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On the Origins of Modern East Asia: Knowledge and the Economic Transformation of Japan and China in the late 19th century*

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March 7, 2026

Abstract

This paper revisits the old thesis of the contrasting paths of modernization between Japan and China. It develops a new analytical framework regarding the role of knowledge acquisition (propositional vs. prescriptive) and political centralization as the key drivers behind these contrasting paths. Our model and historical data highlight how the introduction of these elements contributed to Meiji Japan's decisive turn towards the West and Qing China's lethargic response to Western imperialism. Our analytical framework, developed from a comparative historical narrative and quantitative data, sheds new insights onto the importance of knowledge acquisition for enabling developing countries to reach the world's economic frontier.

Keywords: propositional knowledge, prescriptive knowledge, China, Japan, economic development, economic divergence, Meiji Reform, centralization, decentralization

JEL Codes: P52, N45, N40, Z10

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1. Introduction

Adopting capital from countries at the world's technological frontier is widely considered to be among the quickest and most effective ways for developing countries to converge with leading economies (Solow 1956; Swan 1956). Yet, catch-up growth does not always happen—many of the poorest countries in the world were also poor two centuries ago. One of the most important episodes of catch-up growth—or lack thereof—was the differential responses of China and Japan to Western military and economic dominance, which ultimately fueled economic divergence within East Asia during the 19th and 20th centuries (Brandt, Ma and Rawski 2014; Koyama and Rubin 2022). Beginning in the mid-19th century, Japan rapidly and comprehensively adopted Western technology, capital, knowledge, dress, and much more while China selectively adopted a narrow set of Western techniques. In the ensuing decades, the Japanese economy rapidly advanced while the Chinese economy stagnated (apart from the construction of a few government-sponsored modern enterprises). This ultimately resulted in China's humiliating defeat in the Sino-Japanese War (1894–95) and the fall of the Qing empire thereafter (1912).

These differential responses to the West pose two puzzles. First, why did China and Japan respond differently to Western dominance? Second, how did this matter for their subsequent economic development? We argue that the key to resolving these puzzles lies in the way the two countries acquired knowledge from the West. Employing the terminology of Mokyr (2002), the Meiji Restoration evolved from the acquisition of *prescriptive* knowledge—which involves knowing what works and how, but not why—to that of *propositional* knowledge (i.e., knowledge of why things work). Meanwhile, the Chinese reform known as the Self-Strengthening Movement focused on obtaining prescriptive knowledge until after its military defeat by Japan in 1894–95.

The accumulation of propositional knowledge serves as a fundamental engine for sustained technological progress and economic expansion (Mokyr 2002, 2009). Unlike prescriptive knowledge, which often limits the possessor to the execution of specific techniques without understanding their underlying principles, propositional knowledge provides the theoretical scaffolding necessary to answer the 'why' questions behind technical success. This deeper epistemic understanding is transformative; it empowers individuals to not merely operate existing machinery, but to deconstruct, reverse-engineer, and adapt the advanced technologies of others. By rendering the "black box" of superior technology transparent, propositional knowledge lowers the cost of imitation and innovation, allowing societies to internalize technical advances rather than relying on exogenous transfers. Consequently, the capacity to recover and re-engineer complex techniques ensures that technological improvement becomes a self-reinforcing process, thereby allowing economic growth to occur endogenously.

This paper provides a unified framework for understanding why and how China and Japan acquired knowledge from the West. In our framework, we treat the onset of Western imperialism as a common exogenous shock to both nations after nearly three centuries of self-imposed isolation. The ruling elites faced a tradeoff: they could invest in acquiring new propositional knowledge, acquiring new prescriptive knowledge, or maintaining the status quo (i.e., traditional or domestic knowledge). Propositional knowledge offers the highest returns, followed by prescriptive knowledge, followed by traditional knowledge. However, adopting foreign knowledge, particularly propositional knowledge, comes with the risk that the broader population will update their internalized beliefs regarding "how the world works" (Denzau and North 1994; North 2005; Rodrik 2014; Greif and Mokyr 2017). Such changes may carry negative consequences for political elites, as they may call into question the very principles upon which the ruling regime derives *legitimacy* (Greif and Rubin 2024). This is because the adoption of propositional knowledge requires "reverse engineering" what worked elsewhere while also learning the underlying principles or worldviews that generated the knowledge in the first place. Therefore, the adoption of propositional knowledge poses the gravest threat to the ruling elites' political legitimacy. On the other hand, prescriptive knowledge does not necessarily change the way that one views the world and adopting it involves the admission of foreign superiority only on some dimensions. It is therefore not as threatening as propositional knowledge in terms of undermining the legitimacy of traditional rule.

Propositional knowledge can be acquired via codified knowledge (e.g., translating manuals) or tacit knowledge (e.g., sending students to school in Europe), both of which can be costly. Hence, a second factor that determines the choice of acquiring foreign knowledge is its cost. We propose that this cost is increasing in *cultural distance*: the closer are two cultures, the less reverse engineering is required and thus the less costly is knowledge adoption.

Why did Japan proceed towards adopting propositional knowledge from the West while China only adopted prescriptive knowledge until its 1894–95 defeat by Japan, given that both China and Japan were culturally close to each other but equally distant from the West?[1] Our framework addresses this puzzle, focusing on one critical pre-existing institutional difference—that of a centralized, bureaucratic Qing China versus a decentralized, feudal Tokugawa Japan. In our comparative framework, the institutional dichotomy between "prefectural" China versus "feudal" Japan in the mid-19th century impacted how the introduction of foreign knowledge affected legitimacy through their interpretations of external/foreign threats, the amount of resources required to overcome threats, and the degree to which regional experimentation could be conducted free from the intervention of the center, and hence how cultural obstacles to learning could be overcome.

In a decentralized (feudal) system, relatively autonomous states face different levels of threat, both from the outside and from rival states within. Hoffman (2015) argued that it was precisely such decentralization, and its associated threats, that encouraged early modern European nations to experiment with new military technologies; otherwise, they would have been in danger of falling behind their nearby rivals. Yet, early modern Europeans did not simply copy technologies from each other, they also copied the underlying ideas of how to produce new military technologies and employ them effectively. The general theoretical insight is that decentralized states have greater incentivize to invest in propositional knowledge to gain the resources to combat threats. Experiments occur on a smaller scale, conducted by local authorities who invest when the benefits of additional resources outweigh its cost of loss of legitimacy. Once some states adopt foreign propositional knowledge, it lowers the cultural distance for other states to experiment, as they can borrow from those who have

[1] An English speaker needs 600–750 class hours to achieve professional working proficiency in Spanish and French, but needs 2,200 hours for Chinese and Japanese (Roberts 2025).

already adopted. On the other hand, centralized states do not face such threats from domestic rival polities and thus have less incentive to invest in propositional knowledge.

For reasons laid out above, once Japan (or, at least, segments of Japan) experimented with or adopted Western propositional knowledge, it lowered the cultural distance first for other Japanese daimyos, and ultimately for China to follow suit.[2] After initial adoption, other states could "reverse engineer" what Japan had done, as Japan was culturally much closer to China than the West. However, such knowledge adoption did not happen immediately in China. This changed after the 1894–95 Japanese victory over China, which undermined the Qing basis of legitimacy and thus swung the political trade-off in favor of adopting Western propositional knowledge. Hence, our framework explains the timing of change in both countries.

This paper contributes to three distinct strands of literature. The first is the scholarship on the causes of the economic and political divergence between China and Japan in the 19th century (Ma 2004; Brandt, Ma and Rawski 2014). Existing work largely attributes Japanese growth during the late Edo and early Meiji periods to the early adoption of specific modern institutions. These include the codification of technical knowledge (Juhász, Sakabe and Weinstein 2025), the reduction of risk premia on government bonds (Sussman and Yafeh 2000), the development of modern banking (Tang and Basco 2023), railroad construction (Tang 2014), firm subsidization (Morck and Nakamura 2007, 2018), and trade liberalization (Bernhofen and Brown 2004, 2005). However, a critical puzzle remains: why were these growth-enhancing initiatives largely absent in Qing China before 1895, despite exposure to similar colonial threats? Echoing Sng and Moriguchi (2014) and Koyama, Moriguchi and Sng (2018), we emphasize political economy as the driver of these divergent trajectories. Yet, our argument extends beyond geographical factors to highlight the role of knowledge acquisition. Building on Ma and Rubin (2024), we provide a theoretical model and empirical evidence showing how political (de)centralization dictates the type of knowledge a society adopts—specifically, why Japan moved toward "propositional" knowledge while China remained stuck with "prescriptive" knowledge.

[2] For a discussion of the similarities between early modern Europe and Tokugawa Japan as highly decentralized regimes, see Mukoyama (2022).

Second, this paper contributes to the literature on the role of ideas in economic development. We build primarily on Mokyr (2002), who distinguishes between prescriptive knowledge (knowing techniques) and propositional knowledge (understanding underlying principles). While Romer (1993) argues that idea diffusion can raise standards of living, he notes that sustained growth requires countries to eventually produce their own ideas—a distinction we find salient between Meiji Japan and Qing China. Furthermore, Juhász, Squicciarini and Voigtländer (2024) demonstrate that propositional knowledge takes time to accumulate, creating a lag between adoption and productivity growth. Our paper offers a mechanism for why this accumulation might be delayed: the political cost of legitimacy. We argue that when acquiring propositional knowledge threatens the legitimacy of a centralized authority, societies may opt for prescriptive knowledge instead. This choice comes at the cost of the efficiency gains and the "invention of invention" that characterize modern economic growth (Mokyr 2016; Hanlon 2025).

Third, this paper sheds light on the institutional determinants of technology adoption. A common assertion is that vested interests block new technologies to protect their rents (Acemoglu and Robinson 2006; Chaudhry and Garner 2006). However, technology is often blocked even when vested interests are weak or not antagonistic (Iyigun, Rubin and Seror 2021). We propose that the structure of the state is a decisive factor. Consistent with theories suggesting Europe's decentralized system fostered innovation by preventing any single state from blocking progress (Mokyr 1990; Hoffman 2015), we argue that Japan's decentralized feudal system allowed for regional experimentation with Western propositional knowledge. In contrast, China's centralized system allowed the government to block innovations that threatened the ideological basis of the regime (Coşgel, Miceli and Rubin 2012; Rubin 2017; Bénabou, Ticchi and Vindigni 2022). By placing ideas at the center of political economy, as advocated by Rodrik (2014), we explain how the interaction between the level of centralization and the nature of foreign knowledge determined the economic fate of East Asia.

This paper is structured as follows. The next section presents a motivating example of the differences in knowledge accumulation in 19th century China and Japan. The subsequent sections lay out our framework of knowledge adoption and generate predictions for this specific historical context. Section 5 presents historical narratives of both country's responses to Western military and economic power, as well as China's response to its defeat in the Sino-Japanese War. Section 6 presents quantitative data supporting the model's predictions, and the final section concludes.

2. Background: Wei Yuan Raising the the Alarm

In 1839, a British navy squadron arrived on the Southern Chinese coast to launch the now infamous First Opium War that shattered the once mighty Qing Empire. This marked the beginning of a long and tortuous process of East Asia coming to grips with what we know today as the rise of the West. Just four years later in 1843, Wei Yuan (who was considered the first person to "open Chinese eyes to the world") compiled a fifty volume version of what would become the landmark *Illustrated Treatise on the Maritime Kingdoms* 海国图志, a massive encyclopedia on Western and world military, technology, religion, geo-politics, geography, and culture, including the latest on the British Industrial Revolution and European slavery. Wei's work relied heavily on the translation activities of Western Christian missionaries in China, which led him to lament to his Chinese compatriots that "for a nation [England] that traded with China for nearly two centuries, we knew nothing about her geography and history." But "contrast that with England who studied Chinese, employed Chinese teachers and published Chinese classics...we have no one on our side who knows their situation or studies their technique" (Wei 1992).

Wei's most iconic line in the encyclopedia became the rallying cry for the East Asian response to the Western challenge for the next century: "Learn the tools of the Barbarians to subdue the barbarians" 师夷长技以制夷 (Wei 1992). Wei's classification of the West as the new "barbarian," even after being defeated by them, reflected a deeply entrenched Chinese worldview of cultural superiority, which made his call for learning from the West all the more poignant.

In 1852, Wei's treatise reached the port of Nagasaki, Tokugawa Japan's only port open to a strictly regulated overseas trade under its self-imposed isolation regime. The book was immediately confiscated at customs for its detailed description of Catholicism, a religion banned and persecuted in Japan for over two centuries. But two years later, when the "black ship" led by American Commodore Perry barged into Japan's seaside and forced the specter of Western imperialism, Wei's treatise began to spread rapidly, generating waves of reprints, translations, annotations, and debates among Japanese elites. Inculcated in classical Chinese and scripts, Japanese intellectual elites like Sakuma Shozan, Japan's foremost enlightenment proponent of opening up, devoured the treatise, jotting down copious notes and admiringly referring to Wei as his "comrade overseas." Wei's call for Western learning found a particular echo in Shozan, who was to coin the phrase "Japanese spirit, Western technique" (東洋道德，西洋藝術), later rephrased as "Japanese soul with Western learning" 和魂洋才, to call for Japan's opening to the West.

In contrast to the wide publicity of Wei's book, probably known to most Japanese elites of the time, its reception was surprisingly subdued for nearly two decades after its initial appearance in China.[3] However, Wei's call for Western learning eventually formed the cornerstone ideology of the Self-Strengthening Movement in the Tongzi Restoration (1862–74). The Self-Strengtheners summed up Wei's call for Western or barbarian learning in a new phrase "Chinese fundamentals, Western practicals" 中体西用 coined by Zhang Zhidong, one of the leading bureaucrats of the Self-Strengthening Movement.

Despite the seeming convergence toward Western learning in China and Japan from the 1860s, the nature and pace of such learning diverged substantially from the beginning. The Self-Strengthening Movement under the Tongzhi Restoration of 1862–74 introduced Western military and industrial technologies but treated these Western "tools" as merely machines or material components while keeping the traditional Confucian economy intact (Wright 1957, p. 1). On the other hand, the Western "learning" that Japan borrowed during the Meiji Restoration (1868–1912) gradually expanded from importing machinery and weapons to railroads, modern banks, stock exchanges, corporations, double-entry bookkeeping, universities, and eventually parliament and even hairstyles and dress

[3] When the Chosun Samurai Takasugi Shinsaku—widely considered one of the most important military heroes that later helped overthrow the Tokugawa Bakufu in 1867—visited the treaty port of Shanghai in 1862, he made a point of visiting a local bookshop to inquire about Wei's book, only to find out with shock that nobody there ever heard of Wei or his book. Indeed, after its publication, the *Treatise* faced attacks and rejection from the government and society for compiling information about "barbarian foreign lands." As a result, the book saw only a limited circulation domestically, with just over a thousand copies printed.

code. The second half of the 19th century therefore saw two important political and institutional experiments, out of which the Japanese experiment emerged as the clear winner, as symbolized by its naval victory over China in the First Sino-Japanese War in 1894–95. This defeat shattered China's Self-Strengthening Movement and heralded a much more radical Meiji-inspired reform in China at the end of the 19th century. Table 1 displays this two-plus decade lag in the pace of Western learning between Japan and China.

Table 1: Chinese and Japanese Reforms

	Japan	China
Commercial Code	1881	1904
Double Entry Bookkeeping	1870s	1890s
Modern Banking Act	1872/1876	1904
Patent Law	1885	1944
First Industrial Exhibition	1877	1909
Sale of State Enterprise	1880s	1900s
First Modern University	1877	1895

Sources: see the text.

The key difference between the Japanese and Chinese responses to Western military dominance lies in the philosophy associated with adoption. The Chinese response—"Chinese fundamentals, Western practicals"—was to adopt Western capital but not the underlying knowledge that enabled its emergence. Meanwhile, the Japanese response—Japanese soul with Western learning—gradually evolved into a wholesale adoption of Western knowledge as it applied to Japan. Using Mokyr's (2002) terminology, China only adopted Western prescriptive knowledge, while Japan adopted Western propositional knowledge as well. China sought to adopt what worked practically while keeping the Confucian paradigm regarding *why* it worked as part of a broader institutional and cultural complex. Meanwhile, the wholesale adoption of Western techniques, institutions, and cultural elements by the Japanese allowed it to gain propositional knowledge, thereby understanding not only what worked but *why* it worked, which allowed technological progress to occur endogenously in Japan. We provide detailed evidence of this differential knowledge adoption in Section 6. The next section builds a model of knowledge adoption (prescriptive vs. propositional), focusing on the role that political decentralization can play in incentivizing elites to invest in one type of knowledge over another.

3. A Model of Knowledge Adoption

3.1. Knowledge, Political Legitimacy, and Shared Mental Frameworks

All societies have shared mental frameworks for constructing models through which one perceives how the outside world works and why it does so (Mann 2012; Denzau and North 1994; North 2005; Rodrik 2014; Mokyr 2016; Greif and Mokyr 2017; Iyigun, Rubin and Seror 2021; Ma 2024). These frameworks shape how people perceive reality, providing both an interpretation of the environment and a prescription as to how that environment should be structured. Such mental models cover all aspects of one's life. For instance, they determine what one believes will be the outcome of prayer, what one perceives will be the outcome of hard work, and how one perceives the outcome of government actions.

Shared mental models are therefore central determinants of how political authorities generate *political legitimacy*. According to Greif and Rubin (2024), political legitimacy is the internalized belief that a political authority has the right to govern and have its demands obeyed. Shared mental models can be used to generate shared beliefs in an authority's legitimacy.

Hence, new types of knowledge that are in opposition to the prevailing mental frameworks can undermine an authority's legitimacy. Such knowledge can alter the mental models which yielded the authority legitimacy in the first place. But not all knowledge is the same with respect to how it impinges upon a society's shared mental models. Using the terminology of Mokyr (2002), we distinguish between two types of knowledge: propositional and prescriptive. Propositional knowledge refers to generalized principles regarding *how* the world works and why it works in certain ways. Such knowledge can be quite useful for scientific endeavors—the generation of propositional knowledge was at the heart of the Scientific Revolution and has been central to most technological advances of the last two centuries. But propositional knowledge can also have deleterious effects on political legitimacy. New propositional knowledge can affect the way that the world is viewed. This includes shared beliefs in what justifies political authority and makes a certain political actor legitimate (Greif and Rubin 2024).

