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BOOK REVIEW ROUNDTABLE

Jeffrey Ding's

Technology and the Rise of Great Powers: How Diffusion Shapes Economic Competition

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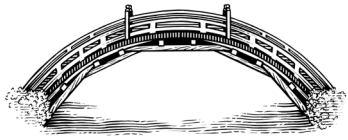

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Jeffrey Ding

An Apolitical Theory of Great-Power Transitions

Daniel W. Drezner

The 21st century has been a boom time for power transition theorists. International relations scholars and policy analysts have been debating whether and when China will overtake the United States in relative economic power since the 2008 financial crisis, producing a confusing mélange of predictions ranging from persistent U.S. hegemony to a new Pax Sinica. One source of this heterogeneity of perspectives has been the lack of clarity over which economic sector will prove crucial to determining the future distribution of power. For some, China's domination of green technology presages its economic rise.[1] For others, persistent U.S. strengths in semiconductor chip design and quantum computing mean not much will change.[2]

Who is right? Jeffrey Ding provides a provocative albeit unsatisfying answer. In *Technology and the Rise of Great Powers: How Diffusion Shapes Economic Competition*, Ding argues that scholars are asking the wrong question about power transitions. Economic historians and power transition theorists have focused excessively on national innovation rates in "leading sectors"—textiles and steam engines during the First Industrial Revolution, electricity and chemicals during the Second Industrial Revolution, and so forth. Instead, Ding argues that the crucial question is not the location of invention but the rapidity of diffusion. Power transitions occur when a national economy is able to adopt and employ a new general-purpose technology (GPT) more quickly than any other economy. A GPT is an innovation like electricity that has so many uses that it transforms most sectors of the national economy. When a rising power can exploit a GPT across the entire economy, overall productivity and per capita growth surge and a power transition is more likely. For Ding's analysis, this means that the

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1 See, for example, Amy Myers Jaffe, "Green Giant: Renewable Energy and Chinese Power," *Foreign Affairs*, March/April 2018, 83–93; and Kevin Honglin Zhang, "Geoeconomics of U.S.-China Tech Rivalry and Industrial Policy," *Asia and the Global Economy* 4, no. 2 (2024): 100098.

2 See, for example, Stephen G. Brooks and William C. Wohlforth, "The Once and Future Superpower: Why China Won't Overtake the United States," *Foreign Affairs*, May/June 2016, 91; and Stephen G. Brooks and William C. Wohlforth, "The Myth of Multipolarity: American Power's Staying Power," *Foreign Affairs*, April 18, 2023, 76.

crucial metric to determine when a power transition occurs is not whether a national economy dominates a leading sector but whether an economy has institutions flexible enough to diffuse innovations across most sectors.

To substantiate this thesis, Ding examines the three prior industrial revolutions as well as the current moment. Great Britain did well during the First Industrial Revolution because the country's trade associations were able to support a large class of mechanical and civil engineers and connect them with both scientists and entrepreneurs. This enabled the rapid spread of mechanization and the factory system in England. Similarly, when the United States supplanted the United Kingdom during the Second Industrial Revolution, it was not because of the United States' mastery of innovation in leading sectors such as chemicals. Ding argues that it was the American system of manufactures, combined with the unsexy but vital diffusion of machine tools, that led to the U.S. productivity burst in the late nineteenth century. The book also explores the deviant case of the Japan-U.S. economic rivalry of the 1980s. While Japanese firms dominated leading sectors in consumer electronics, Ding shows how computer technology diffused more widely and more quickly across the U.S. economy, thereby enabling the productivity boom of the 1990s.

Ding is persuasive in arguing that the extant literature has focused too much on leading sectors and not enough on GPTs. The book marshals both quantitative and qualitative evidence to bolster this thesis. He then applies his argument to the current moment and the contestation between the United States and the People's Republic of China over artificial intelligence (AI). Contrary to the claims of the Graham Allisons and Eric Schmidts of the world,[3] Ding concludes that, "at present, the United States is better positioned to develop the skill infrastructure suitable for AI" (p. 197). This is because the United States is better poised to have computer scientists and AI specialists spread throughout its economy—as opposed to China's obsession with leading sectors. For that prediction alone, *Technology and the Rise of Great Powers* has something of note to say about the current great-power debates.

Of course, Ding's argument hinges on whether AI really is the next GPT. In a comment at the start of chapter 7 on the United States, China, and AI, Ding acknowledges "the speculative nature of technological forecasting" (p. 180). This highlights some issues with his thesis. The most

[3] Graham Allison and Eric Schmidt, "Is China Beating the U.S. to AI Supremacy?" Harvard Kennedy School, Belfer Center for Science and International Affairs, August 2020 ~ https://www.belfercenter.org/publication/china-beating-us-ai-supremacy.

obvious problem is that it is purely retrospective in its utility. Saying that GPTs matter more for power transitions than leading sectors is all well and good, but without any *ex ante* ability to identify *which* technologies might be general purpose, it is a distinction without a difference. One could argue that Ding's argument implies focusing on institutions and structures that would ensure the rapid diffusion of a new innovation across the entire economy. Ding abstains from such analyses, however, "due to practical constraints of time and space" (p. 81). Without such indicators it becomes difficult to craft any useful policies. If, for example, green technologies wind up being more widespread in use than AI, the diffusion institutions would likely differ. Ding's argument helps explain the past but is of limited use in thinking about the present and the future.

