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The Dragon Takes Flight: China's Journey Toward Building Its C-919 Large Passenger Aircraft and Its Impact on the US and Boeing

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Abstract

Despite the enormous risk associated with the development of a large indigenous airliner, China after a failed attempt in the mid-1980s, since 2003 has decided once again to embark on a journey toward the development of a 190 seat commercial airliner. Nations are typically interested in the development of indigenous airliners because of the potential spillover effects that years of research and development have on the economy and the military. Equally important is that China no longer wants to relinquish its large commercial airplane market to foreign companies such as Boeing and Airbus with their market expected to constitute nearly 25% percent of the world's demand worth $340 billion.

With the aviation industry naturally driven toward a natural monopoly, the Chinese government has agreed to not only subsidize the C919's development, removing the potential risk associated with launching a technologically advanced aircraft, but upon the aircraft's arrival, which is expected in 2016, but also guarantee sales of the plane by forcing its State-owned airlines to purchase it. This could potentially be harmful to current commercial aircraft producers Airbus and Boeing. If the three manufacturers: Boeing, Airbus and COMAC split the market in three ways, it will dig deep into the profits of all three manufacturers. This may force Boeing to contract the size of their work force, including skilled engineers and scientists, thus slowing down the process of innovation and product efficiency and the ability of the military and the economy reaping such benefits.

This dissertation weaves the work of Peter's Evans's "Embedded Autonomy and Michael Porter's "Determinant Model" to determine that given the current nature of the Chinese state, it possess an adequate level of embedded autonomy to implement favorable policy for constructing an internationally competitive airliner, which consists of both creating an innovative airliner and selling enough of them to develop scale economies. A state's institutional configurations whether it possess a high level of autonomy, high level of embeddedness, or a balance between the two, influence the essential society variables in Porter's Determinant model for developing industry differently.

Using a combination of primary source and secondary data from China, the United States and France, which include conducting interviews with key officials and experts in the aviation field from those countries, this research project compares and contrasts the institutional arrangements of China in the 1980's during its failed attempt at commercial aircraft development with today and concludes that different internal structures lead to different levels of effectiveness and success with respect to implementing policy choices favorable to the development of the commercial aviation industry.

Secondly, this Dissertation looks at the potential implications the success of the C919 may have on the United States and Boeing and the ways in which Boeing might prepare to meeting the challenges it faces.

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CHAPTER ONE

INTRODUCTION

Only a few countries have successfully developed a commercial aviation industry. Most that have tried have failed: The size of the investment is usually greater than a firm's worth. Therefore, any country seeking to develop an indigenous aircraft must be willing to provide subsidies or other forms of assistance to its airplane manufacturer in order to minimize the risk of monetary losses that could potentially bankrupt it. As a result, only Europe's Airbus has thus far been able to successfully pose a direct challenge to American dominance in the large passenger airplane market. With the massive amounts of money channeled by the members of the European Consortium (France, Great Britain, Germany, Spain, etc.) over the last twenty years toward developing, producing, and marketing large passenger aircraft, Airbus has managed to capture about 50 percent of the market in an industry that has traditionally been driven toward a natural monopoly.

Now, with demand for commercial aircraft in China over the next 20 years expected to constitute nearly 25 percent of the world market, and to exceed over $340 billion (3,560 jumbo jets and 993 regional jets), the Chinese have embarked on a journey to produce a 190-seat passenger aircraft (COMAC 919) within the next five years.[1] Like Airbus, the support of a government will make entry possible for China, whose emergence into the industry is expected to have major implications for both the United States and Europe.

The Uniqueness of the Aviation Industry

Nations typically attempt to develop an indigenous airliner because of the potential benefits to its economy and military. The level of a country's indigenous aircraft is usually indicative of the level of scientific and technological development in both sectors, advances in one of which will spill over into the other. However, for a state to successfully break into the aviation business, it must understand the industry's unique economics and competitive nature,[2] which, as is true of other high-technology industries, demands above average spending on research and development, and greater employment of scientists and engineers, so the university system must provide modern facilities and skilled faculty.

The aviation industry differs from most other high-tech industries because the huge up-front development costs and immense technological risk associated with the launch of an aircraft create a natural monopoly protected by barriers that defeat typical market forces. It takes years of losses for a new firm to develop a family of aircraft and produce it on a scale large enough to benefit from economies of scale. Therefore,

[1] "China to Deliver a Fleet of ARJs by 2012", Industry Research Solutions, www.rncos.com/Blog/2009/02/China-to-Deliver-a-Fleet-of-30-Homemade-ARJs-by-2012.html.(accessed July 1, 2009).

[2] Ibid., p156.

states are inclined to offer aircraft-manufacturing firms assistance in the form of subsidies to offset the risk associated with their development.

A state wishing to develop an indigenous airliner must be aware of the huge price tag associated with integrating numerous technologies and systems originating in unrelated industries and fields, the cost of which lies somewhere in the ballpark of $4 to 6 billion in up-front expenditure and materials.[3] Even if a firm has the capital to meet these costs, there is no guarantee it will earn enough revenue to realize a profit.

Even when a state issues subsidies to aircraft manufacturing firms, they still face immense risks associated with the launching of a new aircraft. Industry leaders will, if possible, choose to remain competitive by making slight modifications to already proven models and delay innovation because the costs remain enormous, and to draw on their economies of scale to maintain a competitive advantage over start-ups producing similar aircraft.

By comparison, airline manufacturers new to the industry must look to find a niche in the market through product innovation and differentiation, which can be ruinously risky because of technological uncertainties. Government intervention reduces the risk by issuing subsidies and protection to its indigenous firms, which also prevents a natural monopoly from occurring. In short, developing or sustaining an advantage in the industry requires the state successfully manipulate all the resources associated with developing a high-tech industry, including financial and human capital, in order to produce an innovative and technologically advanced aircraft cheaper than, or as cheap as, the competition's.

[3] Ibid., 162.

Success in the aircraft industry is thus defined in terms of the start-up producer's ability to secure a niche in the market and produce enough aircraft to develop economies of scale that bring down the cost of the product. Finding the niche is no easy task, for it often involves producing a technologically innovative aircraft, which entails working with unproven technologies, thus greatly increasing the chances of manufacturing and design flaws that will delay the aircraft's launch date for months or even years. This is troubling, because even if the airplane manufacturer believes when production commences that it has found its niche, no one can be certain what the market will demand several years hence when the aircraft is ready to debut. Therefore, it is imperative to roll the aircraft off the assembly line as soon as possible.

In order to profit, a manufacturer must also produce enough aircraft to bring down per-unit costs. There is an initial learning curve associated with workers being able to do their jobs efficiently. As they begin to repeat the same job, they can produce the same number of products in less time. Doubling of the number of airplanes produced achieves a 20- percent reduction in direct labor costs.[4] Great pressure exists for a company to move down the learning curve, because, when a new plane hits the market, it is priced on the per-unit cost of producing 400 to 600 units.[5]

In order for a firm to break even, it must in fact be able to sell roughly 600 units, which in the past constituted half of the large airplane market. This can take at

[4] John Newhouse, *The Sporty Game* (New York: Alfred A Knopf Inc., 1982), p19.

[5] Laura D'Andrea Tyson, *Who's Bashing Whom? Trade Conflict in High Technology Industries* (Washington, D.C.: Institute for International Economics, 1995), p167.

least 8 years and as long as 12 if the time it takes to develop the aircraft is factored in.[6] There remains a high possibility a firm may never sell enough of its aircraft to break even, never recover from the huge losses it has incurred, and be forced to leave the industry.

Implications for the Aviation Industry

The arrival of a viable third competitor whose home demand will constitute approximately one-fourth of the large passenger aircraft market will make it even more difficult for existing companies like Airbus or Boeing to profit when either is producing a derivative of an existing model or an entirely new aircraft to compete with the Chinese airplane in the 190- seat range. Furthermore, it is likely that the Chinese government will force domestic airlines to purchase indigenous aircraft regardless of whether or not they are comparable to rival products, which might result in splitting that market three ways. If each company is able to acquire an adequate market share, it will dig deep into the profits of all three.

With these risks in view, if other firms seek to enter the fray with government subsidies, as did Airbus, they may further disadvantage competitors who are not receiving as much help from their governments.

These heavily subsidized firms who are looking to gain greater market share at the expense of their rivals may, as a form of predatory behavior, sell their product at below cost to entice customers, especially if not much difference in quality or style exists among the products on the market; the strategy of a firm that sells its product

[6] Ibid., p167.

below cost is to drive competitors out of the market: The firm will take a hit now and reap the benefits of less competition later.

Yet, despite the fierce competition that will ensue as a result of China's entry into the large passenger aircraft industry, both airlines and passengers will reap the benefits. Increased competition improves the airline business because more products appear on the market among which customers can choose. Also, greater competition will force airplane makers to seek out more efficient ways to keep their production costs down while adopting the latest technologies. If airlines are cheaper to buy, air travelers will pay lower plane fares.

Implications for the United States and Europe

If China's COMAC 919 succeeds, it will cause concern in the United States and Europe. Boeing and Airbus would lose market share, and without greater help from their respective governments to cover their losses, they could be forced to contract, resulting in less money channeled toward research and development and, therefore, a slowing down in innovation and product efficiency that will make their products less competitive internationally and, in turn, affect the overall health of their respective economies because innovation generates important spillovers in the private sector and the military.[7] As companies begin to contract, the downsizing includes a reduction in the number of its scientists and engineers, who are needed to create, innovate, and thereby add value to the broader economy. There is already growing concern in the United States over decreasing numbers of engineers and scientists

[7] Ibid., p13.

completing their higher education compared to their Chinese and Indian counterparts. Such contractions further discourage students from entering the engineering field, which will hinder a country's ability to make substantial contributions to its economy in the future.

In an attempt to offset these potential losses, Airbus and Boeing have reached out to China to probe the possibility of working together on the project with COMAC. A joint venture would almost guarantee one or both of the current aerospace leaders a degree of the market from which they could profit immensely.

Both aircraft manufacturers have also decided to create derivatives of their existing models to satisfy the growing demand for aircraft in the 190 seat large passenger aircraft range and for competing with the C919. Boeing at first, committed to developing an entirely new technologically advanced aircraft, but has recently decided against it as its market research determined that many airlines over the next several years would be looking to retire their less fuel efficient planes for new cost-efficient models. Boeing understands there are a lot of uncertainties with producing a new aircraft from scratch and would not want to forfeit large chunks of the market to Airbus if its plane's debut date is delayed.

Airbus on the other hand, never believed that current technology is mature enough to warrant the building of a new aircraft. Both manufacturers, whose primary concern at this point is competing with one another for market share, still see a lot of potential for their aircraft in the Chinese market even after the government has reserved a portion of it for its indigenous aircraft, and both believe that their new aircraft will be attractive to Chinese airlines because they will contain newly innovative and cost-saving features.

LITERATURE REVIEW

It is widely acknowledged among scholars that the state plays an important role in promoting technology. That role has been widely debated by two primary schools of thought: the Developmental State and the Dirigiste. The Developmental State approach looks at the developing of the state's capacity and ability to create, guide, protect, and nurture key industries they deem important for greater economic development and growth until they have developed well enough to compete with and possibly surpass their foreign rivals.

The Dirigiste school looks at how industrialized nations assist and guide faltering or less competitive industries that are considered important for the country's economy and national security. This is done, not by enforcing an economic direction, but by encouraging firms through various incentives, such as subsidies and government procurement, to follow the desired path. This literature review will cover the major works of each school in chronological, order beginning with the State Developmental approach. Lastly, I will devote a section to covering literature on the aviation industry.

State Developmental Approach

The State Developmental approach was pioneered by Chalmers Johnson with his book MITI and the Japanese Miracle, which reviewed the historical origins of

Japan's modern industrial policy and how it achieved great economic growth and success in a relatively short period of time. He attributed Japan's economic success to Japan's Ministry of International Trade and Industry's (MITI) ability to meet state objectives by nurturing strategic key industries such as steel, chemical fertilizers and ship building.

Johnson's perspective has been reinforced by many scholars who have applied his findings to other societies. Alice Amsden's Asia's Next Giant, for example, attributes South Korea's unprecedented economic growth over the past century to the government's intervention in the economy. Amsden argues that all successful late-industrializing countries must have a strong centralized government capable of directing the pace and direction of growth in the economy. Her main thesis is that Korea's success rests heavily on a strong state and its ability to implement sound policies that promote the development of indigenous industry.[8] South Korea has grown faster than other economies because of the state's ability to exert power over private firms.[9]

Robert Wade's Governing the Market builds on the work of Johnson and Amsden by advancing his "governed market" theory, which emphasizes the government's role in the promotion of high levels of direct investment in key industries with the intent of competing internationally.

For the purposes of my analysis, the most significant work of this school is Peter Evans's Embedded Autonomy, which extracts and generalizes from those

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[8] Alice Amsden, *Asia's Next Giant* (New York: Oxford University press, 1989), p147.

[9] Ibid., p14.

already mentioned. Evans examines the role of the state in both fostering and hindering economic development. While Johnson, Amsden, and Wade offer a detailed empirical analysis of the economic success of East Asian countries that exhibit state intervention in the economy, Evans takes the state developmental approach a step further by considering which configurations and arrangements between state and industry are best suited to international competitiveness and economic success.

Evans's book starts with the assumption that states best play the role as agents of economic transformation when they exhibit characteristics of what he labels "embedded autonomy," that is, when they best approximate the Weberian ideal type, which allots the state a degree of autonomy but enables it to maintain good working relationships with other sectors of society. When both variables are met, a state is considered developmental. Evans's book argues persuasively that such a state plays a major role in the economic development of a nation.

Institutions meet the Weberian ideal type when they are highly selective, are based on a meritocracy, and offer long-term career rewards for their employees, which in turn creates a sense of corporate coherence and a loyalty to the institution's long-term goals and principles.[10] When institutions meet these conditions, individuals see pursuing corporate goals as the best way to maximize their self-interest. Additionally, corporate coherence gives the members working in the institution a sense of autonomy along with access to institutionalized, rule-based channels for dealing and negotiating with societal groups. These dense networks and deep social ties and contacts with society are known as "embeddedness." Having either autonomy or embeddeness alone

[10] Peter Evans, *Embedded Autonomy* (New Jersey: Princeton University Press, 1995), p30.

will not suffice; only when embeddedness and autonomy are joined together can a state be called developmental.[11]

Predatory State

The solely autonomous predatory state employs state resources for its own personal gain, in total disregard of the welfare of its people, thus impeding economic transformation and development. Several characteristics define the predatory state. Firstly, control of state apparatus is vested within a tight-knit, closely connected group. An absence further exists of rule-governed behavior: officials are not bound by rule of law, therefore leaving the door open for corrupt practices and self-aggrandizement, which include the pursuit of individual interests at the expense of the public good. When such behavior dominates and predictable, rule-governed norms no longer guide bureaucratic behavior, the development of an entrepreneurial class interested in pursuing long-term productive investment is virtually impossible.

Without protection by and from the government through the implementation and the execution of laws including the protection and preservation of both individual property rights, anyone seeking long-term investment would be naïve and ignorant rather than a true entrepreneur.

In the predatory state, limited institutional ties exist between state and society; state officials interact with citizens mainly for the purposes of maximizing their utility. “Personalism and plunder at the top destroys any opportunity for rule governed

[11] Ibid., p41.

behavior."[12] In order to remain in power, for example, an incumbent who needs monetary support from members of a society may provide lucrative jobs or contracts in exchange for that support. They may implement favorable policies benefitting those who make monetary contributions, usually at the expense of society as a whole. Officials however, may be united, and act as a cohesive unit when using their repressive capacity to silence its opposition or anyone who poses a direct challenge to the current authority. Evans categorizes the solely autonomous state of Zaire as being predatory.

Developmental State

The developmental state, as defined by Evans, maintains the ability to preside over markets and capital accumulation, which is necessary for strong economic growth. This can be accomplished if state bureaucratic institutions are motivated and united around corporate ideals and goals. The institutions that make up the developmental state possess a deeper sense of corporate coherence because they develop a highly selective and rigorous recruitment process, and offer promotions, high wages and life-long career opportunities for worthy employees, all of which occur in accordance with established rules and norms. This creates a sense of honor, respect, and prestige associated with work. Individuals will therefore see pursuing corporate goals as the most effective way for maximizing their self-interest: an employee's interest and success are tied to the success of the company.

[12] Ibid., p46.

If a nation recruits government officials from its elite universities, a deeper sense of pride, prestige, and loyalty become associated with such employment, thus further establishing corporate coherence. In fact, if a country also recruits its government officials from top companies who negotiate with such officials, negotiations will run smoothly, as many will be alumni of the same universities, or even former classmates.

The state's relation with society is bounded by a concrete set of laws, rules, and norms that provides formal channels for the negotiation of goals and policies as well.[13] As long as the state can provide an environment where rules and laws, including those affecting private and intellectual property rights, are enforced and respected, returns on investment become predictable, thus providing incentives for entrepreneurs to invest money in the economy. In a state that is solely autonomous, in which only limited institutionalized channels bind it to society, levels of suspicion and distrust arise between the state and societal actors, and the former is unable to count on society for sources of information or the implementation of important initiatives.

If the state is not strong enough, on the other hand, the private sector may be able to unduly influence government policies, as the incumbent interested in remaining in power may enact policies favorable to powerful and wealthy societal agents to ensure that they do not throw their support behind the opposition."Dense connecting networks without a robust internal structure would leave the state

[13] Ibid., p59.

incapable of resolving collective action problems of transcending the individual interests of its private counterparts."[14]

When the state is both embedded and autonomous, it can therefore be truly developmental. Evans considers Japan a developmental state, because it possesses the characteristics of embedded autonomy.

Intermediate States

An "intermediate state" can be described as one that maintains a degree of both autonomy and embeddedness but at times often falls prey to imbalances that can take the form of excessive clientelism or isolated autonomy.[15] In other words, from the onset the state exhibits a tendency to disrupt the balance between autonomy and embeddness, thus complicating the developmental process as neither quality has been fully legitimized by the state or society. This balancing always presents a challenge. Such a state is plagued by inconsistencies often reverting to solving problems in ways that are most familiar and that can be traced back in its history. Both Brazil and India in the 1980s were classified by Evans as intermediate states. The Brazilian state suffered from low levels of autonomy, which stem from the absence of a meritocratic system of hiring and promotion in its bureaucracies. India, on the other hand, suffered from a lack of "embeddedness" between its extremely autonomous and corrupt bureaucracy and its business classes.[16]

[14] Ibid., p12.

[15] Ibid., p60.

[16] Ibid., p66.

The intermediate state may at times display only pockets of efficiency. In some cases it will implement meritocratic recruitment of bureaucratic officials, and in others rely on political appointments. State-society relations differ across industries as well. In some cases, negotiations take place through rule-based channels, at other times through informal channels in disregard of law. Companies willing to invest in such a country are always taking a risk and often make their decisions on a cost-benefit analysis.

State Policy and Roles

The ability a state has to develop a given industry depends to a large degree on its institutional structures. Certain institutional configurations lend to choosing or favoring certain policy roles over others. Therefore, states possess different levels of effectiveness as agents of industrial development and transformations. Of four possible roles (custodial, demiurge, midwife, and husbandry), a state will choose one role, or a combination of roles, that fit its style of governance for managing or developing an industrial sector. There is an element of predictability in predicting the course a state will pursue and how successful its implementation will be based on an understanding of its internal structure. However, it is also possible that certain roles will be assumed by elites who don't fit the state's style of governance, thus further hindering the successful development of an industry.

Custodian and Demiurge

Both custodian and demiurge roles grow out of mistrust of the motives of the private entrepreneurial class; the intent of the custodial role is to protect an infant industry by making it difficult or virtually impossible for greedy entrepreneurs to enter a promising industry; it seeks to restrict or police investment efforts, domestic or foreign, by imposing high tariffs, import prohibitions, and other investment restrictions.[17] The state is concerned with anyone seeking to exploit the nation's scarce resources and markets for individual gain. The custodial role is often implemented when a state enterprise or firm is not capable of developing the industry according to world standard. When the state takes on the custodial role, it's primarily concerned with policing rather than the development of rules that can facilitate industrial transformation.

When the state decides to assume the responsibility for developing an industry or producing a good, it is playing the producer role. All states at one time or another have played the demiurge, especially when delivering collective goods for society, such as bridges, roads, water supplies, and communications that would have been undersupplied if left to private producers.[18] Governments usually takes on the role of producer when they recognize the limitations of capitalism or do not believe local capital can do as good as job as the state itself. However, the demiurge takes the producer role to a whole other level, for it harbors great mistrust of private firms and therefore assumes the responsibility for producing goods in important industrial

[17] Ibid., p80.

[18] Ibid., p13.

sectors of the economy that would have otherwise been left to the private sector to supply. In this account, the state establishes enterprises that produce goods for society.

Midwifery and Husbandry

The role of "midwife" is an optimistic view the state adopts of entrepreneurs and private firms as it wishes to draw them into new and promising industrial sectors through the implementation of promotion policies designed to offset the risks and uncertainties associated with the development of industry. Through a variety of promotion policies, including the issuing of subsidies, the state will encourage and nurture chosen firms to develop an industry that is technologically challenging, making it otherwise unattractive to the private sector to enter. Another promotion technique may be to "help local entrepreneurs bargain with transnational capital or even just signaling that a particular sector is considered important are other possibilities."[19] The more risky the venture, the more reluctant private firms on their own would be to enter the industry; with promotional policies that offset risk and uncertainty, the firm will be more willing to enter the industry. Promotion policies are not limited to domestic firms or local entrepreneurs; states may induce or encourage multinational corporations to develop an industry, thus passing along advanced technology with linkage effects that stimulate all facets of the economy. It is also possible the state will help facilitate a joint venture between transnational capital and local firms to take on the task of developing a particular industry.

[19] Ibid., p14.

"Husbandry" can be as basic as offering monetary or financial support to firms that are willing to take on risky ventures that include the production of advanced and complex technologies, though the state may also be inclined to take over some arduous and risky complementary tasks, such as research and development.[20] In short, husbandry offers assistance and support to a firm in challenging sector of the economy. "In some respects it is less demanding than midwifery because there are already private counterparts in the sector to work with. It is more challenging for the same reason."[21]

Evans notes that different institutional arrangements are advantageous to implementing policy roles in different industries. The policy choices of a particular state are usually determined by the organizational characteristics of the state. The demiurge role is the preferred policy choice when barriers to entry in an industry are high and when technology is not carefully guarded and held by a few global firms, as in the steel industry. However, when barriers to entry are low, as in the textile industry, midwifery is the best course of action as it encourages local firms to enter a given industry. When advanced and sophisticated technology is tightly guarded, as is the case in the aerospace industry, the development of joint ventures with large international firms (midwifery), and independent research (husbandry), provide to be the best courses of action. [22]

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[20] Ibid., p81.

[21] Ibid., p81.

[22] Ibid., p93.

Critics of Evans's Theory

Michael Bollom's challenges Evans's theory by arguing that it does not take into account the need for the state to develop the necessary infrastructure for the development of new industries such as informatics. This is important in countries where infrastructure is not well developed and cannot support the demands of high technology. [23] For example, the Indian software industry has been successful in that its average growth is over 30 percent.[24] During this period, the most significant government contribution was its promotion of the industry through the development of its infrastructure.

Philippe Faucher criticizes Evans for creating descriptive categories that lack any essential analytical capability. According to Faucher, Evans explains how a state is sufficiently embedded at a certain point in its history, and how, when this level of embeddedness is combined with the right amount of state capacity, growth-generating policies will soon emerge.[25] The hard questions concern how much autonomy and embeddedness is needed, and in what situations. The term "embedded autonomy" usefully directs us to look at both terms separately, but how much of each is needed for the term to apply?

Despite the criticisms that have been leveled at this theoretical framework, they are not sufficiently powerful enough to suggest that the framework is not useful. I

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[23] Michael Bollom, review of *Embedded Autonomy: States and Industrial Transformation, Comparative Political Studies* 29, no. 105 (1996): 107.

[24] Ibid., p107.

[25] Phillipe Faucher, review of *Embedded Autonomy: States and Industrial Transformation*, *Canadian Political Science Association* 29, no. 1 (1996): 180.

will deal with these criticisms in the conclusion of this project. In this study, I will analyze China and pay particular attention to the institutional arrangements of the 1980s, and the role it played in its unsuccessful bid to create an indigenous airliner then, with the situation today. We will then be able to determine what China is getting right, wrong, and where it needs to improve. Specifically, I will examine how different levels of autonomy and embeddedness play an important role in the state's ability to influence various social elements enough to create an indigenous airline.

Evans's theory has in fact been very influential, and many scholars have applied his model to other settings. Bruno Treszzini's article "Embedded state autonomy and legitimacy: Piecing together the Malaysian development puzzle," for example, analyzes Malaysia's unique and impressive development through a theoretical framework centering on the concepts of embedded state autonomy and sociological legitimacy. The article notes that Malaysia's social, economic, and political features, including its abundance of natural resources, developed economic infrastructure, absence of dominant social groups opposed to industrialization, and democratic political system all evolved into a self-reinforcing social system conducive to fostering economic development. [26]

Other scholars, notably Habibul Haque Khondker in his article "Globalization and State Autonomy in Singapore," have broadened the concept of embedded autonomy to include local and global institutions and norms in the definition of embeddedness to better explain the positive effects globalization has on economic

[26] Bruno Trezzini, "Embedded State Autonomy and Legitimacy: Piecing Together the Malaysian Development Puzzle," *Economy and Society* 30, no. 3 (2001): 1.

development in Singapore. This paper also examines the potential problems that Singapore may face now that its society encompasses global institutions and norms; in other words, as the state still wishes to maintain a degree of its autonomy, will it undermine the possible formation of a democratic culture. Also, how will state autonomy affect Singapore's knowledge-based economy?[27]

The Dirigiste School

There is a second relevant body of scholarship that attributes a different role to the state. The position of this school is well summarized and articulated in the book Manufacturing Matters, the thesis of which is that the United States continues to send its manufacturing overseas in the mistaken belief that our nation will be better off if our economy moves more toward providing services. Our economic decline is the result of our inability to find a niche in the market; therefore, we attempt to remain competitive by exploiting cheap labor abroad. We can only begin to become more competitive if our government helps in making it possible for our manufacturing facilities to remain at home; they must play a role in helping firms to automate their production facilities. Relying more on automation rather than unskilled human labor would bring down production costs and facilitate the rapid diffusion of new technology to other sectors of the economy, making our products more competitive.

This perspective is echoed by Laura Tyson in her book Who's Bashing Whom, which argues that the poor state of the U.S. economy emanates from the unfair and

[27] Habibul Haque Khondker, "Globalization and State Autonomy in Singapore: Asian Journal of Social Science," *Asian Journal of Social Science* 36 (2008): 1.

manipulative state- interventionist polices of our Japanese and European trading partners. In attempt to combat these disadvantages, Tyson devises a "cautious activism" strategy calling for the United States to do its best to open foreign markets to American products, and suggest that, if they are unsuccessful, policymakers ought to threaten the closure of U.S. markets and subsidize selective high-tech industries.

Adherents of this school differ, however, on the appropriate policy responses. Gene Grossman takes issue with Tyson's assertions that we ought to subsidize selective high- tech industries, should our trading partners engage in unfair trading practices despite our best efforts, in his article "Strategic Export Promotion: A Critique." Although he acknowledges the advantages a nation might gain should it choose the correct industry to target, he also claims that policymakers don't have, and may never have, sufficient and reliable information that would warrant the targeting of such industries.[28] Instead, U.S. policy should seek to create an environment conducive to innovation and entrepreneurship, as well as to prevent market failings. Government should therefore support education and industrial R&D, which would help to improve its international competitiveness.

This school of thought has gained wide recognition as a result of Porter's well-known book The Competitive Advantage of Nations, which explains why some nations' industries prosper more than others. According to Porter, industries are likely to succeed when the determinants in his national diamond model as a system are

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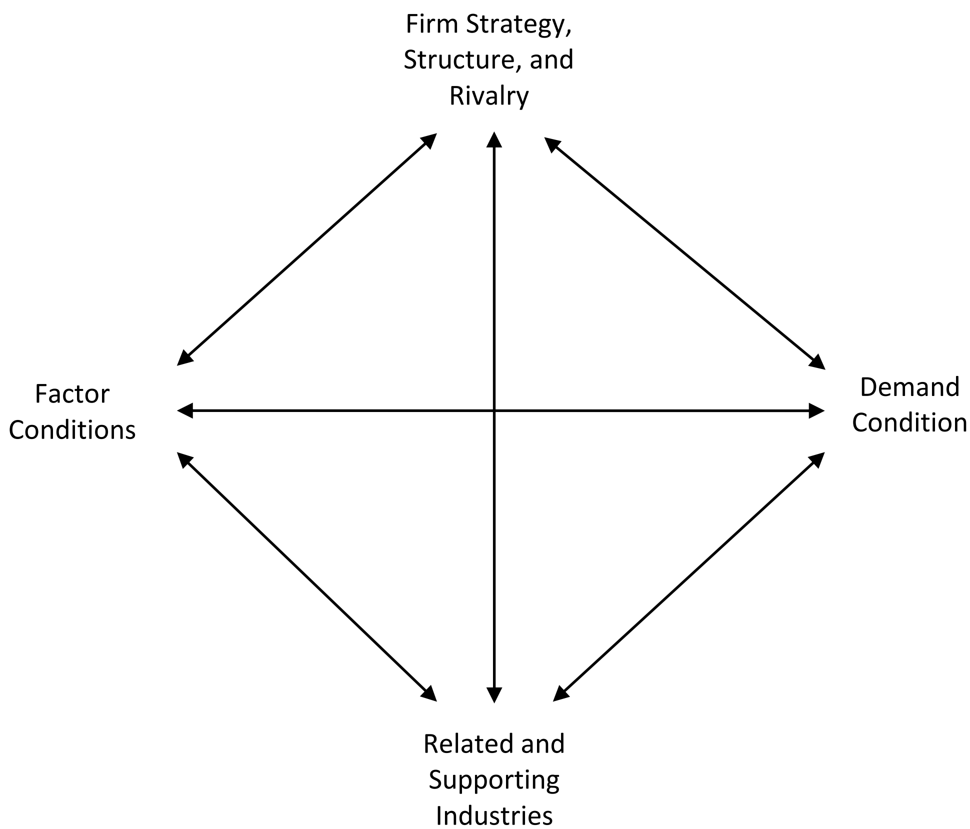
[28] Gene Grossman, *Strategic Promotion: A Critique. Strategic Trade Policy and the New International Economics*, ed. Paul R, Krugman (Massachusetts: The MIT Press, 1986), 48.

favorable. His model contains four determinants: factor conditions, demand conditions, related supporting industry, and firm strategy and rivalry.

PORTER'S DIAMOND OF NATIONAL COMPETITIVE ADVANTAGE



Factors of Production

In order for nations to successfully compete in a given industry, they must be able develop their factors of production, which are the necessary skilled labor and the infrastructural inputs (roads, highways, telecommunications, etc.) to a degree comparable to those of their competitors. Nations succeed and sustain competitive advantages when they continuously upgrade these necessary factors. The most essential factors for developing a competitive advantage in most industries have little to do with the nation's natural endowments and more to do with how creative it is at getting around the resources that it doesn't have in abundance or is lacking. It may be the case that nations possessing an abundance of natural resources are unable to efficiently or effectively deploy them to selective industries. "This reflects the choices made by a nation's firms about how to mobilize factors as well as the technology used to do so."[29]

On the other hand, a nation that possesses limited natural resources is more prone to rely on its highly skilled labor force, if available, to invent ways in which it can reduce production costs, create new products, or add new features to existing product. For example, Japan faced a clear disadvantage because many of its firms faced extremely high land costs and had limited factory space. To redress these difficulties, they created the just-in-time and other space- saving production techniques, which reduced inventory immensely.[30]

Nowadays, most international trade takes place among industrialized nations that have comparable endowments and infrastructure; these nations share similar stocks of both high school- and university-educated workers needed to develop and maintain a competitive advantage. The U.S. no longer maintains its unique competitive advantage in possessing the skilled labor that it once did. Many other

[29] Michael Porter, *The Competitive Advantage of Nations* (New York: The Free Press, 1990), p76.

[30] Ibid., pp83-84.

industrial nations now possess an abundance of skilled labor as well as infrastructure, such as telecommunications, road systems, and ports crucial for competition in manufacturing industries. However, the U.S. does maintain an advantage with respect to having an education system that specializes in training students in specified scientific areas important for creating and sustaining competitive advantage in industry.

