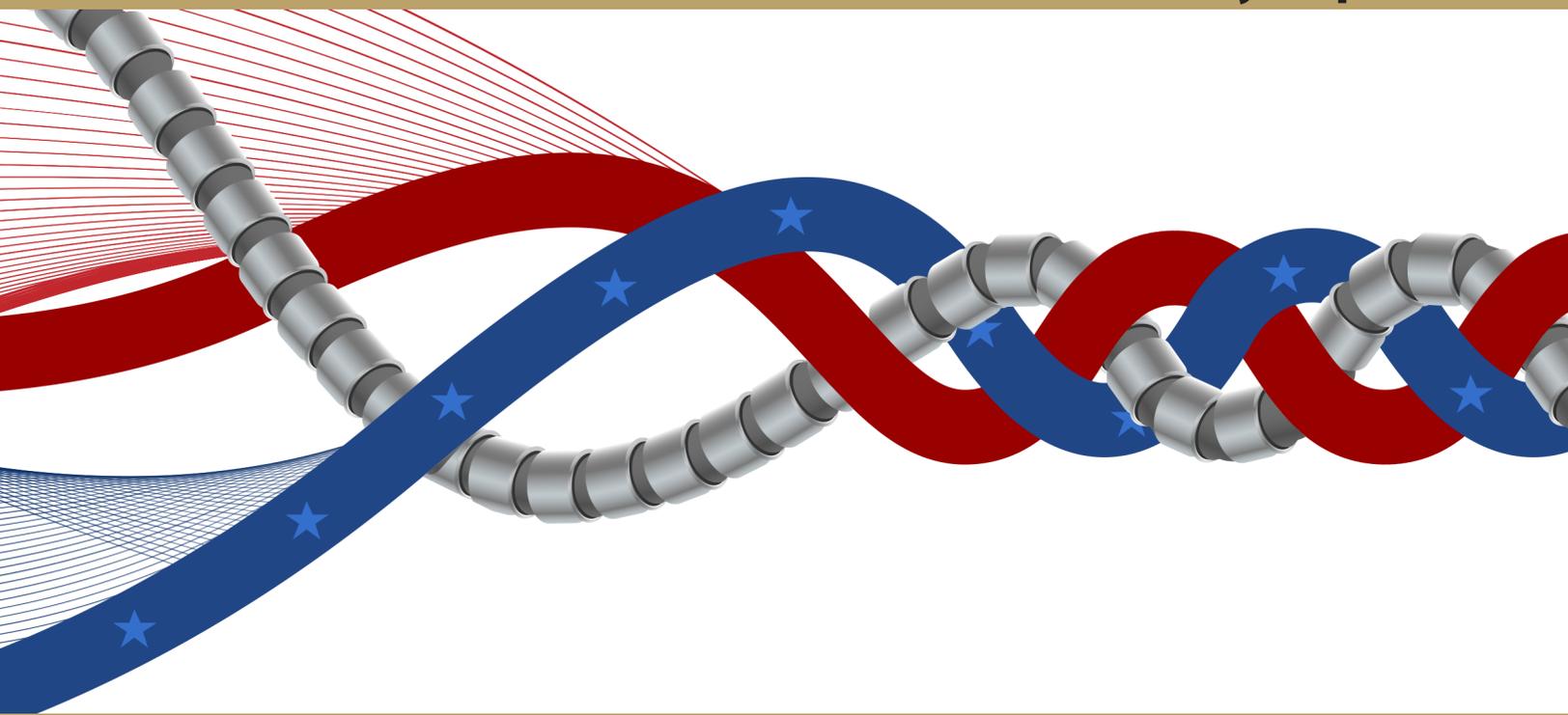


SYMBIOSIS AND STRIFE

WHERE IS THE SINO-AMERICAN RELATIONSHIP BOUND?

**An Introduction to the APL Series “Measure Twice, Cut Once:
Assessing Some China-US Technology Connections”**

National Security Report



Richard Danzig | Lorand Laskai

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Foreword

This paper is part of the “Measure Twice, Cut Once: Assessing Some China–US Technology Connections” research series sponsored by the Johns Hopkins University Applied Physics Laboratory.

As competition has intensified between the United States and China, actions to disengage their technology establishments from one another have also intensified. The two countries’ systems for research and development, production, and sale of cutting-edge technologies have been substantially, though by no means uniformly, commingled. More recently, there have been concerted efforts by both nations’ governments to reverse some or all of that commingling. Policymakers’ priorities include perceived risks to national security, worry about economic disadvantage from proliferation, and concern about uses of technologies that intentionally or indifferently may harm civil liberties or the environment.

To explore the advisability and potential consequences of decoupling, the Johns Hopkins University Applied Physics Laboratory commissioned papers from experts in specific technology areas. In each of these areas, the authors have explored the feasibility and desirability of increased technological separation and offered their thoughts on a possible path forward. Other papers in this series include:

- *Two Worlds, Two Bioeconomies: The Impacts of Decoupling US–China Trade and Technology Transfer* by Rob Carlson and Rik Wehbring
- *The History and Future of US–China Competition and Cooperation in Space* by Matthew Daniels
- *An Entwined AI Future: Resistance Is Futile* by Christine Fox
- *Cutting off Our Nose to Spite Our Face: US Policy toward Huawei and China in Key Semiconductor Industry Inputs, Capital Equipment, and Electronic Design Automation Tools* by Douglas B. Fuller
- *The Telecommunications Industry in US–China Context: Evolving toward Near-Complete Bifurcation* by Paul Triolo
- *Addressing the China Challenge for American Universities* by Rory Truex
- *US–China STEM Talent “Decoupling”: Background, Policy, and Impact* by Remco Zwetsloot

Summary

In Washington and Beijing, as a natural response to the deterioration of relations between the United States and China, “decoupling” and “disconnection” have become watchwords of the day. Interdependencies created during better times have come to be viewed as vulnerabilities, and both sides are jockeying to control the technologies that bind them. This introduction provides strategic context to the “decoupling” impulses within which the papers in this series are situated. It begins by assessing the changing premises of the US–China relationship that animate the current desire to decouple. It finds that this impulse is shaped by both countries’ historical experiences vis-à-vis the Soviet Union. It notes, however, that unlike the US approach against the Soviet Union, the US view of China lacks the strategic clarity that would make broad disconnection desirable. This is but one critical difference among many that make the lessons of the Cold War a poor fit for the present moment. The authors question how current decoupling initiatives mesh with the interdependence that continues to characterize the US–China relationship and whether decoupling can be effectively pursued with the limited tools that both countries have at their disposal for comprehensively reducing existing interdependencies. Like conjoined twins whose circulatory systems cannot be separated, the United States and China are tied together. For this reason, the authors argue in favor of an incremental approach rooted in the indeterminacy of the current moment and recognition of the fact that interdependence is likely to continue.

When relations between two nations deteriorate, interdependencies created during better times come to be viewed as vulnerabilities. Recognition grows that a partner that provides a service or material may gain leverage by threatening to withhold that material or service, and in a crisis, it may use that leverage to improve its prospects of prevailing. A dominant supplier is also advantaged in its efforts to gain intelligence about the subordinate nation's efforts. Most ambitiously, over the longer term, a party that dominates in one area may seek to preserve the status quo by rationing its support so as to retard the development of competing capabilities in the dependent nation.

At the dawn of this third decade of the twenty-first century, many of the most important interdependencies are associated with modern technologies. As a result, interactions that determine the flow of ideas, information, goods, services, and talent related to these technologies become contested spaces.

These contests cannot be isolated. The larger relationship shapes and is more important than its attributes in particular areas. But each contentious interaction remakes and tests the larger relationship.

The United States and the People's Republic of China (PRC) are in this situation at the time of this writing. Leaders in both countries have been trying to enhance their technology positions through a wide array of means, including investment, training, subsidies, market protection, manipulation of international standards, export controls, and the legal or illegal acquisition of intellectual property. Now, after four decades of increasing interdependence, the watchwords of the day have become "disconnection," "decoupling," and "disengagement."

Reflecting on the papers in this "Measure Twice, Cut Once" series, we think efforts at "decoupling" are better described as a conflict over the terms of interdependence in a relationship that cannot be ended. Each country is trying to make itself more

independent and the other more dependent with respect to key technologies. Both are also struggling with spillover, sometimes desired and sometimes undesired. The implications of this turbulence are profound, first for these two countries, but then also for technological progress, global trade, and international interoperability.

To better understand these issues, the Johns Hopkins University Applied Physics Laboratory (APL) commissioned papers focused on six different subjects: artificial intelligence, biology, semiconductors, space, STEM (science, technology, engineering, and mathematics) graduate education, and telecommunications.¹ Summaries of these papers, attached to this short introduction, convey their essence.

This introduction attempts to put this work in the broader context of the Sino-American relationship. In successive sections, we discuss the changing premises of that relationship, the ways in which views about disconnection are influenced by each nation's different experiences with the Soviet Union, how disconnections in particular areas are intertwined with the broader relationship, and how inadequacies in our tools and our plans for using them undermine otherwise plausible courses of action. We emphasize that success or failure will not so much be about competition in a particular technology as about the larger relationship, which is deep and of transcendent importance. Like a couple quarreling in a shared house or, more dramatically, like conjoined twins whose

¹ Fox, *An Entwined AI Future: Resistance Is Futile*; Carlson and Wehbring, *Two Worlds, Two Bioeconomies: The Impacts of Decoupling US-China Trade and Technology Transfer*; Fuller, *Cutting off Our Nose to Spite Our Face: US Policy toward Huawei and China in Key Semiconductor Industry Inputs, Capital Equipment, and Electronic Design Automation Tools*; Daniels, *The History and Future of US-China Competition and Cooperation in Space*; Truex, *Addressing the China Challenge for American Universities*; Zwetsloot, *US-China STEM Talent "Decoupling": Background, Policy, and Impact*; and Triolo, *The Telecommunications Industry in US-China Context: Evolving toward Near-Complete Bifurcation*.

circulatory systems cannot be separated, China and the United States can find means of securing greater independence, but they cannot be “decoupled.”

A Search for Strategy between the Poles

Each reader’s assessment of the papers in this series will be greatly affected by his or her views of the broader US–China relationship, where it is going, and how it should, or for that matter can, be shaped. Each of the authors, no doubt, is responding to his or her own perspectives about this. Driven by our desire to have these experts focus on technical complexities and nuances of these issues, it was probably a mistake on our part to encourage them to dive into their analyses without stating their premises. We aim here to at least mitigate our error by discussing the context in which we consider these papers.