The relationship between propositional knowledge and legitimacy was particularly relevant in the mid-19th century. Imperial China had successive periods of outside invasions and conquest, mostly from its northern nomadic frontier which possessed superior calvary forces but inferior intellectual resources (hence the term "barbarian" denoted to them even in the face of military defeat). However, it gradually dawned on the Chinese and Japanese that the threat from the West was far greater, as it was armed with a brand new and sophisticated set of ruling philosophies, religions, institutions, and cultural values, many of which diametrically opposed to China's traditional system. What China and Japan were eventually forced to confront—and to some degree adopt—from the West was not just science and technology, but a wide range of propositional knowledge in the areas of social sciences and humanities that would directly impinge on their legitimacy.

On the other hand, prescriptive knowledge is more easily observable: it involves understanding techniques or organizational structures that work, without necessarily knowing why or how they work. That is, it provides insight into *what* the state of the world is, but not *why* it is so. Prescriptive knowledge can still bring with it economic gain, as new techniques may be improvements upon existing ones. But it is unlikely to lead to continued improvement, as one cannot continuously build on existing techniques or organizations without understanding why they worked in the first place. However, this also means that new prescriptive knowledge imposes less of a threat to political legitimacy, as it does not involve an entirely new interpretation of how the world works. Mastering prescriptive knowledge may allow one to see the outcomes that foreign knowledge produces but not which elements of the cultural package are necessary for the outcome (e.g., rational education was important for the Second Industrial Revolution, Western dress was unimportant, and Christianity was likely, if anything, a hindrance (Squicciarini 2020).

For example, adopting prescriptive knowledge from a foreign culture may include adopting their machines or techniques. It is not necessary to know why those machines and techniques work; it is sufficient to know that they work and how they work. However, adopting propositional knowledge from a foreign culture entails gaining an understanding of why those machines and techniques work. This could include sending people to be educated in the foreign land, translating foreign books containing such knowledge, as well as adopting political institutions, forms of education, or economic organizations that help perpetuate the production of propositional knowledge.

Mental frameworks are therefore susceptible to change in response to outside (exogenous) events or new knowledge. This is especially the case when events in the outside world occur that are inconsistent with one's mental framework. Such events can change how one perceives reality. When these events happen—and if one is aware of these events—it may affect how one perceives the mapping of inputs to outputs (Bénabou 2008; Rodrik 2014, p. 194). As Greif and Mokyr (2017, p. 31) put it, the cognitive rules that form such frameworks "tend to become unstable …when new evidence emerges that is viewed as incontrovertible yet is inconsistent with accepted cognitive rules."

Yet, as long as new evidence is justifiable under the prevailing shared mental framework, the framework can serve as a mechanism to mitigate the *perception* of how bad the shock is. From the perspective of a political authority, a useful mental framework can account for a wide number of external events and yield similar interpretations of the way the event is perceived. The extent to which authorities are successful in justifying negative shocks in the context of the prevailing framework depends in part on the type of outside information that individuals receive. Information that is difficult to verify can more easily be justified than information that is incontrovertible (Akerlof and Michaillat 2018; Hong, Slingerland and Henrich 2024). New propositional knowledge can be particularly hard to justify under the prevailing mental framework, as it requires a new conception of how the world works.

Finally, when foreign knowledge is adopted, the "cultural distance" between the borrowing and adopting society determines the likelihood that adoption efforts will be successful. It is much harder to adopt knowledge that is fundamentally foreign. Individuals will have little, if any, direct experience with foreign knowledge, making it difficult to know what the potential outcomes are given that the prevailing shared mental framework may be inconsistent with the new knowledge (Denzau and North 1994, p. 10). There are simply too many differences between distant and domestic knowledge to cleanly identify which elements are important for making the knowledge "work" during the process of reverse engineering. On the other hand, "culturally close" knowledge is more likely to be adopted successfully since there are fewer elements to reverse engineer. The cultural distance between China and Japan was much closer than that between China and Europe due to the shared usage of Chinese characters. The uniqueness of this logographic system created a distinct boundary; for those outside the Sinosphere, the cost of access was significantly higher due to the steep learning curve required to decode the script. However, within this linguistic sphere, the shared script lowered the cost of learning, facilitating the rapid diffusion of ideas through the invention of standardized terminologies and direct translation, effectively bridging the gap that might have otherwise impeded the flow of knowledge.

3.2. Model Setup

We formalize the connection between knowledge, cultural distance, and state centralization with a model that accounts for the salient relationships between the three. We consider the actions of political elites, since they are the individuals that have access to the resources and political power necessary to engender change.

We begin with the supposition that while society produces goods using the standard inputs of production (land, labor, and capital), the efficacy of these inputs is based on the type of knowledge used to produce capital, repair it, manage labor, and so forth. We consider two types of knowledge: prescriptive and propositional. In our conception, prescriptive knowledge is orthogonal to a society's shared mental framework. However, propositional knowledge can impinge on shared mental frameworks because it alters the way that people view the world.

Moreover, we posit that propositional knowledge yields greater economic returns than prescriptive knowledge in the long run. The reason is that propositional knowledge builds on itself; when producers understand the underlying mechanics of their machines, the scientific principles behind their technology, or the philosophy undergirding the organizational structure, they can build upon them and improve them (Mokyr 2002). The same is not true for prescriptive knowledge, which merely links inputs to outputs without an understanding of why the linkage occurs.

With the distinction between prescriptive and propositional knowledge in mind, we consider a one-period model in which society produces goods using prescriptive knowledge (R) and propositional knowledge (S). We are interested in technology adoption by societies far from the technological frontier. Thus, we assume that R and S must be imported from abroad. In line with the above discussion, the type of knowledge that a society invests in affects the production function that translates standard inputs into outputs. In this economy, there is a third type of knowledge, denoted traditional knowledge (T), which is domestic knowledge associated with the standard way that outputs have been produced in the past.[4]

Elites have one decision to make: invest in prescriptive knowledge (R), propositional knowledge (S), or make no investment and default to traditional knowledge (T). The production functions associated with these types of knowledge are F^R, F^S, and F^T respectively. Since the society is far from the technological frontier, we assume that foreign propositional knowledge yields more output (all else equal) than foreign prescriptive knowledge, which in turn yields more output than traditional knowledge. In other words:

Assumption 1 $F^S > F^R > F^T$ *for the same level of inputs.*

We expand the model to consider two types of societies. They differ only by the type of political authority they have, centralized (C) (“prefectual” in our context) or decentralized (D) (“feudal” in our case). Both types of authorities choose whether to invest in R, S, or neither (thus defaulting to T). Their choice reflects the tradeoffs they face. On the one hand, they need resources to combat potential threats to their rule. Society’s resources reflect the total amount of goods produced minus the cost of production. Abstracting away from the decision regarding input levels, we denote re-

[4] By this definition, traditional knowledge could have components of prescriptive and propositional knowledge. There has been a long-standing debate going back to Needham puzzle regarding why traditional China lacked hypothesis testing and experimental methods (Lin 1995). We do not model this here, as it is less relevant for our focus, which is the impact of foreign knowledge.

sources, V^j, as: $V^j = F^j - d1_S$, for $j \in \{R, S, T\}$, where 1_S is an indicator equaling 1 if S is chosen and d is a parameter reflecting the cultural distance between foreign and traditional knowledge.[5] The underlying assumption is that foreign prescriptive knowledge is more easily observable than propositional knowledge and thus less expensive to acquire. Moreover, since propositional knowledge requires understanding underlying principles, it is more costly to acquire the more foreign the culture is that is being borrowed from. Acquiring propositional knowledge requires sending students to the foreign land, translating codified knowledge into the domestic language, adopting foreign institutions, building universities, and the like. All these activities are costlier the further the cultural distance between the traditional and foreign societies.[6] Since it is trivial that the authority will never choose S if $F^S - d < F^R$, we make the following assumption:

Assumption 2 $F^S - d > F^R$.

Both C and D face two types of threats: an external threat and an internal revolt by the masses. In addition, D faces a threat of domestic conflict between various (unmodeled) decentralized authorities (Hoffman 2015). Each threat impinges upon the tradeoffs faced by the ruler.

The external threat is from a foreign enemy. There is an exogenous component to this threat, a, which reflects the perceived power of the enemy. The political authority can combat the threat with resources, V^j. Formally, the probability that the external threat is suppressed is $p(V^j, a)$, where $p_1 > 0$, $p_2 < 0$, $p_{12} > 0$, and $p_{22} < 0$.

Both C and D also face the possibility of an internal revolt from the masses. The probability that the authority suppresses the revolt is increasing in their legitimacy, L, which itself is a function of the society's shared mental framework, M. The traditional framework yields the greatest level of legitimacy, as it is based on principles that are common knowledge and accepted as the appropriate way to gain legitimacy (Greif and Rubin 2024). If the authority adopts foreign prescriptive knowledge (R), legitimacy is lower than when the authority relies on traditional knowledge. Legitimacy

[5]More realistically, there would be a cost to acquiring foreign prescriptive knowledge, though it may not depend on cultural distance. We do not include such a cost here because it does not add to the insights of the model.

[6]Learning new propositional knowledge has high fixed costs and thus has properties of increasing returns and public goods. Therefore, there could be a time lag in productivity improvements from propositional knowledge.

is even lower if the authority adopts propositional knowledge (S). This assumption is based on the idea that propositional knowledge entails a fundamentally new way of thinking about how the world works, which can undermine prevailing legitimacy beliefs. The greater the cultural distance, the stronger the negative effect propositional knowledge has on legitimacy, since this represents a fundamentally new way of interpreting the world. In short, adopting foreign propositional knowledge affects both the level of output and the political authority's legitimacy. Denoting legitimacy, $L(M(j), d1_S)$, as a function of the type of knowledge used, entails the following assumption:

Assumption 3 $L(M(T), 0) > L(M(R), 0) > L(M(S), d)$,

where $L_1 > 0$, $L_2 < 0$, and $M(T) > M(R) > M(S)$.

The political authority can combat the internal revolt with resources. Formally, the probability that the authority suppresses the internal revolt is $q(V^j, L)$, where $q_1 > 0$, $q_2 > 0$, and $q_{12} < 0$.

Finally, D also faces the potential threat of domestic conflict among other authorities. C does not face this threat because it is the only authority in its state. D is more likely to win the domestic conflict the greater its access to resources. Formally, the probability that D wins the domestic conflict is $z(V^j)$, where $z' > 0$ and $z'' < 0$.

The authorities derive utility from staying in power. For the sake of a parsimonious solution, we assume log utility.[7] Hence, for choice $j \in \{R, S, T\}$ we write utility for C and D as follows:

$$U^C = \log[p(V^j, a)q(V^j, L(M(j), d1_S))], \tag{1}$$

$$U^D = \log[p(V^j, a)q(V^j, L(M(j), d1_S))z(V^j)]. \tag{2}$$

In short, the political authority has one decision to make—which type of knowledge to employ: R, S, or T. This decision involves tradeoffs. Propositional knowledge (S) offers the most access to resources, which can be used to suppress all three types of conflicts. However, it comes with the biggest loss of legitimacy, which lowers the capacity to suppress the internal revolt. Meanwhile,

[7] Other forms of utility would require straight-forward assumptions on third-order conditions.

traditional knowledge (T) offers the least access to resources but is associated with higher legitimacy for the authority. Prescriptive knowledge (R) offers legitimacy and resources in between S and T.

3.3. Equilibria

First, consider when an authority will choose T. The higher the outside threat (a) is, the more that resources are valued on the margin, since $p_{12} > 0$. Since a does not affect the probabilities that either the internal revolt or domestic conflict are suppressed, it follows that the authorities will only choose T—which provides the fewest resources—when a is sufficiently small.

Next, it is straightforward to show that the threshold value of a for which C chooses T is higher than it is for D. Resources are more valuable on the margin for D, since D can also use resources in a domestic conflict. Hence, there is a larger set of parameters for which D chooses R or S than there is for C. We formalize this logic in Proposition 1. All proofs are in Appendix C.

Proposition 1 *There exists a^* and a^{**}, where $a^* > a^{**}$ such that C chooses T when $a < a^*$ and D chooses T when $a < a^{**}$.*

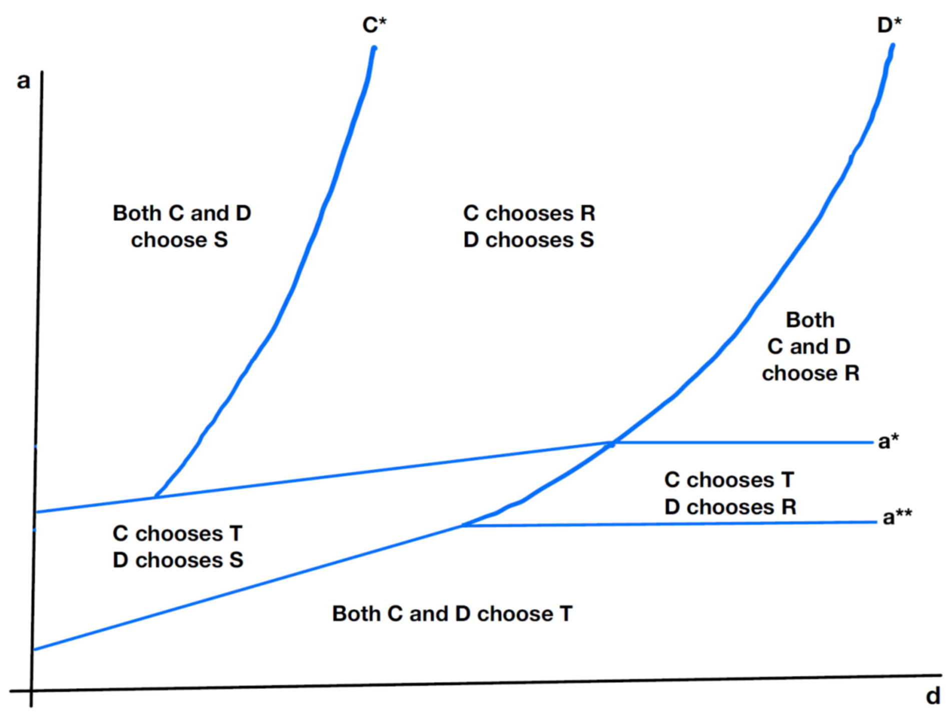
Next, consider the part of the parameter space in which the authorities choose either R or S. For each type of authority, there must be a threshold value, denoted C^* and D^*, for which C chooses S if $a > C^*$ (and R otherwise) and D chooses S if $a > D^*$ (and R otherwise). The logic is straightforward. At higher levels of a, resources are more valuable on the margin to both C and D, thus increasing by more the utility associated with the choice that incurs the highest level of resources (S).

Moreover, the threshold levels C^* and D^* are both increasing in cultural distance (d). As cultural distance increases, the value of choosing S decreases for both the level of resources and the legitimacy loss associated with S. Hence, at higher levels of d, it takes a larger perceived outside threat for either type of authority to choose S.

Finally, and importantly for our narrative, for all values of the outside threat (a), it must be the case that $C^* > D^*$. The intuition is that resources are more valuable for D, since unlike C they also face the threat of domestic conflict, which can be suppressed with resources. Hence, there is a larger part of the parameter space in which D optimizes by choosing S than there is for C. We formalize this logic in Proposition 2 and represent it qualitatively in Figure 1.

Proposition 2 *For $a > a^*$, there exists C^* such that C chooses S if $a > C^*$ and chooses R if $a \leq C^*$. Likewise, for $a > a^{**}$ there exists D^* such that D chooses S if $a > D^*$ and chooses R if $a \leq D^*$. For all values of d, $C^* > D^*$. Both C^* and D^* are increasing in d.*

Figure 1: Equilibria in the $d \times a$ plane



4. Context-Specific Predictions

The model provides intuition for how different types of political authorities may respond to outside threats, internal rebellions, domestic conflicts, and new types of knowledge. We begin below by introducing the well-known historical fact that Tokugawa Japan was much more decentralized than Qing China. Hence, in the context of the framework, we can consider individual Japanese daimyos to be the D authority and the Chinese emperor to be the C authority.

4.1. Historical Setting: Prefecturalism versus Feudalism

The imperial regime of a single emperor ruling over all "under heaven" governed by directly appointed and rotating bureaucrats came into form two millennia ago under China's first unified empire, the Qin Empire (221–206 BCE). This system of direct administrative rule, encapsulated in the classical Chinese terminology as a "prefectural regime" 郡县制, was based on an ideology developed and championed by the Legalist school of thought during the Warring States era (BCE 476–221). It formed a contrast to the Confucian ideal, born earlier in the era of Warring States, characterized by feudal lordship, decentralization, and indirect rule subsumed under the term "feudal regime" 封建制. (Qin 2015; Zhao 2015).[8] Both the theory and practice dating to the Qin regime progressed through the Sui and Tang dynasties in the 7th century CE, with the rise of a nationwide civil service examination system (Wen, Wang and Hout 2024). However, the classic prefectural system came into maturity in the Song dynasty (960–1279): a system of direct imperial rule under the monopoly of a single emperor through directly appointed officials rotated nationwide with no independent military or fiscal bases. This three-layered nationwide civil service examination system produced a class of non-hereditary educated elites (gentry) inculcated in Confucian classics and thus eligible to serve as bureaucrats.

Japanese state-building commenced by systematically borrowing the Chinese centralized political system during the Tang dynasty (618–907 CE). But Japan's ambitious attempts to form a Tang style of political centralization quickly lost momentum and slowly disintegrated into a reversion to a feudal regime marked by decentralization and fragmentation in subsequent centuries. It is striking that Japan's reversion to feudal structure occurred in the 12th century, precisely when

[8] Although there were episodes of prolonged and violent reversals to decentralization and fragmentation, China's Prefectural Regime of rule—a form of centralized absolutism founded under the Qin—sustained for the next two millennia (Chen and Ma 2022). Even though the Han dynasty—the dynasty that succeeded the short-lived Qin—officially sanctioned the pro-feudal Confucianism as the orthodox ruling ideology, many claim that Chinese rule is fundamentally Legalist in nature and only Confucian in outlook. Contemporary scholars have pointed to this ideological and institutional bifurcation as the contrast of a tripartite structure of a Qin regime/Legalism/Prefecturalism (秦制/法家/郡县) versus a Zhou regime/Confucianism/Feudalism (周制/儒家/封建). For a recent exposition on the Qin/Zhou contrast in Chinese political history, see Qin (2015).

