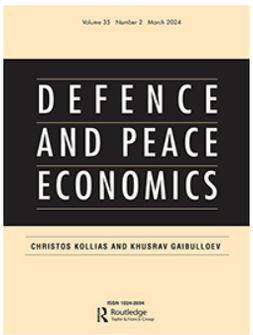

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Insecurity and Ambition: Dual Drivers of Chinese Innovation?

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ABSTRACT

This article seeks to explain why some nations make greater efforts than others do to innovate. We examine for our case study the People's Republic of China (PRC or China), which has emerged over the past several decades as a global technology leader and remains committed to bolstering its science and technology (S&T) capabilities. Applying a modified theory of 'creative insecurity,' we examine whether the balance between external and internal threats explains the variation in China's innovation efforts. The hypothesis: when faced with greater threats from abroad than at home, China will have increased its innovation endeavors, measured by its innovation-related policies and research and development (R&D) intensity. Our mixed methods approach finds some support for this hypothesis. Our initial theory, however, seems unable to account for the observation that China also *increased* its R&D intensity even when external threats *decreased* and its internal security remained stable. Thus, we introduce a complementary theory of 'creative ambition,' which proposes that China's efforts to innovate may not be merely defensive in nature but also offensive in intent to expand the PRC's power and influence abroad. We conclude with potential theoretical and policy implications of this study.

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Introduction

Why do some nations strive harder than others do to innovate? Wealth, prestige, power – the benefits of technological innovation are well known. Yet, some countries clearly spend more, and their governments devise stronger policies than others do to enhance their science and technology (S&T) programs. Why? A recent theory posits that the main driver of innovation rates is politics (Taylor 2016). As this theory of 'creative insecurity' goes, when a nation faces greater dangers from external actors than from internal forces, that state is temporarily willing to redirect some of its limited resources from serving parochial interests to funding national S&T programs.

Any holistic innovation theory must account for the People's Republic of China (PRC or China). Since the founding of the PRC, China's leaders have sought to transform the country into a technological powerhouse (Gewirtz 2019). Through a combination of copying, massive subsidies, and outright theft of intellectual property, among other policies, China has made tremendous strides in developing its indigenous technological capabilities (Atkinson and Foote 2019). In the past few decades, China has closed the gap or caught up with leading nations across many indicators of innovation; in some sectors China has taken the top position (Atkinson and Foote 2019). China leads the world in papers published and patents filed (Mervis 2022). In 2019, China spent $525 billion on research and development (R&D), falling second only to the United States at $657 billion (Burke,

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Okrent, and Hale 2022). Each year, Chinese universities graduate about three PhDs in science, technology, engineering, and mathematics (STEM) for every two such graduates from U.S. universities (Zwetsloot et al. 2021). By 2025, China may annually produce about twice as many STEM PhDs as the United States does (Zwetsloot et al. 2021). China also boasts many of the fastest start-ups to achieve a $1 billion valuation (Dychtwald 2021).

Yet for all its success, the PRC was only ranked 12th in the Global Innovation Index in 2021. Many Chinese patents and papers are of questionable quality (Heilmann 2021). Principally, China suffers from poor institutions (China Power Project 2022). Weak and uneven implementation of rules, processes, and policies have prevented China from reaching its full innovation potential. Nevertheless, China's leaders remain determined that the nation will not only catch up but one day surpass the world's most innovative countries, particularly in the area of emerging technologies. China has invested significant resources in this effort, seeking to establish world-class industries in key technologies from 5G and artificial intelligence to biotechnology and quantum computing (Gewirtz 2019). Given its exceptional rise as a technology leader and its continued will and capacity to innovate, China must be examined as part of a comprehensive theory of innovation (Seawright and Gerring 2008).

This paper uses a mixed methods approach to test a modified 'creative insecurity' theory to China. The original creative insecurity theory does well to explain how threats affect innovation *outputs*. It does so by counting patents weighted by forward citations. This paper seeks, however, to assess whether creative insecurity also explains *inputs*, measured by changes in its innovation policy and R&D intensity. Assessing inputs is a more direct way to test the threat-response relationship: doing so allows a closer look at a country's *reactions* to the balance of external and internal threats, rather than solely at the *results* of the country's innovation efforts.

Through this modified framework of creative insecurity, the evidence should show that when China's external threats outweighed internal dangers, Beijing increased its innovation efforts. This article finds some support for this hypothesis. The results show that Beijing revised national innovation policies and increased its R&D intensity after perceiving heightened threats to the security environment.

But the results also leave room for additional exploration. Contrary to expectations, China also increased its R&D intensity rates *even when external threats decreased* and its internal security remained stable. Our modified theory of creative insecurity seems unable to account for this anomaly. Thus, this article proposes a complementary theory of 'creative ambition.' Under this theory, China's efforts to innovate may not be merely defensive in nature, but also offensive in intent to expand its power and influence. This thesis is not intended to be exclusive and deterministic, but is designed to supplement the gaps in the modified creative insecurity theory.

This case study should interest scholars of innovation, China, and international relations. Innovation scholars would want to know how this case study could support, question, or sharpen a compelling theory of innovation that appears to be gaining traction in the field. For their part, China scholars would benefit by understanding how this theory illuminates the drivers underlying China's innovation rise. International relations (IR) scholars should care about this study, given that advancements in science and technology (S&T) affect almost every topic of the IR subfield, including trade, the balance of power, and alliances. Finally, policymakers would find practical implications of this study as Sino-American competition intensifies. If decisionmakers – both in Washington and Beijing, as well as around the world – gain a firmer grasp of what propels China's innovation efforts, they may be able to better shape the PRC's policy and investment decisions.

The article proceeds as follows. The first section summarizes the relevant literature on innovation and from it offers a hypothesis. The second section lays out a mixed methods approach to test the hypothesis. The next section analyzes the qualitative and quantitative evidence for the argument. The fourth section details the theoretical implications of the findings. The piece concludes with policy considerations.

Literature Review and Hypothesis

This article adopts the OECD's definition of innovation: innovation is something new or improved and available for use, whether as a product or a process (OECD and Eurostat 2018; OECD 2015). Efforts to innovate, thus, can be defined as a country's investments, attention, and policies dedicated towards improving those processes and products.

