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Abstract: The many innovations of the Chinese aerospace industry have been and are associated with pro-market policy since the 1980s. In this paper, we will discuss the activities of the Chinese state and its comparative advantage in judgemental decision making during uncertainty. By exploring how the Chinese state has handled entrepreneurial events over the decades, we will gain insight into the driving forces of re-combinative innovation in the aerospace industry.

Keywords: *pro-market policy, judgmental decision making, entrepreneurial crisis, entrepreneurial opportunity, aerospace innovation*

Introduction

China is a late entrant in the aerospace industry, which encompasses defense, aviation and space sectors and covers products including military and civilian aircrafts, satellites, space stations and rockets. America and Russia created historical legacies with the Wright Brothers' patent on the first flying machine and the Soviet space dog Laika's orbit around the earth respectively. Though it only entered the industry in the 1950s, the Chinese state has managed to make successive judgmental decisions that facilitated its aerospace conglomerates (AVIC, CASC, CASIC, COMAC) to pursue re-combinative innovation. Re-combinative innovation relates to firms that produce products with better performance on the basis of synthesizing existing innovation; examples include the Shenzhou spacecraft and the regional jet ARJ21. According to China's "Guidelines for the Medium- and Long-Term National Science and Technology Development Program (2006–2020)", the concept of re-combinative innovation or Zizhu Chuangxin is defined as the reassembling of existing technologies in different ways as to generate innovation as well as absorbing and upgrading of imported technology. In this paper, we will elaborate the entrepreneurial events that faced China since the pro-market

reform in the 1980s. Pro-market reforms relate to the elements of the Chinese economic reforms that enable former state-owned enterprises (SOEs) to accumulate market and technological knowledge and has been studied in the context of emerging economies (Cuervo-Cazurra and Dau, 2009; Dau, 2013). The significance of this paper is to provide a framework to elaborate judgmental decision making underlied the dramatic changes and subsequently accelerated the pace of Chinese aerospace innovation. We will employ a longitudinal industry case study investigation. Table 1 summarizes China's achievement by the mid-2010s.

Table 1: Chinese Aerospace Achievement in a Comparative Setting

	Missile Success	Satellite Success	Military/Commerical Aircraft success
USA	High	High	High
EU	High	High	High
Russia	High	High	High
China	High eg Ground-based midcourse defense system (GMD)	High eg Mobile telecoms satellite	High* eg 5th generation stealth fighter
India	Moderate	Moderate	Low
Brazil	Low	Low	High

Note: This was regarded as "Medium, rising" by Erickson and Goldstein. As China is currently undertaking the commercial aircraft C919 project, its position could be considered as 'High'.

Source: Based on Erickson and Goldstein (2011).

Entrepreneurial Events and Judgemental Decision Making

Entrepreneurial events are external, historical events that take place at certain conjecture of an industry's development, and could positively or negatively influence the development of the industry. Entrepreneurial event can be classified as entrepreneurial crisis or entrepreneurial opportunity; the former is an event that could hamper industrial growth while the latter relates to an event that could enhance growth. An example of entrepreneurial event that has kick-started the Chinese aerospace industry is US government's deportation of rocket scientist Qian Xuesen in 1956. Qian went to the Massachusetts Institute of Technology with a scholarship in 1935, and then became one of the early participants in CalTec's Jet Propulsion Laboratory. He established himself as an expert in propulsion and aerodynamics and worked on forefront research projects and became an advisor for the US Air Force. Qian was also involved in the interview of German rocket scientist Werner von Braun after the defeat of Germany in the Second World War (Stokes 1999). Qian's arrival in a new China in 1956 enabled him to collaborate with other US/Europe Chinese returnees; Qian also supported China's defense research and his proposal led to the new state's resource allocation in projects such as missile and satellite.