Michael Porter identifies two factors that he deems most important for creating an enduring competitive advantage: "basic" and "advanced" ("general" and "specialized"). Basic factors predominantly consist of a nation's unskilled and semiskilled labor. Advanced factors constitute the general college-educated population and specialized personnel consisting of scientists, engineers, and research institutes in advanced disciplines that yield advantages in the development of modern infrastructure and innovative products in industry and production.[31] In order to sustain advantages, nations must be able to develop their factors through long-term investment over a period of time, which can be difficult.

Basic factors tend to be inherited or, if there is a degree of creation involved, it requires little to no social investment.[32] These factors are unimportant to a nation's competitive advantage, or, if they do provide advantages, it is not sustainable over time. For example, 20 to 30 years ago, Korea had an abundance of unskilled labor, which translated into a high degree of success producing goods for the international community because it could make them far more cheaply than most industrialized

[31] Ibid., p77.

[32] Ibid., p77.

countries. However, firms from nations such as Thailand and Malaysia started to offer their unskilled workers even lower wages, thereby canceling out Korea's competitive advantage. Competitive advantage based on generalized factors is unsophisticated and often short lived. It lasts only until some new nation is able to replace them.

Advanced specialized factors are now the most significant for developing or maintaining a competitive advantage within most industries; they are the engines driving the creation of differentiated or new products, new features on existing products, and proprietary production technology. These specialized factors have a narrowly specific skill set for a particular field of industry. For example, the United States has unique expertise in computer software, which has given it a significant advantage in the computer industry and other related industries such as medical electronics and financial services. It requires, however, a huge commitment on the part of any nation to develop its specialized advanced factors.

Advanced factors are difficult to develop because they require a huge amount of human and physical capital: modern institutions and facilities, along with a pool of educated personnel capable of developing, training, and educating and upgrading advanced and specialized factors; the institutions, technology and personnel must moreover be committed to constant improvement in order to compete with other countries in selective fields. "Competitive advantage doesn't come from just one time investment but continual reinvestment to upgrade their quality not to mention keeping the current pool of factors from depreciating."[33]

[33] Ibid., p80.

With respect to advanced factors, there is a clear distinction between generalized and specialized factors. "Generalized factors" consist of a pool of well-motivated employees who are college educated and can be used in a wide range of industries precisely because they are not narrowly specialized. Most nations have an abundance of generalized factors.

"Specialized factors" are more useful for sustaining or developing a competitive advantage than generalized factors, which support only rudimentary advantages during the early stages of development, which, over time, can be nullified or sourced through global corporate networks available in many nations.[34] Industries that depend on generalized factors for labor-intensive operations require workers with a low skill set, managerial positions, all of which are still valued within a nation; however, they could easily be outsourced to other countries.

Advanced specialized factors are key for developing and sustaining a competitive advantage and are hard to acquire and maintain because of the technology and financial capital needed to invest in education programs to create and sustain.

Demand

The second determinant in Porter's model is "demand." Most firms are most sensitive to the needs of their home market. Nations gain a competitive advantage in industries when the home demand gives them an early indication of the needs of buyers. The design of a product always mirrors the needs of the home market. A nation's firm is able to gain competitive advantage internationally if its domestic

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[34] Ibid., p78.

buyer demands either reflect or are a future indication of international need. However, the reverse is also true. If home demand is slow to reflect new needs of the international markets, it will translate into a competitive disadvantage. For example, the recent financial crisis created a demand for small, compact cars worldwide; however, in the United States, Americans have long preferred larger-sized automobiles, so car manufacturers satisfied the home demand.

If a firm's home market is significantly large and is able to satisfy its home demand, it may gain a competitive advantage over its competitors by achieving economies of scale. The firm would, further, get down the learning curve, devising ways in which a product can be developed more cheaply, thus allowing it to compete successfully with its competitors. On the other hand, if the home market is small and a firm can only satisfy its home demand, it is unlikely it will see a great return on its investment. Scale economies, in this case, could only be achieved by successfully competing against foreign rivals for a share of the international market.

In order to stay ahead of the competition, not only must firms develop a competitive advantage, they must sustain it over time. In order to do so, they must be motivated to continuously upgrade existing products, produce current products more cheaply than their competitors, or develop new products that command premium prices. A lot of products are created or upgraded because there is a growing demand, which usually begins when a nation experiences rapid economic growth. As income increases and more of the buyer's salary can be used for entertainment and leisure activities, the populace begins to demand specific and higher-quality items or goods. The Japanese, during the economic boom of the 1980s, for example, became very particular about buying high-quality electronics and audio equipment. Such equipment nowadays is considered a status symbol for them. Their desire for quality leads to rapid improvements by manufacturers for they want to meet the demand.

Related and Supporting Industries

Firms can gain a competitive advantage when internationally competitive suppliers or related industries are based on their home soil.[35] The main benefit to firms from working closely with such suppliers and related industries is that the firms find new methods and uncover opportunities for the use of new technologies to make their products more cheaply and efficiently. Home-based suppliers and related industries, in order to stay competitive worldwide, must continue to innovate and upgrade by devising new strategies or technologies for improving production and showing firms how their cost-effective inputs will help them to create a better product.

Suppliers

Suppliers help firms find new ways to incorporate existing and new technologies into the production line of a product. A competitive advantage accrues from the close working relationship with their suppliers that enables firms to gain "preferential treatment and early access to new ideas, insights and supplier innovation."[36] Suppliers and firms, if close enough, can in fact work together, bouncing new ideas off one another, engaging in joint problem solving, and

[35] Ibid., p100.

[36] Ibid., p103.

exchanging R&D, thus insuring that solutions to the most pressing issues can be solved faster and more efficiently:[37] shortened lines of communication become important to the process as a whole.

Having a competitive domestic supplier industry is, thus, far better than having to rely on qualified foreign suppliers. The cultural affinities between them offer both parties an instant bond and similar understanding of the ways in which the industry operates. These cultural similarities make the sharing of information more likely, since both parties have a vested interest in improving the country's economic well-being. It becomes a matter of pride, and transaction costs can be kept to a minimum. Foreign suppliers may also be under pressure from their home governments not to pass along sensitive technology that could spill over into strategic areas such as the military, especially if the nations are rivals or competitors. If a nation doesn't possess a strong industrial base, naturally a firm is left with no choice but to rely on foreign suppliers for the materials they need.

Related Industries

"Related industries" are those that that do not create the same products but do share similar production channels, which are extremely beneficial because they can learn each other's cost-saving strategies, which could help them make their products more cheaply or efficiently. Such sharing of activities can occur in technology development, manufacturing, and so on. Additionally, new technologies or product methods may in fact inspire the creation of entirely new product using the same

[37] Ibid., p103.

production channels and methods. For example, fax machines were created from the already-established distribution channels and similar technological inputs of copy machines.[38]

The benefits of both home-based suppliers and related industries, however, can only be reaped if other variables within Porter's diamond are strong. For example, if a nation contains a shortage of advanced factors, it will become difficult to satisfy domestic demand, which often alert firms to choose a new direction for product change. If such factors are unavailable, then proximity to internationally successful domestic suppliers may not be of much use.[39]

Firm Strategy, Structure and Rivalry

The fourth determinant mentioned in Porter's model for gaining a competitive advantage in industry involves the context in which firms are organized, managed, and in which they compete with one another (rivalry).[40] A firm's competition or rivals play a large role in influencing and motivating it to innovate or offer products with new features in order to satisfy a market demand, or to produce existing products more cheaply by developing scale economies. How efficient a firm will be at gaining an advantage over its competitors is largely determined by how suited its organizational structure and strategy are to competing and adapting to market demands in a given environment.

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[38] Ibid., p105.

[39] Ibid., p107.

[40] Michael Porter, *The Competitive Advantage of Nations* (New York: The Free Press, 1990), p107.

Different organizational structures and management systems lead to different methods for competing and different levels for success. “No managerial system is universally appropriate.”[41] For example, a family-owned business will compete differently than would a publicly owned company; each will be advantaged and disadvantaged in a variety of ways. Success emanates from having an organizational structure and management practices that are favorable or more conducive to competition within a given environment. Moreover, a given institutional structure can benefit from a competitive advantage in some industries and impede it in others.

However, a firm’s ability to compete may in fact have less to do with its organizational structures and practices if its national government plays an active role in manipulating competitive outcomes through enacting policies that advantage certain firms over others. The enacting of such policy tools as foreign exchange controls may not be favorable or in fact limit or ease the difficulty of domestic firms selling their products abroad. Italy has had difficulty competing in industries where FDI is essential for success because of government restrictions on foreign exchange.[42] Additionally, a country’s political views or actions are likely to some degree to affect how well its companies will do when trying to sell their products abroad. Switzerland’s and Sweden’s position of neutrality have helped them to establish international networks far easier than nations in politically and militarily sensitive industries.[43]

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[41] Ibid., p108.

[42] Ibid., p110.

[43] Ibid., p110.

Company Strategy and Goals

A company's strategy and goals are often determined by its ownership structure and the motivation of its shareholders. However, if the firm is publicly owned, its goals will reflect the interest of the state. Vast differences exist among nations with respect to goals of firms as well as the motivations of their employees and managers. "Nations will succeed in industries where the goals of owners and managers match the requirements of the industry."[44] Different managerial and organizational structures are more conducive to competing in certain industries and environments than others.

Management can be highly influential in motivating its employees. In other words, it is important that not only management have a vested interest in meeting company goals but that its employees do as well. Management can enhance its probability of success in an industry by setting up a reward system to motivate its employees through financial incentives to perform their tasks at the highest level. If a firm is lacking such a system, there is always concern about how much effort employees will expend to perform their job well, and much of an incentive exists for them to learn new skills that will help the firm to maintain or develop a competitive advantage. Promotions, bonuses, and pay raises remain a big motivator in the U.S. and many other Western countries, helping companies align their interests with those of their employees.

[44] Ibid., p112.

Domestic Rivalry

Strong empirical research exists that highlights the relationship between domestic rivalry and the creation and sustenance of competitive advantage in a given industry. Some scholars have argued that direct competition between firms is not as beneficial as it seems, for it leads to duplication. Also, the presence of many firms in an industry makes it difficult to achieve scale economies. This group of scholars sees domestic rivalry as a hindrance and therefore argues that nations ought to nurture one or two firms to become national industry leaders, and that, when they become strong enough to stand on their own two feet, these firms should compete internationally.[45]

Despite this view, evidence points to the contrary, because nations that have firms that are national leaders tend to have several local rivals, even in small countries such as Switzerland and Sweden.[46] Absent domestic competition, few national industry leaders have become internationally competitive. These rivals firms push one another, not only to improve the quality of their products and to create new ones, but also to lower the prices of their products. Still, improving technology will always lead to a sustainable advantage. In the face of such competition, companies will often look to sell their products abroad so they can achieve greater profit once economies of scale have been achieved at home, which will help make their products more competitive.

It is thus extremely rare that a firm can compete with other leading companies in the industry when it doesn't have adequate competition at home. In such cases,

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[45] The State Developmental approach scholars mentioned in the "Literature Review" section of this project advocate this point of view.

[46] Michael Porter, *The Competitive Advantage of Nations* (New York: The Free Press, 1990), p117.

industries are heavily subsidized and protected by their home countries. In fact, in such industries as aerospace and telecommunications, where there is only one national rival if any, the government plays a major role in influencing the competition through protection and nurturing.

Porter's work has been highly criticized for being more empirical than it sets out to be, which is to formulate a theory on measuring a nation's international competitiveness that is explanatory and possesses predictive power.[47] This criticism will not apply to this dissertation, which employs Porter's work, not for its elegance and precision, but only for its analysis of how state institutions put decision-makers in a position to enact policy that will influence the four major variables in the Porter model that are necessary for enhancing international competitiveness in the aviation industry. Porter's diamond actually groups the work of some of the most prominent scholars in the field of economics and development, including Adam Smith, Ricardo, and Schumpeter, into a diamond.

Scholars have also criticized Porter for choosing the firm as his unit of analysis rather than the state. As a result of this, his assumptions and conclusions have been questioned. Critics are quick to point out that Porter's analysis is far from sufficient at answering the broad and difficult questions related to the competitive advantages of nations.[48] This criticism will not apply to this project because my research builds on Porter's firm level variables by explicitly analyzing the role of the state and how

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[47] Robert Grant, "Porter's Competitive Advantage of Nations," *Strategic Management Journal* 12 (October 1991): 535-48.

[48] Terry Clark, "The Competitive Advantage of Nations Book Review," *Journal of Marketing* 55 (1991): 118-20.

successful it is likely to be at influencing those elements of society necessary for the building of a successful airliner.

Despite these criticisms, Porter's model has been widely applied, though many scholars have limited their analysis specifically to the firm level, with little to no mention of the government at all. They have neglected to recognize that the state is an important actor in influencing the variables of Porter's model. For example, Eoin O'Malley's article "Competitive Advantage in the Irish Indigenous Software Industry and the Role of Inward Foreign Direct Investment" looks at why that industry has grown at such an accelerated pace and has become internationally competitive. His research finds that the there is no single one reason for its success, which can be nonetheless be attributed to all four determinants in model.[49]

Similarly, Paul Curran's article "Competition in UK Higher Education: Competitive Advantage in the Research Assessment Exercise and Porter's Diamond Model" primarily focuses on the firm level as he examines why some institutions of Higher Education contain a large number of successful departments and others do not?[50] Curran's research has found that those institutions which house a large number of successful departments were best able to manipulate the variables in Porter's diamond.

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[49] Eion O'Malley, "Competitive Advantage in the Irish Indigenous Software Industry and the Role of Inward Foreign Direct Investment," *European Planning Studies* 9, no. 3 (2000): 303.

[50] Paul Currran, "Competition in UK Higher Education: Competitive Advantage in the Research Assessment Exercise and Porter's Diamond Model," *Higher Education Quarterly* 54, no. 4, (Oct. 2000):386.

Civil Aviation Literature

There is a vast amount of literature dealing with various aspects of competition in the civil aviation industry. For example, John Newhouse's book The Sporty Game is widely regarded as the best work to date portraying the fierce competition that has existed among American commercial jet manufacturers, airlines, and engine manufacturers in the aviation industry. Newhouse's research primarily focuses on the risks that commercial airplane manufacturers and designers take when building a new commercial jet.

Matthew Lynn's Birds of Prey Boeing vs. Airbus: A Battle for the Skies builds on the work of Newhouse by offering a historical account of how Airbus mounted a successful challenge to Boeing's dominance in the commercial aircraft industry. The book highlights how the arrival of Airbus turned an industry driven towards a monopoly into a duopoly.

While many scholars have covered the competition between American and European airplane manufacturers, very little has been written about China's airplane industry. To date, there has been one scholarly account, A Political Economy Analysis of China's Civil Aviation Industry, by Mark Dougan, who examines the changes that China's civil aviation industry has gone through since undergoing reform since the late 1970s. His main thesis is that this new environment can be explained with reference to four variables: marketization, destatization, decentralization, and globalization. The state now must be aware how the industry has changed, so it can better influence it in the future.

This dissertation will attempt to fill two gaps in the literature. First, my intention is to examine China's civilian industry, an area in which little scholarship exists. Second, little work has been done on what a nation must do to successfully build an indigenous airliner. This research will be the first of its kind to examine international competitiveness in the aviation industry through a theoretical lens that combines the work of Peter Evans's "Embedded Autonomy" and Michael Porter's "Determinant Model"; it meshes two theories from two unrelated fields to better understand and explain this phenomenon.

DISSERTATION RESEARCH QUESTIONS

This dissertation will look at whether or not China has the capability, given the nature of the state, to develop the firm level variables that are essential for success in the aviation industry, more specifically with respect to the construction of large-scale aircraft. Does China possess a reasonable degree of embedded autonomy sufficient to meet the special challenges of the aviation industry? Applying China's level of embedded autonomy to Porter's Determinant model will be particularly useful because the model has captured the various societal elements essential for success in the aviation industry. It lays out important variables that must be manipulated for continuously producing innovative aircraft that airlines want, need and desire.

This dissertation has two primary objectives. First, it will evaluate how competitive China's indigenous large passenger aircraft can be, which will be determined by the criterion for success mentioned in the beginning of this chapter. A state must be able to build a technologically advanced aircraft and produce enough of them as to develop economies of scale. Second, the author will evaluate how Boeing is planning to meet the potential challenge it will face from the arrival of China's large passenger aircraft.

THEORETICAL FRAMEWORK

The author will modify Evans's theory so that it goes beyond the institutional level and takes the organization and firm into account. Each state, whether it contains a higher level of autonomy or a higher level of embeddedness, or has the right balance of the two, influences the variables in Porter's model differently from other states. In other words, states possessing different institutional arrangements can influence to a greater or lesser degree the categories of Porter's diamond. The author will categorize, and compare and contrast, the institutional arrangements that existed in China in the 1980s with those that exist today, and consider how they influence the variables in Porter's model differently. Different levels of effectiveness with respect to developing a particular industry can be tied to differences in state internal structures.

Second, this project will modify one of the determinants in Porter's model dealing with domestic rivalry. Instead of focusing on rivalry among firms within states, which Porter emphasizes, this project will focus on competition among firms on the international level, because, when dealing with the aviation industry, it is safe to say that nations have one airliner company, if any, competing for international market share. Porter's determinant model focuses on how a firm can create a new and innovative product, or produce it cheaper than its competitors, so that it can profit;

there is no limit to how many firms could profit, however, when dealing with the aviation industries: only a few firms can survive.

SOURCES OF DATA

To conduct this study, the researcher has used both primary and secondary source data. Primary source data were obtained through conducting interviews and corresponding with professors, professionals, key figures, and scholars in the aviation industry in China, France and the United States. I am truly grateful for the help of my Chinese colleagues and mentors, Ming Xia and Danian Hu of the City University of New York (CUNY), for guiding and helping me set up interviews with key professionals and personnel in the aviation field, such as Professor Chengzhi Li, the Dean of Management and Humanities at the Institute of Beijing University's Department of Aeronautics and Astronautics, and Professor Baichun Zhan of the Chinese Academy of Natural Sciences. Both introduced me to their former students who are now working as scientists, as engineers, or in managerial and government jobs related to the aviation industry. I truly understand the sensitivity involved in sharing information with a foreigner on information related to China's past and present national secrets, and was lucky enough to be treated kindly and with respect by the interviewees. They were very happy to share information, especially if it could help with China's overall development.

I conducted open-ended interviews with some of the key figures in the industry, which allowed me to develop, adapt, and generate questions, and ask follow-up questions that were important for truly getting at the heart of knowing why China failed in its attempt to develop an indigenous airliner in the 1980s, and what they are doing differently today.[51] A questionnaire in the Appendix A section lists a set of preliminary questions that I asked my interviewees in order to open the dialogue.

Conducting field research on China's aviation industry was no easy task. For example, the building of the Y-10 was a highly secretive project, and even today very few publications are available for the public to research this topic. I was, however, fortunate enough to see the limited published material on the story of the Y-10 soon before it became unavailable in China, quickly removed from circulation and no longer available in China's collegiate, national, or local libraries. Many Chinese scholars and students alike believe that, as China moves closer the building of its C919 aircraft, which is part of China's national strategy and plan, any books revealing sensitive information about its prior shortcomings (which may in fact have never been resolved) have been sequestered. All of the open sources that I have consulted are listed in the bibliography.

For this study, the researcher also obtain secondary source data published daily, containing the most up-to-date information regarding the building of China's large passenger C919 aircraft, in newspapers and on Chinese websites. I also visited Beijing University's Aeronautics and Astronautics library to sample the vast array of resources available in books, government publications, scholarly articles and statistical data on China's aviation industry.

[51] Bruce Berg, *Qualitative Research Methods for the Social Science* (Massachusetts :Simon &Schuster, 1989), pp16-17.

Through my contacts, I have also been able to obtain an important primary source that is listed as classified. My source elaborates on the failures of China's strategy in the 1980s and what changes the Chinese government has made, and ought to make, to become more competitive in today's aviation industry. The source outlines the economic and military reasons why China decided to manufacture its aircraft, and what incentives it ought to award domestic airlines for purchasing Chinese-manufactured airplanes.

I spoke, and corresponded with, representatives from Boeing and Airbus as well, in order to better understand each company's relationship with China and its strategies for competing with the C919. My research also took me to Toulouse, France, to meet with representatives from Airbus in order to get a better idea of how Airbus was structured and managed, and to examine its strategies for competing with Boeing and China.

CHAPTER OUTLINE

Chapter 2 will analyze the evolution of the large passenger aircraft industry in chronological order. The history will be analyzed in order to explain how the industry acquired the special characteristics that shape its behavior today. It will elucidate how both Airbus and Boeing, each of whom occupies about 50 percent of the market, continue to compete with one another over market share as they have, over time, changed their strategies to adapt to the changes, demands, and challenges of competing in the industry.

Chapter 3 will apply the theoretical framework to China's first attempt at developing an indigenous large passenger aircraft (Y-10) in the 1980s. According to the criteria laid out by Evans, I will show how Mao's China could be categorized as a predatory state. The limitations of the policy choices available hindered the Chinese state's ability to satisfy Porter's model. Meeting the requirements of Porter's model is essential for developing the Aviation industry.

Chapter 4 applies the theoretical framework to China's development of its C919 aircraft. It classifies the Chinese state beginning under Deng as Intermediate. The intermediate state, according to Evans, oscillates between rule of law and rule of man. At times the state shows signs of being developmental, and, other times, predatory. An intermediate state has four different policy choices at its disposal to influence Porter's model, two of which, according to Evans, are important for the development of high-tech industries: midwifery and husbandry. Conversely, the demiurge and custodial roles run counter to the development of an industry. China has come a long way since its failed attempt at developing the Y-10, and it is likely to succeed in its initial development of the C919. It still, however, remains quite a long way from successfully competing with industry giants Boeing and Airbus because it has not been able to fully satisfy the requirements of Porter's model.

Chapter 6 will begin by discussing the strengths of the framework and how it has helped us to understand the remarkable strides China has made over the last three decades with respect to aircraft development. In the 1950s it relied solely on the Soviet Union for aircraft. China today--in part because of the reforms implemented under Deng--stands on the threshold of competing with Airbus and Boeing in the large passenger aircraft industry. This chapter will also examine the potential implications the C-919 will have on Boeing and Airbus and offer a viable strategy for competing against the heavily subsidized and protected aircraft.

The framework used in this project makes very clear that there are different levels of effectiveness with respect to the development of the commercial aviation industry that are tied to differences in the internal structures of states and their relationship to society.

The framework however, is not without weaknesses. This study will highlight important variables that were left out and that have clouded or impeded our understanding of why China was not successful at developing the Y-10 and may not be able to produce an internationally competitive aircraft in the future either. Lastly, this study, after refining the theoretical framework to account for its shortcomings, will consider how it can be applied in other areas of future research, such as the automobile and railway industries.

CHAPTER TWO

EVOLUTION OF THE LARGE AIRCRAFT INDUSTRY

Given the nature of the commercial aviation industry and its strategic importance to both the military and the overall health of the economy, the United States has over the years adopted an aviation policy that has ensured the survival and the success of its indigenous aerospace manufacturers. American aerospace firms provided aircraft for both the military and the commercial side of the industry. Understanding their importance to national security, the government has implemented policies to prevent the bankruptcy of these firms through various means, such as guaranteed military hardware contracts, capital for both civilian and defense research and development, bailouts when needed, and airline regulation. It was understood from the outset that technological developments on one side of the industry would certainly spill over to the other. Most innovative technologies over the last fifty years that have appeared on the commercial side of the industry, such as the jet-engine and the Internet were created through military-funded contracts.

Through regulation, the government still maintained an environment designed to stimulate innovation on the commercial side of the industry by rewarding aerospace manufacturers for introducing technologically innovative aircraft, as airlines purchased aircraft based on comfort and service to attract customers, and not price, since plane ticket prices were set by the government.

The American government's aviation policy has structured aircraft manufacturer competition in a way that has determined who the major players are, what their strategies must consist of to successfully compete with one another, and who the likely winners have been. Government policy, that is, has influenced outcomes. The free market played a reduced role in determining who the winners and losers in the industry would be as the government assumed a greater role in deciding how the competition functioned, forcing manufacturers to organize around competitive conditions created by it and not by the free market. This resulted in aircraft that were in demand by airlines that would not be satisfied by American aerospace manufacturers. American aviation policy tampered with the nature of free market, leaving market demands unsatisfied. These gaps in demand, largely unsatisfied by American aerospace manufacturers, created space for another aircraft manufacture to occupy. The European Consortium, Airbus, answered the call and developed the A300B. It did rely on the subsidization of its member governments to build such a plane. The U.S. government's tampering with the nature of the way manufacturers compete thus proved to be very costly, creating a viable competitor in an industry that was naturally driven toward a monopoly.

Past shortcomings and successes shape the future of this industry. The visible hand of government influencing how American manufacturers would compete lagged behind the new European entrant, as it will behind any potential new entrant, for two main reasons: because of the unique characteristics of the industry and because that newcomer will learn from the successes and failures of the prior industrial policy of its predecessors.

GOVERNMENT AIRLINE REGULATION

In 1938, the United States government declared the civil aviation industry a public utility, thus granting it the autonomy to exercise complete control over the industry. The United States government's policy of regulation shaped how the industry functioned for the first 40 years of its existence. The government saw the need to regulate because airlines would otherwise be solely interested in serving highly popular and profitable routes, leaving the less popular ones underserved. Moreover, if most airlines flocked to what they perceived as the most profitable routes, the industry would evolve into a monopoly, since the market was not large enough for more than one firm to profit in unrestricted competitive zone. The formation of a monopoly would also stymie the further development of a fledging industry, because, without competition, there is little incentive to create, innovate, or upgrade existing products. To prevent this problem, the government in 1958 placed the Civil Aeronautics Board (CAB) in charge of exercising a custodial role in which it determined routes flown by carriers, flight schedules, and the price of airline tickets.

To ensure the continuation of underserved routes, the government raised the ticket prices of the popularly traveled ones above market while keeping fares of the less profitable routes low. The busier routes thus made up for the losses sustained by the less popular, so airlines could continue servicing parts of the country that would probably have been discontinued if airlines have been left to compete through the invisible hand of the free market.

The government also set ticket prices across the board to prevent destructive competition from taking place in which bigger airlines could price their tickets below cost in order to gain a greater share of the market at the expense of smaller carriers who could not offered to take such a loss and would therefore have to leave the industry. Therefore, airlines were forced to compete with one another on the services and amenities they offered to passengers. Government- structured competition thus had a positive effect on technological development, because aircraft manufacturers were motivated to develop new planes based on improvements in speed and comfort.

Regulation of the airline industry through the 1980s thereby proved to be an indirect, unintentional, but significant source of public support for the post-war development of the civilian aircraft industry**.** The large regulated domestic market provided a strong base of demand for technological innovation by the aircraft producers. They knew that, if they came up with a highly innovative product that an airline purchased because it conferred an advantage over others in attracting new customers, those competing airlines would follow suit. None would dare to fall behind with respect to aircraft acquisition because of the potential loss in customer base.

On the other hand, this government-controlled competition proved a detriment to smaller airlines. Airlines with larger budgets were able to attract customers by offering fine dining and live entertainment, which included poker machines, piano bars, and musicians, etc.[52] This was beyond the reach of smaller carriers, which complained bitterly for regulation to be abandoned.

JET ENGINE TECHNOLOGY REVOLUTIONIZES THE INDUSTRY

The commercial aviation industry grew at a pace that it had never witnessed before in the years 1958-1968, largely due to Britain's introduction of the jet engine to the world. This technology was particular appealing to the airlines, because it meant that passengers would be able to reach their destinations in half the time that it took propeller driven engines; airlines possessing such technology would certainly be able to attract many new passengers, considering that the price of airline tickets would remain the same, which would create a potent advantage over the competition. The airlines also knew that, with the speed of the jet engine approximating 500 miles per hour, they could offer more flights per day with flexible scheduling, further expanding their customer base.

Airline manufacturers wanted to be the first one to introduce this jet-engine technology on their planes. If an airplane manufacturer is able to produce a technologically advanced plane faster than its competitors, it will seize a larger share of initial orders, which will bring it closer to developing scale economies and moving further down the learning curve, as a result of which it can produce its aircraft more cheaply and efficiently. Since the market for any type of aircraft is limited, such a first-mover advantage can make the difference between success and failure.

[52] Ibid., p78.

Britain introduced the de Havilland Comet, the first commercial jet airplane, to the world in 1952; it was powered by the pioneer of jet engine technology, Rolls Royce.[53] Orders for this plane were heavy among airlines, largely for two reasons: firstly, it was the most technologically advanced aircraft in the market, offering superior efficiency and passenger comfort; secondly, if one airline purchased the airplane, all of its competitors would be obliged do so, because they did not want to cede any advantages to their competitors.

Despite such high demand for the plane, the Comet fell short of gaining a strong foothold in the market due a series of fatal crashes in 1953 and 1954. The plane suffered from structural fatigue, which caused it to rip apart in midair.[54] Airlines canceled their orders, and the first long-range transport was seen as unreliable. The Comet's severely damaged reputation paved the way, however, for the safer and more efficient aircraft that Boeing would provide.

COMPETITION AMONG AMERICAN AIRCRAFT MANUFACTURERS

American aircraft manufacturers profited immensely from the military's voracious appetite for buying new aircraft during the Second World War. The military

[53] "Jet engines were able to increase the speed of an aircraft dramatically because it drew air into compressors and after being squeezed through normal atmospheric pressure, it was forced into a combustion chamber, where it is mixed with fuel and ignited. A portion of the burning gas drives a multi-bladed turbine, which in turn drives the compressors. The rest of the burning gas, expanding rapidly, is blasted out of the engine's exhaust nozzle. The apparent miracle of the air being exhausted at a speed higher than it was ingested pushed the airplane forward." John Newhouse, *The Sporty Game: The high risk competitive business of making and selling commercial airliners* (New York: Alfred A Knopf Inc, 1982), p111.

[54] Ibid., p123.

requested over 304,139 planes; money was pouring into the industry at the time.[55] However, after the war, demand for aircraft plummeted, and along with Allied Victory in 1945 came a major round of cutbacks in military orders, forcing aircraft manufacturers to scale back their production and workforce. Boeing, for example, closed a secondary plant in Wichita, and Seattle plant production was to be cut from 122 to just 22 planes a month. The workforce went from a peak of 45,000 to 15,000 in November 1945.[56] Boeing soon realized that it would have to explore other opportunities during peacetime should it want to sustain itself as a profit-making aerospace manufacturer. Many pioneering technologies had been developed by American aircraft manufacturers during their wartime effort for the United States military, which they would try to successfully exploit on the commercial side.

In 1952, Boeing decided it would attempt to develop a commercial jet air transport superior to, and more reliable than, the Comet. Boeing had acquired the skill and the technological know-how to develop a large jet engine transport with its work on two long-range bombers, the B47 and the B52, for the military when the government grew interested in containing the Soviet Union by acquiring bombers capable of delivering nuclear weapons anywhere in the world.[57] With government funding and access to German military technologies (Germany still claims today that it was the actual

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[55] Matthew Lynn, *Birds of Prey: Boeing Vs. Airbus: A Battle For the Skies* (New York: Basic Books, 1998), 48.

[56] Ibid., p50.

[57] "The B-47 was Boeing's first long range bomber that was capable of traveling over 600mph. The B-52 was a bomber with intercontinental range designed for delivering nuclear bombs to the Soviet Union." Mathew Lynn, *Birds of Prey: Boeing vs. Airbus, A Battle for the Skies* (New York: Basic Books, 1995), p51.

pioneer of jet engine technology) that the U.S. military had confiscated after the war, Boeing was able to mount a successful challenge to the Comet with its 707 commercial jet aircraft, with little of its own money or risk.[58]

The 707 was judged far superior to the Comet, not only because it possessed a lot of pioneering technology from government-supported research, but because it carried twice as many passengers as the Comet and traveled at a considerably faster speed.[59] Boeing had also intentionally designed the plane so that it could easily be converted into a cargo plane for the military. In fact, the United States military did buy several hundred of these planes, to be used as airborne fuel tankers. This helped Boeing get a step closer to the breakeven point, which takes nearly a decade to achieve; until then, the company would report losses. By the end of 1959, Boeing was recording a loss of almost $200 million on the 707 project. During the many years it wasn't profiting, the many military contracts it acquired provided a much-needed safety net that ensured Boeing would survive in the industry.

America thus supported its aircraft manufacturers by providing them with lucrative military contracts, especially when facing loss on the commercial side. The government would not allow a military defense contractor to fail. It was good for the development of military hardware to have several contractors to compete with one another for lucrative contracts. This would bring out the best in the firms, thus improving overall development of military hardware.

