The enhancement of industrial chain resilience inevitably depends on the combined efforts of the innovation chain, capital chain, and talent chain. Promoting the deep integration of these “four chains” holds fundamental and strategic significance for improving industrial chain resilience.

Nevertheless, it's worth noting that “Four-chain Integration” doesn't refer to the integration within a single industry or sector. Instead, it involves integration within a unified domestic large market. The goal is to build a comprehensive and inclusive ecosystem where these elements can move with ample mobility, ensuring the security and resilience of strategic industries in an inclusive manner.

As previously mentioned, the key to deeply integrating the “four chains” is to establish an ecosystem that encompasses innovation activities, financial support, and talent assurance. Specifically, this involves several steps:

(1) Optimize innovation support policies, including fiscal, financial, tax and intellectual property protection policies, to encourage firms and social capital to increase their investment in research and development (R&D) and innovation activities and to increase the intensity of R&D investment.

(2) Strengthen talent cultivation and mobility by enhancing education levels, promoting STEM education, intensifying talent development efforts, conducting skill training and vocational education programs to enhance technical expertise, encouraging talent aggregation, establishing channels for cross-regional, cross-sector, and cross-disciplinary talent flow.

(3) Promote two-way interaction between science and technology and industry by accumulating experience and creation in industrial practices, emphasizing industry-led technological innovation and invention, increasing the innovation content of Chinese enterprises, and striving to nurture more science and technology innovative enterprises.

(4) Remove systemic barriers and leverage the coordinating role of the government in the coordinated development of the "trinity system". This includes implementing deep reforms to bridge the gap between innovation and industrial development, guiding the market to cultivate, introduce, and effectively utilize various high-end talents based on industrial demands, concentrating efforts on strengthening key points in the industrial chain, deploying innovation chains around the industrial chain, improving the funding chain around the innovation chain, and eliminating the "isolated island phenomenon" in scientific and technological innovation.

(5) Overcome institutional obstacles in the integration process of the "four chains" by innovating collaborative mechanisms, incentive models, and evaluation systems. This would enhance the sense of participation among the entities in the chains. To achieve this goal, cross-departmental collaboration mechanisms should be established among the government, enterprises, educational institutions, and social organizations to generate synergy and promote the integration of the "four chains".

## IV. Enhance digital transformation to improve the predictability and adaptability of the industrial chain

Digital transformation plays a crucial role in modern industrial development. It not only enhances efficiency and productivity but also elevates the intelligence level of innovation, production, and supply management. It improves the predictability of the

industrial chain, enabling it to respond to evolving market conditions and unforeseen events, ultimately enhancing the resilience of the industrial chain. Strengthening digital transformation creates tighter connections between various elements within the industrial chain, enabling the relevant stakeholders to better adapt to market changes and external shocks, and thus, increasing resilience to remain competitive in a fierce environment. There are five key requirements to strengthen digital transformation:

(1) Build a robust digital infrastructure to ensure high-speed internet connectivity and data storage capacity that supports digital transformation.

(2) Develop the capability for data collection, analysis, and application to facilitate data-driven decision-making.

(3) Promote the application of technologies such as the Internet of Things (IoT) to enhance real-time monitoring of equipment and systems, thereby improving production efficiency. Additionally, advance the application of automation and artificial intelligence technologies to further promote productivity and product quality. Accelerate the digitization of supply chain management to achieve real-time visibility and improve supply chain flexibility.

(4) Enhance network security to ensure the safety of digital systems and data, reducing the potential risks of network attacks and data breaches.

(5) Strengthen digital training and skill development for the workforce involved in the industrial chain's digital transformation, ensuring their adaptation to the digital transformation environment.

## V. Improve the market environment with effective macroeconomic policies and strengthen China's weak links in key industries

China's achievement of establishing a comprehensive industrial chain economic system is closely linked to its market size, robust market competition, and effective macroeconomic policy. Over the past decades, China's macroeconomic policies have continuously driven the upgrading of high-tech manufacturing industries, elevating China's position within the global value chain. However, this progress has also revealed several shortcomings, such as inefficiencies in some policies, inherent deficiencies in certain industries, and issues related to market resource allocation and supply

distortions.