A related problem is that a crucial element of Ding's causal story is the long time lag between the development of a GPT and its suffusion throughout the rest of the economy: "the GPT mechanism involves a protracted gestation period between a GPT's emergence and resulting productivity boosts" (p. 7). Such a lag is not terrifically surprising; economists such as Zvi Griliches have previously argued that it can take a generation for a new technology to be optimized in any particular sector.[4] Robert Solow famously said, "You can see the computer age everywhere but in the productivity statistics," just before the boom of the 1990s when the effects of computerization finally became visible in the productivity statistics.[5]

The problem is not whether such a lag exists—Ding is persuasive in demonstrating its plausibility. The problem is that this poses a considerable quandary for policymakers and analysts alike. If Ding's thesis is correct, then power transitions are set in motion decades before they actually occur. Such a long-term perspective is beyond the political incentives of even the most far-sighted policymakers. Much of the grand strategy literature is devoted to the maintenance of hegemony and the forestalling of power transitions. If Ding's argument is correct, even the best grand strategy is for naught if another country moves down the technology diffusion curve more quickly.

This leads to a final weakness of the book. While its argument is persuasive, it is also devoid of politics. There are no choice variables or

4 Zvi Griliches, "Hybrid Corn: An Exploration in the Economics of Technological Change," *Econometrica* 25, no. 4 (1957): 501–22.

5 Robert Solow, "We'd Better Watch Out," *New York Times Book Review*, July 12, 1987, 36.

policy trade-offs in *Technology and the Rise of Great Powers*. States that fail to have GPTs diffuse across their economy will lose out to economies that experience such diffusion. Ding is mostly silent, however, about the trade-offs of such a facilitation and the political economy of innovation and diffusion more generally. Even the productivity burst created from GPT adoption will create political winners and losers. Indeed, the current debate over the utility of general AI highlights how, in the present moment, the value-add of diffusion remains unclear.

Technology and the Rise of Great Powers will be useful for policymakers as they contemplate the economics of a power transition in the coming decades. When it comes to developing politics and strategy for such a transition, however, policymakers will have to look elsewhere. ◈

Why Diffusion Wins (Sometimes)

Xinyue Wei and Etel Solingen

The relationship between technology and power remains one of the most enduring themes in international political economy. Technological innovation has underpinned the rise of great powers, especially when it has been accompanied by scaling and application across broader swaths of the economy. In *Technology and the Rise of Great Powers: How Diffusion Shapes Economic Competition*, Jeffrey Ding reframes the debate over the role of technology in economic power transitions: it is not about who invents first, but who diffuses best. The diffusion of general-purpose technologies (GPTs)—technologies distinguished by their scope for continual improvement, broad applicability, and synergies with other technological advances (p. 16)—is, according to Ding, the true driver of long-term competitive advantage. Drawing on a blend of historical and quantitative evidence, Ding's GPT diffusion theory hinges on states' capacity to spread technology across sectors as key to explaining cross-national variation in their economic ascendance. From the steam engine to electricity to artificial intelligence (AI), states that scaled and embedded these technologies most effectively in their economies enjoyed long-term advantages, even if they were not GPT pioneers.

Ding pits his theory against an established "leading sector" approach whereby a state's dominance of key emerging industrial sectors is regarded as the holy grail for overtaking others in the global hierarchy. Accordingly, monopoly-like advantages in breakthrough sectors enable states to translate innovation into hegemony aspirations. Germany's rise in the late 19th century through the dominance of chemical industries is considered a paradigmatic case. Ding, however, argues that this conventional wisdom should be revised. Though Germany's star scientists and inventors shone brightly, it was the United States that ultimately secured a strategic advantage by scaling up basic chemical processes across many industries. Ding proposes instead that successful economy-wide diffusion and integration of GPTs is the deeper source of durable economic leadership.

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The diffusion argument is not necessarily novel.[1] Albert Hirschman, for instance, emphasized investments in industries with strong backward and forward linkages to the broader economy (external economies) as conduits to technological diffusion (spillovers).[2] Yet Ding provides a novel framework on the "GPT-skills-infrastructure" triad that enables diffusion not only through physical (capital) goods but also through the engineering knowledge of the 21st century. Flexible and inclusive education and training systems yield both a small cohort of world-class technologists and a broader base capable of applying, improving on, and integrating GPTs widely. This is how, in Ding's view, the United States outpaced Japan in information and communications technology (ICT) innovations.

