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Introduction

IN JULY 2018, the BRICS nations (Brazil, Russia, India, China, and South Africa) convened in Johannesburg around a specific, noteworthy theme: "Collaboration for Inclusive Growth and Shared Prosperity in the Fourth Industrial Revolution." The theme was noteworthy in part because of its specificity. Previous iterations of the BRICS summit, which gathers five nations that account for about 40 percent of the world's population and 25 percent of the world's GDP,[1] had tackled fuzzy slogans such as "Stronger Partnership for a Brighter Future" and "Broad Vision, Shared Prosperity." What stood out not only about that year's theme but also in comments by BRICS leaders at the summit was an unambiguous conviction that the world was undergoing a momentous season of technological change—one warranting the title "Fourth Industrial Revolution."[2]

Throughout the gathering, leaders of these five major emerging economies declared that the ongoing technological transition represented a rare opportunity for accelerating economic growth. When Chinese president Xi Jinping addressed the four other leaders of major emerging economies, he laid out the historical stakes of that belief:

> From the mechanization of the first industrial revolution in the 18th century, to the electrification of the second industrial revolution in the 19th century, to the informatization of the third industrial revolution in the 20th century, rounds of disruptive technological innovation have . . . fundamentally changed the development trajectory of human history.[3]

1. Iqbal 2022.
2. Klaus Schwab (2017a), founder and executive chairman of the World Economic Forum, first popularized the term "Fourth Industrial Revolution."
3. Qiushi 2018, cited in Doshi 2021, 286.

Citing recent breakthroughs in cutting-edge technologies like artificial intelligence (AI), Xi proclaimed, "Today, we are experiencing a larger and deeper round of technological revolution and industrial transformation."[4]

While the BRICS summit did not explicitly address how the Fourth Industrial Revolution could reshape the international economic order, the implications of Xi's remarks loomed in the backdrop. In the following months, Chinese analysts and scholars expanded upon them, especially the connection he drew between technological disruption and global leadership transitions.[5] One commentary on Xi's speech, published on the website of the authoritative Chinese Communist Party publication *Study Times*, detailed the geopolitical consequences of past technological revolutions: "Britain seized the opportunity of the first industrial revolution and established a world-leading productivity advantage. . . . After the second industrial revolution, the United States seized the dominance of advanced productivity from Britain."[6] In his analysis of Xi's address, Professor Jin Canrong of Renmin University, an influential Chinese international relations scholar, argued that China has a better chance than the United States of winning the competition over the Fourth Industrial Revolution.[7]

This broad sketch of power transition by way of technological revolution also resonates with US policymakers and leading thinkers. In his first press conference after taking office, President Joe Biden underscored the need to "own the future" as it relates to competition in emerging technologies, pledging that China's goal to become "the most powerful country in the world" was "not going to happen on [his] watch."[8] In 2018, the US Congress stood up the National Security Commission on Artificial Intelligence (NSCAI), an influential body that convened leading government officials, technology experts, and social scientists to study the national security implications of AI. Comparing AI's possible impact to past technologies like electricity, the NSCAI's 756-page final report warned that the United States would soon lose its technological leadership to China if it did not adequately prepare for the "AI revolution."[9]

4. Ibid.

5. Xi's emphasis on a new round of scientific and technological revolution [新一轮科技革命] dates as far back as September 2013, when he presided over a collective study session of the Politburo (Huang 2018).

6. Li 2018, cited in Doshi 2021, 287.

7. Jin 2019, cited in Doshi 2021, 288.

8. The White House 2021.

9. National Security Commission on Artificial Intelligence 2021, 19–20.

Caught up in the latest technical advances coming out of Silicon Valley or Beijing's Zhongguancun, these sweeping narratives disregard the process by which emerging technologies can influence a power transition. How do technological revolutions affect the rise and fall of great powers? Is there a discernible pattern that characterizes how previous industrial revolutions shaped the global balance of power? If such a pattern exists, how would it inform our understanding of the Fourth Industrial Revolution and US-China technological competition?

