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The U.S.-China Innovation Gap: The Chinese Advantage of Backwardness[1]

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Latecomers in the economic development process can leverage existing innovations and technologies available globally. This paper examines China's "advantage of backwardness" using data on innovation provided by the Global Innovation Index (GII), published by the World Intellectual Property Organization (WIPO). I develop a simple theoretical framework to explain the advantage of backwardness and apply this to analyse China's innovation gap with the United States. The analysis assumes that the United States represents the leading country in innovations. This assumption enables a comparison between the two large economies and tests a hypothesis with not only economic but also purported political and military implications. According to the theory of backwardness, China's innovation level is converging with that of the United States. This raises the question: can China's innovation level eventually surpass that of the United States? In other words, if China is developing by capitalizing on its technological backwardness relative to the United States, can it, at some point, become the global leader in innovations? This paper explores this question by analysing 18 observations spanning the period from 2007 to 2024, offering a speculative perspective on whether China can surpass the United States in innovation leadership.

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Keywords: *Advantage of Backwardness, GII index, WIPO, US, China, Innovation, Technology, Leadership, Development*

Introduction

Countries and societies vary significantly across time and space. However, what matters most for the economic well-being of their citizens is the ability to develop innovative solutions to their most pressing challenge: scarcity. Hesiod, writing in the 8th century BCE, was the first to observe that scarcity compels people to work hard to meet their basic needs. Without scarcity, he noted, it would be possible to produce in a single day everything required for an entire year.[2]

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[2]As I have argued in Papanikos (2023, 2022a, 2022b, 2022c), Hesiod can be considered the first economist, and his book *Works and Days* the first economics textbook. In Hesiod's work, economic development is described as a technological process characterized by the use of metals: gold, silver, bronze, and iron. He also narrates the beautiful story of Prometheus. He also provides an excellent description of how to construct a plow, a remarkable innovation that greatly enhanced the productivity of labor.

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What Hesiod believed to be impossible could become reality if an unbounded Prometheus were to steal the gods' well-kept secrets—secrets that would enable humans to apply new knowledge to their daily lives, allowing them to produce more goods with less effort and fewer resources. When a society unleashes its Prometheus, new ideas drive discoveries and inventions, some of which may prove invaluable when applied to various production processes.

At a certain point in time, the accumulation of discoveries and innovations constitutes the stock of innovations, which may vary from country to country. The portion of these innovations applied to production processes to enhance people's welfare defines technology—that is, useful innovations. In this context, we use the terms *innovations* and *technology* interchangeably.[1]

Some countries are leaders in discoveries and innovations, while others lag behind. This paper raises the question of whether countries that lag behind can take advantage of the innovations produced by leading countries. In today's world, innovations resemble pure public goods: it is very difficult to exclude someone from using them (the non-excludability principle), and one country's use of an innovation does not prevent another from using it as well (the non-rivalry principle). If this is the case, the stock of innovations in a relatively technologically backward country can increase if it is able to copy the innovations developed in other countries and apply them to its own economy and society at large. After all, there is no point in 'reinventing the wheel' or 'rediscovering the Americas.' These things have already been done, and all of humanity—both current and future—can benefit from them.

We apply the concept of innovation gaps to the US-China case. Given that the US has historically maintained a higher level of innovation compared to China, how has China taken advantage of its technological backwardness by absorbing innovations created in the US? To explore this, I use the Global Innovation Index (GII), published by the World Intellectual Property Organization (WIPO) since 2007, to investigate the extent of innovation absorption by China. According to WIPO (2024, p. 14), "The goal of the Global Innovation Index (GII) is to be a holistic and flexible measure of the innovation happening all around the world today." It is this concept of *holistic performance* that is the focus of this paper.

While China has the capacity to discover, innovate, and develop new technologies, this paper focuses on its overall performance in innovation. A simple theoretical model is employed to empirically test this hypothesis, as discussed in the next section. Subsequently, I provide a more descriptive and narrative analysis of the data

[1]It is interesting to note that in Plato's *Protagoras*, *techne* was considered a practical profession, learned through hands-on experience under the guidance of a master. Generalizing this concept, we can say that technologically backward countries can acquire *technes* by being trained by more technologically advanced countries. Applied to China, this idea is exemplified by the many Chinese students who have pursued advanced studies and conducted research at leading U.S. educational institutions. On the other hand, the production of new ideas is more complex and seemingly cannot be taught. Socrates, for instance, explains that his ideas stem from an inner *daimon*. In ancient Greek, the word *daimon* (δαίμων) did not carry the negative connotations it does today. One of its meanings was "spirit," and it was associated with the gods. Thus, Socrates' ideas could be seen as a form of divine revelation. It also implied good fortune. Interestingly, the process of discovery and innovation often requires not only a good spirit (idea) but also a stroke of luck. Many discoverers and innovators have acknowledged that, in addition to having a great idea, they also benefited from a stroke of luck. Those who are religious might refer to this luck as a miracle.

to evaluate whether China could ever produce as many top innovations as the United States. This section is more speculative than the previous one. The final section offers concluding remarks.

A Simple Theoretical Model Applied to China

Gerschenkron (1962) introduced the term "Advantage of Backwardness," referring to the idea that countries lagging in creating innovations and transforming them into new technologies can benefit from the advancements of leading nations, thereby accelerating their economic growth. He specifically had in mind his native Russia and other less-developed European countries of the 19th and 20th centuries, such as Italy and Bulgaria. Although he does not mention China in his book, his framework is highly applicable to China's remarkable economic growth in the early 21st century.

