

Entrepreneurial state vs liberal market

Chinese comparative advantage in the transformation of national science to technology artefacts

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Abstract

Purpose – This paper aims to assess the comparative position of the national innovation system of Chinese state entrepreneurship versus liberal market entrepreneurship. Based on the comparative institutional framework, it asks whether Chinese state entrepreneurship has a comparative disadvantage because of its incoherent institutions in liberal or coordinated economies. Hence, does the Chinese institutional system of innovation lag behind that of US or liberal countries of Organisation for Economic Co-operation and Development (OECD) economies in the transformation of national science into economic products measured as high-technology exports?

Design/methodology/approach – This study uses panel data analysis based on 29 OECD economies and the Chinese economy over 23 years. Regarding national science productivity (explorative capabilities), it includes published and patented science streams; regarding technological transformation (exploitative capabilities), it measures the percentage of high-technology exports in gross domestic product (GDP). The interactions between the types of entrepreneurship and national science institutions serve as predictors in the design.

Findings – The results show that Chinese state entrepreneurship has a comparative advantage over liberal economies in published science. However, Chinese state entrepreneurship has a comparative disadvantage compared to liberal entrepreneurship in patent science. Regarding the dyadic level of comparability between the national economies, there are mixed results in the transformation of national science.

Research limitations/implications – This study supports the three following theoretical points: national institutions differ regardless of the pressure of convergence through globalization; national science contingencies influence different paths of the transformation of national science to technology; and mixed economies, such as state entrepreneurship, can achieve high performance without fully conforming to liberal markets.

Practical implications – This study emphasizes institutional mechanisms for future research to support the innovation of incoherent institutions and suggests the benefit of cross-pollination of senior managers between state and private organizations for a defined duration.



Originality/value – Theoretically, this research combines an interdisciplinary and interinstitutional level of analysis, and in so doing, it deals with the transformation of national science in scientific publications and patents in the vertical value chain. Empirically, this study links the national published and patented science with the national economic artifacts in high-technology sectors. This novel approach to assess the national and discipline-level interaction sets a context for the future research in other settings. It also informs policy decisions regarding the growth of science, innovation and development.

Keywords National innovation system, Chinese development dilemma, Chinese state entrepreneurship, Explorative-exploitative divergence, Institutional contingencies

Paper type Research paper

Introduction

The Chinese economy faces a dilemma of transforming national science into economic products. This transformational linkage between national institutional paths for national innovation performance raises many theoretical and empirical questions. For instance, in the eyes of scholars and analysts, China has become the second largest economy in the world, and yet, it lacks genuine innovation capabilities. Regardless of the growth in Chinese performance in published and patented science as a signal of upstream explorative capabilities, and despite China being ranked as second in the world after the USA in scientific publications (Nature, 2017) and patent applications (WB, 2018), it has been observed that the transformation of national science into economic products is an issue that needs to be addressed. Implicitly, these observations refer to a paradox, which is similar to that of the European paradox. The European paradox refers to the comparative advantages of these economies in terms of their explorative and scientific discoveries and exploitative disadvantages in economic exploitation *vis-à-vis* the US institutional structure and performance (Dosi *et al.*, 2006). Thus, if the empirical evidence supports this phenomenon, then Chinese state entrepreneurship compared to US liberal market entrepreneurship forms a “Chinese Paradox”.

However, the Chinese Paradox addresses the missing links between national science and technology on explorative–exploitative paths. The Chinese economy has performed better in high-technology exports than many liberal economies. It has also outperformed some liberal economies in various other sectors. These patterns of socioeconomic institutions, production systems and the transformation of knowledge into artifacts are symbols of developed economies (Pavitt, 1998). Then, the Chinese Paradox focuses on a different comparative question. Is the state entrepreneurship of China behind liberal market entrepreneurship in the transformation of national science into economic products?

The question addressed in this paper follows the institutional perspective and focuses on the Chinese Paradox. First, it deals with the comparative position of Chinese institutions in the transformation of national science into technology *vis-à-vis* liberal economies (Ahlstrom *et al.*, 2018). Thus, it compares the entrepreneurship in China with that in OECD economies and liberal economies. Second, it compares the system in China with liberal market entrepreneurship in the USA in terms of the transformation of national science into technology. This is logical because the USA leads both liberal economies and developed economies outside the liberal category. Recently, China emerged as a system that is challenging the liberal perspective (Li *et al.*, 2015). These steps in the analysis of the Chinese versus the US entrepreneurial system have several merits.

First, Chinese published science and patented science have reached quality and quantity levels comparable to any other OECD economy (Freeman and Huang, 2014). Second, as a state entrepreneurship system (Block, 2008; Duckett, 1996), the Chinese innovation system fits with mixed market economies. The literature on these economies has shown that such economies lag behind others because of their incoherent institutional structure (Hall and Soskice, 2001). This

incoherence has also triggered some suggestions that the National Innovation System (NIS) lacks the power to explain the state entrepreneurship of China (Fuller, 2009). This implies that the Chinese entrepreneurial state is responsible for incoherent institutions and radical innovation.

However, recent evidence shows that China's economy has shifted from incremental to radical innovation at the explorative stage and exploitative stage in the value chains of some sectors (Malik, 2018). Analysts and writers often forget the patterns in the transformation of published versus patented science to technological products. The Chinese state entrepreneurial system supports universities and firms. Universities generate published science and firms generate patents. Published science follows the principles of inclusivity, whereas patented science follows the principles of exclusivity. In China, both paths conform to the Chinese state entrepreneurship system. As different levels of the national innovation system offer better research design and analysis of vertical technology transfer (Ahlstrom *et al.*, 2018; Fagerberg, 1994; Mowery *et al.*, 2010), the state versus liberal entrepreneurship framework can assist with the analysis and interpretation of the institutional spectrum.

On the right side of the institutional spectrum, the liberal entrepreneurship of the USA operates through market mechanisms and on the left side lies the Chinese entrepreneurial state. The proponents of the right position favor the market mechanisms that have had an enduring influence on liberal markets for many decades (Friedman, 1962). The liberal market has been less flexible and has resisted the role of state entrepreneurship in the sciences. Proponents on the left favor the entrepreneurial state to balance the gaps in market institutions and the needs of context-specific contingencies (Block, 2008; Polanyi, 1944). Although several economies in the world conform to the liberal institutions of the US innovation system and the state entrepreneurship of the Chinese system, these two economies typify liberal versus mixed entrepreneurship. Yet, whether and how they differ in the transformation of national science rests in the framework.

Framework

The institutional framework follows a major and minor complementary institutional configuration across various levels of space and time. Because of the different temporal and spatial histories and events, these institutional systems differ between nations and groups of nations vertically and horizontally. They differ vertically at various levels of analysis. The highest level on the vertical line tends to be stable and enduring because of path-dependent rules and norms that shape the actors' behaviors in the institutional system (Hollingsworth, 2003). The lowest level on the vertical line aligns with practical institutional arrangements under changing scripts (Campbell, 2004). Therefore, the middle part of the institutional interaction on the vertical line varies in structure and dynamics across nations, sectors, organizations and performance. Table I shows a brief framework adopted from the literature that is attributed to the vertical and horizontal linkages within national institutions.

Horizontally, the institutional configuration shows subtle differences between national economies. Liberal institutions support market mechanisms to govern economies, and mixed market institutions support interdependence between the market and interorganizational interaction (Hall and Soskice, 2001). Similarly, the national institutional influence within the same sector shows various practices (Malik, 2018). Chinese state entrepreneurship and US liberal entrepreneurship reflect opposite poles on the spectrum. Because of these institutional differences within the same sector or sectoral differences within the same institution, variegated interpretative decisions for the technical and social values are often generated. In particular, the temporal meaning can differ between institutional contexts based on industrial value chains, business decisions and actions

(March, 1999). Thus, the interactions among national institutions shapes the national innovation system, and the contrast between the signals of economies shows variety in knowledge exploration and exploitation (Fagerberg, 1994; Mowery *et al.*, 2010).