Conventional Wisdom on Technology-Driven Power Transitions

International relations scholars have long observed the link between disruptive technological breakthroughs and the rise and fall of great powers.[10] At a general level, as Yale historian Paul Kennedy has established, this process involves "differentials in growth rates and technological change, leading to shifts in the global economic balances, which in turn gradually impinge upon the political and military balances."[11] Yet, as is the case with present-day speculation about the effects of new technologies on the US-China power balance, largely missing from the international relations literature is an explanation of *how* technological change creates the conditions for a great power to leapfrog its rival. Scholars have carefully scrutinized how shifts in economic balances affect global military power and political leadership, but there is a need for further investigation into the very first step of Kennedy's causal chain: the link between technological change and differentials in long-term growth rates among great powers.[12]

Among studies that do examine the mechanics of how technological change shapes economic power transitions, the standard explanation stresses dominance over critical technological innovations in new, fast-growing industries ("leading sectors"). Britain became the world's most productive economy, according to this logic, because it was home to new advances that transformed its burgeoning textile industry, such as James Hargreaves's spinning jenny. In the same vein, Germany's mastery of major breakthroughs in the chemical industry is seen as pivotal to its subsequent challenge to British

10. Gilpin 1981, 1987; Kennedy 1987; Modelski and Thompson 1996.
11. Kennedy 1987, xx.
12. Gilpin 1981; Kennedy 1987; Kirshner 1998.

economic leadership. Informed by historical analysis, the leading-sector (LS) perspective posits that, during major technological shifts, the global balance of economic power tips toward "the states which were the first to introduce the most important innovations."[13]

Why do the benefits of leading sectors accrue to certain countries? Explanations vary, but most stress the goodness-of-fit between a nation's domestic institutions and the demands of disruptive technologies. At a general level, some scholars argue that rising powers quickly adapt to new leading sectors because they are unburdened by the vested interests that have built up in more established powers.[14] Others point to more specific factors, including the degree of government centralization or sectoral governance arrangements.[15] Common to all these perspectives is a focus on the institutions that allow one country to first introduce major breakthroughs in an emerging industry. In the case of Britain's rise, for example, many influential histories highlight institutions that supported "heroic" inventors.[16] Likewise, accounts of Germany's success with leading sectors focus on its investments in scientific education and industrial research laboratories.[17]

The broad outlines of LS theory exert substantial influence in academic and policymaking circles. Field-defining texts, including works by Robert Gilpin and Paul Kennedy, use the LS model to map out the rise and fall of great powers.[18] In a review of international relations scholarship, Daniel Drezner summarizes their conclusions: "Historically, a great power has acquired hegemon status through a near-monopoly on innovation in leading sectors."[19]

The LS template also informs contemporary discussion of China's challenge to US technological leadership. In another speech about how China could leverage this new round of industrial revolution to become a "science and technology superpower," President Xi called for China to develop into "the world's primary center for science and high ground for innovation."[20] As US policymakers confront China's growing strength in emerging technologies

13. Akaev and Pantin 2014, 869; see also Modelski and Thompson 1996; Thompson 1990.
14. Gilpin 1996; Moe 2009.
15. Drezner 2001; Kim and Hart 2001; Kitschelt 1991.
16. Nuvolari 2004.
17. Drezner 2001; Moe 2007.
18. Gilpin 1981, 1987; Kennedy 1987; Modelski and Thompson 1996; Rostow 1960; Schumpeter 1934, 1939; Thompson 1990.
19. Drezner 2001, 7. Drezner (2019, 289) repeats this claim in an article marking the centenary of the international relations discipline.
20. Xi 2021. This speech was delivered at a joint meeting of the Chinese Academy of Sciences and the Chinese Academy of Engineering in May 2018.

like AI, they also frame the competition in terms of which country will be able to generate radical advances in new leading sectors.[21]

Who did it first? Which country innovated it first? Presented with technical breakthroughs that inspire astonishment, it is only natural to gravitate toward the moment of initial discovery. When today's leaders evoke past industrial revolutions, as Xi did in his speech to the BRICS nations, they tap into historical accounts of technological progress that also center the moment of innovation.[22] The economist and historian Nathan Rosenberg diagnoses the problem with these innovation-centric perspectives: "Much less attention . . . if any at all, has been accorded to the rate at which new technologies have been adopted and embedded in the productive process. Indeed the diffusion process has often been assumed out of existence."[23] Yet, without the humble undertaking of diffusion, even the most extraordinary advances will not matter.