While this framework helpfully redirects focus toward the institutional foundations of GPT diffusion, it also invites further refinement. One might wish for more conceptual clarity in the book regarding the precise institutional configurations that distinguish effective from ineffective GPT-skills-infrastructure triads *a priori* rather than via *post hoc* inferences from actual outcomes. Rather than asserting success because diffusion happened, a more generative framework might hypothesize the precise institutional mechanisms that proactively incentivize curriculum reform, attract and retain skilled instructors, and foster coordination between universities and industry.

A major empirical strength lies in the book's mixed-methods design. Historical chapters on the three industrial revolutions provide a rich, very readable foundation for theory-building. Ding is especially meticulous in addressing competing or alternative explanations. One might argue that countries achieving early monopolies are also more likely to diffuse GPTs widely. The case of Japan (chapter 5), where GPT diffusion remained limited, offers a crucial point of differentiation. Despite Japan's dominance in innovations across key sectors during the Third Industrial Revolution—an outcome that, according to leading-sector theory, should have precipitated a shift in economic leadership—the expected power transition did not materialize. This case offers strong support for the diffusion mechanism over the leading-sector mechanism. More broadly, this practice exemplifies the analytical utility of negative cases, in which theoretically anticipated

1 Joseph A. Schumpeter, *Capitalism, Socialism and Democracy* (New York: Harper and Brothers, 1942); Carlota Perez, *Technological Revolutions and Financial Capital: The Dynamics of Bubbles and Golden Ages* (Northampton: Edward Elgar, 2002); and Nathan Rosenberg, *Inside the Black Box: Technology and Economics* (New York: Cambridge University Press, 1982).

2 Albert O. Hirschman, *The Strategy of Economic Development* (New Haven: Yale University Press, 1958).

outcomes fail to materialize, and reminds us that the absence of expected patterns can be as theoretically instructive as their presence and no less deserving of sustained scholarly engagement. The final empirical chapter—on the software engineering skill infrastructure and computerization (chapter 6)—extends the analysis from great powers to a broader cross-national sample. While the historical case analysis establishes the internal validity of the GPT diffusion theory, the large-*n* quantitative analysis assesses its generalizability across a wider range of countries.

Chapter 7 examines U.S.-China competition in AI through the lens of GPT diffusion. Moving beyond the leading-sector framework, which emphasizes China's rising innovation indicators such as R&D expenditures, scientific publications, and patent counts (p. 191), Ding instead underscores the persistent gap between the United States and China in areas such as software engineering infrastructure, enterprise-level adoption, and ICT absorption. He provocatively calls for rethinking national AI strategies: countries should focus less on headline innovation metrics and more on investing in skills, institutions, and infrastructure that enable broad-based diffusion.

The historical chapters capture the process of domestic diffusion well. Yet, the framework could be enriched by taking non-diffusion and, in particular, political firewalls against diffusion into account more explicitly.[3] A timely example are the efforts by the Trump administration and the U.S. Congress to block the creation and commercialization of renewable energy and ancillary sectors with GPT potential. Beyond the important role of firewalls, given so much contingency regarding diffusion, are there threshold effects? Is diffusion a matter of scale or sequence? Can GPTs always be identified successfully a priori? Crucially, can agency overcome structural firewalls? After all, technological advantage is often the product of intentional policies aiming broader than at just the economy.

This leads to another important consideration: can diffusion be understood in isolation from the broader international system? The book's primary focus on domestic institutions may undervalue the fact that a global context shaped by hierarchy, dependence, and strategic interaction undergirds power transitions. Further work on this topic might include a more explicit engagement with the ways in which characteristics of

[3] Etel Solingen, "Of Dominoes and Firewalls: The Domestic, Regional, and Global Politics of International Diffusion," *International Studies Quarterly* 56, no. 4 (2012): 631–44; and Daron Acemoglu, "Institutions, Technology and Prosperity," Massachusetts Institute of Technology, January 25, 2025 ~ https://economics.mit.edu/sites/default/files/2025-01/Institutions%2C%20Technology%20and%20Prosperity.pdf.

the international system may condition, but not determine, national trajectories, opening up many potential research questions. Could dependencies on foreign platforms, standards, or ecosystems introduce structural bottlenecks? When and why are technological dependencies created or constructed? When and why would hegemons readily acquiesce with diffusing technology, as the United States has done vis-a-vis China for several decades? What role does bargaining for technology play in such processes?[4] How do trade regimes, evolving transnational supply chains, or standard-setting bodies shape the scope and timing of diffusion? Which international mechanisms are associated with diffusion success? Which facilitate learning and domestic sedimentation of innovation?