Song China consolidated its prefectural system (Morishima 1982, ch. 1).[9] By the 17th century, the structure of the Tokugawa regime that emerged out of Japan's own Warring States era (1467–1567 CE) consisted of a nominal emperor with a ruling general (i.e., the Shogun) controlling or sharing power with multiple and semi-autonomous feudal lords called daimyos, with their domains being called *han*. Despite Japan's continued borrowing of Chinese ruling ideology, the Tokugawa structure remained a version of China's abandoned feudal past.[10]

We can now summarize three key institutional differences between "prefecturalism" in Qing China and "feudalism" in Tokugawa Japan: i) the absolutist Qing emperor with direct rule versus a nominal and symbolic emperor whose power delegated to the Tokugawa shogun; ii) a nationwide structure of provinces and counties governed by officials directly appointed by the emperor versus autonomous and semi-autonomous daimyos; iii) an exam-based, non-hereditary bureaucracy versus a hierarchy of hereditary samurais. We proceed to show, in the context of our model, how these institutional differences shaped the nations' differential responses to Western threats and their variation in the adoption of Western knowledge.

4.2. Predictions: Knowledge Adoption in Japan and China

The first prediction regards the period prior to contact with Western military might (i.e., prior to the First Opium War and Perry Expedition). In this period, the perceived outside threat (a in our model) would have been low for both Japan and China. According to our model, as seen in Figure 2, this means that both states should have invested in traditional knowledge (T):

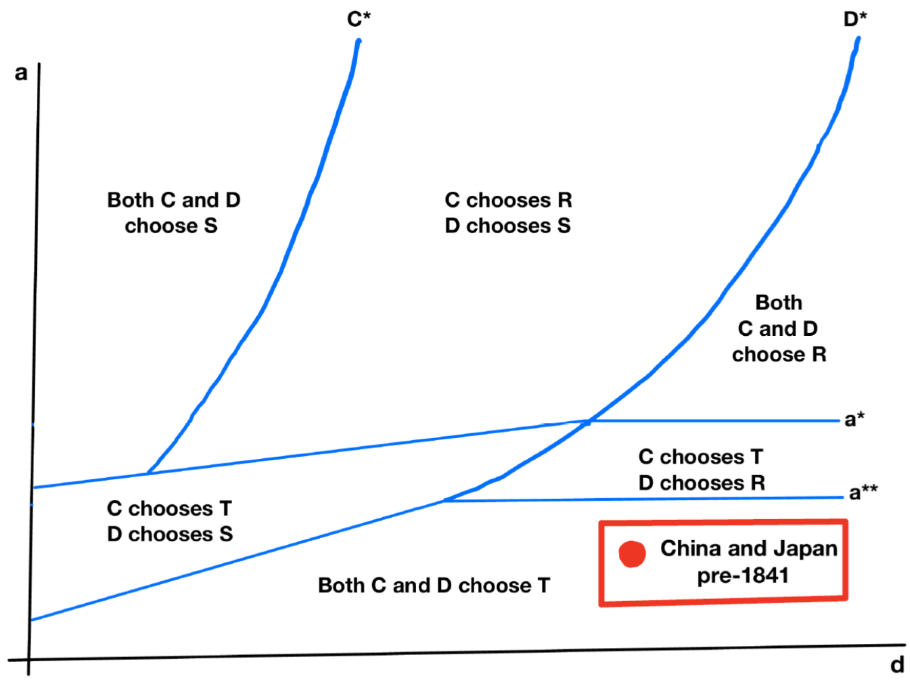
Prediction 1 *Prior to military contact with the West, the outside threat (a) was low enough that both China and Japan should have relied on traditional knowledge (T).*

Next, consider the period after both China and Japan were aware of Western military power. This would have caused a significant increase in the perceived threat (a), while the cultural distance

[9] This was in part due to the Sea of Japan, which sheltered it from nomadic invasion from the Chinese continent (Ferejohn and Rosenbluth 2010; Koyama, Moriguchi and Sng 2018; Chen and Ma 2022).

[10] Chinese scholars who sought refuge in Japan during the fall of Ming noted this curious anomaly, even praising Tokugawa Japan for approximating the original ancient Confucian model of governance (Lu 2017; Ge 2023).

Figure 2: China and Japan prior to military conflict with the West



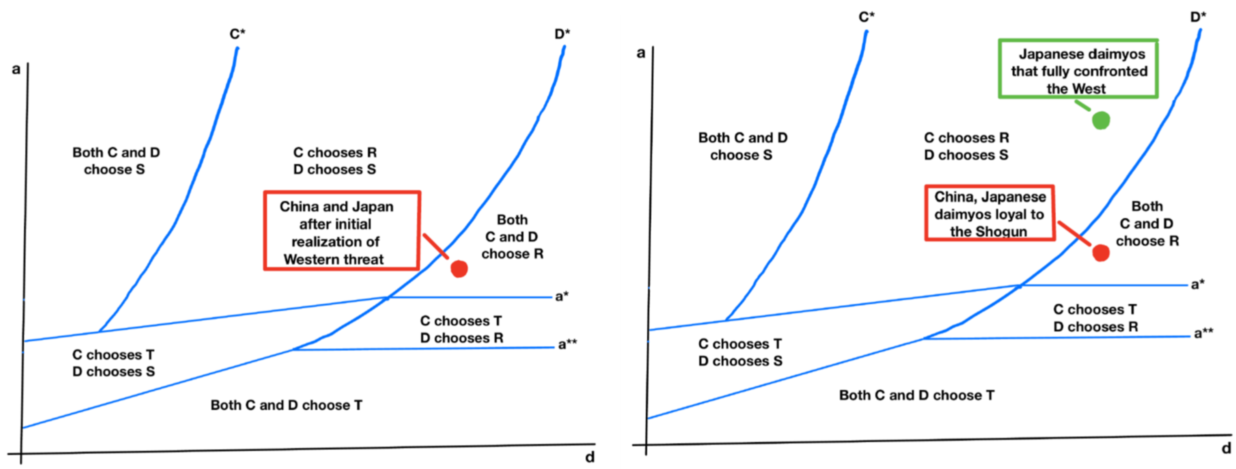
(d) with the West remained very high. The model predicts that Japan should have been the first to adopt prescriptive knowledge (R), in the part of the equilibrium space in which "C chooses T, D chooses R". As the perceived threat became clearer, both China and Japan should have adopted prescriptive knowledge (i.e., the part of the equilibrium space in which "both C and D choose R", see Figure 3a). If certain Japanese daimyos had greater exposure to the Western threat—and thus had a greater value of a—then those daimyos should have been the first to adopt propositional knowledge (see Figure 3b).[11]

Prediction 2 *After the initial Western military intrusion, the perception of the outside threat (a) rose. Given the significant cultural distance to the West, both China and Japan should have moved from traditional knowledge (T) to prescriptive knowledge (R). After some daimyos experienced the*

[11]Besides the contrasting reception of Wei Yuan's book in two countries, we can illustrate further Japan's great awareness of Western threat through Japan's great enlightenment thinker, Fukuzawa Yukichi (1835–1901). As a low class samurai and highly accomplished classical Chinese scholar, Fukuzawa turned to Dutch studies in the early 1850s and became one of the few Japanese intellectuals who managed to travel to and spend time in the West as part of the Tokugawa mission. Based on his readings and own travel 1861, Fukuzawa published the landmark ten volume book *Things Western* 西洋事情 in 1866 which contains a detailed description of political, economic, military, and industrial aspects of Western society. The book was printed over two hundred thousand times.

overwhelming force of Western military technology, the perceived threat should have been even higher for these daimyos, who should have therefore sought propositional knowledge (S).

Figure 3: China and Japan after initial military contact with the West



(a) (b)

We can also make a prediction regarding which Japanese daimyos were most likely to revolt against the Shogunate. Prediction 2 suggests that those most exposed to the outside threat should have been the first to adopt propositional knowledge. Indeed, the first Japanese domains that embraced modernization reforms through importing propositional knowledge were those located in West Japan that confronted European powers directly, such as Satsuma (which fought a war with the British in 1863), Choshu, Tosa, and Hizen. For example, Hizen Domain's engagement with Western technology required not merely imitation but "the study of the theoretical background" of Western science and "a challenge to understand a new technique, a new theory" (Pauer 1991, p. 3). This theoretical understanding was empirically demonstrated through their successful operation of reverberatory furnaces, where technicians from Saga had been casting guns with modern Western methods since the 1850s. It thus follows from the logic of the model that these daimyos should have had the resources generated from propositional knowledge that would have allowed them to succeed in a domestic conflict.

Prediction 3 *Those daimyos most likely to revolt were those that were most likely to invest in S, as these resources were most beneficial on the margin in a domestic conflict.*

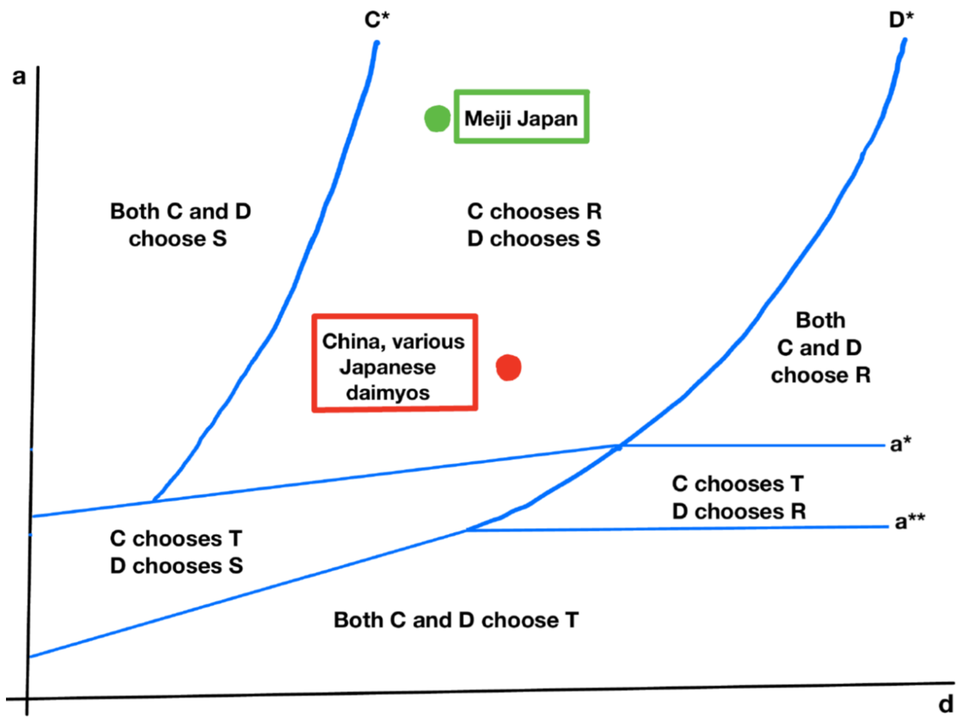
Next, the model can speak to how propositional knowledge may have spread within East Asia. Once some daimyos adopted propositional knowledge (Prediction 2), this would have greatly decreased the cultural distance for both other daimyos and the Chinese to do the same. In the context of Figure 1, this would have decreased d. Being in a decentralized state, other daimyos should have been the first to adopt propositional knowledge (see Figure 4). For example, following the initial adoption by pioneering domains, reverberatory furnace construction spread rapidly to at least eleven sites across Japan by 1868, demonstrating how limited cultural distance facilitated the diffusion of Western industrial technology throughout the country. This diffusion was further accelerated as skilled technicians from early-adopting domains carried their knowledge to other regions—a process made possible precisely because early and late adopters shared the same Japanese cultural context, minimizing the barriers to knowledge transfer (Pauer 1991).

Prediction 4 *Once some daimyos adopted S, the cultural distance (d) for other daimyos to do so decreased, so S should have spread throughout Japan.*

Finally, the model permits a prediction regarding how the Chinese should have responded to their devastating loss in the Sino-Japanese War. As we will detail in subsequent sections, this loss was devastating to Qing legitimacy. In the context of the model, this would reflect an outward shift in C^* (to $C^{*'}$, see Figure 5). This is because the (further) loss of legitimacy associated with choosing S became smaller relative to the benefit of additional resources. Combined with the significant decrease in cultural distance arising from the Japanese adoption of Western propositional knowledge (Prediction 4), this should have incentivized the Chinese to adopt S.

Prediction 5 *After the Sino-Japanese War, the Chinese should have been more likely to choose S. Once China chose to adopt S, it should have done so through Japan, since the cultural distance was much lower than it was with the West.*

Figure 4: China and Japan after knowledge adoption by some daimyos

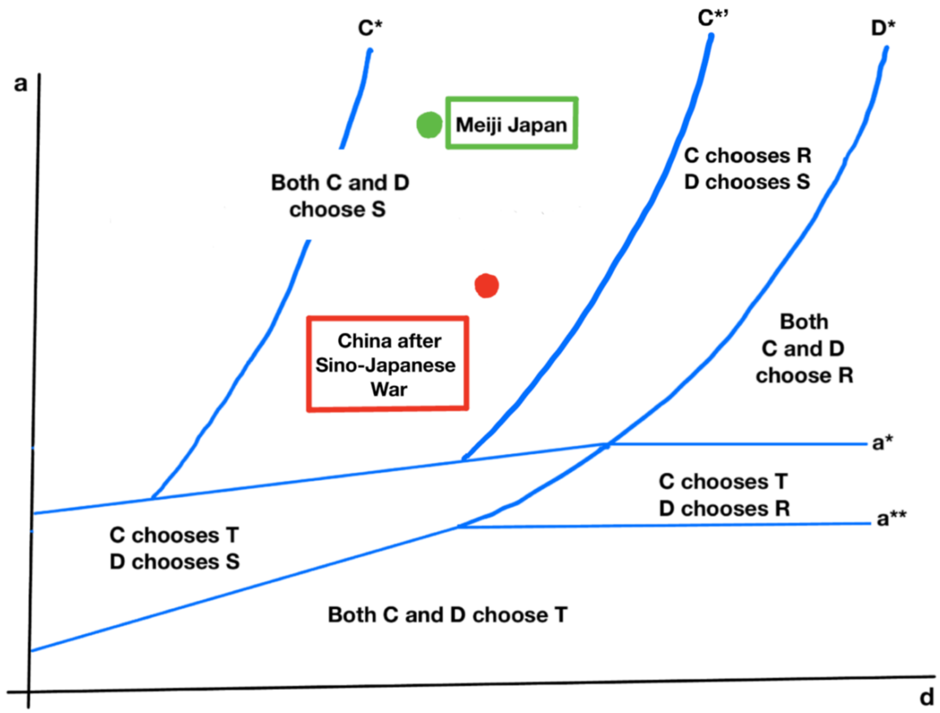


5. Historical Narrative

5.1. China and Japan before 1894

Predictions 1 and 2 indicate that both China and Japan should have employed traditional knowledge prior to military contact with the West. After contact, Japan should have been the first to adopt prescriptive and then propositional knowledge. Meanwhile, China should have been slower to adopt propositional knowledge. This section discusses the period of transition, which substantiates the model's predictions. China engaged in what became known as the Self-Strengthening Movement, which adopted Western capital but not know-how. That is, it adopted prescriptive but not propositional knowledge. Meanwhile, Japan's Meiji Restoration involved a wholesale adoption of Western capital, knowledge, and institutions. Japan aimed to adopt Western propositional knowledge in addition to prescriptive knowledge.

Figure 5: China and Japan after the First Sino-Japanese War



China's Response Under the prefectural system, where the Qing emperor ruled directly and absolutely, the first threat Western imperialism posed was a direct challenge to the legitimacy of the emperor. The Qing initially sought to deflect the crisis by either not acknowledging the reality of their humiliating defeat or blaming it on bureaucrats after it was no longer possible to conceal it. While the Qing managed to accommodate Western imperialism with reparations and a forced opening of free trade treaty ports, they eventually faced the much bigger domestic Taiping Rebellion that ravaged much of China's agrarian and commercial heartland in the Middle and Lower Yangzi for more than a decade after 1850.

When the Qing could no longer cope with the Taiping rebels, it was the elites who had attained high-level degrees—in an unusual departure for China's prefectural system—who raised and mobilized independent local militias based in Middle Yangzi's Hunan and Anhui provinces and eventually defeated the Taipings. Zeng Guofan, the leader of the Hunan army and the architect of the local military suppression of the Taiping rebellion, disbanded his Hunan army just months after the capture of the Taiping capital of Nanjing in 1864. A devout Confucian bureaucrat, Zeng's military dissolution signaled his allegiance to the legitimacy of a single imperial ruler and returned China to a longstanding centralized Prefectural System. Meanwhile, the Anhui military under the leadership of Li Hongzhang remained to form a new military force that would shape China's modern army in the decades to come. The Qing, under the new child Emperor Tongzhi (1861–75), repaid the Han Chinese elites with some delegation of power and autonomy that formed the political structure behind the Self-Strengthening Movement (Chen and Ma 2022).[12]

Nonetheless, the key institution that underpinned the Self-Strengthening Movement remained "prefectural" and centralized, as the Qing emperor retained the crucial power of appointing, rotating, and dismissing officials nationwide.[13] In fact, one of the hallmarks of the Self-Strengthening Movement was the restoration of the civil service examination that had been suspended during the Taiping rebellion era. It was the restoration and re-enforcement of the examination system and the status of gentry and bureaucrats inculcated in Confucianism that was upheld as the cause of the Tongzhi Restoration's success (Wright 1957).

Hence, the Self-Strengthening Movement always operated under the constraints of the Qing prefectural system. In the context of our model, Prediction 2 states that once the Qing elite recognized the superiority of Western military power and technology, they should have been keen to acquire what we term prescriptive knowledge, as Wei Yuan's quote "learn the tools of the Barbarians to subdue the barbarians" would suggest. In fact, Western weaponry was widely adopted by the Hunan and Anhui militia, and Western mercenaries that were hired to fight the Taipings. Not surprisingly, the Self-Strengtheners started by modernizing the military through a series of government financed, Western style, capital-intensive industrial enterprises (1860–94). But there was no introduction of any reforms that touched the fundamentals of the traditional regime: no introduction of a modern constitution or commercial law, no reform in the currency system, and no investment in modern banks and infrastructure. There was little attempt at creating a legal framework for

[12] The new commercial tax, a transit tax called likin, had been set up to fund the suppression of the Taiping Rebellion. It was retained by the local authorities to support various modern enterprises during the Self-Strengthening Movement.

[13] The rise of Han Chinese bureaucrats such as Zeng Guofan and Li Hongzhong and some form of de facto fiscal revenue led some to claim the China was politically decentralized in the post-Taiping era (Koyama, Moriguchi and Sng 2018). While this may be true compared with the pre-Taiping era, it would not hold by our criteria.

private initiatives in the modern sector, few critical modern public goods were provided, and, in most cases, private efforts to build public infrastructure such as railroads and inland steam shipping were opposed (Brandt, Ma and Rawski 2014). The nature of reform in this period stayed within the narrow and literal definition of Wei Yuan's "Barbarian tools" and was later aptly summarized by Liang Qichao—China's foremost intellectual and reformer of the era—as the phase of reform in "materials things" 器物 only.