The NIS perspective for comparative analysis deviates from conventional economic assumptions. First, the NIS addresses the interacting parties that engage in the innovation process and their linkages. For instance, the university–industry–government linkage simultaneously interacts in multiple forms. Unlike the linear shapes of institutional roles, these interactive structures imply complex forms. Second, the NIS perspective has a broader approach (Freeman, 2004; Mowery *et al.*, 2010). The broader approach to institutional structure implies that the actors follow multiple logics rather than a single logic of profit orientation and process efficiencies. The NIS framework promotes an institutional perspective that goes beyond these rational, economic and technological contingencies (Hollingsworth, 2003). Therefore, the NIS can better explain why national technological trajectories differ across national economies (Pavitt, 1998).

The explanatory scope of national innovation systems depends on the components and complex relationships among symbols, people, products and systems (Dosi *et al.*, 2006). Each of these elements varies in shape, form and structural mechanism, which reinforces the diversity of the path and performance. For instance, macro-level institutions in the hierarchy seek feedback from micro level institutions in practice and performance (Campbell, 2004; Hollingsworth, 2003). National institutions shape the frame and value of organizational decisions. Sometimes economies share similar institutions but differ in micro-practices, whereas other times they share micro-practices but differ in macro principles. As a result, the explorative and exploitative performances are certain to differ across national institutions.

Another perspective of the national institutional analysis alludes to multiple types of performance across the innovation value chain, i.e. explorative versus exploitative outcomes. The NIS framework suits national publications, patents, machinery, equipment and high-technology exports (OECD, 1997, p. 7). Therefore, the “national level may be the most relevant due to the role of country-specific interactions in creating a climate for innovation” (OECD, 1997, p. 8). The current argument rests on the contrast between the vertical level and the horizontal level of interinstitutional analysis in line with the national innovation system. Based on OECD countries (liberal, coordinated and mixed types of capitalism) in the different capitalism literature (Hall and Soskice, 2001; Malik, 2017), we introduce the Chinese state entrepreneurship *vis-à-vis* the US liberal market entrepreneurship to understand its effectiveness in transforming national science into economic products.

Components	Constituents
Institutions:	Norms, rules, conventions, habits and values
Institutional arrangements:	Markets, states, corporate hierarchies, networks, associations and communities
Institutional sectors:	Financial system, system of education, business system, system of research and social system of production
Organizations:	Private and public, state and non-state and universities and firms ^a
Outputs and performance	Statutes, administrative decisions, the quantity and quality of industrial products and sectoral and societal performance

Sources: Hollingsworth (2003, p. 131); added to the original^a

Table I.
Components of
institutional analysis

Chinese institutions and innovation

Chinese state entrepreneurship drives innovation through the supply side, and liberal entrepreneurship drives innovation through the market demand side. The supply side of entrepreneurship indicates that Chinese state entrepreneurship influences policy and strategy in the development of science, technology and innovation (Fagerberg, 1994; Freeman, 2004; Mowery *et al.*, 2010). Unlike market economies, where organizational actors seek economic development, state entrepreneurship seeks socioeconomic development. These paths are developed from the regularized patterns of history, and in turn, they support a vision of the future and coping capabilities to deal with uncertainty (DiMaggio and Powell, 1983; Hollingsworth, 2003). Where the liberal system focuses on the growth and profit maximization of entrepreneurs, the state entrepreneurship system focuses on the integrated values of the social system. The liberal entrepreneurship system has had an enduring influence on research and practice in economics and business studies since its inception (Friedman, 1962). The state entrepreneurial system, which is rooted in the “great transformation” (Polanyi, 1944), has resurfaced in recent years after a period of hibernation (Block, 2008; Duckett, 1996).

Table II shows the contrast between the two types of institutional entrepreneurship and configurations in line with the framework (Hollingsworth, 2003). This background context of the Chinese versus US institutions projects national, sectoral and production system-level differences.

Compared to the US liberal system, the Chinese state entrepreneurship system matches the characteristics of a mixed system because it has a set of diversified institutional components at a higher level and at a subsystem level. In addition, it shares parts of the liberal system, the coordinated system and Chinese characteristics. The local system, which is associated with its culture, history, procedures and structures, dominates in some parts of the policies on the top and in practice in the field. The Chinese state entrepreneurship system’s policies and practices show that it strives to catch up with developed economies (similar to many emerging economies) (Pavitt, 1998). At the same time, China has surpassed some OECD countries in its published and patented science, except for the USA. Regarding the transformation of national science into products, relevance mechanisms have been established to support the process. For instance, policies for the high-technology sector, induced state-funded R&D and uncertain management techniques reflect China’s efforts to catch up with developed economies.

Nevertheless, and as noted earlier, the assessment of Chinese entrepreneurial performance in the existing literature alludes to the paradox of the linkages between science and technology. A natural question is in regard to the origin of the confusion for scholars at the conceptual level of institutional and technological contingencies. Here, the technological contingencies refer to the problems that define institutions; thus, the technological contingencies precede the institutional configuration. In contrast, the institutional contingencies refer to the preexisting historical paths of institutional configuration. The focus on technological contingencies rests on explorative science and exploitative analytical tools to explain economic performance. The institutional contingencies focus on the liberal versus other types of capitalism to explain innovation and economic development. The institutional framework in this study rests on the interaction and coevolution between institutional and technological contingencies.

This diversity explains the codified science in publications or patents as repertoires of national knowledge. Their transformation toward the exploitive direction depends on the configuration, incentives and broader institutional norms and rules for the transformation and processes at the functional stage (Fagerberg, 1994; Freeman, 2004; Pavitt, 1998). In other

				Chinese comparative advantage
Concepts and indicators	China	The USA	Ratio	
<i>Institutional arrangements</i>			China/the USA	555
Capitalism type	State entrepreneurship	Private entrepreneurship		
Capital and judicial discretion	Abstractness	Concreteness		
Female legislators	24%	20.7%	1.2	
PhD	31%	6%	5.2	
Master's degree legislators	100%	16%	6.3	
Political/politics	17%	31%	0.5	
Economy/business	21%	29%	0.7	
Law	14%	27%	0.5	
<i>Education system</i>				
Education financing	Public	Private		Table II. Components of institutional analysis
Literacy	96.4%	86% ^a	1.1	
Skills distribution	Even	Variant		
English language	Chinese 10 million	English 276 million	0.04	
<i>Social/Business system</i>				
Ease of doing business-2017	78	6	13.0	
Start-up procedures	7	6	1.2	
Enforcing contract days	496	420	1.2	
Capital-listed-domestic % GDP	215.24	241.90	0.9	
Legal rights (1-12 strength)	4	11	0.4	
Risk-taker enterprises	State-owned	Private-owned		
<i>Financial system</i>				
Banks branches (10,000 adults)	8.8	32.7	0.3	
Finance sector credit % GDP	215.24	241.90	0.9	
Bank capital/asset ratio-2017	7.4	11.7	0.6	
<i>System of research</i>				
R&D % GDP-2014	2.02%	2.79%	0.7	
R&D % GDP-2014	\$22.02 billion	\$40 billion	0.6	
Researchers/million	1113	4231	0.3	
Scientific publications-2016	426,165	408,985	1.0	
Design applications-2016	631,949	24,430	25.9	
<i>Foreign Integration</i>				
Net migration-2017	-1,624,595	4,500,000	-0.4	
FDI net % GDP-2017	1.4%	1.5%	0.9	
OFDI % GDP-2017	0.8%	22%	0.0	
High-tech % exports-2016	20%	25%	0.8	
Sources: Direct and indirect proxies, Official websites, World Bank, Literature and the World Atlas ^a				

words, the actors, structures and meanings differ for different institutions and economic actions. For instance, universities produce knowledge and firms exploit it for the economic value. Similarly, small high-technology firms explore knowledge and large development firms exploit it for commercial purposes. This explorative and exploitative duality appears to be free from the state's engagement in liberal economies but is interdependent with the state in Chinese institutions. In China, the explorative–exploitative duality appears distal in the context of university–industry relationships and the relationships of supplier–buyer firms. Chinese state entrepreneurship links supply and demand and is more focused on the former than the latter.