It is striking that strategic thinking about the relationship between China and the United States does not now generally begin, as it did for the decade of the Soviet–American relationship, with reflection on the risks of a major war.

We provide this strategic context because many policymakers replicate this shortfall. This is understandable. As we will discuss below, there is good reason to think that any American strategy toward China should be incremental and tentative, without the clear, long-term, and persuasive implications that characterize more definitive fixed positions. The relationship is shifting, its manifestations are complex, and the number of actors and actions influencing its course are beyond reckoning. As a result, the shape of the relationship over the years ahead cannot confidently be predicted.

However, it can confidently be said that there will be a relationship, and indeed, we think it should and will be robust. This premise—or an alternative premise—demands attention. Without an articulated and persuasive larger view of the relationship between the United States and China, judgments about “disconnections” in particular technology areas remain disconnected from each other—prescriptions for a patient whose health has not been well assessed and whose illness is not well diagnosed.

It is striking that strategic thinking about the relationship between China and the United States does not now generally begin, as it did for the decade of the Soviet–American relationship, with reflection on the risks of a major war. There is widespread recognition that this is a risk—war could arise from accident, over Taiwan, or from some third cause not now readily identifiable.² Both countries are building military forces with an eye to the other. Evidently, however, neither the authors of these papers nor national leaders presume that a major war is likely in the decades immediately ahead. If policymakers or these authors thought war was probable, they would be advocating for blockades and embargoes, dramatically increased military investment, and other positions much more draconian than anything discussed in this series.³

² Brands, “Does the U.S. Need to Fear?”

³ Even while arguing for increased military investment, the US Department of Defense (*Military and Security Developments*) implies a similar view:

Beyond 2021, China will use the “moderately prosperous society” as the basis for Xi’s “two-stage” plan to achieve national rejuvenation by the PRC’s centenary in 2049. In the first stage from 2021 to 2035 . . . China will likely continue to prioritize economic development as “the central task” . . . By 2035, China will also seek to increase its economic and technological strength . . . to “basically” complete its military modernization. China will also seek to strengthen its international “soft power” significantly and improve its domestic rule of law and governance systems. In the second stage from 2035 to 2049, the Party will seek . . . an international status that Xi describes as being a “global leader in terms of

We think it is appropriate to focus on issues apart from armed conflict and to presume that at least for the next decade, warfare is unlikely. It is evident that neither the United States nor China wants to conquer and occupy the other. Unlike many powers that go to war, the Chinese leadership appears to believe that its power relative to the United States will increase in the decades ahead. It has incentives, accordingly, to avoid armed conflicts that would upset present trajectories.⁴ Nor is the United States likely to believe that it can improve the balance of power with a military conflict, especially one conducted on the borders of a state with at least equal and by many reckonings locally superior power backed up by nuclear weapons.

This view, however, has three important qualifications. First, we often misjudge the risks of warfare. Therefore, deterrence and prudence demand vigorous, continued military investment. Second, peace and stability need to be nourished. Readers of the papers in this series should recognize that stability is a more realistic goal than invulnerability. Proposals to decouple a particular technology

composite national strength and international influence.” China will have also attained—among the Party’s many goals—its objectives to field a “world-class” military . . .

⁴ H. R. McMaster (“How China Sees the World”) takes a different view of Chinese expectations. In his judgment:

The party’s leaders believe they have a narrow window of strategic opportunity to strengthen their rule and revise the international order in their favor—before China’s economy sours, before the population grows old, before other countries realize that the party is pursuing national rejuvenation at their expense, and before unanticipated events such as the coronavirus pandemic expose the vulnerabilities the party created in the race to surpass the United States and realize the China dream.

However, the article in which General McMaster offers this appears to adopt premises like those we state. He focuses on conflict other than military warfare. See also Evan Medeiros’ testimony before the House Permanent Select Committee on Intelligence, in which he offered his opinion that “[n]either Washington nor Beijing now appear to believe that time is on their side to adjust to the threats posed by the other.” *Hearing on U.S.-China Relations*, Medeiros testimony.

should be judged according to not just whether they reduce Chinese or American vulnerabilities, but also whether they may render the relationship more unstable and the risks of war consequently higher. Third, the presumption that near-term armed conflict is unlikely does not translate into an expectation of an absence of conflict in other forms. To the contrary, the authors in this series implicitly or explicitly anticipate that China and America will aggressively wrestle for advantages in trade, technology, and finance. The authors anticipate (and we agree) that these advantages will be used by both countries to influence each other’s behavior and that of third-party nations, international institutions, and multinational corporations.

What strategies might the United States adopt in this context? Polar positions bound a spectrum on which possible US approaches to the PRC may be considered. One pole would apply to China the position that George F. Kennan presented about the Soviet Union in his famous 1946 “Long Telegram.” This view and its accompanying recommendations—famously organized under the concept of “containment”—were somber:

In summary, we have here a political force committed fanatically to the belief that with US there can be no permanent *modus vivendi* that it is desirable and necessary that the internal harmony of our society be disrupted, our traditional way of life be destroyed, the international authority of our state be broken, if Soviet power is to be secure. This political force has complete power of disposition over energies of one of world’s greatest peoples and resources of world’s richest national territory, and is borne along by deep and powerful currents of Russian nationalism. . . . Finally, it is seemingly inaccessible to considerations of reality in its basic reactions.”⁵

⁵ Kennan, “Long Telegram,” 14–15. We are indebted to Jim Miller for emphasizing this basic premise and pointing to this comparison.

The opposite pole characterized US policymakers' views of China over the decades after President Richard Nixon and Chairman Mao Zedong resumed a direct relationship between their countries.⁶ For some forty years, the predominant American position was that openness in trade, travel, and communication would at least make China a stakeholder in a community of nations.⁷ This goal was the converse of Kennan's expectation for America's relationship with the Soviet Union: it presumed that a "modus vivendi" with China could be achieved and sustained. At its most optimistic, this view went further: it was coupled with a hope, and for some no doubt a belief, that a prominent position in the global order would seed and cultivate the values of an open society in China.⁸

American hopes for a democratic China have fallen by the wayside.⁹ China's system has become

⁶ Schell, "Death of Engagement."

⁷ Tom Wright puts this in a global context: "If there is one idea that has consistently influenced western foreign policy since the Cold War, it is the notion that extending interdependence and tightening economic integration among nations is a positive development that advances peace, stability, and prosperity." Wright, "Sifting through Interdependence," 7. Wright presciently observed seven years ago that "[s]tates are seeking to carve out spheres of independence for themselves to hedge against the risks of interdependence, and these efforts are likely to accelerate over the next decade." Wright, "Sifting through Interdependence," 8.

⁸ Among pieces summarizing this view and how it has been overtaken by the evolution of Chinese authoritarian state, see H. R. McMaster's view in "How China Sees the World":

Americans, as Hans Morgenthau noted long ago, tend to view the world only in relation to the United States, and to assume that the future course of events depends primarily on U.S. decisions or plans, or on the acceptance by others of our way of thinking. The term for this tendency is strategic narcissism, and it underlies the long-held assumptions I mentioned earlier: about how greater integration of China into the international order would have a liberalizing effect on the country and alter its behavior in the world.

⁹ In a statement emblematic of this view, US Trade Representative Robert Lighthizer stated in his 2017 report to Congress on China's World Trade Organization (WTO) compliance that "the United States erred in supporting China's

increasingly totalitarian in the political domain even while it leaves some choice in private affairs. Its high premium on control has led to the internment and forced sterilization of Uighurs in Xinjiang, repression of Tibetans and their culture, suppression of dissent on the mainland, and renegeing on agreements that guaranteed freedom in Hong Kong. Externally, this evolution has been accompanied by aggressive actions, including cyber theft, military actions in the South and East China seas, and the bending of many economic and information relationships to serve the interests of the Chinese state.¹⁰

American leaders display little inclination to move to a Kennan-like view of China, and they cannot go back to the viewpoint of the late twentieth century.

However, we doubt that American distrust of China is, or should be, anything like Kennan's view of the Soviet Union. Even under its assertive leader Xi Jinping, China does not present the existential threat to America that the Soviet Union presented in 1946.¹¹ Significantly, unlike Kennan's assessment of the Soviet Union, we cannot conclude that

entry into the WTO on terms that have proven to be ineffective in securing China's embrace of an open, market-oriented trade regime." US Trade Representative, *2017 Report to Congress*. Similarly, in their seminal *Foreign Affairs* piece, Kurt Campbell and Ely Ratner conclude that "diplomatic and commercial engagement have not brought political and economic openness" to China. Campbell and Ratner, "The China Reckoning."

¹⁰ In their 2012 article "Addressing U.S.-China Strategic Distrust," Wang Jisi and Kenneth Lieberthal provided a good survey at an early stage in the deterioration of the Sino-American relationship.

¹¹ "The Cold War analogy is a powerful and resonant concept, but it is also historically inapt and strategically ill-fitting. Most fundamentally, the Cold War was an existential struggle. . . . Beijing is less threatening than Moscow was, but it is also more competitive, and both of these facts should inform US strategy." Campbell, "Changing China Debate."

China is “seemingly inaccessible to considerations of reality.” The contemporary Chinese Communist Party’s lodestar is not ideology, but rather a pragmatic sense of self-interest and aggrandizement, which it believes it can advance through global markets and institutions and pervasive control of domestic politics and opinion.

American leaders display little inclination to move to a Kennan-like view of China, and they cannot go back to the viewpoint of the late twentieth century. The problem with which American policymakers and the authors of these papers (all of them Americans)¹² grapple is how to operate between these poles. No one has provided a strategy that would resolve this indeterminate position,¹³ and Kurt Campbell puts the point well when he says that this “is not a problem to be solved; it is a condition to be managed.”¹⁴

Some would argue that this is a failure—either of the imagination to conceive a grand strategy or of the will to grasp the nettle. We think differently. This is because we see many unpredictable variables affecting China (for example, the goals, attitudes, and capabilities of Xi Jinping’s presently unidentifiable successor) and the United States (for example, how economic challenges and domestic politics may intensify efforts to demonize China)¹⁵ and around the relationship (for example, how COVID-19 and climate change can amplify

or, if cooperation is achieved, moderate conflict). Significantly it is also because as we discuss below in the Dependence on Imperfect Tools section, tools for shaping the relationship are so imperfect and their effects so imperfectly understood, tentative restraint is the right posture as governments experiment with their use.