A Simple Theoretical Model[1]

This section develops a simple theoretical model to analyse the level of innovation of a country (i) in period (t) for a latecomer nation, denoted as (A_{it}). Backwardness, represented as B_{it}, is measured as the gap between the world's available innovations in period t, A_t, and the country's level of innovation denoted by A_{it}:

$$B_{it} = A_t - A_{it} > 0 \qquad (1)$$

Catching up implies that B_{it} tends toward zero as (t) increases, meaning the country progressively closes the innovation gap. This can be done in a linear or nonlinear way. In each time period, it is assumed that the country (i) can absorb a certain portion of the world's available stock of technology (A_t). This absorption rate, denoted as (α) is assumed to depend on (a) the country's ability to absorb and (b) the foreign country's willingness to allow it. For simplicity, it is assumed that absorption depends on time. Thus, at time (t), the country adds the following amount to its stock of innovation, derived from the existing global stock of innovation:

$$A_{it}^{f} = \alpha(t) \cdot B_{it} \quad 0 \leq \alpha(t) \leq 1 \qquad (2)$$

Where A_{it}^{f} is the foreign country's innovations stock which is absorbed by country (i). Notice that if the innovation gap is zero, then A_{it}^{f} is also zero. Here (α) is treated as a function of time and is greater or equal to zero. If (α) is zero, then country (i) is either entirely unable to absorb any foreign innovation, or the foreign country is both capable and willing to prevent other countries from copying its innovation. The country (i) is also capable of producing its own

[1]In Papanikos (1993), I present an economic model of aggregate supply and aggregate demand, explicitly modelling technical progress as both an endogenous and exogenous process.

innovation, contributing to its total stock of innovation by an amount A_{it}^{d}. This amount is assumed to be exogenously determined primarily by government policies. Here it is assumed that it depends on time given an initial level of innovations and grows at a rate g:

$$A_{it}^{d} = A_{i0}(1+g)^{t} \quad (3)$$

A_{i0} represents the initial stock of total innovation in country (i). The total available stock of innovation in country (i) at period (t) is the sum of foreign-absorbed innovation and domestically produced innovation at period (t):

$$A_{it} = A_{it}^{f} + A_{it}^{d} \quad (4)$$

By substitution we obtain:

$$A_{it} = \alpha(t)\cdot B_{it} + A_{i0}\cdot(1+g)^{t} = \alpha(t)\cdot(A_{t} - A_{it}) + A_{i0}\cdot(1+g)^{t} \quad (5)$$

Equation 5 indicates that, in period (t), country i's level of innovation is determined by its ability to absorb internationally available innovation (α). As mentioned, this absorption rate is assumed to depend on time, forming a testable hypothesis about whether the country's ability to absorb international innovations increases or decreases over time.

The total innovation level also depends on the country's ability to produce its own innovations. These domestically produced innovations are assumed to grow at a constant rate (g), conditioned by the initial stock of innovations which is constant. Notably, it is highly likely that a country's ability to produce its own innovations increases with the stock of foreign-acquired innovations. Thus, this ability can be considered a function of the given stock of foreign innovations.

In the literature, domestically produced innovations are often modelled as a function of population growth, an argument made earlier by Kremer (1993). A larger population increases the likelihood of producing innovators, which in turn enhances the country's capacity to generate its own innovations, absorb internationally available innovations, or both. We also test this hypothesis.

Developing an Empirical Model to Estimate China's Innovations

The simple theoretical framework outlined above can help determine whether a country can leverage its backwardness. A backward country is defined as one where $A_{it} < A_{t}$. Given that this index is a composite index, it is quite possible that in some areas, innovations may exceed those in the leading country.[1] This issue, while very important, is not examined in this paper, as it falls within the scope of the literature on industrial clusters.

In its general form, the A_{it} function to be estimated is given by:

[1]The GII index comprises 78 indicators. According to the 2024 report (WIPA, 2024, p. 22), China ranks first in 8 of these indicators, the US in 9, and Singapore in 14. However, what ultimately matters is the overall index. In 2024, in the overall index the US ranked 3rd, while China ranked 11th. Notably, China's position in the institution's indicator is 44th, and it ranks 22nd in the human capital and research indicator. This may explain why, at this stage of its development, China is better positioned to replicate other countries' innovations, as illustrated in Figure 1 below.

$$A_{it} = \Phi_i(A_{i0}, A_t, g, n, t) \quad (6)$$

The empirical specification of the above general function takes the following form:

$$A_{it} = \beta_o + \beta_1 \cdot A_t + \beta_2 \cdot A_t^2 + \beta_3 \cdot t + \beta_4 \cdot t^2 + \beta_4 \cdot n_{it} \quad (7)$$

Where:

β's: constant/parameters to be estimated
A_{it}: the innovation level of country (i) at period (t)
A_t: the innovation level of the leading country in the world at period (t)
t: time
n_{it}: population growth in country (i) at period (t)

The above equation is estimated using data from the GII for the period 2007 to 2024. We approximate the world's available level of innovation with the U.S. level of innovation, while A_i represents the total level of China's innovations.

Table 1 presents two specifications of the model. We report only the specifications for which the parameter estimates were statistically significant, and for which there is a theoretical background justifying the variables used and the functional form (i.e., quadratic). Additionally, we present first the equation with the highest coefficient of determination and the smallest Akaike Information Criterion, even though the differences are small.

Before discussing the findings, it is important to note a potential limitation due to the low degrees of freedom. The dataset includes only 18 observations. While this is sufficient to estimate the parameters, the small sample size should be taken into consideration when interpreting the results. One key consequence is the potential underestimation of the statistical significance of the parameters, leading to a false assumption that they are insignificant. However, this does not appear to be an issue here, as all our parameters are statistically significant. To enhance the robustness of the estimation, heteroskedasticity and autocorrelation-consistent (HAC) standard errors were used to obtain more reliable parameter estimates. The reported t-statistics are based on HAC standard errors.

