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Examining the Competition between China and the United States in the Context of Technological Advancements during the Fourth Industrial Revolution

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Abstract: The relative distribution of power among the world's leading states has never been static. Since the eighteenth century, the international system has repeatedly undergone profound transformations marked by shifts in power among advanced nations.

The purpose of this article is to analyze the transformative role of emerging technologies and their implications for reshaping the global power structure, with a specific focus on the technological rivalry between China and the United States in the era of the Fourth Industrial Revolution. It seeks to address the central question of how the acquisition and diffusion of new technologies during successive industrial revolutions have influenced the redistribution of power among states.

This study assumes that technological innovation—by generating uneven patterns of industrial growth—has simultaneously accelerated economic development, enhanced the strategic capabilities of rising powers, and triggered major shifts in the international balance of power. The research employs a descriptive–explanatory method, and its findings demonstrate that technological innovation constitutes one of the most critical determinants of national power. Since the primary objective of states in every industrial revolution has been to secure frontier technologies in order to consolidate political and economic influence while curtailing the advancement of rivals, China's rapid technological ascent poses a significant challenge to the United States and threatens its dominant position within the international system.

Keywords: *Technological Innovation, China, United States, Fourth Industrial Revolution, Power Transition.*

Cite this Article

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Introduction

The history of international relations is characterized by continual transformations in the global system and the cyclical rise and decline of major powers. In such a context, the struggle to acquire and preserve sources of power has consistently remained one of the foremost objectives of states. The pursuit and expansion of power appear directly tied to the adoption of economic and technological strategies capable of maximizing wealth, influence, and survival.

Since the emergence of the first technological breakthroughs in the eighteenth century and the onset of the First Industrial Revolution, international trade has witnessed unprecedented growth. On the one hand, the increase in the quantity, quality, and variety of goods, and on the other, the reduction of reliance on manual labor, fostered human development, strengthened economies, and elevated living standards. Yet, the same process also widened disparities: while living standards rose significantly in some countries, others were left behind, burdened with persistently low per capita incomes.

These divergences were primarily the result of technological change. With the growing weight of international trade in the global economy, the intensification of capital flows, and the divergent performance of states in terms of trade and economic growth, technology became central to discussions of international competition. Thus, technological innovation has long stood at the heart of wealth creation and power accumulation, serving as a decisive factor in shaping great power rivalries and redefining the balance of power. Historically, leadership in the international system has been closely tied to mastery of frontier technologies, enabling one state to assume global preeminence while distinguishing itself from other major players. Consequently, relative stability within the great power system has repeatedly shifted in tandem with rotations in technological leadership.

Given the centrality of this dynamic, the present study employs the **Power Transition Theory** to analyze how access to new technologies reshapes the power curve of states within the international system. Specifically, it examines how successive

industrial revolutions have altered the global hierarchy of power. According to this framework, states occupy positions along a vertical scale of national capabilities, organized under the leadership of a hegemonic power (Yilmaz & Xiangyu, 2019: 322).

As Organski and Kugler argue, the United States currently occupies the apex of this hierarchy, having succeeded Great Britain as the dominant power. Beneath the hegemon stand the great powers—states that, while not yet capable of challenging the hegemon directly, possess the potential to do so in the future. Below them lie the middle powers, small powers, and former colonies (Kugler & Organski, 2011: 173). A view of this division can be seen in the figure below.

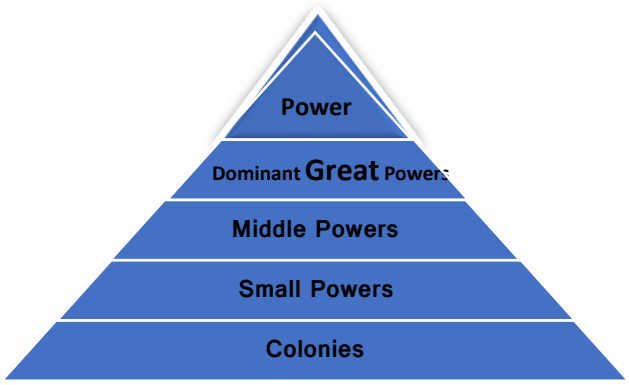

Figure (1): Power hierarchy in the power transmission network

In such a configuration, the hegemon shapes the international order, sets the rules of conduct, and manages interstate relations with the cooperation of satisfied great powers (DiCicco & Levy, 1999: 681).

However, not all states consent to the hegemon's leadership. Dissatisfied powers often perceive the distribution of benefits within the international order as unjust, believing their societies are deprived of rightful gains. In such conditions, technological progress and industrial growth within rising states generate internal transformations that directly influence interstate power relations. Thus, national power at the highest level has historically depended on industrial capacity, making industrial revolutions among the most decisive drivers of systemic change in the international order.

Research Background

Extensive literature has explored the relationship between power and technology in both English and Persian scholarship. Some of the most significant contributions are outlined below.