If the benefits of technological innovation are widely acknowledged, why do some countries make greater efforts than others do to advance their science and technology (S&T) programs? A recent theory posits that the answer lies in politics (Taylor 2016). According to this theory of 'creative insecurity,' it is the balance between the countervailing forces of external and internal threats that shapes innovation rates. On one end, external threats accelerate a nation's innovation pace, because foreign dangers motivate a nation to improve its economic position in the global market and to strengthen its domestic defense capabilities. On the other end, internal instability decelerates innovation rates, because disparate interest groups with competing interests – such as for education, policing, or tax subsidies – draw down limited state resources that could otherwise be applied towards science and technology initiatives. Combining the two factors we get the following formula: when foreign dangers pose greater threats than those posed by internal rivalries, a nation and its people are willing to temporarily prioritize the collective good over more parochial interests. This prioritization often takes the form of diverting some of its resources that serve narrower domestic needs towards national S&T programs (Taylor 2016, 224-229). To test this theory, Taylor undertook case studies on the technological developments of Taiwan, Israel, and Mexico, and applied statistical methods to a cross-national data set that spanned several decades, using patents as a measure of innovation rates (Taylor 2016, 236-274).

In arguing for such linkages, the theory of creative insecurity implicitly builds on three theoretical foundations: 1) state-building, 2) military development, and 3) economic and business studies. There is a large body of literature examining the relationship between threats and state-building, going as far back as Thucydides' account of a Corinthian delegate's speech to the Spartans: during peace, the old ways are best; but in times of turmoil, leaders must develop new ideas (Thucydides 1954, 77). In essence, the argument is that war – or the prospect of war – can spur state-building efforts (Gerschenkron 1962; Tilly 1990; Breznitz 2009). This idea has been tested in different regional and country contexts (Friedberg 2012; Doner, Ritchie, and Slater 2005). But these theories do not incorporate both the push factor of external threats with the countervailing pull factor of internal threats in shaping innovation rates.

Military scholars have also examined why armed forces innovate. Well-known theories credit interservice rivalries and external threats for increasing spending and shaping investment decisions in the development of military technological capabilities (Posen 1986; Dombrowski and Gholz 2006). A more recent approach frames military technological innovation as the product of the threat environment and a nation's innovation infrastructure (Schmid 2018, 31-36). These theories, however, limit their scope to military innovation, leaving civilian innovation unexplained.

Economic and business scholars have also made major contributions to the innovation literature (Schumpeter 1939). Many of these studies coalesce around the argument that a nation's domestic institutions and policies, among other factors, determine the rate of technological innovation (Rogers and Greenhalgh 2010; Fagerberg 2006). These theories only explain, however, *how* nations innovate. They describe what mix of policy tools are useful in pursuing national innovation goals. Institutions and policies, however, do not explain *why* nations decide to innovate in the first place (Taylor 2016). Similarly, other studies identify why some countries invest more in innovation than others. The reasons include differences in the long-term costs of borrowing, the extent of the protection of intellectual property rights, and a government's capacity to mobilize resources (Lederman and Maloney 2003).

Yet again, these studies focus on the factors that can aid or restrict a country's ability to invest. They do not explain why countries decide to use those policies tools to advance S&T at all. The

unique contribution of creative insecurity is that it combines both internal and external threats in explaining what drives innovation behavior.

No study yet tests the relationship between threats and innovation to China. Past studies on Chinese innovation tend to focus on *how* China has sought to innovate (Breznitz and Murphree 2012; Yip and McKern 2017). Others focus on the obstacles that constrain China's national innovation system (Schmid and Wang 2017). Some studies do qualitatively analyze why China innovates: explanations include economy, prestige, and security factors (Cheung 2022; Huang and Shen 2020). But these studies do not use quantitative analysis nor directly apply the theory of creative insecurity. The author of creative insecurity offered a first impression analysis of China. But his in-depth case studies were conducted not on China but on Taiwan, Israel, Mexico, and Ireland (Taylor 2016, 141-157, 243-274). Building on Taylor's foundational work, another scholar has conducted extensive quantitative analysis across different specifications and time periods to reach robust findings about the positive relationship between international security and innovation rates (Brummer 2020). But that scholarship, too, has not yet paired this quantitative analysis with a qualitative assessment of China.

This article seeks to fill this gap by testing the theory of creative insecurity to China, with an important modification. The author of creativity insecurity measured innovation rates through *outputs*, specifically, patents weighted by forward citations. Patents are useful for looking at the results of innovation. But there are many possible intervening factors in the process of creative activity, including policies, institutions, education systems, and sometimes luck, that could influence the eventual creation of a patent. That space between effort and result lies what scholars call the 'black box of innovation' – the unobservable, unmeasurable area where innovation actually occurs (Taylor 2016, 318).

This article measures innovation through innovation *inputs*. Such an approach better addresses the concept this article is testing – a country's *response* to its security environment, not necessarily the final products of those efforts. By using this framework, we close the gap between stimulus (threat) and response (innovation efforts), reducing the likelihood of omitting possible intervening variables that could influence the result. With this approach, this article also assesses how well the theory of creative insecurity applies to inputs.

In sum, this article tests a *modified* version of creative insecurity, looking at the relationship between threats and innovation inputs to China. If this relationship exists, we expect the data to support the following hypothesis:

> *As China perceives an increase in external threats while its internal situation remains relatively stable, we should see China's innovation efforts increase.*

Methods

This research design follows a mixed methods approach used by the author of creative insecurity and other scholars of similar studies (Taylor 2016; Jon, Brummer, and Taylor 2017; Brummer 2020). These studies found that a strong correlation exists between security threats and innovation across a global sample size.

Scope

Due to the limitations on the available quantitative data, this article chiefly examines China's innovation motivations and efforts between the years of 1991 and 2014. As described further below, the data for the independent variable range from 1816 to 2014. The data for the dependent variables are available from 1991-2019. The overlapping period of these two datasets is between the years of 1991 to 2014. Though brief, these twenty-four years provide an opportunity to pair the limited quantitative data with more qualitative analysis. The qualitative section will provide more

historical context and will extend the analysis to 2019, but the central focus will remain on the period that corresponds with the quantitative data.