This unsettled posture will be especially contentious because it is likely to contrast with the greater clarity and decisiveness with which China deals with America. This is partly a result of process. Authoritarian regimes reap the benefits of forced consensus.¹⁶ Xi, in particular, has consolidated power unlike any leader since Mao Zedong.¹⁷ It is also a consequence of the disparate circumstances of the United States and the PRC. President Donald Trump’s original theme of “Make America Great Again” and its counterparts from the Democratic Party could be interpreted to imply positions about trade with China but not about the larger relationship. In contrast, the Chinese program of “national rejuvenation” includes China’s return to its historical position as a global power second to none (perhaps preeminent above all). Read against a history of foreign occupation during World War II and nearly a century of colonial subjugation before that, China’s leaders and their constituents see the United States as an opponent mobilized more by resistance to China’s rise than by any principled concerns about human rights, property, or democracy.

Technology plays a central role in China’s mission to return to historical greatness. Chinese leaders have long viewed dependence on foreign technology as a straitjacket used to hold China down and constrain its exercise of power. This view

¹² We anticipate sharing these papers and soliciting comments from Chinese analysts.

¹³ We have benefited from the many scholars and practitioners who have put forth impressive commentary on how to navigate this period of indeterminacy: Campbell and Sullivan, “Competition without Catastrophe”; Friedberg, “Competing with China;” Ratner, Rosenberg, and Scharre, “Beyond the Trade War”; Donilon, “Trump’s Trade War”; and Haas, “U.S.-China Relations.”

¹⁴ “There is another way forward that starts from the premises that neither collapse nor condominium are tenable end-states. It recognizes that great power politics is not a problem to be solved; it is a condition to be managed.” Campbell, “Changing China Debate.”

¹⁵ Gewirtz, “No One Knows.”

¹⁶ This quality has grown more pronounced under Xi Jinping, who has done away with collective leadership in favor of personalistic rule. See Cheung, “Chinese National Security State Emerges.”

¹⁷ Hornby and Mitchell, “Xi Jinping Confirmed”; and Doshi, “Hu’s to Blame?”

was powerfully reinforced by the 2013 Edward Snowden revelations, which provided objective lessons in how networks built with US equipment provided avenues for espionage and intelligence collection.¹⁸ The Trump administration's aggressive use of export controls against China's preeminent tech companies, most notably Huawei, has further strengthened resolve to reduce technology dependency.¹⁹ The only way for China to be assuredly free of subordination, according to this view, is through self-reliance at least in so-called "core technologies."

The goal of independence, however, paradoxically runs through some dependent means. China's time-tested playbook for indigenous innovation does not eschew foreign technology—and frequently requires it.²⁰ Foreign equipment and know-how are often a prerequisite and always an accelerant for building those technologies domestically.²¹ This means inviting greater dependency on foreign sources in the interim—buying foreign components, licensing and stealing foreign intellectual property (IP), inviting foreign multinationals to invest in China, and sending talent abroad to receive education and training.²² However, PRC leaders have grown adept at a Houdini-like escape act in which they invite greater

dependency on foreign technology, even as they plot eventual escape from present constraints.²³

An irony of present controversies is that they have been catalyzed not by American ambitions to dominate China or by long-standing Chinese goals for shedding its dependence on foreign technologies, but instead by the emergence of a Chinese company, Huawei, as the potentially dominant international force in the next generation of telecommunications. This puts the shoe on the other foot. In telecommunications, it is the United States that fears Chinese dominance and is seeking to avoid dependence.²⁴ We will comment on this case below, but it is worth first considering how the two countries' different twentieth century experiences reinforce the different Chinese and American perspectives about technological interdependence.

Seductive "Lessons" from Soviet Experiences

The papers in this series are about American and Chinese efforts to control a complex techno-trading system. In this situation, policymakers' natural tendency is to simplify, and their first recourse for

¹⁸ The US-Israeli cyber operation against Iranian centrifuges in 2010, often referred to as Stuxnet, also raised concern in Beijing: "If we're classified as an enemy country like Iran is and are attacked, when encountering a flame virus like Stuxnet the country's electrical grid and entire economy could be paralyzed," said the editor of the influence government infosec publication China Information Security. *Economic Observer*, "Information Sovereignty Concerns."

¹⁹ Segal, "Seizing Core Technologies."

²⁰ As Julian Gewirtz succinctly put it, "[The] paradox in the CCP's relationship to technology [is] pursuing an ultimate state of self-reliance has relied above all on foreign technology and expertise." Gewirtz, "China's Long March."

²¹ Cheung, "Role of Foreign Technology Transfers."

²² For other examples, see Ahmed and Weber, "China's Long Game."

²³ Chinese development of high-speed rail provides a well-documented example. Starting about fifteen years ago, German, Canadian, and Japanese suppliers entered contracts that required technology transfer alongside sales. The Chinese market now effectively excludes foreign suppliers and competes with them abroad. See Railway Technology, "Importance of China's High-Speed Tech Transfer Policy." See also Nowak, "On the Fast-Track."

²⁴ This fear may be overstated. David Ignatius ("We May Be Dramatically Overestimating") points to British intelligence assessments of Huawei's failings and writes:

Kurt Campbell, the chief Asia strategist during the Obama administration, who now heads a consulting firm, explains: "As in the past — with the supposed 'missile gap' between us and the Soviets in the 1950s and the supposedly unstoppable Japanese economy in the '80s — we have '10-footed' Huawei. The company is not the nimble dynamo depicted in the media."

See also HCSEC Oversight Board, *Annual Report*.

simplification is to search for historical antecedents. Early in the current escalation, American commentators and officials began referring to the impending conflict as a “tech cold war.” Many experts have criticized the parallel, noting significant differences between the Cold War and modern day.²⁵ Yet the validity of this criticism should not obscure the important role recollections of past struggles play in shaping Washington and Beijing’s conceptions of great power competition.²⁶ For both countries, visions of the future are colored by recapitulations of the past.

From the US perspective, framing the current conflict as one modeled after the Cold War creates optimism about confrontation with China. The United States, of course, prevailed in the Cold War and did so by exploiting its extraordinary economic and technological advantages. World War II left the United States with half the world’s gross domestic product (GDP), an untouched and revitalized infrastructure, and a talent base enriched by exodus from Europe. The tools that the United States developed to isolate the USSR reflected this strength. Through the Export Control Act of 1949 (later replaced by the Export Administration Act), the United States put in place the first

²⁵ See, for example, Campbell, “Changing China Debate”; Del Pero, “US-China Rivalry Is Not a New Cold War”; and Fontaine and Ratner, “U.S.-China Confrontation Is Not Another Cold War.”

²⁶ Comparisons to the Cold War have been a frequent refrain for Trump administration officials. See Williams, “Cold War Language.” In his first remark after the Trump administration blacklisted ZTE, General Secretary Xi drew a parallel to the Cold War-era “blockade” against China and issued a call to action by invoking the country’s technological response to Cold War containment, “two bombs, one satellite.” Triolo et al., “Xi Jinping Puts ‘Indigenous Innovation.’” Key Chinese scholars have treated the Cold War as a starting point for understanding the current situations. As Yuan Peng, president of the influential state think tank the China Institutes of Contemporary International Relations, put it in an influential article, “high-tech competition [with the United States] is just like the arms race during the Cold War and will become the central issue of international politics.” Peng, “COVID-19.”

peacetime export control regime to organize its technological embargo of the Eastern Bloc. It also formed the Coordinating Committee for Multilateral Export Controls, a multinational association of allied nations to coordinate national controls of the most sensitive military and dual-use technologies. These export regimes formed separate layers of a global tech embargo that continued until the USSR’s dissolution.

Suspicion of foreign dependence has been a feature of Chinese Communist Party thinking since its rugged origins as a guerrilla force operating in China’s western hinterland.

Today, the same approach informs the Trump administration’s attitude toward great power competition, revealing itself in comments of senior officials such as the following one: “We know how to win these races and we know how to spend the adversary into oblivion.”²⁷ The administration’s strategic vision for long-term competition with China—encapsulated in the idea of an “economic prosperity network” of like-minded countries rerouting their supply chains around China—hearkens back to the Cold War’s neat delineation between the communist East and capitalist West.²⁸

The Cold War also left a deep impression on China, creating a strong preference for industrial resilience and technological independence. Suspicion of foreign dependence has been a feature of Chinese Communist Party thinking since its rugged origins as a guerrilla force operating in China’s western hinterland. The Cold War, and particularly, the 1959 Sino-Soviet split, powerfully reinforced this predisposition. China did not experience the Cold War as a “cold” conflict but rather

²⁷ The quoted comment is from arms control envoy Marshall Billingslea. Reuters, “US Prepared to Spend.”

²⁸ Pamuk and Shalal, “Trump Administration Pushing.”

General Secretary Xi Jinping's push to reduce dependency on foreign technology is neither an atavistic turn nor a momentary zeitgeist. It reflects a consensus, passed down by all of China's leaders since Mao.

as a perilously hot one playing out on China's doorstep, always on the verge of engulfing the country. The fear—indeed, the terror—of a land invasion or nuclear attack convinced party leaders to expend massive resources to uproot the country's industrial base and move it to the greater safety of the country's interior.²⁹ Today, even as China's financial and tech hubs flourish in coastal cities, much of China's defense-related industrial capacity, like scar tissue covering old wounds, remains in the remote western part of the country.³⁰

The Cold War experience also shaped what China's leaders believe is possible under adverse conditions. The 1959 Sino-Soviet split confronted China with the loss of Soviet assistance and an ominous technology. The departure of Soviet technical advisors stopped China's atomic bomb program in its tracks at a time when China regarded itself as surrounded by two hostile, nuclear-armed powers. In response, China embarked on a series of large domestic science projects that have since been immortalized in party lore. Although "self-reliance" (*zili gongsheng*), as Mao Zedong called it, motivated disastrous decisions like the ones that led to

²⁹ At a cost of RMB 205 billion, the Third Front was the most expensive Mao-era industrialization campaign, costing more than the First Five-Year Plan and Great Leap Forward combined. It also came at enormous personal cost, involving the mobilization of fifteen million workers and one million family members who were sent to China's west. Meyskens, *Militarization of Cold War China*, 1.