However, despite an increase in the development of national science in China, some observers have raised flags regarding the Chinese dilemma. For instance, according to a “Testimony before the US-China Economic and Security Review Commission,” Chinese R&D has grown and its national talent has grown, but millions who graduate in science and engineering leave every year even though China has ample equipment and modern laboratories. Therefore, “one might then ask, so what is wrong? What’s not working? What is the problem?” (Simon, 2012). Such observations in the Western literature reflect part of the dilemma. Although this observation lacks evidence and it ignores the productivity of the Chinese system in the downstream, it adds to the explorative–exploitative capability question.

Table III offers an analytical tool to analyze the explorative and exploitative capabilities of China and the USA. The topology shows national science output in the rows and commercial products in the columns. Science generation occurs in the upstream, and the exploitation of science for commercial products occurs in the downstream. The national scientific output has two components: the first part consists of publications and the second part consists of patents. To complement this topology, Appendix 1 shows the input of national science in publications and patents across countries, which shows different paths. Regarding national published and patented science, China leads most of the OECD economies. China’s performance in publications and patents has caught up with the level of US science. Some analysts predicted this point to be reached in a decade (Li *et al.*, 2015), but evidence shows such trends occurring earlier. Moreover, compared to the USA, China shows diverse trends in institutional configuration and scientific performance.

At the global interaction level, China has integrated its international supply chain through foreign direct investment both inward and outward. As the early 1990s, foreign enterprises across sectors have entered into the Chinese market, and those early entrants have benefited from the turmoil of the financial crises (Malik, 2012). Looking toward the future, China has set its policies for further global integration through the one-belt-one-road (OBOR) project, which indicates that Chinese institutions will partially converge with global institutions because of the inward influence, and China will partially influence this convergence through its outward influence. Thus, the entrepreneurial state shows a divergence from other national innovation systems in interdisciplinary analysis.

The argument of interdisciplinary institutional integration explains the difference in liberal versus state entrepreneurship. The US innovation policy starts with industry and aligns universities (and vice versa). In other words, university–industry interactions and the transactions of knowledge have moved closer to one another (Rosenberg and Nelson, 1994). These liberal market systems focus on technical logic and aligning resources with production to improve productivity. The role of policy institutions has a limited role in practice. The

Economic products (exploitative)		
	High	Low
Science in publications and science in patents (explorative)		
High	Explorative and exploitative	Explorative > exploitative
Low	Explorative < exploitative	Neither explorative/ exploitative

Table III.
Explorative–
exploitative topology

Notes: Q1: ambidextrous; Q2: upstream; Q3: downstream; Q4: neither

Chinese entrepreneurship system shares some of these technical contingencies. For instance, the Chinese university–industry interaction partially emulates these patterns at various levels. State entrepreneurship influences the coordination, cooperation, competition and vertical configuration of institutional structures across space and time. However, Chinese policy institutions play a role at the practice level for setting socioeconomic goals, aligning resources and shaping action in the explorative–exploitative duality.

Unlike explorative and exploitative transactions through market mechanisms that occur in a linear fashion in the USA, the Chinese explorative and exploitative transactions develop vertically, horizontally and diagonally. Thus, the Chinese innovation system encourages interregional and interactions between state-owned enterprises compared to those in liberal systems. For instance, the network systems in the USA emerge from the market side of the spectrum, which leads to micro integration between suppliers and users in the USA (Powell *et al.*, 1996). In China, the supply side drives integration with the demand side of national science at multiple levels. For instance, state policy has created multiple science parks in major regions in China, and within these parks, state-owned and private institutions from the supply side and demand side interact. These differences show linear versus network systems of institutions and innovation.

Liberal and state entrepreneurship differs in the vertical, i.e. explorative versus exploitative stages, in science and technology linkages. The liberal system tends to be more linear than the state entrepreneurial system; for instance, there is a long history of the supply of science and the demand for products organized on a linear value chain. The Bay-Dole Act of the 1980s narrowed the distance between buyers and sellers of knowledge, which reduced the scope and indirect flow of science to other sectors. State entrepreneurship and its diverse institutional systems suggest cross-pollination between public and private, national and international and science and technology institutions. Although the USA has cross-pollinated the interaction of multidisciplinary institutions from the R&D side and the exploitation side (Mowery *et al.*, 2010), China's university–industry interactions occur in a narrow scope and then lead into the broader scope. In short, if the Chinese Paradox persists, it appears in the vertical transformation of published and patented science in response to propositions.

Propositions

The topology in Table III shows explorative science in the upstream and exploitative technologies in the downstream. Ideally, an efficient and effective national science and technology system needs to achieve ambidextrous quality based on both strength in explorative and exploitative capabilities. Typically, the US economy meets this duality in Q1 in the topology. It shows strength in science and its commercialization compared to the European economies that create the European Paradox (Dosi *et al.*, 2006). According to the European Paradox, OECD Europe shows strength in the explorative side of the dilemma and weakness on the exploitative side. For instance, coordinated economies meet this criterion in Q3. Outside the explorative and exploitative stream, most developing countries fall into the Q4 category. The Chinese innovation system is both partially explorative and exploitative, i.e. it shows both capabilities. When China joined the trade-related aspects of intellectual property rights agreement in 1994, it adopted the intellectual property rights standards. Since then, the World Bank shows that its comparable data on science and innovation has been rising at a steady speed and rate (WB, 2018). Then, the empirical question is whether Chinese state entrepreneurship has a disadvantage compared to the developed economies of liberal markets.

The extant literature affirms this proposition of a Chinese comparative disadvantage; we expected to see a Chinese comparative advantage in the best case and a mixed advantage in

the worst case. Our analysis captures the comparative merits and demerits at two levels. First, it deals with the interinstitutional analysis. Second, it deals with inter-capitalism analysis. The interinstitutional comparison explicates the comparative disadvantage of the Chinese state entrepreneurship based on the economies of the OECD countries. The inter-capitalism literature explains that Chinese state entrepreneurship has a disadvantage compared to liberal, coordinated or mixed systems in the OECD membership. Furthermore, the interinstitutional and inter-capitalism analyses further divide the national science output into two paths: published science and patented science. The disintegration of science into the two paths should elucidate the Chinese science growth dilemma.

P1. China's transformation of science into products is likely at a comparative disadvantage to OECD economies.

P2. China's transformation of patents into products is likely at a comparative disadvantage to OECD economies.

The inter-capitalism view emphasizes the integrated level of the institutional analysis. The preceding comparison of China to OECD countries occurred at the national level. In the following section, China is placed in the state entrepreneurship category of capitalism with liberal and coordinated systems because of the inherent configuration of its institutions (Hall and Soskice, 2001). This literature on institutional coherence argues that without the advantages of liberal or coordinated configuration logic, the explorative knowledge in science and patents fails to translate into exploitative knowledge in economic products (Hall and Soskice, 2001). For instance, the literature and popular assumptions expect that mixed market economy (MMEs), such as that in China and that deflect the liberal market and coordinated systems, will have a comparative disadvantage in the innovation performance aspect. Thus, the following creates a contrast between the liberal and state economy.