Qualitative Methods

The qualitative analysis begins with a brief account starting from the founding of the PRC in 1949 of how China's leaders understood the role of technology in shaping their history. The section proceeds with a more thorough analysis of Beijing's innovation goals and efforts beginning in 1991. The section shows how changes in China's external threat environment (independent variable) led Beijing to undergo three stages of innovation reforms (dependent variable). For the qualitative analysis, this paper defines external threats as any actions by a foreign actor that hold at risk China's military, economic, diplomatic, or ideological assets. Changes in innovation policies include adjustments to military purchases in new technology, changes in civilian innovation programs, and national industrial policies focused on science and technology.

Quantitative Methods

This article does not attempt to prove causation with its quantitative methods. Rather, it uses statistical methods to perform some basic plausibility tests. If threats have any influence on innovation, then that relationship should be observed in simple correlative tests of relatively noncontroversial data (Taylor 2016).

In keeping with recent quantitative research designs used for empirical work in this field, this article applies regression analysis. It will use many of the same definitions employed in the previous literature to analyze the results. This article draws from standard datasets to measure threats and innovation, as explained below. For statistical analysis, this article applies ordinary least squares (OLS) regression with Huber-White standard errors to control for heteroskedasticity and autocorrelation. This article did not need to lessen the effects of collinearity, because it is only examining one independent variable.

Dependent Variable: Innovation Spending

This article measures China's quantitative innovation efforts through its R&D intensity – that is, R&D spending as a share of GDP. These figures include both private and public sector investments and are drawn from the Organisation for Economic Cooperation and Development (OECD). As mentioned above, this proposed approach departs from other articles that have applied the theory of creative insecurity, which counted outputs, measured by patents weighted by forward citations. R&D intensity is relevant in explaining China's behavior on innovation. As Elizabeth Economy notes, China's approach to surpassing the United States can be described in renminbi: 'spend on talent, spend on infrastructure, spend on R&D, spend on others' technology' (Economy 2018). Indeed, some degree of R&D spending is necessary for innovation – money provides for the salaries, equipment, and infrastructure, among other expenses, essential for any transformative endeavor (Taylor 2016; Fagerberg 2006). Gross R&D alone, however, provides an incomplete picture. R&D intensity provides insights into the proportional effort of governments to advance its innovation capabilities (OECD and Eurostat 2018; Directorate for Science, Technology, and Innovation 2021). In short, it is a good measure of how much a nation prioritizes innovation over other interests.

Independent Variable: Threats

To measure how Beijing perceives threats, it is necessary to identify variables that represent a spectrum of reactions to threats, from sending public warnings to engaging in war. Of course, perception is necessarily subjective and there will be no single perfect measure that captures the nuanced, varied reactions of the Chinese Communist Party (CCP) leadership, the People's Liberation

Army (PLA) leadership, and the CCP General Secretary himself. But using standardized metrics allow us to compare changes in various reactions to threats over time.

External threats: Militarized Interstate Disputes (MID). To measure both the threats and reaction to the threats, this article draws from a widely accepted database in the field of international relations: Militarized Interstate Disputes (MID) from the Correlates of War project, which covers the period from 1816 to 2014 (Palmer et al. 2020). MIDs are defined as 'united historical cases of conflict in which the threat, display or use of military force short of war by one member state is explicitly directed towards the government, official representatives, official forces, property, or territory of another state' (Jones, Bremer, and Singer 1996). The MID dataset provides enough granularity to distinguish between a range of responses, from low-level activity (such as warnings and public pronouncements) to high-level confrontation (military conflict). To calculate the MIDs per year, this paper added up all the 'highest actions' taken every year by Beijing. 'Highest action' represents the most severe response taken by a state in dispute, such as a warning or kinetic action, as described above. This indicator would capture the greatest sense of threat that Beijing felt that year.

Internal threats: constant

This article holds the levels of internal stability as a constant, because the CCP's control over the population has arguably remained stable during the period of our study. In PRC history, there have been only a few notable incidents – including the Tiananmen protests, which ended in 1989 – that threatened the CCP's control on power. But those incidents ended prior to the period we examine (starting 1991) and since then, there have been no serious challenges to CCP rule. Such constancy is supported by the Political Terror Scale, which collects ratings including from the State Department and uses a scale of 1 to 5, the higher number representing higher degrees of oppression.[1] Between 1991 and 2014, the State Department changed China's ratings only three times: from a three to a four in 1997, and back to a three in 2007 before returning to a four the following year. This is not to say that the state of human rights in China is benign, nor that the CCP is free from anxiety about its rule. This article only holds that such infrequent changes suggest that the level of domestic turmoil has been relatively constant between 1991 and 2014.

Analysis

This section proceeds with the qualitative analysis followed by the quantitative assessment.

Qualitative Analysis

From the founding of the PRC in 1949, Chinese leaders have harbored deep anxieties about China's lagging position in S&T. Mao Zedong, alongside other Chinese revolutionaries, blamed in part the country's economic underperformance on its failure to keep pace with global technological changes. In 1957, Soviet Premier Nikita Khrushchev announced the country's intent to 'catch up and surpass the United States.' Mao admired and envied the Soviets' modernization project. As the beneficiary of extensive technological and technical assistance from the Soviet 'old brother,' China needed a technological Renaissance to have any chance of regaining its lost imperial glory. Mao borrowed the Soviet concept, making the Chinese innovation efforts to catch up and surpass – *ganchao* – at the center of the CCP's long-term goals. The plan was to wed developments in technology with its politics, agriculture, industry, and national defense. Despite uneven implementation throughout the PRC's turbulent history, from disasters such as Mao's Great Leap Forward to progress through Zhou Enlai's Four Modernizations to the economic transformations through Deng Xiaoping's market reforms and trade liberalizations, this nationwide project of technological integration has been a consistent goal (Gewirtz 2019).

The desire to catch up and to surpass seems to have represented the leaders' insecurities. Mao, as well as other Chinese reformers, learned the hard-earned lessons from the so-called 'century of humiliation.'[2] Without catching up to others in technological prowess, the PRC would be unable to convert its immense size, natural resources, and population into sufficient power to repel foreign invaders and their influence. Under Deng, China followed the industrial growth model of the East Asian tigers, boosting its innovation performance through domestic investments, forced technology transfers, and replication, among other tactics (Atkinson 2012).