Japan's Response For Japan, Western imperialism exerted a legitimacy crisis on different actors, where the Tokugawa shogun ruled in the name of the Japanese emperor over a system of independent *hans* or domains. The Shogunate and its liege vassals (*hatamoto*) only directly ruled one quarter of the territory of Japan, with the remaining three quarters divided into some 250 domains or *han* led by daimyos. By contemporary standards, the domains resembled semi-independent sovereign states, with authority to maintain and command an independent standing army, set and collect taxes, appoint local officials, and control borders. To consolidate the Shogunate's rule, daimyos were classified into two major categories based on their historical relations with the Tokugawa clan. One class of daimyos were called Fudai, or insiders, who were from families that had been loyal vassals of Tokugawa Ieyasu before the Battle of Sekigahara in 1600 (i.e., before he rose to national primacy). The other group was the Tozama, which literally means outsiders of questionable loyalty.[14] Within this coalition of states was the nominal Japanese emperor installed in Kyoto, who carried no real power but formed the pillar of legitimacy for any rulers who intended to rule, including the Tokugawa Shogunate (Ge 2023).[15]

When the Tokugawa Bakufu (Shogunate) signed a series of trade treaties with Western powers in the 1850s without the approval of the Komei emperor, it immediately caused resentment from Japanese samurais and daimyos, triggering a major legitimacy crisis for Tokugawa rule for having failed the Japanese emperor. This eventually coalesced into the central slogan of the anti-Shogun

[14] The Tozama ancestors did not support Tokugawa Ieyasu until 1600 or fought against him in the Great Battle. The Tozama daimyos were discriminated against in their political careers (Mitchell and Yin 2022).

[15] This unusual feudal structure bore some semblance to that of China during the Warring States era (roughly 4th to 2nd century BCE), where states formed alliances or rivalries yet claimed legitimacy from the largely defunct Zhou King (Zhao 2015).

alliance as "Revere the Emperor and expel the barbarians" 尊王攘夷, a term derived from the Confucian classics of Spring and Autumn Annals.

However, these anti-foreigner sentiments soon transformed into efforts to adopt Western knowledge, made possible by Japan's decentralized political structure. A telling example of how the feudal structure impacted Japan's political transition is the case of Choshu Han, one of the largest Tozama domains located in Southwest Japan, and that of the Choshu-based samurai, Yoshida Shoin, the intellectual inspiration behind the "Revere the Emperor" movement and anti-Tokugawa alliance. Like other reformers, Yoshida Shoin became a great admirer of Wei Yuan's works and later became a strong advocate of the "Revere the Emperor" movement that was to influence a generation of future Meiji leaders through his Choshu-based academy.[16] Shoin himself was repeatedly imprisoned and eventually executed in 1859 for his plot against the Bakufu. His martyrdom strengthened the resolve of the "Revere the Emperor" movement, which was characterized by samurai attacks on Bakufu elites and the very few Westerners in Japan. The Choshu and Satsuma domains took matters into their own hands by mounting a frontal naval assault on Western ships in 1863 and 1864. It was their utter and humiliating defeat that opened their eyes to Western military superiority. From then on, defeat turned into admiration and eventually converted into an alliance between England and these two daimyos (and against the alliance formed between France and the Shogun) (Feng 2001). Such diverging positions among local rulers, which created an opportunity for the spread of Western knowledge and technology, were simply not possible in the highly centralized imperial China.[17]

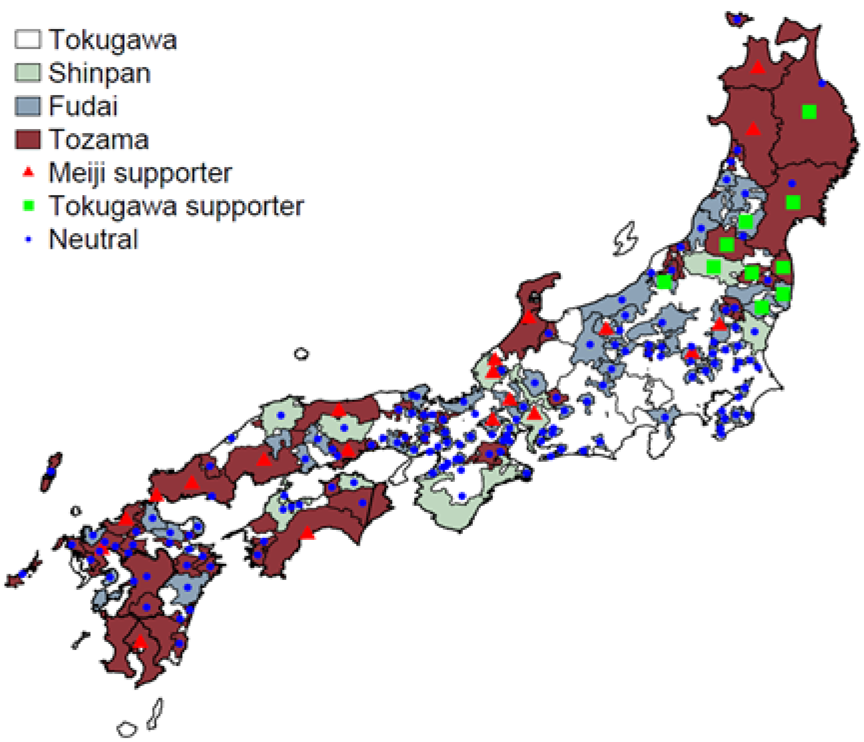
Figure 6 reveals several distinguishing features that connect political decentralization to regime change in Japan. First, the anti-Shogun alliance was dominated by the Tozama domains largely

[16] The students of Yoshida Shoin included Kido Takayoshi, a founding father of Meiji Japan, and Ito Hirobumi, Japan's first prime minister, among at least dozens or so influential figures.

[17] Among Shoin's most prominent students was a lower-class Choshu samurai named Takasugi Shinsaku, who in 1862 visited Shanghai—a treaty port opened up to Western trade after the First Opium War—as part of Choshu samurais' overseas tour. In Shanghai, two experiences gave Shinsaku long-lasting influence. First, he was stunned by the marvels of a modern Western-style city as well as the Chinese subjugation to Western imperialism on their own soil. It was also in Shanghai that he saw the arrival of Hunan and Anhui militia men, who suppressed the local Taiping bandits in Shanghai. That experience may have inspired him to found the *Kiheitai*—the Choshu irregular militia that recruited men from outside the samurai class—that was later to play a critical role in overthrowing the Tokugawa regime (Feng 2001).

located in the southern coastal area, and the pro-Shogun alliance was dominated by Fudai domains situated in northern Japan. The outlying southern coastal Tozama domains not only were individually larger in size but also grew substantially by taking advantage of their early exposure to the West compared with those of the Fudai domains. The Tozama-based alliances translated their relative economic expansion into overwhelming military success in the Boshin War (1868–69), a civil war fought between the Tokugawa shogunate and a coalition of daimyos seeking to overthrow the shogunate. Specifically, it was the four relatively powerful Tozama domains from Southwest Japan (Satsuma, Choshu, Tosa, and Hizen) that led a rebellion against the Tokugawa and ended the 260-year Shogunate rule.[18]

Figure 6: Daimyo Classification in Tokugawa Japan and Positions in the Boshin War



Note: Modified from Mitchell and Yin (2022).

Part of the reason that the anti-Bakufu forces overthrew the Tokugawa Shogunate was the sheer economic and military weight of their forces in the Boshin War. The total *Kokudaka*—a traditional

[18]Statistical evidence supports that Tozama domains were more likely to support the Meiji Government against the Shogunate in the Boshin War, controlling for numerous potentially confounding factors (see Appendix Table A.1).

Japanese weight unit of rice for determining land value and taxation—of all 94 Tozama daimyos stood at 12,711 against those of 3,594, 6,806 and 4,392 for the Shogunate, Fudai, and Shinpan daimyos respectively. On the eve of the Boshin War, anti-Bakufu alliances (composed mostly of Tozama daimyos) had a combined total of 8,650 *kokudakas* versus the 6,511 *kokudaks* for the pro-Shogunate alliances, whereas those in a neutral position had a combined total 12,793 *kokudakas*.[19] This reveals that the combined economic forces of the anti-Shogun alliance exceeded those of pro-Shogun forces, which was a scenario rendered possible under a decentralized feudal structure.

The second phenomenon facilitating feudal Japan's regime change was that the anti-Bakufu forces managed to secure the endorsement of the new Meiji emperor after the mysterious death of the Komei emperor in 1867. The nominal and symbolic status of the Japanese emperor in the feudal system was a powerful legitimating tool. The transition between Tokugawa and Meiji was framed as the transfer of power back to the emperor, termed as *Taisei Hokan* 大政奉还, after 260 years of Tokugawa rule. The young Meiji emperor served as a powerful legitimizing force for the new Meiji government, which was composed of a coalition of a tiny core of Imperial court elites and powerful oligarchs from southern daimyos who replaced the Tokugawa Shogun. Unlike the Chinese Self-Strengthening bureaucrats who had to operate within the confines of absolutist Qing rule, the Meiji rebels set their own reform agenda with the young Meiji emperor only acting as a source of legitimacy.

Not surprisingly, given the entrenchment of Chinese ideology among Japanese elites, the early Meiji reform invoked traditional Chinese classical terminologies: "Restoration of Imperial Power" 王政复古, "the Replacement of Hans by Prefectures" 废藩置县 in order to "Enrich the State and Strengthen the Army" 富国强兵. Even the phrase "Restoration" denoted for the Meiji era 明治维新 was lifted from the Chinese classics *The Book of Documents* 尚书 during China's *Spring and Autumn* era (770–476 BCE). Framing Meiji's intended modernization project in the phraseology of traditional Chinese ideology was a powerful legitimating tool that enabled a relatively bloodless

[19]The statistics are aggregated from the village-level data of Ledger for Investigating Former Land Values and Territories (*Kyudaka Kyuryo Torishirabecho*), which was a government survey record compiled in the early Meiji period that documented landholdings and agricultural output during the late Edo period.

transfer of power and justified Meiji's initial agenda to dismantle their pre-existing ruling foundation by abolishing the samurai class and feudal daimyos and establishing a nationwide prefectural system and civil bureaucracy. The establishment of the central government was a result of the reform, not a cause of it.

This led some scholars to argue that the initial stage of Reform was as much Westernization as it was Sinification (Ge 2023, p. 1). But Meiji Japan's centralization was not a mere reversion to Chinese-style "prefecturalism." The Imperial Meiji motto was to seek the best wisdom throughout the world. One of the hallmarks of "seeking wisdom" was the launch of the well-known Iwakura mission (1871–73), which sent cabinet level ministers to tour the West for two years. After that, Japanese thought progressed from what was once "Japanese spirit, Chinese learning" to "Western learning," and eventually to "Leave Asia, Join Europe" 脱亚入欧, a phrased coined by Japan's great enlightenment thinker Fukuzawa Yukichi. Meiji Japan was on a path to thoroughly acquire all aspects of Western propositional knowledge and institutions. This was a huge contrast to the contemporaneous Tongzhi Restoration, which restored the traditional Civil Examination System and strengthened all aspects of China's Prefectural system.

5.2. The Sino-Japanese War and Its Aftermath

The 1894 naval confrontation between China and Japan became a litmus test of the two reform movements. China's 1894–95 shocking naval defeat to Japan, a nation long regarded as inferior, inflicted a profound mental shock on Chinese elites and the public at large. It spelled the end of the Self-Strengthening Movement and dealt a personal blow to Li Hongzhong, the main architect of China's new army. Like the Opium Wars half a century prior, which awoke China to the island nation of England, it led to sudden surge of interest this time in another island nation, Japan. This is seen in the reception to *The Treatise on Japan* 日本国志, a massive two volume work written by Huang Zunxian, the first Qing ambassador to Meiji Japan. Originally written in 1887, Huang's work was circulated privately and delivered to the leading bureaucrats of the Self-Strengthening Movement. It drew little attention when it was officially printed in 1895 until the news of China's stunning defeat turned the book into an instant best seller. In a new forward to the Treatise, a leading gentry lamented that had they all paid attention to Huang's book earlier, China would have been spared over two hundred million silver taels of war reparations—equivalent to around five times of the Qing state's annual peacetime revenue—extracted by Japan following its military victory (Jin and Liu 2011, p. 66).

China's defeat triggered a huge legitimacy crisis for the Qing. During the lead up to the humiliating signing of the Treaty of Shimonoseki, several Chinese elites organized a series of daring open petitions in Beijing known as the *Gongche Shangshu* Movement 公车上书 to protest the treaty. In the two years following the Treaty, the main architect of the Beijing petitions entered Hunan, the heartland of agrarian conservatism that rose to political dominance in the Self-Strengthening era due to their defense of the Qing realm.[20] Inspired by the model of the Meiji rebellion, the reformers claimed Hunan as the center of reform in China and succeeded in reaching out to the young Guangxu Emperor (r. 1875–1908). The series of radical reform measures launched in the name of Guangxu is now known as the Hundred Day Reform. The Reform lasted approximately 100 days before it was crushed by the powerful Empress Dowager Cixi.

The failure of the Hundred Day Reform illustrates the perils of radical reform in a Prefectural System. Unlike Tokugawa Japan, where the imperial court was largely symbolic and long sidelined in Kyoto, the entrenched imperial elites and bureaucracy embedded within the absolutist Qing regime quickly fought back. Further, when resistance eventually turned into a brutal crackdown on the reformers, neither the young Guangxu nor the main scholarly elites had any form of military backing like the kind enjoyed by Japan's anti-Bakufu forces. The only powerful bureaucrats with military forces like Li Hongzhong and Yuan Shikai—a disciple of Li—stayed away from the reformers at that critical moment. The fallout from the crushing of the Reform was that Dowager Cixi turned towards conservatism and subsequently supported the xenophobic Boxer rebels, which eventually led to the sacking of Beijing by Western (as well as Japanese) military forces. In the end,

[20] The architects were Guangdong based elites (Kang Youwei and Liang Qichao). Their arrival was followed by other coastal based elites who also had prior exposure to the West, joined with the Self-Strengthening elites centered in Hunan (Bai, Jia and Yang 2023).

a thoroughly defeated and humiliated Cixi had no options but to bring back the agenda of the failed Hundred Days reform. Subsequently, the Qing constitutional movement of 1903–11 commenced, modeled directly on Japan's Meiji reforms.

This time, China's reform effort was comprehensive and ambitious. It aimed to prepare China for a constitutional monarchy modeled on Japan by drafting a formal constitution that would establish national, provincial, and local parliaments. Administrative reforms sought to modernize public finance and adopt a national budget. The reform initiative gave birth to new Ministries of Education, Trade, and Agriculture, and encouraged the founding of local chambers of commerce. Policy initiatives aimed at currency reform, the establishment of modern banks, and the expansion of railroads and other public infrastructure. Most significant of all was the abolition of the millennium-old civil service examination in 1905.[21]

All of these initiatives marked a sharp departure from the Self-Strengthening Movement. Part of the guiding light for the new reform was the widely influential "Exhortation to Learning" 劝学篇 by Zhang Zhidong. Zhang—perhaps the last important scholar-bureaucrat of the Self-Strengthening Movement—wrote the most eloquent line of attack against radical reform in defense of the Qing monarch: "Chinese as fundamentals and Western as practical 中体西用." Even still claiming "Chinese as fundamentals," Zhang fully recognized the need to reform beyond just "materials." His treatise was also a call for comprehensive reform through learning from the West through Japan: "Western books are exceedingly numerous, and the Japanese have already abridged and adapted those parts of Western learning that are not essential …By taking the path through the East (Japan), we save effort and achieve rapid results." He further stated: "The Eastern script (Japanese) is close to Chinese, making it easy to comprehend and master."

[21] See Ma (2022) and Kung (2022) for an overview on the turn of the century break point in education, missionaries, and numbers of treaty ports, which became the institutional foundation underpinning the rise of modern industry, banking, public finance, and the monetary regime.

6. The Adoption of Propositional Knowledge

We operationalize the adoption of propositional knowledge through several lens. The first is the creation and translation of new terminologies to accommodate Western propositional knowledge. Second, we report data revealing the changing number and categories of publications in China and Japan. Third, we examine the destination and timing of overseas students and the establishment of universities as evidence of diffusing and reinventing new propositional knowledge. Finally, we provide an in-depth comparative case study of the silk industry in the two countries as an illustration of how acquiring propositional knowledge manifested in agricultural and industrial production.

This section will point to two patterns based on our model and historical narrative. First, Japan's initial channel of information about the outside world relied on China. However, it was far more perceptive of the crisis imposed by the West than China, which prompted Japan to acquire knowledge directly from the West. Japan's learning about the West had spillover effects on China through the sharing of language and culture, particularly after the First Sino-Japanese War. Second, the impact of propositional knowledge would take time due to the cost of learning. Japan's full blown success only came two to three decades after its initial learning. It would take another two to three decades for China to catch up with Japan.

6.1. Revolution in Terminologies and Concepts

The process of finding the potential causes of Asia's backwardness gave rise to an assault on a vast litany of cultural and social customs ranging from religion, rituals, dress, hairstyles, female foot-binding, and even rice (rather than wheat) consumption. While viewed in hindsight as mostly frivolous, each one of these condemnations witnessed real agitations and sometimes even violent social movements during the modernization phase. No sphere received a more sustained and systematic attack than the traditional language, especially the use of Chinese characters, shared among the Sinic-language family regions that include China, Japan, Korea, and northern Vietnam (Murata and Lamarre 2005).

In the 19th century, it was easy to find faults with the ideogrammatic feature of Chinese characters, which evolved for several millennia independently from the rest of the world. The thousands of unique characters required years of rote memorization. This was viewed as pedagogically inefficient and technologically incompatible with a new world of typewriters and modern printing.

Not surprisingly, Japanese elites were the first to agitate for reform in the use of Chinese characters soon after the Meiji Reform. Chinese characters were cited as an impediment to education, a barrier to civilization, and a cause of national weakness. These critiques were followed up by radicals advocating for replacing characters with the Roman alphabet. The Romaji Society (羅馬字会), founded in 1885, explicitly linked alphabetic writing to international science and diplomacy. In the early twentieth century, radical Chinese reformers echoed the Japanese attack by portraying Chinese characters as obstacles to enlightenment and incompatible with mass education, scientific discourse, and democratic politics. China's iconoclastic writer, Lu Xun, famously wrote in 1934 that "Chinese characters are the tuberculosis on the bodies of the poor masses" (Lu 1934). Script reform thus became a crucible in which questions of cultural inheritance, national identity, and modern rationality were contested.