The concept of judgemental decision making, which is critical within entrepreneurial events, could be traced to Casson's (1982) notion of entrepreneurship. Casson incorporated the historical themes of risk, uncertainty, innovation, perception and change to provide a synergy of entrepreneurship that highlighted the role of coordination. He wrote that the function of entrepreneurs are 'taking judgemental decisions about the coordination of scarce resources' (1982, p.13); judgemental decisions occurred when 'different individuals, sharing the same objectives and acting under similar circumstances, would make different decisions' (p. 24). Different decisions were results of different access to information or different interpretations of the same information, and entrepreneurs possess a comparative advantage in making decisions. Casson elaborated on the importance of possessing complementary information as follows: 'the entrepreneur does not necessarily possess any single item of information that no one else does. His advantage lies in the fact that some items of information are complementary, and that his combination of complementary items of information is different from everyone else's' (1982, p. 147). Casson also suggested that the channel of communication was imperfect and successful entrepreneurs needed 'to be in contact with primary sources wherever possible' in order to ensure that the information was up to date and accurate (ibid.). A useful feature of the primary source is that the information has not been distorted by the providers with selective mechanism or personal attitudes and beliefs.

Table 2 highlights a framework for judgemental decision making within entrepreneurial events. The process of judgemental decision making involves information gathering, interpretation of information and then applying the relevant data to the decision criteria. Judgemental decision making in relation to China's capitalizing on the returned scientific talents and invested in satellite technology during the 1950s is as follows. After the Russian's successful launch of the world's first satellite Sputnik in 1957, Qian and other leading scientists began submitting formal proposals in relation to the possibility of China's satellite program. Their ideas were presented in the Second Plenary Meeting of the Eighth Party Congress in1958, and gained the support of Mao Zedong (Kulacki and Lewis 2009). An expert committee of fifteen headed by Zhou Enlai condoned the endeavour; Qian was appointed to establish three specialists research institutions within the Chinese Academy of Sciences: the First Design Academy to be in charge of the design of the rocket and the satellite; the Second Design Academy for the control system and the Third Design Academy to be responsible for satellite instrument packages (Liu, 2013). As the aerospace industry has been and is of strategic in nature, judgmental decision makings inevitably intertwined with China's political system of democratic centralism, which involves China's elites and members of the Communist Party. Despite the size of the Chinese state organization, judgemental decisions tend to be relatively speedy and are based on national interests and industry consensus.

Table 2: Judgemental Decision Making concerning Entrepreneurial Events

		ENTREPRENEURIAL EVENTS	
		Entrepreneurial Opportunity	*Entrepreneurial Crisis*
		(Return of foreign Trained scientists)	

FORMULATION OF THE DECISION PROBLEM	Specification of the objective	*Developing satellite technology*
	Alternative Option	*Future catch up*
	Specification of the constraints	*Resource*
	Derivation of the decision rule	*Self-reliance*
DATA GENERATION	Data Collection	*Expert opinions*
	Data Estimation	
EXECUTION OF THE DECISION	Application of data to the decision rule	*Specialists research institutions*
	Initiation of the implementation process	

Source: Based on Casson (1982).

Pro-Market Reform and Innovation

Context of Marketization

Administrative units had been the institutional form in China's centrally planned economy between 1949 and 1978; these units were assigned a number such as No. 1 Factory. Government officials with little managerial power would lead these units and fulfill the requirement of the state. These units were politico-socio-economic units that took care of their employees from cradle to grave. Pro-market reform that has taken place since 1978 has gradually transformed the ownership, governance and employment within these units. One of the first initiatives of the Chinese economic reforms was to provide the former administrative units management decision making rights and therefore transformed them from miniature societies to entities with profit objective and the means to achieve it. Subsequent pro-market reform has not only restructured and consolidated managerialism, but has also diffused western corporate governance and employment system during these units' attempts to be marketized and corporatized. Fei et al. (2016 p.13) wrote "Although the Chinese government owns SOEs, they operate to some extent as independent entities"; hence, the State-Owned Assets Supervision and Administration Commission (SASAC) was created in 2002 to oversee the growth of aerospace conglomerates using objective, quantifiable performance measures.

Table 3: Evolving Operational Contexts for SOEs

Years	Key Characteristics and Changes
1949-78	Centralized operation with little corporate autonomy
1978-83	Emergence of corporate autonomy : Able to retain a share of their benefits :Development of small businesses
1984-92	Emergence of managerial autonomy : Decisions on wages and employment : Decisions on hire and fire : Tax-for-profit system
1993-2003	Centralized monitoring and control : Accounting Law : Hard budget constraint : Corporate Governance
2003-	Central Coordination with new shareholding governance : SASAC as a supervisory institution
2006-	Opening Up to Capital Markets :11th Five Year Plan and the Defense Industry 2006-2020 Development Plan emphasizes the listing of aerospace firms in China's stock exchange
2006-2020	Innovation with Chinese characteristics

Source: Based on Fernández and Fernández–Stembridge (2007) and Liu (2013).