³⁰ The fear that motivates these extreme actions has stayed with the party, shaping its internal culture and outlook. As Xi put it in a 2017 speech, "[o]ur party was born under a sense of peril, grew up under a sense of peril and matured under a sense of peril." Buckley, "How Xi Jinping Made His Power Grab."

the Great Leap Forward, it also produced early triumphs in science and technology, including China's atomic bomb, early space program, and cure for malaria, which went unacknowledged by the world until recently.³¹

Rather than die with Mao, "self-reliance" continued to evolve as China joined the global economy and found expression in concepts like "indigenous innovation" (*zizhu chuangxin*) and big research and development (R&D) initiatives like the 863 Project and 973 Program.³² Hu Jintao's 2006 promulgation of "The National Medium- and Long-Term Program for Science and Technology Development" (MLP) offered another marker of this aspiration to mobilize resources intended to bolster homegrown technological capabilities and reduce foreign dependencies.³³

Today, Chinese leaders urge China's engineers and scientists to harness the spirit of "two bombs, one satellite" (*liangdan yixing*)—a reference to China's atomic and hydrogen bombs and first satellite—to overcome adversity and build a domestic technology base.³⁴ In this context, General Secretary Xi Jinping's push to reduce dependency on foreign technology is neither an atavistic turn nor a momentary zeitgeist. It reflects a consensus, passed down by all of China's leaders since Mao. It also reflects real confidence, no doubt mixed with bravado, that even if transitional sacrifices are required to close the technology gap, the Chinese people can once again, in the words of Xi, "tighten their belt" and "grit their teeth."³⁵

³¹ Perlez, "Answering an Appeal by Mao."

³² We should not ascribe greater intellectual coherence to these concepts and policies than they deserve. Reviewing China's techno-nationalist policies in the '80s and '90s, Barry Naughton and Adam Segal conclude that such policies "represent purely adaptive, opportunistic policies of 'muddling through.'" Naughton and Segal, "Technology Development in the New Millennium." See also Feigenbaum, *China's Techno-Warriors*.

³³ State Council, "National Medium- and Long-Term Program."

³⁴ Cheung, *Fortifying China*, 161.

³⁵ Triolo et al., "Xi Jinping Puts 'Indigenous Innovation.'"

Just as Bill Clinton was kept focused on the American economy by the phrase “it’s about the economy, stupid” when he ran for president in 1992, we urge decision-makers in the United States and China to supplement particular analyses with a broader consideration: “it’s about the relationship, stupid.”

Influenced by their histories with the Soviet Union, both US and Chinese leaders will find information in these papers that suggests the potential for disconnection. Matthew Daniels’ paper on the space industry chronicles a history of decoupling that may be appealing to both nations. For US policymakers, continued leadership in space can be taken as proof that preeminence can be maintained even while paying a price for disconnection. For their part, Chinese leaders can point to gains in space technology, bringing it well past the Soviet Union even though in many respects (for example, heavy launch and reusable rockets) it is still well behind the United States.

Yet the situation is notably more complicated and uncertain in other sectors described in this series. In biotechnology, China and the United States have a symbiotic relationship in which China is highly dependent on access to American basic research, while the United States depends on China for a significant supply of pharmaceutical products. The paper on this subject suggests that the United States could slow China’s short-term progress in biotechnology but questions the longer-term benefits of such a strategy. In semiconductors, American control of key tools and equipment can at least limit the pace of indigenous development in China. However, the size of China’s market makes China an important source of revenue to US chip companies, and extending controls risks displacing Chinese demand from American to other European and

Asian suppliers. Telecommunications is uniquely different because America has no systems integrator on a par with Huawei. At the same time, China’s position in 5G is severely weakened by dependence on US semiconductors, the lifeblood of this activity. In sum, other technology areas do not seem likely to establish the relatively stable disconnection that has characterized space programs.

Conjoined Siblings

These perceptions of the past and expectations about the future encourage national leaders to believe that at least in some important cases opportunities for decoupling are available and desirable. The papers in this series valuably assess these possibilities. After pondering them, we recommend that readers go further and consider particular steps within the context of the Sino-American relationship. Just as Bill Clinton was kept focused on the American economy by the phrase “it’s about the economy, stupid” when he ran for president in 1992, we urge decision-makers in the United States and China to supplement particular analyses with a broader consideration: “it’s about the relationship, stupid.”

The relationship is shaped by three powerful realities. The first is that when China and the United States deal with each other, they are grappling with a counterpart whose economic power and global engagement far transcends that of the Soviet Union. The second is path dependency. It is not just the power and engagement of these two countries with the world. It is their engagement with each other. Sino-American connections built over forty years cannot be erased or revised like chalk on a blackboard. The third is that to realize their potential and protect their citizens, China and the United States must achieve some measure of partnership. Neither can dominate the world. They must share it.

Chinese and American Power. Neither country can deal with the other as it dealt with the Soviet Union. The Western policy of isolating the Soviet Union triumphed when “disconnection” was paired with a strategy to step up defense spending beyond the USSR’s capabilities. This exploited a strategic advantage: the Soviet Union’s economy was never even half as large as the United States.³⁶ China, though behind in key technologies, has a GDP that is projected to surpass that of the United States within a decade at current exchange rates, and may have already passed it when measured by purchasing power parity.³⁷ Even before the COVID-19 pandemic brought the United States to a point where its debt exceeds its national product,³⁸ it was not feasible for the United States to couple a containment strategy with one built on spending the Chinese government “into oblivion.”³⁹

The converse is similarly true. Though an important strand of Chinese thought sees America as in decline, America’s often-manifested innovative capabilities and resilience, its demographic advantages, and its global trading relationships and

alliances make it an unquestionably central actor over the next decades. Unlike the USSR, whose economic strategy focused on Russian domestic production supported by subservient states behind an iron curtain, both countries are globally integrated trading powers. Neither will fall by the wayside or surrender in a technology, economic, or military competition. Both must presume that the other will be a peer.

Path Dependency. Though the USSR and the United States were wartime allies, their economies were never substantially connected. They could as plausibly be separated as two strangers turned enemies, each pursuing separate paths. By contrast, more than forty years of connection have turned the United States and China into something resembling siblings with a common nervous system. They are not twins because they are very different, but they are conjoined, that is, bound together.⁴⁰ The blood loss and nerve damage from separation confounds confident assessment, but indubitably would be immense.

A Shared World. Interactions between the USSR and the United States were not premised on a shared future. Implicitly, the relationship was zero sum—Soviet gains were US losses and vice versa. Even amidst the present conflict, this is not and should not be the dominant point of view in America and China. As a result, even while actively competing, leaders must consider some transcendent questions: How can their countries avoid war and dampen conflict? Can they maximize material and technological progress within both societies? Can they cooperate on the range of projects essential to

³⁶ “Both individually (China) and collectively (China, Russia, Iran), the revisionist powers’ economic might is substantially greater than any power or group of powers the United States has faced over the past century. Consider that at the time the United States entered World War I in 1917, the U.S. economy as measured by GDP was nearly three times that of Imperial Germany. When Imperial Japan’s production peaked in 1943 during World War II, along with Nazi Germany’s, their combined economic power was less than 40 percent that of the United States. . . . During the Cold War, Soviet Russia could do little better than these earlier rivals. In 1980, with the United States suffering from stagflation and the oil shocks following Iran’s revolution, the USSR’s economy was barely 40 percent that of the United States, and perhaps less.” Krepinevich, *Preserving the Balance*, 38–39.

³⁷ Tang, “China Overtakes US as No 1 in Buying Power.”

³⁸ “The United States is the only country whose debt-to-GDP ratio is expected to continue rising after 2021, according to the International Monetary Fund’s Fiscal Monitor Report.” Davidson, “U.S. Debt Is Set to Exceed Size of the Economy Next Year.”

³⁹ Reuters, “US Prepared to Spend.”

⁴⁰ Farrell and Newman used the same metaphor: “[China’s] economy is not a discrete organism that can easily be separated from the global economy but rather a Siamese twin, connected by nervous tissue, common organs, and a shared circulatory system.” Farrell and Newman, “Folly of Decoupling from China.” In a newspaper column reporting on this study (“‘Decoupling’ the U.S. from China Would Backfire”), David Ignatius employed this metaphor as well.

the future of humanity, notably including working in concert to avert climate catastrophe?⁴¹

Rather than eliminating interdependencies, Chinese and American leaders appear to be trimming and policing them, restructuring connections where security risks can be mitigated or leverage extracted while maintaining core components of a larger and still robust relationship.

While the rhetoric and indeed reality of competition take center stage, policymakers tacitly respond to the gravitational pull of these transcendent considerations. Outside the focus of these papers, we are struck by how many important aspects of the relationship remain robust. These include extensive China-US trade and access by corporations to both markets; transnational capital flows, including Chinese holdings of more than \$1 trillion of American debt; and travel for study, work, and tourism between the two countries. While leaders in both countries decry interdependencies, neither

⁴¹ An APL paper discussed the need for cooperation at greater length, observing: “The United States cannot solve [global] problems by forming alliances only with like-minded democracies. America must do something harder, which is to cooperate with adversaries and potential adversaries. . . . An effort of this kind would need to transcend concerns that information shared for cooperation could be used against us in conflict. The risk is real. Our strategic premises, however, incline us to proceed down this path, analyzing periodically whether benefits outweigh costs and accepting a measure of risk so long as likely gains outweigh risks.” Danzig, *A Preface to Strategy*, 44–45. Climate change is perhaps the most formidable example of the need to pursue broad-based cooperation. As Jeff Colgan argues, China is an indispensable partner in decarbonizing the global economy, and decoupling from China will eliminate any leverage that the United States has over China to induce its participation in reducing global emissions. Colgan, “Climate Case Against Decoupling.”

country has committed to broad movement away from these basics.