In recent years, in order to safeguard the development of strategic industries, China has implemented strategic planning, directed state-owned enterprises, and provided monetary and fiscal policy support to guide the development of related industries. However, in the long term, addressing bottlenecks in strategic areas requires more than just monetary and fiscal policy guidance. It necessitates legislative measures to ensure effective legal protection for strategic industries.

To some extent, China can draw lessons from legislative examples in developed countries such as the European Union and the United States to strengthen effective rule of law protection for strategic industries. Furthermore, from a longer-term perspective, it is essential to create a market-oriented, rule-of-law-based, and international business environment that optimizes the development conditions for private and foreign-invested enterprises. This includes protecting property rights and entrepreneurial interests through legal means, allowing all forms of ownership to equally utilize production factors and participate in market competition. This approach facilitates the seamless integration of research and development, commercialization, production, and distribution stages in strategic industries.

In this regard, the “Opinions of the CPC Central Committee and the State Council on Promoting the Growth and Development of Private Economy” (known as the “31 Measures for Private Economy”), released in July 2023, serves as a recent positive example of macroeconomic policy.

Additionally, policies that promote capital markets to provide more convenient financing for talent development and innovation transformation are important. Efforts should be made to coordinate and guide the alignment of capital markets with the short-term and long-term interests of high-tech startups, providing these enterprises with more room for growth and competitive resilience.

# Appendix: Theories and Models Related to National Industrial Chain Resilience

## I. Overview of Indices Related to National Industrial Chain Resilience

As an inevitable outcome of the advancement of a market economy to a specific historical stage, the industrial chain represents a crucial system that revolves around enterprise activities, harmonizes the progress of multiple industries, and upholds regional economic stability. Resilience, as a prominent concept in macroeconomics, quantifies the capacity of economic entities to withstand shocks, recover, and regenerate.

The evaluation of industrial chain resilience holds great significance within industrial chain research. It necessitates a comprehensive utilization of knowledge from various disciplines such as economics, management, and ecology to explore the origins, meanings, fundamental factors, and their interrelationships concerning the industrial chain and its resilience. Additionally, it requires the application of statistical methods to quantitatively showcase the state of industrial chain resilience through indicators. This approach enables a relatively accurate representation of a country's industrial competitiveness, independent innovation capacity, governance and operational proficiency, facilitating practical evaluations and analyses.

The evaluation indicators of the resilience of a country's industrial chain can be broadly categorized into two main types: effectiveness indicators and attribution indicators. The former reflects the ability of a country's industrial chain to accommodate and withstand shocks, i.e., the degree of oscillation after experiencing certain impacts; the latter reflects the causes or determinants of the formation of industrial chain resilience.

Given the intricate nature of the components within the industrial chain, this report incorporates three globally acknowledged comprehensive indices: the Competitive Industrial Performance Index (CIP Index), the Global Innovation Index (GII), and the Ease of Doing Business Index. These indices provide assessments of the resilience of

the industrial chain in various countries from diverse perspectives.

## 1. Competitive Industrial Performance Index (CIP Index)

The Competitive Industrial Performance Index (CIP Index)[①] is a comprehensive measurement tool published by the United Nations Industrial Development Organization (UNIDO). It aims to gauge the manufacturing capabilities of major countries worldwide, specifically in terms of their production and export of manufactured goods in both domestic and international markets. Since its inception in 1996, the CIP Index has consistently employed standardized criteria to assess the competitiveness of manufacturing industries in 152 countries. These assessments are presented through performance evaluations and rankings depicted on charts. By utilizing the CIP Index, it becomes possible to evaluate and compare the recent performances of countries, as well as their respective positions within the global manufacturing industry.

**Table4.1 Composition of Competitive Industrial Performance Index 2020**

| Dimension | Indicator |
|---|---|
| **Capacity** | Country's manufacturing value added per capita |
| | Country's manufacturing exports per capita |
| **Impact** | Share of country's manufacturing value added in world manufacturing value added |
| | Share of country's manufacturing exports in world manufacturing exports |
| **Structural change** | Share of country's manufacturing value added in country's GDP |
| | Share of country's manufacturing exports in total country exports |
| | Share of country's medium- and high-tech industrial sectors in country's manufacturing value added |
| | Share of country's medium- and high – tech industrial sectors in country's manufacturing exports |

The CIP Index has undergone continuous enhancements, with its most recent indicator system being established by UNIDO's Department of Policy, Research and Statistics in the "The Inclusive and Sustainable Competitive Industrial Performance Index"[②] published in May 2021. This index system comprises three fundamental

① Data source of CIP Index: https://stat.unido.org/cip/
② Description of the components of CIP Index: https://unido-

dimensions: manufacturing capacity, international influence, and structural changes, incorporating a total of eight secondary indicators.

