Market Structure, Directed Innovation, and the Electrification Transition

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Electrification is a key lever for decarbonization. Achieving it requires not only abundant, low-cost clean electricity, but also new technologies that can convert electricity into valuable economic services. While the Directed Technical Change (DTC) literature emphasizes that innovation responds to relative profit opportunities, these profits are shaped by market structure and competition intensity. Building a novel model of directed technical change with endogenous markups across energy generating and consuming sectors, we analyze how imperfect competition and technological linkages jointly shape the pace and direction of electrification. We show that competition effects, in particular free exit and entry of firms, can weaken lock-in effects that typically favor fossil technologies. Furthermore, the competition effects dampen the speed of transition, especially under strong climate policy. Policies that combine carbon pricing with research subsidies and competition policies that reduce fossil-sector markups can direct innovation incentives, achieving faster and more cost-effective electrification. (JEL: H23, L13, O33, Q43, Q55)

Electrification is widely recognized as a major pathway of decarbonization and a central lever for mitigating climate change. Realizing its potential, however, depends on sustained technological progress on both the supply and demand sides of the energy system. On the supply side, delivering affordable and reliable electricity requires innovations that reduce generation costs and address intermittency. On the demand side, electrification hinges on efficient end-use technologies that convert electricity into valuable services, enabled by technologies such as heat pumps, electric vehicles, and high-temperature electric furnaces. Together, these examples illustrate that an evolving portfolio of technologies is critical to large-scale electrification. Understanding how innovation is directed—and how it shapes the feasibility and cost of electrification—is therefore essential.

We study this question in a framework that captures coordinated innovation along both sides of the energy system—generation and utilization—under imperfect competition and sectoral heterogeneity. Specifically, we investigate how endogenous markups and technological linkages across the energy supply chain affect innovation incentives, the sequencing of electrification, and the design of optimal policy mixes.

We show that electrification is slowed down by endogenous entry and exit of firms, and proceeds unevenly across sectors due to initial electric penetration and market structure. Carbon pricing alone is insufficient to spur a rapid transition in