Another concern arising from the small sample size is the stationarity properties of the variables. Testing for stationarity and cointegration becomes more challenging with a small sample. I used the Augmented Dickey-Fuller (ADF) test to assess stationarity. The results indicate that China's innovation variable is stationary. This is not the case for the U.S. innovation level, which may be due to a structural break that occurred in 2010 following the Great Recession of 2007-2009. In that year, the index dropped significantly to 45 from an average of 58 but quickly returned to its long-term value of around 60. This was further tested using an ADF test with a break, which failed to reject the hypothesis of stationarity.

Table 1. *Regression Results*

Variables	(1)	(2)
Constant	-199.50** (2.34)	-226.88** (2.54)
US Innovation Level (A_t)	8.33* (3.20)	9.17** (2.69)
US Innovation Level Squared (A_t^2)	-0.07** (2.42)	-0.08** (2.55)
Time (t)	2.69* (10.57)	2.09* (9.89)
Time Squared (t^2)	-0.07* (6.51)	---
China's Population Growth (n_{it})	---	1030* (6.80)
R^2	0.9758	0.9739
R^2-Adjusted	0.9683	0.9659
F	131.00*	121.45*
Akaike	3.841	3.915
DW	1.98	2.19
Observations	18	18

* Significant at 1% level; **Significant at 5%.
Note: In parentheses, absolute values of t-statistics based on HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth of 3).

Additionally, a Johansen cointegration test was applied. The hypothesis that the two variables have one cointegration vector could not be rejected when a quadratic deterministic trend was included. The growth rate of China's population growth rate was found to be stationary after differencing twice, integrated of order two I(2).

The Durbin-Watson statistic suggests no issues with autocorrelation. The null hypothesis that the independent variables as a group have no effect on China's innovation level is rejected by the F-statistic for both empirical specifications reported in Table 1. Finally, the coefficient of determination indicates that 97% of the variation in the dependent variable can be explained by the predictors.

I will use only the first specification to explain the effect of the independent variables. The most important variable is the effect of the US's innovation level on China's innovation level. This effect is non-linear and is best approximated by a quadratic specification. China's innovation level increases at a decreasing rate as the US innovation level rises. Evaluating at the mean values of China's and the US's innovation levels, the marginal effect is given by:

$$\text{Marginal Effect} = \partial Ai/\partial A = \beta_1 + 2\beta_2\bar{A} = 8.33 - 0.14 \cdot 58.58 = 0.1289 \qquad (8)$$

Where $\bar{A}$ is the mean value of US's innovation level. China's elasticity of innovation with respect to U.S. innovation is estimated as follows:

$$\text{Elasticity} = (\beta_1 + 2\beta_2 \cdot \bar{A})(\bar{A}/\bar{A}\iota) = 0.1289 \cdot (58.58/47.35) = 0.1595 \qquad (9)$$

If the U.S. innovation index increases by one unit, China's innovation index will increase by 0.1289 units. The elasticity of China's innovation with respect to the U.S. innovation level is 0.1595. A 10% increase in the U.S. innovation index—from an average value of 58.58 to 64.64—will result in a 1.6% increase in China's innovation index. This represents an estimate of China's absorption rate. It is likely that this effect unfolds over a period of years.

The effect of the trend variable is quadratic: China's innovation increases over time, but at a decreasing rate. The trend variable can be interpreted as the impact of domestically produced innovations on China's overall innovation level. As before, we can estimate both the marginal effect of time and its elasticity. The marginal effect is 1.36, and the elasticity is 0.273. Thus, each year, China's innovation index increases by 1.36 units.

The empirical findings reveal that China's innovations depend on U.S. innovations in a nonlinear fashion. Absorption is positive and increases with U.S. innovations, but at a decreasing rate. Ultimately, China cannot absorb all U.S. innovations in one year. Similar results are observed for the trend variable.

Population growth exhibits the expected positive sign, but its interpretation is problematic because the hypothesis of stationarity was rejected. A positive association was also found by Kremer (1993), though stationarity and cointegration of the two variables were not tested. There may be a third factor causing the two variables to move together.

Technological change implies an increase in per capita income, which, at early stages of development for populations living at or below subsistence levels, translates into higher population growth. The demographic transition suggests a negative effect on the size and growth of the population over time. Countries in the post-industrial modern world are able to achieve high levels of innovation, resulting in higher per capita incomes and wealth. As suggested by the demographic transition, this leads to a reduction in population growth. However, the mechanism driving this effect may differ and requires more careful analysis and interpretation, which lies beyond the scope of this research.

The next section delves further into this issue, focusing primarily on the political question of whether China will overtake the U.S. in innovation. For this to happen, China must generate its own innovations and leverage its position of relative backwardness. This argument is explored in the following section.

Can China Overtake the US?

This section adopts a different approach from the previous one. It is more journalistic and political. In both the popular and less mainstream press, there is significant concern—often lacking evidence—about China potentially overtaking the U.S. in innovation. Drawing inspiration from Socrates, who saw himself not as Athenian or Greek but as a citizen of the world, I question: what would truly be wrong if China were to surpass the U.S. in innovation at some point in the future?

Some argue the issue lies in military superiority. The fear is that we would all be subjugated to the Communist Party of China. According to this narrative, they are the "bad guys," and we, in the West and pro-U.S., are the "good guys." It is claimed that Western military strength will prevent such an outcome. Yet, U.S. superiority in innovation has not necessarily translated into a better or more democratic world. When the U.S. has attempted to "liberate" the world from its so-called bad guys, it has often failed miserably. Why, then, would China succeed in imposing its political system globally, even if it were to achieve overall innovation superiority?