Even the aspiration to surpass more advanced industrial nations seems, in part, to have been rooted in fear. As Chinese scholars have pointed out, 'China did not participate in the steam engine and mechanical revolutions of the 18th century or the power and transportation revolution of the 19th century; China partially participated in the electrical and information revolution of the 20th century' (Doshi 2021, 287). These failures contributed to China's inability to defend itself against Western nations that leveraged their technological advantages. The inability to surpass others might lead to domination, again, by other nations who are able to successfully exploit the innovation frontier first (Doshi 2021, 286-87). As a corollary, dominating the emerging technologies – such as artificial intelligence, machine learning, biotechnology – could help China exploit the promises of 'great changes unseen in a century' and slingshot it to the edge of the technological frontier (Doshi 2021, 287).

As will be shown below, in the past 30 years China underwent three major innovation policy phases. This paper argues that each of these shifts was driven by fear of external threats. External threats were not the sole forces shaping Chinese innovation policy; Chinese policy is not wholly reactive. Particularly after the 2008 financial crisis, CCP leadership appeared to seize on opportunities long hoped for, but out of reach to overtake the West. Yet, as we shall see, China is extremely sensitive to changes in the external security environment whether near its borders or around the world, especially when the threat involves the United States.

First Phase: Technological Shocks (1991-2006)

In the first phase, from 1991 to 2006, Beijing awoke from its technological slumber. In early 1991, television screens around the world broadcasted the Persian Gulf War, as U.S. M1 Abrams tanks and satellite-guided missiles decimated Iraqi forces with minimal U.S. casualties. The entire U.S.-led ground campaign lasted only 100 hours. Half a globe away, Chinese leaders were shocked by the quick and decisive victory. Jiang Zemin, who was the CCP General Secretary at the time of the war, admitted that seeing U.S. modern warfighting capabilities against Iraq arrested his attention on the importance of developing the country's S&T programs (Fewsmith 2012, 47). In early 1993 after a comprehensive review, the People's Liberation Army (PLA) called for a major doctrinal change, shifting its focus from a reliance on sheer manpower to the development of high-tech weaponry and communications capabilities (Office of the Secretary of Defense 2021; Anthony, Hess, and Yarosh 2013; Chase et al. 2015). The goal: to win in modern, networked warfare conditions.

Beijing's fears of its underdeveloped technological capabilities were reaffirmed in the 1996 showdown with the United States over Taiwan's first democratic elections. Despite having the homefield advantages of initiative, proximity, and number of troops against U.S. forces in the Pacific, Beijing stepped down. Some have argued that Beijing was bluffing, that it never intended to invade Taiwan (Ren 1997). But that argument only underscores the same point: the PLA simply could not invade Taiwan without the undesired risk of direct conflict with U.S. high-tech naval power. As with the case in Iraq, the superior technological capabilities of the United States were vital to determining victory.

China did not allow this lesson to go to waste. China subsequently ordered modern attack submarines and warplanes to counter the U.S. Navy's carrier groups (China Power Project 2016). In 1997, China pushed the development of 'leapfrogging' technologies. This would be supported by modernization efforts from mechanization to 'informatization,' based on software and networking capabilities (Nan 2007, 58). These advancements in the military were supplemented by efforts in the

civilian sector to accelerate advanced information technologies. The same year, the State Science and Education Steering Group issued the '973 Program,' or National Basic Research Program of China, designed to mobilize China's specialists to conduct innovative research in 'agriculture, energy, information, resources and environment, population and health, materials, and related areas' (Consulate General of the People's Republic of China in New York 2022). These policies aligned with the economic reforms advocated by then retired Deng, following his famous 1992 southern tour (Xiwei and Xiangdong 2007, 319). Altogether, these reforms positioned China for the next phase of its technological development.

Second Phase: Return to Industrial Policy (2006-2010)

The second phase beginning in 2006 marked the return of centralized industrial policy. On the one hand, China saw the unassailable evidence that Deng's economic reforms had a positive effect for its country. On the other hand, the years leading up to this change in policy were marked with sharp foreign encounters. In 1999, a U.S. B-2 bomber under NATO accidentally dropped a bomb on the Chinese embassy in Belgrade, killing three Chinese diplomats and injuring an additional twenty-plus people. After watching Iraq's decimation from afar, China now had first-hand experience of devastating U.S. stealth technologies and precision-guided munitions, however misguided (Shambaugh 2013). In 2001, a U.S. spy plane collided with a Chinese fighter jet over the South China Sea, leading to the death of the Chinese pilot. In the same period, the United States initiated counterinsurgency operations in Afghanistan and Iraq, showing the Chinese the use of unmanned aerial drones and network warfare in action. Despite China's entry into the World Trade Organization in 2001 and the U.S. normalization of trade status by 2002, the United States maintained a bevy of trade and technology sanctions on China related to, among other issues, the Tiananmen massacre and China's exportation of missile technology (Rennack 2006). Amidst these tensions, China's State Council released the 2002 national defense strategy, singling out informatized warfare as an essential element underlying military transformation (You 2007).

Given its reliance on foreign technology, the PRC leadership concluded that it needed to reduce its vulnerability to non-Chinese firms (Heilmann 2017). In 2006, after consulting more than 2,000 scientists, engineers, and business leaders, the CCP leadership released the Medium- and Long-Term Program of Science and Technology (MLP) (Popper et al. 2020). Highlighting the commitment to developing 'indigenous innovation' capabilities, this new document revealed China's intent to become an 'innovation-oriented society' by 2020 and a global innovation leader by 2050 (Cong, Suttmeier, and Simon 2006). This new approach promulgated that by 2020, R&D was required to reach 2.5% of GDP, the country should reduce its dependence on foreign technology to 30%, and increased productivity should account for 60% of total growth (Naughton 2021, sec. 3.1). The MLP targeted a range of technologies and listed sixteen 'megaprojects' to be funded by the government (Naughton 2021, sec. 4.1). These programs were not only different in degree but also in kind and scale, marking a return to government industrial policy.