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[58] Kenny Kemp, *Flight of the Titans. Boeing, Airbus and the battle for the future of air travel*" (London: Virginia Books, 2006), p60.

[59] Boeing was also "able to find new ways of forging metal resulting in the vacuum melted steel that had excellent ductility and tensile strength higher than any other aircraft. This was some of the pioneering technologies created as a result of government supported research that would make its way into the 707.

Boeing was the first American manufacturer to introduce a jetliner, partly because then-current market leaders Douglas and Lockheed were skeptical about building a plane with the new jet engine technology in its infant stage, believing that suppliers and airlines would encounter many problems working with unproven technology. Douglas, also a major beneficiary of defense contracts and pioneering technology, was particularly hesitant to introduce any risky technology to the commercial side of the industry. First and foremost, its interest was to exploit the advantages it had over other firms with its existing aircraft. Douglas wanted to maintain and not jeopardize in any way its position as the leading company in commercial aviation production. Launching into the expensive and uncertain field of jet technology was extremely risky and could potentially damage its position in the market in relation to other companies if unsuccessful. In fact, both Douglas and Lockheed believed that the turbo-propeller and piston engines would prove to be more feasible and economical for airline carriers than jet-engine transports because of the high price tag associated with building and running such a technologically sophisticated piece of machinery: that is, the purchase price of the aircraft, along with the cost of the fuel, would make it unprofitable for airlines, considering that ticket prices were controlled. They assumed instead that many airlines would prefer the next generation of propeller engines, known as "turboprops," in which a more fuel-efficient gas turbine engine drives the propeller.[60] Both companies decided they would enter the fray only after jet-engine technology matured and proved reliable.

[60]John Newhouse, *The Sporty Game: The high risk competitive business of making and selling commercial airliners* (New York: Alfred A Knopf Inc, 1982), p111.

Both firms were incorrect in believing that most airlines would not buy jet-engine transports. Their analysis failed to take into consideration the fact that the American market was regulated, and that airlines therefore were competing with one another on product efficiency and passenger comfort. No airline that wanted to remain in business would want to surrender a service advantage to one of its competitors and so would therefore be drawn to jetliners at whatever cost. For example, in 1955 even though American Airlines was interested in turboprop planes, it decided to borrow heavily from the bank and purchase 30 Boeing 707s because its arch-rival, Pan American World Airways, had purchased 20 707s.[61] Jet-engine technology was certainly more appealing to customers than turboprop engines.

The loss of American Airlines as a loyal Douglas customer propelled Douglas into building its jet transport, the DC-8. Since World War II, Douglas held the dominant position as the leading aircraft manufacturer in the American market with its very successful propeller-driven plane, the DC-3. Because of the company's highly regarded reputation, when it decided to build a jet transport, 10 major airlines placed initial orders for it.[62] The jet-powered airplane known as the DC-8 was very expensive for Douglas to build; however, it managed to cover the costs through the profits it earned from the success of its older aircraft, its contracts with the military, and through borrowing money from banks and customer-advanced payments

[61] Laura Tyson, *Who's Bashing Whom? Trade Conflict in High-Technology Industries* (Washington D.C.: Institute for International Economics, 1992), p183.

[62] Ibid., p183.

In an attempt to lure customers away from Boeing, which was already further down the learning curve by having introduced its plane first, Douglas decided to price its aircraft below cost to promote the sale of the DC-8 and its smaller derivative, the DC-9. This strategy was a dismal failure, for such price cutting overstretched the company financially; in 1967, in order to stave off a Douglas bankruptcy, the government facilitated through federal loan guarantees a merger between Douglas, which specialized in civilian aircraft, and McDonnell, a major military contractor.[63]

Even though U.S. government policy isn't designed to ensure that American manufacturers succeed in the commercial sector, regardless of misdeeds they have committed and risky ventures they have taken on, if a firm is threatened with the possibility of bankruptcy, the government, unwilling to let a major defense contractor fail, will step in with a rescue option.[64] This was evident in the 1967 McDonnell Douglas merger. The makeshift strategy of shoring up a company too big and too important to fail emboldened American firms to partake in risky ventures that had the potential to yield large dividends. They would no longer be daunted by the fear of going out of business, at least as defense contractors. Not allowing firms to fail also rewards companies that have not adapted well to the demands of the market, in essence robbing market share from those firms that have adapted well to the market and met its demands.[65]

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[63] Ibid., p183.

[64] Laura Tyson, *Who's Bashing Whom? Trade Conflict in High-Technology Industries* (Washington D.C.: Institute for International Economics, 1992), p171.

[65] In recent years as a result of the 2008 Financial Crisis, the "Too Big to Fail" doctrine has been reborn; however, it is still heavily contested by free market advocates.

Wide-Body Aircraft Competition

More than 10 years after the original turbojet engine was built, its successor, the more powerful turbofan engine,[66] revolutionized the aviation industry, because it could power large wide-body jumbo aircraft capable of carrying hundreds of people at a time when passenger traffic was on the rise. This technological breakthrough was timely, because airlines, as a result of increased traffic, began competing with one another for limited runway space at airports--a problem that could easily be solved by increasing the size of the aircraft.

Though the turbofan was considered a British invention, its many deficiencies, such as fan overheating, excess weight, and aerodynamics limited the engine's use in the commercial industry. It wasn't until the Pentagon began looking for a new large jet transport that it recruited General Electric (GE) to remedy the deficiencies associated with the turbofan engine. With substantial monetary support from the government, General Electric was able to create a turbofan engine three times more powerful than any other. [67]

In the early 1960s, with reliable turbofan engine technology available, the Pentagon invited aircraft manufacturers to submit proposals for a large jet transport capable of rapidly deploying military personnel anywhere in the world during times of crisis. It sought a piece of machinery that could ship several hundred military men, and equipment, faster than any previous form of transportation. American aircraft

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[66] The Turbofan, created by Rolls Royce, was an engine capable of both pushing as well as pulling air with the intent of being able to provide greater thrust for large aircraft. Ibid., p184.

[67]Ibid., p185.

manufacturers Boeing, Lockheed, and McDonnell Douglas, with government financial support, would submit proposals for the C-5A project.

Though all manufacturers were bent on producing the best airframe for the military's jet transport, Secretary of Defense Robert McNamara chose the winner on the basis of cost-efficiency. Although Boeing's design was judged the best, Lockheed's proposal won out because it cost the Department of Defense the least amount of money to build while meeting the military's simple carrying-load and speed objectives. Lockheed's aircraft design was actually ranked last of the three proposals submitted.

Despite losing the C-5A bid, which eventually ended up being a big failure,[68] all three American manufacturers gained immensely from their work on the government-funded proposals. Several key inventions came out of that research, including the wide-body design that all three manufacturers attempted to exploit on the commercial side of the business. Another key innovation, incorporated into the Boeing 747, was having the "pod sprout from the top of the machine like a bruise on the head of a cartoon character."[69] This made it easier to load cargo on the plane if the front of the aircraft could be swung open.

As new technologies became available as a result of military research and hardware contracts it had funded, the government set its sights higher; it became interested in pursuing a jet capable of traveling at the speed of sound, the Supersonic Jet Transport (SST), believing this was the wave of the future.

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[68] The C-5A had cost the Pentagon nearly cost two times the amount that was expected. The plane was not of much use either because its size made it vulnerable to small arms fire. Matthew Lynn, *Birds of Prey: Boeing vs. Airbus, A Battle for the Skies* (New York: Four Walls Eight Windows, 1995), p85.

[69] Ibid., p88.

The Supersonic Jet-Transport

"American industrial policy was clearly motivated by military objectives, which often had unintended spillovers to the commercial side of the industry."[70] It was clear that the government wanted to ensure that its aerospace manufacturers remained in business at least as defense contractors. However, that did not prevent the exit of military suppliers from the commercial side of the industry. The only time the American government showed support on the commercial side of the industry was when President Kennedy publicly announced that the government would issue funding in support of the development of a supersonic jet transport, in direct response to the cooperative arrangement formed between Britain and France in the early 1960s to build such an advanced plane. Kennedy wanted to make sure that American manufacturers maintained their competitive edge against their Europeans and remained the commercial-technology leader of the world.

The United States did, however, terminate funding for the supersonic jet transport program in 1971, largely due to environmental issues that limited the plane to serving only overwater routes, thereby substantially shrinking the market demand for it. The government also realized that it wasn't economical for airlines to purchase the aircraft: The plane consumed an enormous amount of fuel,[71] especially in the late 1960s and early 1970s, when the price of oil soared.

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[70] Laura Tyson, *Who's Bashing Whom? Trade Conflict in High-Technology Industries* (Washington D.C.: Institute for International Economics, 1992), p172.

[71] Despite the fact that the Concorde would debut in 1976, it was judged a market failure because it just wasn't economically efficient for airlines to purchase. The Europeans missed their mark by losing sight of the economics of commercial aviation industry. Ibid., pp76-77.

Until the point of cancellation, the government spent more than $1 billion on the project. It left behind 13,000 pieces of hardware and 2,000 boxes of engineering data.[72] It wasn't a complete loss because the technologies and production skills derived from R&D in the project, and the C-5A competition, which consisted of 4,000 pages, containing engineering data and airframe designs with a price tag worth over $10 million, would make its way into future Boeing planes.[73]

The Boeing 747

Boeing was the first to capitalize on what it had learned from these government projects and produced a large jumbo aircraft plane, the 747. This plane happened to be one of the riskiest ventures in the history of aviation. Boeing decided to build it without conducting a detailed market analysis. If it had done so, it would have reached the conclusion that developing a plane that was too big for must commercial routes was a big mistake. However, Boeing was emboldened to take on the risk because it knew that the bulk of its business was with the military, and that, if the 747 project failed, the company would probably opt out only of the commercial side of the business. If the plane was successful, the company could grow to become a market leader. It knew that if Pan Am, its launch customer, took a chance on the plane and was successful, others would, for reasons already explained, follow suit.

Even though the U.S. government absorbed much of the Research and Development costs for this plane from the work Boeing had done previously in its pursuit

[72] Ibid., p73.

[73] Ibid., p84.

of the CA-5 contract, much of Boeing's own money was spent when the design of the plane changed while it was being built at the request of Pan- Am.[74]

The plane grew to be nearly three times its original size because Boeing agreed to meet Juan Trippe, the president of PanAm's, request for the design of the interior of the plane, which included a double-decker configuration, with larger seats and cargo containers lying side by side, with a hump-like upper deck that could be used either as first-class lounge or for additional seating. The plane was designed so that it could also be easily converted into a cargo plane as well, because there was still a fear that the plane might be rendered obsolete by the SST. Consequently, "these requests resulted in the plane growing to be more than 310,000 lbs, forty tons more than anticipated. As a result, Boeing needed an engine with 43,500 lbs of thrust."[75]

The increase in the size of the plane meant that Pratt and Whitney's engine (the JTD-9) lacked sufficient thrust to power the plane, which led to delays in the plane's delivery. Originally, Boeing had put itself in a tough position by agreeing to deliver the first 747 to Pan Am by November 1969. The delivery date left only 28 months to design the aircraft and a workable engine in two-thirds of the traditional time, which wasn't nearly enough.[76] Delays in deliveries of innovative aircraft translate into heavy losses for the airlines. They expect a certain amount of business at the time they acquire the aircraft.

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[74] The advantages of being a launch customer are that it possesses power and has say over how the product is made. Not only will the launch customer be the first to operate the plan thereby giving it a competitive advantage, but the plane is tailored made to suit its own wants and needs.

[75] Kenny Kemp, *Flight of the Titans. Boeing, Airbus and the battle for the future of air travel*" (London: Virginia Books, 2006), p111.

[76] John Newhouse, *The Sporty Game: The high risk competitive business of making and selling commercial airliners* (New York: Alfred A Knopf Inc, 1982), pp164-168.

If they don't receive it on time, they count it as a loss of money. Also, some older aircraft that would have been retired have to be expensively maintained.

Things got even worse for Boeing when a recession hit the country in 1968 during the Vietnam War and excessive government spending triggered inflation, resulting in a cancelation of a significant number of B747 orders. "At the beginning of 1968, the company had 328 aircraft orders worth $2.6 billion, and twelve months later the cushion was thinning as the number of orders receded to 164 aircraft."[77] Boeing feared that all ongoing orders would eventually be canceled.

With the 747 already costing Boeing an estimated $1.2 billion, three times more than Boeing's actual net worth, it was forced to lay off more than 64,000 people, from vice-presidents to unskilled laborers.[78] This helped it cut nearly $100 million from its payroll.[79] Boeing decided to make up for the reduced workforce by automating its production facilities, so that it could produce aircraft more quickly and efficiently.

Due to these changes Boeing had implemented, in 1970 Boeing was able to weather the storm and deliver its 747 plane to Pan Am. Boeing did however, have to pay late fees because it was not able to meet the agreed-upon date. Despite the twists and turns the plane has faced over the years, it has grown to be a safe, efficient, and reliable transport and has become the most profitable commercial aircraft ever made, largely due to it being a symbol of status and having been unrivaled for nearly 40 years.

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[77] Ibid., p94.

[78] Ibid., p186.

[79] Mathew Lynn, *Birds of Prey: Boeing vs. Airbus, A Battle for the Skies,* (New York: Four Walls Eight Windows, 1995), p99.

Lockheed versus Douglas

Despite Boeing's achievement, what the market actually demanded at that time was best articulated by Frank Kolk, the Technical Director of American Airlines in 1966, when he sent a message to all three American airplane manufacturers laying out the details of what he felt would best satisfy passenger growth then and in the future: a wide-body, double-aisle aircraft capable of carrying as many as 250 passengers a distance of 2,100 miles at subsonic speed.[80] The plane would have two large bypass engines, which would make the plane more fuel-efficient than any other in addition to carrying a lot of passengers, all of which would generate greater profit. Kolk understood that increasing the size of the plane would lower operating costs because, as the number of passengers a plane can carry rises, the cost to the airline for transporting each of them individually, which is known as the "passenger seat-mile cost," goes down.[81] This however, could be not marketed to attract more passengers in a regulated market. Comfort, speed, and reliability were appealing to the public, not how airlines could save money. Ticket prices were still being regulated by the government.

Both McDonnell Douglas and Lockheed decided in 1967 to build wide-bodied, mid-range airplanes although neither of their models resembled Kolk's airplane. The DC-10 and the L-1011 had three engines instead of two because many people in the airline industry, including pilots and executives, were worried by the idea of a wide-bodied airplane dependent on two engines. The two resulting aircraft were virtually

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[80] John Newhouse, *The Sporty Game: The high risk competitive business of making and selling commercial airliners* (New York: Alfred A Knopf Inc, 1982), p122.

[81] Ibid., p10.

indistinguishable from one another, which did not make sense because the market was not large enough for two mid-range, wide-bodied planes. However, both manufacturers were emboldened to enter this competition head on, without much worry, because they were secure in the belief that, if they failed on the commercial side of the industry, they would continue to profit from lucrative military defense contracts.

Duplication of aircraft would not likely have occurred in a deregulated market, as producers would have striven to introduce planes that offered greater benefits with respect to price or performance in the industry. Both aircraft manufacturers were able to take on such a risk because they were kept in business by massive military contracts.

Although Lockheed's plane was seen as being more aesthetically pleasing, McDonnell Douglas had developed a great reputation over the years; many airlines were attracted to their reliability and high-quality airplanes, and were aware that if both Lockheed and McDonnell Douglas split their orders, both manufacturers would have a hard time remaining in the industry. They also feared that, if one manufacturer left the industry, prices would be at the mercy of the surviving firm.

Due to the nature of the regulated market, airline carriers would choose the plane that possessed features they believed would inspire greater ticket sales. Orders for McDonnell Douglas and Lockheed were therefore split right down the middle and nearly bankrupted both firms, in addition to the sole engine producer for Lockheed, Rolls Royce. What kept McDonnell Douglas alive was the backlog of government contracts, including the 60 KC-10s that the Air force had purchased. "The KC-10 was virtually identical to the DC-10 (except for the additional of in-flight refueling equipment), and helped McDonnell Douglas keep its production line open until the market rebound in the late 1980s, allowing the development of its derivative the MD-11."[82]

"The collapse of Lockheed was temporarily averted thanks to the federal loan guarantee of $250 million."[83] Lockheed faced trouble when Rolls Royce went bankrupt; this delayed deliveries of planes--and other potential customers previously interested in Lockheed's L-1011 plane were turned off. The British government later agreed to take over Rolls Royce's aero-engine division and would continue to power the L-1011, but only if Lockheed was financially sound and protected by the government from going bankrupt. Congress approved a hotly contested $250 million loan guarantee for the company. President Nixon lobbied in favor of the loan because, if the TriStar failed, Lockheed would likely have gone out of business, and subcontractors, airlines, and banks would have stood to lose close to $1 billion that they had invested in the project. Also, if Lockheed had folded, an estimated 60,000 job would have been lost.[84]

Despite the loan administered by the government being a huge success, in that Lockheed was able to repay all it owed to the banks and to the government, it decided in December 1981 to exit the commercial industry and stop producing the unprofitable L-1011, since it had lost nearly $2.5 billion since it entered service in 1968.[85] The company

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[82] Laura Tyson, *Who's Bashing Whom? Trade Conflict in High-Technology Industries* (Washington D.C.: Institute for International Economics, 1992), p170.

[83] Ibid., p187.

[84] *Time*, Lockheed Bailout Battle, August 1971, http://www.time.com/time/magazine/article/0,9171,903076,00.html (accessed August 1, 2009).

[85] John Greenwald and Jerry Hannifin, "Catching a Falling Tri-Star", *Time*, December 21, 1981, page nr. http://www.time.com/time/magazine/article/0,9171,925159-2,00.html (accessed August 19th, 2009).

decided to channel all of its energies to defense production, which was far more profitable and reliable.

THE EUROPEAN CONSORTIUM: AIRBUS FILLS A NICHE IN THE MARKET

All three American aircraft manufacturers tried to capitalize on what they had learned from their contracts with and proposals to the U.S. military rather than strive to satisfy what the market demanded. Knowing that the government would guarantee their company's survival at least on the military side of the industry through the continuous and steady flow of military contracts, the aircraft manufacturers hardly thought twice about risking their commercial business, mainly because military contracts were so much more lucrative.

Companies competing in an unregulated market and according to free market principles would look to introduce aircraft to either satisfy a niche in the market not well served by existing firms, or produce an aircraft comparable to the most advanced of its kind, but to sell it more cheaply than the competition. Duplicating an already existing model aircraft, or producing an aircraft indistinguishable from a competitor's, would be ruinously risky--and an unlikely occurrence, because a free market is not large enough to support two planes of similar kind. Given the nature of government-structured competition, American aerospace companies looked to exploit advantages and new technologies developed from their extensive military contracts, and to introduce them to the commercial side of industry whether a demand for them existed or not.

Lockheed and Douglas both therefore developed a three-engine, mid-range, wide-bodied aircraft that was too large and not fuel efficient enough for most airlines to yield maximum profits. On the other hand, Boeing's 747, though a success, was judged too big for most routes. This left a huge hole in the market for a wide-bodied, two-engine aircraft, which was filled by a new entrant--Airbus, with its A300B model.

The Airbus Consortium was founded approximately 1 year after the British government formed a committee headed by Lord Plowden[86] to study why Britain had suffered grave setbacks and frustrations and continued to lag behind American suppliers despite having pioneered key technologies, such as the jet engine. The Plowden Report, as came to be known, appeared in December 1965 and revealed that the costs of making airplanes were 10 to 20 percent lower in the U.S. than in Britain because longer production runs allowed American companies to absorb the learning curve more rapidly."[87] Plowden recommended that, in order to meet this challenge successfully, European countries ought to seek greater collaboration with one another. Europe should pool all of its resources together and form a consortium of nations.

Though experience has proven that a multinational consortium consisting of several different countries with very different cultures and styles usually encounters great difficulty in reaching decisions, whether they are technical or marketing in nature, Airbus created a management scheme that worked. The consortium established a division of

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[86] Plowden began his Civil Service career as a Temporary Civil Servant at the Ministry of Economic Warfare (1939-1940) before moving to the Ministry of Aircraft Production (1940-46). Towards the end of his time at the Ministry he also served as Chief Executive and Member of the Aircraft Supply Council (1945-46). He then worked for a time in the Cabinet Office (1947), and then the Treasury (1947-53), as Chief Planning Officer and Chairman of the Economic Planning Board. Outside the Government, Plowden served as Vice-Chairman of the Temporary Council Committee of NATO (1951-52). On leaving the Treasury, Plowden became Adviser at the Atomic Energy Organization (1953-54), then Chairman of the Atomic Energy Authority (1954-59). "The Papers of Lord Plowden," on web, July, 7, 2009, (http://janus.lib.cam.ac.uk/db/node.xsp?id=EAD percent2FGBR percent2F0014 percent2FPLDN) p1.

[87] John Newhouse, *The Sporty Game: The high risk competitive business of making and selling commercial airliners* (New York: Alfred A Knopf Inc, 1982), p124.

labor among the member countries; in other words, each country would be responsible for building a specific part of the plane and then ship it in huge freighters to Toulouse, France, where the final assembly of the plane would take place. The French partner, Aerospatiale, was responsible for assembling the various parts into a completed airplane. "The wings were flown from England to Bremen for flaps and other accessories and then on to Toulouse. Eventually the airplane was flown to Hamburg to have the interior installed; it then returns to Toulouse where the customer test flies it and takes delivery."[88]

"Airbus would not have stood a chance against American producers without massive development and production support from its member nations,"[89] since a new firm in the industry is burdened with much higher production costs than incumbent firms, for it has not come down the learning curve; therefore, its products tend to be more expensive and less efficient. It is known throughout the industry that labor costs decline with the increase in the number of aircraft produced because workers learn as they work; they will make the product more efficiently and less costly. "There emerged the rule that with every doubling of the number of airplanes produced, a 20 percent reduction of direct labor is achieved."[90]

In order to offset the advantages of industry incumbents, the members of the European Consortium used taxpayer money to pay for the production and development costs associated with building their twin-jet aircraft, the A300, and its smaller derivative,

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[88] Ibid., p195.

[89] Laura Tyson, *Who's Bashing Whom? Trade Conflict in High-Technology Industries* (Washington D.C.: Institute for International Economics, 1992), p157.

[90] John Newhouse, *The Sporty Game: The high risk competitive business of making and selling commercial airliners* (New York: Alfred A Knopf Inc, 1982), p19.

the A300B. The expenses amounted to over $1 billion, which was originally divided among Britain, Germany, France, and other smaller countries in Europe; however, Britain opted out after it was offered an exclusive deal to power the L-1011.[91]

The Airbus 300B came out at the right time, because in the years following the Yom Kippur War (the mid-1970s), the world was experiencing a spike in fuel prices, which created a demand in the market for a fuel-efficient plane with substantial seating capacity. In actuality, the A300B, a twin-engine, wide- bodied airplane that resembled the plane Frank Kolk had requested several years before, was created to fill the market void.

It would take several years for the A300B to gain the confidence and the respect of American airlines before it became a success; it had to surmount a lot of obstacles along the way. Problems first began to surface when Airbus enlisted Rolls Royce to design an engine for the A300B airplane. Although Rolls committed to the Airbus project, it was offered a contract of exclusivity with Lockheed to design an engine for the wide-bodied TriStar, the L-1011. It had always been one of Rolls Royce's goals to secure a contract with an American airplane manufacturer, so it could gain a foothold in the American market.

In April 1969 Rolls Royce officially opted out of powering the A300B, which left Airbus with no other choice than to seek out a replacement engine. After temporarily suspending the program, it decided that the development of a new engine was not needed and that it would instead choose the GE CF6-50 engine (this engine also powered the DC-10), which reduced the plane's developmental costs and, it was believed, would

[91] Laura Tyson, *Who's Bashing Whom? Trade Conflict in High-Technology Industries* (Washington D.C.: Institute for International Economics, 1992), p172.

attract U.S. customers, for the plane now contained American components. The plane made its debut when Air France flew the A300B on May 24, 1974, in the midst of a recession.[92] Things began to look bleak for Airbus between the years 1975-1977, when the company failed to secure a single order for the A300B. However, during this economic downturn, Airbus did not lose sight of its goal of becoming a major player in the aviation industry and decided to work on new versions of the A300B, such as the smaller A310 derivative. It had confidence in its products and believed that airlines would soon take notice.

Airbus understood that it could only achieve great success if it could find a way to penetrate the large, seemingly impenetrable American market. After much effort, Airbus was only able to do so by offering the near-bankrupt Eastern Airlines an extremely attractive offer that no other aircraft manufacturer could match. The lucrative deal included a 6-month free trial period, operating cost guarantee, and favorable export credit terms.[93] The deal was very risky for Airbus because if the A300B failed to satisfy Eastern Airlines, the airline could return the aircraft, which could have caused severe damage to Airbus's reputation as a player in the commercial airline industry. However, the benefit of a successful deal was gaining entry and the respect of the American market.

After a successful 4-month trial, Eastern Airlines agreed to buy 23 planes from Airbus, with an option for 8 others, on April 6, 1978. Airbus was accused by American airplane manufacturers and members of the U.S. government of giving the plane away

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[92]Ibid., p194.

[93] Laura Tyson, *Who's Bashing Whom? Trade Conflict in High-Technology Industries,* (Washington D.C.: Institute for International Economics, 1992), p197.

and employing predatory policies just to be able to gain a foothold in the American market, as well as providing $96 million of its own money to secure the Eastern Airlines deal, which was covered by the members of the consortium.[94]

DEREGULATION OF THE AMERICAN MARKET

At the time of the Eastern Airlines purchase, the United States passed the Airline Deregulation act, which changed the way both aircraft manufacturers and airlines would compete with one another. "The act renounced the conventional view that the airline industry was a public utility," thereby removing governmental control over the industry except for safety-related issues.[95] The industry would henceforth function in accordance with free market economics, under which airlines can decide what routes to fly and at what price to offer tickets. Regulation was believed to be the main reason why much of the industry was operating at a loss. "By 1978 six of the original 16 trunkliners were history and no new trunkliners had been allowed to come into existence." The 10 that survived accounted for 90 percent of the air carrier market, mainly because they had been awarded busier and more lucrative routes than their competitors, who went bankrupt. However, regulation was ill-equipped to handle the energy crisis of 1974, which further exacerbated conditions in an airline industry operating $100 million in the red.[96] "Between 1969 and 1978, the price of jet fuel increased by 222 percent amounting to

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[94] Kenny Kemp*, Flight of the Titans. Boeing, Airbus and the battle for the future of air travel"* (London: Virginia Books, 2006), p116.

[95] John Newhouse, *The Sporty Game: The high risk competitive business of making and selling commercial airliners*, (New York: Alfred A Knopf Inc, 1982), p17.

[96] Ibid.

nearly one-fifth of operating costs and labor costs which accounted for 45 percent of airlines expenses."[97]

This forced the CAB to raise air ticket prices across the board. Due to high ticket prices set by the government because of the increased price of oil, airlines were operating their routes at less than 40 percent of capacity.[98] Even during the crisis in the absence of pricing flexibility, airlines competed with one another on service rather operating cost reductions. Planes were not purchased because they were fuel efficient or had low operating costs, but by their attractiveness to passengers. The CAB regulation forced airlines to compete on service rather than reductions in operating costs, which alone would not attract a greater amount of passengers

Deregulation changed the nature of competition at a time when fuel prices were uncontrollably high and so were air ticket prices. Airlines themselves were operating at loss because their acquisition of aircraft was based on pleasing the public. Deregulation was expected to lead airlines to purchase aircraft that were both fuel efficient and had low operating costs, thus allowing them to offer lower ticket prices to customers. Between 1976 and 1990, fares paid by passengers if adjusted for inflation decreased by 30 percent.[99] From 1974 to 2010, passenger growth has increased to 721.1 million. In 1974, the cheapest round-trip New York to Los Angeles flight, adjusted for inflation, was

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97 Richard H.K. Vietor, "Contrived Competition: Airline Deregulation, 1925-1988," *Business History Review* 64 , No. 1 (September 15, 1988): 75.

98 John W Barnum, "What Prompted Airline Deregulation 20 Years Ago?" Mcquire Woods, http://www.mcguirewoods.com/news-resources/item.asp?item=639 (accessed August 16th, 2010).

99 Alfred E. Kahn, "Airline Deregulation," Economics Library, http://www.econlib.org/library/Enc1/AirlineDeregulation.html (accessed June 19th, 2011).

$1,442. [100] Competition based on price and efficiency has increased the number of ticket sales across the board. Today one can fly the same route for approximately $268.[101] A deregulated market puts American aircraft manufacturers in a better position to compete with Airbus, because it forces them to refocus their attention on satisfying the actual demands of the market rather than what was rewarded in the structured competition by the American government.

DIFFERENCES IN INDUSTRIAL POLICIES OF BOEING AND AIRBUS

Airbus has become relevant in the aviation industry largely as a consequence of the failure of American firms to meet market demands largely because of regulation and the financial life preservers the American government provided to its aerospace manufacturers in the form of military contracts. The aviation industry, since the arrival of Airbus, has become more of a competition between industrial policies and government support measures that further the positions of their indigenous firms. The competition has now become international.

The differences in policy intervention between the United States and the European consortium reflect their different objectives. United States industrial policy with respect to the aviation industry has been traditionally designed first and foremost to meet its military objectives, with important spillovers trickling down to the commercial side of the industry. All of the nation's commercial aircraft producers have been major

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[100] Stephen Breyer, "Airline Deregulation, Revisted", *Bloomberg Businessweek*, June 10, 2010, http://www.businessweek.com/bwdaily/dnflash/content/jan2011/db20110120_138711.htm (accessed January 20, 2011).

[101] Ibid.

recipients of defense contracts that have yielded enormous profits and in turn animated the commercial side of the industry. On the other hand, the European consortium has designed its industrial policy mainly for reaching its commercial objectives, with potential spillovers going to their militaries. “Direct financial support in the form of subsidies has been the principal mechanism for which the European consortium has helped its Airbus program.”[102] A major advantage Airbus had over Boeing was that military aircraft were built based, not on cost efficiency, but on performance, which was a competitive disadvantage with the spike in oil prices the industry faced in the ‘70s and ‘80s.

Airbus Expands Policy to Include Commercial Diplomacy

Boeing and Airbus were competing, not only for markets within Europe and the United States, but for small third-world markets as well, which were usually government owned; the stakes for these orders were especially high, because with only 100 or so customers worldwide, each order can make the difference between profiting or failing in the industry.[103] Securing orders for aircraft, even if these airlines only purchase a few, also brings a manufacturer further down the learning curve because costs fall and product quality improves with increased sales.

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[102] Kenny Kemp, *Flight of the Titans. Boeing, Airbus and the battle for the future of air travel*” (London: Virginia Books, 2006), p172.

[103] Mathew Lynn, *Birds of Prey: Boeing vs. Airbus, A Battle for the Skies* (New York: Basic Books, 1995), p3.

Knowing the importance of the third-world market, Airbus introduced a new marketing strategy known as "commercial diplomacy" in order to entice buyers to purchase the A310 over its competitor, the Boeing 767. This strategy required the consortium to send political figures from its member countries to visit potential Airbus customers and attempt to get them to purchase aircraft by offering favorable foreign policy initiatives, inducements, and deal sweeteners.

This strategy was particularly successfully in 1980, when Boeing and Airbus were competing fiercely over sales of their wide-bodied twin-engine planes to countries in the Middle East. In order to tilt the playing field in Airbus's favor, President Giscard of France visited Kuwait on behalf of the consortium in 1980 to encourage his hosts to buy the A310. Giscard introduced a number of mutually beneficial business arrangements that the Kuwaitis were very interested in, including a French investment in a petrochemical plant in Kuwait. He also encouraged Kuwaiti investment in some real estate in Paris.