I believe the underlying animosity stems from vested interests that benefit from such antagonisms. This is partly because discoveries and innovations and their successful transformation into technologies are primarily driven by government policies. In many countries—especially authoritarian regimes—people are not free to discover and innovate unless approved by the state. Historically, many pioneering innovators migrated to freer environments, such as the U.S., to fully develop their talents. However, the most critical government policy in the democratic world is financing innovation. I do not address government policy issues in promoting innovation here. Katz (2025) provides an excellent overview of government policies aimed at fostering innovation in a global context, emphasizing the role of technological supremacy in driving innovation.

In the U.S., researchers and institutions often struggle to secure funding for Research & Development (R&D). Being an academic does not automatically ensure ethical behaviour in any country, US and China included.[1] Thus, many academics, researchers and institutes capitalize on the perceived 'threat' of China to secure funding from U.S. government agencies and other resources.

I will not delve further into these issues here, but they are crucial for understanding the widespread concern about China—similar to past concerns about the Soviet Union and, to some extent, Japan or even the 'Asian Tigers' of the 1960s to 1990s (Hong Kong, Singapore, South Korea, and Taiwan). In the 21st century, the tigers have become domesticated pussy cats.

Instead, this section focuses on two specific issues. First, I compare the innovation models of the U.S. and China, arguing that as long as China's model relies on the advantage of backwardness, it cannot surpass the U.S. This possibility is excluded by definition: one cannot simultaneously be backward and an overall leader. Second, I analyse data often presented by journalists, politicians, and researchers with vested interests to demonstrate how the (deliberate) misuse of data can support false claims—such as the argument that China's discoveries and innovations will soon surpass those of the U.S.

US and China's Innovation Models Compared

The United States maintains a technological advantage over China primarily due to its factor endowments,[2] which enable it to excel in new ideas, discoveries

[1]For a discussion on academic virtue and integrity, see Papanikos (2025a).

[2]The most important factor endowment is human capital, as many economists have pointed out (Papanikos, 1994). It is noteworthy that one of the specific factor endowment comparative advantages of the U.S. is

and innovations. Once something is discovered or invented, new technologies are developed. If these technologies offer an economic advantage over existing ones, they are adopted to produce new or improved goods and services. As production progresses, iterative improvements often lead to further advancements and new (improved) products.

The car and the airplane are excellent examples. The car, for instance, was invented only once but has undergone countless improvements. By the early 21st century, it had become a completely different product from its original form. China is now a leader—or is on the verge of becoming one—in producing cars that incorporate the most advanced technology to date. Part of this technology was created in China. This serves as a prime example of how an invention can be continually improved through technological advancements by a country other than the one that originally invented it. It is also an excellent example of how the discovery of a new tool can evolve into technology that is improved exponentially and used extensively. If one compares this process with the invention of the fork, which was initially invented by the Egyptians, Greeks, and Romans, but was first used for eating by the Byzantines in the 10th century, its use expanded to Europe in the 17th century, where it was technologically improved in both design and practicality (with four tines) in the 19th century.

Figure 1 compares the innovation models of the U.S. and China. The process described above characterizes a leading nation in discoveries and innovations, such as the U.S. In contrast, China is portrayed as a latecomer that capitalizes on its position of innovation backwardness. China often imitates the discoveries and innovations of the U.S. However, this does not imply that China lacks the capacity for innovation or discovery. On the contrary, China is capable of producing a wide range of goods and services. Nonetheless, its current factor endowments—particularly in terms of human and institutional capital—restrict its ability to generate more innovations and technologies than the United States. We do not illustrate this dynamic in Figure 1 to avoid complicating the visual representation. However, the theoretical and empirical model presented in the previous section explicitly accounted for these limitations.

The U.S. innovation model in Figure 1 begins with a big question mark, reflecting the mystery of how certain nations advanced in ways that produced new ideas, expanded knowledge, and fostered wisdom. For instance, why were the Ancient Athenians the first to achieve such progress, rather than the Ancient Persians, Ancient Chinese, or Ancient Indians? Although these civilizations existed simultaneously, their remarkable achievements had minimal influence on the broader world.

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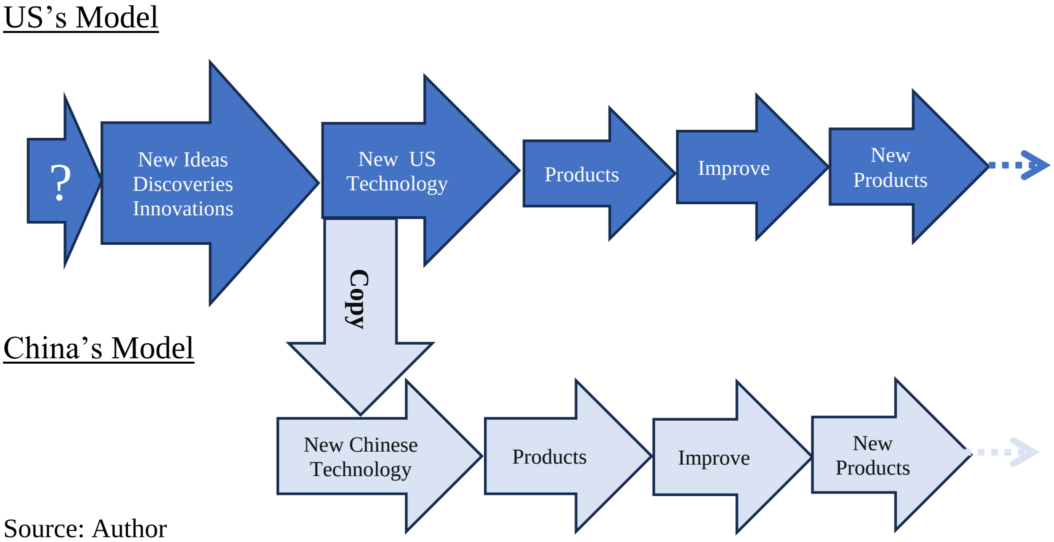
the large migration of the best minds from around the world to the country. This trend has been ongoing throughout the 20th century, resulting in a significant global brain drain. Some of these 'brains' were, and still are, Chinese. While some of these Chinese individuals have returned to China, most have remained in the U.S. However, this important issue is not discussed in this paper.