It turned out that none of these radical calls stood the test of time as both Japan and China ultimately rejected abolition of characters. Instead, both pursued vernacularization (言文一致), simplification, limitation, and standardization of scripts as part of the linguistic modernization.[22] Further, it was precisely the ideogrammatic feature of the characters—those very often viewed as backward and anachronistic—that could transcend enormous differences in grammar, dialects, and pronunciations thanks to a common and shared script.[23] This unusual feature of shared Chinese characters was a direct cause of the revolution in terminologies in modern East Asia. A good example is the translation of the English word "humidity," for which both the Chinese and Japanese had similar concepts but no exact equivalent term. In 1886, the Japanese coined the term *shitsudo*

[22] With hindsight, it is curious to note that countries that are part of the Sinitic language group currently boast the highest levels of literacy and human capital, controlling for their income level, irrespective of whether or not they retained the use of Chinese characters. See Chen, Kung and Ma (2020) and Baten et al. (2010) for the historical legacy of human capital.

[23] Scholars have noted the interesting phenomenon of merchants and diplomats within the Sinitic language group communicating through the method of "talking in writing" (*bitan*) even in person.

(湿度) which additively combined *shitsu* (湿), meaning "wetness," and *do* (度), meaning "degree." That same character (湿度)—pronounced as *shidu* in Mandarin but in potential vastly different sounds in other local dialects—would later appear in a natural science encyclopedia published in China in 1909. Japan's pioneering translation of this term using Chinese characters allowed educated Chinese readers to immediately grasp its meaning.[24]

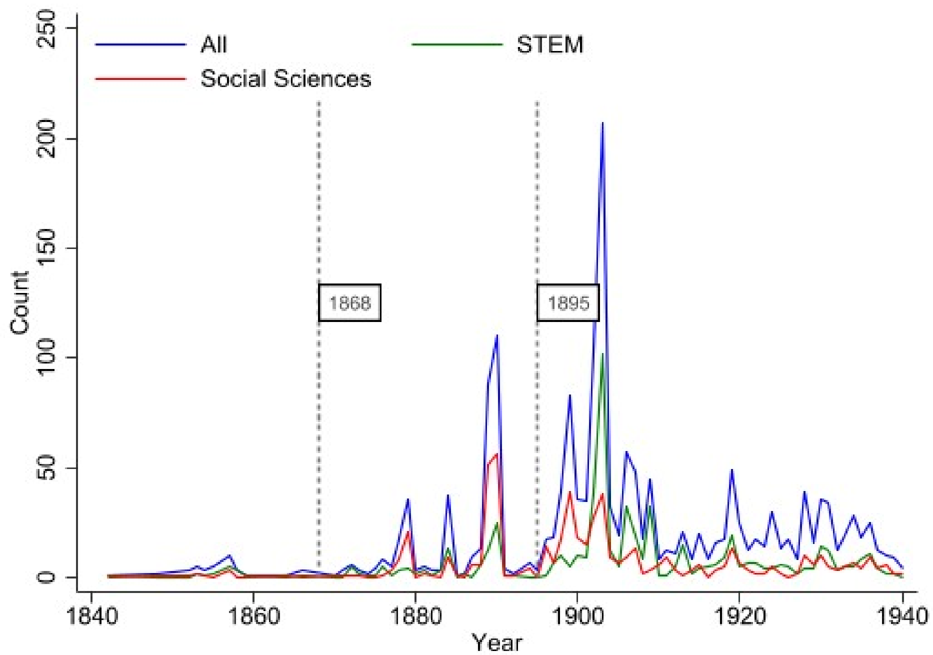
Western missionary scholars—whose works Wei Yuan already used for his *Treatise*—were the pioneers in generating new vocabularies through their efforts to translate Western texts into Chinese, with the first major work being the Bible. This led to world's first major compilation of the massive Chinese-English and English-Chinese dictionary published between 1815 and 1823, where a large number of new Chinese terminologies were coined. The Japanese most likely got hold of this dictionary as early as 1828. Until about 1886, Japanese knowledge of the West and the coining of new terminologies and phrases relied heavily on the Western missionaries' Chinese translations, with topics ranging from religion, law, international relations, science, and social science (Chen 2019, p. 111). For example, there was no exact Chinese equivalent to the English term *vacuum*, a crucial concept behind the use of steam engine. It was British missionary Joseph Edkins who coined the term 真空 (*zhenkong*)—which additively combines the character *zhen*, meaning "real" and *Kong*, meaning "emptiness"—in his 1859 translated work 重学 (*zhongxue*). This book, which introduced modern mechanics to China, later became influential in Japan, where its translated title was used to refer to mechanics as early as 1870 (Shogakukan Dictionary Editorial Department 2000). The term 真空 (vacuum) first appeared in Japan in a 1876 physics textbook which was then reintroduced to China. Other notable examples that were first created by missionaries in China but only gained popular use after re-importation from Japan include parliament (议会) and nationality (国籍) (Chuang and Chou 2009).

[24] Even when Chinese and Japanese use different translations for the same concept, Chinese intellectuals with no training in Japanese can often infer the meaning of Japanese words due to their shared use of Chinese characters. For instance, while the Chinese word for "patent" is 专利 (*zhuanli*), the Japanese term is 特許 (*tokkyo*). Despite this difference, an educated Chinese speaker can deduce the meaning of the Japanese term, as the characters literally translate to "special permission."

Japan was soon to break out of this reliance on Western missionary translations in Chinese to proceed to direct translation from the West and the creation of its own new terminologies using Chinese characters. The recent work by Juhász, Sakabe and Weinstein (2025) confirms an explosion of new technical terminologies created after the Meiji Restoration of 1868, an indication of the massive growth in codified knowledge that was to play an increasingly important role in supporting Japanese manufacturing competitiveness. The new terminologies that had previously been created from the much-touted indigenous Dutch Studies in the Tokugawa era were far too limited to compare with the explosion of new terminologies after the Meiji Restoration. Moreover, while Juhász, Sakabe and Weinstein (2025) focus on the introduction of Western technologies, Japanese borrowing through the translation and creation of new terminologies represents far more than that. They were nothing short of a profound modern enlightenment that encompassed science, social science, and shared worldviews.

The Japanese creation of new phrases in Chinese characters became a crucial public good for countries in the Sinic language group. According to Shi (2019), among a comprehensive compilation of Chinese words with foreign origins, 1,736 new words introduced into China originated from Japan between 1840 and 1940. Of these, 578 were related to STEM, while 547 were closely tied to modern social sciences. Figure 7 illustrates the annual number of newly introduced words of Japanese origin appearing in China between 1840 and 1940. The first peak of social science terminology emerged in 1889, when important legal and political concepts were introduced, such as constitution (*xianfa* 宪法), criminal (*xingshi* 刑事), and pardon (*teshe* 特赦). Although this first wave occurred before the First Sino-Japanese War in 1894–95, the largest influx of Japanese-originated words and that of STEM-related terminology occurred in 1903, when 102 STEM words of Japanese origin were introduced to China. Many of these terms laid the groundwork for the development of modern biology, including blood circulation (*xueye xunhuan* 血液循环), cell membrane (*xibao mo* 细胞膜), and gland (*xian* 腺). They also contributed to advancements in modern physics, with terms such as elasticity (*tanxing* 弹性), fulcrum (*zhidian* 支点), and power supply (*dianyuan* 电源).

Figure 7: Chinese STEM and Social Science Words Imported from Japan



Note: The horizontal axis represents the year in which the word first appeared in China. Source: See Appendix B.

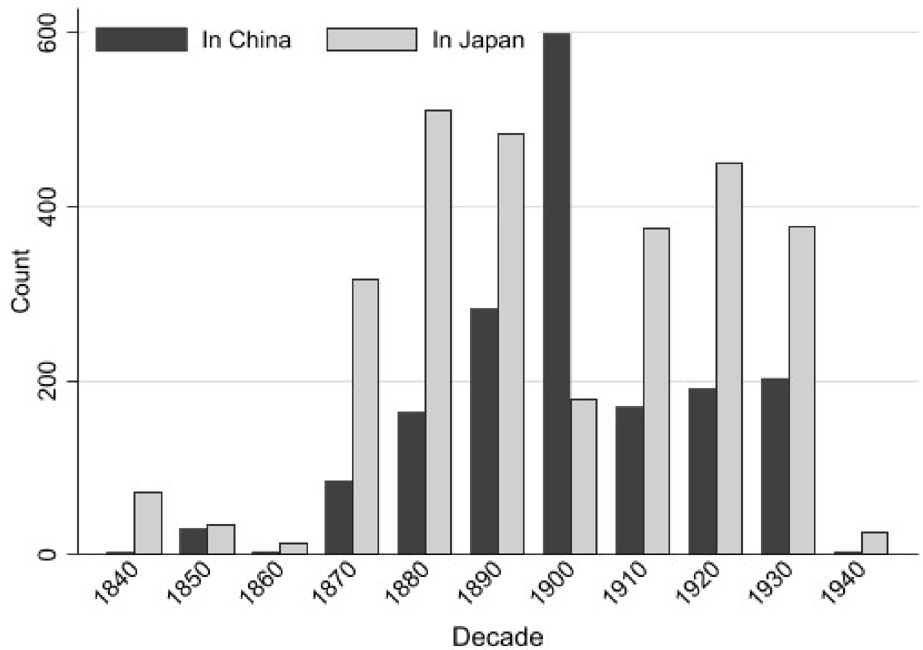
A recent in-depth study by Sun (2023) claims that nearly the entire modern economics vocabulary in China was borrowed from Japanese sources. Between 1896 and 1910, China adopted 1,057 economic terms from Japan, of which 755 remain in active use today. These terms range from abstract theoretical concepts—such as economics (经济学), utility (效用), and credit (信用)—to practical notions essential for commercial activity, including trademarks (商标), insurance (保险), and limited liability (有限责任). Importantly, the introduction of these terms into China signified more than a mere expansion of vocabulary; it entailed the emergence of novel economic theories and practices, largely modeled on Japanese precedents of borrowing. As a result, while the number of specialized economic phrases in traditional Chinese sources ranged in the teens and hundreds, they saw a one hundred fold increase by the end of the 19th century (Sun 2023, p. 2).[25]

Figure 8 displays the count of these loanwords by year of first appearance in the respective countries, aggregated by decades. It confirms that Japan was indeed the locus of origin, with their usage predating their appearance in China. In Table 2, we select a few terms that correspond to the

[25]For the surge of new political terminologies in China at the turn of last century, see Jin and Liu (2008).

specific policy instruments in Japan and China, illustrated earlier in Table 1. It is notable that the timing of their first appearance in new vocabularies in Japan and China nearly matched their policy implementation.

Figure 8: Year of First Word Use in China and Japan



Note: the horizontal axis represents the decade in which the word first appeared in China or Japan. The vertical axis represents the count of these loanwords plotted according to when they first appeared in the respective countries. Source: See Appendix B.

Table 2: Selected Loanwords and the Year of Their First Use in Japan and China

Japanese	Chinese	English Meaning	First Use in Japan	First Use in China
Shoho 商法	Shangfa 商法	Commercial Code	1866	1890
Boki 簿記	Buji 簿記	Bookkeeping	1879	1899
Kinyu 金融	Jinrong 金融	Finance	1878	1899
Shohyo 商標	Shangbiao 商标	Trademark	1886	1889
Tenran 展覧	Zhanlan 展览	Exhibition	1826	1907
Shiei 私営	Siying 私营	Privately owned	1860	1890s
Gakushi 学士	Xueshi 学士	Bachelor	1885	1897
Kisen 汽船	Qichuan 汽船	Steamship	1868	1888

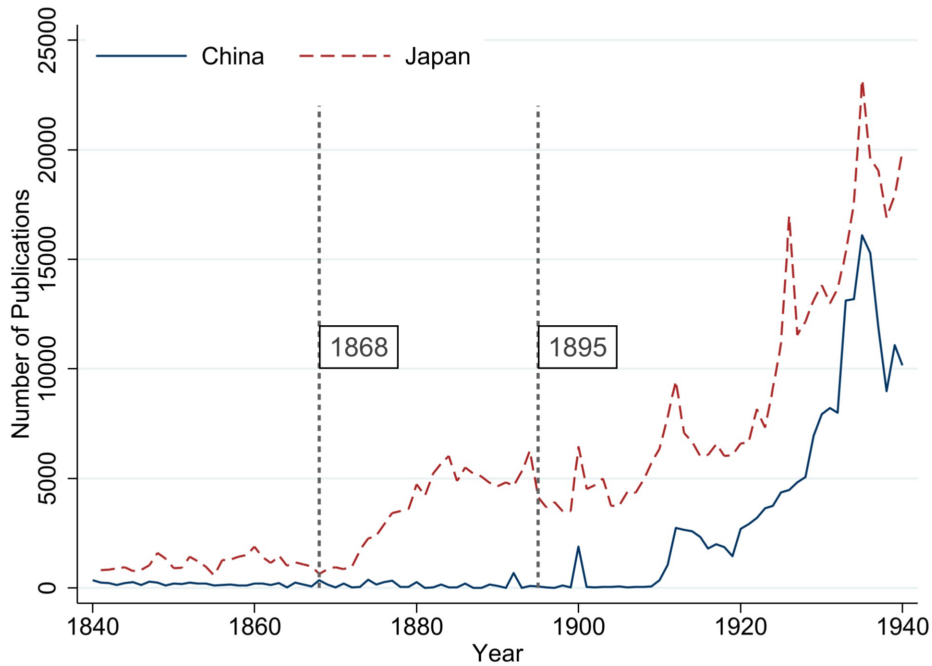
6.2. Publications

Predictions 2 and 4 indicate that Japan should have invested in acquiring Western-style human capital in the wake of the Meiji Revolt. Meanwhile, Prediction 5 indicates that China should have invested in acquiring Western-style human capital after its loss in the Sino-Japanese War (1894–95). Such human capital can come in the form of codified knowledge (e.g., handbooks) or tacit knowledge (i.e., that acquired by in-person contact). We discuss the former approach in this subsection and the latter mechanism in the next subsection.

Two metrics of human capital acquisition through codified knowledge are: i) the number of publications, and ii) the number of STEM publications (science, technology, engineering, and mathematics). The growth in the number of publications is demonstrated in Figure 9, which presents the time series of Chinese and Japanese publications in the century 1840–1940. Over the course of this century, approximately half a million books were published in Japan, among which 27,406 were translations of Western works. With the exception of roughly 250 titles, all these translations were issued after 1868, the commencement of the Meiji Restoration. While the year 1868 marks a pivotal shift in the composition and quantity of Japanese scholarly output, this radical transformation did not manifest in China until the end of the Qing Dynasty in the 1910s. By 1935, on the eve of the Second Sino-Japanese War, the gap between China and Japan had narrowed significantly.

We proceed to examine the makeup of these publications, concentrating on topics that may reflect the impact of Western expertise and technological advancements. Specifically, we focus on STEM publications in China and Japan. Figure 10 shows a significant surge in the number of Western science and technology publications in Japan beginning in 1868, suggesting that the Meiji Restoration was a pivotal turning point. Even more intriguing is the pattern revealed by the Chinese data. The first peak in Chinese STEM publications appeared around 1900, following China's humiliating defeat in the First Sino-Japanese War in 1895 and the Boxer Rebellion in 1900. The takeoff in Chinese STEM publications began in the second decade of the 20th century, right after the collapse of the Qing Empire. By the second half of the 1930s, China had caught up with—and even surpassed—Japan in terms of the number of STEM publications. Meanwhile, works on

Figure 9: Number of Publications in China and Japan in 1840–1940



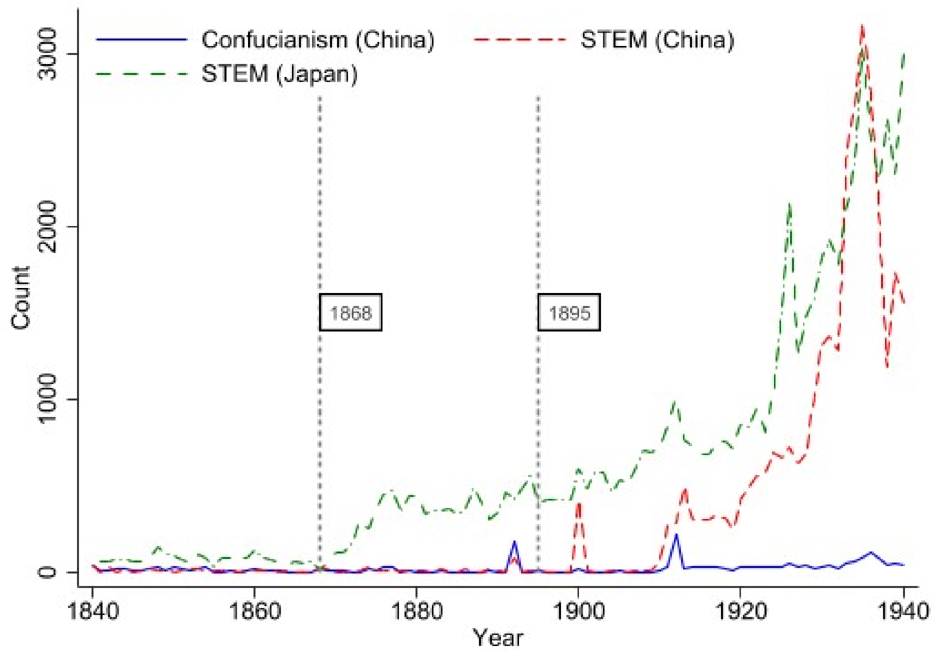
Source: See Appendix B.

Confucian theory in China remained low in the entire period under study, suggesting a decrease in its relative importance and influence in the intellectual community of China.

These data, especially those on STEM publications, reflect progress in modernization in a broad sense. We reach a few conclusions from this comparison: i) soon after the Meiji Restoration, Japan witnessed a substantial increase in its number of publications, particularly in the STEM area; ii) a similar growth in total publications was observed in China from the 1910s, after the end of the Qing Dynasty; iii) the number of STEM publications in China began to surge in the 1910s, while books on Confucianism, which represented the traditional mental framework, remained stagnant throughout 1840–1940. These findings support our predictions that Japan took off earlier in the import and build-up of propositional knowledge, while China caught up later.