The Competitive Industrial Performance Index encompasses the key measurement indicators of prominent industry participants: manufacturing industry, and it serves as a valuable reference for evaluating the value-added capabilities and structural integrity of industrial chains in assessing national industrial chain resilience.

## 2. Global Innovation Index (GII)

The Global Innovation Index (GII)[①], published annually since 2007 by the World Intellectual Property Organization (WIPO), ranks the innovation ecosystems of 132 economies worldwide using standardized performance metrics. The GII also conducts research and analysis on the strengths and weaknesses of innovation in different countries. Based on a broad dataset, which includes 81 indicators collected from both public and private sources, the GII has become a cornerstone for economic decision-making by an increasing number of governments since its launch in 2007.

The 2022 Global Innovation Index report, which focuses on "the future of innovation-driven growth," evaluates and compares the performance of each economy based on seven dimensions and 81 indicators related to factors such as political environment, education, infrastructure, and knowledge creation.

The capacity to innovate independently provides the basis for a country's economic independence, playing a decisive role in ensuring the integrity and regulatory capacity of its industrial chain.

Over the years, the Global Innovation Index has continuously broken through the traditional concept of "innovation" and expanded the perspective of constructing a resilience evaluation system for national industrial chain.

**Table4.2 Composition of Global Innovation Index**

| Dimension | Measure | Indicator |
|---|---|---|
| Institutions | Political environment | Political and operational stability (index) |
| | | Government effectiveness (index) |
| | Regulatory | Regulatory quality (index) |

gc.org/Publications/The%20extended%20inclusive%20and%20sustainable%20index.pdf#:~:text=The%20CIP%20index%20is%20a%20composite%20index%20that,sub-indicators%20encompass%20domestic%20production%20as%20well%20as%20exports

① https://www.wipo.int/global_innovation_index/en/

| Dimension | Measure | Indicator |
|---|---|---|
| | environment | Rule of law |
| | | Cost of redundancy dismissal |
| | Business environment | Policies for doing business |
| | | Entrepreneurship policies and culture |
| **Human capital and research** | Education | Expenditure on education, % GDP |
| | | Government funding/pupil, secondary, % GDP/cap |
| | | School life expectancy, years |
| | | PISA scales in reading, maths and science |
| | | Pupil–teacher ratio, secondary |
| | Tertiary education | Tertiary enrolment, % gross |
| | | Graduates in science and engineering |
| | | Tertiary inbound mobility, % |
| | Research and development (R&D) | Researchers, FTE/mn pop. |
| | | Gross expenditure on R&D, % GDP |
| | | Global corporate R&D investors, top 3, mn USD |
| | | QS university ranking, top 3* |
| **Infrastructure** | Information and communication technologies (ICTs) | ICT access (index) |
| | | ICT use (index) |
| | | Government's online service (index) |
| | | E-participation (index) |
| | General infrastructure | Electricity output, GWh/mn pop. |
| | | Logistics performance (index) |
| | | Gross capital formation, % GDP |
| | Ecological sustainability | GDP/unit of energy use |
| | | Environmental performance |
| | | ISO 14001 environmental certificates/bn PPP$ GDP |
| **Market sophistication** | Credit | Finance for startups and scaleups |
| | | Domestic credit to private sector, % GDP |
| | | Loans from microfinance institutions, % GDP |
| | Investment | Market capitalization, % GDP |
| | | Venture capital investors, deals/bn PPP$ GDP |
| | | Venture capital recipients, deals/bn PPP$ GDP |
| | | Venture capital received, value, % GDP |
| | Trade, diversification, and market scale | Applied tariff rate, weighted avg., % |
| | | Domestic industry diversification |
| | | Domestic market scale, bn PPP$ |
| **Business sophistication** | Knowledge workers | Knowledge-intensive employment, % |
| | | Firms offering formal training, % |
| | | GERD performed by business, % GDP |