Taking diffusion seriously leads to a different explanation for how technological revolutions affect the rise and fall of great powers. A diffusion-centric framework probes what comes after the hype. Less concerned with which state first introduced major innovations, it instead asks why some states were more successful at adapting and embracing new technologies at scale. As outlined in the next section, this alternative pathway points toward a different set of institutional factors that underpin leadership in times of technological leadership, in particular institutions that widen the base of engineering skills and knowledge linked to foundational technologies.

GPT Diffusion Theory

In September 2020, the *Guardian* published an opinion piece arguing that humans should not fear new breakthroughs in AI. Noting that "Stephen Hawking has warned that AI could 'spell the end of the human race,'" the article's "author" contends that "I am here to convince you not to worry. Artificial intelligence will not destroy humans. Believe me."[24] If one came away from this piece with the feeling that the author had a rose-tinted view of the future of AI, it would be a perfectly reasonable judgment. After all, the author was GPT-3, an AI model that can understand and produce humanlike text.

21. Allison and Schmidt 2020; National Security Commission on Artificial Intelligence 2021; Tellis 2013.

22. Edgerton 2010, 2011.

23. Rosenberg 1982, 19.

24. GPT-3 2020.

Released earlier that year by OpenAI, a San Francisco–based AI lab, GPT-3 surprised everyone—including its designers—with its versatility. In addition to generating poetry and essays like the *Guardian* op-ed from scratch, early users demonstrated GPT-3's impressive capabilities in writing code, translating languages, and building chatbots.[25] Six months after its launch, one compilation listed sixty-six unique use cases of GPT-3, which ranged from automatically updating spreadsheets to generating website landing pages.[26] Two years later, OpenAI's acclaimed ChatGPT model, built on an improved version of GPT-3, would set the internet aflame with its wide-ranging capabilities.[27]

While the name "GPT-3" derives from a class of language models known as "generative pre-trained transformers," the abbreviation, coincidentally, also speaks to the broader significance of recent breakthroughs in AI: the possible arrival of the next general-purpose technology (GPT). Foundational breakthroughs in the ability of computers to perform tasks that usually require human intelligence have the potential to transform countless industries. Hence, scholars and policymakers often compare advances in AI to electricity, the prototypical GPT.[28] As Kevin Kelly, the former editor of *WIRED*, once put it, "Everything that we formerly electrified we will now cognitize . . . business plans of the next 10,000 startups are easy to forecast: Take X and add AI."[29]

In this book, I argue that patterns in how GPTs diffuse throughout the economy illuminate a novel explanation for how and when technological changes affect power transitions. The emergence of GPTs—fundamental advances that can transform many application sectors—provides an opening for major shifts in economic leadership. Characterized by their scope for continuous improvement, pervasive applicability across the economy, and synergies with other technological advances, GPTs carry an immense potential for boosting productivity.[30] Carefully tracking how the various applications of GPTs are adopted across various industries, a process I refer to

25. To the best of my knowledge—and believe me, I have searched far and wide—AI models have not yet figured out how to write original academic books.

26. Dickson 2021. There are also concerns about the use of language models like GPT-3 to generate toxic speech and misinformation; see Kreps, McCain, and Brundage 2022.

27. Hu 2023.

28. A Google search for the exact phrase "AI is the new electricity," conducted on November 18, 2022, returned over sixteen thousand hits. Andrew Ng, founder of Google Brain, first popularized this comparison in a 2017 speech at Stanford.

29. Kelly 2014.

30. Bresnahan 2010; Bresnahan and Trajtenberg 1995; Lipsey, Carlaw, and Bekar 2005.

as "GPT diffusion," is essential to understanding how technological revolutions disrupt economic power balances.