Among the new publications in China were a vast number of translations, with Japan remaining the dominant medium. As Figure 11 illustrates, the majority of translated works on economics in China originated from Japan. Since 1900, the number of newly published translations from Japanese exceeded those from Western countries in most years. However, from the late 1910s,

Figure 10: Number of Publications in Confucianism (China) and STEM (China and Japan)



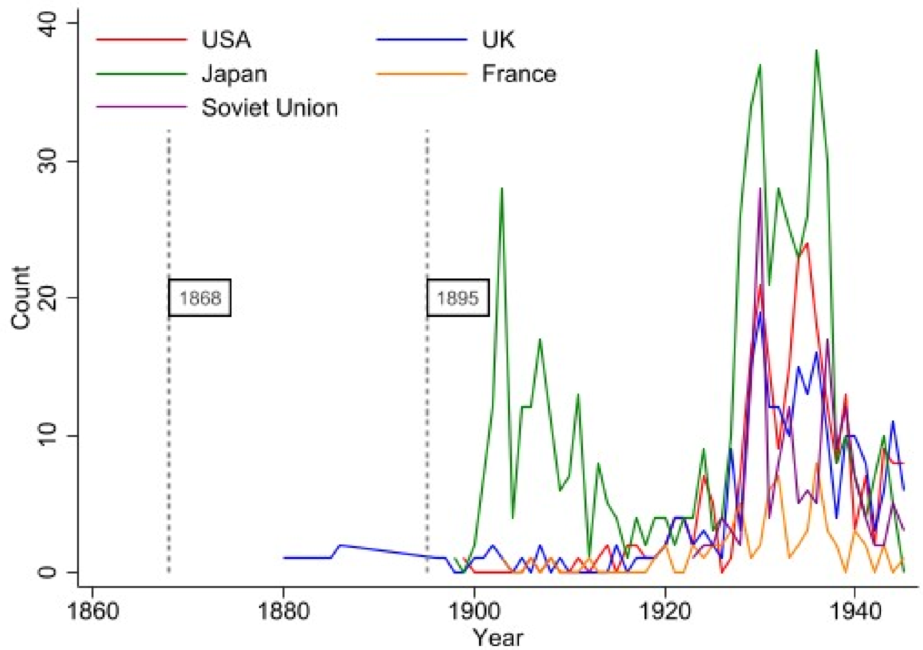
Source: See Appendix B.

works from the UK and USA began to increase along with France and the Soviet Union, indicating that China was also turning from learning through Japan to learning from the West directly.

6.3. Universities and Overseas Students

Another mechanism for acquiring Western knowledge was the establishment of modern, European-style universities. In Japan, the first modern comprehensive university, the University of Tokyo, was established in 1877 as part of the Meiji Government's broader modernization agenda. By contrast, in China, while missionary universities had previously been established by foreign entities, the first state-sponsored modern university, Peking University, was not founded until 1898. Notably, it was the sole surviving reform initiative from the Hundred Days' Reform. This sequence underscores Japan's early leadership over China in adopting modern higher education. However, China's subsequent progress in this domain is also noteworthy. By the early 1900s, the total number of universities in operation in China had already surpassed that of Japan. Japan did not regain

Figure 11: New Translated Works on Economics in China by the Origin of Country

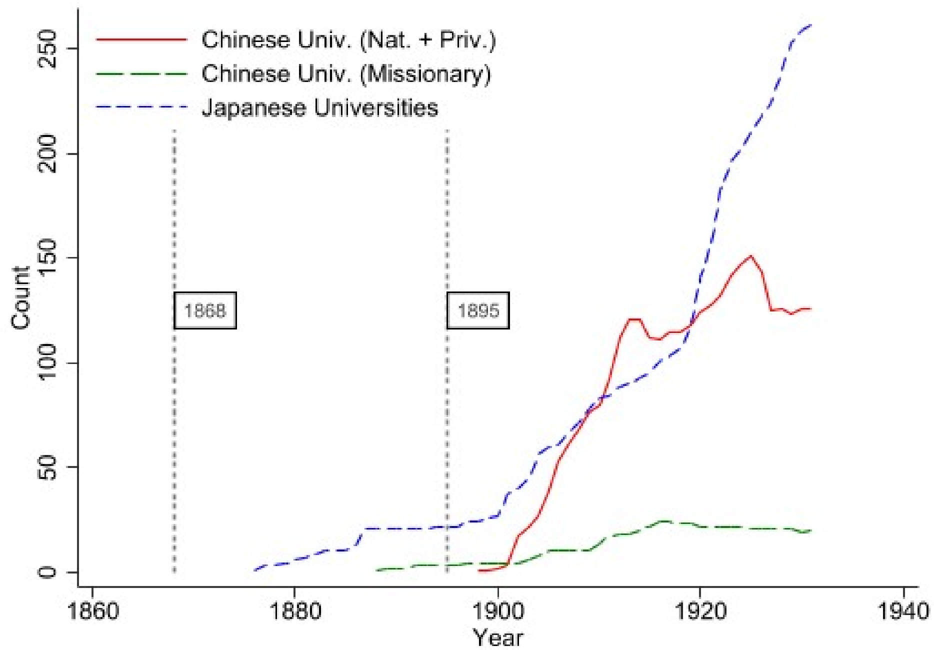


Note: Source from Sun (2023). The horizontal axis represents the year of publication.

its leading position until the 1920s, when it expanded its system of Higher Schools (*Koto Gakko*), which functioned primarily as pre-university institutions (see Figure 12).

In addition to the establishment of modern universities, knowledge diffusion through in-person contact was also made possible thanks to the large number of Chinese students who studied overseas. Compared to Japan, China initially lagged behind in terms of sending students abroad to study modern knowledge. While the Tokugawa Shogunate had sent the first batch of students abroad in 1862, prior to the Meiji Restoration (Machida 2015, p. 257), Qing China did not begin sending government-sponsored students overseas until 1872, when it dispatched 120 children to the United States for education. Almost simultaneously, the newly established Meiji government initiated a large-scale overseas study program, sending some 500 students to the US alone (Ministry of Education, Culture, Sports, Science and Technology (ed.) 2009). The 120 Chinese students sent to the U.S. were abruptly recalled in 1881, and Qing China did not resume sending students overseas until 1896.

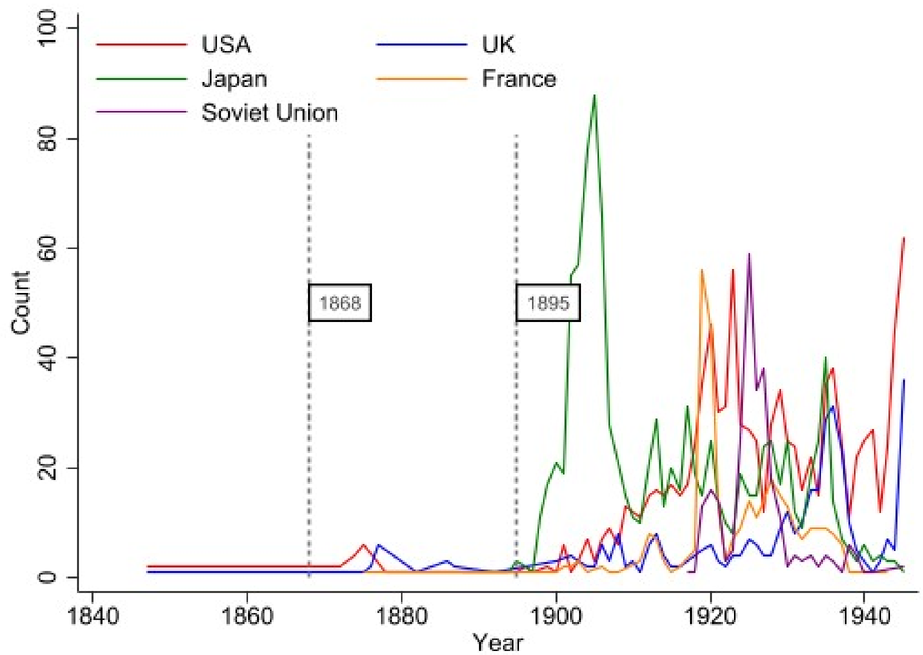
Figure 12: Number of Chinese and Japanese Universities



Note: The number of Chinese universities—including national, private, and missionary ones—is based on Kung (2022). The list of Japanese universities (including higher schools, *Koto Gakko*) is collected from the Ministry of Education (ed.) (1981).

After China's defeat in the First Sino-Japanese War, Chinese intellectuals began to view Japan as a model worth emulating. As Figure 13 indicates, Japan became the first major destination for overseas Chinese students, and its dominance remained until the 1920s. According to Zhou (1999), Japan was the second most frequent study destination for Chinese students between 1840 and 1945, with 1,023 students—second only to the United States (1,334) and exceeding the numbers for the Soviet Union (591), the United Kingdom (423), and France (359). Japan was particularly attractive to Chinese students for several reasons. First, it was geographically close to China, making travel more convenient. Second, the cost of living and tuition in Japan was significantly lower than in Western countries—sometimes even lower than studying domestically in China. Most importantly, Japan's remarkable progress in science, technology, and thought was highly accessible to Chinese scholars due to its linguistic and cultural similarities with China (Saneto 2012, p. 13; Kung and Wang 2025).

Figure 13: Number of Newly Admitted Chinese Students in Foreign Countries



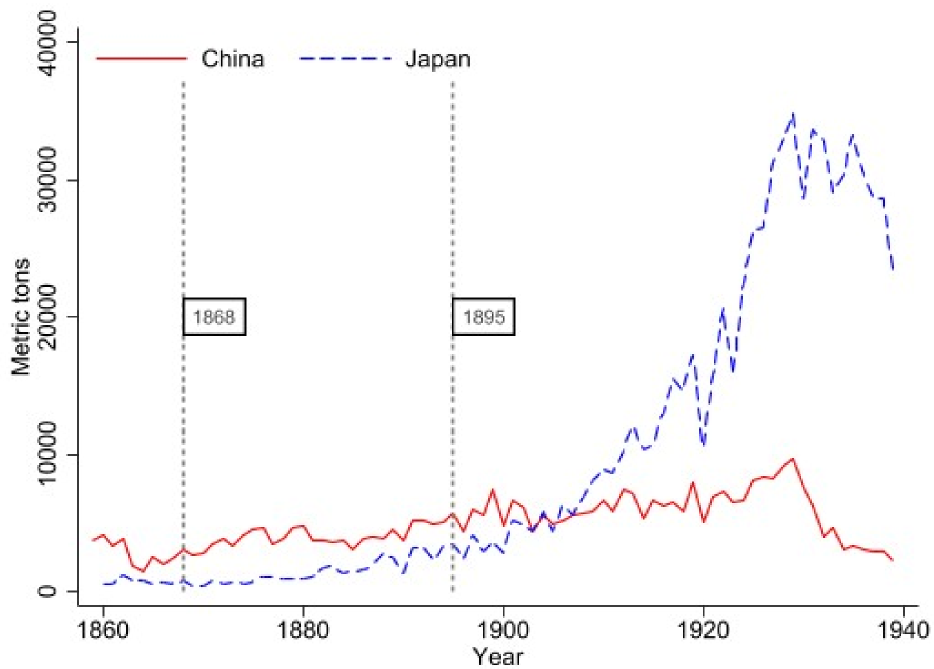
Note: Data from Zhou (1999).

6.4. Knowledge, Productivity, and Competitiveness: The Case of Silk Production

This subsection examines the economic consequences of the divergence and convergence in knowledge adoption between China and Japan, focusing on the silk manufacturing industry. Silk production depends not only on technical know-how, but also on a deeper understanding of scientific principles in fields such as biology and chemistry. Therefore, it serves as a useful indicator of advances in propositional knowledge adoption.

The Rise of Japan Between 1850 and 1930, raw silk ranked as the leading export for both China and Japan, accounting for 20–40% of Japan's total exports and 20–30% of China's. However, the performance of the two countries' raw silk was a sharp contrast. As Figure 14 shows, while in 1873 Japan exported a third of that of China, it exceeded the Chinese for the first time in 1905 and later tripled that of China, taking 80 to 90 percent of the world market (Ma 2004). It is particularly notable that the Japanese dominance in export competitiveness came after the 1910s, when its domestic wages rose sharply relatively to that of China and Italy due to its pace of industrialization.

Figure 14: Raw Silk Exports of China and Japan



Source: Ma (1996).

This modern era reversal was stunning and dramatic. China had maintained its global leadership for two millennia, from the invention of silk until about the 17th to 18th century, when the lead may have been partially overtaken by the French and Italian producers. Even by the mid-19th century, China remained the number one exporter of raw silk, followed by Italy, while Japan remained a distant third. This dramatic reversal offers a nearly ideal controlled experiment on how propositional knowledge directly impacted productivity and competitiveness, given that both Japan and the Lower Yangzi—China's most advanced silk-producing region—were comparable in size, population, climate, factor endowments, crop choice, and small-scale farming (Ma 2004). Specifically, in the 19th–20th centuries, raw silk production in both regions was completely domestically produced through sericulture that involved the cultivation of mulberry trees and harvesting of leaves to feed the silkworms for spinning cocoons. It was then necessary to reel cocoons into threads of raw silk by specialized reeling machines. The production of cocoons constituted about 60% to 80% of the value added share in raw silk production.

In the most comprehensive work on the modern silk industry in Asia, Japanese scholar Yukihiko Kiyokawa developed a schematic graph of technological indicators of Chinese, Indian, and Japanese silk technology. The scheme shows that during 1800–1868, the Japanese level not only remained far lower than that of China but also India. By about 1868, the Japanese level began a steep ascent, catching up first with India then China in 1880 and 1905, respectively. After 1905, the Japanese level continued its upward trajectory, and it would eventually emerge as the world leader, leaving China further behind and even possibly overtaking Italy by the 1920s (Kiyokawa 2009, p. 12). In particular, Japan's global technological leadership in raw silk production was defined by four completely self-developed epochal innovations, with two each in sericulture and industrial reeling: (1) the development of the First Generation Cross-Breeding silkworm variety (1911); (2) the method of artificial hatching of silkworm eggs; (3) the multiple-end reeling machine (1925); and (4) the automatic reeling machine (1950) (Kiyokawa 2009, pp. 45–49). All these innovations came in the 20th century, which matched Japan's rise to global dominance in raw silk exports seen in Figure 14, at a time when Japanese labor costs were rising sharply above those of its major competitors.

We proceed to demonstrate that this was achieved by Japan's head-start in acquiring both prescriptive and propositional knowledge from both world leaders and its rivals. Eventually, it was the acquisition and application of propositional knowledge, namely R&D and experiment-based science, that supported Japan's growth in raw silk production. While a comprehensive treatment of comparative silk production in Japan and China is beyond the scope of this paper, we showcase the major sericulture innovation in the development of the F_1 cross-breeding silkworm variety.[26]

A hallmark of the Meiji directive of seeking wisdom from around the world was the well-known Iwakura mission that sent government ministers on a two-year study tour of Europe and the US in 1871–73. Following the mission, a group of Japanese sericultural experts headed by Nagaatsu Sasaki attended the Vienna World Expo in 1873. During that nearly one year visit, Sasaki visited Austria, Italy, and Switzerland at a time when Europe's silkworm rearing was transformed by the application of modern science, particularly the discovery and diffusion of Louis Pasteur's germ

[26]For a comprehensive review, see Kiyokawa (2009) and Ma (2004).

theory of disease and microscopic examination method of pebrine disease. The sericultural institute that Sasaki visited and studied for one full month in Gorizia (in Northern Italy) was the first of its kind, set up in 1869. Sasaki returned to Japan with the most up-to-date silkworm rearing tools such as microscopes and hygrometers, and he actively advocated for the establishment of modern sericultural research and education in Japan. The Japanese Home Ministry also set up the first experimental station in 1875 and by the mid-1880s, sericulture study became part of the curriculum of the newly established modern Japanese agricultural schools.

Meanwhile, higher-level science commenced in the University of Tokyo, newly founded in 1877. Most notable was the young Chujiro Sasaki —the son of Nagaatsu Sasaki —who was part of the first cohort of the University's biology major graduates, taught mostly by European scientists recruited by the Japanese government. The young Sasaki went on to spend two years studying in Munich during 1889–91 and subsequently returned to his alma mater to become the second chaired professor of Zoology, Entomology, and Sericulture after the first generation European scientists finished their term in Tokyo University.

The Sino-Japanese War of 1894–95 became a critical turning point for the silk sectors in both Japan and China. The signing of the Shimonoseki Treaty, which legalized the establishment of foreign industries in China, inadvertently set off a wave of Chinese private initiatives in industrialization and modernization to replace the previously state-centered developmental model under the Self-Strengthening Movement. Japan responded to this intensifying pressure by institutionalizing a system of sending specialists to survey the European and Chinese silk sectors. From about 1897 to the 1930s, these surveys produced a steady stream of technical reports with a total of about 40 volumes just on China and similar numbers on Europe (Ma 2004). In a report published in 1897, one Japanese specialist warned that once Qing China awoke and learned how to utilize modern methods to improve silkworm eggs, employ its abundant cheap labor, and introduce Western style machines, it could pose an immediate, existential threat to Japan's silk sector and erode any limited advantages Japan had gained through minor technical or general infrastructural improvements during the second half of the 19th century (Kiyokawa 2009, p. 223).