## Appendix: Theories and Models Related to National Industrial Chain Resilience

| Dimension | Measure | Indicator |
|---|---|---|
| | | GERD financed by business, % |
| | | Females employed w/advanced degrees, % |
| | Innovation linkages | University–industry R&D collaboration |
| | | State of cluster development and depth |
| | | GERD financed by abroad, % GDP |
| | | Joint venture/strategic alliance deals/bn PPP$ GDP |
| | | Patent families/bn PPP$ GDP |
| | Knowledge absorption | Intellectual property payments, % total trade |
| | | High-tech imports, % total trade |
| | | ICT services imports, % total trade |
| | | FDI net inflows, % GDP |
| | | Research talent, % in businesses |
| **Knowledge and technology outputs** | Knowledge creation | Patents by origin/bn PPP$ GDP |
| | | PCT patents by origin/bn PPP$ GDP |
| | | Utility models by origin/bn PPP$ GDP |
| | | Scientific and technical articles/bn PPP$ GDP |
| | | Citable documents H-index |
| | Knowledge impact | Labor productivity growth, % |
| | | New businesses/th pop. 15–64 |
| | | Software spending, % GDP |
| | | ISO 9001 quality certificates/bn PPP$ GDP |
| | | High-tech manufacturing, % |
| | Knowledge diffusion | Intellectual property receipts, % total trade |
| | | Production and export complexity (index) |
| | | High-tech exports, % total trade |
| | | ICT services exports, % total trade |
| **Creative outputs** | Intangible assets | Intangible asset intensity, top 15, % |
| | | Trademarks by origin/bn PPP$ GDP |
| | | Global brand value, top 5,000, % GDP |
| | | Industrial designs by origin/bn PPP$ GDP |
| | Creative goods and services | Cultural and creative services exports, % total trade |
| | | National feature films/mn pop. 15–69 |
| | | Entertainment and media market/th pop. 15–69 |
| | | Printing and other media, % manufacturing |
| | | Creative goods exports, % total trade |
| | Online creativity | Generic top-level domains (TLDs)/th pop. 15–69 |
| | | Country-code TLDs/th pop. 15–69 |
| | | GitHub commit pushes received/mn pop. 15–69 |
| | | Mobile app creation/bn PPP$ GDP |

## 3. Ease of Doing Business Index

The Ease of Doing Business Index[①], released annually in the World Bank's Doing Business report, provides a comprehensive assessment of the ease of doing business by combining scores and rankings. It evaluates 190 economies across 10 key areas and 41 indicators. This index not only reflects the changes in business friendliness over time but also highlights the variations in performance among economies regarding business regulations. The establishment and advancement of industrial chains depend not only on internal management of enterprises and utilities of the market economy, but also on macroeconomic regulations implemented by the government.

**Table4.3 Composition of Ease of Doing Business Index**

| Factor | Criteria |
|---|---|
| **Starting a Business** | Procedures (number) |
| | Time (days) |
| | Cost (% of income per capita) |
| | Minimum capital (% of income per capita) |
| **Dealing with Construction Permits** | Procedures (number) |
| | Time (days) |
| | Cost (% of warehouse value) |
| | Building quality control index (0-15) |
| **Getting Electricity** | Procedures (number) |
| | Time (days) |
| | Cost (% of income per capita) |
| | Reliability of supply and transparency of tariff index (0–8) |
| **Registering Property** | Procedures (number) |
| | Time (days) |
| | Cost (% of property value) |
| | Quality of land administration index (0-30) |
| **Getting Credit** | Strength of legal rights index (0–12) |
| | Depth of credit information index (0–8) |
| **Protecting Minority Investor** | Extent of disclosure index (0–10) |
| | Extent of director liability index (0–10) |
| | Ease of shareholder suits index (0–10) |
| | Extent of shareholder rights index (0–6) |

① https://databank.worldbank.org/metadataglossary/jobs/series/IC.BUS.EASE.XQ

| | |
|---|---|
| | Extent of ownership and control index (0–7) |
| | Extent of corporate transparency index (0–7) |
| **Paying Taxes** | Payments (number per year) |
| | Time (hours per year) |
| | Total tax and contribution rate (% of profit) |
| | Postfiling index (0–100) |
| | Time to comply with VAT refund (hours) |
| | Time to obtain VAT refund (weeks) |
| | Time to comply with corporate income tax correction(hours) |
| | Time to complete a corporate income tax correction(weeks) |
| **Trading Across Borders** | Time to export (hours) |
| | Cost to export (US$) |
| | Time to import (hours) |
| | Cost to import (US$) |
| **Enforcing Contracts** | Time (days) |
| | Cost (% of claim) |
| | Quality of judicial processes index (0-18) |
| **Resolving Insolvency** | Recovery rate (cents on the dollar) |
| | Strength of insolvency framework index (0-16) |