Figure 1. *The Interaction Between the Innovation Models of the U.S. and China*



Source: Author

It is noteworthy that in Hesiod's great work, the gift of fire was credited to one man, Prometheus, who stole it from the gods and suffered for his act until another ancient hero, Hercules, freed him from his torment. From what we know, nobody financed Prometheus' endeavor. Prometheus symbolizes talent. Thus, the answer to the question mark is an unbounded Prometheus. Today, individuals form businesses that drive innovation. Governments should craft industrial policies that unbind modern businesses, enabling them to innovate freely.[1]

Why was England the first to lead the innovations that gave rise to the Industrial Revolution? Why was the U.S. the first to pioneer the post-industrial revolution? I believe the primary cause of these advancements is democracy. It is not an accident that, for centuries, democracy had disappeared as a political system. Many great—and not-so-great—empires did not have democracy, including the Byzantine Empire, the Ottoman Empire, and all the European kingdoms from the fall of Rome until the Magna Carta (1215) in England. These years are called the Dark Ages, and rightly so—not because there was no progress, but because they did not embrace the light of democracy. It took many years for the world to discover this light. Democracy began to spread to Europe and the U.S. by the end of the 18th century. Coincidentally, or perhaps because of this, the 19th and 20th centuries saw revolutions in discoveries, innovations, and, most importantly, their applications—what we now call technology. It is no coincidence that electricity was discovered in the 19th century.

It seems that the causality runs from democracy to discoveries, innovations, and technologies. Democracy is required for this to happen. Many countries made discoveries and innovations in the past, going back to the ancient civilizations of Mesopotamia, but it was democracy that enabled these advancements to benefit

[1]This critical issue is not addressed here. The GII index includes two of its seven pillars related to market and business in its holistic measurement of innovation. Van der Duin et al. (2016) and Boer & Ihlenburg (2020) explore the topic of business innovation. The former examines the Dutch government's policies to support top innovative industries, while the latter focuses on business collaboration in fostering innovation.

humanity at large. China, too, made many important discoveries and innovations in the 15th century, but it was the democratic West that transformed them into technology.

The Ancient Athenians are credited with the discovery of democracy, which later evolved into a *techne*—a practical art—in the hands of politicians, effectively transforming it into a form of technology, i.e., the technology of ruling.[1] Over time, the rest of the world adopted this model, creating variations such as parliamentary democracy, presidential democracy, liberal democracy, constitutional democracy, social democracy etc. As it is the case with good brands, for the brand-name democracy there exist today very bad and cheap imitations such as the so-called people's democracy, illiberal democracy, authoritarian democracy etc.

While I will not delve further into this issue here, I firmly believe that no country can excel in discoveries and innovations if its citizens lack freedom of thought. This is distinct from freedom of speech in general. The issue of democracy and freedom of speech and thought have been discussed extensively in my series of publications; see Papanikos (2016, 2017, 2020, 2022d, 2022e, 2022f). Even in societies that held great respect for freedom of thought and speech, they did not always make the right decision. Socrates was very democratically sentenced to death by a jury of 501 jurors, who were randomly selected from a pool of 5,000 potential jurors on the day of the trial. And what a trial it was! Socrates' *Apology* (defence) during his trial is a masterpiece of what freedom of thought and freedom of ideas are all about. Despite this, he was sentenced to death by a very small margin. Living in a democratic and free society, and despite the offer to escape, Socrates gave another lesson that humanity cherishes: respect for the law is the duty of every citizen in a democratic and free society. Compare Socrates' trial with the next famous trial of a free mind: Galileo Galilei, who was tried in 1633 for his belief in the heliocentric model. Who tried him? The Roman Catholic Inquisition. This is a difference between a democracy and a theocracy or a democracy and a kleptocracy in our times.

Figure 1 provides a descriptive answer to the question, "Can China overtake the U.S.?" The answer is no—unless China adopts characteristics similar to those of the U.S. While this is a necessary condition, it is not sufficient. At the same time, for China to become a sustained leader in innovation, the U.S. would need to adopt a model characteristic of an authoritarian regime and enter a period of regression. This would constitute the sufficient condition for China's ascendancy.

As it stands, over the long term, the gap between the two countries is expected to narrow, though at a decreasing rate. At some point, China will likely reach a limit in its capacity to absorb internationally produced technologies, as other countries continue to remain one step ahead. This issue is further examined below, with a focus on the use—or rather misuse—of descriptive statistics, a

[1]According to Herodotus, the war between the Greeks and Persia was a conflict between Europe and Asia. Aeschylus's tragedy *The Persians (Perses)* contains a beautiful discussion on the military superiority of Ancient Athens over the Persian Empire. Aeschylus, however, framed it as a war between democracy and authoritarian regimes. It seems, both then and now, that democracy demonstrates superiority over non-democratic regimes.

practice frequently employed by the mass media, politicians, and government-funded institutions.