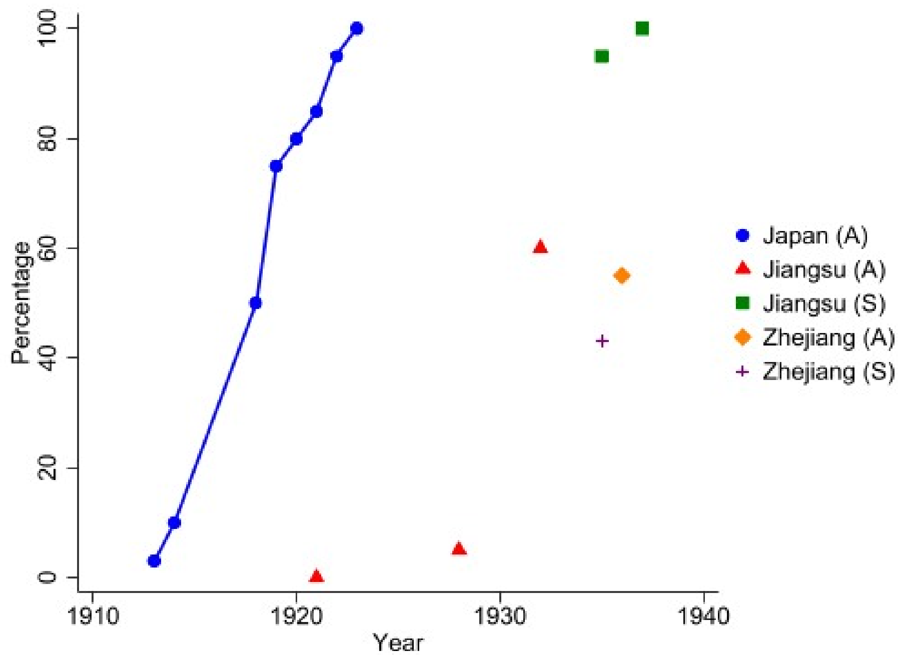
As it turned out, warnings like this elicited precisely the type of decisive technological breakthroughs that propelled the Japanese silk industry to global dominance through the development and application of new propositional knowledge. The clearest case in point was the discovery of the first filial (F_1) hybrid silkworm in the early 1910s based on the systematic application of Mendel's theory of genetics. Mendel's original work was published in 1866—nearly contemporary with Louis Pasteur's germ theory of disease—but remained largely forgotten until 1900, when it was rediscovered by three European scientists. In 1906—barely six years after the rediscovery of Mendel's work—a Tokyo University graduate by the name of Kametaro Toyama published both in English and Japanese on the application of Mendel's genetic theory to silkworm breeding.

The concept and practice of hybridization was recognized in ancient East Asia through purely empirical observations, lacking what Mokyr termed the "epistemic base." Hence, the key element of Mendel's theory of heterosis, established through his controlled experiments on peas, was missing. The superior traits of the two pure strain parent varieties were stable only in their first generation of crossbreeds, but not in the succeeding generations derived from this cross. This important theoretical recognition led to the rise of modern experimental labs that specialized in the selection and breeding of pure strain varieties and the mass production of the crossed F_1 variety silkworm eggs for cocoon production. The development of the F_1 variety was also founded on cumulative research on embryology and cellular biology

The performance of the F_1 variety surpassed the previous types in almost all technical indices. Lab tests confirmed that the F_1 variety shortened the rearing period, produced longer fibers, yielded fewer defective cocoons and were better suited to the demands of machine reeling (Kiyokawa 1984, pp. 37–38). The publication of Toyama's work represented the cumulative outcome of nearly two generations of Japanese scholarly borrowing of Western science starting from the 1870s, as marked by Nagaatsu Sasaki's visit to Italy. Toyama graduated from the University of Tokyo Agricultural college in 1890. With his scientific training, Toyama also accumulated practical experience serving as the director of the Japanese sericultural school, technical director for the Japanese Ministry of Agriculture, and sericultural advisor to the Thailand government (Ma 2004; Kiyokawa 2009).

The ultimate success of the F_1 discovery hinged on a diffusion network, which consisted of experimental stations, specialized silkworm egg dealers, and industrial silk reelers and associations. The diffusion among sericultural farmers started in the early 1910s, and by 1923, the F_1 variety's share in the spring crop reached one hundred percent; by 1929, one hundred percent of the summer and fall crop used the F_1 breed in Japan (see Figure 15) (Kiyokawa 2009).

Figure 15: Diffusion of Scientifically Produced Silkworm Varieties in Japan and the Lower-Yangzi



Source: Ma (2004). Silkworms are capable of breeding in multiple seasons throughout the year. In this context, (A) denotes autumn, and (S) denotes summer.

The diffusion of the F_1 variety had a direct impact on both the productivity and quality of cocoons in Japan. Major technical indicators of Japanese silkworm varieties and rearing showed a rapid acceleration in the first two decades of the 20th century. Overall, Japanese TFP in the cocoon sector between 1903–27 grew four times faster than that of the Lower Yangzi, with biological innovation accounting for nearly 60 percent of total cocoon output growth. By the late 1920s, when the diffusion of the F_1 variety was complete, the quality and productivity of Japanese silkworm variety had far surpassed Italy, the world leader (Kiyokawa 1984, p. 38; Ma 2005).

China's Catch-up In China, while foreign investment and merchants made numerous attempts to introduce modern reeling machines and factories, silkworm rearing practices in rural Lower Yangzi were largely untouched in the 19th century. Indeed, among the numerous Japanese observations made in surveys conducted after 1897, the silkworm rearing practices of the one-time global leader in silk production seemed backward, naïve, and superstitious, resembling Japan's own practice thirty years prior (Ma 2005).[27]

The 1894–95 Sino-Japanese War was as much of a pivotal point for Chinese silk production as it was for Japan. China's first two sericultural schools were established in 1896 and 1897 (Kiyokawa 2009, p. 338). As part of the Late Qing Constitutional reform, experimental stations, research institutes, schools of various levels, departments in universities, and a scientific community grew, actively promoting sericultural reform, popularizing scientific principles, and diffusing new technology. Learning from and through Japan began after the onset of the twentieth century, marked by a massive flow of ideas and technologies from Japan to China—reversing the historical direction of technological and cultural transfer between these two regions in the pre-modern era. That the Lower Yangzi took Japanese sericulture as a model of learning can be confirmed by the large number of sericultural reformers with degrees from Japanese sericultural schools and institutes, the extensive discussion and introduction of Japanese sericultural technology in Chinese journals and books in the 1920s and 30s, and the invitation of Japanese specialists and advisors to the Lower Yangzi sericultural regions and schools to give direct guidance for reform (Ma 2005). Kiyokawa (2009, p. 343) documents that among the nearly one hundred Chinese graduates from three Japanese institutions of vocational education, two-thirds graduated from a prominent specialized sericultural school in

[27] A case of introducing Italian sericultural technology by Qing bureaucrats presented a curious contrast to the Japanese model. In 1899, an Italian sericultural book translated by John Fryer was published. Fryer was a well-know English translator employed by the Jiangnan Arsenal, the most important mega-enterprise in the Lower Yangzi sponsored by the Self-Strengthening Movement. The Italian sericultural book was authored by Vincenzo Dandolo, a specialist who pioneered the introduction of scientific methods into European sericulture. Dandolo's original work was published in the late 1810s and subsequently translated into English. The Italian sericultural technology introduced to the Lower Yangzi in 1899 by Fryer, himself a non-specialist in sericulture, was more than half a century behind the technology that Sasaki had personally witnessed in Italy in his study mission in 1873. Furthermore, Fryer complained that his translated works were seldom used by the various departments of the Arsenal (Ma 2004).

Tokyo. This resulted in the introduction of the Pasteur method of microscopic inspection for disease around 1900 and the F_1 variety in 1925.

This process accelerated in the wake of the Great Depression and collapse of the global commodity market. Lower Yangzi sericulture embarked on a remarkable catch up with Japan. This was seen in the appearance and diffusion of the improved variety of silkworm eggs in the Lower Yangzi, which included both the scientifically selected superior variety that had passed microscopic examination for pebrine disease and later the F_1 variety. Figure 15 plots diffusion curves for the improved variety for both Japan and the Lower Yangzi. The speed of diffusion, particularly for Jiangsu province, was remarkably swift. Within a period of only 5 to 7 years, the percentage of scientifically produced silkworm eggs increased from 5% to almost 100%. Jiangsu province also took the leadership in rearing fall silkworms following the Japanese method of artificial hatching. In 1935, the ratio of fall crops to total crops was 42% for Jiangsu and 18% for Zhejiang province. Although diffusion lagged in Zhejiang province, overall the rate of diffusion in the Lower Yangzi in the 1930s was comparable to the Japanese diffusion of the F_1 hybrids in the 1910s and 1920s (Ma 2005).

These positive developments along with the rise of large-scale manufacturing clustered in the city of Wuxi greatly strengthened the competitive position of Lower Yangzi raw silk in the global market in the wake of the Great Depression. This was the second time that the Japanese competitor would be alarmed. But in the end, it was geo-political tension—the outbreak of second Sino-Japanese War in 1937—that would disrupt the Chinese catch-up. Despite this, the seeds of modern East Asia were sown.

7. Conclusion

This paper seeks to understand the conditions under which societies that are behind the technological frontier adopt new types of knowledge. Using the framework proposed by Mokyr (2002), we distinguish between two types of knowledge: prescriptive (what works and how, but not why) and propositional (why things work). We argue that several features determine which type of knowledge a society will adopt.

First, at a time of external threats, political competition within decentralized societies offers great incentive for adoption even though such knowledge is damaging to the political legitimacy of the prevailing authority. Autonomous polities within a decentralized regime also need to compete with their peers in addition to external powers and thus need the potential resources that propositional knowledge offers. More importantly, political autonomy allowed independent decision making for decentralized societies which could become laboratories of experimentation; one part of the society may not find the costs associated with propositional knowledge worth it, while others do. In this regard, our paper sheds new light on the possible historical association between political fragmentation and the growth of knowledge. Indeed, one could argue that it was the intense competition for resources and domination in a politically and religiously fragmented Europe that sent generations of Europeans—starting with Marco Polo, the Jesuits, and Protestants—to China to convert, seek knowledge, and profit. Similarly, a fragmentated Tokugawa regime—although inherently unstable in the face of external threat—endowed Japanese elites a keener sense of crisis, a greater space for political experimentation and more importantly a thirst for learning when the knowledge frontier had clearly gravitated towards the West by the mid-19th century.

Second, this paper also highlights cultural distance as a barrier to the acquisition of propositional knowledge and hence the importance of learning. East Asian intellectual isolation from the West had become particularly costly by the 19th century, when Western Europe had seen an enormous surge in the growth of what Mokyr termed useful knowledge. Propositional knowledge adoption requires reverse engineering; it is possible to see what works, but how it works requires experimentation, translation of codified knowledge, and tacit learning via experience. Such knowledge acquisition becomes more costly as the cultural distance between the source and recipient increases. Our research sheds new light on an often neglected aspect in the economic history research of East Asia: the onset of a profound shift in world view or an intellectual enlightenment that preceded the economic transformation during the late 19th century. This paradigmatic change was engendered mostly by elites with vision and courage. Hence, the role of the government and the process of enlightenment had been predominant from the beginning. The process was far deeper and more wide-ranging than industrial policy, which often captures a superficial aspect of a much more profound transformation in world views. By emphasizing the importance of borrowing foreign propositional knowledge, we highlight the importance of learning. Only by acquiring propositional (rather than prescriptive) knowledge can a country truly build its own knowledge base most suited to its own cultural and historical tradition. Radical processes of modernization or Westernization—as in the movement to eliminate Chinese characters—reveals precisely the perils of slavishly copying or imitating modernity without grasping the propositional knowledge.

Third, our research points to the prominent role of cross-cultural learning and borrowing in the East Asian modernization process. Such a process cannot be taken for granted. It was pioneered by Japan, whose relatively peripheral and independent position within the Sinic world order, along with its decentralized political structure, made possible a bold political experiment in adopting propositional knowledge from the West. Japan's success in this experiment and the knowledge gained during this process lowered cultural barriers, challenged traditional legitimacy, and provided impetus for change for other nations in a similar cultural environment.

Moreover, our study has implications for economic development that extend beyond the cases of 19th century China and Japan. It also helps explain one critical feature other scholars have noted as accounting for China's phenomenal growth in the era of reform under Deng Xiaoping: the role of intermediaries such as Japan, and more importantly by the 1980s, that of Hong Kong, Taiwan, and to a certain degree Singapore. These countries and regions shared linguistic and cultural heritages with China but remained in the Western economic sphere after the Second World War. These intermediaries helped mainland China rapidly integrate into the market economies of the West through knowledge transfer in technology, marketing, and even institutional practices.

References

Acemoglu, Daron and James A. Robinson. 2006. "Economic Backwardness in Political Perspective." *American Political Science Review* 100(1): 115–131.

Akerlof, George A. and Pascal Michaillat. 2018. "Persistence of False Paradigms in Low-power Sciences." *Proceedings of the National Academy of Sciences* 115(52): 13228–13233.

Bai, Ying, Ruixue Jia and Jiaojiao Yang. 2023. "Web of Power: How Elite Networks Shaped War and Politics in China." *Quarterly Journal of Economics* 138(2): 1067–1108.

Baten, Joerg, Debin Ma, Stephen Morgan and Qing Wang. 2010. "Evolution of Living Standards and Human Capital in China in 18–20th Century." *Explorations in Economic History* 47(3): 347–359.

Bénabou, Roland. 2008. "Ideology." *Journal of the European Economic Association* 6(2-3): 321–352.

Bénabou, Roland, Davide Ticchi and Andrea Vindigni. 2022. "Forbidden Fruits: The Political Economy of Science, Religion, and Growth." *Review of Economic Studies* 89(4): 1785–1832.

Bernhofen, Daniel M. and John C. Brown. 2004. "A Direct Test of the Theory of Comparative Advantage: The Case of Japan." *Journal of Political Economy* 112(1): 48–67.

Bernhofen, Daniel M. and John C. Brown. 2005. "An Empirical Assessment of the Comparative Advantage Gains from Trade: Evidence from Japan." *American Economic Review* 95(1): 208–225.

Brandt, Loren, Debin Ma and Thomas G. Rawski. 2014. "From Divergence to Convergence: Reevaluating the History Behind China's Economic Boom." *Journal of Economic Literature* 52(1): 45–123.

Chaudhry, Azam and Phillip Garner. 2006. "Political Competition between Countries and Economic Growth." *Review of Development Economics* 10(4): 666–682.

Chen, Liwei. 2019. *Dong Wang Dong Lai: Jindai Zhong Ri Zhi Jian De Yuci Wanglai [East Goes, East Comes: Lexical Exchanges Between Modern China and Japan]*. Beijing: Social Sciences Academic Press.

Chen, Shuo and Debin Ma. 2022. "States and Wars: China's Long March towards Unity and its Long-Term Consequences, 750 BC–1911 AD." Working Paper.

Chen, Ting, James Kai-sing Kung and Chicheng Ma. 2020. "Long Live Keju! The Persistent Effects of China's Civil Examination System." *Economic Journal* 130(631): 2030–2064.

Chuang, Yin-yung and Ching-hai Chou. 2009. "The Historical Place of Nineteenth-Century Basel Missionary Translators in the Formation of Chinese Neologisms: A Case Study of Karl Gützlaff's Chinese Translation Neologisms." *WAKUMON* 17: 1–20.

Coşgel, Metin M., Thomas J. Miceli and Jared Rubin. 2012. "The Political Economy of Mass Printing: Legitimacy and Technological Change in the Ottoman Empire." *Journal of Comparative Economics* 40(3): 357–371.

Denzau, Arthur T. and Douglass C. North. 1994. "Shared Mental Models: Ideologies and Institutions." *Kyklos* 47(1): 3–31.

Duan, Li and Xiaoming Zhang. 2023. "Awakening Latent Human Capital: The Opening-up and Entrepreneurship in Early Modern China." Working Paper.

Feng, Tianyu. 2001. 千岁丸上海行 *Qiansuiwan's Shanghai Tour, Japanese Observation of China in 1862*. Beijing: Shangwu Publishers.

Ferejohn, John A. and Frances McCall Rosenbluth. 2010. *War and State Building in Medieval Japan*. Stanford: Stanford University Press.

Ge, Zhaoguang. 2023. “什么是中日传统政治文化的结构性差异 (What are Structural Differences between Traditional Chinese and Japanese Political Culture).” *Tsinghua University Journal (Philosophy and Social Science Edition)* 清华大学学报”（哲学社会科学版*)* 1(2): 1–39.

Greif, Avner and Jared Rubin. 2024. “Endogenous Political Legitimacy: The Tudor Roots of England’s Constitutional Governance.” *Journal of Economic History* 84(3): 655–689.

Greif, Avner and Joel Mokyr. 2017. “Cognitive Rules, Institutions, and Economic Growth: Douglass North and Beyond.” *Journal of Institutional Economics* 13(1): 25–52.

Hanlon, W. Walker. 2025. “The Rise of the Engineer: Inventing the Professional Inventor during the Industrial Revolution.” *Economic Journal* 135(670): 1749–1781.

History Group Series Editorial Department (eds.). 2006. *Zusetsu Bakumatsu Boshin Seinan Sensō [Illustration of the Late Edo Period Boshin War and the Southwest War].* Gakken Plus.

Hoffman, Philip T. 2015. *Why did Europe Conquer the World?* Princeton, NJ: Princeton University Press.

Hong, Ze, Edward Slingerland and Joseph Henrich. 2024. “Magic and Empiricism in Early Chinese Rainmaking: A Cultural Evolutionary Analysis.” *Current Anthropology* 65(2): 343–363.

Iyigun, Murat, Jared Rubin and Avner Seror. 2021. “A Theory of Cultural Revivals.” *European Economic Review* 135: 103734.

Jin, Guantao and Qingfeng Liu. 2008. *Guannian Shi Yanjiu: Zhongguo Xiandai Zhongyao Zhengzhi Shuyu De Xingcheng [Studies in the History of Ideas: The Formation of Important Modern Chinese Political Terms].* Beijing: Falv Chubanshe [Law Press China].

Jin, Guantao and Qingfeng Liu. 2011. 开放中的变迁，再论中国社会超稳定结构 *(The Transformation of Chinese Society (1840–1956): The Fate of Its Ultrastable Structure in Modern Times).* Beijing: Falu Chubanshe.

Juhász, Réka, Mara P. Squicciarini and Nico Voigtländer. 2024. "Technology Adoption and Productivity Growth: Evidence from Industrialization in France." *Journal of Political Economy* 132(10): 3215–3259.

Juhász, Réka, Shogo Sakabe and David Weinstein. 2025. "Codification, Technology Absorption, and the Globalization of the Industrial Revolution." NBER Working Paper 32667.

Kiyokawa, Yukihiko. 1984. "The Diffusion of New Technologies in the Japanese Sericulture Industry: The Case of the Hybrid Silkworm." *Hitotsubashi Journal of Economics* pp. 31–59.

Kiyokawa, Yukihiko. 2009. *Kindai Seishi Gijutsu to Ajia: Gijutsu Donyu no Hikaku Keizaishi [Modern Silk Reeling Technology and Asia: A Comparative Economic History of Technology Transfer]*. Nagoya: Nagoya Daigaku Shuppankai [Nagoya University Press].

Koyama, Mark, Chiaki Moriguchi and Tuan-Hwee Sng. 2018. "Geopolitics and Asia's Little Divergence: State Building in China and Japan after 1850." *Journal of Economic Behavior & Organization* 155: 178–204.

Koyama, Mark and Jared Rubin. 2022. *How the World Became Rich: The Historical Origins of Economic Growth*. Cambridge: Polity Press.