Rather than eliminating interdependencies, Chinese and American leaders appear to be trimming and policing them, restructuring connections where security risks can be mitigated or leverage extracted while maintaining core components of a larger and still robust relationship.⁴² At present, 370,000 Chinese citizens, including the daughter of Xi Jinping, study at American universities; Apple continues to be indirectly responsible for employing over three million workers in China;⁴³ General Motors continues to sell more cars in China than it does in the United States;⁴⁴ and American investors continue to be a major and growing source of foreign direct investment in China.⁴⁵ Over the longer term, the desirability of the tactics discussed in these papers is likely to be determined not just by their effects on interactions around a particular technology but also, and probably most significantly, by their effects on these and other aspects of the broader relationship.

Students and semiconductors, the focus of three papers in this series, are illustrative of connections that are fundamental, presently stressed, but still largely intact.⁴⁶ A substantial contingent of students leaves China every year to study in the United States. For China, this migration opens a channel of foreign influence in an otherwise controlled society and creates a serious “brain drain” as many of the best and brightest of this cohort end up not coming back. Yet building a high-tech economy

⁴² This is the outcome that several forward-thinking scholars on the subject of interdependence contemplate. Wright, “Sifting through Interdependence”; and Farrell and Newman, “Weaponized Interdependence.”

⁴³ Mickle and Kubota, “Tim Cook and Apple Bet Everything on China.”

⁴⁴ Yang, Liu, and Shepard, “China Cautious on Hitting Back.”

⁴⁵ Wang, “US Investors Still Piling FDI Money into China.”

⁴⁶ Zwetsloot and Truex write about students; Fuller writes about semiconductors. Triolo’s paper on telecommunications also significantly considers semiconductors.

requires a skilled workforce, a component of which is best acquired through sending students abroad. In some areas, like biotech—as described by Rob Carlson and Rik Wehbring—China is making progress toward indigenous innovation but currently remains dependent on importing knowledge, especially basic research, from overseas. Hence the country’s leaders put a positive spin on this outward flow of talent, referring to talent that stays abroad as “storing brainpower overseas” and contriving ways to extract greater benefits from the status quo such as returnee recruitment initiatives and technology transfer schemes.

Semiconductors, the building blocks of so much in the modern world, provide another example of how the relationship is conjoined and how for quite different reasons, both countries resist separation, even while they are attracted to it.

For the United States, Chinese students provide considerable benefits in the form of cultural capital, STEM talent, and, particularly for undergraduates, tuition payments. Many of these students settle in the United States and contribute to its long-term competitiveness. (Remco Zwetsloot’s paper documents the stay rate of STEM PhDs to be as high as 90 percent.) However, Zwetsloot also notes considerations that could readily justify American restrictions:

It is clear from official documents and statements that the CCP intends to use students and researchers abroad for technology transfer, and it has built an extensive policy infrastructure . . . in pursuit of this goal. Many of these policies are in conflict with traditional research norms, for example by requiring nondisclosure of professional affiliations or funding

sources. Similarly, there is little doubt that technology transfer activities have contributed to China’s growing economic and military power.

Despite these undeniable facts, restrictions on students remain, and in our view should remain, as Rory Truex and Zwetsloot recommend, at the margins. Zwetsloot observes, for instance, that postdoctoral and visiting researchers, especially those affiliated with the Chinese military, account for a disproportionate number of technology transfer and illicit theft risks.⁴⁷ Accordingly, imposing restrictions and targeted visa screenings will go a long way to reduce concerns.⁴⁸ Similarly, Truex provides a number of practical steps that policymakers could put into place to bolster research security without fundamentally changing the composition or culture of US campuses.

For us, the most fundamental questions transcend technology. A large number of Chinese citizens studying in America nourishes the relationship. It builds a constituency that understands both nations and creates professional relationships that endure after the period of study. Presently, the Chinese Communist Party seems effectively to be minimizing the political opportunities of those judged to be influenced by their time in the West. Over the long term, though, we value the possibility that this group may influence China in a positive manner. And, even in the short term, we value the opportunity this culturally broad-gauge and bilingual group presents to create a common understanding, especially in scientific and technical communities where a shared identity is key to global progress.⁴⁹

⁴⁷ Subsequent work provides more insight on this point. Fedasiuk and Feldgoise, *Youth Thousand Talents Plan*.

⁴⁸ Further adjustments at the margin, we believe, can be made through working in concert with our allies. Imbrie and Fedasiuk, “Untangling the Web.”

⁴⁹ Snyder, “As U.S. and China Fight.”

Semiconductors, the building blocks of so much in the modern world, provide another example of how the relationship is conjoined and how for quite different reasons, both countries resist separation, even while they are attracted to it. To Douglas Fuller's detailed analysis in his "Measure Twice, Cut Once" paper, we would add the observation that a credible estimate calculates that 85 percent of the semiconductors used each year by China come from outside the country.⁵⁰ China will almost certainly fall woefully short of its 2015 goal of reaching 70 percent self-sufficiency in chips by 2025.⁵¹

Both countries recognize the coercive and espionage power that would stem from controlling the other's telecommunications infrastructure. They are accordingly moving to independent systems.

The intractability of this dependency is evidenced by the tightrope that one Chinese national champion, the Semiconductor Manufacturing International Corporation (SMIC), walks. Despite being a prime mover in China's chip self-sufficiency push, SMIC relies heavily on US-origin semiconductor manufacturing equipment. This no doubt is what prompts otherwise surprising statements by SMIC executives suggesting that the company would stop producing chips for Huawei so as to comply with US export controls.⁵² SMIC, of course, is concerned

⁵⁰ IC Insights, "Can We Believe the Hype?"

⁵¹ IC Insights, "China to Fall Far Short."

⁵² According to *Nikkei Asian Review*, "SMIC Co-CEO Zhao Haijun . . . has said the chipmaker remains fully committed to complying with all U.S. regulations and that the company has been in constant communication with its equipment and material suppliers and the U.S. Department of Commerce . . . SMIC still relies heavily on U.S. chipmaking equipment and design tools, which are essential for its plans for advanced 14-nm chip production." Tabeta and Ihara, "China Chipmaker SMIC." Subsequent events suggest that the United States may nonetheless take action against SMIC given its connections to

that it too will be blacklisted by the United States if it does not comply.

The interdependence illuminated by this example runs in both directions. While Fuller's paper explains how capital equipment and electronic data automation (EDA) tools are dominated by Americans, he also describes how the resulting Chinese revenue is important to sustaining US semiconductor R&D. Beyond capital equipment and EDA, Fuller's paper points out that a third of American semiconductor company revenue comes from China. Probably for this reason, the United States shows no inclination to restrict the 85 percent of chips shipped to China, or even the significant subset of them that no doubt flow to the People's Liberation Army (PLA).⁵³ To us, the US objective with respect to semiconductors may best be described as seeking to maintain the present terms of interdependency, not end it.⁵⁴

We see the struggle over telecommunications, a third subject of the papers in this series, against this backdrop. Both countries recognize the coercive and espionage power that would stem from controlling the other's telecommunications infrastructure. They are accordingly moving to independent systems. But, as Paul Triolo emphasizes, telecommunications equipment runs on and through a technological stack of software, chips, standards, code, manufacturing processes, and infrastructure such as submarine cables. Even as the Trump

China's defense establishment. SMIC firmly denied having ties to the military. Whalen, "U.S. Considers Cutting Trade." For its part, the Chinese government can be expected to pressure SMIC to continue working with Huawei through covert channels.

⁵³ US officials have become increasingly concerned about "end users" like the PLA and have tightened controls around military end users. Gibson Dunn, "U.S. Moves to Tighten Export Controls."

⁵⁴ We are grateful to Jason Matheny who wrote to us in August 2020 observing that "American controls on semiconductor manufacturing tools and equipment [have the effect of preserving] connections by preempting Chinese capabilities for disconnection."

administration holds a tough line on Huawei, it has relaxed restrictions on US companies cooperating with Huawei in standards-setting processes after recognizing that barring US companies from such cooperation would hamper their influence over these processes and the reach of their technology.⁵⁵ Standards setting appears likely to be an intensified area of competition, but not of disconnection.⁵⁶

Leaders of both nations have begun to explore a journey over terrain that is badly mapped. They do so with vehicles that are hard to control, difficult to maintain, and subject not only to accidents and errors but also to sabotage. The resulting uncertainties will inhibit and distort initiatives.

Similarly, hardware interdependencies remain. China relies on US chipmakers for crucial components in its 5G base stations. Conversely, Qualcomm, the primary 5G hardware manufacturer in the United States, relies on the Chinese market for over half its net revenue, a significant portion of which it, in turn, plows back into R&D to remain competitive.⁵⁷ In addition, the two wireless system integrators that the United States and like-minded allies have turned to since rebuffing Huawei—Ericsson and Nokia—rely on

⁵⁵ Xie, “In Rare Move.” Similar issues will arise over cooperation on open-source software, which is not now subject to US Commerce Department controls.

⁵⁶ “Geopolitical antagonisms threaten to politicize the work of technical committees. Gone are the days ‘when international technical standardisation was all about a cooperative search for technical solutions to the economic benefit of transnationally acting corporations, trade and technological innovation.’” Dieter Ernst, quoting Tim Rühlig (*Technical Standardization*), in “Introductory Remark.”

⁵⁷ Domm, “Qualcomm, Deere, Best Buy.” Laskai and Sacks, “Right Way to Protect.”

manufacturing plants in China to produce at least some of their 5G equipment.⁵⁸ In a fully decoupled ecosystem, both countries would need to sever these connections too.

In sum, the papers in this series focus on the foreground of controversy about disconnection but should be read against the less-illuminated background of connection. The critical question is whether background realities will keep the siblings more closely bound than initiatives and rhetoric in the foreground at present would suggest. If the actors cannot control the effects of their actions, much broader and more painful consequences will follow.

Dependence on Imperfect Tools

With this in mind, it behooves us to consider the inadequacies of instruments available for charting and effectuating changes in Sino–American technological interdependencies. To switch metaphors, the leaders of both nations have begun to explore a journey over terrain that is badly mapped. They do so with vehicles that are hard to control, difficult to maintain, and subject not only to accidents and errors but also to sabotage. The resulting uncertainties will inhibit and distort initiatives.

Instances of these difficulties recur in papers in this series. Carlson and Wehbring, for example, describe massive inadequacies of data collection with regard to biotechnology, a rapidly changing field whose revenues they estimate to be larger than that of semiconductors. They contend that the paucity of metrics and data debilitates decision-making. Triolo argues that it will be very difficult to create a confined area of disconnection for telecommunications because any such efforts implicate the much larger technology stack we have described. He warns that the attempted bifurcation

⁵⁸ Lin, Woo, and Wei, “China May Retaliate.”

may overshoot and end the globally interoperable internet as we know it.