Misusing Descriptive Data

The proposition to be examined here is whether the limited evidence from 18 annual observations can provide insights into the declining trend of the innovation gap between the U.S. and China, eventually reaching a point where further reductions in the gap are no longer possible. These data are reported in Table 2. It is argued that the gap will remain positive as long as the U.S. model and China's model remain unchanged. Not only must China modify its model to encourage more discoveries and innovations within the country, but the U.S.—and, more broadly, the so-called Western world—would need to abandon their successful model of continuous encouragement of discovery and innovation. There is no apparent reason why the U.S. and other leading countries would adopt such a policy.

A small sample size has not stopped the mass media, politicians, researchers, or institutes from drawing sweeping conclusions based on even smaller datasets, as I will demonstrate below. For them, a timeframe as brief as ten years—or even less—often suffices to generalize and validate their concerns about an issue. Similarly, I will use this approach to illustrate how misusing data can lead to absurd conclusions.

Examples of such claims abound in mass media and reports. A notable instance is the 2022 report by Ian Clay and Robert Atkinson. The second author, Robert Atkinson, is a member of the advisory committee for the Global Innovation Index and serves as the president of the Information Technology and Innovation Foundation (ITIF) in the United States. Their report, titled *"Wake Up, America: China Is Overtaking the United States in Innovation Output,"* exemplifies this trend. 'Overtaking' implies that China has not yet surpassed the U.S., but such a title is effective at grabbing attention in the media and I guess funding from tax-payers money.

But why should the rest of the world care if China overtakes the U.S. in innovations? The authors argue that this shift would undermine U.S. security, implying that if China becomes a leader in innovation, it could translate these advances into military supremacy, potentially enabling it to attack and win a war against the U.S. They do not explicitly state this, but it is clearly implied, and such statements are universally understood in this way.

Table 2. *US and China's Innovation Data*

Year (1)	A (2)	A_i (3)	$A-A_i$ (4)	2007-2024 $A_i = -0.8t+19$ (5)	2007-2011 $A_i = -3.6t+27$ (6)	2013-2018 $A_i = -1.7t+28$ (7)	2019-2024 $A_i = -0.005t+7$ (8)
2007	58	32.1	25.9	17.93	23.21	26.01	6.97
2008	52.8	35.9	16.9	17.14	19.62	24.29	6.96
2009	49.25	34.55	14.7	16.35	16.03	22.57	6.96
2010	45.7	33.2	12.5	15.56	12.44	20.85	6.95
2011	56.57	46.43	10.14	14.78	8.84	19.12	6.94
2012	57.7	45.4	12.3	13.99	5.25	17.40	6.94
2013	60.31	44.66	15.65	13.20	1.66	15.68	6.93
2014	60.09	46.57	13.52	12.41	-1.93	13.96	6.93
2015	60.1	47.47	12.63	11.62	-5.52	12.23	6.92
2016	61.4	50.57	10.83	10.84	-9.12	10.51	6.92
2017	61.4	52.54	8.86	10.05	-12.71	8.79	6.91
2018	59.81	53.06	6.75	9.26	-16.30	7.07	6.91
2019	61.73	54.82	6.91	8.47	-19.89	5.35	6.90
2020	60.56	53.28	7.28	7.68	-23.48	3.62	6.90
2021	61.3	54.8	6.5	6.90	-27.08	1.90	6.89
2022	61.8	55.3	6.5	6.11	-30.67	0.18	6.89
2023	63.5	55.3	8.2	5.32	-34.26	-1.54	6.88
2024	62.4	56.3	6.1	4.53	-37.85	-3.27	6.87
			$A_i>A$	2030	2014	2023	3298

Source: Annual publications of the Global Innovation Index from 2007 to 2024, published by WIPO, and the author's calculations. The Global Innovation Index and Report for 2008 was not released due to unprecedented economic shifts in the global economy (INSEAD, 2009, p. 3). In 2010, WIPO's reports referred to the periods 2008–2009 and 2009–2010. I used the first dataset as the 2008 figure and the latter as the 2010 figure, calculating the 2009 value as the average of the two. Of course, the authors correctly report on p. 6 that «This has translated into slower but still significant progress in indicators accounting for the size of each country's economy or population, where China still lags behind the United States».

This, to me, represents a prime example of a ridiculous conclusion. Furthermore, why should the rest of the world care about this hypothetical scenario? And if the authors' premise is correct, why doesn't the U.S. pre-emptively attack China now, while it supposedly holds an innovation-driven military advantage? The U.S. has had military supremacy since World War II but has failed to impose its will in many countries where its military might has been used.[1] Why would a Chinese military supremacy be any better?

[1]Actually, when it comes to choosing between a U.S.-type democracy and a theocracy of any denomination, I will definitely choose and fight for the former. However, this is not the issue. The United States believed it could enforce democracy from the outside, which is a contradiction in terms. People, and only the people of a country, must decide on this; otherwise, it is not democracy. A good example of massive failure was the Arab Spring, which, despite all the support given by the U.S., miserably failed. Why? Because, in Egypt, for example, people very democratically decided not to have a democracy, but

Additionally, what evidence do the authors provide? They compare innovation capabilities between 2010 and 2020. While the U.S. still leads, China has narrowed the gap, moving from 58% of U.S. capabilities in 2010 to 75% in 2020. Data from Table 2 tells the same story: China's innovation level in 2010, as a percentage of the U.S. was 73%. By 2020 it rose to 88%. But is this sufficient for China to overtake the U.S.? The answer is no, as I will demonstrate in this section. Nevertheless, the authors misuse the data to predict that *"if this relative growth continues apace, China will surpass the United States by 2035"* (p. 6).