Even more influential in getting Middle Eastern countries to buy Airbus aircraft than tempting hosts with commercial ventures was what Giscard said in the Arab countries that he visited (Kuwait, Bahrain, Qatar, Abu Dhabi, Jordan, and Saudi Arabia). He told audiences what they wanted to hear, which was that Israel ought to withdraw from the Arab territories occupied since 1967; he was, he averred, a strong advocate of the Palestinian people's right to self-determination. Never had the chief of state of a Western nation been so outspoken in line with the prevailing view among Arabs in the

Middle East.[104] What the Arab world finds troubling about U.S. policy is its unwavering commitment and support for Israel and its people. The United States is viewed as being unsympathetic to the Palestinian cause. This was the game changer that encouraged Middle Eastern countries to purchase Airbus aircraft. It managed to secure 41 orders worth roughly $40 million per aircraft.[105]

AIRBUS CHALLENGES BOEING IN VARIOUS SECTORS OF THE MARKET

Airbus realized that, if it wanted to mount a serious challenge to Boeing, which owned 60 percent of the market in late 1980s, it would have to introduce technologically innovative aircraft at various ends of the market.[106] After surveying that market, Airbus believed that there was a demand for a 150-seat, narrow-body plane that would replace the aging B727.[107] Airbus saw this as a golden opportunity to introduce a technologically advanced aircraft to meet this demand, especially when the competition would produce derivatives of their previous narrow-body models. Boeing was acting with caution and would seek to maintain its position as the current industry leader by exploiting its large, dynamic scale economies rather than betting the commercial side of the company by

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[104] John Newhouse, *The Sporty Game: The high risk competitive business of making and selling commercial airliners* (New York: Alfred A Knopf Inc, 1982), p38.

[105]Ibid., pp30-31.

[106] John Newhouse, *Boeing Versus Airbus The Inside Story of the Greatest International Competition in Business* (New York: Random House Inc., 2007), p116.

[107] “The Boeing 727 is a mid-size, narrow-body, three-engine, T-tailed commercial jet airliner. The first Boeing 727 flew in 1963 and for over a decade it was the most produced commercial jet airliner in the world. When production ended in 1984, a total of 1,831 aircraft had been produced. The 727's sales record for the most jet airliners ever sold was broken in the early 1990s by its younger stablemate, the Boeing 737.” Guy Norris and Mark Wagner, *Modern Boeing Jetliners* (Osceola, WI: Motorbooks International, 1999), p110.

producing a technologically innovative aircraft. In its complacency it produced a derivative of the 727, the 737-400, in 1984. McDonnell Douglas was in no position to build a new aircraft because it had lost more than $1 billion and was now struggling to survive as a result of its competition with Lockheed. It would introduce a spinoff of the DC-9, the MD 80.[108]

Airbus capitalized on the financial advantages it had over its competitors to in fact produce the most technologically innovative aircraft of its time. Consortium members channeled nearly $2 billion toward the A320 and produced an aircraft that was considered generations ahead of both the MD 80 and the B737. A portion of the aircraft was built out of composite materials, which drastically reduced its weight, so that it would burn considerably less fuel than its competition; this was appealing to airlines at a time when oil prices had soared. Direct subsidies on the commercial side of the industry proved to be invaluable when the market demands cost-efficient aircraft. Aircraft designed for the military is primarily based on durability and performance rather than cost efficiency.

Some of the other never-seen-before technologies that the plane possessed included the fly-by-wire system. "The fly by wire system featured 5 main computers which operated the hydraulic jacks and all the primary and secondary flight controls. The system was so advanced that it would not permit the pilot to exceed the aircraft's limitations."[109] It was going to take some time before airlines and manufacturers would

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[108] Laura Tyson, *Who's Bashing Whom? Trade Conflict in High-Technology Industries* (Institute for International Economics: Washington DC, 1992), p190.

[109] Kenny Kemp, *Flight of the Titans. Boeing, Airbus and the battle for the future of air travel*" (London: Virginia Books, 2006), p125.

be able to convince pilots to give up full control of the cockpit. The pilots argued that, with the new fly-by-wire system, they would no longer be in full control of the aircraft, but mere servants of a computer. However, airlines became strong advocates of this technology because the computers could maneuver the aircraft in such a way that it would burn even less fuel.[110]

Airbus was able to score points over Boeing, not only because the A320 was more environmentally friendly, but because all of its planes shared commonality: They had similar flight decks and would require only limited additional training for pilots should they want to switch between operating an A300B to an A320. Since pilots earned over $130,000 a year, much of their time would be spent learning how to fly new planes, and with their salaries being an extremely expensive asset, airlines believed more of their time should be spent flying passengers from one destination to another. It would normally take a pilot as long as 25 days to learn about another aircraft.[111] Airbus had planned to build at least ten planes, consisting of different ranges, but they would share a high degree of commonality, which would save airlines a significant amount of money when it came to pilot training. Airbus calculated that the commonality that its family of aircraft possessed would save an airline approximately $1 million a year per aircraft.[112]

The A320 sold very well in the United States and around the world even before the plane debuted in the late 1980s, because Airbus was able to sell planes far more cheaply than its competitors, and because the price of oil skyrocketed in the mid-1970s;

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[110] Ibid., p126.

[111] Ibid., p 127.

[112] Ibid., p128.

the airlines were interested in energy- efficient planes. With the funding that it received, Airbus was able to leapfrog both Boeing and McDonnell Douglas in technology, thereby controlling the pace of what new technologies would be introduced in the 1980s.[113] The success of the A320 gave Airbus the confidence and the momentum it needed to mount a formable challenge to Boeing's throne.

The Battle for new Mid-Sized Aircraft

Throughout the 1980s, Boeing largely had the middle market to itself with its 757, a long, single-aisle plane able to seat between 218 and 304 passengers, along with its double-aisle 767 seating 181 passengers.[114] However, a new round of competition was sparked in the early 1990s when all three aircraft suppliers attempted to meet the new demand for replacing older wide-bodied aircraft (DC-10s and L-1011s).

In 1987, the European consortium decided that it would introduce two state-of-the-art medium-sized planes: the A330, which had two engines and was capable of carrying 335 passengers a distance of 4,800 miles; and the four-engine A340, which was capable of carrying 295 passengers over 7,000 miles.[115] However, due to the financial pressures felt by the consortium members with the introduction of the A320 only a year

[113] Laura Tyson, *Who's Bashing Whom? Trade Conflict in High-Technology Industries* (Institute for International Economics: Washington DC, 1992), p189.

[114] John Newhouse, *The Inside Story of the Greatest International Competition in Business. Boeing Versus Airbus* (New York: Random House Inc., 2007), p7.

[115] Ibid., pp190-191.

before the launch of the A330/340, they tightened the purse strings and agreed to cover 65 percent of the start-up costs, which amounted to $3 billion.[116]

The A330 and A340 become an instant hit with the airlines as they trounced the older Boeing 767 because they were 38 percent more fuel efficient than the wide-bodied Boeing airplane and possessed many of the A320's pioneering technologies, including the fly-by-wire system and the state-of-the-art flight deck.[117] Common features among the planes reduced design and engineering costs for the manufacturer, therefore making them cheaper for airlines to purchase. The launch of the A330/340 showed that Airbus could compete with Boeing in nearly every major sector of the market. By the end of the decade its market share had grown to around 20 percent.

McDonnell Douglas set out to compete against the A330/340 and strengthen its position in the market with the introduction of its MD-11, a three-engine wide-body derivative of the DC-10, which was composed of composite materials along with a stretched fuselage.[118] With demand for world aircraft in this range very high, McDonnell Douglas had accumulated enough orders to sell out the company's production capabilities through 1995. However, the McDonnell Douglas plane was plagued with technical and engineering deficiencies.[119]

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[116] Laura Tyson, *Who's Bashing Whom? Trade Conflict in High-Technology Industries* (Washington D.C.: Institute for International Economics, 1992), p174.

[117] Michele Maynard, "To Save Fuel, Airlines Find No Speck to Small," *New York Times*, June 11, 2008. http://www.nytimes.com/2008/06/11/business/11air.html (accessed July 1, 2009).

[118] Ibid., p190.

[119] Ibid., p191.

Because of these problems, the plane failed to meet its expected maximum flight range, thus resulting in American Airlines and other carriers canceling their orders. McDonnell Douglas was not able to solve its financial problems, especially after feeling the effects of huge cutbacks in military contracts; it was barely able to survive. The only alternative to going out of business was to merge with Boeing, a move orchestrated by the government in 1996.

Boeing entered the middle-market competition 2 years later with its new 777 model, a technologically advanced twin-engine airplane that can seat between 300 to 370 passengers. Boeing knew that, in competing for the narrow-body market, it had exerted too much caution by not introducing a technologically advanced model, thereby surrendering a good portion of the market to Airbus. Before building this aircraft, Boeing broke with its strategy of the past and solicited the advice of eight airlines, along with design teams to make decisions on important airframe features of the plane, including the wings and avionics.[120]

Boeing, faced with competing against Airbus subsidies in the commercial market and the shortcomings of building domestic versions of military planes with respect to cost efficiency, discovered another way to compete with Airbus. Risk was minimized in building innovative technologies associated with 777 by enlisting three major Japanese companies, Mitsubishi, Kawasaki, and Fuji, to build 20 percent of the airframe and fund a portion of the development costs.[121] This agreement was made to help offset the

[120] Ibid., p192.

[121] Kenny Kemp, *Flight of the Titans. Boeing, Airbus and the battle for the future of air travel*" (London: Virginia Books, 2006), p134.

development-subsidy advantages provided to Airbus, and to strengthen Boeing's position as the main aircraft supplier to Japan. The company could now take on risk without the fear that, if unsuccessful, it would have to exit the commercial-side of the industry. Boeing was also quick to make this deal with Japanese firms because they feared that a potential alliance might emerge between either McDonnell Douglas (prior to the merger) or Airbus and those firms. At the time the aircraft was ready to debut, American Airlines ordered the 777 as part of a $22 billion deal that included other Boeing aircraft as well.[122]

The plane made its debut in 1995, nearly 3 years after the A330/340; this worked to the advantage of Boeing, for it was then able to build a more advanced plane that could fly similar routes while carrying more passengers than the A330 and with two fewer engines than the A340. The plane possessed more computer technology and next-generation composite material than any other plane on the market. It adopted Airbus's computerized fly-by- wire system, but with a mechanical backup, so that the pilot could have the last say and directly take over the plane during an emergency.[123]

This plane that mainly competed with the A340, was judged more comfortable, and cost less to operate. By industry standards, the 777 was considered a much better airplane; it has outsold the A340 by a large margin.

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[122] Ibid., p192.

[123] John Newhouse, *The Inside Story of the Greatest International Competition in Business. Boeing Versus Airbus* (New York: Random House Inc., 2007), p106.

Forecasting the Future

By early in the 21st century, Boeing and Airbus had both introduced new aircraft that they believed would satisfy market demand over the next two decades. Airbus sought to challenge Boeing's unrivaled dominance in the large aircraft market by introducing its own behemoth the A380 to rival the 747. It believed that its jumbo transport, the A380, would satisfy the demand, expected to reach around 500 new aircraft, within the next 20 years. According to Airbus, this aircraft will be the choice of airlines all over the world because its operating costs would be 20 percent lower than those of the Boeing 747-400, and it will provide greater comfort for its passengers.[124] This is appealing to airlines because with lower operating and seat- mile costs, airlines will be able to lure customers their way by lowering ticket prices as much as 25 percent.[125]

Airbus believes that the A380 is timely because air traffic has been over saturated in most of large airports in the United States and around the world. Despite the growth in air traffic, there are still no plans in the works for expanding airport facilities anytime soon to meet the demand. Because airports can only absorb a certain number of take offs and landings in one day, they could not handle more flights than they already have. In order to circumvent this problem and still meet the growing demands of air travel, Airbus believes the only sensible thing to do is to build a large aircraft capable of transporting between 550 and 850 people to major hub cities.

[124] Ibid., p149.

[125] Ibid., p156.

Currently, more than 10 percent of flights at the world's busiest airport, England's Heathrow Airport, are Boeing 747 planes.[126] Since the A380 is 35 percent bigger than the 747-400, it will have 144 more seats and therefore will allow for 10 million more passengers to fly to and from the airport without adding any additional flights.[127] This will also create many jobs. "The Port Authority reports that with the increased traffic of the A380, it would bring 1,040 jobs and $82 million in annual economic activity to JFK."[128] Already, Airbus has spent $18 billion (35 percent of which has been picked up by consortium members) developing the 525-seat A380 and has already secured orders worth $65 billion at listed price.[129]

Contrary to Airbus's belief that the market will require large transport planes over the next 20 years to fly passengers to and from major hub cities, Boeing believes that it is more responsive to market trends because its 787 plane will fly about 300 passengers directly to where they want to go; they will not have to stop off at another city and take a connecting flight to their final destination. Passengers will not have to worry about missing their connecting flights and being stuck at an airport hub, or about whether their luggage makes it onto its connecting flight. Flying from hub to hub also nearly doubles the travel time of passengers headed to smaller cities, which is a major inconvenience for passengers. Congestion is at the hubs, not elsewhere.

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[126] Ibid., p31.

[127] Ibid., p157.

[128] Ibid., p160.

[129] "Airbus A380 Sales Pitch Frays," Bloomberg, www.gulfnews.com/business/Aviation/10296486.html (accessed July 1, 2009).

The Boeing 787, also known as the Dreamliner, intends to regain its position as the industry leader in the medium-range market that Airbus now holds with the A330, which has helped it to gain 50 percent of the civilian aviation market. The A330 took more than three-quarters of the midsize wide-body market, rendering the Boeing 767 obsolete; this proves that new planes can overtake a successful older model very quickly.[130] Boeing believes that, despite a three-year delay in its launch, when the plane debuts it will be competing against a middle-aged A330-200 that does not have the technological sweeteners the 787 will possess.

Boeing's new approach to develop new aircraft will help it to create the most technologically advanced plane to date. It created a new role for itself as systems integrator; Boeing outsources various parts of the plane, including the wings and the flight deck, to foreign companies all over the world, and then ships them back to the Everett Facility in Seattle for final assembly of the plane. Boeing, as systems integrator, shifts financial risk, to a much greater degree than it did when building the 777, to suppliers--especially the Japanese and Italians, because they are heavily subsidized by their governments.

The plane's price tag is expected to exceed $14 billion; this is much more than Boeing's net worth, but it understands that, in order to compete with Airbus, it must produce new and innovative aircraft.[131] Boeing also knows that it is the only remaining

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[130] Kenny Kemp, *Flight of the Titans. Boeing, Airbus and the battle for the future of air travel*" (London: Virginia Books, 2006), p213.

[131] John Newhouse, *The Inside Story of the Greatest International Competition in Business. Boeing Versus Airbus* (New York: Random House Inc., 2007), p27.

American commercial airplane manufacturer, and that, if it was in financial trouble, it is likely that the government would not let it go bankrupt, so it can take on greater risk.

Outsourcing has another advantage besides being cheaper and sharing risk; by contracting work to foreign companies, it encourages the governments of those nations to buy Boeing aircraft, since their indigenous companies are working on the product. This is another strategy employed by Boeing to gain greater market share: outsource in exchange for gaining market access to the suppliers' home countries. The problem with outsourcing keys parts of the aircraft, such as the wings and the fuselage, is that other countries gain the know-how and become familiar with these state-of-the-art technologies, so that Boeing can be potentially grooming future competitors.

The B-787's appeal extends beyond contracting foreign companies; it is depicted by industry specialists as an engineering marvel. Half of the 787's primary structure, including the entire fuselage, is built with composite materials, which was a first in the industry. The composites offer unique advantages in that they are lighter, which will lower operating costs by 20 percent over the A330.[132] Just as important to the aircraft carriers, composites are more durable than metal and don't corrode or fatigue as easily, saving a lot of money on maintenance and natural wear-and-tear.

Greater use of composites will also save airlines money by extending the time at which planes must get inspected from every 5 years to every 10. When planes are inspected, they get stripped down, and all of their systems are tested. Planes are as a result out of service for lengthy periods of time and not generating money for the carriers.

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[132] Kenny Kemp, *Flight of the Titans. Boeing, Airbus and the battle for the future of air travel*" (London: Virginia Books, 2006), p188.

Extending service requirements from every 5 years to every 10 will prove to be very cost-effective for airlines.

The 787 was also designed to appeal to its passengers. Its interior has levels of comfort that the industry has never seen before. The cabin has large windows, wider seats, and spacious aisles; it also has a new crystal lighting system that changes throughout the flight. There are improvements in cabin humidity and air quality, and more space is available in the overhead bins.

The plane has done remarkably well. It is scheduled to debut at the end of 2011 and has thus far secured more than 850 orders from over 56 different airlines.[133] The claim that people are more interested in flying directly to their final destinations, rather than hub-to-hub, appears accurate, because the 787 has outsold the A380 thus far. Orders, as of August 2011, have been 234 for the A380 and 896 for the Dreamliner.[134]

Airbus's 350 to Challenge the B787

In October 2005, Airbus made its intentions clear: It would also begin working on its new mid-ranged transport, the A350, which had a price tag of over $5.2 billion.[135] This 250- seat passenger plane, which is scheduled to debut in 2013, is intended to compete with the B777 and the B787 in the mid-range market. Over the next 20 years,

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[133] Bellamy Pailthorp, "No Takeoff in June For Boeing's 787," NPR News, http://www.publicbroadcasting.net/kplu/news.newsmain/article/0/0/1521492/U.S./No.Takeoff.in.June.for.Boeing's.787 (accessed June 24, 2009).

[134] James Connolly, "Boeing Dreamliner Vs. Airbus 380," Wikinvest, http://www.wikinvest.com/concept/Boeing_Dreamliner_vs._Airbus_A380 (accessed April 19, 2010).

[135] Kenny Kemp, *Flight of the Titans. Boeing, Airbus and the battle for the future of air travel*" (London: Virginia Books, 2006), p212.

airlines are expected to replace their old A330s and the B767s. Customers purchasing this new plane would benefit from an unmatched level of commonality that it will share with other members of the Airbus family (the A320, A330, A380, etc). “The A350 will be the first Airbus with both fuselage and wing structures that will be made primarily of carbon fibre-reinforced polymer.”[136] This airplane is being touted as more comfortable for passengers than the 787, for its seats will be larger and it will have more headroom.

Airbus’s decision to develop a second plane while it was developing the $16 billion A380 outraged Boeing, which knew this would not be possible without massive government subsidies that were no longer needed now that Airbus owned 50 percent of the market.

U.S. RESPONSE TO EUROPEAN SUBSIDIES

The United States largely ignored early European efforts to break into the civil aviation industry, through massive levels of financial support issued by the British and French and Germany, until Airbus began to make inroads in the U.S. market beginning with the deal it offered to Eastern Airlines. Airbus’s selling of its aircraft at heavily discounted rates created such a stir among American aircraft manufacturers that President Carter sought the help of GATT to address the issue of European subsidies and predatory export financing policies.

The matter was referred to GATT in 1979, and after much negotiation an agreement was reached between the European Commission and the United States. The

[136]Arun Rajagopal, “The Airliners of the Future from Airbus, Boeing,” Arun Rajagopa, http://arunrajagopal.com/2010/11/20/the-airliners-of-the-future-from-airbus-boeing-comac/ (accessed June 1, 2011).

key section that dealt with government support was in Article 6, which stipulated that the signatories in their participation in, or support of, civil aircraft shall seek to avoid adverse effects on trade in civil aircraft. It also stated that aircraft should be priced on a reasonable expectation of recoupment costs.[137] Lastly, it liberalized trade, which led to cross-national subcontracting and sourcing of components.

Despite the vague and ambiguous language, and the fact that the agreement did not spell out a ban on government subsidies, the head of the American negotiating team, Stephen Piper, reasonably expected the Europeans to terminate subsidizing Airbus. The Europeans, however, rejected the view that subsidies were restricted under this agreement and pointed to the language of "seek to avoid" and reasonable expectation used in the agreement" as a justification for still being able to support Airbus. [138]

The American government remained silent on the issue until the mid-1980s, when the consortium made further inroads in the U.S. market by selling its aircraft below cost to American airlines such as Pan Am and Northwest, which hurt American aircraft manufacturers. They lost market share as a result of such subsidies. Equally troubling was Airbus's announcement in 1985 that it would develop the A320, the most technologically advanced aircraft to date, which would rival the Boeing 727.

While the A320 was in its production phase, Airbus managed to secure orders around the world for the plane by offering special discounted rates. For example, in 1985 it offered to deliver Air India the A320 by 1989 and would lease B737s to Air India in the

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[137] Laura Tyson, *Who's Bashing Whom? Trade Conflict in High-Technology Industries*, (Institute for International Economics: Washington DC, 1992), pp201-202.

[138] Stephen Aris*, How Airbus Challenged America's domination of the skies Close to the Sun* (Great Britain: Aurum Press Ltd., 2002), p156.

meantime. Airbus covered 85 percent of the cost of the purchase.[139] Despite intense bickering on the part of American airplane manufacturers, the European Consortium remained unconcerned.

It wasn't until Ronald Reagan's much-publicized speech in 1985, in which he accused the European Consortium of unfair trading practices in the form of subsidies that had caused harm to American aircraft manufacturers that the Europeans went back to the negotiating table. In his speech, Reagan signaled his support for taking action to resolve this problem in the form of issuing a 301 suit.[140] The threat of such retaliation in the eyes of the Europeans caused great panic, because if such action were taken, it could severely injure the European economy.

The Europeans engaged in talks with the United States over the next 5 years more as a way to show their willingness to resolve the subsidy issue, so as to prevent any American retaliatory measures, than to reach any concrete agreement. In negotiations lasting from 1986 to 1991, not much was accomplished other than heated exchanges and controversy over one another's trading practices. Both the Americans and the Europeans hired economists and research analysts to highlight their points during bilateral negotiations.

In September 1990, the U.S. hired the services of Gellman Research Associates to bring to light the predatory practices of the European Consortium with respect to the

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[139] Laura Tyson, *Who's Bashing Whom? Trade Conflict in High-Technology Industries* (Institute for International Economics: Washington DC, 1992), p203.

[140] "A 301 action suit which would enable the United States to take countervailing measures against European goods by imposing duties or taxes on other European products…" Stephen Aris, *How Airbus Challenged America's domination of the skies Close to the Sun* (Great Britain: Aurum Press Ltd., 2002), p159.

aviation industry. Their report showed that, by 1989, Britain, Germany, and France of had given Airbus $13.5 billion; the breakdown was 58.9 percent from Germany, 25.1 percent from France, and 16 percent from Britain.[141] The study also calculated that the funds would have been worth more than $25.8 billion if member countries had borrowed the money at normal rates rather than it having it donated to Airbus by consortium members.[142] By the end of 1990, only a total of $500 million had been paid back. In short, it was the massive amounts of money ploughed into the making and sales of Airbus aircraft that had helped it to enter and remain in the commercial aircraft industry.

The report also examined the profitability of aircraft introduced by Airbus since its inception and came to the conclusion that there had not yet been a return on investment. The report arrived at this conclusion by looking at the prices airlines were paying for the planes and adding in estimates of the commercial cost of capital. Even with the amount of launch aid channeled toward the A300, A320 and the A330/340, the aircraft had sustained negative cash flow. "These losses had been compensated for in part by additional government support in the form of production subsidies and equity infusions to Airbus member companies."[143] It never generated enough returns to repay the initial investment fees.

The report also addressed the effects of European subsides on the American aviation industry and concluded that, if Airbus continued to sell at prices below what

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[141] Stephen Aris, *How Airbus Challenged America's domination of the skies Close to the Sun* (Great Britain: Aurum Press Ltd., 2002), p167.

[142] Mathew Lynn, *Birds of Prey: Boeing vs. Airbus, A Battle for the Skies* (New York: Four Walls Eight Windows, 1995), p189.

[143] Ibid., p190.

were necessary to generate a profit, U.S. firms would have to accept a loss in market share or begin to lower the price of their planes to meet the challenge. In either case, they will not only generate less profit but lose the ability to channel adequate funds toward R&D for the launching of new aircraft. This in fact could discourage, or even eliminate, the possibility of Boeing introducing technologically advanced aircraft, thus potentially robbing the economy of important spillover benefits resulting from the pioneering of key technologies that would otherwise be introduced by aircraft suppliers.

AIRBUS ACCUSATION OF U.S. INDIRECT SUBSIDIES

Airbus countered the Americans with a report of its own, in which its research revealed that, between 1978 and 1988, the U.S. government had channeled subsidies to Boeing and McDonnell Douglas. Nearly 65 percent of the $23 billion was allocated to the Defense Department to hire American manufacturers to work on research and development projects and contracting work related to aviation.[144] The rest of the money was contributed to NASA for research in aircraft development and space technologies. The benefits of indirect subsidies are not exact and are a lot harder to trace than those of direct subsidies.

FAILURE OF GATT AGREEMENT

After nearly five years of bilateral negotiations and not much accomplished, the issue was referred to the GATT by the United States. In 1992, before President George H.W. Bush left office, a bilateral agreement was reached between the European

[144] Ibid., p191.

Commission and the U.S. Trade Representative that capped development subsidies issued by governments at 33 percent for a new airplane.[145] Although Boeing wanted the government to fight for an outright ban on subsidies, it thought that a lower percentage was good first step. The agreement also did define subsidies as loans that had to be paid back with interest, but only if the airplane that was the recipient of the loan would profit.

Despite many government officials believing that the 1992 agreement was a step in the right direction, it still allowed Airbus to continue to subsidize aircraft, which worked to the disadvantage of Boeing. In early 1993 Airbus's market share was on the rise while Boeing's had plummeted, resulting in a decision to reduce its workforce by 28,000 people; President Clinton attributed much of the blame to the federal government's previous lack of support for its indigenous airplane manufacturers; in other words, how could the U.S. government allow Airbus to channel more than $26 billion into Airbus projects and do nothing about it? [146]

Clinton's willingness and determination to help the aviation industry, by doing something other than addressing the issue in GATT, was evident when he secured an additional $1 billion per year in NASA spending on research on civil aviation, specifically with respect to helping indigenous manufacturers regain their technological edge.[147] He also became the first president to lobby a foreign country (commercial diplomacy) for the purpose of securing orders for its indigenous aircraft suppliers.

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[145] John Newhouse, *The Inside Story of the Greatest International Competition in Business. Boeing Versus Airbus* (New York: Random House Inc., 2007), pp46-47.

[146] Ibid., p48.

[147] Mathew Lynn, *Birds of Prey: Boeing vs. Airbus, A Battle for the Skies*, (New York: Four Walls Eight Windows, 1995), p227.

In 1993, Clinton traveled to Saudi Arabia to meet with King Faud when he was made aware that the Saudi Arabian airline, Saudia, was interested in purchasing new planes expected to be worth $6 billion.[148] Clinton felt that the Saudis owed the Americans a favor for having liberated Kuwait from Iraq in 1990 and protecting Saudi oil fields; therefore, they should purchase American-made aircraft

Despite multiple visits from consortium members, including the German Vice-Chancellor and Foreign Affairs Minister, and even Prince Charles, President Clinton's superb negotiating skills landed the deal for Boeing. While the Europeans continued to express their support for the Palestinian cause, Clinton managed to one-up them by advocating a Western policy for stopping the war in Bosnia. "The Saudis see themselves as defenders of the Muslim faith and the suffering of the Bosnian Muslims in the civil war had attracted worldwide attention."[149] Clinton advocated a firm Western policy to stop the war in Bosnia. The Europeans had remained silent, and their refusal to take action against the Bosnian Serbs cinched the aircraft deal for the Americans.

Clinton's successor, George W. Bush, did little to follow in his footsteps with respect to the aviation industry. Even though he was much consumed by wars in Afghanistan and Iraq, the Bush administration did manage to instruct its U.S. Trade Representatives in 2004 to pursue all options to end the Airbus subsidy, including the filing of a WTO (the successor to GATT) case. The World Trade Organization handed down a ruling on this matter in June 2011 in support of the claim that consortium had illegally channeled approximately $18 billion in subsidies, which had caused great harm

[148] Ibid., p2.

[149] Ibid., p7.

to Boeing with respect to market share worldwide.[150] The WTO granted the European Union six months to either withdraw the subsidies or remove the effects of those subsidies.[151] Airbus has agreed to comply with the WTO ruling. According to Boeing, the WTO ruling has set a precedent on the harmful effects of launch-aid subsidies and should prevent Airbus from issuing launch aid for its A350 airplane. Boeing has claimed victory and believes that the last 40 years of subsidization of Airbus planes should come to an end. The playing field has become closer to level.

The WTO still has to deliver, in February 2012, its ruling on the Boeing appeal in February 2011, in which it will decide whether Boeing has channeled more than $5.3 billion in subsidies from federal and state governments as suggested by Airbus.

CONCLUSION

The unique characteristics of the aviation industry have provided a springboard for greater government intervention in the industry to ensure its proper functioning. In order to maintain some order, structure, and stability in an industry naturally driven toward a monopoly, the U.S. government declared aviation a public utility, enabling it to exercise control over the way airlines compete with one another for business. It set the price of airline tickets, assigned specific routes to airlines, and determined flight

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[150] Frank Jordans, "Boeing, Airbus Each Claim Win with Wto Ruling," MSNBC, http://www.msnbc.msn.com/id/43079916/ns/business-us_business/t/boeing-airbus-each-claim-win-wto-ruling/ (accessed May 20, 2011).

[151] Frank Jackman, "Eu Has Six Months to Withdraw Airbus Subsidies." Aviation Week (http://www.aviationweek.com/aw/generic/story_generic.jsp?channel=comm&id=news/awx/2011/06//awx_06_03_2011_p0-331052.xml&headline=EU percent20Has percent20Six percent20Months percent20To percent20Withdraw percent20Airbus percent20Subsidies (accessed June 12, 2011).

schedules and flight frequencies. This type of control set and defined the way airlines competed with one another. They acquired and upgraded their fleets based, not on planes with low operating costs, but on what services would attract the greatest number of passengers. Aircraft manufacturers themselves were encouraged to produce planes that provided added comfort and amenities, or build planes that would reduce travel time to passenger destinations.

Due to the nature of defined competition set by the government, American aircraft manufacturers converted military aircraft and technologies that were developed from lucrative defense contracts into commercial airplanes. The American government did sustain aircraft manufacturers' existence through the extensive and guaranteed military contracts they were given. If the industry allowed a monopoly to form, as was believed, without regulation, the surviving firm would become complacent, feeling no pressure to significantly upgrade its products and develop new ones, the motivation to produce without was competition lost. Having several American firms competing for lucrative military contracts would bring out the best in firms, which would directly translate into the development of advanced technologies. The military would suffer a huge blow should military contractors be allowed to go bankrupt.

In instances when the price of fuel was low and passenger growth was on the rise, aircraft built on performance would be in the interest of airlines. For example, the B707 was originally a plane built for the military, and because of its improved performance compared to its competition, it grew to be a huge success on the commercial side of the industry. When fuel prices soared in the late 1960s and early 1970s as a result of the Yom Kippur War, the government-regulated market proved inadequate at handling the task at hand. The industry experienced a loss of over $100 million in 1974. Even though the government raised the price of air tickets in conjunction with the price increase in oil, airlines still competed with one another by offering better services to attract more passengers. This put American aircraft manufacturer out of touch with what the industry actually demanded.

The government's structuring of the way airlines and aircraft manufacturers competed created a space for an aircraft manufacturer to produce fuel-efficient planes capable of carry 250 passengers. This is what the market demanded in the midst of a severe oil crisis. Such a plane, it was believed, would bring down costs immensely, so that airlines could a generate profit at a time when they were operating in the red.

The Airbus consortium capitalized on satisfying market demand by developing its A300 airplane. Airbus understood the unique economics of the industry and knew that, for it to successfully gain a foothold in this market, governments would have to heavily subsidize the development of its aircraft. Otherwise the entire company would have to be bet on this one aircraft, and the company itself would not have enough capital to fund its development. The return on investment for a commercial aircraft, if successful, would not be seen until at least a decade later. Therefore, a lot of capital was needed. The plane was able to successfully penetrate the market when Eastern Airlines was willing to take a chance with its plane. Others followed suit.

Instead of satisfying market demand, McDonnell Douglas and Lockheed produced planes that were nearly identical to one another. This would not have happened if both companies' survival had not been guaranteed by their extensive military contracts. Neither feared having to exit the commercial aviation industry, considering that the bulk of their profit was from their vast military contracts. If they had, they wouldn't have risked duplicating an existing aircraft or something that was similar to what its competitor would produce: Firms will rather seek to find a niche in the market unsatisfied by the competition. Both companies used technology learned from government-funded proposals they had submitted while vying for the CA-5 contract. McDonnell Douglass produced the DC-10, and Lockheed the L-1011. They practically split the market right down the middle, so neither could generate a profit. The market was not big enough for two planes of the same kind to profit. Because of the poor ways in which these aircraft manufacturers competed, Lockheed left the commercial industry in 1981, and MD merged with Boeing in 1997.