As economic competition is increasingly mediated through transnational value chains, understanding how technological capabilities circulate—often asymmetrically—through firms, subcontractors, and regulatory regimes becomes essential. A state's ability to harness GPTs is no longer confined to national borders but is embedded in complex interdependencies shaped by global sourcing, knowledge transfers, and standard setting. Recent disruptions in East Asia's semiconductor supply chains underscore how geopolitical rivalries intersect with logistical chokepoints and technological dependencies.[5] There is a growing literature focused on how states navigate, resist, or leverage global interdependencies to foster domestic diffusion.

Some of the lingering questions turn technological diffusion into the thing to be explained and raise issues of necessity and sufficiency. Is technology destiny? After all, not all top diffusers invariably become geopolitical hegemons. Is technology a necessary but insufficient condition for hegemony? Are regime types (democracy versus autocracy) relevant to steering top diffusers into successful hegemony? Do different regimes respond differently to technological opportunities? Does technological diffusion follow rather than drive geopolitical ambitions? Are wars key precursors of technological diffusion? Is AI *sui generis* insofar as it replaces workers at an accelerated rate, turning its own self-replication into the crucial driver of diffusion?

All these questions do not detract from how important and timely this book is. In fact, they are inspired by Ding's stimulating *tour de force*,

4 Etel Solingen, *Industrial Policy, Technology, and International Bargaining* (Stanford: Stanford University Press, 1996).

5 Etel Solingen, ed., *Geopolitics, Supply Chains, and International Orders: Crisis and Continuity* (New York: Cambridge University Press, 2021).

one that opens fruitful lines of inquiry, updates the diffusion argument to the contemporary era of great-power competition, and unpacks the causal chain between technological change and economic power transitions. The policy takeaway from *Technology and the Rise of Great Powers* is clear: policymakers must prioritize not just R&D but long-term investments in education, institutional resilience, and workforce development over short-term techno-nationalist fervor. The real contest is not about reaching the frontier first but about building the most inclusive and adaptive system to spread the benefits of technology widely. ◈

Why Japan Was Never Likely to Catch Up to the United States but China Is

David C. Kang

Technology and the Rise of Great Powers: How Diffusion Shapes Economic Competition—Jeffrey Ding's book on the technological sources of power transitions among great powers—is provocative and interesting. Arguing that disruptive technological breakthroughs dramatically influence the rise and decline of countries, Ding contends that the key factor in how these technological breakthroughs reshape economic might is overlooked. Conventional accounts prioritize a "leading sector" approach that views initial breakthroughs as the most important element in technological change influencing subsequent economic growth. However, Ding argues that this is not the case. Instead, he argues that the real question is which country can best capitalize on technological breakthroughs so that they diffuse widely throughout various sectors in the economy as general-purpose technologies (GPTs). It is not the initial innovation but its subsequent widespread technological diffusion that matters for which great power will ultimately benefit most from tectonic changes in technology.

The book includes four case studies and concludes with a discussion of the possible U.S.-China power transition. In each of the case studies, Ding contrasts his GPT approach with two other common theories of power transition: threat-based and varieties of capitalism. This book is interesting and thought-provoking, and it rightly, in my opinion, turns our attention to the sources of power transitions, not just their consequences. In this short review essay, I want to focus on one issue that seems important to me—the question of why Japan did not catch the United States, and whether China can.

In chapter 5, Ding argues that although Japan had some leading-sector technology in the 1980s and 1990s, it never translated that into GPTs, and thus the United States was able to maintain its economic lead over Japan. This is a plausible explanation, but the book never really addresses the reasons that I would argue might be more central to the explanation.

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Ding himself mentions these possible alternatives early in the book: geography and culture (p. 31).

The first and foremost broad factor, it appears to me, that was likely to preclude Japan from ever catching up with the United States in economic terms I would call material—not necessarily geographic but demographic. Japan was highly unlikely to catch the United States because its population was far smaller. In the 1990s, Japan had 130 million people, and the United States had 350 million people. Even in the 1990s, scholars were skeptical that a country with one-third the population of the United States could ever truly match it in economic terms. As Ding himself points out, the issue is not per capita GDP—if that were the case Switzerland would be a great power (p. 181). The issue is the overall size of the economy. And on that measure, Japan would have required a per capita GDP *three times* that of the United States to equal it, something even the most fevered Japan-basher did not predict.

But even more than the material/demographic constraints on Japan have been the cultural constraints. I use the term "culture" here widely to describe a country's worldview, its politics, the sense of urgency in its population, and the institutions it crafts over time. Japan has not even had typical economic growth over the past three decades, yet for the most part, the country appears comfortable with where it is. The Liberal Democratic Party has continued to hold power, even though needed economic reforms have not truly appeared. Even Shinzo Abe, the most dynamic Japanese prime minister in a generation, was unable to fundamentally change Japan's domestic or foreign policy trajectories. Abe was seen as "tough on China," but the reality is that he did not modify Japan's "peace" constitution or radically increase defense spending, nor was he able to institute actual economic reforms that revitalized the economy.