Third Phase: From Catching up to Surpassing (2010-2019)

In the span of a few years, China shifted its overarching innovation goalfrom catching up to now seeking to surpass the United States. Rather than simply building more megaprojects and investing greater sums in low value commodities in the global supply chain, Beijing sought to surge ahead on emerging technologies, hoping to overtake the lead in key advanced industrial sectors.

The shift came in the wake of the 2008-9 global financial crisis. China suffered a precipitous drop in exports due to the ensuing global recession (Linyue, Willett, and Zhang 2012; Whalley et al. 2009). As the post-mortem was being pieced together, Chinese leaders saw this calamity as a turning point in world history (Friedberg 2012, 131). It had become clear that the U.S. financial system, driven by greed and weak accountability, was not fully reliable, and even served as a threat to Chinese interests. After more than a year of deliberations, in 2010 the State Council issued a new document laying out an ambitious industrial plan titled, 'Decision to Accelerate the Cultivation of Strategic

Emerging Industries,' or known as Strategic Emerging Industries (SEI) program. The SEI outlined seven sectors of focus. Over the next decade, this list grew to twenty industries, including emerging areas such as next generation information technology, biotechnology, and high-end machinery. To implement the SEIs, the State Council and various national ministries passed 439 additional policies (Naughton 2021).

This program marked an important shift in China's approach. The previous MLP reflected the long-standing approach of catching up in sectors. But the SEI showcased China's patent desire to enter new industries. If China focused its efforts in developing emerging technologies where there were no entrenched incumbents, China could bypass legacy systems and take the lead in certain emerging industries. Doing so, however, would require a greater prioritization and investment from the government. The MLP was a major push towards this direction but was modestly resourced. With the SEIs, Beijing committed significant funding to its strategic priorities and gave the central government more control to develop these sectors (Naughton 2021; Friedberg 2022, 105-107).

This shift in industrial policy accompanied a shift in aggressive maritime activities. In 2013, China began to build islands and construct bases in the South China Sea. Over the next several years, China occupied the Paracel Islands and seven sites in the Spratly Islands, reclaimed reportedly more than 3,200 acres of land, and militarized these areas with reported aircraft, missile, and radar ranges, as well as lengthy airfields (Baldor 2016; O'Rourke 2022). China mobilized its naval forces to contest overlapping maritime claims. As public awareness of these developments increased, the South China Sea emerged as a key domain of competition between China on one side and the United States and those Southeast Asian nations with maritime claims on the other. While the United States had long maintained that it takes 'no position on the PRC's sovereignty claims to particular islands in the South China Sea' (Baumert, Stern, and Williams 2022, 13), Washington, along with its allies and partners and other claimants, voiced strong concern over Beijing's unilateral land reclamation efforts (Tian 2021; Al Jazeera 2021). Moreover, the United States and several allies continued freedom of navigation (FON) operations and overflight operations in contested areas (Ching 2018). Beijing perceived these activities as intrusions into sovereign territory and efforts to 'stir up trouble' in an otherwise peaceful region (Gomez 2015; O'Rourke 2022, 15).

China's land reclamation efforts in the South China Sea itself featured a host of policy innovations, including artificial island-building, privatization of the South China Sea as Chinese territory, and brinkmanship against the U.S. navy under the justification of protecting sovereign territory (Corr 2019). Back in Beijing, China's leaders pressed forward on cultivating domestic innovation programs. The Made in China 2025 (MIC) industrial plan was issued in 2015 (Kennedy 2015). In 2016, China tied these various civilian innovation programs under a single strategy. This new framework, called the 'Innovation-Driven Development Strategy' (IDDS), expanded the range of sectors covered and increased the funding. Now under the single framework of the IDDS, the existing disparate initiatives – MLP, SEI, MIC 2025, and more – were brought under one policy roof and boosted by billions of dollars (Kennedy 2015).

In 2018 when the Trump administration initiated a trade war against China, implementing trade and investment restrictions on critical technologies, Chinese concerns about their reliance on U.S. technology further heightened. Huawei launched a new investment fund in 2019 to reorient its semiconductor supply chain following U.S. export bans (Strumpf 2022). In 2019, Xi set up a new, secretive science and technology advisory commission (Feng 2021; Pao 2021). The CCP leadership continued to upgrade the IDDS, adding new or modernized policy programs. These programs included the Updated SEI plan in 2016, a spate of plans in 2017 – the Military-Civilian Fusion Plan, Artificial Intelligence Plan, and AI 3-Year Action Plan – the Information Consumption Plan in 2018, and the Internet and Services plan in 2019. Each program was designed to be interlocked under the broad meshwork of the IDDS (Naughton 2021).

The interwoven relationship between China's insecurity and its enhanced innovation policies has been evident in this qualitative account. But if China seeks to improve its innovation capabilities as a shield against foreign dangers, we should also expect to see a correlation between a rise in external

Table 1. Correlation between external threats and China's R&D intensity.

	Results	
	Dependent variable	China's R&D Intensity
Militarized Interstate Disputes	0.017***	(0.003)
Constant	2.051***	(0.014)

Note $p < 0.1$; $p < 0.05$; $p < 0.01$

disputes and an increase in R&D spending. In the next section, we test this hypothesis with quantitative tools.

Quantitative Analysis

To reiterate, the quantitative methods used here do not seek to prove causation. The purpose of this section is to perform basic plausibility tests. If threats have any impact on innovation, then that relationship should be apparent in simple correlative tests using widely accepted data (Taylor 2016). The following results examine the relationship between MIDs (threats) and R&D intensity (innovation spending).

The quantitative analysis here suggests there is a positive and statistically significant relationship between the MIDs and R&D intensity (Table 1). When China experienced higher levels of external threats, the country invested a greater share of its GDP on innovation. After correcting for auto-correlation and heteroskedasticity, the p-value is less than 0.05 (at 4.086e-05). This relationship is also depicted in Figure 1. The black line represents the line of best fit, using the coefficient of the relationship as the coefficient of the line.

Despite its statistical significance, the effect of threats on innovation efforts (coefficient) appears weak (0.017). For every additional unit of a MID, R&D intensity increased by a mere 0.017 points.