By incorporating indicators in the Ease of Doing Business Index into the evaluation system of national industrial chain resilience, a well-balanced assessment is achieved, considering both the influence of market principles (invisible hand) and governmental intervention (visible hand). This approach enhances scientific rigor of the evaluation system.

# II. Building a National Industrial Chain Resilience System

## 1. Guiding Theories in the Evaluation System

Enhancing the resilience of industrial chains is crucial for promoting their modernization and strengthening economic resilience of a nation.

On one hand, keep improving the level of national industrial chains, enhancing their value-added capabilities across various stages of the global value chain, and

upgrading their position in the global value chain are of significant importance for promoting synergy among factors such as industries, talents, innovation, and capital, as well as for national economic development; On the other hand, ensuring stability of industrial as well as supply chain and enhancing the coordination, integrity, collaboration, and resilience of industrial chains become imperative in the face of great changes that have not been seen in a century, addressing the risks of trade protectionism, deglobalization, and global economic downturn in the post-pandemic era.

From a national standpoint, the ability to withstand risks, recover, and adapt is fundamental to the resilience of industrial chains; from a developmental perspective, development of entities is influenced by both internal and external factors.

Therefore, in constructing the evaluation system, our report has established an evaluation framework focusing on enterprises and industries, with consideration given to important factors such as talents, innovation, and capital. Simultaneously, it adopts a dual perspective of market and government to reflect the changes in industrial chains during the year of the COVID-19 outbreak and assess the performance and potential of industrial chain resilience.

## 2. Basic Principles in Building an Evaluation System

**i. Scientific**

When constructing the "National Industrial Chain Resilience System", the report integrates the latest advancements in industrial chain research and merges them with existing evaluation frameworks. It sets up indicators that are closely aligned with the unique features of the industrial chain, guaranteeing a scientific and comprehensive reflection of the core essence of industrial chain resilience within the evaluation system.

**ii. Quantifiable**

Despite the direct influence of social factors such as systems, mechanisms, and institutional environments on the national industrial chain, evaluating these factors often entails subjective judgment. Evaluations can be influenced by evaluators' subjective awareness, cognitive abilities, and even personal preferences, making it challenging to achieve objectivity and impartiality. Consequently, our report avoids using qualitative evaluations obtained through methods such as questionnaire surveys in the design of the evaluation system. Instead, all indicators are based on quantitative results derived from statistical data published by institutions like the World Bank. This

approach ensures a more scientific and unbiased evaluation of the industrial chain.

**iii. Comparable**

Given that industrial chain resilience is a concept that describes differences, this report employs an index-based approach to standardize different indicators of national industrial chain resilience. This method ensures that the objects of study are comparable to each other.

## 3. Structure of the Evaluation System

Based on the aforementioned principles, a dedicated evaluation system architecture for national industrial chain resilience has been designed. In this evaluation system, national industrial chain resilience is categorized into five primary indicators: talent capital, innovation resources, overall industry situation, manufacturing performance, and enterprise vitality.

Amongst them, the talent capital indicator measures a country's talent capital, talent reserves, and talent development capabilities; the innovation resources indicator assesses a country's innovation inputs and outputs; the enterprise vitality indicator evaluates a country's enterprise development vitality from various perspectives of business environment and business performance. These primary indicators mainly belong to attribution indicators.

The overall industry situation indicator measures the overall development of industries in different countries, while the manufacturing performance indicator assesses the performance of the manufacturing industry. These two indicators represent the current state of national industrial chain resilience and reflect the impact of a country's talent, innovation, enterprise, and policy inputs on the industry.