Daniel Drezner (2001), in *State Structure, Technological Leadership, and the Maintenance of Hegemony*, emphasizes the role of state structures in fostering innovation. He argues that decentralized state structures are a crucial condition for sustaining technological progress, noting that such conditions in Germany and Japan explain their technological dynamism compared to Britain and the United States. Similarly, Mark Zachary Taylor (2006), in *The Political Economy of Technological Innovation: A Shift in the Debate*, examines why some countries exhibit greater technological innovation than others. Contrary to the dominant view among political economists, Taylor contends that domestic institutions do not primarily determine national innovation rates. Instead, he highlights the importance of international linkages—such as capital goods imports, foreign direct investment, and educational exchanges—in shaping innovation outcomes.

Jeffrey Ding (2021), in *The Rise and Fall of Technologies and Great Powers*, offers an innovative explanation of how technological revolutions influence shifts in economic power. Drawing on the theory of multi-purpose technological diffusion, Ding argues that fundamental advances only enhance productivity when they diffuse broadly across multiple sectors rather than remaining concentrated in leading industries. This requires institutional adaptation and the expansion of engineering capabilities, offering a compelling framework for understanding the systemic impact of the three previous industrial revolutions (Steinsson, 2022: 56).

Britain's trajectory illustrates this dynamic. With the adoption of laissez-faire policies and the liberal order established through key reforms—such as the New Poor Law (1834), the Bank Act (1844), the repeal of the Corn Laws (1846), and the repeal of the Navigation Acts (1849) (Wolfe, 1981: 82)—Britain created conditions for its technological products to spread globally. To protect its competitive edge, Britain initially restricted the transfer of technology and skilled labor. Nevertheless, by the mid-nineteenth century, industrialization had diffused to European and Western states, including Belgium, France, Sweden, Germany, and the United States. By the early twentieth century, the United States had surpassed Britain as the leading industrial power (Mohajan, 2019: 14). Indicators such as per capita industrialization, GDP, and labor productivity confirm this transition, with Germany also significantly narrowing the gap (Ding, 2021: 10).

These developments marked a decisive shift in the global power curve. By 1914, the international distribution of technological leadership had moved far beyond Britain, reshaping productivity, real wages, and living standards. This transformation altered not only the geography of technological leadership but also the very nature of technological change itself, laying the foundations for subsequent innovations (Mokyr & Strotz, 1998: 14).

A similar transformation occurred in the final third of the twentieth century (1960–2000), when information technologies—including advances in computers and semiconductors—revolutionized industrial foundations and introduced an era of computer-based information systems (Ding, 2021: 25). Unlike earlier periods, this technological wave extended beyond Western powers to include developing and non-Western countries.

During this era, many states increasingly embraced liberal market mechanisms. For example, Maharaja notes that governments in this period became nearly ten times more market-oriented, aligning with capitalist practices to project stability and peace (Mossipasandi & Poladi, 2021: 201). Yet, trajectories diverged: Japan's technological rise was shaped by the agreements of 1986 and 1990, while China developed under a model of state capitalism and authoritarian governance, in stark contrast to the U.S. free-market model (Zhao, 2019: 382).

China's relationship with the liberal international order further highlights this complexity. While Beijing has sought to integrate into and influence economic and political-security institutions, its engagement with the normative and ideological dimensions of the post-Westphalian system—largely championed by the United States—remains fraught (Shariatini & Masoudi, 2019: 25–26). Consequently, China is widely regarded as an emerging yet dissatisfied power, whose technological ascent and contestation of the liberal order pose significant challenges to U.S. hegemony. Taken together, these studies and historical patterns strongly

suggest a direct relationship between technological change and shifts in the international power curve.

Industrial Revolutions

Allen (2009:199) demonstrates, initiated more than two centuries of sustained economic expansion, which in turn underpinned the unprecedented rise in income levels characteristic of advanced economies in the contemporary world.

This study posits that these technological and economic transformations constitute the principal determinants in reshaping the global distribution of power and recalibrating the hierarchical position of leading states.

Accordingly, this section provides a systematic examination of each industrial revolution, analyzing their defining technological breakthroughs, their economic ramifications, and their implications for the evolution of the international power structure.

The First Industrial Revolution

The First Industrial Revolution (1760–1840) was characterized by significant technological advances that transformed the international economic and power structure. This revolution encompassed four major sectors: the cotton textile industry, energy generation through new coal-based sources, the iron and steel industry, and transportation, particularly with the introduction of railways.

Prior to 1700, European textile industries primarily used linen and wool, and cotton was a costly, specialized material. Rapid technological developments, however, transformed production; by 1850, only countries such as the United States, which implemented protective tariffs, maintained viable textile industries (Clark, 2005). Britain pioneered the practical steam engine in 1705, with James Watt significantly enhancing Newcomen's design through inventions such as the double-acting mechanism and sun-and-planet gears. Despite its initial inefficiency—consuming 12 to 15 pounds of coal per horsepower per hour—subsequent improvements, including John Smith's water wheel, the water turbine, and high-pressure modifications to Watt's engine in the 1840s, enabled the mechanization of British industry on a large scale (Steinsson, 2022).