Japan's inward turn and nonresponse to China's rise have taken place in society and culture, as well as in the military and economic realms. Japanese students do not study abroad in nearly the same numbers or proportions as Korean and Chinese students do; Japanese tourists are far less likely to visit the United States in 2025 than they were a generation ago.[1]

[1] In 2000, there were 46,497 Japanese studying in the United States; in 2023 there were 13,959. Similarly, in 2000, 5.06 million Japanese tourists visited the United States, compared with 1.58 million in 2023. Open Doors Student Data ~ https://opendoorsdata.org/data/international-students/all-places-of-origin; and "Statistics of Japanese Visits Abroad," JTB Tourism Research and Consulting ~ https://www.tourism.jp/en/tourism-database/stats/outbound/#region-courtry.

This inward turn, this complacency in Japan, is reflected in its economy. In 1990, Japan's GDP was $4.7 trillion in constant 2010 dollars. By 2019, Japan's economy was $6.2 trillion in constant 2010 dollars. Although that might appear impressive, it works out to only 0.97% annual growth. Over that same time span, China's economy grew from $200 billion in 1990 to $11.5 trillion by 2019 (again in constant terms).[2] That is, China's economy grew at an annual average rate of 9.5%. If Japan had grown at even the "normal" expectation of 3% annually, its GDP would be closer to $11 trillion—almost even with that of China. In other words, Japan has foregone almost five trillion dollars in national wealth over the past generation simply because of its unwillingness to engage in needed economic reforms. To me, this is more telling about Japan than a difference in technology diffusion. Brad Glosserman wrote in 2016 that "the inability of Abenomics to gain traction mean[s] that Tokyo's international influence is likely to be at its apogee, and will level off and eventually decline. Tokyo won't be irrelevant, but we may well be witnessing 'Peak Japan.'"[3] Robert Dujarric seemingly concurred, arguing that "stasis, lethargy, and fatalism, along with a pleasant lifestyle, best describe the archipelago in 2016."[4]

That leads us to discussions about China's potential challenge to the United States. In contrast to Japan, China—possessing a population four times that of the United States—can catch up with the United States with an efficiency or per capita GDP that is 25% that of the United States. It would seem that China has far more innate material potential to catch up to the United States as a great power than Japan ever did.

And the question of whether China can continue to innovate and catch up to the United States is an important one. As the book notes, none of us can predict technological innovations (p. 135). But I would point out that Ding himself notes that 78% of China's economic growth between 1978 and 2007 was a result of total factor productivity increases more than labor deepening, capital deepening, and human capital (p. 183). This is a direct empirical challenge to common dismissals of East Asian growth as being exceptional.[5] A standard critique of East Asian growth is that it was simply an increase in inputs rather than actual increases in efficiency. If Ding is

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2 World Bank, World Development Indicators, 2024.

3 Brad Glosserman, "The Regional Implications of 'Peak Japan,'" Australian Strategic Policy Institute, Strategist, March 31, 2016 ~ http://www.aspistrategist.org.au/the-regional-implications-of-peak-japan.

4 Robert Dujarric, "Japan Without Ambition," *Diplomat*, January 22, 2016 ~ http://thediplomat.com/2016/01/japan-without-ambition.

5 Paul Krugman, "The Myth of Asia's Miracle," *Foreign Affairs*, November/December 1994, 62–78.

right, and much of China's growth is a result of total factor productivity, then China might actually have more potential to innovate and grow than other countries, and it might prove much more likely to catch up to the United States in economic terms. I do not know if this obviates or supports the approach regarding GPT versus leading sectors, but I do think these factors could have received more attention.

I write this not to critique *Technology and the Rise of Great Powers* overall—indeed, this book is a welcome addition to a discussion about power transitions that queries the sources of power and where power comes from. This book encourages us to confront unknowns about national cultures, approaches, and institutions in ways that lead to interesting new answers and even further questions. ◈

The Steel Flea and the Diffusive State

Victor Seow

In his short story "The Left-Handed Craftsman," the Russian writer Nikolai Leskov tells of a foreign technical marvel that sets a nation's artisans to work.[1] Tsar Alexander returns from England with a steel flea, "made out of the best English steel" and so small that it appears only as "a speck of dust" on a silver tray.[2] Under a microscope and with the help of a tiny key, the mechanical insect springs into life and dances a quadrille. Admiring the craftsmanship, the Tsar boasts that no Russian could match it. To prove him wrong, a team of smiths, the titular left-handed craftsman among them, set out to equal the feat. With considerable care, they shoe the flea, fitting each of its six feet with iron horseshoes, each marked with a smith's initial.