P3. China's transformation of science into products is likely at a comparative disadvantage to liberal economies.

Research on innovation policy and performance argues that national patents serve as a reliable measure of national innovation performance (Dosi *et al.*, 2006; Smith, 1992). Like OECD economies, Chinese entrepreneurship promotes patented science, its transformation and aggregated databases to meet global measurement standards. These principles and practices make Chinese patents comparable with OECD economies, and within these economies, it draws a contrast with liberal, coordinated and mixed economies. Then, the empirical question returns to the comparative disadvantage of the mixed economy of Chinese state entrepreneurship. Does China's mixed economy lag behind OECD economies in the creation and transformation of national published and patented science?

Prior literature affirms that the Chinese entrepreneurship system lacks the right combination of required quantity and quality of institutions to transform national patents into radical innovation. After all, only liberal or coordinated economies transform national science into national products (the liberal economies align more with the radical side and the coordinated path more with the incremental side) (Hall and Soskice, 2001). As China falls into the incoherent category, it lags in the production of science (patented) and transformation into innovation projects for economic performance:

P4. China's transformation of patents into products is likely at a comparative disadvantage compared to liberal economies.

[Appendix 1](#) displays the visual links between national published and patented science on the left side and economic performance on the right side. The links between the two sides predict institutional explorative and exploitative roles for the transformation of science into technology. The appendix streamlines the methods section for empirical data.

Methods

Sample and data sources

We used 29 OECD economies and compared them with China at two levels, i.e. the interinstitutional level (types of capitalism) and the interdisciplinary level (published and patented sciences). We used several sources for the database. First, the bulk of the data came from the World Bank ([World Bank, 2018](#)), which provides reliable and commensurable data on related indicators. For instance, scientific articles, national patents and high-technology exports measure the explorative and exploitative performance of the national innovation system ([Pavitt, 1998](#)). These high-technology exports and their scientific bases also reflect the science growth dilemma for OECD countries ([Dosi et al., 2006](#)), and there is a similar dilemma for the Chinese innovation system. As national institutions support the link between national science and high-technology exports as economic products ([Dosi et al., 2006](#)), these data measures sufficiently support our analysis in the panel data.

The panel data spans 23 years (1993 to 2015) and includes 30 groups. This focus period is relevant to the question because it coincides with medium- and long-term planning for innovation in China. After China joined the World Trade Organization in 1995 (following earlier negotiations), state entrepreneurship entered a new era of high-technology sectoral development. In parallel, information technology has played a dual role. On the one hand, it emerged as a focal sector in the innovation system of China. On the other hand, it facilitated the gathering and storing of reliable data for analysis by the World Bank. Together, the academic research benefits from these parallel developments occurred during this period.

Variables

Dependent variable. The main dependent variable measures high-technology exports as a percentage of total manufactured exports. The [World Bank \(2018\)](#) refers to high-technology products as those with a high R&D intensity (aerospace, computers, pharmaceuticals, scientific instruments and electrical machinery). This definition conforms to the exploitative performance measures in the academic literature in national innovation system research ([Smith, 1992](#)) and comparative institutional capitalism studies ([Hollingsworth, 2003](#); [Malik, 2017](#)).

Independent variables. We used two sets of independent variables for the critical analysis. The first set shows binaries of the national economies of OECD countries plus China. Then, it shows three types of capitalism (liberal market economy, coordinated market economy and MMEs) as composite variables. Chinese entrepreneurship is the fourth category for comparison in this set. The second set of independent variables includes published science and patented science. The published science measures the number of publications over 23 years. Similarly, national patents show yearly patents at the national level over 23 years. The interaction between the science variables and the four categories produces four interaction variables each for published and patented science.

Modeling and analysis

The panel data, which includes 23 years and 30 countries, have an advantage over conventional measures of cross-sectional studies, and most prior studies relied on cross-sectional data. From the institutional perspective, the panel data analysis better serves the

purpose of understanding the institutional role of the transformation of policies into practices through innovation activities for economic development (Campbell, 2004). In line with this view, we applied two types of supplementary analysis for the panel data analysis. First, we used random effects and fixed effects in the different models in the analysis. The Hausman test is suitable for regulating the preference for the fixed effect when the null hypothesis shows a significant difference. Otherwise ($p > 0.05$), a random effects model suits the analysis. Based on this statistical theory, we followed fixed or random effects models:

$$Y_{it} = c + X_{it}'\alpha + \delta_t + \delta_i + \varepsilon_{it}$$

Y_{it} = dependent variable;

c = constant;

X_{it} = a vector of the independent variable;

α , = interested parameters;

δ_t = a vector of the time dummies;

δ_i = a vector of the individual dummies; and

ε_{it} = error term.

Results

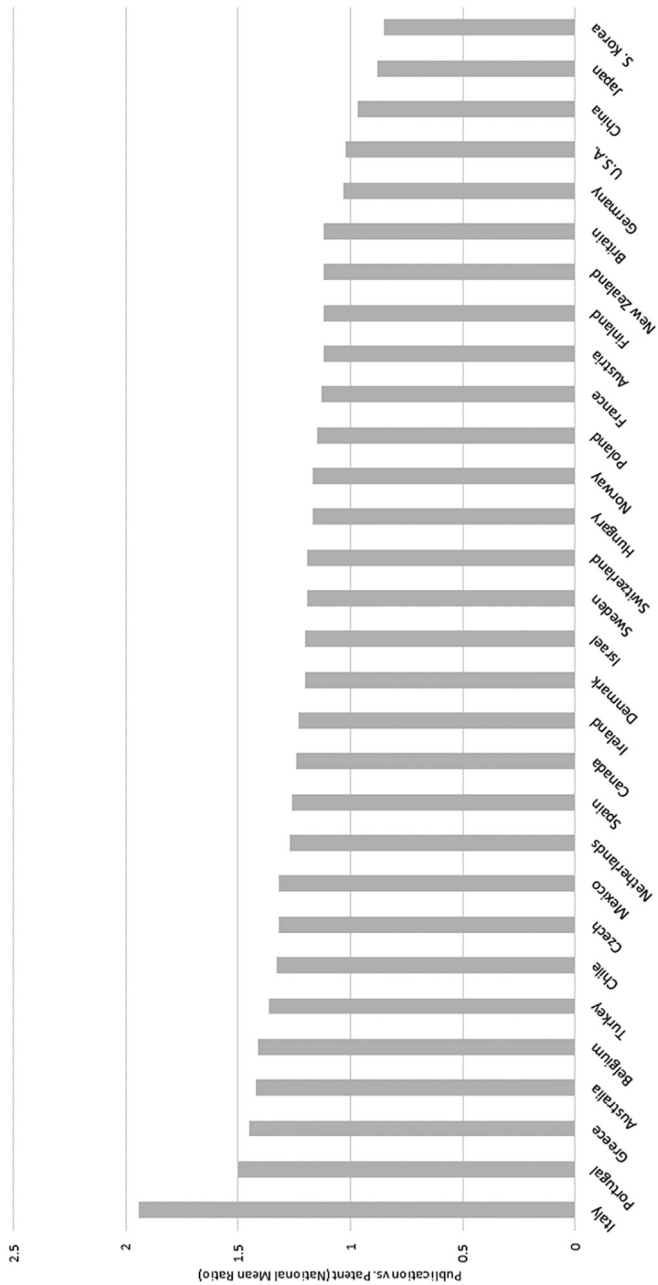
Figure 1 shows the ratio between the published and patented national science of the sampled entrepreneurial economies of OECD countries and China as the comparative category. Most OECD countries from the West show a higher proportion of published science than patented science (ratio > 1). However, *China* and two Asian OECD countries (*Korea and Japan*) show the opposite (ratio < 1), which indicates that their patents outpace their publications. China, Korea and Japan produce more patents than scientific publications compared to their western counterparts.