Technological transformations in iron and steel also accelerated. Abraham Darby's 1735 innovation of smelting iron using coal, followed by Anjouens (1763) and Cort (1785) independently developing the conversion of pig iron to steel, dramatically increased iron production and revolutionized the railway sector (Clark, 2005). These changes illustrate the technical interconnection between different sectors, where advancements in one area stimulated progress in others. While some inventions relied on European scientific discoveries, industrial engineering innovation primarily occurred in Britain, positioning it as the leader of the industrial era.

The Second Industrial Revolution, which followed, expanded these innovations and transformed long-term technological shifts (LTS) from rare occurrences into widespread practice (Mokyr and Strotz, 1998:3). By the 1870s, electricity's application had increased rapidly. Frank J. Sprague's development of the electric motor, electric railway, and elevator in 1886, alongside the electrification of trams and subways in major European cities by the 1880s, marked significant progress (Mohajan, 2019:12). Initially, electricity's primary application was not power transmission but

Since the advent of the First Industrial Revolution, humanity has undergone successive and increasingly complex waves of technological transformation, culminating in the current era of the Fourth Industrial Revolution. These successive revolutions, as

communication, exemplified by the telegraph and, later, the telephone. Alexander Graham Bell's telephone, enhanced through complementary inventions such as the keypad and coiled wire, became one of the most impactful inventions of the era, while the wireless telegraph reflected the reverse influence of science on technology (Mokyr and Strotz, 1998).

In the steel industry, Andrew Carnegie's establishment of mass-production steel mills in the United States fostered abundant steel output, fueling industrial growth during the Second Industrial Revolution (Mohajan, 2019:10). Concurrently, the United States experienced social and economic conditions that accelerated technological transformation, including the American production system, which assembled complex products from individual components, and the application of scientific principles to machine-shop management, giving rise to scientific management (Mokyr and Strotz, 1998; Jovens, 1931:2).

The Fourth Industrial Revolution is now driven by nanotechnology, biotechnology, information technology, 7D printing, artificial intelligence, and robotics (Mohajan, 2021:1). Japan's advancements in robotics, IT, and AI are particularly notable. The first modern Japanese robot, Gakuten-soku, was created in 1928 by biologist Makoto Nishimura. Standing 3.2 meters tall with a gold-plated upper body, it simulated desk work, facial expressions, and automated writing using a compressed air system (Alvarez Sanz, 2018:5). Japan's first robotics project in the 1970s, the Wabot Project at Waseda University, developed intelligent humanoid robots capable of object manipulation, communication, and sensory perception. Subsequent developments included Honda's humanoid robots in the 1990s and Sony's first pet robot in 1999, commercialized for domestic use in the U.S. and Japan (Alvarez Sanz, 2018).

Klaus Schwab emphasized that the Fourth Industrial Revolution will disseminate technologies faster and more broadly than previous revolutions, profoundly transforming the global economy and affecting macroeconomic variables such as GDP, investment, consumption, employment, trade, and inflation (Schwab, 2016). Its core framework involves the deep integration of information and network systems and widespread adoption of cyber-physical production systems (Li, Hou, & Yun, 2017:626). This revolution is central to contemporary great-power competition (Hammes & Euliis, 2020:105–106), as absolute and relative state development increasingly depends on the mastery of emerging technologies.

From a security perspective, advanced military technologies—such as nano-energy, AI, unmanned aerial vehicles, and 7D printing—are critical determinants of the global balance of power (Breitenbauch & Liebetrau, 2021:21; Hammes, 2018:52–53). China, for instance, has invested over $100 billion in this sector, prioritizing supply chain de-Americanization and leveraging technology to enhance national power (Grochmalski et al., 2020; Allen, 2023:3). Knowledge-intensive industries now form the basis of competitive advantage, with high-productivity resources driving national prosperity (Krugman, 1992:13; Haque, 1992).

The table below presents advanced technology exports of major powers from 2015 to 2022 (in billions of USD), illustrating the

centrality of technological capability in contemporary power dynamics.

Country	2015	2016	2017	2018	2019	2020	2021	2022
United States	174.24	173.92	154.55	153.81	153.92	141.54	169.22	166.44
China	652.21	594.52	654.16	731.32	715.3	757.46	942.31	769.7
Japan	98.25	99.1	106.18	110.74	103.9	102.75	116.51	83.1
Germany	199.43	205.08	195.25	209.72	208.15	182.35	209.74	223.37
United Kingdom	74.58	73.81	73.69	75.58	76.89	58.14	66.7	72.66

These developments have transformed industries globally, elevating Japan to a leading power and creating new challenges in U.S.–Japan relations. Similarly, during the Fourth Industrial Revolution, China has emerged as the United States' primary competitor, leveraging technological innovation to alter the international power curve. Although China engages with the existing liberal order to maximize benefits, its historical experiences and strategic ambitions drive efforts to achieve technological leadership, potentially reshaping the future international system and altering the nature of great-power competition.

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