Table 4: Entrepreneurial events and judgmental decisions in Chinese Aerospace

	Pro market reform and entrepreneurial events		
Period	Reshaping Socialism 1980s	Crisis in post-Soviet 1990s	Deepening Reform 2000s-now
JUDGEMENTAL DECISION			
Possible Goal	Global cooperation via joint venture/ alliance	Technical knowledge diffusion and transfer	Outward facing, competitive firms
Alternative Option	Foreign ownership and control	Maintain self-sufficiency	Continue state involvement

Source: Author.

Entrepreneurial Opportunities since the 1980s

Reshaping socialism and technology accumulation

First, the re-orientation of the economic ideology in China provided an opportunity for the Chinese aerospace industry to globalize. The Open Door Policy launched in 1978 meant that the Chinese state was faced with the choice of encouraging global cooperation through joint venture and alliance on the one hand versus attracting wholly owned foreign investment on the other. Under Deng Xiaoping's economic vision, joint venture in the aerospace sector was selected as the official approach to globalize high tech investment. By the mid-2010s, eight aviation clusters that have evolved from the post-1949 regional manufacturing units were taken from a number of globally based firms as shown in Table 5. The Chinese state has opted for some degree of control and equity investment from foreign investors in aviation as a requirement for their entering China. For example, Airbus's high profile joint venture began its operation in the Tianjin aerospace cluster in 2008, and is currently a final assembly site for its A320 model. Airbus has also planned to open a second plant in Tianjin in 2017. Collinson and Narula's (2014) case study on the aerospace joint venture in China suggested that it involved capability transfer "in terms of both process routines (such as quality circles and lean management systems) and problem-specific knowledge, through formal training and on-the-job learning" (p.20).

Table 5: Joint Ventures in Aviation Clusters

Aviation Cluster	Global Cooperation	Detail
Beijing	Boeing China Service Centre	Established in 2011 as to increase service and engineering support.
Chengdu	Pratt & Whitney Aerotech	A JV established in 1996 to produce components.
Harbin	Harbin Embraer Aircraft Industry	Assembly of business jets between 2004 and 2016.
Shanghai	Boeing Shanghai Aviation Services Co Ltd	A JV with China Eastern Airlines and the Shanghai Airport Authority to undertake maintenance, repair and overhaul.
Shenyang	Bombardier	Shenyang Aircraft Corporation as structural components supplier for Q400 turboprop in 2006 and also a long-term SA in C series final assembly project in 2007.
Tianjin	Airbus	A JV consortium among Airbus, Tianjin Free Trade Zone (TJFTZ) and AVIC in 2008.
	Boeing Tianjin Composites Co Ltd	A JV with AVIC to manufacture composite structures for Boeing commercial aircrafts
Xian		Supplier improvement programme since 2012.

Zhuhai	Avic-Boeing Manufacturing Innovation Centre Aviage Systems	Founded in 2012, a 50-50 JV between AIVC and GE Aviation.

Source: Authors.

Chinese aerospace conglomerates have taken advantage of the economic reform and co-operated with leading foreign firms. An early co-production involved Airbus's AS365N Dauphin 2 Helicopter with AVIC's Harbin Aircraft Industry Group Company Limited (HAIG) in 1980; HAIG received 48 sets of AS365N kits, which it assembled under technical guidance during the 1980s (Shen 2012). HAIG built on the acquired technological knowledge and began to design helicopters that used Chinese component suppliers for the air force since 1988; with the economic growth and increasing demand for private helicopters, HAIG has expanded its customer base and now also sells its products directly to wealthy end users (eF 2016). China's re-combinative innovation as seen in COMAC's ARJ-21 and C919, built on its accumulated knowledge during joint venture activities that enabled it to design final high performance end products that utilized outsourced sub-systems from global suppliers. Outsourced components of ARJ-21 and C919 accounted for some 90 per cent and 70 per cent of their total contents respectively (Cheung 2011, p.331); the high percentage of external components used in recent projects illustrated COMAC's system integration expertise.