While this prediction may seem plausible, it assumes a linear reduction in the gap between the two countries. However, if a non-linear trend—arguably the more realistic scenario—is applied, China may never overtake the U.S. This is evident in Table 2, where Columns 2 and 3 show the Global Innovation Index scores for the U.S. and China, respectively. Column 4 highlights the innovation gap between the two countries. The final four columns provide forecasts based on linear trends in the data, revealing how substantial differences in outcomes can arise depending on the time periods and assumptions considered, as will be discussed further below.

Figure 2 illustrates the gap between the US innovation level and China's innovation level ($A\text{-}A_i$) from 2007 to 2024. It is evident that a linear approximation is not appropriate, as demonstrated in the previous section. The innovation gap depends nonlinearly on the US innovation level and follows a quadratic trend. What is noteworthy here is that, over the 18 years for which the index is available, the difference has undergone four distinct phases: three negative phases and even one positive phase (started in 2011 and ended in 2013).

The negative phases are outlined in Table 2, corresponding to the periods 2007–2011, 2013–2018, and 2019–2024. Table 2 also provides parameter estimates for a fitted trend during the three periods where the relationship could be approximated by a linear equation. It is important to note that while 2012 and 2013 were the primary years during which the innovation gap widened, increases were also observed in 2019, 2020, and 2023. However, these increases in the gap were relatively minor.

Linear projections can lead to absurd conclusions. For example, if we assume a linear trend for the entire period (2007–2024), China is predicted to surpass the U.S. by 2030. However, as noted in the previous section, the relationship is not linear but quadratic. I'll come back to that. Using data from the first phase (2007–2011), China would have been projected to overtake the U.S. by 2014. In contrast, using data from the second phase (2013–2018), the projection suggests China would have been ahead of the U.S. by 2023. However, the last six years present a different picture. If the U.S.-China innovation gap continues to close at the rate observed between 2019 and 2024, China would not surpass the U.S. until the year 3298.

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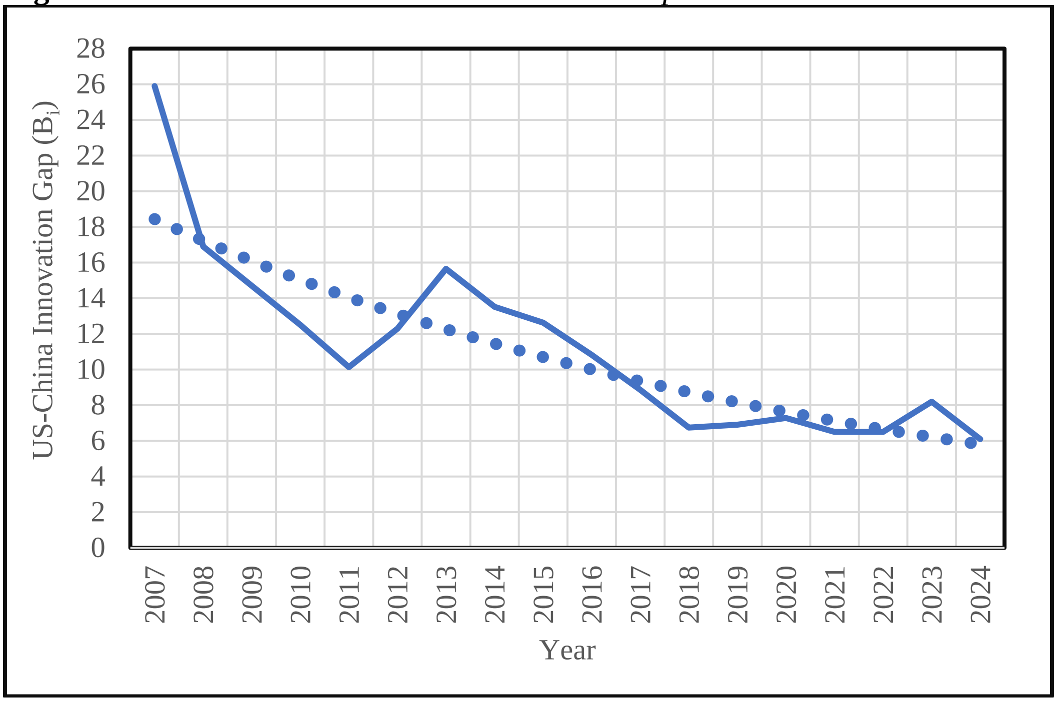
a theocracy. Hamas in Gaza was elected to power once very democratically and then decided to abolish democracy.

Figure 2. *US-China Innovations Backwardness Gap*



At first glance, this may seem like an absurd conclusion. However, considering that China's first known dynasty—the Xia Dynasty of the 2nd millennium BCE, whose existence is still debated—and many others that followed, none of which played a leading global role comparable to that of the Hellenes after Alexander the Great or the Romans thereafter, discussing the 2nd and 3rd millennia CE makes perfect historical sense.

The long-term perspective is also evident in the best-fit line of the innovation gap shown in Figure 2. A log-linear (exponential) function provided the best fit[1], with parameters estimated using a HAC (Heteroskedasticity and Autocorrelation Consistent) estimation. The results are as follows:

$$\text{Log}\ (B_{it}) = \beta_0 + \beta_1 \cdot t = 2.91 - 0.067983 \cdot t \tag{10}$$

HAC standard errors. R2-Adjusted = 0.7826, Obs.=18
t-statistic (β_0) = 25.62 (0.0000). t-statistic (β_1) = -6.75 (0.0000)

Both estimates were statistically significant, as indicated by the t-statistics and the probabilities shown in parentheses. The trend explains 78.26% of the variation in the innovation gap between the U.S. and China.