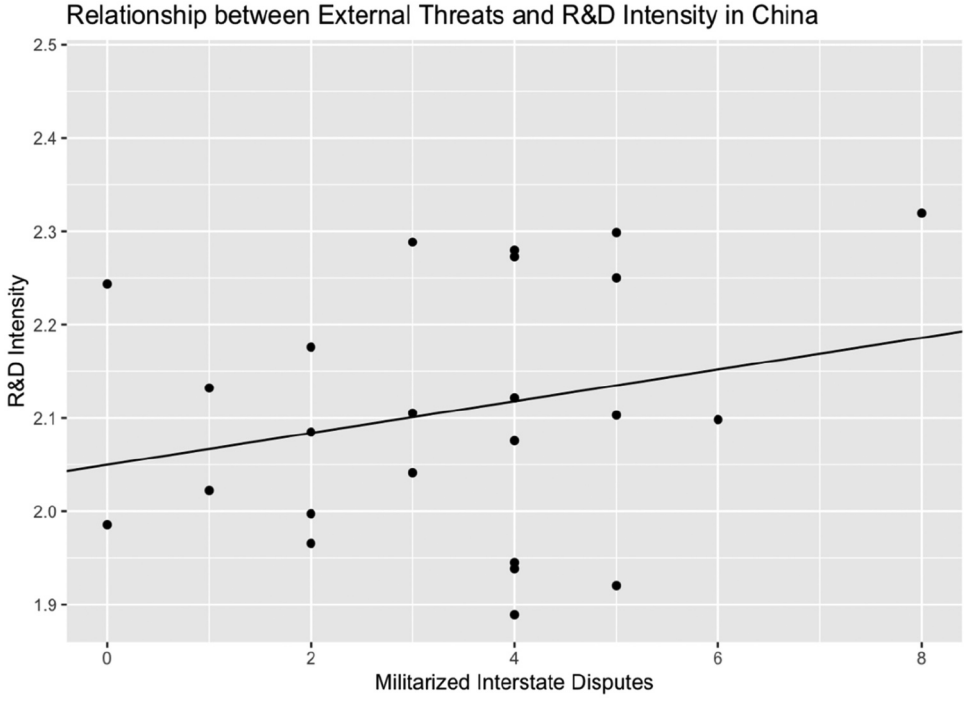

Figure 1. Relationship between external threats and China's R&D intensity.

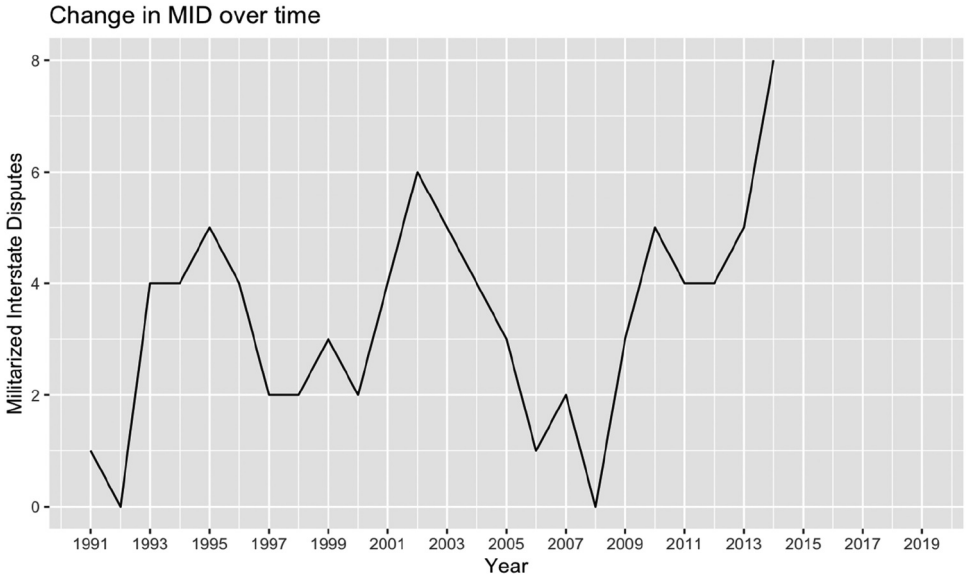

Figure 2. Changes in MIDs between 1991-2014.

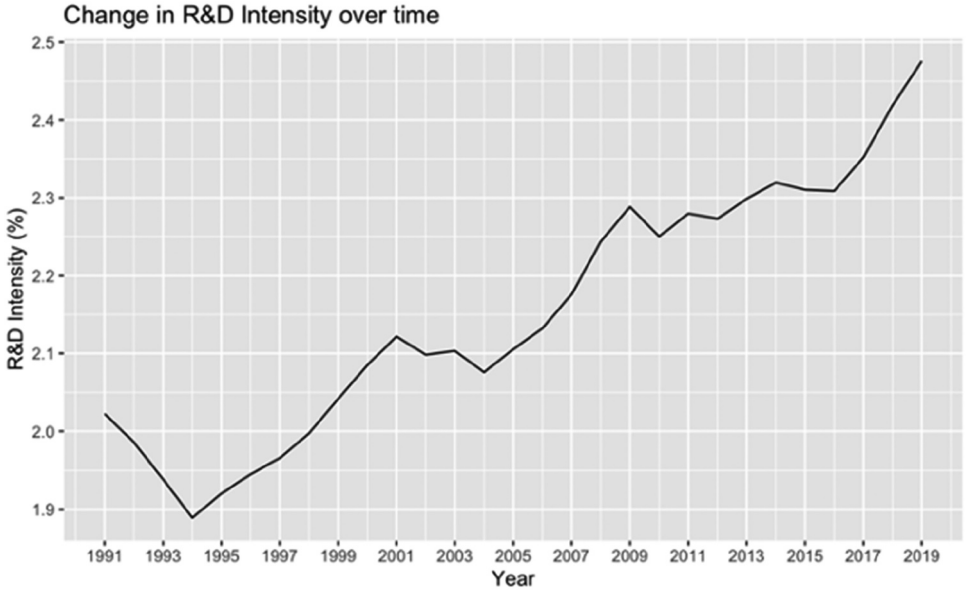

Figure 3. Changes in R&D intensity between 1991-2019.