The American government, because of the vast difficulties airlines had with generating profit and the incredibly high ticket prices customers had to pay for air tickets, then deregulated the industry. This allowed airlines to compete with one another, not only on service, but on routes and ticket prices, and it changed the nature of the game, allowing airlines to acquire aircraft that were fuel efficient and had low operating costs. The industry was to function to a much greater degree according to free market principles. Aircraft manufacturers were now more inclined to produce aircraft that met the demands of the changing market. Even though Boeing is the nation's only commercial aircraft producer, it still competes with Lockheed for military defense contracts and at times can still capitalize by incorporating technological developments originating in the military into the commercial the industry. Since many of these technologies hinge on improvements in performance without taking cost efficiency into consideration, it may not be beneficial for the commercial side of the industry.

This has put Boeing at a competitive disadvantage with respect to Airbus, whose member nations channel money in the form of subsidies directly into producing technologies for the commercial side of the industry. Though its primary objective is the development of technologies for the commercial side of the industry, the military does stand to benefit from its pioneering technologies at times. The competition that has taken place between these two aircraft-producing giants has become more of a battle between their nations' industrial policies, and about whose policies are more effective for creating aircraft that meet the demand requirements of the airlines.

Because of the subsidy advantages Airbus has had, Boeing has enlisted foreign partners such as Japan to take on a percentage of the risk. In this way, Boeing can compete with Airbus by offsetting the potential risk of betting the company on the production of new aircraft.

On many occasions Boeing has argued that the amount of subsidies offered to Airbus vastly exceeds the benefits it itself receives from military contracts and NASA. Airbus, however, maintains that its subsidization is a direct reaction to the hidden subsidies that the military, government organizations, and state governments have offered to Boeing. Both firms, along with their respective countries, have filed suits with the WTO in order to organize the competition for market share in a stable, predictable, and fair way. Knowing that other aircraft manufacturers from countries, including China, will enter the aircraft development market, the creation of clear and well-defined rules about what is allowed and how competition ought to take place is in the interest of both Airbus and Boeing. The winner of market share competition should not be decided by which government channels more to its firms in pursuit of developing state-of-the-art aircraft for satisfying a niche in the market. The amount that nations channel toward aircraft development should be capped, and what subsidies are actually allowed and not allowed should be clearly identified. This ought to define the nature of future competition for current and future aircraft manufacturers.

CHAPTER THREE

THE DEVELOPMENT OF THE Y-10 PASSENGER AIRCRAFT

In 1970, China attempted to restore its dignity at home and internationally, after nearly a century of humiliation and embarrassment suffered at the hands of the West, by embarking on a strategy to achieve what only four other nations in the world have done: build a large state-of-the-art commercial aircraft. China's leaders desperately sought the creation of an indigenous large aircraft chiefly because of what the capability represented to the overall economic development of China and potential technological spillover benefits it would bring to its military industrial complex. If China were able to successfully develop a large and effective air transport service network, and build it using indigenous resources, it would signal to the rest of the world that China was a nation possessing great national strength and a well-developed economy capable of competing in a wide range of related industries and high technology products.

PREDATORY STATE UNDER MAO

As noted in Chapter 1, the essential feature of Evans's predatory state is that its leaders are unconstrained by law or regulation. The predatory state contains a system that prioritizes rule of man over rule of law, paving the way for massive amounts of corruption. It can undertake any course of action it chooses without any form of institutionalized negotiation with societal members.[152] Goals are not shaped by society. Leaders in the predatory state are not held accountable by the people and therefore become more interested in self-aggrandizement, which includes maximizing their power by silencing their opposition or enriching themselves by extracting resources for their own personal gain at the expense of society. In such a state, the governing elite plunder with little regard for the welfare of their people.[153] In this system, members of the governing elite are not chosen through meritocracy but by relations developed and solidified over the years with the most powerful person or people in government. Without the standardization and the legitimacy of rule of law, it is virtually impossible for business to flourish. Capitalism, and the market economy, can only exist with respect for private property and with laws dictating and protecting the exchange of goods. China, under the leadership of Mao Zedong, clearly met the criteria of a predatory state.

In 1949, Mao created a government that almost mirrored the governing apparatus of the Soviet Union, which favored highly centralized rule. It remains amazing how much power Mao was able reserve for himself. He designated himself chairman of the nation and could, at his own discretion, implement or repeal any law as he saw fit. "No other Communist government had such a position higher than the General Secretary or Chief Administrative Officer."[154] Basically, his power was unchecked, which invited a high degree of distrust among his colleagues and members of society. However, the Chinese people were accepting of such a predatory system mainly because of the historical

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[152] Peter Evans, *Embedded Autonomy* (New Jersey: Princeton University Press, 1995), p45.

[153] Ibid., p44.

[154] Kenneth Lieberthal, *Governing China: From Revolution Through Reform* (New York: W. W. Norton & Company, 2004), p85.

tradition of strong imperial rule; they also yearned for a strong charismatic figure to help bring them back from financial ruin and a history of foreign occupation.

Under the Maoist predatory system, market forces and material incentives were nonexistent. It was virtually impossible for an entrepreneurial class to emerge and further economic development, because Mao repealed all laws respecting private property or private ownership. There was also no international trade and minimal direct foreign investment, because contracts were not honored or respected. In a system that did not prioritize rule of law, investment in the nation would have been ruinously risky.

Mao relied on a small decision-making elite within the party to devise an economic policy which the government, through its vast bureaucratic institutions, would be responsible for carrying out. The party effectively controlled the state. Mao blamed China's backwardness on the greed of capitalism. China prevented the emergence of a capitalist class by employing the custodial role, which consists of policing or preventing the emergence of an entrepreneurial class. Without an entrepreneurial class, the roles of midwife and husbandry could not be played. However, Mao did adopt the demiurge role, which is common in a predatory state to rely on State-owned enterprises to carry out development of the country. Under predatory rule, people become much less productive as the incentive to work hard, create, and innovate was lost without respect for market principles and rule of law.

The ruling elite responsible for creating policy consisted of Mao's most trusted colleagues and advisors, chosen for positions of prominence within the party because of the service they had provided to their country in helping to defeat both the Japanese and the Nationalist Party. Most of those leaders had fought side by side with Mao for many years and developed a personal bond with him on the battlefield. Positions in the party and the government were thus determined more by one's contacts and connections than by rule-based, competitive procedures. The Chinese system lacked a recruitment process based on merit where an exam would be administered that was open to all to attract the country's best and brightest people to occupy important positions in government to chart a path for development.

As Chairman, Mao ensured his power was supreme and made all important decisions for China. At all Party meetings, he would sum up the main points of the discussions, and, more often than not, the summations he arrived at were very different from the conclusions that ought to have been reached at the meeting.[155] He used this venue as a platform to get his ideas and important points out to his compatriots. Mao also passed a directive order in 1953 stipulating that that no document issued in the name of the Communist Party could become a legitimate law unless he approved it.[156] Mao intervened in all matters that dealt with China's national plan.

Those who diverted from the Maoist agenda, openly spoke out, or were critical of him were jailed or punished in the most severe ways. For example, at the Lushan Conference, Peng Duhai, who was Minister of Defense and Vice-Chairman of the Military Affairs Commission, took the liberty of severely criticizing the Great Leap Forward initiative, stating that such a dismal policy had been launched with a clear and total disregard for the consultative decision-making process that the leadership was supposed to follow in accordance with the original constitution drafted in the 1954. He,

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[155] Ibid., p85.

[156] Ibid., p85.

as well many others members of the Party, believed that Mao ignored the Constitution of 1954 because he wanted to make sure that no document would erode his power. Peng and his supporters believed that the country was facing an impending crisis because of the conditions created by the Great Leap Forward.[157]

Though Mao encouraged his critics to speak out at the Lushan Conference, he took these attacks on the Great Leap Forward as a personal attack on him. After they spoke, he attacked them and accused them of being antirevolutionary. He demanded that all of the other officials attending the conference raise their hands if they agreed and supported Peng's verbiage. "Under this pressure, the party leadership sided overwhelmingly with Mao and branded Peng and some others an 'antiparty group.' These individuals were purged."[158] This incident changed the rules with respect to debates among leaders. Prior to the Lushan Conference, debate was allowed and expected at high-level meetings before decisions were made. The purge of Peng suggested it was no longer possible.

By the end of the Mao era, China was left in dire straits. All independent media sources were suppressed, and people feared expressing thoughts or opinions that differed from those of the party. The interests of the people were not well represented because the leaders were not held accountable to the people. There were no laws in place constraining Mao from doing virtually what he wanted. The Chinese people, and the leaders themselves, saw China's predicament of millions having died from the Great Leap Forward, and millions of intellectuals having been purged--as a system failure. Rule

[157] Ibid., p107.

[158] Ibid., p107.

of law did not prevail, thus inviting corruption and disastrous policies as power was unchecked and unresponsive to the needs of the people. As in the Cultural Revolution, members of society that actively spoke out or were perceived as embracing capitalism were deemed enemies of the revolution and were either killed or sent to the countryside to be reeducated.

PORTERS DETERMINANT MODEL AND ITS APPLICATION TO THE Y-10

DEMAND FOR THE Y-10

According to Porter's Demand variable, a nation's home market gives local firms an early indication of wants and needs.[159] As noted in the first chapter, in order for a firm to stay ahead of its competition, it must be motivated to continuously upgrade existing products and make them more cheaply than its competitors can offer. Products are usually upgraded to meet the demands of its home market. When a nation experiences a high level of economic growth, consumer salaries increase and create disposable income. This leads to such consumer demand for higher-quality products.

The decision to the develop China's Y-10 aircraft was in direct contradiction of what Porter's demand determinant advises. Mao Zedong- along with an upper echelon of elites in the party, decided to launch the production of a large indigenous passenger aircraft mainly to indulge a sense of pride associated with having a civilian air transport system, and so Chinese leaders could travel abroad on a domestically made aircraft. To a

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[159] Michael Porter, *The Competitive Advantage of Nations* (New York: The Free Press, 1990), p86.

much lesser degree they also realized the potential spillover benefits it would bring to the military.

Both Premier Zhou Enlai and the Minister of Foreign Affairs Chen Yi believed that flying to foreign countries on foreign-brand aircraft showed China's inferior status vis-à-vis developed and industrialized countries. It was incomprehensible that China did not have a domestically built commercial jet, considering it was already able to mass-produce military jet aircraft, including the J-5 in the early 1950s, and built the H-6 military aircraft in the later 1960s.

At the time, still only four nations possessed the technological capacity and expertise to manufacturer their own airliner: the United States, the Soviet Union, France, and the United Kingdom. China was bent on becoming the fifth.

Differences between Civil and Military Aircraft

China's elites failed to realize that there are major differences between developing civilian and military aircraft. Having mass-produced military aircraft doesn't necessarily translate into commercial success. The emphasis in military transport aircraft lies predominantly on battle-field requirements, such as take-offs and landings.[160] Greater attention is paid to speed, and there is less concern over fuel consumption, passenger comfort, safety, and noise pollution as with commercial aircraft. Military aircraft are

[160] Feng Lu, "China's Large Aircraft Development Strategy Research Report," ("Zhongguo Dafeiji Fazhan Zhanlve Yanjiu Baogao"), *Business Watch Magazine*, (Shangwu Zhoukan), 2005, p38.

built for warfare, and wear-and-tear is expected. By contrast, civilian aircraft have traditionally been built for longevity and for profit.[161]

To meet their different objectives, the planes are built very differently. A large military transport has a fuselage closer to the ground, so that cargo and troops can easily be unloaded even in harsh weather.[162] The wings cannot be close to the engine, because landing the aircraft can damage the aircraft due to the sand and gravel entering the engine. On the other hand, passenger aircraft are constructed with the engine beneath the wing to achieve a reduction in cabin noise. There is also greater emphasis on passenger comfort.[163] Aircraft safety measures are stricter in civilian planes; the foremost concern is to protect life. Basically, civil aircraft are built to face market competition, which was absent in China.[164]

Without prior experience or a niche in the market to satisfy, producing a civilian aircraft would prove to be extremely difficult for the Chinese to build. The Chinese did not possess the technological capability to produce a fuel efficient airplane or engine and lacked the ability to adequate test a commercial aircraft to ensure passenger safety. China's experience with building aircraft was based on reassembling licensed knockdown military aircraft provided by the Russians during the mid-twentieth century. The Russians did not teach the Chinese how to design aircraft; the Chinese at best were able

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[161] Ibid., p10.

[162] Personal Interview with Professor Chengzi Li, (expert on technology policy and management) of Beihang University, School of Aeronautics and Astronautics, on August 18, 2009.

[163] Ibid.

[164] Ibid.

to replicate unsophisticated Soviet aircraft with the licensed blueprints provided by the Russians.

Top-Down Decision-Making

The decision to launch the Y-10's development did not reflect a growing demand by the populace for air travel because the country was not witnessing high economic growth and an increase in income. Contrary to what Porter's model describes as the case for development of an industry, at the time of the project's launch in 1970, the Chinese people were still struggling to survive, as the country's Gross National Income per person was only 235 Yuan ($95) per year, as shown in Appendix B-1.[165] China's GDP per capita in 1970 was $111.82, ranking 114 out of 128 countries listed and way below the world average of $952.13.[166] People faced harsh living conditions, so travel by air was not on the radar for most of the citizens of China; in fact, they were in dire need of basic life necessities. Even in 1978, just 2 years before the Yunshi 10 took its maiden flight, the average person was only earning 343 Yuan ($204) per year, with living expenses hovering around 311 Yuan ($185).[167] They still could not afford a plane ticket and, even if they could afford airfare, it would not have mattered because flying was a luxury reserved for Chinese leaders and officials.

[165] Jiacheng, Zheng, *Statistical Yearbook of China*, (Zhongguo Tonji Nianjian), (Beijing: China Statistical Publishing House, 1999), (Beijing Zhonggup Tonji Nianjian Chubanshe, 1999), p32.

[166] "Nation Master," Nation Master, http://www.nationmaster.com/graph/eco_gdp_percap-economy-gdp-per-capita&date=1970 (accessed July 17, 2010).

[167] "Statistics of Henan Province Network," HA Stats, http://www.ha.stats.gov.cn/hntj/lib/tjnj/2009/html/1001.html (accessed June 19, 2011).

The year before the central government approved the Y-10, demand was very low, as only 16,788 flights took off, carrying a total of 26,400 people, mainly consisting of party elites and government officials who enjoyed the luxury of traveling by air for free. Even by 1978, just 2 years before the plane took its maiden flight, civil aviation only accounted for 0.1 percent of total passenger traffic and .001 percent of total freight traffic.[168] The main method of transport was rail, with water playing subsidiary roles, as shown in appendix B-2.[169] Clearly, the decision to launch the Y-10 was made at the expense of the people, as massive amounts of money and resource were channeled toward this project.

FACTOR CONDITIONS FOR THE Y-10

Porter notes that the most important factors for creating and sustaining an industry are advanced specialized factors. Advanced specialized factors are the engines driving the creation of differentiated or new products, new features on existing products, and proprietary production technology. These specialized factors have a narrowly specific skill set for a particular field of industry. It is, however, a huge commitment on the part of a nation to develop its specialized advanced factors. They require modern institutions and facilities, along with a pool of educated personnel capable of developing, training, educating, and upgrading their specialized factors. "Competitive advantage

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[168] Jiacheng, Zheng, *Statistical Yearbook of China*, (Zhongguo Tonji Nianjian), (Beijing: China Statistical Publishing House, 1999) (Beijing Zhonggup Tonji Nianjian Chubanshe, 1999), p505.

[169] Planning & Development Department of Civil Aviation Administration, (Zhongguo Minyong Hangkong Zongju Guihua Fazhan Si), (*Statistical Data on Civil Aviation of China (2004*), (*Cong Tong Ji Kan Min Hang (2004*), (China Civil Aviation Publishing House, 2004), (Zhongguo Minhang Chubanshe, 2004), pp20-21.

doesn’t come from just one time investment but continual reinvestment to upgrade their quality not to mention keeping the current pool of factors from depreciating.”[170] China, during the Mao era, was unable do so, thus contributing to its inability to create and sustain a modern, large indigenous passenger aircraft.

What Porter’s model doesn’t address, though it is not important for this case, is what percentage of highly- skilled personnel a nation needs to develop an industry, and what specific curriculum or training is most conducive to developing and sustaining a competitive advantage.

Education System during the Pre-Reform Era

During the Mao era, China embarked on a series of social experiments on a scale unmatched in human history, which included the Hundred Flowers Campaign, the Great Leap Forward, and the Great Proletariat Cultural Revolution, which set China back with respect to development several decades vis-à-vis Western industrialized nations. The implementation of these massive social experiments led to China losing nearly a generation of students with specific and highly specialized skills important for the development of the country.

Mao’s Revolutionary Ideals

Mao strongly believed that it was feasible to achieve rapid economic development while creating an egalitarian society, if pursued correctly; he believed that mobilizing the masses around his revolutionary ideals would produce greater economic development for

[170] Ibid., p80.

the Chinese than training and educating generations of Chinese in highly specialized fields. Ideological fervor that could be realized through properly educating the masses was more important for industrialization than would be the purchasing, or developing large physical assets and training a select few in advanced specialized knowledge.[171]

Mao also believed that, if much of China's population could develop rudimentary knowledge in field in demand or an elementary education, the return on investment would exceed that if resources were channeled toward advancing specialized knowledge for a few. It is more beneficial to have a large number of industrial workers improve their technical skills than for a few laborers to possess a very modern skill set.[172]

Mao believed a lot of knowledge could be gained from job experience because, as one's job duties become repetitious, the worker would be able to devise ways in which they could produce goods more efficiently. This would basically stimulate worker curiosity, making them more innovative, and result in the continual upgrading of skills in the workforce. Worker motivation would also be stimulated by the quotas demanded by the planners, and these expectations would continue to increase as workers became more familiar with their jobs, because they were expected to produce more over a shorter amount of time. This was in direct contradiction of Porter's diamond model, which advocates nations developing their science and technology fields in order to modernize.

In order to further carry out its commitment to the Marxist-Leninist experiment, China enlisted the help of the Soviet Union, a nation with over 30 years of experience

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[171] "More On Promoting the Concept of Public," *Beijing Review* 9, no. 46 (1966): 20.

[172] Fred Herschede, "Chinese Education and Economic Development: An Analysis of Mao Zedong's (mao Tse-Tung's) Contributions," *The journal of Developing Areas* 14, no. 4 (July 1980): 440.

with communist construction and development. Prior to Mao's mass mobilization campaigns it not only copied the Soviet Union's central planning system, but the structure and process of higher education as well. China's education system practically looked more and more like the Soviet's beginning in the mid-1950s.The Chinese didn't just build new schools but merged similar departments from various schools into mono-disciplinary colleges as the Soviets had instructed.[173] For example, the East China University of Science and Technology, originally named East China Institute of Chemical Technology (华东化工学院), founded in 1952, was the first single-subject institution serving China, after merging the chemistry departments of various schools in China including National Chiaotung University, Université d'Aurora, Utopia University, Soochow University, and Yangtze University.[174] Also in 1952, the Beijing University of Aeronautics and Astronautics was established by consolidating aviation-related departments of Tsinghua University, Peiyang University, and Xiamen University, etc.

Not only was this process encouraged by the Russians, but it allowed Chinese government to assert greater control over the direction of key industries like chemistry and aviation. This would lead to be better coordination and efficiency in the use of state resources while resulting in less duplication and waste.

The Chinese also followed the footsteps of the Soviet Union by eliminating humanities courses and departments from the college curriculum. Many departments, like Political Science, were cut because the government didn't want to teach Western political

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[173] Ibid.

[174] "A Brief Introduction to East China University of Science and Technology," (Hua Dong Li Gong Da Xue Xue Xiao Jian Jie*), East China University of Science and Technology*, (Hua Dong Li Gong Da Xue), August 20, 2010, (http://www.ecust.edu.cn/s/2/t/94/p/1/c/33/d/48/list.htm).

science and humanities courses, since they was deemed unimportant to the development of China. They could also have potentially caused problems for the government by opening students' minds to counter-revolutionary ideas. Students were encouraged to study engineering and the natural sciences, which was considered the most effective way to contribute to the country's economic development.

While Porter's factor conditions highlight the importance of continuously upgrading and improving knowledge in the engineering and science fields in order to stay ahead of the competition, his model does not clearly spell out the importance of advanced-degree training, which promotes and triggers creativity and innovation. The Chinese education system under Mao lacked the theoretical and philosophical rigor and curriculum that stimulate and trigger creativity. This system was primarily geared toward the natural sciences, training experts and not thinkers. The ability to think in the abstract was removed. Additionally, without access to interdisciplinary education, graduates became more narrow-minded and limited in their focus. Their knowledge at best would be remain at the level of the information they were taught.

Hundred Flowers Campaign

In the early 1950s Mao set out to improve agricultural output by creating labor-intensive water conservation projects, using fertilizers and the close planting of crops, etc. Mao believed that best way to achieve optimal results was through collectivization and higher levels of indoctrination of the masses. By 1955, nearly 90 percent of the farm population had been collectivized. Despite Mao's best efforts, production only rose in

1956 and 1957 by 5 percent and 1 percent, respectively.[175] The state's plan to increase the workforce to meet higher targets did not translate into greater production and consumption as Mao predicted. According to Mao, however, the reason why the production targets were low was that the state still needed to a better job of raising the consciousness of the peasants to match the new social reality; greater indoctrination to meet the socialist agenda was needed.

Despite the vast economic setbacks and the demoralization of the workers in not meeting production targets, the leadership began to understand the importance of not alienating the masses and being able to meet the socialist expectations of the people. This was especially true in 1956, when thousands of Hungarian students revolted against their government and its Soviet- imposed policies. The uprising almost lead to the overthrow of the communist system in Hungary until the Soviet Union invaded Budapest and crushed the rebellion, resulting in more than 3,000 casualties.[176] This incident made Chinese party members realize that gaps between the party and the masses could be catastrophic for the country. In order to bridge them and prevent the possibility of an uprising, the Chinese government saw the need to develop better relations with the masses. It decided to work on campaigns that would release new energies among the intellects and the masses for national construction.[177]

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[175] Kuo chia t`ung chi chu, *Ten great years; statistics of the economic and cultural achievements of the People's Republic of China, compiled by the State Statistical Bureau* (Peking: Foreign Languages Press, 1974), p119.

[176] "Hungarian Uprising," *Spartucus Educational,* (http://www.spartacus.schoolnet.co.uk/COLDhungarianU.htm).Acsessed August 12, 2010.

[177] Robert Bowie and John Fairbank, *Communist China 1955-1959: Policy Documents With Analysis* (Massachusetts: Harvard University Press, 1971), pp11-12.

In 1957, Mao gave a talk entitled, “On the Correct Handling of Contradictions among the People,” in which he called for a relaxation of constraints on the intellectuals in the country.[178] Mao saw this as a gesture to become closer to intellectuals and experts in China. He relaxed restrictions on what intellectuals could say about party policies. This campaign, later called “Let a Hundred Flowers Bloom and a Hundred Schools of Thought Contend,” was designed to call upon the intellectuals to point out the current problems in economic development and to help devise new strategies for such development in accordance with Mao’s revolutionary ideals.

Unexpectedly, most of the intellectuals questioned the achievement of socialist construction and called for an end to the political monopoly of the Communist party. They also blamed the party for its irresponsible policies that repressed scientific inquiry. They argued that the party often made important policy decisions without the necessary technical expertise and without asking for input or feedback from the professionals and experts who were capable of making well-considered decisions in those areas. The criticisms did not address the shortcomings of government policy but were mainly directed at challenging the usefulness of Marxist-Leninist ideology and the Party's role in governing the country.[179]

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[178] John M. Jackson, “An Early Spring: Mao Tse-Tung, the Chinese Intellectuals and the Hundred Flowers Campaign,” Filebox, http://filebox.vt.edu/users/jojacks2/words/hundredflowers.htm (accessed October 23, 2011).

[179] Ibid.

Intellectuals who spoke out against the party were deemed rightists and quickly became enemies of the state.[180] Party members have traditionally been wary of intellectuals, mainly because they are not well understood. The intellectual group consisted mainly of university professors, students, and staff members who were believed by the party to have strong bourgeoise ties because they were well educated and some had received their training in Western nations. Others received their education in China under the previous regime, under where education was afforded to those families who were born into land-owning or business-working families.[181] In sum, the intellectual class at the time was believed to have been highly influenced by the West or the corrupt Nationalist Party.

Old cadres knew little about the nature of academic work other than that it was often an individual endeavor, undertaken by experts and scholars whose motivations might value the pursuit of their own intellectual interest and scholarly accomplishments over that of the state. This worked against the teachings of the revolution and the creation of an egalitarian society. While communist cadres were working for the common cause of the people, they found it difficult to accept, nor did they understand, how intellectuals such as scientists, engineers and, scholars could contribute to the overall goals of the revolution in the pursuit of their personal achievements.

Cadres remained highly suspicious of professors, as they pursued their own esoteric knowledge at the expense of focusing their attention on the transition towards

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[180] Lee S. Zhu, “Communist Cadres on the Higher Education Front, 1955-1962,” *Twentieth Century China* 34, no. 1 (November 2008): 74-75.

[181] Ibid., p77.

communist reconstruction. Professors did not have much use for teaching politics, and many favored increasing teaching hours for science and technology courses at the expense of political content advocating Marxist Leninist thought.[182] Intellectuals saw the Chinese leadership's urge to strictly enforce ideological orthodoxy as the main source of its conflict with the government. Professors barely read newspapers, hardly participated in Nationalistic parades or events such as May Days, and found it useful to participate in political study only when it was pertinent or influenced their research. They played a small role in teaching Mao's revolutionary ideals or ideologically indoctrinating the hundreds of students they would see on a daily basis.

Communist cadres therefore perceived professors as major obstacles to the nation's social transformation and economic development. After the Hundred Flowers Campaigns, the distrust among party members for intellectuals was at an all-time high, which led to nearly 800,000 of them being thrown into penal camps or sent to the countryside to do forced labor.[183] This was a great setback to Mao Zedong's revolution, since the country lost a significant number of engineers, professors, economists, and scientists who were crucial to the successful development of the country and the further implementation of the Socialist model. The persecution of these intellectuals and experts robbed the country of its current stock of intellectuals, who could contribute to China's development. Porter would see this as a huge blow to industrial development of a nation.

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[182] Ibid., p78.

[183] Barry Naughton, *The Chinese Economy Transitions and Growth* (Massachusetts: The MIT Press, 2007), p69.

Porter notes that many of these trained professionals would be needed to educate future generations of scientists and engineers; otherwise, there would be a shortage of specialized factors in the future.

Engineering graduates in China fell from 22,047 in 1956 to 17,162 in 1957.[184] There were many engineering students that spoke out against the party and were jailed, reducing the overall number of graduates. Students were also discouraged from entering such fields because the teachers chosen to replace those jailed intellectuals at schools and universities were unqualified, having had merely an elementary education, and had been chosen to teach because of their loyalty to the party. Thus, research was halted and future generations of students were robbed of a quality education as assistants or less-qualified instructors with strong communist-leaning views taught their classes.

Intellectuals, who fell under the radar of this movement, would not dare to speak out either, or take on any critical research that was deemed unacceptable by the party, even though it might be beneficial to the overall economy. This hindered creativity and innovative development in China and set it further back. All in all, the attack on intellectuals did irreparable damage to the country's economy. The Hundred Flowers campaign practically eliminated an entire class of intellectuals Mao deemed capitalists and opponents of the revolution. "Despite his ambitions for China's development, the

[184] R. C. Hunt, "Change in Higher Education in the People's Republic of China," *Higher Education*, (4, 1975) p49.

chairman would never again be tempted to sacrifice Party domination for economic gain."[185]

Great Leap Forward

No longer able to rely on intellectuals for the further development of the country, Mao Zedong went completely in the opposite direction from what Porter's model advises by unleashing the masses towards collectively orchestrated social projects that would lead to China to surpass Britain, the leading producer of steel, within 15 years. The 1958 Great Leap Forward was launched on the belief that manual laborers, once properly motivated through an indoctrination campaign, could achieve a great deal more than intellectuals.

Communization was set up to ease the diffusion of new knowledge, spread the risk of innovation, and allow indigenous techniques and human labor to be used in place of modern agricultural technology and equipment.[186] Nearly 30 million new workers were absorbed into the state sector during 1958.[187] In rural China alone, millions of workers were relocated from their agricultural units to work in factories, including backyard steel mills. Without sufficient knowledge of metallurgy, Mao ordered every

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[185] Jackson, John M. "An Early Spring: Mao Tse-Tung, the Chinese Intellectuals and the Hundred Flowers Campaign." Filebox. http://filebox.vt.edu/users/jojacks2/words/hundredflowers.htm (accessed October 23, 2011).

[186] Fred Herschede, "Chinese Education and Economic Development: An Analysis of Mao Zedong's (Mai Tse-tung's) Contributions" *The Journal of Developing Areas* (Vol.14: No.4, July 1980), p457.

[187] "Communes were established in the countryside. A combination of governmental and economic functions. It was used to mobilize labor for construction projects, provide social services and develop rural small scale industries." Barry Naughton, *The Chinese Economy Transitions and Growth* (Massachusetts: The MIT Press, 2007), p70.

commune and every urban neighborhood to build small backyard furnaces. Peasants were told that they had to produce steel out of scrap metal, so they used their own pots, pans, and other metal artifact to supply the scrap for the backyard furnaces, hoping to meet the unrealistic steel production targets set by the government. Laborers at all levels were pushed to work overtime seven days a week in an attempt to meet these targets. The output consisted of low-quality iron that was basically useless. The targets were never met.

Mao's Socialist Education Campaign

Mao launched a social indoctrination campaign predicated on the belief that people's love for communist ideals could move mountains, and that collective goals could transcend individual interests; he believed an egalitarian society would produce far greater results than would a society in which individuals merely pursued their selfish interests.[188] It was the capitalist tendencies that bred greed and corruption, which ultimately led to the failure of the Nationalist Party. To support his goal of creating an egalitarian society, Mao created part-time and part-work/part-study institutions for peasants and working class children. This bold new experiment allowed both student and workers to acquire productive labor experience, contributing to the economic development of the country, as well as access to an education. Red and expert universities were set up by local governments throughout China, which took on the role of indoctrinating the masses in support of the revolution.

[188] Tsang, Mun C. "Education and National Development in China Since 1949: Oscillating Policies and Enduring Dilemmas" *China Review*, (Hong Kong: The Chinese University of Hong University, 2000), p585.

Many of these institutions taught advanced agricultural techniques, because a greater emphasis was placed on practical training, which could be used to develop the country, rather than on theoretical abstract concepts, for which Mao believed China had little use at that stage of development. This type of work experience helped develop appreciation for manual labor and offered keen insight into the lives of peasants in the countryside, advancing revolutionary ideals by deepening the masses' understanding of the class struggle.[189] However, this strategy was not conducive to the industrial development of the country, since educating scientists and engineers took a back seat to manual labor. In the end, China was set back even further.

Cultural Revolution

After 3 years of sharp economic decline as a result of bad harvests and poor planning, China was suffering from severe food shortages that claimed the lives of over 30 million people. Hunger became a major problem particularly, since grain output fell sharply from 200 million tons in 1958 to 170 million tons in 1959 and further declined to 144 million tons in 1960.[190] The Great Leap Forward was also disastrous because it further split the party leadership along ideological lines and exacerbated tensions between party moderates and conservatives.[191] Additionally, the withdrawal of the Soviet Union's

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[189] R.C. Hunt, "Change in Higher Education in the People's Republic of China," *Higher Education*, (4: No.1, Feb. 1975), pp48-49.

[190] Maurice Meisner, *Mao's China And After*, (New York: The Free Press, 1999), p236.

[191] Moderates wished to see the introduction of a degree of market reform that embraced the individual over the collective as the way forward while conservatives sought deeper forms of indoctrination in the name of the Communist Revolution.

technical assistance in 1960 led China toward a policy shift that closely resembled the First Five-Year Plan, which was technologist in nature.

In an attempt to improve China's overall economic condition, Mao decided to temporarily retreat into isolation and hand over the reins to moderates Liu Shaoqi and Deng in 1960. Mao understood that a fresh start was needed after the devastation from the Great Leap Forward. The moderates in power shifted the country's approach to education by placing an emphasis on training experts and highly skilled technicians over offering a rudimentary education and productive work experience.