Figure 2 shows comparative publications (China vs the USA) from 1996 to 2017. Two patterns are distinct in these competing systems. First, the USA leads in publication counts despite its smaller size in population. Second, Chinese growth in published science has rapidly increased to catch up with the US level. In some disciplines, China has surpassed published science in the USA. Overall, China is second in regard to the amount of published science in the world.

Figure 3 shows resident patent applications in China versus the USA. The pattern shows that China has long surpassed the USA in yearly patent application counts. After approximately 2009, the Chinese trend shows an upward trajectory, and the US trend shows a stable trajectory until 2016. In patented science, China has also shown gains and has surpassed OECD countries.

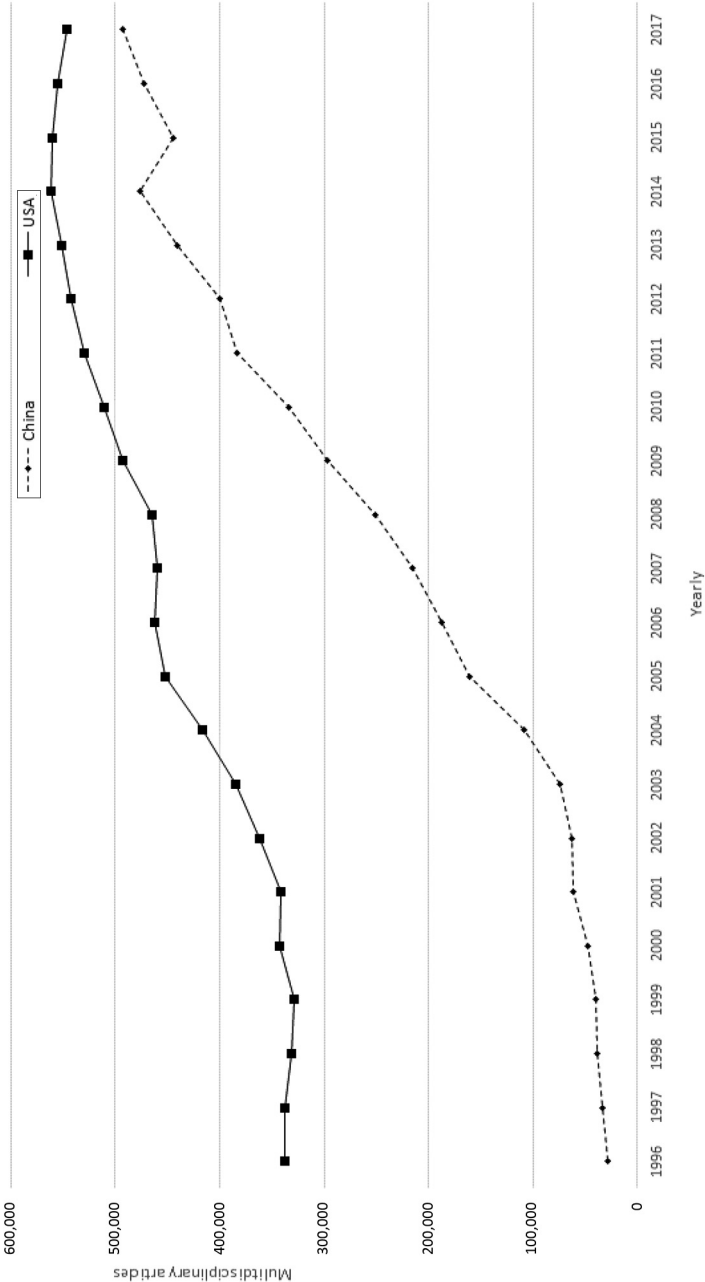
Figure 4 shows patents and design applications of China alone for a good reason. A general view in the academic and popular literature implies that Chinese patents tend to reflect design and process-oriented preferences compared to new product-oriented preferences. The design and process patents often align with incremental innovation. The patent versus design application comparison shows that after 2012, Chinese patents have continued an upward trajectory, and Chinese design patent applications show a downward trend. Therefore, the latter part of the temporal line and patent types shows trends toward quantity and quality.

Figure 5 shows the high-technology exports of China versus the USA. This figure shows three distinctive parts as follows: before the Financial Crisis of 2007, during the crisis (2007 to 2009) and after the crisis. Before the 2007 economic crisis, Chinese high-technology exports showed an upward trajectory and a path toward the top position. During the crisis,



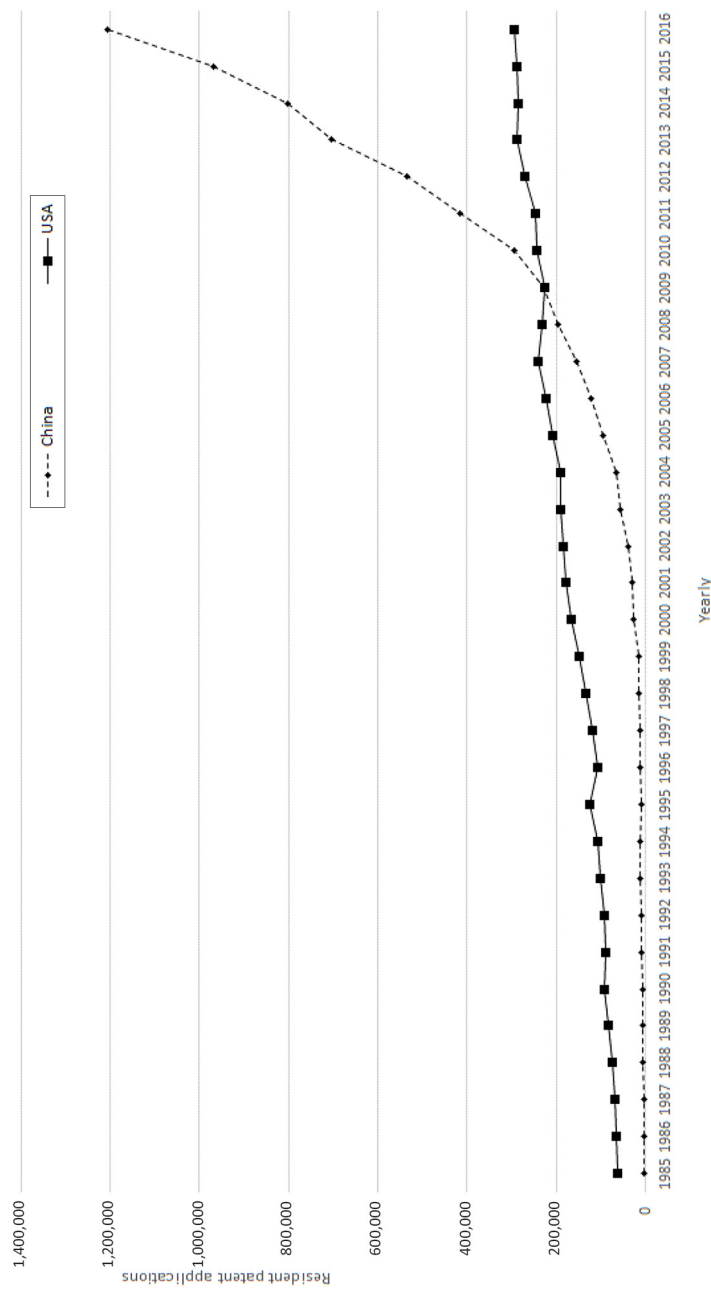
Sources: World Bank: Japan, Korea and China (article/patents < 1)