Post-Soviet and knowledge transfer

The Russian policy on technology exchange during the 1950s was driven by ideological consideration while that in the 1990s was primarily based on economic concern (Sergounin and Subbotin 2000). The break-up of the Soviet Union provided further entrepreneurial opportunities for the Chinese aerospace industry's technology learning. Bell and Pavitt (1997, p.106) wrote that in science-based firms such as aerospace, reverse engineering or analyzing and copying competitors' products, was a method for international technology transfer. Kim and Nelson (2000) found that reverse engineering of existing foreign technology as the first stage of a developmental path in technology accumulation in Asia among newly industrialized economies during the period after the Second World War; in particularly, re-combinative innovation was preceded by duplicative imitation where firms simply copied competitive offering. They further stated that the value involved in reverse engineering on the basis that "skills and activities required in these processes are in fact the same as in the innovation process in R&D" (2000, p.5). The technological accumulation during the development of the Chinese aerospace industry has proceeded from duplicative imitation to re-combinative innovation; for example, Niosi and Zhao (2013) stated that China's Z8 model helicopter was built on some ten years of reverse engineering efforts of the French helicopter SA321-JA.

The transfer of aerospace knowledge to China further involved tacit knowledge. Stokes (1999) pointed out there was an influx of Russian and Ukrainian academics visiting China and technical exchanges that assisted the Chinese aerospace industry to acquire further skills to solve technical issues. He added that the lack of an effective regime since 1994 had led to substantial flow of manufacturing, electronics, and materials technology from the former USSR to China. Pollpeter (2011, p.407) also discussed the extensive cooperation between China and Ukraine in the late 2000s covering "29 long-term projects on the joint development of space rocketry, earthquake monitoring and remote sensing satellites, and satellites to monitor and

study space weather" in addition to "projects for the exploration of the Moon and Mars, engine manufacture, welding in space, and use of solar energy".

Deepening of Economic Reform

The deepening of economic reform in the domain of SOEs as seen in the recent "Guiding Opinions on Promoting the Transformation of Defense Industries into Joint-Stock Enterprises" represents another entrepreneurial opportunity for Chinese aerospace conglomerates. The corporate autonomy gained by these conglomerates since the 1980 have transformed their process and structure. The 2008 guideline enables AVIC, CASC, CASIC and COMAC to further transform their ownership structure and raise capital to fund research and development through listing of selected subsidiaries in Hong Kong, Shenzhen and Shanghai. In other words, judgemental decisions had been made in allowing selected firms to seek funding externally rather than from the state. By the mid-2016, 27 of AVIC's subsidiaries, 12 of CASC's subsidiaries and 7 of CASIC's subsidiaries have been listed in the stock exchange; the listed firms are therefore subjected to the rules of the relevant securities regulatory commission. Overall, the judgmental decision enabled the aerospace conglomerates to become more independent from the state and provided external source of external funding for increasingly costly R&D activities.

Discussion and conclusion

Building on Casson's entrepreneurial decision making framework, we have explored how the judgemental decisions made by the Chinese state has served as a globalizing force of technology. The current stage of global exploitation of innovative products by the aerospace conglomerates has been preceded by their technological collaboration with leading foreign firms and institutions, which were associated with Chinese leaders' strategic response towards entrepreneurial events. The state initiated pro-market reforms have opened up unprecedented entrepreneurial opportunities that impacted upon technological, managerial and financial resources; aerospace technocrats were able to make judgemental decisions that generated re-combinative innovation. Why Chinese technocrats seem to have a comparative advantage in making judgemental decisions during uncertainty? What characterizes their decision rules? One of the characteristic is a long term perspective which derives from a vision concerning the importance of the strategic industry for the Chinese nation's place in the global community. The aerospace industry is strategic in nature not only because the requirement of its outputs by the military, but also because of the technological impact upon the development of engineering and production technique. Additionally, the decision rule was holistic rather than based on the analysis of quantifiable variables, and exhibited a Chinese characteristic (Nisbett 2003). Key ideas such as self-reliance have influenced decision making and are products of China's prolonged economic weakness and reliance on imported technology during the 19th century. Finally, the practice of democratic centralism further means that decision makers were able to formulate the decision problem, generate data and execute the decision that enhanced national interests in timely fashion.

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