A change in a few outliers could swing the line closer to a coefficient of 0 or even to a negative relationship. To visualize this relationship from a different angle, this article disaggregated threats and innovation efforts into two separate charts that show 1) number of MIDs over time (Figure 2) and 2) R&D intensity over time (Figure 3). Figure 4 combines these two metrics into a single chart.

In comparing Figures 2 and 3, it seems that in general, as the number of MIDs increased from 1994 to 2019 (Figure 1), R&D intensity also tended to increase (Figure 3). But when the charts are combined (Figure 4), the data show that even when MIDs went into a freefall (for example, between

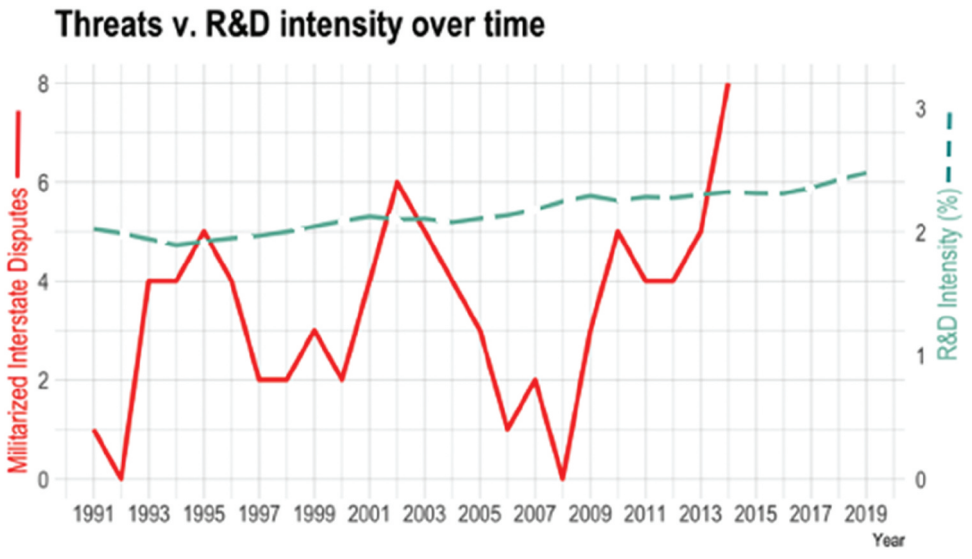

Figure 4. Comparing threats and R&D intensity over time.

1995 to 2000, and between 2002 and 2008), R&D intensity continued to increase. What explains this unexpected result? While it is beyond the scope of this paper to answer this question in full, the next section offers some initial thoughts and a roadmap for further exploration.

Implications

At the beginning of this article, we noted the purpose of this paper was to test a modified version of creative insecurity to a case study of China. One motivation was to examine the robustness of a novel theory on an important test subject; the other motivation was to better understand why China, or any nation, tries to improve its innovation capabilities.

The findings in this article support the argument that there is a substantive link between China's internal-external threat balance and its R&D intensity. While every country seeks to improve its innovation performance for various reasons, and China is no different, it is clear that China either developed new S&T programs or accelerated existing ones owing at least in part to external events that threatened China's security across a wide domain of issues. For some of these changes, the external threats – such as U.S. capabilities in the Gulf War and the economic crash from the global financial crisis – were likely the foremost drivers of change. During this time, China's internal security environment remained stable. The original creative insecurity theory sought to measure innovation performance (by patents by weighted citations, per capita); this article sought to measure the efforts to improve innovation input (by policy changes and R&D intensity). Both sets of measures point to a similar positive and significant relationship between threats and innovation rates.

At first glance, this argument does not seem entirely novel. As mentioned above, the political science literature is replete with studies on how war, or the threat of war, accelerates nation-building. When a country faces grave threats, many sectors, whether manufacturing, the financial industry, or the defense industrial base, are likely to see more committed focus and resources from the central government. Yet this idea has not pervaded studies on innovation. The theory of creative insecurity helps to bridge the gap between innovation and political science studies. Our modified version of the theory on a single case study contributes to this discussion. To be sure, we were able to hold the internal security constant in this case study with a high degree of confidence. If applied to other countries with more volatile internal politics, this approach would not apply.

At the same time, the data revealed that creative insecurity alone does not seem to fully explain China's behavior. Why did R&D intensity continue to increase even when external threats decreased? Though there is a positive statistical correlation between threats and innovation efforts, threats alone do not seem to provide a full account of China's innovation behavior. An alternative or additional explanation is required.

This paper thus proposes for further exploration a complementary theory: 'creative ambition.' As described above, from the founding of the PRC, Chinese leaders have expressed their desire not only 'to catch up' but also 'to surpass' others in technological supremacy. Since 1991, China has evolved from an innovation imitator to a global leader in key S&T sectors. China's anxieties about falling behind seem to align with the theory of creative insecurity – its push towards innovation is a reactive and defensive measure. But China has also behaved in ways that can be described in offensive terms: as its economic might has grown, China has sought to expand its influence around the world by dominating and leading certain technological industries, while continuing to intensify its efforts and spending on next generation technologies. This desire and behavior can be defined as creative ambition. In fact, many books and articles with a strong policy orientation have supported just this argument, with varying degrees of documentation (Pillsbury 2016; Friedberg 2012; Wang 2017; Doshi 2021; Cheung 2022; Friedberg 2022). But they have not applied quantitative analyses for testing that hypothesis.

In the realm of international relations theory, creative insecurity would be consistent with defensive realism, while creative ambition aligns with offensive realism (Mearsheimer 2014). If one were to construct a realist theory of innovation, one might begin with the following premises: in an anarchic system of power, all states compete for better innovation performance to ensure their survival (Taylor 2012, 151). As no state will ever achieve S&T security without effort, different states will seek to ensure their security through different measures. Defense-oriented states will seek positive-sum measures that maintain a balance of innovation power and preserve the status quo. Offense-oriented states will try to maximize their innovation efforts, seeking 'innovation hegemony' as the ultimate, if aspirational, goal. In the real world, both motivations are likely to exist to different degrees, as states rarely adopt a single paradigm and often behave with mixed motives (Cheung 2022, 3).