Based on the experience of past GPTs, this potential productivity boost comes with one notable caveat: the full impact of a GPT manifests only after a gradual process of diffusion into pervasive use.[31] GPTs demand structural changes across a range of technology systems, which involve complementary innovations, organizational adaptations, and workforce adjustments.[32] For example, electrification's boost to productivity materialized about five decades after the introduction of the first electric dynamo, occurring only after factories had restructured their layouts and there had been interrelated breakthroughs in steam turbines.[33] Fittingly, after the release of GPT-3, OpenAI CEO Sam Altman alluded to this extended trajectory: "The GPT-3 hype is way too much . . . it still has serious weaknesses and sometimes makes very silly mistakes. AI is going to change the world, but GPT-3 is just a very early glimpse. We have a lot still to figure out."[34]

Informed by historical patterns of GPT diffusion, my explanation for technology-driven power transitions diverges significantly from the standard LS account. Specifically, these two causal mechanisms differ along three key dimensions, which relate to the technological revolution's impact timeframe, phase of relative advantage, and breadth of growth. First, while the GPT mechanism involves a protracted gestation period between a GPT's emergence and resulting productivity boosts, the LS mechanism assumes that there is only a brief window during which countries can capture profits in leading sectors. "The greatest marginal stimulation to growth may therefore come early in the sector's development at the time when the sector itself is expanding rapidly," William Thompson reasons.[35] By contrast, the most pronounced effects on growth arrive late in a GPT's development.

Second, the GPT and LS mechanisms also assign disparate weights to innovation and diffusion. Technological change involves a phase when the technology is first incubated as a viable commercial application ("innovation") and a phase when the innovation permeates across a population of potential users

31. David 1990, 356.

32. Brynjolfsson, Rock, and Syverson 2017; David 1990.

33. Devine 1982.

34. Vincent 2020. Many also noted that some of the most impressive examples were cherry-picked, and that GPT-3 still requires a lot of fine-tuning from humans. For more background on GPT-3, see Dale 2021.

35. Thompson 1990, 211; see also Freeman, Clark, and Soete 1982, 80; Gilpin 1987, 112.

("diffusion"). The LS mechanism is primarily concerned about which country dominates innovation in leading sectors, capturing the accompanying monopoly profits.[36] Under the GPT mechanism, successful adaptation to technological revolutions is less about being the first to introduce major innovations and more about effectively adopting GPTs across a wide range of economic sectors.

Third, regarding the breadth of technological transformation and economic growth, the LS mechanism focuses on the contributions of a limited number of leading sectors and new industries to economic growth in a particular period.[37] In contrast, GPT-fueled productivity growth is spread across a broad range of industries.[38] Dispersed productivity increases from many industries and sectors come from the extension and generalization of localized advances in GPTs.[39] Thus, the LS mechanism expects the breadth of growth in a particular period to be concentrated in leading sectors, whereas the GPT mechanism expects technological complementarities to be dispersed across many sectors.

A clearer understanding of the contours of technological change in times of economic power transition informs which institutional variables matter most. If the LS trajectory holds, then the most important institutional endowments and responses are those that support a monopoly on innovation in leading sectors. In the context of skill formation, institutional competencies in science and basic research gain priority. For instance, the conventional explanation of Germany's industrial rise in the late nineteenth century attributes its technological leadership to investments in industrial research labs and highly skilled chemists. These supported Germany's dominance of the chemical industry, a key LS of the period.[40]

The impact pathway of GPTs brings another set of institutional complementarities to the fore. GPT diffusion theory highlights the importance of "GPT skill infrastructure": education and training systems that widen the pool of engineering skills and knowledge linked to a GPT. When widespread adoption of GPTs is the priority, it is ordinary engineers, not heroic inventors, who matter most. Widening the base of engineering skills associated with a GPT cultivates a more interconnected technological system, spurring cross-

36. Modelski and Thompson 1996, 91.
37. Grübler 2003, 118.
38. See Harberger (1988) for the original formulation of these two views of long-term economic growth.
39. Crafts 2001, 306; David and Wright 1999, 12.
40. Drezner 2001, 13–18; Moe 2007, 253–66; Thompson 1990.