The moderates understood that, in order for China to develop, it was important for people to possess all levels of skills, from highly skilled technicians and experts to semi-skilled laborers. The party in 1962 shifted its orientation for learning in order to elevate the importance of fundamental theoretical knowledge instead of practical knowledge. There was a renewed emphasis on stressing individual achievement in a classroom setting rather than group progress. There was less of an emphasis on learning in the form of labor.[192]

In order to avoid their mistakes of the past, Deng and Liu would seek to link the number of schools and students enrolled in higher education to the needs of the national economy. Heavy enrollment, in essence, would put a drain on already scarce resources. Educational levels needed therefore simply to meet the current level of economic development. According to the Ministry of Education, only a few full-time schools were actually required to train skilled manpower for China's economic development. Under

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[192] Fred Herschede, "Chinese Education and Economic Development: An Analysis of Mao Zedong's (Mao Tse-tung's) Contributions" *The Journal of Developing Areas* (Vol. 14: No 4), July 1980, p459.

Mao's previous education policies, enrollment at all levels was greater than required for development. Deng and Liu sought to reverse the expansionist policy. They also realized that work-study skills were especially important in order to meet most of the technological demands of the rural areas by training a small number of agrotechnicians.[193] By 1965, Deng and Liu had accomplished what they set out to do, as the number of institutions had been reduced to 434, returning to their 1958 level (see Appendix B-3).

In 1961 Deng and Liu also implemented their two systems of labor and two systems of education policy, which allowed students and workers either to work or study both full and part time. By 1965, a system was put in place in which education consisted of both regular schools and work-study skills designed to diversify the workforce for satisfying all facets of economic development. The dual system would produce intellectual elites and experts on the one hand, but also educate the masses for employment in manual labor. The regular schools were attended by those students who sought a university level education, because it had much higher academic standards and prepared them for further study. Work-study schools were attended by children from peasant backgrounds; these children had little probability of ever getting a university level education; they were developing basic skills fit for full-time labor. Schools that were expected to educate the next generation of professionals had the best teachers and facilities. The party began to emphasize the importance of developing expertise while remaining loyal to the party.

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[193] Peng Chong, "Take the Acceleration of Agro-Technical Reform as a Glorious Duty of Your Own, Guang-Ming Ri-Bao (kuang-Min Jih-Pao)," *Union Research Service* 20, no. 25 (1960): 369-70.

Despite the shift in fundamental policy that Porter would consider conducive to industrial development, Mao returned from isolation in 1966 with his launching of the Great Proletariat Cultural Revolution, in response to the sharp divisions between party members. Though the moderate policies may have lifted the economy during the first half of the 1960s, Mao saw the long- term consequences of these policies as a movement away from socialism, even if production continued to expand. Mao and his followers, mainly the Gang of Four--Wang Hongwen, Jiang Qing, Zhang Chunqiao, and Yao WenYuan--argued that, in spite of the recent increases in production, the allocation of state investment resources was not producing optimal results. The educational policies of the early 1960s were not serving the interest of the proletariat class, who were studying under teachers with capitalist world views. Mao sought a reversal of Deng and Liu's policy that would once again emphasize collectivity, ideology, and commitment to social egalitarian society. According to Mao, the adjustment policies of Deng and Liu had promoted social differentiation and elitism.[194]

The conservatives blamed the capitalists within the party for sabotaging the Great Leap Forward and of being opponents of the revolution. Just as Peng Duhai had spoken out against Mao at the Lushan conference, other rightists were against the revolutionary goals and needed to be dealt with. Mao enacted the Great Proletariat Cultural Revolution to get the younger generation on board with his revolutionary ideals and to root out all of the capitalists he believed were opponents of the revolution. Mao mobilized China's youth, who would later be referred to as "Red Guards," consisting of high school- and

[194] Tsang, Mun C. "Education and National Development in China Since 1949: Oscillating Policies and Enduring Dilemmas" *China Review*, (Hong Kong: The Chinese University of Hong University, 2000), p588.

college-age students, to instigate, demonize, and torture their elders and party members accused of being capitalists. In 1966 Mao rallied Chinese youth against corrupt officials in government and around his revolutionary ideas.

There is no reliable data available of how many people the Red Guards killed, jailed, or tortured, before they were forced to relocate to the countryside in 1969 when they began to turn on each other. Scholars estimate that nearly a million people died during the purges and related violent incidents, and that more than three million were sent to the countryside and forced to do manual labor. During the Cultural Revolution serious damage was also done to the CCP, as a large percentage of leading figures were relieved of their duties and some were also forced to do manual labor in the countryside, if not killed. "The Cultural Revolution also caused economic disruption; industrial production dropped by 12 percent from 1966 to 1968."[195] Intellectuals were considered elitist and opponents of the revolution as well. Mao once again reemphasized the importance of collective economic production and egalitarian values.

The Red Guards destroyed libraries, books, and modern facilities it deemed capitalist in nature. They also persecuted and tortured professors, teachers, and educational administrators. Many of these professionals, if not killed or tortured, were sent to work in factories to be retrained and to get a real sense of what the revolution was about. For example, "1,200 of the 2000 staff members of Beijing University were sent to experimental farms in Shaanxi province. Most of the staff was on farms for two years

[195] "Cultural Revolution: Mao Zedong," Lycos, http://www.lycos.com/info/cultural-revolution--mao-zedong.html (accessed June 1, 2010).

largely between1968 to 1970."[196] The PLA's strategy ran counter to continuously upgrading its factor conditions, as Porter advises.

During this period, urban elementary and secondary education were disrupted for at least 6 years, and for much of the period from 1966 to 1968 schools in many urban areas were closed altogether. Despite what has been listed in official Chinese publications, most universities were closed intermittently for about 12 years; there were very few to no new entrants in universities from 1967 through 1970 and a sharp decrease in the total number of enrollments during the Cultural Revolution, which lasted ten years (1966-1976).[197] When they did open, one's political background and class would determine if one was eligible for college.

Students were enrolled in the university if they were able to get a recommendation from their local political unit, with little or no attention paid to one's scholastic or academic abilities. Second, class background prevailed over merit as the important determinant for entry into college. This favored workers and peasants rather than children who were perceived to have had a middle- or upper-class background. Prior to 1966, students had to take a national entrance exam, which clearly favored the urban over rural youth, because the resources available and the level of education were better in the cities. The schools were better equipped and better staffed. By 1958 only 36.42

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[196] Edward J. Kormondy, "The People's Republic of China: Revitalizing an Educational System," *Change* 14, no. 4 (August 1982): 33.

[197] Personal Interview conducted with Dr. Baichun Zhang (expert on technology transfer and innovation), Scholar at the Institute for the History of Natural Science at the Chinese Academy of Sciences on August 20, 2009.

percent of college students consisted of workers and peasants.[198] Mao found this highly problematic for a society that aspired to be egalitarian in nature when peasants consist of 85-90 percent of the population.[199] It was proof that the old privileged class still had many advantages over the majority of people in society.

Unquestionably, the nationwide exam favored urban over rural youth. "Therefore from 1970 to 1972 the colleges and universities admitted nearly 200,000 students from among workers, peasants and soldiers,"[200] in a clear demonstration of Mao's commitment to an egalitarian society.

Mao also shortened the length of time it would take to earn a college degree from 4 years to two or three.[201] He argued that students did not have to waste much of their time reading books that were theoretical in nature and could not be put into practice in the short term. Fifty aviation technical schools and technical high schools, for example, were changed or transformed into factories. Consequently, the aviation industry was on the brink of collapse by 1969 and wouldn't ultimately recover to until 1972.[202]

Most of the students were chosen to attend college based on their family and class background rather than their academic achievement. Therefore, these students' basic

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[198] Peter J. Seybolt, "Higher Education in China," *Higher Education* 3, no. 3 (August 1974): 273.

[199] Ibid., p. 274.

[200] "Chairman Mao Once More Receives a Million Young Revolutionary Fighters-To Greet the New Upsurges in the Great Proletarian Cultural Revolution and in Socialist Construction," *Beijing Review* 9, no. 39 (September 28, 1966): 5-9.

[201] Peter J. Seybolt, "Higher Education in China," *Higher Education* 3, no. 3 (August 1974): 279.

[202] Liu Yazhou & Yao Jun (eds.) *The History of Chinese Aviation (2nd Edition)*, (*Zhongguo Hangkong Shi De Er Ban)* Changsha: Hunan Science & Technology Press, 2007 (Hunan: Hunan Ke Xue Ji Shu Chu Ban She, 2007), p371.

reading, writing, and math skills were substandard. Studies show that quite a large number of "enrolled students were incapable of doing university level work even with curriculum and teaching methods modified to accommodate them."[203] Universities were then forced to offer remedial courses at the college level.

The effects of Mao's policies did untold damage to the nation. It deeply felt the effects of the 10-year period in which schools were closed down intermittently, and when higher education was only offered to students based on their class background and not their academic abilities. This was evident by 1980, when there were 250 seats available for graduate study at Beijing University and only 78 students qualified to take on graduate level work.[204] The level and quality of education received during the period were dismal. The nation's best scholars and intellectuals had been brutally treated. Those who survived physically were forced to countryside for reeducation. They were not employed to teach the next generations of professionals and scholars, nor were they able to resume their research, which could have been an asset to the development of the country--Research, innovation, and creativity were stifled, considered out of line with communist thought.

The failure to maintain universities and research institutes, and respect for the teaching profession, has been one of the main explanations for the technological gap that existed between China and the West. Knowledge is gained by building upon previous research and existing information; China lost that ability because universities, colleges,

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[203] Ibid., p274.

[204] Edward J. Kormondy, "The People's Republic of China: Revitalizing an Educational System," *Change* 14, no. 4 (August 1982): 33.

institutes, and research facilities were dismantled. Basic research was ignored and an anti-technological slant encouraged by the party elites.[205]

The aviation industry suffered immensely during the years of the Cultural Revolution. From 1966 to 1976, graduates of aviation schools reached 54,000, 38,000 less than in prior years.[206] Those who actually graduated, moreover, were not sufficiently trained, considering that many of the teachers had limited experience as well. Therefore, developing an indigenous aircraft would remain a huge obstacle for China to overcome because the country was facing a shortage of qualified people to work on its development.

RELATED AND SUPPORTING INDUSTRIES

Porter's third determinant, Related and Supporting Industries, posits that firms gain a competitive advantage when they have internationally competitive suppliers or related industries based in their home nations.[207] The main valuable benefit that firms gain from working closely with internationally successful home-based suppliers and related industries is that the connection helps them find new methods and presents new opportunities for the use of new technologies to make their products more cheaply and efficiently. From such a relationship, firms can gain "preferential treatment and early

[205] Fred Herschede, "Higher Education and the Expansion of Technically Qualified Industrial Workers During China's Modernization," *Bulletin of Concerned Asian Scholars* 11, no. 3 (1979): 65.

[206] Liu Yazhou & Yao Jun (eds.) *The History of Chinese Aviation (2nd Edition),* (*Zhongguo Hangkong Shi De Er Ban)* Changsha: Hunan Science & Technology Press, 2007 (Hunan: Hunan Ke Xue Ji Shu Chu Ban She, 2007), p373.

[207] Michael Porter, *The Competitive Advantage of Nations* (New York: The Free Press, 1990), p.100.

access to new ideas, insights and supplier innovation."[208] As Porter describes, such relations develop when there are commonalities or cultural affinities between the firm supplier and related industry.

The gains from working with world-class suppliers and related industries who share common productions cannot be understated. China benefitted immensely from its big brother- little brother relationship with the Russians. They shared a common commitment to Marxist-Leninist ideology. The Chinese were given state-of-the-art technology and aircraft and were helped to improve their production facilities. What is not apparent from Porter's determinant is that many suppliers and industrial firms are hesitant about passing along information that can potentially groom another competitor, or that such technology could make its way to an unfriendly military. This shortcoming in his model is an important reason why China lacked the ability to design an indigenous aircraft. Its trade relationships with the Russians were based on acquisition of production technology and aircraft. They were taught how to reproduce existing aircraft without knowing how they were built and designed. Therefore, they lacked the ability to advance knowledge of existing products.

The Soviet Union was hesitant about passing along technology that had the potential to change the dynamics of the big brother-little brother relationship. In order to prevent an alteration of the relationship, the Russians gave technology to the Chinese without teaching them how products were made, thus creating a continued dependency.

[208] Ibid., p103.

Different kinds of technology

Technology acquisition is of interest to all developing nations; as they are gained, some form of technical knowledge- whether it is an advanced skill, technique, or piece of technological equipment- is also gained to enhance the overall quality of a product/and or reduce production costs. Missing from Porter's model but still an important variable for understanding why China lacked the ability to create aircraft are the two different categories of technological acquisition and know-how, one being the tools man creates (design technology) to meet the demands and challenges of his environment. The second is the application of learned techniques and tools (manufacturing technology) used in production.[209]

Manufacturing technology relates most directly to the latter of the two types of technology acquisitions, more specifically "the actual physical production—skills of fabrication techniques of processing refinement of materials and so forth."[210] It is in this area of technology that the Chinese have become really skilled, mainly due to the knowledge and technology gained from the Soviet Union throughout the 1950s.

Since firms may be reluctant to pass along sensitive information and the latest generation of technology, the best method for developing design technology, as Porter states, is for a nation to develop its science and engineering fields. Experts and scholars in the natural sciences should continually, or over extended periods of time, be able to conduct research, testing, and experimentation in up-and-coming areas in which their

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[209] Hans Heyman Jr., *China's Approach to Technology Acquisition: Part 1-The Aircraft Industry* (R-1573-ARPA: Rand Corporation, February 1975), 1.

[210] Ibid., p2.

findings could potentially yield benefits for all facets of the economy and the military. This type of research is aimed at developing new and advanced products, machines, and production process.[211]

China remains relatively underdeveloped in this area largely due to its focus over three decades of Communist rule on developing an egalitarian society where all citizens were entitled to the same rudimentary education. The system placed greater emphasis on being Red. Nations that have achieved great success in design technology have managed to develop and sustain strong science and engineering programs in their countries.[212] China under Mao was not one of them.

Secondly, the assistance offered by the Soviets emphasized manufacturing technology over design technology. This strategy prevented the Chinese from acquiring the theoretical and analytical training for aircraft design. Consequently, their technology was only as sophisticated as the last shipment they received from the Soviets; this is shown in the next section.

SUPPLIERS AND RELATED INDUSTRIES INVOLVED IN THE MAKING OF THE Y-10

To strengthen communism around the world and to be better prepared to meet the capitalist challenge, the Russians transferred modern technology to the Chinese over a seven year period. The Russians helped the Chinese develop its military, heavy industry,

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[211] Ibid., p2.

[212] Personal Interview conducted with Dr. Baichun Zhang (expert on technology transfer and innovation), Scholar at the Institute for the History of Natural Science at the Chinese Academy of Sciences on August 20, 2009.

and supporting economy. China's plan was to absorb as much knowledge as possible from foreign countries until it could stand on its own two feet and become self-sufficient.

This plan was first put into practice when the Russians and the Chinese signed an accord calling for the construction of 291 major industrial plants by 1967, with equipment worth approximately $3.3 billion.[213] Also included was the transfer of vast array of blueprints, specification standards, and posting of more than 10,000 Soviet experts, specialists, and advisers to assist the Chinese in its development; the Soviet Union also allowed 38,000 Chinese technicians, scientists, students, and skilled workers to come to the Soviet Union for further training.[214]

The massive technological assistance supplied by the Russians was instrumental in developing the building blocks of a modern economy and military for the Chinese. The Russians helped develop 156 key industries, which supplied a foundation for industrial development that ultimately led to massive industrial output by 1957. Of 156 key industries, the Russians agreed to help China develop 12 related to aviation, 44 to the defense industry (12 aviation-related, 10 electronic industry, 16 weapons-related, 2 space industries, and 4 shipping industry), 20 to metallurgical enterprises (7 steel, 13 nonferrous metal), 7 chemical enterprises, 24 machining enterprises, 52 energy enterprises, 25 electricity, and 2 petroleum, and 3 light industry and pharmaceutical

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[213] Hans Heyman Jr., *China's Approach to Technology Acquisition: Part 1-The Aircraft Industry* (R-1573-ARPA: Rand Corporation, February 1975), p9.

[214] A.H. Usack and R. E. Batsavage, "The International Trade of the PRC," *People's Republic of China: An Economic Assessment* (Joint Economic Committee, February 1967), pp335-346.

industry.[215] "The Soviet Union supplied $300 million in loans divided into 5-year payments, with 1 percent interest rate," which added up to approximately $60 million per year.[216]

In 1952, when the Russians agreed to offer assistance, China's industry constituted only 28 percent of China's total GDP, and agriculture 64 percent. By 1975, industry was taking up 72 percent of GDP, and agriculture 28 percent. Industry had grown 30 percent larger than in 1949.[217] By 1976 China's GDP was 283 percent higher than that of 1949. Steel production for example, went in 1952 from 1.4 million tons to 31.8 million by 1976, increasing 22.71 times the 1952 amount. Production of crude oil, virtually non-existent at the start of the Mao era, jumped to 104 million tons by 1975. Coal production soared to 66 million tons from 3 million, or 21.67 times 1952 production. Fertilizer production jumped from 39,000 tons to 222.9 times that amount in 1976.[218] More than 20,000 kilometers of railway were completed over the next 20 years. Over 1 million kilometers of highway were developed as well during this period.[219]

Many of the industries established during the era are considered the backbone of the economy today, despite the dismal effects that the Great Leap Forward had on the

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[215] Qingmin Liu, "The first five-year plan and 156 Projects of Industrial Construction," ("Di yi ge Wunian Jihua Yu 156 Xiang Gongcheng Jianshe)" *History and Essence* (Wenshi Jinghua, 1999), p7.

[216] Zhihua Shen, ""The Basic Situation of Soviet Union Economic Aided Reconstruction to China Since the Early Days of the People's Republic of China ---- from Chinese and Russian archive materials,' ('Xinzhongguo Jianli Chuqi Sulian Duihua JingjiYuanzhu de Jiben Qingkuang)," *Russian Studies, (Sulian Yanjiu)* 1 (2001): 55.

[217] Maurice J. Meisner, *The Deng Xiaoping Era: an Inquiry into the Fate of Chinese Socialism, 1978-1994* (New York: Hill and Wang, 1996), p191.

[218] Ibid., p190.

[219] Ibid., pp192-193.

country. It did take away from these achievements, but many industries, including aviation, benefitted immensely, especially from the building of military aircraft, which was one of the primary reasons for Soviet aid.

Technology Transfer and Acquisition of Aircraft

China witnessed its first shipment of Soviet aircraft during the first 3 weeks of the start of the Korean War. The PLA received Soviet Mig-15 jet fighters in addition to other combat aircraft. The Russians also provided training for Chinese pilots and ground crews to fly and maintain the aircraft at their main aircraft plant in Shenyang and in the Soviet Union. The Russians replaced the estimated 2,000 aircraft the Chinese had lost during the course of the war.[220] This was only the start of the Soviet build-up, which continued through the 1950s. "They created a Chinese Air force of some 4,000 aircraft (fighters, tactical and strategic bombers, transports and support), a complex of training establishments as well as maintenance and overhaul facilities."[221] The Chinese at this time did not possess the technological capability or the know-how to build or develop aircraft. Therefore, they acquired them by purchasing them from the Soviet Union, which put them heavily in debt.

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[220] Richard M. Buschel, *Communist Chinese Airpower* (New York: Praeger Publishers, 1968), p26.

[221] Hans Heyman Jr., *China's Approach to Technology Acquisition: Part 1-The Aircraft Industry* (R-1573-ARPA: Rand Corporation, February 1975), p9.

Technology Acquisition during the First-Five-Year Plan

During the First-Five-Year Plan, beginning in 1953, the Russians systematically rebuilt China's aircraft industry, which was virtually nonexistent prior to receiving Soviet help. Not only did they supply the Chinese with state-of-the art aircraft, but they rebuilt and expanded the Manchurian plants previously damaged, especially those in Shenyang and Harbin, as a result of the Civil war and the multiple Japanese invasions. Russian engineers and technicians completely rebuilt airframe and engine factories with its most advanced equipment and technology.[222] They provided Chinese factories with complete metal fabricating and forming plants, components, and avionics manufacturing facilities.[223] Most of these factories and equipment were for assembling aircraft. The Chinese were not, however, taught how to design aircraft or to improve on the current production technology and equipment.

The technology transfer provided by the Russians was quite similar to what the United States provided the Japanese subsequent to World War II. Firstly, the United States supplied the Japanese with a relatively unsophisticated and simple T-33A jet trainer, and, as they became familiar with the assembling technology and process, they were given more advanced aircraft like the F-104J to work with. They followed a phase-in procedure beginning with the reassembling by the Japanese of a licensed knockdown

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[222] Ibid., p10.

[223] Hans Heyman Jr., *China's Approach to Technology Acquisition: Part 1-The Aircraft Industry* (R-1573-ARPA: Rand Corporation, February 1975), p12.

aircraft that was manufactured and shipped under an American license. As the Japanese became more familiar with the aircraft, they would reproduce it on their own.[224]

Using the same method, the Russians, in 1954, after equipping China's newly named National Aircraft Factory in Shenyang with state-of-the-art technology, the Russians began to ship the relatively unsophisticated Yakolev Yak-18 jet trainer in knockdown form so it could be reassembled.[225] The Soviets also provided the Chinese with the production licenses, engineering drawings, assembly tools, and production tooling, so they could develop the knowledge and experience necessary for advancing from the assembly stage to producing the components on their own, and ultimately to reproducing the entire aircraft on their own.[226] The plan was for China to be able to develop the Russian jet fighters Yak-18 and Mig-15 with indigenous components. Aeroengine production developed in the same manner.

With Soviet help and assistance, China was able to build a series of aircraft at their Nanjing Aircraft Manufacturing plant in 1954. Although the Chinese could not yet develop all the components indigenously, including the plane's propeller, it still represented a milestone when it successfully copyied 18 Jacques CJ-5 trainers using Soviet parts.[227] China was also able to replicate the MIG-17 using the drawings and

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[224] Icon Group International, *Rand Corp: Webster's Timeline History, 1894 - 2007* (P-3875: ICON Group International, Inc., 2009), 24-30.

[225] Personal Interview conducted with Dr. Baichun Zhang (expert on technology transfer and innovation), scholar at the Institute for the History of Natural Science at the Chinese Academy of Sciences on August 20, 2009.

[226] Yazhi Wang, Zhihua Shen, and Danhui Li, Memoirs *of Peng Dehuai's Military Staff: Witness Sino-Soviet Relation in 1950s*(Peng Dehuai Junshi Canmo De Huiyi; 1950 Niandai Zhongsu Junshi Guanxi JianZheng), (Shanghai: Fudan University Press, 2009), (Shanghai: Fudan Daxue Chubanshe), p71.

[227] Ibid., p71.

blueprints that it received from the Russians in 1954; their version of the aircraft was called the J-5. In 1958, China produced a carbon copy of the Soviet 10-passenger Antonov An-2 biplane, which was powered by the Shevtic 750-hp Ash-21 piston engine until an upgraded Chinese version, the 1000-hp Soviet ASH-62 radial engine, was produced by the Chinese.[228] China's domestic version of the An-2 aircraft, the Y-5, was in production for over 10 years; hundreds were produced and used for passenger and utility transport in addition to agricultural purposes.[229]

Change in Strategy

China had been grateful for all of the assistance provided by the Russians, but during the late 1950s political turmoil erupted China when Mao Zedong set out to lead the country down a path toward self-sufficiency rather than remaining dependent on foreign help for economic development. Mao was bent on mass mobilization, beginning with the Great Leap Forward, where the proletariat served as the main source for innovation, which ultimately failed. It placed stress-producing limits on the country's scarce physical and material resources. This was the first sign of China's seriousness in trying to reduce its dependency on the Soviet Union. There was a degree of pulling away from Soviet guidance and assistance beginning with the Great Leap Forward. It picked up

[228] Hans Heyman Jr., *China's Approach to Technology Acquisition: Part 1-The Aircraft Industry* (R-1573-ARPA: Rand Corporation, February 1975), p12.

[229] Ibid., p12.

momentum overtime and ultimately led to Soviet withdrawal in 1960.[230]

Despite the rejection of everything foreign that permeated the country at that time, aircraft production was considered vital for national security, so it had been insulated from Maoist rhetoric. China and the Soviet Union signed their last two Sino-Soviet technical cooperation accords in August 1958 and February 1959, which was the main reason for why aviation remained productive during the midst of the Great Leap Forward. During these last 2 years of joint Sino-Soviet cooperation, China's aircraft industry took a major leap forward, becoming relatively more sophisticated and complex.

The Russians granted the Chinese the licenses to produce the highly sophisticated Supersonic MIG-19 aircraft along with the state-of-the-art Klimov RD9B axial-flow turbojet engine at its Shenyang plant; they also supplied the Chinese with the Mil Mi-4 Whirland helicopter, with its 1700-hp ShetovASH-82V 14- cylinder radial engine, at its Harbin plant.[231] Such licenses clearly spelled out what components were needed and how to carefully assemble the aircraft. They didn't explain the justification for each component's use; therefore, the Chinese would be unable to advance the aircraft.

The Chinese were provided with massive assistance with the expansion and the spreading out of its aircraft industry deep into the nation's interior. This was referred to as the Third Line Project and was considered deeply strategic because, in the event China was attacked by its capitalist adversaries, its plants would be scattered sufficiently across the country to remain virtually unharmed; this wouldn't be the case if they were located

[230] Tensions between China and the Soviet Union began to escalate as the Soviet Union pursued Peaceful Co-existence with the United States when Marxist-Leninist ideology clearly postulates that war with capitalism would be inevitable.

[231] Hans Heyman Jr., *China's Approach to Technology Acquisition: Part 1-The Aircraft Industry* (R-1573-ARPA: Rand Corporation, February 1975), p113.

along the coast. The Russians also helped the Chinese build two large complexes in Xian and Chengdu, where the Chinese versions of the Tupolev Tu-16 medium bomber (the H-G) and the MIG-21 fighter (F-8) were produced. The Russians provided over 20,000 project documents, which contained information that it had acquired over several decades.[232] All China was required to do was to pay for the cost for reproducing the documents, assistance; such assistance was unheard of in modern history.

Path towards Self-Sufficiency

Understanding the limitations associated with acquiring knock-downs of Soviet aircraft, the Chinese sought to break the chain of dependency. They began to emphasize the importance and relevance of studying science and technology, and determined to rely on its own experts and specialists, which is in line with what Porter advocates, in order take foster its economic development and meet the country's most pressing and urgent needs. China allegedly plunged into a frenzied campaign of mass innovation and independent design adaption. While the campaign yielded no truly original designs, it at least served to build up engineering confidence. Students, instructors, and workers from various aeronautical institutes worked together to try to develop original Chinese design aircraft in 1958 and 1959. They produced dozens of different types of aircraft claimed to be of original design but actually were replicas of Soviet aircraft and engines. It was a still a major accomplishment for the Chinese and a confidence booster because they were able to apply what they had learned in practice on their own.

[232] Peng Ming, *A Brief History of Sino-Soviet People's Friendship* (*Zhongsu renmin youyi jianshi)*, (Beijing: China Youth University Press, 1955), (Beijing: Zhongguo Qingnian chubanshe:1955), pp316-317.

At the Shenyang Aeronautical Institute, Chinese engineers built the Chinko No.1 in just 75 days. It was a prototype of the Soviet Yak-12, a general purpose monoplane powered by the Soviet Shvetov M-11FR radial engine. The Chinese also produced the Hiryu No.1, developed in Shanghai in 48 days; it was a seaplane version of the Yak-12 and used the same Soviet engine. The Heilungkiang No.1 was made in Harbin Aircraft Engineering College and was an agricultural crop-dusting version of, again, the Yak-12. The Yenan No.1, created by the Northwest Technological University in Xian, was also an exact replica of the Yak and also powered by the 260-hp Soviet Ivchenko Al-14R radial engine. The Peking Shou-tu capital No.1 was the most sophisticated of all of China's copied planes, but it was a still a copy of the Soviet Anatov an-14 twin-engine light utility aircraft, built in just 68 days. Of all the planes produced at this time, only one, the Peking No.1, was mass-produced in the 1950s and 1960s.[233]

The Chinese were kept at bay since the Soviet Union offered little to no training in research development and aircraft design. They wanted to ensure that the Chinese would remain dependent upon them for technology and military hardware. The Russians would always negotiate with the Chinese from the more dominant, big-brother position, and China would be forced to take on more of a subservient role. The Russians wanted the Chinese to follow their lead in both domestic and world issues.

In keeping with this strategy, Chinese engineers and designers were forbidden from visiting or participating in the pioneering research conducted at leading Soviet Aeronautical Research Institutes such as TsAGI and TsIAM. These special institutes had

[233] Hans Heyman Jr., *China's Approach to Technology Acquisition: Part 1-The Aircraft Industry* (R-1573-ARPA: Rand Corporation, February 1975), p14.

a virtual monopoly on all specialized and advanced scientists and equipment (wind tunnels, test rigs, etc.) capable of carrying out advanced designs, testing, and experimentation. Russian scientists would then provide their tried and proven findings in the form of designer handbooks to Chinese aircraft designers in the bureaus, who would then be responsible for executing those plans.[234] The Chinese were not granted access to, nor did they have any contact with, the key Soviet airframe design bureaus such as that of Vladimir Klimov, whose aircraft and engines they were learning to build under license.[235] On this account, Chinese engineers were not prepared for independent design and development tasks that they might be called upon to meet in the 1960s. Only after the severing of ties between the Soviet Union and China in 1960 did the Chinese move forward with development on its own.

The Chinese set up a Military Science Academy under the Ministry of National Defense for purposes of conducting R&D for defense, which also included aircraft design. The academy did play a pivotal role in fostering independent design subsequent to the Soviet Union's departure; however, because Mao prioritized being Red over being an expert during the 1960s, there was an overall rejection and downplaying of the importance of developing scientific and technical personnel for the economy, which retarded overall growth and overall development of aviation industry, including aeronautical design.

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[234] Personal Interview conducted with Dr. Baichun Zhang (expert on technology transfer and innovation), scholar at the Institute for the History of Natural Science at the Chinese Academy of Sciences on August 20, 2009.

[235] Hans Heyman Jr., *China's Approach to Technology Acquisition: Part 1-The Aircraft Industry* (R-1573-ARPA: Rand Corporation, February 1975), p16.

Soviet Departure Leads to Aviation Industry Stagnation

All of China's plans with respect to reproducing advanced Soviet aircraft came to an abrupt end in 1960, when the latter withdrew 1,390 experts, opted out of 343 contracts, and abandoned 257 scientific and technical projects. The Russians withdrew, not only their advanced equipment, machines, and tools from the national factory in Shenyang, but also the highly detailed blueprints they had provided the Chinese to reproduce the Mig-19. For more than 3 years following the Soviet departure, virtually nothing of an aeronautical nature was produced in China, and the aircraft industry was in a state of shock and complete disarray.[236]

China was so completely dependent upon the Soviets for technology that a profound degree of helplessness settled in after the Russians left. However, given the level of production capability, and with its level and familiarity with aircraft technology the Chinese had obtained from the Russians over the previous decade, the nation was more than capable of resuming the production of the MIG-17. After the Russians departure, another contributing factor in the aviation industry's stagnation was Mao's apparent shift in priorities. At that crucial moment, he diverted the country's scarce resources (human and physical capital) from aircraft production toward its nuclear development program and rocket propulsion programs.

[236] Personal Interview conducted with Professor Chengzi Li, (expert on technology policy and management) of Beihang University, School of Aeronautics and Astronautics on August 18, 2009.

China's Pursuit of Nuclear Weapons

By 1962, Mao set up three major production facilities for the development of a nuclear weapon. He created a uranium conversion plant, a 600-megawatt plutonium plant, and a gaseous diffusion plant near Lanzhou in Gansu province.[237] The shift in priorities placed aircraft development behind that of nuclear weapon and rocket propulsion development.[238] At the time, there was an intense competition over China's limited resources between proponents of air force modernization and nuclear weaponry. Because fuel shortages had become a pressing issue, production of new aircraft ceased. The aviation industry, which had come out on the losing side of this competition, experienced a slow and dramatic decline, and industry morale fell to an all time low.

Yet, although the Russians withdrew equipment, personnel, and technology from China in 1960, they did not completely cut off all supplies. They did not want to destroy their relationship with the Chinese for fear that the latter might establish better relations with Western countries, through which a potential alliance could be formed to bring down the Soviet Union. Therefore, the Russians continued to provide critical parts, spare materials, and replacements when needed for China's manufacturing machinery and equipment. Despite their differences, the Soviet Union provided the Chinese with two TU-16s (one in 1961, and another in 1964) and MIG 21 fighter aircraft with their

[237] Charles H. Murphy, "Mainland China's Evolving Nuclear Deterrent," *Bulletin of Atomic Scientists*, January 1972, 29.

