

一致(高低生态势样本: $p<0.001$;高低生态位样本: $p<0.001$),即创新生态势较低和创新生态位较专一的创新主体,其中心度越高,其专利被引频次越高。该结论也印证了创新生态系统的扩散效应,即当创新主体位于中心度较高的生态系统中,其创新场越强,活跃度越高,与其他创新主体的互动越多,技术创新成果更容易扩散到其他创新主体,因而其专利被引用频次也会增多。

五、研究结论与展望

本文分析了重大工程创新生态系统的基本特征,主要表现为多主体共生竞合、多阶段交互演化和跨项目动态迁移。通过考察重大工程创新生态系统的运行状态,本文揭示了创新生态位和创新生态势的内涵,解析创新场对于重大工程创新力提升的作用机理;基于港珠澳大桥的相关专利数据,刻画其创新生态网络,分析创新主体构成、动态演化及其对于创新力提升的影响效果。本文发现在重大工程创新生态系统中生态位较专一和生态势较低的创新主体,创新力将得到更大的提升。

(一)研究贡献

本文研究基于创新生态系统理论,并结合港珠澳大桥工程案例,分析重大工程创新生态系统的演化特征和创新力提升的影响机理,考察创新主体的涌现过程、创新主体生态位和生态势的交互变化,证实了重大工程创新孤岛现象。主要理论贡献包括:

第一,率先给出重大工程创新生态系统对于创新力提升的理论解释。基于创新生态势和生态位视角,本文提出重大工程创新生态系统的创新场概念,分析创新场对于提升重大工程创新力的作用机理。通过创新生态位明晰以及创新生态势合理匹配能够有效地形成创新场,创新场的有机融合和动态协同能促进创新生态系统健康运转,创新主体的生态位不断演变和生态势不断提升,促进创新力的非线性增长、重大工程创新生态系统螺旋上升,完成创新生态系统的进化。

第二,揭示了不同生态位和生态势的创新主体在重大工程创新生态系统中获得创新力提升的效应差异。现有研究主要关注企业在创新生态系统中网络位置如何帮助其获得更多价值。本文发现,具有不同创新生态位和生态势的企业,其通过创新生态网络所获得的创新力提升的效应存在明显差异性,主要表现为生态位专一的创新主体通过重大工程创新生态系统的培育和演化,可以获得更大程度上的创新力提升,说明“工匠精神”在重大工程创新生态系统的重要性;同时,创新生态势较低的企业也可以获得更大程度的创新力提升,表明原本创新势能较弱的创新主体通过生态系统培育可获得弯道超车的机会。

(二)实践启示

构建重大工程全要素创新生态系统对推动重大工程战略性技术创新具有重要意义。重大工程创新生态系统是以工程需求为导向,基于工程技术关联而形成共存共生、共同进化的全要素创新生态系统,全要素包括全主体、全过程和全方位,其总体目标是致力于提供一整套的重大工程技术解决方案。

从全主体视角看,健康的创新生态系统必须保证多样化的创新主体,即需要来自于不同行业、不同地域和不同部门的创新主体积极参与到创新活动中,为实现技术难题提供解决方案。从全过程视角看,稳定有效的重大工程创新生态系统必须保证各创新主体在重大工程全生命期不同阶段的动态交互和紧密联系,实现创新知识共享,并通过创新资源的合理分配和利用,实现不同创新主体的价值共创。从全方位视角看,重大工程创新生态系统的创新种群和创新群落日益复杂,因此,构建开放、协调的创新生态系统对于提高重大工程创新能力,实现技术链突破、产业链升级和价值链跃迁具有重要意义。

突破创新孤岛对于提高创新生态系统活力有重要作用。首先,需要进行模式创新,例如采用设计施工总承包模式,让设计方和承包商更早融入到重大工程中,有利于消除创新孤岛现象。其次,创新生态系统必须以开放视角,采用不同创新模式提高与跨部门、跨行业创新主体的协调性,通过扩大创新网络范围和联系紧密度来实现创新孤岛的消融。在开放创新生态系统中,创新主体提高其组织学习能力,通过创新生态系统的自身演化,加强创新网络节点强度,实现创新孤岛的联通。第三,位于创新生态势较高的创新主体应积极发挥引领

作用,通过提升信息交流度和知识共享度,实现创新力的共同提升。

(三)研究展望

本文基于理论构建和实证研究来探究重大工程创新生态系统的要素和演化特征,揭示了重大工程创新主体构成、创新模式和动态演化,分析了现有重大工程的创新生态系统所面临的考验(主要表现为创新孤岛显现、全要素创新生态系统不健全等)。由于重大工程的独特性和复杂性,选择多工程案例数据可以弥补现有研究的不足,分析不同重大工程创新生态系统的交互影响机制是未来值得探讨的方向。其次,本文提出了重大工程创新生态系统的创新场概念,但需要在未来展开更加充分的实证研究,以探讨创新场对于创新力提升的影响机制。此外,与企业创新生态系统相比,重大工程创新生态系统更加复杂,未来研究需要将更多社会经济属性融入到创新生态系统中,探究其对于重大工程创新生态系统的影响机理。

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