[1]The Akaike Information Criterion (minimum value) and the adjusted coefficient of determination (maximum value) were used to select the best fit. However, a glance at the diagram makes it clear that a log-linear specification fits the data better. The evidence from segmenting the sample into linear parts, as presented in Table 2, provides additional support for the conclusion that an exponential fit is the best. The slope becomes nearly flat in the last 6 years of the observations.

The mathematical interpretation of the function suggests that for the gap to approach zero, the value of (t) must approach infinity. To illustrate, let us calculate when China will be one unit below the U.S. innovation level. In this case, where log (B_{it})=0, solving equation (10) for time shows that this will occur in 42.8 years. If the gap is reduced to 0.01 (approximately equal but with the U.S. still slightly ahead), then the number of years required for China to reach the U.S. innovation level is 72 years.

These findings make perfect sense and align with theoretical expectations regarding the "advantage of backwardness." As long as China's innovations rely on lagging behind and copying technologies from other countries, it will never surpass the innovation levels of leading nations.

Why, then, is there so much fuss about China becoming a leading country in discoveries and innovations? Based on the evidence presented above, this outcome seems unlikely. The concern is primarily political. Some politicians, researchers, and institutions in the U.S. have a vested interest in persuading society at large that China poses a potential threat if it becomes a leader in innovation. Successfully creating this perception often translates into increased government funding for R&D initiatives aimed at fostering discovery and innovation.[1]

It would be interesting to examine how these institutions and researchers, who portray China as a threat, are financed and by whom. It is also worth noting that the victims of this propaganda, driven by U.S. vested interests, are people around the world who hope to see the U.S. empire collapse and a new superpower emerge. Any superpower would do, even terrorists and other non-democratic regimes, as long as they are opposed to the U.S. All of this serves the interests of those in the U.S. who benefit from such alleged threats. This issue lies beyond the scope of this paper and should be addressed in future research.

Some Final Thoughts and Conclusions

It is very difficult to predict what will happen a thousand years from now, or even just a few centuries into the future. However, even if such predictions were possible, their usefulness might be limited. This is because knowledge of the future could influence the actions and policies of the current generation, potentially altering the predicted trajectory.

For instance, if someone claimed to see in a "magic sphere" that I would die tomorrow in a car accident, I might decide to stay home all day and avoid driving.[2] In doing so, I would effectively falsify the prophecy by taking action

[1]This is not the first time that the U.S. has panicked when another rival country succeeds in something they consider technologically superior. In the 1960s, it was their space program that was boosted to contest the USSR's achievement of sending people to space. They may fear what others would do to them if they ever discovered something like an atomic bomb. In this case, they judge the affairs of others by their own.

[2]Actually, the correct prophecy would have been: *If and only if you go out, then you will die in a car accident.* Similarly, China will surpass the U.S. if and only if adopts a new innovation model that is superior to that of the U.S. Simply reducing the gap by copying the U.S. and other innovation world leaders is not sufficient.

today. Similarly, if scientists were to determine that an asteroid would destroy the planet in 1,000 years, they might first innovate and then develop technologies to change the comet's trajectory. By the way, this has already been tested by the U.S. as part of its OSIRIS-REx program, applied to the asteroid Bennu in 2016. This is called the "gravity tractor," which slightly changed the trajectory of Bennu.

Likewise, if the U.S. perceives China as an 'asteroid' about to hit their world, it can alter either its own innovation trajectory (e.g., by spending more on R&D and/or attracting even more of the best researchers to the U.S.), China's trajectory (e.g., by minimizing China's copying of U.S. discoveries and technologies), or, most likely, both. Many Chinese students have studied in the U.S., gaining firsthand experience in discovery and innovation. By doing so, the U.S. has inadvertently reduced China's costs of overcoming its technological backwardness. Never in history has there been such a wide exchange of ideas on scientific matters. The U.S. can reverse that and prevent China from taking advantage of its backwardness. It can stop admitting Chinese students to U.S. universities and research centres. My feeling is that this would cause more harm to the U.S.'s innovation program than to China's.

This is one of the many benefits of globalization, and it is something that should be preserved. One of the byproducts of such collaborations is worldwide peace—another important issue that is not discussed in this paper. Discoveries and innovations are global public goods, and everyone should benefit from them regardless of political entities or ideologies. Actually, this is what has been happening despite all the obstacles that countries like US may want to impose (Papanikos, 2025b). A recent good example is the rapid development of COVID-19 vaccines, which saved millions of lives worldwide.[1] While the US may be credited with the discovery, the entire world benefited. If this collaborative approach continues, the question of who discovers or innovates becomes irrelevant —at least for those who, like Socrates, prioritize wisdom and the greater good over nationalistic concerns.

As I have shown in Papanikos (2025b), globalization is here to stay because it benefits every citizen of the world—or at least the wealth it generates can be used to compensate those who are negatively affected in the short term. This includes the citizens of the US and China. The evidence is overwhelming: globalization reduces absolute poverty (Papanikos, 2024). Hesiod would have been very happy. While scarcity has not been completely overcome, its effects have been drastically diminished. Prometheus is credited for this, and Prometheus has no nationality.

In today's globalized world, Chinese scientists are able to form multinational teams with colleagues from around the globe to discover and innovate. This can take the form of *ad hoc* teams or more formal structures under the auspices of large private multinational businesses, multinational academic institutes, and other organizations. In a few years, it will likely become very difficult to identify discoveries and innovations by country. Instead, they will be identified by the individuals involved, which will be best for the world. Who leads becomes completely irrelevant if all citizens of the world, especially those living in

[1]For more on this issue, see Boutsioli et al. (2022a, 2022b).

absolute poverty, can benefit. The eradication of absolute poverty should be the primary objective of any scientific endeavor, rather than determining who leads in discoveries and innovations.

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