Figure 1.
Published vs patented science nations (ratio of means)



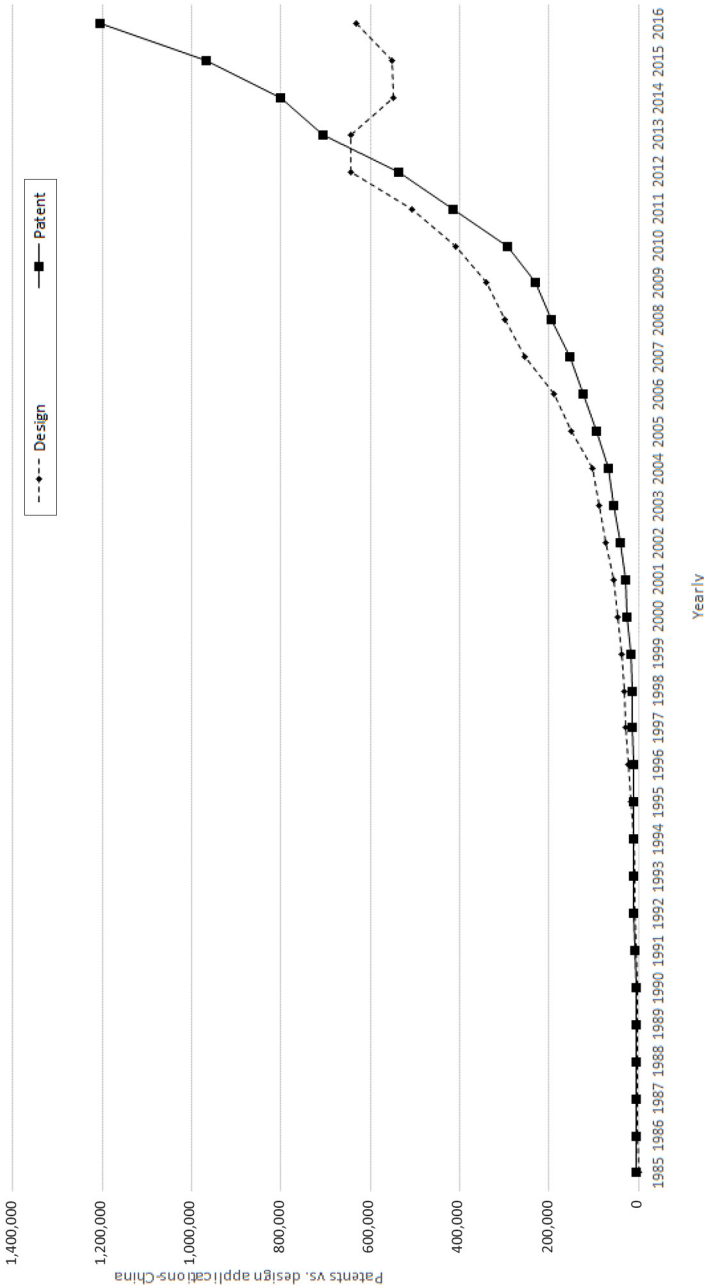
Source: Scimago Journal and Country Ranking; available at: www.scimagojr.com

Figure 2.
The number of
Chinese vs US Citable
National Publications



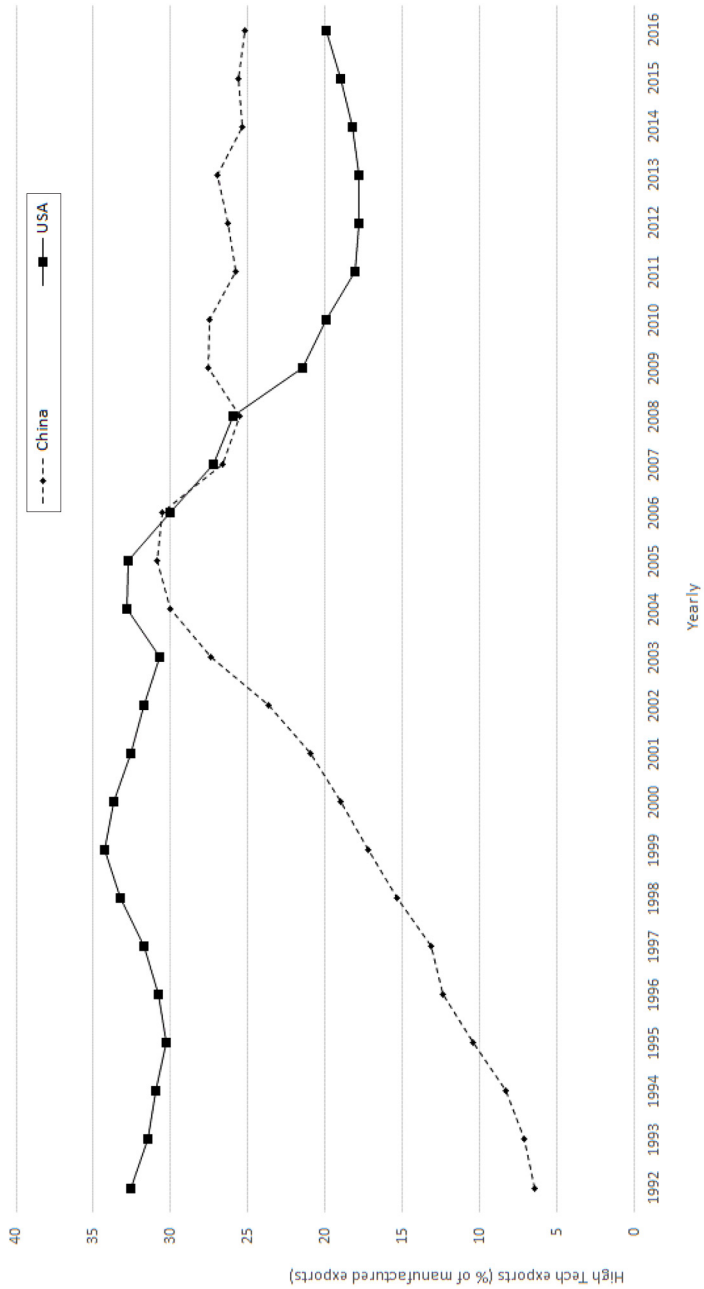
Source: World Bank

Figure 3.
Resident patent applications: China vs the USA



Source: World Bank

Figure 4.
Resident patents vs
design applications:
China



Source: World Bank

Figure 5.
High-technology
exports (per cent of
manufactured
exports)

both economies behaved similarly for high-technology exports because of the global integration of innovation value chains. After the crisis, China surpassed the USA in its high-technology exports and showed stable patterns until 2016. On average, the USA increased by approximately 22.4 per cent and China by approximately 27.5 per cent.

To test the main proposition of the interinstitutional comparison, Table IV shows a preview of the regression results. This shows three sets of findings in two panels, i.e. the upper panel for published science and the lower panel for patented science. China has a comparative advantage, disadvantage and indifference compared to these OECD economies. In the upper panel, the published science becomes the main predictor, and patented science becomes a control variable. The lower panel shows the opposite of the two types of codified knowledge. As China refers to the base category in this analysis, the positive (+) coefficients of OECD countries imply a Chinese comparative disadvantage, and the negative sign (–) shows a Chinese advantage ($p < 0.05$).