It is tempting to oversimplify this question by contrasting the approaches, and therefore the strengths, of the two countries. Chinese five-year plans and the like are emblematic of a top-down authoritarian system.

Christine Fox persuasively describes how artificial intelligence (AI) is comparable to electricity or arithmetic, making it extraordinarily hard to distinguish civilian and military applications. She makes a good case that free exchange and cooperation in basic research animates progress important to a wide range of civilian applications. Accordingly, she recommends that we confine restrictions on AI to military applications and data. But that differentiation will obviously be easier to preach than to practice. Would we, for example, regulate research that facilitates inferences about AI models from observing their behavior?⁵⁹

The effort to differentiate embargoed military technologies from permissible commercial technologies has always been challenging, but national authorities will have more problems now establishing this distinction than they did in the twentieth century. Space technologies such as launch capabilities and processes that harden components against the stresses of operating in space once seemed largely military, but that differentiation is eroded by a proliferation of space-based services and private launch companies using microsatellites, advanced commercial optics, data compression, and encryption. The authors in this series grapple with the difficulties of drawing a line between military

⁵⁹ See, for example, Tramèr et al., “Stealing Machine Learning Models via Prediction.”

and civilian technology in AI, biotechnology, and semiconductors.

Broad controls on civilian technologies are not only more difficult to enforce than bans on military equipment; they also generate more domestic and international resistance. A leading study observes, for example, that in the 1990s, Western IT vendors were never subject to the same level of export restrictions as satellite companies because they benefited from a strong, diverse coalition arguing against controls. Interests in the satellite industry split between those with global market ambitions and those whose market did not extend beyond the Defense Department and thus never argued against restrictions with the same force.⁶⁰

It is tempting to oversimplify this question by contrasting the approaches, and therefore the strengths, of the two countries. Chinese five-year plans and the like are emblematic of a top-down authoritarian system. America trumpets a market-centered, private sector-driven approach to technology development. One would expect, accordingly, that Chinese authorities would be better informed and empowered to direct private sector action, while the American system might be better positioned to respond to rapid, decentralized, and unpredictable changes in technologies.

We think though that the two systems are more pragmatic than their ideologies would suggest. Beijing appears to have recognized that it does best by setting broad goals and leaving local governments, state-owned enterprises, private corporations, and market forces to determine particulars.⁶¹ In America, agencies, especially around the Departments of Defense and Energy

⁶⁰ Hugo, *Trading with the Enemy*, 233.

⁶¹ Allowing decentralized implementation and room for experimentation has long been a central tenet of CCP policy-making. See Perry and Heilmann, “Embracing Uncertainty.” This is particularly true in science and technology policy; see Heilmann, Shih, and Hofem, “National Planning and Local Technology Zones”; and Segal, *Digital Dragon*.

and NASA—including particularly the National Security Agency, the Defense Advanced Research Projects Agency, and a web of national laboratories and federally funded research centers—fund projects, conduct research, and establish markets for prioritized technologies. The differences between the two systems are less than meet the eye. Second-order variables may be more important, like China’s advantage that its leaders often have technical training or its disadvantages from corruption and chilling of dissent.

What both governments share is a core weakness in understanding and affecting the modern technology landscape. Twenty-first century governments are uniquely ill-suited to play a central role containing or redirecting the flow of commercial technology. Unlike during the Cold War, when government was the engine for so many foundational breakthroughs in technology, today the innovation landscape is propelled forward by transnational networks of companies, talent, and capital. Neither the United States nor China currently has the internal capacity to comprehend this landscape, much less influence it without considerable clumsiness and collateral damage.⁶²

⁶² While making this point, Paul Triolo wrote to the authors in September 2020: “A recent good example [of the difficulties of government comprehension] is the WeChat ban, pushed forward without any interagency discussion, which saw Commerce officials admit they did not understand that WeChat was a critical platform in China for US companies! To the tune of supporting \$60–100 billion in sales. US companies questioned the need for a trade deal if the US government was going to potentially undercut their ability to do business in China (Cargill uses WeChat to manage its China operations, etc.). Commerce officials also have had to scramble heavily to come up to speed on how Tencent runs its global and US business operations (ditto ByteDance). . . . The same is true on the Chinese side, where industrial policy bureaucrats are not well equipped to understand the global value and supply chains of a Haier, a Huawei, an Alibaba, let alone a ByteDance, all operating in highly competitive market-driven sectors. Plus, government failure to establish a credible data governance regime, for example, has a huge negative impact on Chinese companies’ ability to expand globally.”

Both countries also confront difficulties orchestrating outside their borders. Daniels’ paper recounts Congress’s decision to unilaterally regulate the export of satellite technology as it would a munition in the 1990s. The decision led foreign customers, mainly in Europe, to design out US components, setting in motion a process that diminished US influence over the diffusion of satellite technology. Zwetsloot and Truex observe that to the extent America limits STEM education opportunities for Chinese students, it will dislocate demand for that education to British, German, Israeli, and Singaporean institutions. Fuller, in his paper, worries that excessive controls on how US semiconductor manufacturing equipment is used in Taiwanese and Korean foundries could lead those foundries to develop alternative sources, particularly from Japan and Europe, even if it takes a decade or so. He observes, as well, that American semiconductor companies are already considering ways to live with, but some would say circumvent, US sanctions against Huawei. These include redesigning products, moving manufacturing and headquarters abroad,⁶³ and turning a blind eye to the ultimate consumers hidden behind intermediate customers.

The strength of the two countries’ R&D establishments is relevant but disproportionately emphasized because it has constituencies that speak for it, mechanisms for achieving it, and metrics (dollars invested, publications, patents, etc.) that validate it.

In this environment success will, we expect, depend on the development of new tools to supplement (for the United States) or subvert (for China) twentieth century mechanisms like the US Committee on

⁶³ Anderson, “RISC-V Business.”

The robust constituency for R&D can be appeased by budgets. Advocates of assimilation of technology change are less numerous and powerful.

Foreign Investment in the United States (CFIUS), export controls, and multinational restrictions through the Wassenaar Arrangement. China has often effectively overcome resistance to the forced sharing of IP by making it a prerequisite for market access. China has been successful in attracting employees to defect from foreign competitors and hacking cyber systems to obtain IP that would otherwise be denied. Any program that prioritizes America's reduction in its vulnerability by keeping vendors like Huawei out of its networks must concomitantly invest in protecting IP, particularly in the areas that are the subjects of these papers: biotechnology, AI, telecommunications, semiconductors, and university research.

On the other side of the coin, software systems present opportunities for export controls that were not available for most of the twentieth century. Carlson and Wehbring, for example, report on biologics manufacturing facilities that are located in China but operate with software that is dependent on updates and data inputs from the United States. They see "an opportunity to sell final products without transferring process knowledge." Fuller describes analogous processes in US EDA systems that operate in China but need to be applied and constantly updated by experts based in the United States. American authorities could encourage more developments of this type by, for instance, giving enterprises that retain software control preferential access to R&D funding and permissive export decisions.

We conclude by noting an often overlooked, but we think particularly important, aspect of how characteristics of our means shape our ends. All papers in this series urge that the greatest rewards

are likely to accrue to the United States from enhancing American performance rather than from attempting to degrade Chinese capabilities. We very much agree. As one of us argued in another APL essay, it is seductive to externalize our problems, but we should attend not so much to our opponents as to ourselves.⁶⁴

However, we think a subtle limitation of our tools frequently leads both policymakers and the authors of these papers to highlight increased R&D funding as their principal, and in some instances exclusive, mechanism for achieving this end. In our view, it is the speed of absorption of technologies—by our government and our corporations—that will primarily determine success in contests of both hard and soft power.⁶⁵ The strength of the two countries' R&D establishments is relevant but disproportionately emphasized because it has constituencies that speak for it, mechanisms for achieving it, and metrics (dollars invested, publications, patents, etc.) that validate it.

Additions to the Pentagon budget for AI, for example, will be easier to promote than changes in military operations. France and Germany had equivalent access to the technologies—notably, the combustion engine, radio, aircraft, and encryption—that reshaped warfare in 1940, but Germany used them to create blitzkrieg. France created the Maginot Line. The robust constituency for R&D can be appeased by budgets. Advocates of assimilation of technology change are less numerous and powerful. The methods for

⁶⁴ Danzig et al., *Preface to Strategy*, 3.

⁶⁵ This is recognized, at least rhetorically, in some US Defense Department statements. For example, the *2018 National Defense Strategy* says, "Success no longer goes to the country that develops a new technology first, but rather to the one that better integrates it and adapts its way of fighting." US Department of Defense, *Summary of the 2018 National Defense Strategy*, 10. Christine Fox captures this priority when she observes, "With respect to relatively new technologies like AI, organizational capacity, or the ability and willingness to absorb a new approach, is as important as, if not more important than, financial capacity or funding." Fox, *Entwined AI Future*.

addressing their requirements are more difficult to mobilize, orchestrate, and sustain.⁶⁶ This difference in tools risks gravely distorting our priorities.

In sum, while the leaders of the PRC and the United States debate ends, the nature of their relationship may be most substantially affected by their mastery of means. In this light, these papers should be seen as studies not just of the rapidly changing tools of technology, but also of the more slowly adapting tools of governance. The balance of dominance and dependence between the countries may be more responsive to the skill with which their governments comprehend and assimilate technologies than to the goals they pursue or the character of the technologies themselves.

Identification of sources of leverage is even more seductive. For both countries, these efforts are attractive as methods of accumulating power without making strategic choices. They are like individuals building individual bank accounts while deferring decisions about more important life choices.

Conclusion

We conclude by returning to where we started. Questions about the Sino–American relationship, settled by hostility in the mid-twentieth century and then reconstructed positively in the last quarter of that century, are now unsettled. This can be dangerous and is, at a minimum, disruptive for all concerned. Policymakers and publics always respond better to clarion calls than to confusion. A war, either hot or cold, creates clarity. Alternatively,

⁶⁶ We discuss the prerequisites for innovation and the barriers to it in Danzig et al., *Preface to Strategy*, 33–37.

a positive, optimistic relationship is comfortable and clear. America and China are now between these poles.