fertilization between institutions optimized for applied technology and those oriented toward foundational research.[41]

Returning to the example of late-nineteenth-century advances in chemicals, GPT diffusion spotlights institutional adjustments that differ from those of the LS mechanism. In a decades-long process, innovations in chemical engineering practices gradually enabled the chemicalization of procedures common to many industries beyond synthetic dyes, which was controlled by Germany. Despite trailing Germany in the capacity to produce elite chemists and frontier chemical research, the United States was more effective at adapting to chemicalization because it first institutionalized the discipline of chemical engineering.[42]

Of course, since GPT diffusion depends on factors aside from human capital, GPT skill infrastructure represents one of many institutional forces at work. Standards-setting organizations, financing bodies, and the competitiveness of markets can all influence the flow of information between the GPT domain and application sectors.[43] Since institutions of skill formation produce impacts that spill over into and complement other institutional arrangements, they comprise the focus of my analysis.[44]

Assessing GPT Diffusion across Industrial Revolutions

To test this argument, I employ a mixed-methods approach that pairs qualitative historical analysis with quantitative methods. Historical case studies permit me to thoroughly trace the interactions between technologies and institutions among great powers in previous industrial revolutions. I then explore the generalizability of GPT diffusion theory beyond the chosen set of great powers. Using data on nineteen countries from 1995 to 2020, I analyze the theorized connection between GPT skill infrastructure in software engineering and computerization rates.

To investigate the causal processes that connect technological changes to economic power transitions, I set the LS mechanism against the GPT diffusion mechanism across three historical case studies: Britain's rise to preeminence in the First Industrial Revolution (IR-1); America's and Germany's

41. Shapley and Roy 1985.

42. Rosenberg and Steinmueller 2013.

43. Timothy Bresnahan and Manuel Trajtenberg (1995) argue that these coordination mechanisms help unleash positive externalities associated with GPT trajectories. See also Rosenberg 1998b; Vona and Consoli 2014.

44. Thelen 2004, 285–86.

overtaking of Britain in the Second Industrial Revolution (IR-2); and Japan's challenge to America's technological dominance in the Third Industrial Revolution (IR-3), or what is sometimes called the "information revolution." This case setup allows for a fair and decisive assessment of the explanatory relevance of GPT diffusion theory in comparison to LS theory. Because the IR-1 and IR-2 function as typical cases where the cause and outcome are clearly present, they are ideal for developing and testing mechanism-based theories.[45] The IR-3, a deviant case in that a technological revolution is not followed by an economic power transition, provides a different but still useful way to compare the two mechanisms.

The IR-1 (1780–1840) is a paradigmatic case of technology-driven power transition. It is well established that the IR-1's technological advances propelled Great Britain to unrivaled economic supremacy. As for the specific causal pathway, international relations scholarship tends to attribute Britain's rise to its monopoly over innovation in cotton textiles and other leading sectors. According to these accounts, Britain's technological leadership in the IR-1 sprang from its institutional capacity to nurture genius inventors in these sectors. Since the publication of these field-defining works, economic and technology historians have uncovered that the impacts on British industrialization of the two most prominent areas of technological change, cotton textiles and iron, followed different trajectories. Often relying on formal econometric methods to understand the impact of key technologies, these historical accounts question the prevailing narrative of the IR-1.

The IR-2 (1870–1914) supplies another opportunity to pit GPT diffusion theory against the LS account. International relations scholars interpret the IR-2 as a case in which Britain's rivals challenged its economic leadership because they first introduced significant technological advances in leading sectors. Particular emphasis is placed on Germany's ability to corner market shares in chemicals, which is linked to its strengths in scientific education and industrial research institutions. More granular data on cross-national differences in engineering education suggest that the U.S. technological advantage rested on the country's wide base of mechanical engineers. Combined with detailed tracing of the pace and extent of technology adoption during this period, this chapter's evidence suggests modifications to conventional understandings of the IR-2.