To support the main proposition, we show the results in Table V. The results show Chinese state entrepreneurship with liberal economies in the transformation of published and patented science in the upper and lower panels, respectively. In the published science, different time-lags show different results. In the one-year lag, Chinese state entrepreneurship shows a comparative disadvantage compared to liberal market entrepreneurship in the transformation of national science to economic products. However, in the three-year lag, Chinese institutions have a comparative advantage to liberal economies in the transformation of published science. Thus, in the panel analysis, Chinese state entrepreneurship outperforms liberal economies in explorative and exploitative capabilities beyond two years.

Conversely, China has a comparative disadvantage to liberal economies in the transformation of patented science. This disadvantage of Chinese state entrepreneurship to liberal entrepreneurship persists for the one-year lag through the three-year lag. Regarding the coordinated economies or mixed economies in the OECD countries, Chinese published science and patented science shows similar patterns in the explorative productivity and exploitative performance through vertical knowledge transformation. Although the Chinese innovation system has performed comparatively better in the exploration and exploitation of national science and it shows mixed support for the main hypothesis, the evidence reveals subtle surprises.

First, multiple figures show proportionally more patents than publications in China. Second, the transformation of published science outweighs the patented science in China. Third, the transformation of published science comparatively shifts in the one-year lag, but

Table IV.
Chinese versus
OECD
entrepreneurial
institutions

Tests/constructs	China has a comparative advantage	China has a comparative disadvantage	China is like OECD members
P1. The transformation of national science to hi-tech exports	AU, CL, IT, JP, PO, TR	AT, BE, CA, CZ, DE, DK, FI, FR, GR, HU, IE, IL, KR, MX, NL, NO, SE, SW, CH, UK	PT, NZ, US
P2. The transformation of national patents to hi-tech exports	AU, BE, CA, CL, DE, IT, GR, NZ, PO, PT, SE, TR	DK, FI, FR, HU, IE, IL, KR, MX, NL, NO, CH, UK	AT, CZ, JP, SW, US

					Chinese comparative advantage
Variables	β 0-lag	β 1-lag	β 2-lag	β 3-lag	
Constant	2.99 (0.06)***	3.05 (0.05)***	3.10 (0.05)***	3.14 (0.05)***	567
National dummies	Entered	Entered	Entered	Entered	
Articles-liberal	0.18 (0.03)***	−0.23 (0.05)***	−0.27 (0.05)***	−0.29 (0.05)***	
Articles-coordinated	0.06 (0.05)	0.01 (0.05)	−0.02 (0.05)	−0.06 (0.05)	
Articles-mixed	0.13 (0.02)***	0.10 (0.02)***	0.06 (0.02)***	0.02 (0.02)	
Patent-liberal	0.00 (0.00)***	0.00 (0.00)*	0.00 (0.00)**	0.00 (0.00)**	
Patent-coordinated	0.00 (0.00)**	0.00 (0.00)**	0.00 (0.00)**	0.00 (00)	
Patent-mixed	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	
CNIS	Default	Default	Default	Default	
F-statistic	3,864***	4,584***	4,643***	4,940***	
R-square	0.87	0.888	0.889	0.90	Table V. State versus liberal entrepreneurship
DOF	35	35	35	35	
N	613	612	611	583	
Notes: Dependent variable = high-tech exports per cent of GDP; CNIS = Chinese National Innovation System; *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$					

the lag time shows no effect on patent transformation. Thus, the dilemma appears to favor the population patents and the transformation of publications.

Discussion

We explored the science growth dilemma in China and asked whether the Chinese economy has a comparative disadvantage compared to liberal economies in the transformation of national science output into economic products. In the analysis, national scientific output has two components. One part shows the national science output published in scientific and engineering articles, and the other part shows the national science output in patented technology. Two levels of results answer this question from the panel data for 20 OECD economies and the Chinese economy. The first level compares China's comparative position against the individual economies of the OECD. The second level compares Chinese state entrepreneurship with the liberal entrepreneurship system. At both levels of analysis, the literature-based (Dosi *et al.*, 2006; Hollingsworth, 2003; Malik, 2017) transformation of national science to exploitative products sets the assessment criteria.

Interinstitutional dyads

The interinstitutional dyadic comparison refers to the inter-country analysis of the Chinese comparative position in the transformation of published and patented science into artifacts. A preview from this analysis (Table IV) reveals a mixture of comparative advantage, disadvantage and parity with the 29 OECD economies in published and patented science transformation. Chinese parity with US performance in published and patented science appears in the last column in the upper and lower panels in this review. In short, the Chinese system has a comparative advantage compared to 6 economies, a disadvantage compared to 20 economies and parity with 3 economies in the transformation of published science. In patented science, it has a comparative advantage with 12 countries, a disadvantage compared to 12 countries and parity with 5 countries. Hence, Chinese entrepreneurial performance resembles most liberal systems (the USA) in its performance.

Chinese comparison with the USA in the transformation of published science to high-technology exports merits attention because of its scope, diversity and radicalness

compared to Chinese patents. The transformation of national science (scientific articles) to high-technology exports captures the national system's radical innovation (Malik, 2017; Smith, 1992). The Chinese innovation system offers three signals for potential links between radical innovation and economic growth. First, China has outperformed its competitors in the codified knowledge in publications and patents. Second, this leads to high-technology exports (World Bank, 2018). Third, it has excelled in new product development in high-technology sectors at the national level. For instance, China leads in high-speed railway innovation, cancer gene therapy and golden rice production in the bio-agricultural field and has the world's fastest supercomputer. Thus, Chinese capitalism shows signs of success in the transformation of scientific discoveries into high-technology economic artifacts more than that realized in past research, especially in contrast to liberal markets' entrepreneurial systems.

Entrepreneurial state vs liberal market

In this analysis, entrepreneurship of the Chinese state shows a comparative advantage in published science and a disadvantage in patented science. In the former case, the transformation of published science into high-technology products in the one-year lag and Chinese performance outpaces the liberal market performance for the same measure. Conversely, in the latter case and for the transformation of patented knowledge into high-technology exports, the Chinese system underperforms compared to liberal economies. This comparative disadvantage of Chinese state entrepreneurship persists in the one-year, two-year and three-year lag periods. Prior literature predicted that the Chinese path of innovation could surpass the US level in innovation and entrepreneurship (Li et al., 2015). As the state versus market institutions symbolize two opposite poles on the theoretical spectrum, the question arises regarding why market institutions perform better based on patented science, whereas Chinese state entrepreneurship performs better based on published science.

Several contextualized reasons can be explained in the comparative study of China versus the USA. The literature on the institutional variety and mixed market economies (such as that of China) favors a framework of comparative entrepreneurship. Based on this comparative analysis (for a better understanding) (Ahlstrom et al., 2018), we draw several inferences. First, the decision-makers differ in their professional and technical knowledge. Chinese legislators hold doctoral and master's degrees, and they come from science/engineering disciplines approximately 25 times more than US legislators. In contrast, US legislators have training in political science and law approximately 3.7 times more than those in China. These disciplinary lenses influence the institutional development and direction setting through policies and practices in the two economies.