Kung, James. 2022. The Economic Impact of the West A Reappraisal. In *Cambridge Economic History of China, vol. II*, ed. Debin Ma and Richard von Glahn. Cambridge: Cambridge University Press pp. 354–413.

Kung, James Kai-sing and Alina Wang. 2025. "Overseas Students, Ideology, and the Fall of Dynastic China." *Journal of Economic Growth* forthcoming.

Lin, Justin Yifu. 1995. "The Needham Puzzle: Why the Industrial Revolution did not Originate in China." *Economic Development and Cultural Change* 43(2): 269–292.

Lu, Xun. 1934. "Guanyu Xin Wenzi [On New Scripts]." *Yonghu Xin Wenzi Liuribao [Support New Scripts Six-Day Journal]* .

Lu, Yuxin 吕玉新. 2017. *Polity, Civilization and Debates on Ethnicities, History of Thought in Tokugawa Japan* 政体，文明，族群之辩德川日本思想史. Hong Kong: Chinese University of Hong Kong Press.

Ma, Chicheng. 2024. "Classicism and Modern Growth: The Shadow of the Sages." *Journal of Economic History* 84(2): 395–431.

Ma, Debin. 1996. "The Modern Silk Road: The Global Raw-silk Market, 1850–1930." *Journal of Economic History* 56(2): 330–355.

Ma, Debin. 2004. "Why Japan, not China, was the First to Develop in East Asia: Lessons from Sericulture, 1850–1937." *Economic Development and Cultural Change* 52(2): 369–394.

Ma, Debin. 2005. "Between Cottage and Factory: The Evolution of Chinese and Japanese Silk-Reeling Industries in the Latter Half of the Nineteenth Century." *Journal of the Asia Pacific Economy* 10(2): 195–213.

Ma, Debin. 2022. Ideology and the Contours of Economic Change in Modern China, 1850-1950. In *Cambridge Economic History of China, vol. II*, ed. Debin Ma and Richard von Glahn. Cambridge: Cambridge University Press pp. 15–47.

Ma, Debin and Jared Rubin. 2024. "Ideology and Economic Change: The Contrasting Paths to the Modern Economy in late 19th Century China and Japan." *Journal of Government and Economics* 15: 100122.

Machida, Akihiro. 2015. *Gurōbaru Bakumatsushi: Bakumatsu Nihonjin wa Sekai o Dō Miteita ka [Global Bakumatsu history: How did the Japanese of the Bakumatsu Period View the World?]*. Soshisha.

Mann, Michael. 2012. *The Sources of Social Power: Volume 1, A History of Power from the Beginning to AD 1760*. Cambridge: Cambridge University Press.

Ministry of Education, Culture, Sports, Science and Technology (ed.). 2009. “Japanese Students Studying Abroad and Foreign Teachers in Japan.”. Accessed February 4, 2026.

URL: *https://www.mext.go.jp/b_menu/hakusho/html/others/detail/1317259.htm*

Ministry of Education (ed.). 1981. “One Hundred Year History of the Education System.”. Accessed February 4, 2026.

URL: *https://www.mext.go.jp/b_menu/hakusho/html/others/detail/1317552.htm*

Mitchell, Austin M. and Weiwen Yin. 2022. “Political Centralization, Career Incentives, and Local Economic Growth in Edo Japan.” *Explorations in Economic History* 85: 101446.

Mokyr, Joel. 1990. *The Lever of Riches: Technological Creativity and Economic Progress*. New York: Oxford University Press.

Mokyr, Joel. 2002. *The Gifts of Athena: Historical Origins of the Knowledge Economy*. Princeton, NJ: Princeton University Press.

Mokyr, Joel. 2009. *The Enlightened Economy: An Economic History of Britain, 1700-1850*. New Haven, CT: Yale University Press.

Mokyr, Joel. 2016. *A Culture of Growth: The Origins of the Modern Economy*. Princeton, NJ: Princeton University Press.

Morck, Randall and Masao Nakamura. 2007. “Business Groups and the Big Push: Meiji Japan’s Mass Privatization and Subsequent Growth.” *Enterprise & Society* 8(3): 543–601.

Morck, Randall and Masao Nakamura. 2018. “Japan’s Ultimately Unaccursed Natural Resources-financed Industrialization.” *Journal of the Japanese and International Economies* 47: 32–54.

Morishima, Michio. 1982. *Why has Japan ’Succeeded’?: Western Technology and the Japanese Ethos*. Cambridge: Cambridge University Press.

Mukoyama, Naosuke. 2022. "The Eastern Cousins of European Sovereign States? The Development of Linear Borders in Early Modern Japan." *European Journal of International Relations* 29(2): 255–282.

Murata, Yujiro and Christine Lamarre, eds. 2005. *Kanjiken no kindai: Kotoba to kokka [Modernity for Nations in the Chinese Character Zone: Words and Nations]*. Tokyo: University of Tokyo Press.

North, Douglass C. 2005. *Understanding the Process of Economic Change*. Princeton, NJ: Princeton University Press.

Pauer, Erich. 1991. "The Years Economic Historians Lost: Japan, 1850–1890." *Japan Forum* 3(1): 1–9.

Qin, Hui 秦晖. 2015. *Out of Empire, a Historical Revisit to the Late Qing and Republican Era 走出帝制：从晚清到民国的历史回望*. Beijing: Qunyan Publishers.

Roberts, Jonathan. 2025. "How Long Does It Take to Learn a Language?". Accessed: January 22, 2026.
URL: https://ancientlanguage.com/how-long-does-it-take-to-learn-a-language/

Rodrik, Dani. 2014. "When Ideas Trump Interests: Preferences, Worldviews, and Policy Innovations." *Journal of Economic Perspectives* 28(1): 189–208.

Romer, Paul. 1993. "Idea Gaps and Object Gaps in Economic Development." *Journal of Monetary Economics* 32(3): 543–573.

Rubin, Jared. 2017. *Rulers, Religion, and Riches: Why the West Got Rich and the Middle East Did Not*. New York: Cambridge University Press.

Saneto, Keishu. 2012. *A History of Chinese Students in Japan*. Beijing: Peking University Press.

Shi, Youwei, ed. 2019. *Xinhua Wailaici Cidian [Xinhua Loanword Dictionary]*. Beijing: The Commercial Press.

Shogakukan Dictionary Editorial Department, ed. 2000. *Nihon Kokugo Daijiten, Second Edition [Great Dictionary of the Japanese Language, Second Edition].* Tokyo: Shogakukan.

Sng, Tuan-Hwee and Chiaki Moriguchi. 2014. "Asia's Little Divergence: State Capacity in China and Japan before 1850." *Journal of Economic Growth* 19(4): 439–470.

Solow, Robert M. 1956. "A Contribution to the Theory of Economic Growth." *Quarterly Journal of Economics* 70(1): 65–94.

Squicciarini, Mara P. 2020. "Devotion and Development: Religiosity, Education, and Economic Progress in Nineteenth-century France." *American Economic Review* 110(11): 3454–3491.

Steele, Abbey, Christopher Paik and Seiki Tanaka. 2017. "Constraining the Samurai: Rebellion and Taxation in Early Modern Japan." *International Studies Quarterly* 61(2): 352–370.

Sun, Daquan. 2023. *Shuyu Geming (A Terminological Revolution in Chinese Naming: The Formation of Major Economic Terms in Modern China).* Beijing: Social Sciences Academic Press.

Sussman, Nathan and Yishay Yafeh. 2000. "Institutions, Reforms, and Country Risk: Lessons from Japanese Government Debt in the Meiji Era." *Journal of Economic History* 60(2): 442–467.

Swan, Trevor Winchester. 1956. "Economic Growth and Capital Accumulation." *Economic Record* 32(2): 334–361.

Tang, John P. 2014. "Railroad Expansion and Industrialization: Evidence from Meiji Japan." *Journal of Economic History* 74(3): 863–886.

Tang, John P. and Sergi Basco. 2023. "Banks, Credit Supply, and the Life Cycle of Firms: Evidence from Late Nineteenth Century Japan." *Journal of Banking & Finance* 154: 106937.

Wei, Yuan. 1992. *Haiguo Tuzhi [Illustrated Treatise on the Maritime Kingdoms].* Zhengzhou: Zhongzhou Guji Press.

Wen, Fangqi, Erik H. Wang and Michael Hout. 2024. "Social Mobility in the Tang Dynasty as the Imperial Examination Rose and Aristocratic Family Pedigree Declined, 618–907 CE." *Proceedings of the National Academy of Sciences* 121(4): e2305564121.

Wright, Mary C. 1957. *The Last Stand of Chinese Conservatism: The Tung-Chih Restoration, 1862-1874*. Stanford, CA: Stanford University Press.

Zhao, Dingxin. 2015. *The Confucian-Legalist State, a New Theory of Chinese History*. Oxford: Oxford University Press.

Zhou, Mian. 1999. *Zhongguo Liuxuesheng Dacidian [A Comprehensive Dictionary of Chinese Overseas Students]*. Nanjing: Nanjing University Press.

A. Additional Tables

Table A.1: Explaining Positions in Boshin War

	(1)	(2)	(3)
	Dependent Variable: Pro-Meiji = 1		
Tozama	1.248**	1.283**	1.153**
	(0.514)	(0.521)	(0.588)
Elevation mean		-0.003	-0.003
		(0.003)	(0.003)
Elevation s.d.		0.002	0.001
		(0.006)	(0.006)
Longitude			-0.885**
			(0.362)
Latitude			0.937**
			(0.384)
Disaster			-0.206
			(0.525)
Distance to Tokyo			-0.006**
			(0.003)
Constant	-2.783***	-2.581***	87.486**
	(0.421)	(0.529)	(38.66)
Observations	182	182	182
Pseudo-R^2	0.051	0.063	0.123

Notes: Logit models. Standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The response variable takes the value of 1 if the domain supported the new Meiji government in the war against the Tokugawa Shogunate, and 0 otherwise. This variable is coded based on History Group Series Editorial Department (eds.) (2006, pp. 106–07). The data for the domain-level control variables are collected from Steele, Paik and Tanaka (2017).

B. Sources of Publications in China and Japan

The Japanese list of publications is compiled from two principal sources. The first source is the Union Catalogue Database of Japanese Texts (UCDJT). This extensive repository, which contains 450,342 publications, provides pre-Meiji data, with 108,607 entries dating to before 1868. The keywords associated with the entries allow classification. Specifically, we assign each publication to an appropriate category based on the Nippon Decimal Classification (NDC) system. This data source also contains some post-1868 publications, which are incorporated in our sample.

The second pillar of our Japanese dataset is sourced from the comprehensive list of publications stored at the National Diet Library (NDL), which serves as Japan's foremost library collection and repository of national publications. The National Diet Library includes a full set of publications from 1868, the year when the Meiji Restoration began. These publications were officially indexed and classified according to the Nippon Decimal Classification (NDC) system, ensuring that each entry is appropriately categorized by its subject matter. By combining the UCDJT and NDL datasets, we have compiled a list of 617,563 works published between 1840 and 1940. Among these, 30,694 were published prior to 1868, accounting for less than 5% of the total sample. It is important to note that the actual number of pre-Meiji publications may be higher, as the exact publication years for some entries in the UCDJT are not specified.

The Chinese time series are built on Duan and Zhang's (2023) novel bibliometric dataset, which spans publications from 202 BCE to 1949 CE. Their dataset is compiled based on a combination of two sources: (1) Grand Catalog of Books in pre-1912 China, a collection of all book titles until the late Qing period; and (2) General Bibliography of the Republican Period, a comprehensive list of publications in 1912–49. Together, there were 293,959 books published in 1840–1940 in China, with 280,839 published after 1912. Duan and Zhang's (2023) data on Chinese publications already include classifications, such as Confucianism and STEM. To create a STEM group in the Japanese dataset, we selected all publications categorized under the NDC classifications of "Natural Sciences" and "Technology and Engineering."

C. Proofs

C.1. Proof of Proposition 1

Assuming indifference is broken by choosing T, C chooses T when:

$$\log[p(F^T, a)q(F^T, L(M(T), 0))] \geq \max\{\log[p(F^R, a)q(F^R, L(M(R), 0))], \log[p(F^S - d, a)q(F^S - d, L(M(S), d))]\}. \quad \text{(C.1)}$$

Denote a^* as the value of a such that:

$$\log[p(F^T, a^*)q(F^T, L(M(T), 0))] = \max\{\log[p(F^R, a^*)q(F^R, L(M(R), 0))], \log[p(F^S - d, a^*)q(F^S - d, L(M(S), d))]\}. \quad \text{(C.2)}$$

Since $p_{12} > 0$ and $F^S - d > F^R > F^T$ by Assumptions 1 and 2, for any values of $a > a^*$, C.1 does not hold, whereas C.1 holds for any values of $a \leq a^*$. A similar logic applies to D's choice, where a^{**} is defined by C.3.

$$\log[p(F^T, a^{**})q(F^T, L(M(T), 0))z(F^T)] = \max\{\log[p(F^R, a^{**})q(F^R, L(M(R), 0))z(F^R)], \log[p(F^S - d, a^{**})q(F^S - d, L(M(S), d))z(F^S - d)]\}. \quad \text{(C.3)}$$

Finally, we show that $a^* > a^{**}$. Start by assuming that $a^* = a^{**}$. Plugging C.2 into C.3, along with a bit of algebra, gives:

$$\max\{\log[p(F^R, a^*)q(F^R, L(M(R), 0))], \log[p(F^S - d, a^*)q(F^S - d, L(M(S), d))]\} + \log[z(F^T)] = \max\{\log[p(F^R, a^*)q(F^R, L(M(R), 0))z(F^R)], \log[p(F^S - d, a^*)q(F^S - d, L(M(S), d))z(F^S - d)]\}. \quad \text{(C.4)}$$

However, C.4 can never hold, since the RHS is always greater than the LHS. This implies that:

$$\log[p(F^T, a^*)q(F^T, L(M(T), 0))z(F^T)] < \log[p(F^T, a^{**})q(F^T, L(M(T), 0))z(F^T)]$$
$$\Rightarrow p(F^T, a^*) < p(F^T, a^{**}). \quad \text{(C.5)}$$

Since $p_2 < 0$, it must be that $a^* > a^{**}$.

C.2. Proof of Proposition 2

This proposition only concerns the parameter space in which R or S are chosen. Hence, assuming that indifference is broken by choosing R, C chooses R (and S otherwise) when:

$$\log[p(F^R, a)q(F^R, L(M(R), 0))] \geq \log[p(F^S - d, a)q(F^S - d, L(M(S), d))]. \quad \text{(C.6)}$$

Likewise, D chooses R (and S otherwise) when:

$$\log[p(F^R, a)q(F^R, L(M(R), 0))z(F^R)] \geq \log[p(F^S - d, a)q(F^S - d, L(M(S), d))z(F^S - d)]. \quad \text{(C.7)}$$

We will first show that C^* exists. Setting $a = C^*$, and thus setting C.6 to equality, we can write:

$$\log[p(F^S - d, C^*)]\log[p(F^R, C^*)] = \log[q(F^R, L(M(R), 0))]\log[q(F^S - d, L(M(S), d))]. \quad \text{(C.8)}$$

Since $p_{12} > 0$, it is straight-forward to see that the LHS of C.8 is greater than the RHS for any value of $a > C^*$ and the LHS is less than the RHS for any value of $a \leq C^*$. It follows that C will choose S if $a > C^*$ and R if $a \leq C^*$.

The same logic follows if we set $a = D^*$ in equation C.7, since z is not a function of a. We can write:

$$\log[p(F^R, D^*)q(F^R, L(M(R), 0))z(F^R)] = \log[p(F^S - d, D^*)q(F^S - d, L(M(S), d))z(F^S - d)]. \tag{C.9}$$

Using the same logic as above, it follows that D will choose S if $a > D^*$ and R if $a \leq D^*$.

Next, we show that $D^* > C^*$. We prove this by contradiction. Assume that $C^* > D^*$. Since $p_{12} > 0$, $\log[p(F^R, C^*)q(F^R, L(M(R), 0))] > \log[p(F^R, D^*)q(F^R, L(M(R), 0))]$. Substituting C.8 into C.9 (and a little algebra) gives:

$$\begin{aligned}
&\log[p(F^S - d, C^*)q(F^S - d, L(M(S), d))z(F^R)] = \\
&\qquad \log[p(F^R, C^*)q(F^R, L(M(R), 0))z(F^R)] > \\
&\qquad \log[p(F^R, D^*)q(F^R, L(M(R), 0))z(F^R)] = \\
&\qquad\qquad \log[p(F^S - d, D^*)q(F^S - d, L(M(S), d))z(F^S - d)].
\end{aligned} \tag{C.10}$$

This inequality can only hold if:

$$\begin{aligned}
&\log[p(F^S - d, C^*)z(F^R)] > \log[p(F^S - d, D^*)z(F^S - d)] \Rightarrow \\
&\qquad \log[p(F^S - d, C^*)] - \log[p(F^S - d, D^*)] > \log[z(F^S - d)] - \log[z(F^R)].
\end{aligned} \tag{C.11}$$

However, C.11 can never be true. Since $p_2 < 0$, the LHS of C.11 is negative, while $z > 0$ implies that the RHS of C.11 is positive. Hence, a contradiction implying that $D^* > C^*$.

Finally, we show that C^* and D^* are increasing in d. C^* and D^* are defined by C.8 and C.9, respectively. Re-writing C.8 gives:

$$\log[p(F^S - d, C^*)] + \log[q(F^S - d, L(M(S), d))] = \log[p(F^R, C^*)] + \log[q(F^R, L(M(R), 0))]. \tag{C.12}$$

The LHS of C.12 is clearly decreasing in d. Hence, as d increases, C^* must adjust so that the LHS increases more (or decreases less) than the RHS in order to maintain equality. Since $p_{12} > 0$, this will be the case when C^* increases. Hence, C^* is increasing in d.

The same logic can be employed regarding D^*. Re-writing C.9 gives:

$$\log[p(F^R, D^*)] + \log[q(F^R, L(M(R), 0))] + \log[z(F^R)] = \\ \log[p(F^S - d, D^*)] + \log[q(F^S - d, L(M(S), d))] + \log[z(F^S - d)]. \quad \text{(C.13)}$$

The RHS of C.13 is clearly decreasing in d. Hence, as d increases, D^* must adjust so that the RHS increases more (or decreases less) than the LHS in order to maintain equality. Since $p_{12} > 0$, this will be the case when D^* increases. Hence, D^* is increasing in d.