45. Beach and Pedersen 2019, 97–98; Goertz 2017.

In the IR-3 (1960–2000), fundamental breakthroughs in information and communication technologies presented another opening for a shift in economic leadership. During this period, prominent thinkers warned that Japan's lead in industries experiencing rapid technological change, including semiconductors and consumer electronics, would threaten U.S. economic leadership. Influential scholars and policymakers advocated for the United States to adopt Japan's *keiretsu* system of industrial organization and its aggressive industrial policy approach. Ultimately, Japan's productivity growth stalled in the 1990s. Given the absence of an economic power transition, the primary function of the IR-3 case therefore is to provide disconfirming evidence of the two explanations. If the components of the LS mechanism were present, then the fact that an economic power transition did not occur would damage the credibility of the LS mechanism. The same condition applies to GPT diffusion theory.

In each of the cases, I follow the same standardized procedures. First, I test three pairs of competing propositions about the key technological trajectories, derived from the different expectations of the LS and GPT mechanisms related to the impact timeframe, phase of relative advantage, and breadth of growth. Then, depending on whether the LS or GPT trajectory better accords with the historical evidence, I analyze the goodness-of-fit between the institutional competencies of leading industrial powers and the prevailing trajectory. For instance, if an industrial revolution is better characterized by the GPT trajectory, then the corresponding case analysis should show that differences in GPT skill infrastructure determine which powers rise and fall. Although I primarily distinguish GPT diffusion theory from the LS model, I also examine alternative factors unique to the particular case, as well as two other prominent explanations of how advanced economies differentially benefit from technological changes (the varieties of capitalism and threat-based approaches).

The historical case analysis supports the explanatory power of the GPT mechanism over the LS mechanism. In all three periods, technological changes affected the rise and fall of great powers in a gradual, decades-long impact pathway that advantaged those that effectively diffused GPTs across a broad range of sectors. Education and training systems that cultivated broad pools of engineering skills proved crucial to GPT diffusion.

Evaluating these two competing explanations requires a clear understanding of the cause and outcome that bracket both the GPT and LS mechanisms. The hypothesized cause is a "technological revolution," or a period characterized by particularly disruptive technological advances.[46] Since the shape of technological change is uneven, not all improvements in useful knowledge are relevant for power transitions.[47] However, some extraordinary clusters of technological breakthroughs, often deemed industrial revolutions by historians, do have ramifications for the rise and fall of great powers.[48] I am primarily interested in the pathway by which these technological revolutions influence the global distribution of power.

The outcome variable of interest is an economic power transition, in which one great power sustains productivity growth at higher levels than its rivals. The balance of power can shift in many ways; here I focus on relative economic growth rates because they are catalysts for intensifying hegemonic rivalries.[49] Productivity growth, in particular, determines economic growth over the long run. Unique in its fungibility with other forms of power, sustained economic growth is central to a state's ability to exert political and military influence. As demonstrated by the outcomes of interstate conflicts between great powers, economic and productive capacity is the foundation of military power.[50]

Lastly, the quantitative analysis supplements the historical case studies by scrutinizing the generalizability of GPT diffusion theory outside of great powers. A key observable implication of my argument is that the rate at which a GPT spreads throughout the economy owes much to that country's institutional capacity to widen the pool of pertinent engineering skills and knowledge. Using a novel method to estimate the breadth of software engineering education at a cross-national level, I analyze the theorized connection between GPT skill infrastructure and computerization rates across nineteen advanced and emerging economies from 1995 to 2020. I supplement my time-series cross-sectional models with a duration analysis and cross-sectional regressions. Robust to many alternative specifications, my results show that, at least for computing technology, advanced economies that have higher levels of GPT skill infrastructure preside over higher rates of GPT diffusion.

46. Other related terms include "technology waves" (Milner and Solstad 2021) and "long waves" (Goldstein 1988).

47. Technology includes both physical manifestations of hardware and blueprints as well as improvements in organizational and managerial practices (Rosenberg 1982).

48. Von Tunzelmann 1997, 2. Though this analytic categorization of industrial revolutions is contested (see, for example, Hull 1996), these periods of technological change also correspond to cases used to support the LS explanation, so they are workable constructs for testing GPT diffusion theory against the standard account.