## 4. Evaluation Model of Industrial Chain Resilience

**i. Developing a Model**

Based on the structure of the industrial chain resilience evaluation system, we have developed the following resilience evaluation model:

$$J_i = \sum B_k * Q_k$$

Where $J_i$ is the industrial chain resilience of different countries, $B_k$ represents the indicators (indices) for the first and second tiers, etc., and $Q_k$ is the weight of the

indicators (indices) respectively corresponding to the first and second tiers. $k$ is the number of indicators of the first and second tiers respectively. In this report, the number of indicators of the first-tier $k$ is fixed at 5 (corresponding to the structure of the talent competitiveness evaluation system); while the number of indicators of the second tier is determined according to the different characteristics of the indicators at different levels.

**ii. Determining Weight**

Each indicator in the evaluation system of national industrial chain resilience plays a diverse role in assessing the resilience of a country's industrial chain. To reflect the importance of each indicator in the evaluation system, different weight coefficients should be assigned to each indicator. The weight of an indicator is a reflection of its relative importance, measuring both subjectivity and objectivity. Reasonable weight coefficients are of great significance in the evaluation of national industrial chain resilience.

Currently, the determination of indicator weights mainly adopts expert collective decision-making methods combining subjectivity and objectivity, such as the Delphi method, Analytic Hierarchy Process (AHP), Grey Relational Analysis and so on.

AHP is a multi-criteria decision-making method that combines qualitative analysis with quantitative assessment, proposed by American scholar T.L. Saaty and others in the 1970s. This method has a rigorous analytical logic for assessing the importance of different indicators and involves meticulous mathematical calculations, making it highly reliable. It reflects the combination of subjective analysis and objective computation, and thus, has been widely applied to determine indicator weights.

In this research report, after clarifying the hierarchical structure of the indicator system, AHP was used to determine the weights of the indicators in the evaluation system of national industrial chain resilience. Nine experts were invited to perform pairwise comparisons and judgments on the first and second-level indicators using a proportional scale of 1 to 9. Their qualitative judgments were quantified, constructing several pairwise comparison matrices. These matrices were then subjected to hierarchical ranking to calculate their respective weight coefficients (accurate to two decimal places) and undergo consistency testing. Due to the tedious calculation process and excessive space occupation, the calculation steps are not listed in detail in this research report.

**iii. Principles and Methods of Data Processing**

## Appendix: Theories and Models Related to National Industrial Chain Resilience

Due to the differing dimensional units of various indicators in industrial chain resilience, it is necessary to integrate these indicators comprehensively and standardize their dimensions. This research report primarily utilizes the indexation method.

The calculation formula for the indexation method is as follows:

$$X_i = \frac{x_i}{x_{0i}}$$

$X_i$ is the index, $x_i$ is the original value, and $x_{0i}$ is the maximum value.

# About CCG and Our Team

## About CCG

The Center for China and Globalization (CCG) is a prominent international think tank based in China. Founded in 2008, it holds the distinction of being the sole Chinese think tank to achieve consultative status at the United Nations. CCG also holds the distinction of being the first Chinese social think tank to be listed among the top 100 global think tanks. It has consistently been ranked as the No.1 social think tank in China by reputable domestic and international rankings.

CCG has received the designation of a postdoctoral research workstation by the Ministry of Human Resources and Social Security, granting it the authority to independently recruit postdoctoral fellows. It is also a member institution of the Think Tank Alliance for the Belt and Road Initiative established by the International Liaison Department of the Central Committee of the CPC. CCG serves as the National Talent Theory Research Base for the Coordination Group for Talent Development under the Central Personnel Work Coordination Group. Additionally, it houses the International Talent Professional Committee of the China Talent Research Association, operating under the Ministry of Human Resources and Social Security. CCG is a founding member of the "U.S. Research Think Tank Alliance" initiated by the Ministry of Finance. Moreover, it holds the position of Vice President Unit in the China Public Relations Association and serves as the Secretariat for the "Global Young Leaders Dialogue (GYLD)" project. In 2021, CCG's "Global Young Leaders Dialogue (GYLD)" project received a reply letter from President Xi Jinping.

CCG is headquartered in Beijing and has multiple branch institutions and overseas representatives both domestically and internationally with a team of more than 100 full-time researchers and professionals. CCG is dedicated to its professional positioning of “Internationalization, Prominence, Constructivity” and its motto of “Global Vision for China, Chinese Wisdom for the World”. The organization is committed to conducting comprehensive research in various fields, including globalization, global governance, international relations, international trade and investment, international talent and corporate globalization, the Belt and Road Initiative, and think tank development.

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