Indeed, creative insecurity and creative ambition seem to be complementary theories. The chief interest of national leaders is to prevent its country's collapse (Winnefeld, Morell, and Allison 2020; Allison, Simes, and Thomson 1996), consistent with creative insecurity. But once they have stabilized the security environment, they would naturally begin to seek to shape global affairs in ways favorable to the nation's other interests, at which point creative ambition may become more evident. The extent of a leader's ambitions will differ according to ideology, political structure, and personality. But every leader invariably seeks to both mitigate risks and seize opportunities, albeit with differing degrees of fear and ambition. Creative insecurity could represent the starting point, the desire to take defensive measures to protect a nation's interests. Creative ambition might become more visible, as a nation feels more secure – that is, when its capabilities match its threat environment. Creative ambition might even be the net sum of creative insecurity (balance of external and internal threats) and a nation's capabilities to address those threats. But both insecurity and ambition can and likely do coexist in nations (Cheung 2022, 3). This idea is not dissimilar to the threat-capacity framework, though creative ambition would be applied to civilian innovation (not only military innovation) (Schmid 2018, 31-36).

Another reason that creative ambition seems complementary to and not a substitute for creative insecurity is that each theory principally tests different dependent variables. Creative insecurity, as originally conceived, examined outputs; creative ambition analyzes inputs. The input-output distinction matters, because each variable uses different measurements, draws from distinct literature, and raises separate implications. Moreover, inputs into the innovation processes, such as R&D spending, do not always lead to the outputs, such as patents and scientific articles. These outputs, in turn, do not always lead to outcomes in actual innovation, including the sale of new goods and services

(Atkinson and Foote 2019). When theorizing specific drivers, each variable should be tested separately. To explain China's *overall* innovation drive, however, scholars can gain a fuller picture with the combined approach of analyzing both creative insecurity and creative ambition.

To test the theory of creative ambition, a new study would need to operationalize China's ambition to innovate. One approach would be to run textual analysis on key phrases that represent Beijing's desire not only to keep pace with but to lead the innovation race: examples include 'overtaking by curve,' 'changes not seen in a century,' 'catch up and surpass.' For a more robust statistical analysis, the study could add control variables. The study would be able to test whether ambition has a stronger correlative relationship to innovation efforts than the traditional factors for innovation do, such as development, governance type, level of government centralization, and trade liberalization (Brummer 2020). The study could also add alternative proxies for threats, such as the International Crisis Behavior dataset (Brecher and Wilkenfeld 2000; Brecher et al. 2021). This approach would allow for a more robust approximation of the role of ambition in driving China's innovation efforts.

Focusing on inputs seems valuable for the continued study of innovation. One could argue that focusing on outcomes is a more fruitful field of study, as outcomes are the ultimate purpose of the innovation process. This position suggests that what matters more is not what China is doing to advance its innovation capabilities, but rather whether China is converting those efforts into actual outcomes. But is this true?

Generally, yes. Outcomes generate profit, allow for further technological and economic advancements, and strengthen a nation's instruments of power. But in the realm of geopolitics even the perception of being an innovation leader can be a form of power. For example, if states cede certain emerging industries to China from the belief that China has dominated those sectors with massive state investments, or if firms decide to establish start-ups in China due to China's reputation as a permissive environment for entrepreneurs, then China has shaped public and private behavior. This is true whether China eventually achieves its innovation goals or not. In such cases, power is reflected not only through actual scientific and technological advancements, but through China's ability to leverage external perceptions of its growing capabilities. Even if China does not realize its financial return on innovation investments – for example, in its highly expensive, so-far failed efforts to produce the most advanced semiconductors (Babones 2020) – China may well be acquiring an influence dividend on the global stage. Such a trend would suggest that China might maintain its innovation spending and policies, even if it suffers financial loss, as an acceptable tradeoff to accumulate geopolitical gains.

Conclusion

While this article does not conclusively state why China innovates, it partially confirmed a modified theory of innovation and proposed a complementary explanation for why China seeks to innovate. In view of what has been presented, this article offers a few speculative policy implications.

If *creative insecurity* holds, then engaging in behaviors that threaten China will pressure Beijing to accelerate its innovation efforts, increasing the PRC's power, wealth, and prestige and allowing it to eclipse competing nations, to further dominate smaller ones, and to increase its leverage over contested arenas. To be sure, not all the fruits of innovation's labors need be ominous; some of them could provide universal benefits. China's breakthroughs across a wide variety of fields, including in science, technology, engineering, energy, and medicine could contribute to the shared global interests of improving the human condition and taming the natural world. As nations perceive China's growing strength, they in turn might invest more in innovation, increasing the potential risks and rewards of an innovation race.

In contrast, decreasing external threats to China and increasing domestic political pressure inside China would theoretically slow the PRC's innovation efforts. Though controversial and politically sensitive, such domestic pressure options might include information warfare, cyber operations, and

both overt and covert support for opposition groups inside China. Even more benign forms of activity – such as support for NGOs seeking to increase human rights and access to information inside the PRC – could incidentally contribute to Beijing's anxieties of losing control over its people.

If *creative ambition* holds, however, then no matter how conciliatory other nations are to China, Beijing will continue to make considerable efforts and pour substantial resources into its national innovation ecosystem. This would suggest that other countries should do all they can to advance their own innovation performance, because Beijing would deeply invest in S&T either way. Nations would fail to build their military and innovative capability at their own peril.

In reality, the fraternal twin engines of creative ambition and creative insecurity are likely both at work in China. An ambitious Beijing that also felt threatened by foreign nations would accelerate all the mechanisms of its innovation system to produce force and motion towards its emergence as a global technology leader. This image could fairly characterize China's innovation efforts since at least 2010, when Beijing shifted its focus from catching up to surpassing the West. If insecurity and ambition have blended into an enmeshed force, and if they are driving Beijing to double down on its commitment to innovation, they may long extend the mighty growth of innovation already under way in China.

Notes

1. The Political Terror Scale also uses the ratings from Amnesty International and Human Rights Watch, but both organizations are missing data from the years of this paper's coverage (Gibney et al. 2022).
2. For a counter narrative that argues that the 'century of humiliation' was unfavorable to Chinese leaders but was, in fact, one of China's most innovative periods and highly advantageous to the Chinese people, see Wang (2017).

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