In this context, it is important both to come to grips with particulars and to see them in the broader context of the relationship. The identification and reduction of vulnerabilities is a seductive enterprise. Identification of sources of leverage is even more seductive. For both countries, these efforts are attractive as methods of accumulating power without making strategic choices. They are like individuals building individual bank accounts while deferring decisions about more important life choices. Even more seductively, both countries can persuade themselves that these steps are strategic because they echo strategies they successfully employed when dealing with the Soviet Union.

We have suggested that this is false comfort. The Sino–American relationship is deeper, more equal, more rewarding, and potentially more cooperative than relationships with the Soviet Union. The dangers of warfare, though more remote than between the United States and the USSR, are still real. National decisions about interdependency in particular technology areas naturally start with narrow judgments about national interests, costs, and benefits in those areas. All relationships are two-sided by definition. Particularly as power becomes more equal, if either country is determined to reduce interdependency, the other must respond.

We believe though that both countries will be better served if they approach judgments about technology in a wider frame that accounts for effects on Sino–American relations. The relationship between the United States and China should be regarded as too big to fail and too dangerous to become unstable.

Both nations would be well-served by recognizing that vulnerability is inherent in the twenty-first century global order in general and in this keystone relationship in particular. That situation cannot

be substantially changed by addressing particular technological dependencies. And if the leaders of either country came to believe that they had achieved substantial invulnerability, that would be a dangerous illusion. In our view, perceived mutual vulnerability in a connected world is more stabilizing than perceived independent robustness in a disconnected world.⁶⁷

Fortunately, while China struggles for more independence and the United States struggles to extend China's dependence, both countries apparently continue to accept large measures of interdependence. However contentious, present initiatives are incremental efforts to change the bathwater while preserving the baby. In the longer term, success or failure will not so much be about competition in a particular technology as about whether the relationship remains strong enough for the leaders of these two countries jointly to invent a more stable future.

⁶⁷ See the discussion of "MUD"—mutually unassured destruction—in Danzig, *Surviving on a Diet of Poisoned Fruit*.

Appendix Summaries of All “Measure Twice, Cut Once” Papers

Two Worlds, Two Bioeconomies: The Impacts of Decoupling US–China Trade and Technology Transfer by Rob Carlson and Rik Wehbring

Biotechnology, the engineering and application of the science of biology to meet human goals, is critical to economic success in the twenty-first century. In the United States, revenues generated by biotechnology (principally drugs, crops, and chemicals) are already larger than 2 percent of gross domestic product and are growing approximately twice as fast as the economy as a whole. Individuals and news articles from China describe similarly sized biotechnology revenues there, but in both nations, the accuracy and precision of estimates is limited by the paucity of data.

Revenues to date have been achieved using first-generation technologies. Second-generation technologies will be more powerful and could supply up to 60 percent of physical inputs to the global economy, with a direct economic impact of \$4 trillion a year. Chinese leaders have identified biotechnology in writings and in pronouncements as critical to their vision of China as a dominant global economic power. To that end, they are pursuing a long-term strategy of climbing up the value chain and using a familiar set of tactics that includes the following: financial support for industry champions, intellectual property licensing from abroad, infrastructure spending (laboratories, technology parks, academic research), as well as IT hacking and industrial espionage. By contrast, the United States has adopted a laissez-faire approach and has little strategy or policy regarding biotechnology.

The bioeconomies of the two nations may be similar in size but are configured differently. The United States relies on China for manufacturing (for example, 75 percent of active pharmaceutical ingredients), for services (for example, DNA sequencing), and for talented students who come to study and work at US universities. Meanwhile, China depends on external basic research to support a bioeconomy focused on commercialization of innovations created elsewhere. In the short term, decoupling would be painful for both countries. In the long term, it would be easier for the United States to replace manufacturing capacity and academic labor than it would be for China to find globally, or to replicate within China, a basic research and academic infrastructure that is the equivalent to that of the United States.

There are no absolute impediments that would prevent the United States from ultimately reducing interactions to near zero. Instead, decoupling decisions must revolve around the cost and the time they would require to implement. These decisions are currently impossible to make in an informed fashion, and we therefore make two recommendations: (1) the US government should measure the domestic bioeconomy, and the bioeconomies of its rivals, with greater granularity and accuracy, and (2) the US government should develop a framework and strategy for competing in biotechnology.

The History and Future of US–China Competition and Cooperation in Space by Matthew Daniels

This paper observes that American and Chinese space programs have been sharply disconnected for the last two decades and remain so today. Both programs lead the world, but between the two countries, America has greater strengths and is likely to maintain its advantages in the decades ahead. Notwithstanding this,

this paper observes that our present policies may have long-term costs that exceed their benefits to America. Principally, this is because constraints on interaction continue to increase the cost of engaging our own allies and partners, are unlikely to significantly hobble the Chinese program, and are likely to impose added challenges on our own programs. These costs are mostly in consequences to America's commercial space industry, to our ability to draw partner nations closer to our space program, and to our ability to understand (and therefore to better compete with) Chinese government space programs. Accordingly, while endorsing the thrust of our present policies toward disconnection, this discussion advises framing next steps with a greater focus on effects on the US space industry and especially clarity about US strategic objectives in space. A focus on US space primacy suggests continued separation is the best path; a greater focus on the United States playing an international ordering role and managing risks of conflict in space suggests some narrow relaxation of these policies, mostly in civil space activities.

An Entwined AI Future: Resistance Is Futile by Christine Fox

Both the importance of artificial intelligence (AI) and the difficulty of controlling its dissemination derive from its character as a general-purpose technology. Although most of the foundational work on AI was initially pursued by the US government, the largest investments and developments of the past two decades have taken place in the commercial sector, with the results publicly available in open source for use by many thousands of programmers collaborating across national boundaries. AI by its nature cannot be stored in a warehouse. Though AI will ultimately, in some form, be present in many, perhaps most, weapons systems, it is not a weapons system. AI is becoming as pervasive and accessible as, for example, electricity or digital computing or even arithmetic in the last century. As such, we do not think its fundamentals can or should be controlled by government action.

We do think, however, that some particular applications and data sets relevant to national security capabilities can and should be controlled. It is also sensible to limit Chinese access to some high-end semiconductor chips required for the most sophisticated AI applications and, especially, to retain US and allied dominance over the tools needed to manufacture those chips.

The preferred Cold War tools for blunting an adversary's technological advances—including classification and export restriction—are not as applicable to most forms of AI (though the Commerce Department is testing that proposition with recent export controls). Many key AI technologies are shared freely through open-source resources such as GitHub and Google's TensorFlow. Beyond that, Chinese access to information, hardware, and software can occur by a variety of means beyond purchase from the United States. These include cyber theft, coercive joint ventures with non-Chinese companies, access to US universities and market programs, and transactions with third-party countries. Plugging these gaps will be of greater benefit than attempting to decouple wholesale from China's AI ecosystem with blunt policy tools.

We believe that Chinese advantages—large and robust markets, talented people, and skilled training programs—will inevitably make China a strong AI competitor. The United States must invest comparably in the robustness of its markets, the talent of its population, and the strength of its training programs. It is more productive to make America stronger than it is to make China weaker. Attempting the latter by decoupling weakens America by isolating us from much of the world that will continue to do business with China while cutting off America's access to a major source of the AI talent and innovation.

This paper explores the US–China AI relationship in its various dimensions and latest developments; then considers what a productive and mutually beneficial relationship would be; and, in closing, offers thoughts on how to reconcile these goals, where possible, with our most critical national security imperatives.

Cutting off Our Nose to Spite Our Face: US Policy toward Huawei and China in Key Semiconductor Industry Inputs, Capital Equipment, and Electronic Design Automation Tools by Douglas B. Fuller

Semiconductors are core components in telecommunications, artificial intelligence computing, and many other high-tech goods. It is not surprising, accordingly, that the United States has placed semiconductors front and center in its policies designed to crush Huawei. By placing Huawei and its affiliates on the Entity List in May 2019, the American government has tried to cut Huawei off from the American semiconductor technology. On May 15, 2020, the US government doubled down on this gambit by restricting Huawei's access to two areas of particular American strength in the semiconductor value chain: capital equipment for chip production and electronic design automation (EDA) for chip design. The US government further tightened those restrictions on August 17, 2020.

This paper has four major findings. First, over the next five years, even substantial Chinese efforts to replace American capital equipment and EDA tools with homegrown alternatives are very unlikely to succeed. Second, the severity of constraints on Huawei will depend more on the availability of international alternatives to American technology than on the availability of Chinese products. The lack of suitable legal alternatives to American EDA tools globally will severely challenge Huawei's ability to design chips. In contrast, for chip manufacturing, alternatives to American capital equipment might be obtained within a comparatively short time, so manufacturing firms might still be able to produce Huawei's chips relatively quickly if they choose to eschew American technology to do so. Third, these constraints will most likely knock Huawei down but will not knock it out of the telecommunications industry. Finally, the longer-term costs for American capital equipment and EDA tool vendors could loom large if foreign customers perceive American-made or -designed products as carrying significant political risk and strive to develop alternative sources.

To illuminate these points, this paper first presents a brief introduction of the evolution of the semiconductor industry's value chain since the 1980s with an emphasis on how the reorganization of the global semiconductor industry helped to revive the American industry in the face of Japanese competition. This point provides important context for considering current calls for decoupling and deglobalization. The paper's next section examines the EDA industry in the United States and China and Huawei's EDA options if the export controls are fully implemented. This is followed by an examination of the fabrication capital equipment industries in the United States and China. This illuminates Huawei's integrated circuit manufacturing options if US export controls are fully implemented. The concluding section of this paper considers whether even the most stringent implementation of the current controls actually will impact Huawei as envisioned. The conclusion recommends an alternative American approach to technological competition with China that is focused on reinforcing our semiconductor capabilities instead of trying to tear down China's.

The Telecommunications Industry in US–China Context: Evolving toward Near-Complete Bifurcation by Paul Triolo

The telecommunications sectors in the United States and China have a long history of interconnection, but both countries are now developing policies with the effect of decoupling technology stacks, supply chains, and markets. Once in motion, these policies will be difficult to reverse, given the political distrust that has engulfed the bilateral relationship and emboldened extreme views on both sides about each other's hegemonic intentions. The costs to both countries' innovation systems and to global value chains built up over decades will be significant. Over the next five years, a full bifurcation may take the industry back to the days of separate and competing national standards, problems with interoperability, and the end of a globalized value chain with all its attendant benefits in terms of cost, innovation, and compatibility. The growing cleavage between the two telecommunication systems will have broad ripple effects across a great number of technological sectors, including an intensifying struggle over the future of the internet.