If Leskov's steel flea represented a marvel of craft, Jeffrey Ding's *Technology and the Rise of Great Powers: How Diffusion Shapes Economic Competition* asks a broader question: how do technological wonders become the basis of geopolitical power? The answer he offers is not invention itself but its breadth of use. General-purpose technologies matter most when they spread widely enough to become ordinary. Britain's leadership in the First Industrial Revolution lay not in the domination of a single frontier industry but in the wide diffusion of mechanization across sectors. The United States pulled ahead when machine tools and interchangeability became pervasive. Germany's celebrated breakthroughs in the chemical industry and its robust scientific and educational infrastructure did not translate into aggregate productivity leadership. Japan's challenge faded when computerization did not transform services deeply enough to raise productivity at scale. China, in Ding's analysis, has learned from earlier revolutions, investing in education and infrastructure to support broad diffusion, though whether these efforts can overcome entrenched barriers remains an open question.

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1 Nikolai Leskov, "The Left-Handed Craftsman," in *Selected Tales*, trans. David Magarshack (New York: Noonday, 1961), 212–52.

2 Ibid., 218.

For historians of technology, this emphasis on the diffusion of use is familiar and welcome. In *The Shock of the Old*, David Edgerton reminded us that contemporary discussions too often equate technology with invention, a habit that obscures more than it explains. He called instead for a turn away from innovation-centric histories toward accounts that capture the more prosaic realities of technology in use.[3] Ding shares this impulse. His framework draws attention to the infrastructural, educational, and industrial mechanisms that determine the extent to which technologies spread broadly and generate economy-wide effects. But where Edgerton stayed close to the ground, tracing the persistence, maintenance, and repurposing of technologies in everyday life, Ding works from the vantage point of the state. He measures diffusion in terms of national capacity and comparative advantage, a perspective that brings clarity to the strategic stakes while necessarily abstracting from the diversity of practices at the ground level.

One of the real strengths of *Technology and the Rise of Great Powers* is the precision with which Ding draws attention to the conditions under which technology circulates. His insistence that national power derives not from who invents first but from who can absorb and scale across institutions is a sharp corrective to the innovation-fixated narratives that dominate both policy and popular discourse. The force of the argument also raises questions about how far it might be carried into the realm of use itself. The ways in which technologies are used, maintained, modified, and interpreted also shape geopolitical outcomes. A high-speed-rail network may be built, but how is it taken up in daily life? What tensions, exclusions, or adaptations mark its routinization? Technologies exert power not only through their spread but through their persistence. Might diffusion capacity also be thought to include these quotidian, yet deeply political, dimensions of technological life?

Relatedly, Ding's framing of the state and its allied institutions as the principal agent of diffusion is both compelling and provocative. Across the book's case studies, governments do not appear as passive adopters but as active system-builders that design curricula, coordinate supply chains, and restructure institutions to enable scale. This is an important corrective to market-centered or inventor-driven models of technological change. From the perspective of the history of technology, though, one is left wanting to know more about the state's own ways of perceiving and

[3] David Edgerton, *The Shock of the Old: Technology and Global History since 1900* (New York: Oxford University Press, 2007).

assessing technology. In the book, diffusion is treated as an observable process, but it is also possible to see it as a category shaped by politics of measurement and interpretation. What counts as successful uptake, and according to whose metrics? Technical systems that often appear coherent from afar are, in practice, uneven, contested, and prone to overstatement. Future work in this area might ask how states know what they know about their techno-industrial assemblages, and what it would mean to historicize diffusion not only as policy implementation but also as a process of negotiation among institutions, practitioners, and knowledge regimes.

Leskov's tale does not end with the shoed flea on parade. The feat, for all its brilliance, leaves the insect unable to dance. The left-handed craftsman, sent abroad as a token of pride, comes home with a warning that Russian muskets were being cleaned with brick dust and would fail when most needed. But he falls sick and dies in an infirmary, and the message never reaches the throne. Placed alongside Ding's account, the story underscores similar lessons. Power follows what is widely adopted and made ordinary, yet it also depends on upkeep, on how systems are sustained, and on whether insights circulate as effectively as technology itself. *Technology and the Rise of Great Powers* carries forward themes familiar in the history and social studies of technology, bringing them to bear on questions of global strategy and political economy. The task ahead is to refine how we see breadth and to remain attentive to the practical signals that show where diffusion succeeds, where it falters, and where it exacts its own costs. ◈

Author's Response: Extensions to General-Purpose Technology Diffusion Theory

Jeffrey Ding

I am indebted to Daniel Drezner, Xinyue Wei, Etel Solingen, David Kang, and Victor Seow for their reviews of *Technology and the Rise of Great Powers: How Diffusion Shapes Economic Competition*. In this business of ours, time spent reading and writing is the most valuable of resources, so I am grateful that these scholars have invested some of their time to deeply engage with my book. My thanks as well to *Asia Policy* for organizing this roundtable.