Second, education and business systems differ in China and the USA. This is especially true in the global business language; the use of English offers advantages to the USA. In China, some 10 million people speak some English. Moreover, China almost has one language, i.e. Mandarin. The USA has the advantage of diverse languages beyond the English language. For instance, each of the top 10 languages spoken in the USA, other than English, has at least 1 million speakers. The aggregated population of these ten languages makes 10 million people. In China, 10 million people speak English as a single secondary language, whereas in the USA, 10 million people speak ten different languages. Another divergence between the two systems relates to the phrase "ease of doing business" (WB, 2018). US business processes are 13 times more competitive than those of the Chinese. Likewise, the strength of legal rights in the USA is 2.8 times more competitive than that of the Chinese. In addition, the national research systems play leading roles in the diverse

national innovation systems. The receipts and payments of intellectual property rights in the USA far exceed those in China (World Bank, 2018), which implies that the USA has a developed downstream market for intellectual products. The US system supports product patents compared to Chinese design patents. The Chinese design patents appear 26 times more than those of the USA. This indicates that the process and design patents complement the published science and product patents reflect themselves. The evidence shows that Chinese exports of information and communication technologies have exceeded those of the USA.

Why does China take longer than the USA to transform national science into economic products? We based our explanation on the institutional incentive structure. The liberal institutional structure induces pressure for efficiencies and short-term performance. For instance, management literature has consistently argued that enterprises in the US liberal market system pay attention to quarterly performance. In contrast, the state entrepreneurial innovation system focuses on a longer strategic duration. Another way to interpret these differences is through institutional differences. The US institutional system comes from the market competition perspective, and the Chinese entrepreneurial system comes from the structural perspective. Thus, the structure-strategy view in the case of the Chinese advantage and strategy-structure view in the case of the US advantage explains these differences. Together, institutional contingencies explain these variations in space and time (DiMaggio and Powell, 1983).

Compared to the institutional contingencies, the technological contingencies of science and technology offer competing explanations of the vertical and horizontal subsystems. First, national science partially focuses on explorative–exploitative interaction and transformation and the contingency of the published science tends to have a broader scope, which leads to a higher level of radicalness for new product development (Pavitt, 1998). Second, some of the explorative science ends in publications because of the national incentive structure. The application and development of patents require legal knowledge, a longer duration and a higher cost. Third, the published and patented sciences differ in inclusivity versus exclusivity perspectives. The published explorative science focuses on inclusive values, which stem from universities in China. Publications diffuse directly to the user. However, patent science focuses on exclusivity and most of these come from firms. The intense exclusivity hampers its transformation because of prohibitive costs and a lack of other incentives. For instance, a clinical trial in the pharmaceutical sector needs the firm to buy the rights to patent claims owned by multiple authors. Thus, the institutional configuration explains the differences and the associated parties of mixed institutional capitalism.

Contribution

This research contributes to the institutional diversity across economies at the first level and the diversity of the knowledge transformation path at the second level. In the first case, it supports the institutional plurality and competing or conflicting logics across institutional configurations vertically and horizontally. For instance, some institutions and their performances converge and other institutions and their performances diverge. These clues allude to the claim against the search for a single best way of a social system of production (Hollingsworth, 2003). State entrepreneurship outperforms liberal or coordinated systems in one or another paths and performance patterns.

Chinese state entrepreneurship shows the successful development of science, its transformation and socioeconomic development and refutes the idea of global isomorphism because of local contextual factors in policy and practice (Boyer, 2011; Hollingsworth, 2003).

Local factors based on norms and rules shape the actors' decisions, the structural forms of an organization and the definition of goals and value propositions. These contextual factors deflect the idea of isomorphism at two levels, i.e. the tension between the institutional bricolage versus translation (Campbell, 2004; Douglas, 1986). The institutional bricolage refers to the coevolution of local policies and practices in incremental processes (Campbell, 2004). Then, the combination between bricolage and translation induces an entirely new path of evolution. Thus, the local–global institutional interaction increases diversity rather than reducing it through institutional and technological contingencies.

Popularized roles of the entrepreneurial system in China highlight these patterns of institutional and social contingencies in several ways. First, “Socialism with Chinese characteristics” partakes an idiosyncratic innovation system; the policy makers set innovation targets and development goals without claiming to become liberal or coordinated economies. Second, the national system of innovation has shifted from the middle of the inverted U-shaped curve toward explorative R&D and developing the legitimacy of its products. The high-speed railway system serves as an example and the fastest supercomputer in the world serves as another. Because of this diverse combination of forms, shapes and structures in input and output, the institutions lead to nation-specific paths and productivity (Casper and Kettler, 2001; Malik, 2013), and the national technological contingencies influence these institutions. For instance, the Chinese national history, habits and health-specific problems attract innovation projects in the biomedical sector for explorative and exploitative purposes that show distinctive patterns (Malik, 2018). Thus, country comparisons reveal clear diversity in institutional versus technological contingencies and bricolage versus translation tension.

In short, by viewing the state entrepreneurial role in the national innovation system more broadly, it appears that Chinese institutions have contributed to socioeconomic development both nationally and internationally. For instance, nationally, the Chinese innovation system has achieved a literacy level of 96 per cent versus less than 90 per cent in the USA. China has improved its health-care coverage for the general population compared to some OECD countries and is better than many others (Malik, 2018). It has developed a high-speed railway system of 22,000 km across the country to foster interregional integration. China has also increased the proportion of female legislators more than the USA and in some other countries. Internationally, the Chinese innovation system has improved interdependence rather than the dependence of some on others. Integrated into the global value chain, China played a role in stabilizing international systems after the crisis of 2007. Now OBOR projects serve as examples of these institutions and their emerging signs of potential value for international socioeconomic development. Therefore, state entrepreneurial systems based on a bricolage of institutions have their undeniable merits as alternatives and competing paths of development.

Conclusion and suggestions

In this study, we briefly recapture the main point and its relevance and limitations toward research and policy recommendations. First, this study discovered that Chinese state entrepreneurship offers an alternative type of national capitalism. At the macro level, the world has an alternative path compared to the liberal market for socioeconomic development. At the micro level, we focus the attention of future researchers on how sectors and organizations interact and transact knowledge for innovation. The analysis of micro-processes and the longer duration of the panel data will strengthen the Chinese position as a rising power in science and technology. Second, we conclude that China shows distinctive patterns in contrast to the USA in the lag time between scientific discoveries and

commercial products. In addition to the divergence between the two systems on science and technology development, this study offers fertile ground for the analysis of national science and environmental sustainability.

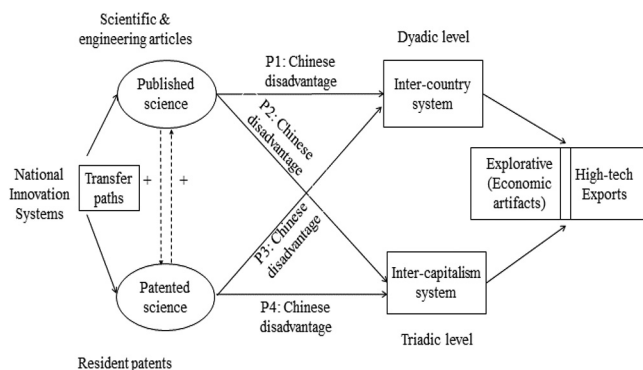
In short and based on the unambiguous evidence and findings, we expect that Chinese state entrepreneurship will attract the attention of public policies for two reasons. First, the alternative arguments that the pure market offers a panacea have lost its appeal as an ultimate solution to socioeconomic development. The world has changed with the changing nature of social awareness and innovative technologies. Second, the OBOR project will integrate east–west and north–south and leave little room for isolated economies. Thus, in the short term, the Chinese system faces questions; in the long turn, it appears to be on the right trajectory to lead and set standards for a greater part of the world.

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Appendix 1. Proposition model



Note: Dyadic = Country level comparison: Chinese vs OECD economies; Triadic = Capitalism level comparison: Chinese vs liberal, coordinated & mixed economies

Chinese
comparative
advantage

573

Figure A1.
Dyadic = country-
level comparison:
Chinese vs OECD
economies

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