The challenge for US policymakers over the next decade will be to counter China's early lead in 5G while simultaneously enabling interoperability and a globalized supply chain. This will require perceptive domestic industrial policies, substantial investment, and skillful diplomacy that values and refreshes global multi-stakeholder governance and standards-setting processes. Navigating this complex geopolitical, technical, and economic landscape will be hugely difficult for existing US institutions and will require US officials to reimagine how the United States sets telecommunications policy.

Addressing the China Challenge for American Universities by Rory Truex

Members of the US government have expressed concern that the Chinese government is targeting American researchers and labs for espionage and theft of information with commercial, military, and intelligence value. There are also separate concerns about inappropriate relationships between US researchers and Chinese institutions and the flow of human capital from US research institutions back to China.

This paper—one of two commissioned on science, technology, engineering, and mathematics (STEM) issues—argues that there is insufficient evidence that academic/economic espionage by Chinese nationals is a widespread problem at US universities. After 20 months of ongoing investigations, the “China Initiative”—a Department of Justice (DOJ) effort—has brought formal charges at only ten US universities or research institutions, and only three cases involved any evidence of espionage, theft, or transfer of intellectual property. Given about 107,000 Chinese citizens in STEM at US universities at the graduate level or above, current DOJ charges imply a criminality rate in this population of .0000934, less than 1/10,000. Given this evidence, we can consider ways to enhance research security at US universities but should be especially wary of overcorrections. Current solutions, which rely on mass visa restrictions and heightened monitoring of Chinese researchers, are counterproductive and will harm American science and national security in the long term.

Efforts to improve research security should proceed from these principles: First, no policy should foster systematic discrimination against a population based on its ethnicity or nation of origin. Second, policies must recognize the importance of foreign-born researchers—and Chinese researchers in particular—to the US economy and US universities, which are themselves of strategic importance. Third, we must acknowledge that our model of science has unavoidable vulnerabilities with respect to plagiarism,

economic espionage, and other forms of theft. Within this framework, US universities and the government can cooperate in addressing security threats from China in a way that is mutually beneficial and consistent with academic values.

In particular, these policy solutions would enhance research security while maintaining a welcoming environment for Chinese researchers and minimizing the possibility of discrimination.

- (1) **A No Dual-Salary Rule:** No full-time employee of an American university should receive salary or substantial compensation from the government or military of, or a university or firm in, a country of high strategic concern.
- (2) **Centralized Disclosure:** The US government should work with universities to create a standardized, centralized disclosure system for faculty professional activities and conflicts of interest. The system can include an audit component conducted by the National Science Foundation.
- (3) **Pretravel Counterintelligence Training:** US citizens traveling to China as part of an academic exchange should receive pretravel training from the US government on issues relating to Chinese espionage and elicitation practices.
- (4) **The No Surveillance Rule:** US universities and their employees should not be expected to engage in monitoring or surveillance on behalf of the law enforcement community.

US-China STEM Talent “Decoupling”: Background, Policy, and Impact by Remco Zwetsloot

One of the most difficult and controversial questions in US policy toward China is how to manage the risk associated with Chinese students and researchers in the United States. There is no doubt that the Chinese government actively seeks to use talent based abroad to advance its technological and strategic aims. Yet openness to international talent has been a key US economic and national security asset for decades. Despite the stakes involved, the US policy debate on this question has been too high on heat and too low on light. Many analyses look at only one side of the cost-benefit equation, and arguments on both sides are often insufficiently grounded in evidence.

To help elevate this debate, this paper—one of two commissioned on science, technology, engineering, and mathematics (STEM) issues—provides an overview of the relevant questions, reviews what we know and do not know about those questions, and distills priorities and principles for analysts and policymakers. While many empirical and policy questions remain unanswered, the arguments and evidence examined in the paper suggest six takeaways.

- (1) **Large-scale reductions in US-based Chinese students and researchers are, at present, unlikely to be in the US national interest.** Openness carries inevitable risk, but it also brings important benefits. There are many scenarios in which US restrictions on Chinese talent hurt the United States more than they hurt China. This assessment is based on the substantial benefits the United States derives from Chinese talent; uncertainty about whether restrictions would significantly reduce China’s ability to acquire technology from abroad; and Chinese officials’ fears of losing valuable talent to the United States.

- (2) **Without allied coordination, reductions in US–China talent flows are unlikely to thwart China’s technology ambitions.** Much of the world’s cutting-edge research and development (R&D), including in emerging dual-use fields, happens outside of the United States, and other countries actively compete with the United States for international talent. Unilateral US restrictions would mainly displace, not decrease, Chinese technology transfer activities. Coordination with allies and partners should therefore be a top priority.
- (3) **It is currently unclear what technologies or capabilities the US government wants to protect and whether restrictions on Chinese talent could protect them.** Lack of specificity about what needs to be protected, and the application of private sector frameworks to university research, makes it difficult to craft targeted policies and contributes to miscommunication between government and academia. Depending on the specific technology transfer concern, limits on US–China talent flows will not eliminate risk; transfers will continue to happen where alternative collection methods are available, such as cyber operations for written documentation. A successful US technology protection strategy will require clearer thinking about both ends and means.
- (4) **Researchers generally pose more risk than students, and different students have very different benefit and risk profiles.** Despite their higher average risk level, researchers receive less attention than students in US policy debates. Among students, those in bachelor’s and master’s programs differ from PhD students in significant ways, for example whether they contribute or cost money and whether they acquire cutting-edge skills or knowledge. Sound policy requires greater recognition of such differences.
- (5) **A successful risk management strategy will require emphasizing transparency and improving intelligence collection and dissemination.** Policies that stress research integrity and transparency resonate within academia and help universities manage risk. The US government needs to invest in better open-source intelligence collection and analysis and improve data integration and sharing between federal agencies. Without this infrastructure, it will be difficult to assess risk and take targeted countermeasures.
- (6) **Building out the domestic talent base and diversifying international intake can prevent US dependence on Chinese talent.** Circumstances can change such that US–China talent flows are, or need to be, reduced. The United States should therefore avoid being dependent on China, or any other country, for talent. US policymakers can accomplish this goal by strengthening other talent pipelines, from abroad and especially domestically.

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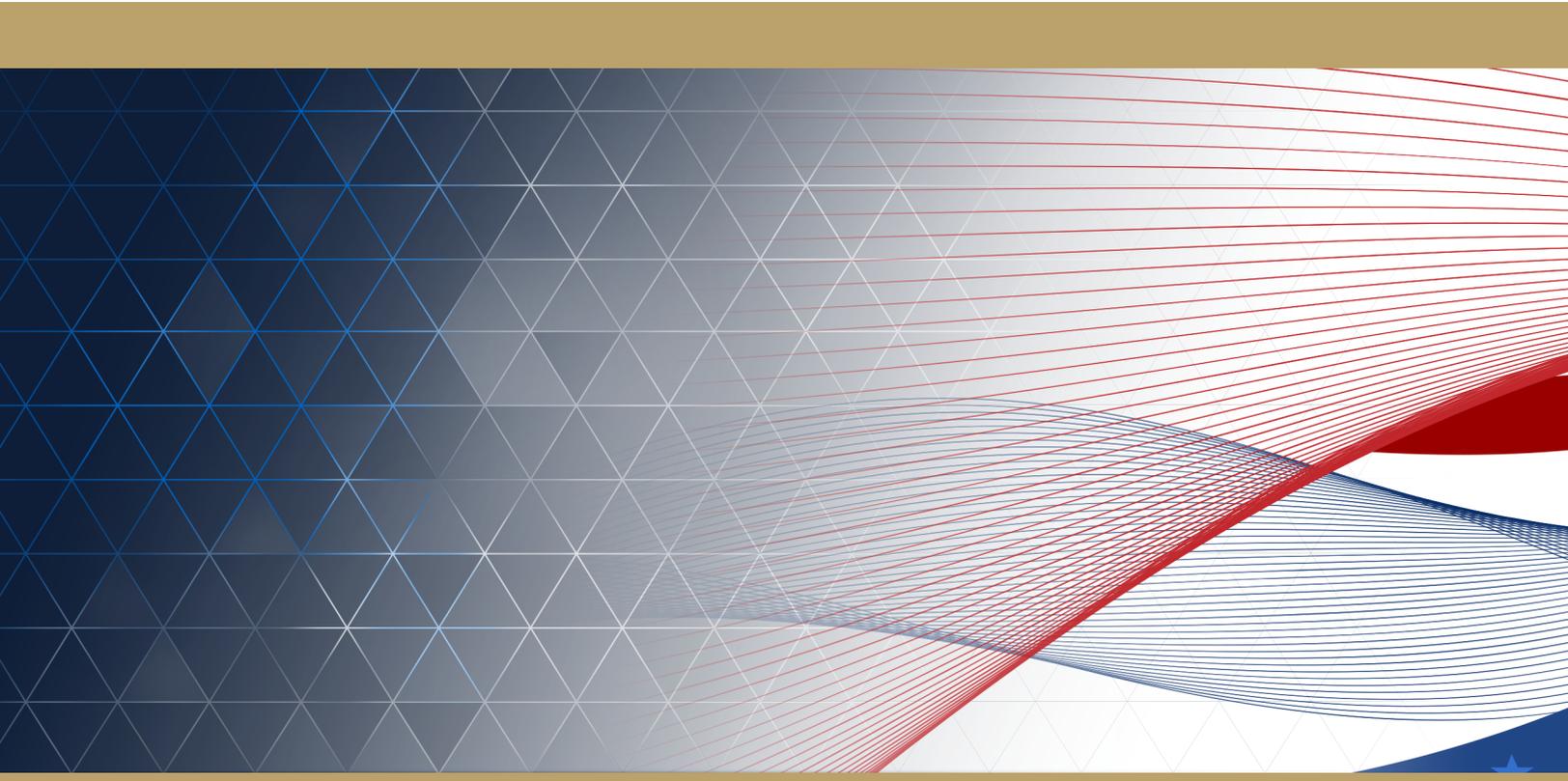
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