49. Kennedy 1987; Kim and Morrow 1992; Kugler and Lemke 1996; Väyrynen 1983.

50. Kirshner 1998; Modelski and Thompson 1996.

Key Contributions

The book makes several contributions to scholarship on power transitions and the effects of technological change on international politics. First, it puts forward a novel explanation for how and when significant technological breakthroughs generate a power transition in the international system. GPT diffusion theory revises the dominant theory based on leading sectors, which holds significant sway over academic and policymaking circles. By deepening our understanding of how technological revolutions influence shifts in economic leadership, this book also contributes to long-standing debates about the causes of power transitions.[51]

Second, the findings of this book bear directly on present-day technological competition between the United States and China. Emphasizing where fundamental breakthroughs are first seeded, the LS template strongly informs not only assessments of the US-China competition for technological leadership but also the ways in which leading policymakers in both countries formulate technology strategies. It is no coincidence that the three cases in this study match the three technological revolutions referenced by Chinese president Xi in his speech on the IR-4 to the BRICS summit.

As chapter 7 explores in detail, GPT diffusion theory suggests that Xi, along with other leading policymakers and thinkers in both the United States and China, has learned the wrong lessons from previous industrial revolutions. If the IR-4 reshapes the economic power balance, the impact will materialize through a protracted period during which a GPT, such as AI, acquires a variety of uses in a wide range of productive processes. GPT skill infrastructure, not the flashy efforts to secure the high ground in innovation, will decide which nation owns the future in the IR-4.

Beyond power transitions, *Technology and the Rise of Great Powers* serves as a template for studying the politics of emerging technologies. An enduring dilemma is that scholars either assign too much weight to technological change or underestimate the effects of new technologies.[52] Approaches that emphasize the social shaping of technology neglect that not all technologies are created equal, whereas technologically deterministic approaches discount the influence of political factors on technological development. By first distinguishing GPTs, together with their pattern of diffusion, from other technologies and technological trajectories, and then showing how social and political

51. Ogburn 1949a.
52. Sprout 1963, 187.

factors shape the pace and direction of GPT diffusion, my approach demonstrates a middle way forward.

Roadmap for the Book

The book proceeds as follows. Chapter 2 fleshes out the key differences between GPT diffusion theory and the LS-based account, as well as the case analysis procedures and selection strategy that allow me to systematically evaluate these two causal mechanisms. The bulk of the evidence follows in three case studies that trace how technological progress affected economic power transitions in the First, Second, and Third Industrial Revolutions.

The first two case studies, the IR-1 and IR-2, show that a gap in the adoption of GPTs, as opposed to monopoly profits from dominating LS innovations, was the crucial driver of an economic power transition. In both cases, the country that outpaced its industrial rivals made institutional adjustments to cultivate engineering skills related to the key GPT of the period. The IR-1 case, discussed in chapter 3, reveals that Britain was the most successful in fostering a wide pool of machinists who enabled the widespread diffusion of advances in iron machinery. In considering the IR-2 case, chapter 4 highlights how the United States surpassed Britain as the preeminent economic power by fostering a wide base of mechanical engineering talent to spread interchangeable manufacturing methods.

The IR-3 case, presented in chapter 5, demonstrates that technological revolutions do not necessarily always produce an economic power transition. The fact that Japan did not overtake the United States as the economic leader would provide disconfirming evidence of both the LS and GPT mechanisms, if the components of these mechanisms were present. In the case of the LS mechanism, Japan did dominate innovations in the IR-3's leading sectors, including consumer electronics and semiconductor components. In contrast, the IR-3 does not discredit the GPT mechanism because Japan did not lead the United States in the diffusion of information and communications technology across a wide variety of economic sectors.

Chapter 6 uses large-*n* quantitative analysis to explore how GPT diffusion applies beyond great powers. Chapter 7 applies the GPT diffusion framework to the implications of modern technological breakthroughs for the US-China power balance. Focusing on AI technology as the next GPT that could transform the international balance of power, I explore the extent to which my findings generalize to the contemporary US-China case. I conclude in chapter 8 by underscoring the broader ramifications of the book.

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