[238] Personal Interview conducted with Dr. Baichun Zhang (expert on technology transfer and innovation), scholar at the Institute for the History of Natural Science at the Chinese Academy of Sciences on August 20, 2009.

relatively powerful 13,000-lb thrust Tumanskii R-37f afterburner turbojet engines, [239] in the hope of dissuading them from establishing a new technological relationship with the West.

Though the Chinese were not granted permission to dissect both of these aircraft for reproduction, they did so anyway. Without the necessary blueprints and tooling once provided by the Russians, reproducing aircraft was not easy. However, after becoming familiar with the disassembled parts and with the Russian production system, the Chinese were able to successfully copy the TU-16 in 1963. The H-6 was the Chinese copy of that aircraft, abut they were able to produce it a rate of only one per month. [240]

The Chinese began working on the MIG-21 in 1962. Not only was the aircraft highly sophisticated for the Chinese, so was its Tusmanskii turbojet engine, which was the main reason why they were only able to produce it in small numbers in 1969. The Chinese version of this plane was the J-7; it would not have its first test flight until April 1970. The engine was quite difficult for the Chinese, considering they had relatively primitive metal-forming technology (forging, extrusion, precise casting) and materials technology (high-quality aluminum alloys, refractory metals, special steels) at their disposal. [241] By most international standards, this engine contained the technology of the

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[239] Hans Heyman Jr., *China's Approach to Technology Acquisition: Part 1-The Aircraft Industry* (R-1573-ARPA: Rand Corporation, February 1975), p24.

[240] Zuodi Zheng and Guoqiang Zhao. “Tragic Y-10-The Whole Story of the Development of Y-10,” (“Bei Qing Yun 10-Yun 10 Yan Zhi Shi Mo”), Aviation Archives, Vol. 6 (2005): 44, (Hang Kong Dang An, Vol. 6 (2005): 44).

[241] Hans Heyman Jr., *China's Approach to Technology Acquisition: Part 1-The Aircraft Industry* (R-1573-ARPA: Rand Corporation, February 1975), p25.

1950s, and China's trouble producing it showed it was already more than a decade behind the most advanced engine technology of the West.

In 1964, after an approximately 4-year layoff, the MIG-19 resumed production at the National Aircraft Factory in Shenyang. Instead of building the aircraft with Soviet components, the Chinese were able to do it using indigenous sources, naming the near-carbon copy the F-6. China was able to produce this aircraft at high rate by 1965, thus allowing it to export the aircraft to Pakistan and Albania in 1966.

China's Acquisition of Foreign Civil Aircraft

When Soviet aircraft and spare deliveries declined sharply in the early 1960s, the Chinese became very interested in the acquisition of Western aircraft and modern turbine jet engine technology. China was aware of its technological backwardness and believed that, if it was able to procure modern aircraft and jet technology that would somehow bridge the gap between it and the West. After China broke ties with the Soviet Union in 1960, it was able to broker a deal with Britain when the two parties signed a contract on December 1961 for China to receive six Viscount aircraft at a cost of $5.6 million, and an additional $4 million for spare engine parts. "The Viscounts became a real workhorse on medium range to long range domestic routes."[242] In 1965, the Chinese worked out another agreement with the British, with a purchase of two Herald 200 short-haul turboprop transports from the British Handley Page company.

[242] Hans Heyman Jr., *China's Approach to Technology Acquisition: Part 1-The Aircraft Industry* (R-1573-ARPA: Rand Corporation, February 1975), p38.

There were serious U.S. objections to these purchases and potential sales between European aircraft manufacturers and China. There was a fear that the Chinese would convert the civil aircraft to military use. Many European aircraft makers went on to ignore U.S. suspicion and brokered deals with the Chinese anyway. France was rewarded for opening diplomatic relations with the PRC's purchase of 15 Aerospatiale Alourtte III helicopters with their 570-shp turbo artouste 3B turboshaft engines in March 1967.

Jet Engine Technology

China's vested interest in purchasing jet engine technology came after the Cultural Revolution in the 1970s, when the PRC purchased its first pure jet transport from the Soviet Union. It acquired five sturdy I1yushin I1-62s, whose four-engine long-range transport resembled the British VC-10. These planes were used for such long domestic routes as Beijing-Canton and as VIP flights abroad for their European routes.

While placing its order with the Soviet Union, China also purchased four used Hawker Siddeley HS-121 Trident 1 jet transports from Pakistan International Airlines (PIA). They particularly wanted this medium-range transport because it was powered by three state–of-the-art Rolls Royce Spey engines. Ever since they saw this model on display at a British exhibition in Beijing in 1964, they had pursued it.

The British were eager to sell their aircraft to all potential buyers, as their main airplane manufacturer, Hawker Siffley, was on the verge of bankruptcy. China understood this and took advantage of the ability to acquire state-of-the-art aircraft, which were not easy to come by. China's large purchases, worth $288 million, kept the company alive, guaranteeing that it would remain open until at least 1976.[243] A relationship developed between China and Hawker Siffley and Rolls Royce that would result in long-term plans for advanced technology transfers for years to come.

After the forging of diplomatic relations in 1972 with the Americans, China acquired 10 Boeing aircraft (four B707-320B passenger planes, and six 707-320c convertible passenger cargo transports) to service its international routes. Additionally, the United Aircraft Corporation signed a $20-million contract for the sale of 40 spare Pratt and Whitney JT3D turbofan engines, which differed from normal international aviation procedures, in which the customary spares ratio is only about 25 percent of the order.[244] The purchasing of additional spare parts had become common practice for the Chinese, to avoid being left without spare parts should their relationships with foreign suppliers go sour; they wanted to ensure they would not be in a position like they were after the Sino-Soviet split in 1960.[245]

China's purchases of foreign air transports and engine technology served two purposes: to have the opportunity to study, dissect, and reproduce advanced western aircraft; and to add them to its current fleet.[246] However, China faced immense difficulty trying to replicate advanced Western aircraft because its technology vis-à-vis the West was at least 20 years behind. In fact, its technical-industrial ability in the 1970s was roughly comparable to that of the U.S., Western Europe, and the U.S.S.R in the mid-

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[243] Ibid., p42.

[244] Ibid., p42.

[245] Personal interview conducted with Shengwu Chen, Chief Engineer and Director of Sales at AVIC's Chengdu Engine Co. Ltd on October 18, 2009.

[246] Ibid.

1950s. This was largely known to experts and scholars at the time, because the three aircraft that China was able to produce--the TU-16, the MIG 19, and the MIG 22--were all produced in the Soviet Union during the 1950s. The United States built the B-50, F-86, and F-104, all possessing comparable technology to the Russian-built planes that had gone into production in the 1940s.[247]

Experts found the technological differences between China and the West extraordinary--they were at different levels when it came to aircraft design, fabricating skills, machining precision, materials application, etc. China was also unable on its own to develop a high-bypass turbofan engine required for supersonic planes. Considering the Chinese had not mastered the technologies of the 1970s, it would have been virtually impossible for them to replicate a state-of-the-art air transport. However, this did not stop them from trying. They carefully dissected and studied the airframes, engines and components, though evidence suggests they could not have been successful at reproducing them.[248]

Reverse Engineering

Porter's model fails to consider is the shortcomings of acquiring production-based technologies from foreign nations and companies. There are also growing misconceptions among developing nations that rapid development can be achieved simply by adopting a deliberate policy for prototype copying. This process entails acquiring a model,

[247] Hans Heyman Jr., *China's Approach to Technology Acquisition: Part 1-The Aircraft Industry* (R-1573-ARPA: Rand Corporation, February 1975), p54.

[248] Personal Interview conducted with Dr. Baichun Zhang (expert on technology transfer and innovation), scholar at the Institute for the History of Natural Science at the Chinese Academy of Sciences on August 20, 2009.

dissecting and analyzing it, and then attempting to replicate it. However, if the engineer does not have access to the design or manufacturing data, he must attempt to recreate the basic blueprints, engineering drawings, and material specification with near-pinpoint accuracy; this becomes especially difficult with something as sophisticated as a modern aircraft.[249]

To devise adequate materials specifications, you have to conduct sophisticated metallurgical analysis, testing, and experimentation; after such testing, it is possible that the level of fabricating technique attained by the copier may not be adequate enough to duplicate the metal casting, forming, shaping, joining, and finishing operations to reach the necessary endurance, tolerances, dimensional accuracies, and critical weight distributions.[250] It is important for the prototype to be at the same level of technological sophistication, with respect to design engineering fabrication, as the original. If the model is too advanced, reverse engineering becomes too difficult.

The ultimate goal when trying to reproduce an original design is to be able to produce it on a large scale, not merely make a single duplicate. But this requires the design standardization to achieve perfect interchangeability of parts and components, in order to achieve which one must have proper production tooling, plant layout, materials, etc.[251] If the copier is successful at serially manufacturing the aircraft, all that it really demonstrates, all that has been learned, is that an existing design can be copied. There has been no advance in the copier's ability to design aircraft.

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[249] Ibid.

[250] Hans Heyman Jr., *China's Approach to Technology Acquisition: Part 1-The Aircraft Industry* (R-1573-ARPA: Rand Corporation, February 1975), p51.

[251] Ibid., p52.

A prototype describes the end result of the original designer's choices: it does little to explain the reasoning or the rationale behind these choices. Every major design features a wing shape and a tail structure, or a rudder control surface, that are the outcome of a very large number of engineering compromises or trade-offs reached through a series of tests and experiments.[252] The prototype copier must be able to reproduce the original designer's calculations and investigations in order to learn how to improve on, or upgrade, a model; this is extremely difficult to do, especially if technological ability is not on par with that of the original producer. "Understanding the design so that the copier can ultimately improve upon it, means understanding and knowing why these compromises were made and how the trade-offs were arrived at."[253]

The copier obtains this information from studying the finished product. This is why little progress with respect to the original design has been made in China. Once the model becomes obsolete, its technology and ability to produce aircraft will be stuck at that level. This provides further evidence for the failed attempt at the development of its Y-10.

Prototype Copy and the Y-10

With, thus, little original design experience of its own, China originally planned to model its large passenger aircraft, the Y-10, after the H-6 bomber, the Chinese

[252] Ibid., p52.

[253] Ibid., p52.

imitation of the Soviet TU-16 made in 1963.[254] However, its plans changed on December 19, 1971, when a Pakistani-owned B707 practically crash-landed in Xinjiang. The Chinese referred to this crash landing as a "Gift from God," because they suddenly had the opportunity to intensively study one of the world's most advanced aircraft.[255]

Marshal Ye Jianying, along with 500 people, including engineers and scientists from over 32 departments, were sent to analyze the wreckage on January 13, 1972, to gather vital information that might be helpful for the development of its own indigenous large passenger transport, the "708 project."[256] The staff sent down included leading engineer Xiong Yan, who was responsible for gathering information related to the plane's structural design and integration system that the Chinese could copy and incorporate into the Y-10,[257] the first plane to be designed in accord with American airworthiness regulations and to use the Boeing 707 that it acquired from the crash as its model.

China's leaders demanded that the Y-10 aircraft not be lower in quality than the 707, so workers worked around the clock, including nights, weekends, and holidays.[258] They used the fallen 707 and its Pratt and Whitney engine to conduct experiments and

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[254] Zuodi Zheng and Guoqiang Zhao. "Tragic Y-10-The Whole Story of the Development of Y-10," ("Bei Qing Yun 10-Yun 10 Yan Zhi Shi Mo"), Aviation Archives, Vol. 6 (2005): 44, (Hang Kong Dang An, Vol. 6 (2005): 44-51).

[255] Ibid., p44-51.

[256] Xitao Hu. The Construction and Development of China Aviation Industry: Classified: Insider Information, (Zhongguo Hangkong Shiye De Jianshe Yu Fazhan: Neibu Ziliao), Book consists of collection of reports for Government Officials and Party Leaders, 1997, (Benshu Baokuo Le Gei Zhengfu Guanyuan He Zhengdang Lingdaoren Baogao De Heji, 1997), p295.

[257] Personal interview conducted with Shengwu Chen, Chief Engineer and Director of Sales at AVIC's Chengdu Engine Co. Ltd on October 18, 2009.

[258] Xiongxin Lou, *Tale of Y-10* (Yunshi de Gushi), (Shanghai Aircraft Manufacturing Factory), (Shanghai: Shanghai Scientific & Technical Publishers, 2009), (Shanghai Feiji Zhizaochang, Shanghai: Shanghai Kexue Jishu Chubanshe, 2009), p68.

test-measure every component, part, and criterion of plane, including the engine, against their prototype.

Ironically, the Chinese were soon also able to get their hands on an undamaged version of the B707 in the 1970s, when the Cultural Revolution was winding down. President Richard Nixon saw it as expedient to develop diplomatic relations with China to serve as a counterweight to the Soviet Union. The opening of diplomatic relations basically signaled the resumption of trade relations between the two nations that had been suspended for more than two decades. Shortly after Nixon's visit, a deal was struck in which the Chinese would purchase 10 Boeing 707 aircraft. The Chinese saw this as an opportunity. not only to add the world's most advanced aircraft to their fleet, but to study a version of a B707 that had not been damaged by a crash.

Boeing officials believe that a B707 was taken out of circulation sometime after the Chinese had received it in 1973 and that there was an attempt to reverse-engineer the plane to again help with their development of the Y-10.[259] The Chinese attempted to carbon copy the plane in the same manner they had reproduced Soviet aircraft decades earlier.[260]

The Y-10's structural design and system integration were almost identical to those of the Boeing 707, while the shape of the wings was copied from the British Trident, which China had purchased in 1975.[261] The designers also managed to salvage parts from

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[259] Mark Dougan, *The Political Economy Analysis of China's Civil Aviation Industry* (New York: Routledge, 2002), pp103-104.

[260] Ibid., p104.

[261] Zuodi Zheng and Guoqiang Zhao. "Tragic Y-10-The Whole Story of the Development of Y-10," ("Bei Qing Yun 10-Yun 10 Yan Zhi Shi Mo"), Aviation Archives, Vol. 6 (2005): 44, (Hang Kong Dang An, Vol. 6 (2005): 44-51).

the JT3D-7 engine they had removed from the downed airplane in Xinjiang, and some parts China had obtained when they purchased B707s in 1972 for replication; China's engineers had studied the engine and made a poor imitation known as the WS-8.[262]

Problems with Copying the JTD-3 Engine

Many problems, however, surfaced around the turbofan aeroengine; China had a lot of trouble reproducing advanced engine technology. Before it had access to the JTD-3 Pratt and Whitney engine, it first attempted to copy the Rolls Royce Spey engine; however, it did not possess the technological capability, the expertise, or the skilled engineers capable of successfully duplicating the engine, and therefore had to stop the project.[263] This did not stop the Chinese from trying to replicate the Pratt and Whitney engine when they had it in their possession. Unlike years earlier, when it tried to carbon copy the British engine, China was quite optimistic about replicating the JTD-3 engine, because the Y-10 was part of the national plan, through which the country allocated an exorbitant amount of resources, money, and equipment toward the project (more than 5 million Yuan).

At first, China planned to use the Pratt and Whitney engine for testing the airplane, later to be replaced with their indigenous copy.[264] Again, the Chinese found themselves unable to master the technology and therefore produced a poor-quality domestic copy. The engine leaked oil badly, a flaw their engineers were not skilled

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[262] Ibid., pp44-51.
[263] Personal interview conducted with Shengwu Chen, Chief Engineer and Director of Sales at AVIC's Chengdu Engine Co. Ltd on October 18, 2009.

[264] Xiongxin Lou, *The Story of the Y-10* (Yunshi de Gushi), (Shanghai Aircraft Manufacturing Factory), (Shanghai: Shanghai Scientific & Technical Publishers, 2009), (Shanghai Feiji Zhizaochang, Shanghai: Shanghai Kexue Jishu Chubanshe, 2009), p7.

enough to repair, so they discontinued making it.[265] Instead, they decided to purchase brand-new foreign Pratt & Whitney turbofan engines.

Problems with Prototype Copying the B707

Though China had the B707 to analyze, its technological sophistication was nowhere near the level of the technology embedded in the 707. Of the 435 parts needed for the Y-10, 305 had never been manufactured in China before.[266] The overall structure of a complicated plane such as the B707 was above the technological ability of the engineers in China. Its technology lagged far behind Europe and America. The Chinese did try to compensate for what it was not familiar with by trying to replicate components using indigenous resources. However, the Chinese did not have the expertise, training or experience to do so. For example, they had to develop an aluminum alloy using indigenous sources but had limited experience developing such metal. This was a relatively new industry in China; they were able to make it but only in small amounts. China's domestic factories could only produce 0.8 meters, while the industry's standard requirement was 2.2 meters.[267] The aluminum alloy the Chinese produced was also too thick, which increased the size and weight of the plane and resulted in high fuel consumption.

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[265] Personal interview conducted with Shengwu Chen, Chief Engineer and Director of Sales at AVIC's Chengdu Engine Co. Ltd on October 18, 2009.

[266] Xiongxin Lou, *The Story of the Y-10* (Yunshi de Gushi), (Shanghai Aircraft Manufacturing Factory), (Shanghai: Shanghai Scientific & Technical Publishers, 2009), (Shanghai Feiji Zhizaochang, Shanghai: Shanghai Kexue Jishu Chubanshe, 2009), p17.

[267] Ibid., p15.

The plane that the Chinese built was not economical; it was too heavy, too noisy, and required too much fuel while only able to fly within a limited range,[268] reportedly only half an hour before having to refuel.[269] There were also safety concerns; the plane's heavy weight, along with a very small CG shift limiting, made it unsafe for civilian application.[270] Yet, despite its many troubles, the Y-10 took its maiden flight on September 26, 1980, flying over Shanghai for 24 minutes. The test flight had been conducted though China lacked the equipment necessary to adequately test the safety of the plane in advance.

To ensure reliability, the Y-10 needed 163 tests, including 1,400 hours in the wind tunnel and static tests of fuselage damage, but this couldn't be done adequately because the wind tunnels were too small.[271] Without adequately testing the plane, in addition to its technical problems, it was perceived as accident-prone, like many other planes built during the Cultural Revolution, when less attention was paid to quality than to quantity, resulting in a lot of unsafe and defective aircraft: as many as 400 F-6 III's manufactured in 1971 were recalled for repair because they had many accidents.[272] They were also not

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[268] Xitao Hu. The Construction and Development of China Aviation Industry: Classified: Insider Information, (Zhongguo Hangkong Shiye De Jianshe Yu Fazhan: Neibu Ziliao), Book consists of a collection of reports for Government Officials and Party Leaders, 1997, (Benshu Baokuo Le Gei Zhengfu Guanyuan He Zhengdang Lingdaoren Baogao De Heji, 1997), p84,159,259.

[269] "Chinese Dream of a Big Airplane," CCTV, http://www.cctv.com (accessed October 15,2010).

[270] "Y-10." Global Security. http://www.globalsecurity.org/military/world/china/y-10.htm (accessed June 1, 2010).

[271] Xiongxin Lou, *The Story of the Y-10* (Yunshi de Gushi), (Shanghai Aircraft Manufacturing Factory), (Shanghai: Shanghai Scientific & Technical Publishers, 2009), (Shanghai Feiji Zhizaochang, Shanghai: Shanghai Kexue Jishu Chubanshe, 2009), p10.

[272] Jun Yao, *A History of China's Aviation* (Zhongguo Hangkong Shi) (Zhengzhou: Elephant Press, 1998) (Zhengzhou: Da Xiang Chubanshe, 1998), p364.

adequately tested before leaving the factory. The Y-10 was discontinued in 1985. It would have been unwise to allow a Chinese official to fly on a plane that was deemed unsafe.

FIRM STRATEGY STRUCTURE AND RIVALRY

The fourth determinant mentioned in Porter's model for gaining a competitive advantage in industry is associated with the context in which firms are organized, managed, and compete with one another (rivalry).[273] A firm's competition plays a role in influencing and motivating it to innovate or offer products with new features to satisfy market demand or produce existing products more cheaply by developing scale economies. How efficient a firm is at gaining an advantage over its competitors is largely determined by how suitable its organizational structure is for competing and adapting to market demands. A firm's competiveness can be determined by how well it can motivate its employees to meet company objectives.

Porter's Firm Strategy, Structure, and Rivalry force us to pay attention to China's rigid planning system and lead us to understand many of the inherent deficiencies it has in developing, maintaining, and sustaining an industry. Decisions were made at the apex of the rigid top-down systems while the free market virtually played no role. Worker motivation was lacking, because they were paid and given welfare benefits that were guaranteed and not based on work performance. This was especially problematic when competition was lacking, which further encouraged stagnation.

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[273] Michael Porter, *The Competitive Advantage of Nations* (New York: The Free Press, 1990), p107.

Structure

Hierarchical decision-making

China's aviation manufacturing was controlled through a hierarchical system. At the request and direction of the Party Politburo, the State Planning Commission (SPC) would draw up production targets and planned schedules for the Ministry of Aviation and Military groups to meet. Due to the complexities of the aviation industry, the SPC would have to ensure that industries from unrelated fields such as metallurgy, electronics, and petroleum were able to supply the needed resources of the aviation industry set in the plan within a given budget. They would also have to make sure that factories were supplied such utilities as electricity, water, and other infrastructure from local governments.[274] Aviation factories did play a major role in local economies because they employed so many people and tended to be significantly larger than other factories. The MAI was responsible for managing the bureaus and factories and had to ensure that they follow through, so the assigned task was completed.

The MAI shared its factories and facilities with equal- ranking military organizations within the army, navy, and air force; production of military aircraft and hardware took precedence over civil aviation, for it was considered crucial for purposes of national security. At nearly every factory, military personnel maintained an active presence, even though they were more actively involved in research and development and

[274] Ibid., p44.

design aspects of the production cycle.[275] More attention and resources were devoted to military aircraft than anything else.

The Ministry of Aviation Industry was divided up into sub-ministerial departments or bureaus, which included the Aircraft Bureau, Engine Bureau, Quality Bureau, etc.[276] These bureaus were assigned and delegated responsibilities by the MAI and were placed in control of the factories under their jurisdiction. For example, the Engine Bureau was in charge of all of the engine factories, while the Aircraft Bureau controlled all of the airframe factories.[277] The Quality Bureau had the authority to exercise quality control across all of the factories. The MAI was responsible, not only for appointing all bureau chiefs, who also had to be party members, but for coordinating all the bureaus and bringing together all of their work so a completed aircraft could be made.[278]

Factory directors were also Party members usually appointed by the MAI; however, if the factory's work was considered important for the national interest, they would be appointed by the central government or military leaders.[279] Each bureau chief and factory director, at times the same person, carried out the plan assigned to them and also made sure that their subordinate factories had the necessary resources to complete

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[275] Liqun Deng and Duan, Z. J (eds.), *Contemporary China's Aviation Industry* (*Dangdai Zhongguo De HangKong GongYe*), (China's Social Science Press, 1988), (Shehui jiaoxue Chubanshe, 1989), pp434-441.

[276] Ibid., p441.

[277] Mark Dougan, *A Political Economy Analysis of China's Aviation Industry* (New York: Routledge, 2002), p.43.

[280] All senior members of the industry were held high ranking and import state positions in the party, government and military-often all at the same time.

[281] Mark Dougan, *A Political Economy Analysis of China's Aviation Industry* (New York: Routledge, 2002), p43.

assigned tasks. Even though factories may have had their own style of management, they did not have much autonomy, nor did they yield much influence over the process, as they were responsible for carrying out the production targets assigned to them by their respective bureaus, which was where decision making actually occurred.

Factories did not have an individual identity; they were often referred to by the number assigned to the factory. For example, Harbin Aircraft Manufacturing Factory was known as 122. Numbers were assigned to factories to shield the actual activities of factories from non-insiders. The process was very secretive because work related to national security was done at these factories. Every aspect of the free market, including individuality, was removed from the process.

The Structure of the Service Side of the Industry

As far as the service side of the industry, the CAAC was originally created in 1954 to handle all responsibilities related to civilian air transport, including making decisions on the purchasing of foreign aircraft, the construction of new airports, the volume of daily aircraft departures, and the designing of airline routes. Like the manufacturing side of the industry, the system was run hierarchically from the part elites at the apex to the Central Military Commission or the State Council, all the way down to the CAAC’s bureaus and factories. Most of the CAAC’s decisions, regarding aircraft acquisition of foreign aircraft were heavily influenced by party elites and were made in consultation with the central government in accordance with the State Planning Commission’s 5-year plans.

The CAAC was also responsible for scheduling daily flights and routes in China. However, it remained difficult for example to predict if there would be enough demand for the number of flights scheduled daily. It wasn't wise for the CAAC to order a bureau to run 1,000 flights between Shanghai and Beijing per year at 20 flights per day, because there was no way of knowing if there would be enough demand or freight to support this forward planning.[280] Such planning could have resulted in many flights being empty.

To run civilian air service operations, planning forward was thus of little use, and the administrative system had to be more flexible with its scheduling. There was very little to no profit to speak of because air travel was only a luxury for high-ranking government officials who, most of the time, did not pay for their air tickets. Chinese citizens were not allowed to fly unless they had special permission from the government. Business was conducted without the free market playing any role. As far as how many aircraft the aviation manufacturing side of the industry needed to produce for the air service side or how many flights should the air service side offer to civilian passengers and specific routes and their frequencies were based on administrative conjecture and speculation. Many of those estimations, along with the industry's lack of flexibility, made the service side of the industry highly inefficient and inadequate, producing many shortages and bottlenecks.

[280] Mark Dougan, *A Political Economy Analysis of China's Aviation Industry* (New York: Routledge, 2002), p53.

Shortcomings of the planned system

As Porter correctly notes, there are major deficiencies within a system that lacks competition. Without it, firms and enterprises are not going to organize in a suitable way conducive to competing with rivals. The Chinese system during the Mao era contained many inconsistencies that emanated from the workings of the economic planning system. In such a system, a unit such as factory would receive a production quota that it was expected to meet from its upper bureaucratic superior, which could be a provincial government department, a bureau, a ministry, and even the state planning commission itself. The factory was given a certain amount of resources to produce the amount of the product its superiors had requested.

There were a host of problems associated with this system in terms of efficiency. The large and powerful bureaucracies were so far removed from knowing the exact amount of resources subordinates needed to meet their target that shortages often occurred, leading to factory failures to meet targets. Also, teams of administrators were responsible for keeping statistical records and were in charge of overseeing the factories to make sure they were doing what they were told. However, these production teams were not often familiar with the subordinate factory's supply chain and with whether the inputs they needed were in abundance or in short supply. They were not even sure if factories could receive what they needed to complete orders they received from above.[281] "Without extensive administrative coordination and communication, bureaucratic decision makers could not know how much their subordinate factories were able to

[281] Ibid., p69.

produce and how much they should produce."[282] The administrators did not know who the end users of the product were or their desires and needs. Not only was the planning system a difficult task, but the work staff lacked any sort of motivation to work hard. These system inefficiencies often led to massive shortages.

State-Run Enterprises

The success of the Planning System was highly dependent on the workers employed at the State-Run Enterprises (SOEs). SOEs were originally established to restore damage to a suffering economy. It was a way in which the top leaders of the country maintained direct control over it. Through this process they would be able to lead and guide the developmental process. However, the production targets set by officials through the planning system were often not met, partly because worker motivation and productivity were low. The Danwei system guaranteed lifetime employment to workers and cadres regardless of work performance or productivity. This encouraged laziness and a lack of incentive to work hard.

Workers in the Danwei system were also entitled to a comprehensive welfare packages known as "iron rice bowl," offering egalitarian wages, health insurance, housing, education for their children, hospital services, and retirement packages, etc. These benefit packages were offered mainly because wages at the plant were so low that the government had to supplement workers' incomes with these welfare packages.[283]

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[282] Ibid., p69.

[283] Alan Williams, *Contemporary Issues Shaping China's Civil Aviation Policy* (Cambridge: Ashgate Publishing Ltd., 2009), p63.

There was also a tradition of occupational inheritance known as “dingti,” through which employees who would soon retire could pass on their jobs and their Danwei services to their sons or daughters. State-run enterprises were required to foot the total cost of lifetime social services for all of their employees and retired employees. “The State-owned enterprises ate from the big iron pot of the state and the members of the Danwei from the big iron pot of the State Owned Enterprise.[284]

The Danwei system in essence created a high level of social dependency on the state. The government was also able to exercise high levels of control over the individual. Workers were restricted to the enterprise for which they were employed and were forbidden to seek employment elsewhere. Any thought of departure would lead to a suspension or revocation their existing Danwei services.

The Danwei was highly inefficient in its execution and produced poor-quality products. Because the government was responsible under this system to provide jobs to the populace, many State Run enterprises and factories were overcrowded. In fact, State Run Enterprises in 1980 employed 80 percent of all workers in the urban labor force.[285] People would come to work having nothing to do. One reporter observed the workers at the Guilin Silk Factory. When the journalist walked into the factory, three female workers were chatting with three other female colleagues. When the workers noticed the journalist had walked in the room, they went back to their seats. In the several minutes that he stayed, only one actually worked. Several days later, he returned to the factory

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[284] Ibid., p64.

[285] Alan Williams, *Contemporary Issues Shaping China’s Civil Aviation Policy* (Cambridge: Ashgate Publishing Ltd., 2009), p64.

and interviewed some of the employees; nobody knew exactly what their job responsibilities were or how much they should produce each day. Chinese workers viewed their jobs as a right rather than an opportunity. The Guilin factory had 2,500 workers, and not one had ever been fired.[286] It was highly inefficient.

Another report was published on a home-appliance enterprise in Qingdao, also indicating the lack of motivation and incentive on the part of the Chinese to be productive at work. A journalist observed the factory for several weeks and noticed that, if the vice general manager didn't come to work, none of the employees would stay more than an hour. People would come to work at 8 a.m. and would leave be by 9 a.m. If you had dropped a bomb on that factory at 10 a.m., nobody would have been hurt. The work environment was anything but professional, as employees treated the corner of the enterprise as a place to relieve themselves. When the vice general manager issued a rule forbidding such behavior, employees still urinated in the corner. There was no fear of being fired or reprimanded for doing inappropriate things. The reporter also noticed that if the employees didn't leave work early, they would instead drink alcohol, play cards, and smoke with their colleagues during designated work hours.[287]

Another journalist who observed the Chongqing steel factory found that there was a machine still in operation that was over 140 years old. Factory hardly upgraded their equipment under this hierarchical system. The reporter asked the head of the factory if there was something wrong with the age of the piece of equipment. He was told, no, the

[286] Wu Xiaobo, *Thirty Years of China Business*, (*Ji Dang San Shi Nian*), (Beijing: China Citic Press, 2007), p10.

[287] Ibid., p127.

machine was of good quality, so it was in still in use.[288] Government officials were not privy to knowing how factories actually functioned. Workers cared little about production and efficiency because of lifetime employment guarantees under the Dan Wei system.[289]

Y-10 STRUCTURE, ORGANIZATION AND RIVALRY

Mao encouraged the development of an indigenous civilian aircraft though he had little knowledge of whether China had the technological capacity to produce state-of-the-art aircraft. Many of the intellectuals and scholars who were able to make such a determination had been forced into penal camps, jailed, or tortured as a result of the Cultural Revolution and the Hundred Flowers campaign. Decisions were made by leaders instead of technicians and experts.[290]

The project was financed solely by the central government, without holding any department or administrative bureaucracy accountable for its success or failure. There was not a clear delineation of responsibility between and among departments, and the main department traditionally responsible for aircraft development, the Ministry of Aviation (MAI), wasn't placed in charge of the entire operation. It was the Shanghai government who was assigned the responsibility.

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[288] Ibid., p10.

[289] Alan Williams, Contemporary Issues Shaping China's Civil Aviation Policy (Cambridge: Ashgate Publishing Ltd., 2009), p64.

[290] Xitao Hu. The Construction and Development of China Aviation Industry: Classified: Insider Information, (Zhongguo Hangkong Shiye De Jianshe Yu Fazhan: Neibu Ziliao), Book consists of a collection of reports for Government Officials and Party Leaders, 1997, (Benshu Baokuo Le Gei Zhengfu Guanyuan He Zhengdang Lingdaoren Baogao De Heji, 1997), pp 356-357, 296-297.

The department, equipped with experts and technicians in position to make an accurate assessment as to whether China possessed such capability to build an indigenous aircraft, was ignored. In fact, the MAI believed that the project was a bad idea. The MAI understood that China lacked adequate design experience, and that the aircraft industry had developed a culture of reproducing aircraft that it had received from the Soviet Union.[291] Manufacturing had been more important throughout China's aviation history than design. It took blueprints and licenses from the Russians and, with their help, was able to produce military aircraft. The MAI had little confidence in China's ability to develop a modern indigenous airliner on its own.