I am very gratified that the reviewers valued my explanation of how technology affects the rise and fall of great powers, which highlights a state's ability to diffuse general-purpose technologies (GPTs) throughout its economy. Xinyue Wei and Etel Solingen call the book a "*tour de force*" that provides important insights for the current era of great-power competition. Daniel Drezner and David Kang also see it as an important contribution to the international relations literature on the sources of power transitions. I was especially glad to read the review from historian Victor Seow, which emphasizes how the book "carries forward themes familiar in the history and social studies of technology, bringing them to bear on questions of global strategy and political economy." He rightly identifies David Edgerton's *Shock of the Old* as a source of inspiration for GPT diffusion theory, providing me the opportunity to underscore that the research behind *Technology and the Rise of Great Powers* draws from the scholarship of many other historians, including (but certainly not limited to) Maxine Berg, Kristine Bruland, Joel Mokyr, Nathan Rosenberg, and Nick von Tunzelmann.

At the same time, the reviewers also raised issues with the book that can productively advance our understanding of technology and great-power competition. In the space that follows, I unpack some of their challenging questions, which I have grouped into three topics: (1) the political fights over the institutions that matter for GPT diffusion, (2) the implications of the U.S.-Japan case for present-day U.S.-China technological competition, and (3) the policy relevance of the book's argument.

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The Political Fights behind the Institutions That Matter for GPT Diffusion

To begin, the reviewers ask for more clarity on the institutional adaptations that enable the widespread diffusion of GPTs. My argument gives pride of place to "GPT skill infrastructure," or education and training systems that widen the base of engineering skills relevant for a particular GPT (p. 8); however, as Wei and Solingen point out, I do not specify the precise configurations that distinguish effective and ineffective skill infrastructure. Indeed, throughout the book's historical cases, the format of these institutional adaptations has shifted, from mechanics' institutes that held night lectures during the First Industrial Revolution to formal computer science degrees in the Third Industrial Revolution. Nonetheless, what has remained consistent is the function of GPT skill infrastructure: to broaden and systematize the engineering knowledge necessary to diffuse a particular GPT.

Why does GPT skill infrastructure vary across countries? Along with Wei and Solingen, Drezner also pushes us to think through the political trade-offs and mechanisms that allow some great powers to be better than their rivals at cultivating these skill-formation institutions. On this point, one could explore whether decentralized science and technology systems are best suited to develop effective GPT skill infrastructure. They might be more responsive to the shifting demands for engineering skills posed by GPTs.[1] Relatedly, one political challenge of diffusion-centered policies is that their benefits accrue to dispersed interests; in contrast, for policies under the "leading sector" framework (i.e., monopolizing innovation in a key industry), the group of winners is less broad and diverse. Possibly, a decentralized approach can promote the horizontal industrial policies that help GPTs diffuse across many applications, not just one or two winning sectors.

I agree that these questions deserve further investigation, but it should be emphasized that GPT diffusion theory establishes the foundation for these future inquiries. If we relied on traditional explanations of how technological revolutions affected the rise and fall of great powers, the institutional adaptations that require explanation would be those linked to pioneering, new-to-the-world innovations in select fast-growing industries.

[1] Dahlia Peterson, Kayla Goode, and Diana Gelhaus, "AI Education in China and the United States: A Comparative Assessment," Georgetown University, Center for Security and Emerging Technology, CSET Issue Brief, September 2021.

Why are some great powers better than others at preventing technological crown jewels from leaking out, investing in cutting-edge R&D, training the best and brightest experts, or developing close-knit networks with businesses in key industries? I am happy that the reviewers are convinced that we should be asking a different set of questions.

The Implications of the U.S.-Japan Case for Present-Day U.S.-China Competition

Next, Kang's review zeros in on the applicability of the U.S.-Japan chapter to China's current challenge to U.S. technological leadership. According to Kang, since Japan's population during its economic boom in the 1980s and 1990s was so much smaller than that of the United States (about half), Japan could never truly match the United States in economic terms. By contrast, Kang argues that China, with a population four times that of the United States, only needs GDP per capita that is 25% of U.S. GDP per capita to catch up as a great power.

First, it is important to clarify that I am interested in productivity differentials among great powers, which I operationalize as states that attain a combination of economic size (not population) and efficiency. Mike Beckley, for example, has convincingly demonstrated that an indicator that combines GDP with GDP per capita provides a sound measure of power.[2] In fact, his work and other studies that systematically measure national power warn against Kang's focus on population indicators because a state with a large population must also invest significant resources into welfare and domestic security, instead of power projection.[3]

While I admit that there is no bright-line that separates great powers from other countries, all the countries I study in these historical cases (including Japan in the 1980s and 1990s) rank among the top-six nations in power resources based on a measure that combines economic size and efficiency (p. 21). On this front, Japan's challenge to U.S. economic power was very real. In the first half of the 1990s, Japan's GDP per capita peaked at around 85% of the U.S. mark, and its total GDP reached 71% of U.S. GDP.[4]

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2 Michael Beckley, "The Power of Nations: Measuring What Matters," *International Security* 43, no. 2 (2018): 2 ~ https://doi.org/10.1162/isec_a_00328.

3 Therese Anders, Christopher J. Fariss, and Jonathan N. Markowitz, "Bread before Guns or Butter: Introducing Surplus Domestic Product (SDP)," *International Studies Quarterly* 64, no. 2 (2020): 392–405 ~ https://doi.org/10.1093/isq/sqaa013.

4 Christopher A. Lawrence, "Where Did Japan Go?" Dupuy Institute, October 23, 2018 ~ https://dupuyinstitute.org/2018/10/23/where-did-japan-go.

This clarified measure of power rebuts Kang's claim that China only needs to attain 25% of the United States' economic efficiency because it has four times the population. Indeed, China still has further to go than Japan at its peak: China's GDP is currently around 65% of U.S. GDP, and the gap is even wider when it comes to total factor productivity and economic efficiency measures.[5]

GPT Diffusion Theory's Relevance for Policymakers

Lastly, Drezner questions GPT diffusion theory's utility for policymakers thinking about the present and the future. He concludes that "when it comes to developing politics and strategy for [the economics of a power transition], however, policymakers will have to look elsewhere." Drezner pinpoints two issues that complicate the theory's implications for policymakers: (1) there is limited *ex ante* ability to identify GPTs, and (2) the prolonged diffusion lag for GPTs means that "such a long-term perspective is beyond the political incentives of even the most far-sighted policymakers." Similarly, Seow prompts us to investigate how states measure successful diffusion and uptake of technologies.

In one sense, Drezner and Seow are absolutely correct to probe the relevance of GPT diffusion theory for policymakers. To Drezner's first point, although it is difficult to forecast GPTs with perfect precision, some scholars have developed empirical approaches for identifying such technologies before their full impact materializes (p. 186). Sergio Petralia's work, for instance, measures a technology's "GPT-ness" by counting the number of different technological classes in the pool of patents that use vocabulary related to that particular technology.[6] The European Commission's effort to identify "key enabling technologies" is a related, worthwhile effort.[7]

As to the second point, whether policymakers can adopt the future-oriented perspective needed for GPT diffusion, I do think the CHIPS and Science Act's STEM workforce initiatives are long-term investments in the United States' GPT skill infrastructure—provided

5 "Unpacking China's GDP," Center for Strategic and International Studies, ChinaPower, September 17, 2025 ~ https://chinapower.csis.org/tracker/china-gdp.

6 Sergio Petralia, "Mapping General Purpose Technologies with Patent Data," *Research Policy* 49, no. 7 (2020): 104013 ~ https://doi.org/10.1016/j.respol.2020.104013.

7 Colin Wessendorf, Alexander Kopka, and Dirk Fornahl, "Key Enabling Technologies (KETs) in the Technological Space: Embeddedness and Regional Knowledge Creation," *European Planning Studies* 33, no. 2 (2025) ~ https://www.tandfonline.com/doi/full/10.1080/09654313.2024.2420857.

they are fully implemented.[8] Furthermore, scholarship can also inform policymaking by telling leaders what not to do. As the book's U.S.-China chapter demonstrates, the United States is well positioned to win the artificial intelligence (AI) diffusion race, yet policymakers—influenced by the leading-sector model—are fixated on preventing cutting-edge innovations from leaking to China. At the very least, even if U.S. policymakers cannot achieve such far-sightedness, they can avoid self-destructive actions such as closing doors to Chinese international students who broaden the United States' base of AI engineering talent.

However, in another sense, I am less sympathetic to Drezner's concerns on behalf of policymakers who might struggle to apply the book's findings. What comes to mind is the scene from the TV show *Mad Men* where Don Draper yells, "That's what the money is for!" My job was to uncover, to the best of my ability, the answer to the question of how technological revolutions affect the rise and fall of great powers. The answer might be difficult for policymakers to put into practice, but at the end of the day, I leave it to them to do their job to the best of their ability as well.

Concluding Remarks

Once more, I would like to express my thanks to the reviewers for raising these thought-provoking questions. After reading and writing about this topic for the better part of seven years, I fear that my thinking has calcified too much to tackle these inquiries with the freshness they deserve. I am hopeful, though, that others will take up the torch and deepen our understanding of the rise and fall of great technologies and powers. ◈

8 Martha Ross and Mark Muro, "How Federal, State, and Local Leaders Can Leverage the CHIPS and Science Act as a Landmark Workforce Opportunity," Brookings Institution, January 4, 2024 ~ https://www.brookings.edu/articles/how-federal-state-and-local-leaders-can-leverage-the-chips-and-science-act-as-a-landmark-workforce-opportunity.