Even though the most competent department in China for aviation, the MAI opposed the Y10 project it was deeply offended when Mao Zedong assigned the Shanghai government the responsibility to centrally manage this project. Since the project was not under its jurisdiction, and the responsibility was believed to have been somehow taken away, the Third Ministry of Machine Building was accused of not working as well as it could have given the responsibility it was delegated by the central government.[292] Every department had its own interest; if the plane was to be successful, they wanted credit. Less attention was paid to the benefit of the country as a whole than to the

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[291] Feng Lu, "China's Large Aircraft Development Strategy Research Report, (zhongguo Dafeiji Fazhan Zhanlve Yanjiu Baogao)," *Business Watch Magazine, (Shangwu Zhoukan)* 5 (2005): 40.

[292] Bushi Cheng, "Refuting the argument of Technical Factors as the Reason for Stopping the Y-10: Thinking about the Controversy Caused by the Y-10" ("Pibo Dangnian Yun 10 Xia Ma De Jishu Xing Yinsu De Hu Yan Luan Yu: Yun 10 Zhenglun Yinqi De Sikao") (*Hunting News military network*, 2006) (*Lie Xun Junqing Wang*, 2006), on web 6, June 2010, (http://www.1n0.net/Article/wqzh/9301.html).

interests of the individual departments involved in the project.[293]

Y-10's Organization and Structure

In 1970, Mao openly decided that the development of the Y-10 plane should take place in Shanghai because of its strong industrial base, which also included a strong ship-building industry and many modern factories.[294] Shanghai's long, rich history of producing military aircraft had convinced Mao that it made it a good candidate for the production of the large indigenous civil aircraft transport.

Immediately after Mao expressed his desire for the development of a large passenger aircraft, the Shanghai government, along with the Air Force developed a proposal for the building of its first commercial indigenous aircraft for the approval of the Central Military Commission and the State Council. It required the approval of both branches because the military controlled the majority of factories, facilities, equipment, and technology needed to build an aircraft. The military was also needed to execute the plan that would be devised. The State Council, however, was responsible for coordinating and organizing the many departments and factories.

The State Council also controlled the aviation-related enterprises, bureaus, and factories, institutes under the Third Ministry of Machine Building, which was important for aircraft design and the research and development aspect of the project. The 1973

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293 Xitao Hu. The Construction and Development of China Aviation Industry: Classified: Insider Information, (Zhongguo Hangkong Shiye De Jianshe Yu Fazhan: Neibu Ziliao), Book consists of a collection of reports for Government Officials and Party Leaders, 1997, (Benshu Baokuo Le Gei Zhengfu Guanyuan He Zhengdang Lingdaoren Baogao De Heji, 1997), pp200,356-358.

294 Feng Lu, "China's Large Aircraft Development Strategy Research Report, (zhongguo Dafeiji Fazhan Zhanlve Yanjiu Baogao)," *Business Watch Magazine, (Shangwu Zhoukan)* 5 (2005): 40.

document proposal presented to the State Council and the Central Military Commission laid out the management structure of this project. This document, in very broad strokes, delineated the responsibilities of the main parties involved and their assignments with respect to the Y-10 project.[295]

Departmental Responsibilities

The Shanghai government was responsible for the overall management of the project. Therefore, on July 28, 1970, the central government handed the 5703 Air force factory to Shanghai, because it had state-of-the-art technology and equipment needed to manufacture the aircraft; they also had use of the military airport to conduct test flights.[296] The official assembly of the aircraft would also take place in the 5703 aircraft factory. Shanghai had to organize the manufacturing and assembly of the aircraft. The engine was also to be built in the Shanghai automotive enclosure factory. The Shanghai Aerospace Equipment Factory produced the landing gear. The Y-10 Shanghai Aviation Electric Appliance Factory also produced parts of the landing gear, and nearly 300 subordinated factories, institutes, colleges, and military units, and over 10 ministries, participated in research and manufacture of Y10.[297]

The Third Ministry of Machine Building, under the authority of the State Council, was responsible for creating innovative technology required for the project. It was placed in charge of managing and organizing the research and development aspect of the project,

[295] Jihe Bian, *The History of Shanghai Aviation Industry* (*Shanghai Hangkong Gongye Zhi, Bian Jihe*, (Shanghai Academy of Social Sciences Press, 1996), (Shanghai ShehuikexueYuan Chubanshe, 1996), p51.

[296] Ibid., p.51.

[297] Ibid., pp53-54.

which included aircraft design. The MMB3 consisted of over 172 factories, 420 factory research departments, and 6 colleges, which also housed 605 research units.

The project, however, could not have been executed without the use of military equipment, engineers, and facilities. The Third Ministry coordinated with the military for use of its equipment and facilities. Factories were often divided between the Air Force and the MMB3, with the former always given priority because of its importance to national security. The military had great experience, having manufactured and produced many aircraft in China. The Third Ministry for Machine Building was held responsible for organizing the various departments and factories, especially those factories that were controlled by local and provincial governments outside the Shanghai jurisdiction. For example they had to coordinate local and provincial governments, who were needed for providing electricity and other important utilities necessary for aircraft manufacturing and assembly.

The State Planning Commission was responsible for creating a budget outlining how resources, equipment, and money would be allocated among the various departments, bureaus, and factories involved in the process. It was keenly aware of how much money could be spent on this project and how to best meet Mao's goal of developing China's first large commercial aircraft. The State Planning Commission, in 1973, first projected a budget of over 150 million Yuan, which was initially approved by both the State Council and the Central Military Commission.[298] In 1974, the State Council approved the SPC's request ordering the CAAC to arrange for the shipment of a B707, pilot, and ground crew, maintenance personnel, and technicians, to Shanghai for

[298] Ibid., p52.

research purposes. The approved budget called for the Ministry of Metallurgy to send metal-cutting machine tools, 31 different kinds of bearings, 90 forgings large non-ferrous and ferrous metals, 25 kinds of large-scale forgings, and 236 non-standard non-ferrous metal and 54 non-standard profile plates, to Shanghai.[299]

By the mid-1980s, the total cost of the project amounted to over 200 million Yuan; the new budget, created by the State Planning Commission and approved by the Military and the State Council, allocated nearly 117.514 million Yuan, which amounts to about 66.02 percent of the entire investment, to infrastructure that was yet to be developed in China and necessary for the building of an indigenous aircraft; instead, such a large scale project should have been investing more than half of its financial resources in product development and technological innovation. In the budget, 66.057 million Yuan was allocated to the building of the Shanghai Aircraft Manufacturing factory, of which 28.848 million was used for construction, and 37.209 million on equipment needed to manufacturer and assemble the plane; 7.39 million Yuan was needed for the Shanghai Aviation Electricity Factory, with 3.299 million earmarked for construction and 4.64 million for equipment for the nose gear and main landing gear of the aircraft; 36.811 million Yuan was needed for rebuilding the airport for testing the aircraft, and 6.708 million for building the Shanghai Electric Tools factory.[300]

According to many official Chinese sources, the Central Military Commission allegedly played a small role in managing the project; however, it was heavily involved

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[299] Ibid., p51.

[300] Jihe Bian, *The History of Shanghai Aviation Industry (Shanghai Hangkong Gongye Zhi, Bian Jihe*) (Shanghai Academy of Social Sciences Press, 1996), (Shanghai ShehuikexueYuan Chubanshe, 1996), pp53-54.

in decision making, including budget approval and the execution of the plan.[301] Given that most aircraft developed since the founding of the People's Republic of China were military in nature, they had a proven track record of being able to manufacture aircraft. The military factories also contained China's most advanced facilities and machine technology, required for executing the plan. It was better aware of what was within the realm of possibility and what was not.

Design

Leaders within the Air Force, Shanghai, and the MMB3 held several meetings in the early 1970s to determine which design would be chosen for their indigenous aircraft. On July 28, 1970, they decided to model their aircraft after the H-6 plane, a prototype of the Russian Tu-16 but with slight and partial modifications.[302] The plane was expected to house three or four engines, have a range of 5,000 kilometers, and able to fly 10,000 meters high at a speed of 1,000 kilometers per hour. In order to meet the requirements of the plane, the Air Force, and the Third Ministry of Machine Building, under the auspices of the Ministry of Aviation Industry, sent the first batch of 150 engineers in 1970 along with hundreds of skilled technical personnel to the Shanghai Aircraft Research Institute (in 1978, this institute was renamed the 708 Institute, after the project) to map out the design for this plane.

[301] Personal Interview with Professor Chengzi Li, (expert on technology policy and management) of Beihang University, School of Aeronautics and Astronautics on August 18, 2009.

[302] Ibid.

After the initial model decision, a team of engineers led by Xiong Yan and Wang Ke-Qing spent 40 days developing a high-speed and low-speed hair model of the dimensions and requirements decided by the three groups in Beijing to test to see if the design was feasible; they developed a 1:1 prototype in wood and soon realized, in 1971, that a prototype of the H-6 would not meet the requirements laid out by the Air Force, Shanghai, and MMB3.[303] Therefore, design engineers had to develop a different design for the plane if China wanted to realize its dream of developing an indigenous aircraft.

On April 21, the Air Force became aware of the design problems and believed that, if a new design had to be created, it should be from scratch and not based on a previously produced aircraft. It should, however, meet the world standard. The Air Force proposed a higher requirement for the plane in 1971; the MMB3 had a different opinion. The Third Ministry believed that China's abilities were not at the world standard and therefore should not aim so high.

When various disputes arose between two different agencies and a compromise is not reached, the issue was taken to superiors in the respective agencies or in the Party.[304] After much discussion among higher-ups in the Party Committee of the air force and the CAAC, a compromise was reached. In January 1972, the design of a new model began with the approval of the State Planning Commission, the State Council, and the CMC. At this meeting, it was decided that the aircraft's performance should be no less than the current world standard. The practical range of the aircraft should be around 7,000

[303] Ibid., p55.

[304] Personal Interview with Professor Chengzi Li, (expert on technology policy and management) of Beihang University, School of Aeronautics and Astronautics on August 18, 2009.

kilometers, and that it should possess a cruising speed of 900 kilometers per hour or more to reach the aircraft ceiling of more than 12,000 meters.[305]

The plane was expected to fly this distance mainly at the request of Zhou Enlai, because he wanted to be able to fly direct from Beijing to Tirana, Albania, which was considered the Communist lighthouse of Europe. China maintained good relations with that nation and therefore wanted a plane capable of flying there non-stop, because other countries along that route were adversaries, so stopping to refuel would be out of the question.[306]

Shortly after the meeting among the three departments, the design team met to discuss the preliminary design standards for the plane. The team agreed on developing a plane with four-wing hanging 8-Turbofan engine programs. [307] To meet this requirement, China's overall design plan and strategy for the aircraft had to change. In the past, it had used Soviet aircraft design specifications. Chinese aircraft design had been blindly following the Soviet methods of standards since 1953. Chief engineer Ma Feng Shan said outright that they ought to follow the American international FAR25 standard. Some engineers believed that the Russian standard should be followed because of its familiarity, but this view was quickly dismissed because Russian standards lacked

[305]Jihe Bian, *The History of Shanghai Aviation Industry (Shanghai Hangkong Gongye Zhi, Bian Jihe*) (Shanghai Academy of Social Sciences Press, 1996), (Shanghai ShehuikexueYuan Chubanshe, 1996), p55.

[306] Tang Yong, "Years of Inside Stories On the Decision-Making of Large Aircraft,(dafeiji Juece 30 Nian Neimu)," *Science and Technology Journal of China, (Keji Zhongguo)* 5 (2007): 66-71.

[307] Jihe Bian, *The History of Shanghai Aviation Industry (Shanghai Hangkong Gongye Zhi, Bian Jihe*) (Shanghai Academy of Social Sciences Press, 1996), (Shanghai ShehuikexueYuan Chubanshe, 1996), p55.

precision and often led to the development of an aircraft that was too overweight, making the plane less economical and efficient. The Soviet method was viewed as imprecise.[308]

After much discussion, the design team decided to make the plane in accordance with United States transport aircraft airworthiness standard FAR-25. The design team decided that its aircraft would be based on the Boeing 707, which it had in its possession since the Xinjiang crash. They would attempt to copy it by way of dissecting it, studying it, and then reverse engineering it. The United Kingdom's Trident, and Russian aircraft, would be used as references if needed. This was the first time in history that China would design a plane according to Western standards and requirements. It was believed that, if the specifications for airworthiness were followed, they could better regulate the weight of the aircraft and better ensure safety. In the process of following FAR standards, China was able for the first time to develop 147 useful technologies, including 35 winners of significant Chinese scientific achievement awards.[309] It received a lot of help from the fallen B707. Many of these technologies were learned when Marshal Ye Jianying and his team dissected and analyzed that plane over a period of 3 months.

Motivation

The country's best and brightest engineers, technicians, and personnel were invited to partake in the Y-10 project. At the start of the project, aviation facilities were in poor condition, lacking adequate infrastructure and basic technologies. Workers such as

[308] Personal Interview conducted with Dr. Baichun Zhang (expert on technology transfer and innovation), Scholar at the Institute for the History of Natural Science at the Chinese Academy of Sciences on August 20, 2009.

[309] Jihe Bian, *The History of Shanghai Aviation Industry (Shanghai Hangkong Gongye Zhi, Bian Jihe)* (Shanghai Academy of Social Sciences Press, 1996), (Shanghai ShehuikexueYuan Chubanshe, 1996), p50.

Fang Xiu Zheng did not even have a calculator or other essential equipment to perform basic tasks.[310] He even had to invent small stuff, like pens to draw up blueprints. Researchers, technicians, and engineers worked in dining halls, because the labs and other research facilities were so poor.

Despite these poor working conditions, highly respected engineers remained highly motivated, because they saw it as an honor to serve their country; they took great pride in the fact that their country's leaders had great confidence in them and had called upon them to participate in a project considered important for the nation's development and national security. In a society that had stamped out capitalist tendencies, money was not considered a motivating factor, especially for the people associated with the project. Ideology and rhetoric were very strong during Mao's tenure. Society valued those who contributed to the country. The most admirable occupations were soldiering, engineering, and the sciences, not commerce or business. Those who contributed to the greater good of the country, and more specifically the Revolution, were held in the highest regard.[311]

The engineers and scientists who designed the plane were so passionate about having national officials trust their abilities that they often worked around the clock, including weekends and holidays.[312] On the other hand, workers and laborers who made up the largest population among those involved in developing the Y-10 felt less of an

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[310] Xiongxin Lou, *The Story of the Y-10, (Yunshi de Gushi*) (Shanghai Aircraft Manufacturing Factory) (Shanghai: Shanghai scientific & Technical Publishers, 2009), (Shanghai Feiji Zhizaochang, Shanghai: Shanghai Kexue Jishu Chubanshe, 2009), p110.

[311] Personal Interview with Professor Chengzi Li, (expert on technology policy and management) of Beihang University, School of Aeronautics and Astronautics on August 18, 2009.

[312] Xiongxin Lou, *Tale of Y-10, (Yunshi de Gushi*) (Shanghai Aircraft Manufacturing Factory) (Shanghai: Shanghai scientific & Technical Publishers, 2009), (Shanghai Feiji Zhizaochang, Shanghai: Shanghai Kexue Jishu Chubanshe, 2009), pp102-103.

allegiance to the project; they were part of the Danwei system. They were not encouraged, and lacked motivation to work hard. There was a great disconnect between them and the project. Regardless of their work performance, they were guaranteed employment for life and were recipients of social services. With the delineation of responsibility between and among factories and departments blurred, if a job or a task wasn't completed, hardly anyone was held accountable.

The Cancellation of the Y-10 Project

Approximately 10 years after the start of the project, despite inadequately testing the plane to ensure its safety, the Y-10 carried out its test flight in Shanghai on September 26, 1980, with no Chinese leaders in attendance. One vice-minister of the Ministry of Aviation said to the Deputy Director of the Shanghai Aviation office Wang Yunxiang: "this plane can't fly."[313] Why did the ministry of aviation have a negative opinion of the Y-10 project when it was a matter of national pride? First, the Y-10 was out of the Ministry of Aviation's jurisdiction. Mao's decision to go ahead with the project and assign the task of management and supervision of the project to the Shanghai government deeply offended the Ministry of Aviation. Secondly, against the advice of the Ministry of Aviation, the Y-10 had followed a degree of self- innovation and design.

There were several reasons for why the Y-10 was canceled, however the Chinese government predominately blames the CAAC for its termination. In January 1981, the CAAC stated that it would not purchase the Y-10 aircraft, and this virtually forced the Y-

[313] Feng Lu, "China's Large Aircraft Development Strategy Research Report, (zhongguo Dafeiji Fazhan Zhanlve Yanjiu Baogao)," *Business Watch Magazine, (Shangwu Zhoukan)* 5 (2005): 40.

10 out of the market.[314] The Civil Aviation Department in China said that there was no need to buy it because they had enough airplanes and did not anticipate buying new ones anytime soon. In reality, between 1981 and 1985, China had purchased many planes from Boeing.[315] Secondly, the CAAC declared due to a lack of adequate testing and the reputation associated with airplanes built during the period of the Cultural Revolution, the Y-10 was considered unsafe; many planes that were built during the Cultural Revolution had serious structural and engine defects and also had malfunctions. [316] The CAAC had concluded, just as the MAI had years earlier, that China lacked the expertise and modern technology to build its own airplane.

Director of the CAAC Shen Tu issued two reports to the State Council in 1981 conveying these points. In the first report, he said that the plane faced severe technological problems and was uneconomical; it would not be an asset to the commercial aircraft industry.[317] In the second report, he wrote that the Y-10 was a poor copy of the B707. China would not need the Y-10 because it had already bought 10 Boeing 707s in 1972. By the time the Y-10 prototype was first flown, debate had surfaced about who would want to fly a plane that was based on a 30-year-old design. The CAAC, which already owned a modest Western fleet, would not purchase the plane

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[314] Ibid., p39.

[315] "In December 1982 the Caac in November 1982 Purchased Ten Boeing 737 Planes. For More Information See Boeing Commercial Airplanes," Boeing, http://www.boeing.com/commercial/products.html (accessed June 1, 2010).

[316] Personal interview conducted with Shengwu Chen, Chief Engineer and Director of Sales at AVIC's Chengdu Engine Co. Ltd on October 18, 2009.

[317] "Official Document: Some Views on the Yun-10 Project," ("Dui Guoachan Yun10 Feiji de Jidian Kanfa"), *General Administration of Civil Aviation of China* (CAAC), 1981, 1.

when it was able to purchase 737s with modern technology if needed. This happened at a time when China was beginning to embrace trade with the West. Also, no one wanted to take chances with flying China's leaders on a plane that was not deemed safe.

Consequently, Director Shen Tu was arrested in 1985 and charged with attempting to sabotage the Y-10 project, after the Chinese government allegedly absconded secret documents showing that the CIA had organized a secret meeting at which the Boeing company bribed Shen Tu with money if he would help bring down the the Y-10.[318] It was allegedly believed that if the Y-10 were successful, American aircraft manufacturers could be potentially shut out of the market.

Despite all of the departmental differences, another reason for the cancellation of the Y-10 that surfaced in the media was due to a lack of funding. The government claimed that China's resources, such as steel, petroleum, electricity, and money, were needed for more urgent projects. It might strke people as odd that the project was canceled because of 30 million Yuan when the government already invested over 5,377,537 Yuan and that, when funding ceased by 1980, Shanghai had provided 29 million Yuan.[319] The engineers were already 65 percent done with their third Y-10 plane and believed that, with an additional 30 million Yuan, the technological and structural

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[318] "Y-10 Folds Its Wings Minhang Zong Ju Juzhang Shen Tu Pan Tao Meiguo Shi Mo): The Whole Story of the Minister of the General Administration of Civil Aviation of China Shen Tu and His Defection to the United States, (yun 10 Zhe Chi," The Federation of Chinese folk Diaoyu Islands, (Zhongguo Minjian Bao Diao Lianhehui), http://bbs.tiexue.net/post2_4116945_1.html (accessed March 16, 2010).

[319] "The Chinese Dream of a Big Airplane, (dongfangshikong),"CCTV, http://www.CCTV.com (accessed March 3, 2008).

problems could be corrected.[320] However in October 1982, the Ministry of Finance argued that it would be foolish to put another 30 million Yuan into a large-scale project when there were no customers remotely interested in the plane.

In reality, while all of the reasons mentioned played a role in the cancellation of the Y-10, the main reason was because the political climate had changed. The Y-10 took on new dimension as the project came to be seen as a political rather than technical failure. The central government changed leadership and policy. Deng Xiaoping, one of many Chinese officials formerly sent to the countryside for reeducation, had become China's next leader. He, along with other Cultural Revolution intellectuals and officials who had purged during the CR, were soon reinstated. They detested anything remotely associated with the Cultural Revolution and advocated terminating more than 100 projects that had begun during that time. The political winds began to blow in a totally different direction after the death of Mao Zedong.

When the Cultural Revolution ended in 1976, the Chinese people had soon become aware of the untold damage it had wreaked upon the country, particularly the economy and the government. Mao's revolutionary policies began to fall seriously out of favor with the Chinese people. Leaders started distancing themselves from projects that had been launched during the Cultural Revolution, particularly the Y-10 project, in order to preserve their own political careers.[321]

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[320] Xitao Hu. The Construction and Development of China Aviation Industry: Classified: Insider Information, (Zhongguo Hangkong Shiye De Jianshe Yu Fazhan: Neibu Ziliao), Book consists of a collection of reports for Government Officials and Party Leaders, 1997, (Benshu Baokuo Le Gei Zhengfu Guanyuan He Zhengdang Lingdaoren Baogao De Heji, 1997), pp200.

[321] Feng Lu, "China's Large Aircraft Development Strategy Research Report, (zhongguo Dafeiji Fazhan Zhanlve Yanjiu Baogao)," *Business Watch Magazine, (Shangwu Zhoukan)* 5 (2005): 30.

No Chinese officials wanted to be associated with any of those people or leaders whose names were associated with the revolution, including Wang Hongwen, a Gang of Four member and strong advocate and supporter of the continuation of the Cultural Revolution even after Mao's death in 1976.[322] Wang Hongwen had been heavily involved in organizing the Y-10 project, as he held the position of Party Secretary in Shanghai when the Y-10 was being developed. Some might even say it was his baby. No governmental officials attended the ceremonies, for fear of being connected to him.[323]

Wang and the other Gang of Four members wound up taking the brunt of the blame for the Cultural Revolution's lack of economic success and for the millions of Chinese officials, experts, and intellectuals tortured, killed, imprisoned, or sent to the countryside. Since the government could not denounce Mao because of his success in fighting off foreign imperialists and founding the PRC, guilt was pinned on these four. Wang Hongwen was arrested for his participation in the so-called attempt to usurp power after Mao's death in October 1976. He was tried, convicted, and received life imprisonment. The Y-10 suffered in consequence.

CONCLUSION

Clearly, the path to developing a successful high-tech industry is for a firm to develop a technologically advanced product and sell enough of it to develop scale economies, which affords the firm the ability to sell more cheaply than its competitors.

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[322] Gao,Liang. "On the Abortion of Y-10," (Cong "Yun 10" De Yao Zhe Tan Qi,"), Aviation History Research Vol.74, (2001):11, (Hang Kong Shi Yan Jiu,Vol.74, (2001):11).

[323] Xiongxin Lou, *The Story of the Y-10, (Yunshi de Gushi*) (Shanghai Aircraft Manufacturing Factory) (Shanghai: Shanghai scientific & Technical Publishers, 2009), (Shanghai Feiji Zhizaochang, Shanghai: Shanghai Kexue Jishu Chubanshe, 2009), p104.

The predatory state, under Mao Zedong, stifled China's ability, not only to develop a large commercial airliner, but to do so competitively. Not only was private enterprise and the market economy abolished under the PRC, the predatory system favored rule of man over rule of law. In the absence of a market economy, decisions were made from the top down, indicating that officials knew what was best for individuals and society as a whole. Along with rooting out capitalism, desire and societal demand is lost, which would otherwise emerge naturally through the workings of a free market. Under the predatory system, there was limited incentive to create products that people wanted and needed, simply because there was no monetary reward or prestige associated with being innovative. Decisions about what direction the country ought to take were made by the government elite. The state, through its role of demiurge, relied on its bureaucracies to carry out the development process, and it was responsible for developing industry.

While Peter Evans's framework is crucial for helping us understand China's limitations and policy choices (demiurge and custodial) available for developing industry under the predatory state, Michael Porter's determinant model guides us through the important societal variables that China was unable to develop and therefore failed to build an indigenous aircraft.

The decision to launch the Y-10 project was not based on projections of great demand that would emerge over the next decade, but on the desire of the upper echelon of elites to travel abroad in an indigenous aircraft as a matter of national pride. There was no demand in China for air travel in the early 1970s, as people barely had enough to survive on a salary of 605 Yuan per year. Travel by air was not even an afterthought in the minds of the Chinese people. An aircraft would clearly not be created or designed to satisfy a demand or a niche in a growing market. As Porter correctly notes and is visible in the Chinese case, without a natural demand, no enterprise or company can work in close collaboration with airlines to create a product to satisfy the existing customer base and to attract new business. Naturally, products improve over time, after the customer base alerts firms to shortcomings in the current product or features that ought to be added to improve the overall product.

Technology advances as firms develop and look to acquire new solutions to address current problems, and if there is no perceived need for a new application, there is no motivation to produce or continuously improve a product to better meet customer or market needs.[324] This part of the process will be virtually absent without a demand for aircraft travel. Also, producing enough planes to develop economies was unrealistic in the case of the Y-10 considering that the majority of Chinese people during and after the Cultural Revolution were looking merely to survive rather than to engage in luxurious travel.

In order for a state to satisfy a potential niche in the market, according to Porter's factor condition variable, it must continuously develop and upgrade its pool of highly skilled and specialized scientists, engineers, and infrastructure. Under China's predatory state, educational policy oscillated back and forth between the moderates and the conservatives on the question of whether to train experts and intellectuals to develop the economy, or to offer all citizens a rudimentary education in the belief that on-the-job training would provide them with the skills needed to better develop the economy. The

[324] Feng Lu, "China's Large Aircraft Development Strategy Research Report, (zhongguo Dafeiji Fazhan Zhanlve Yanjiu Baogao)," *Business Watch Magazine, (Shangwu Zhoukan)* 5 (2005): pp48-49.

tug-of-war between the two camps delivered a severe blow to the education system and the training of experts and intellectuals in society. For years, experts and scholars were mistreated and considered opponents of the revolution. Thousands were jailed, tortured or killed, or sent to the countryside to be re-educated. Many intellectuals were forbidden to do individual research for fear that it wasn't egalitarian in nature. Generations of scholars and intellectuals were unable to carry out their research and participate in developing the economy through their knowledge and expertise. This further exacerbated China's condition, because scientists and engineers were needed to advance China's technology, which this was vital for the current and future success of the Chinese economy.

During the Cultural Revolution, universities were closed for years, and when they did reopen, those most loyal to the revolution, regardless of their prior educational background, were chosen. Those most deserving of a college education were frequently passed over, and most of the people accepted were peasants just beyond a primary education. This further exacerbated China's condition, because, without a strong emphasis on science and technology, it would be nearly impossible for the country to innovate and either pioneer technology or meet the world standard. All of this worked against the development of a competitive aircraft. Though Porter's model doesn't specify a numerical quantity of trained and specialized scientists and engineers a state needs to develop and sustain an industry, it doesn't present a problem in this case, due to the number of intellectuals removed from their posts, jailed, or killed.

China's inability to design an aircraft on its own was partially the result of the loss of a generation of scholars, intellectuals, and students who had been denied the ability to conduct independent research or attend college. Many experts and scholars at the time of the founding of the PRC were forced into blindly accepting the help of the Soviet Union. Porter argues against completely relying on foreign suppliers of technology. His model advocates that firms rely on domestic suppliers and related industries because they are more likely to share technology and production processes beneficial to developing a competitive advantage.

What Porter's supporting and related industries variable doesn't discuss is the importance of the different types of technology and knowledge that a firm can gain from working with other suppliers and industries in manufacturing and design. The Russians provided the Chinese with blueprints, technology, and equipment for imitating and copying their aircraft. The Chinese relied so heavily on imitation and copy that they had limited to no experience designing aircraft. The importance of being able to design aircraft, in establishing an aircraft industry, cannot be understated.

This technical information by the Russians was useful for imitation and duplication; it was useful for copying but it only teaches the skills of manufacturing and assembling. Without the ability to design, you are left able only to develop an aircraft containing the technology you were given without the knowledge or the ability to go beyond, because you lack an understanding of the structural reasons the aircraft was made in the way it was. Being unable to design an original aircraft makes it difficult to create a competitive product. Porter does mention, however, the importance of being able to continuously improve and develop new products, which leads one to believe he stresses the importance in being able to acquire technological know-how needed to develop new products.

Porter does note that no nation, for the sake of its own security, would give away its secrets or tacit knowledge of to develop its most technologically advanced components.[325] Therefore it was imperative that China develop a platform for developing an indigenous technological capability, or it would always remain years behind the most technologically advanced nations.

Porter's Structure, Rivalry and Organization variable clearly shows the importance of the free market and how firms organize and strategize in a way that maximizes their ability to compete with its rivals. Conversely, the organizational system set up in China mirrored the Soviet system. It discouraged factory workers from performing at optimal levels. The Danwei system provided lifetime employment and health benefits unrelated to work performance. As long as such a system is in place and factories are often overstaffed, there is limited incentive to work hard. People were not judged or criticized for how well and what they produce. There was therefore less of a desire to create or devise strategies or new ways to perform jobs more efficiently. Managers, all the way down to the factory workers, had limited incentive to perform at optimal levels because their jobs were guaranteed for life.

The development of a large civilian aircraft is technologically complex and demands the highest quality standards; successfully developing an advanced aircraft requires a major commitment, not only from the engineers designing the aircraft but the factory workers as well. Large aircraft development involves thousands of different types of parts and complex product systems to integrate a large number of techniques, sub-systems, and every single item of technology has its own specific nature and particular

[325] Ibid., p36.

progress in the track.[326] Without such a commitment, the success of the project is unlikely, and with it the development of a competitive airliner with pioneering technology. Furthermore, the hierarchical system set in place was largely inefficient at meeting assigned tasks as there was no clear delineation of responsibility, resulting mass duplication and a waste of scarce resources.

The lesson of the Y-10 is that, if China wants to develop a large aircraft program, it must break with its traditional system and introduce a new organization schematic, focusing on a system favoring the bottom-up rather than the top-down principle as both Evans and Porter advocate. From the onset, a clear strategy, detailing the large aircraft program's objectives and the way forward to achieving them through its new bottom-organizing principles, is the way through which the country will not be doomed to repeating the same mistakes it made in the 1970s.[327]

[326] Ibid., p3.

[327] Xitao Hu, *The Construction and Development of China Aviation Industry: Classified: Insider Information (Zhongguo Hangkong Sheye De Jianshe Yu Fazhan: Neibu Ziliao)* Book consists of a collection of reports for Government Officials and Party Leaders, 1997), (Benshu Baokuo Le Gei Zhengfu GuanYuan He Zhengdang Lingdaoren Baogao De Heji, 1997), p222.

CHAPTER FOUR

THE DEVELOPMENT OF THE C-919 AIRCRAFT

The creation of the intermediate state in China has been credited to Deng Xiaoping, who put China on a path toward both political and economical reform. China's new direction was designed to correct the failed economic policies of Mao Zedong and to further restore faith in the Chinese Communist Party. The new system that was created, which developed slowly over time, blends the essential features of a liberal market economy with authoritarian rule. The state has grown to respect private property and to promote competition to a limited degree while, at the same time, ensuring that the Communist Party maintains a firm grip over society by censoring the media, silencing political opposition, picking and choosing firms to become national champions in select industries, and executing grave human rights violations.[328]

While many scholars are quick to tout these major changes that have taken place over the last 30 years as a model for other developing countries to emulate because of the country's rapid economic growth, most of the changes implemented by the party were not planned in advance but were responses to potential crises that could potentially have threatened or jeopardized the one-party rule system created in 1949. These incremental changes were in line with Deng Xiaoping's strategy of "Cross the River while Feeling the

[328] Suisheng Zhao, "The China Model: Can It Replace the Western Model of Modernization?" *Journal of Contemporary China* 19, no. 65 (2010): 434-35.

Rocks," under which the Party has been tweaking and refining its institutions so as to produce great economic growth and to assert greater control over the populace, which both would reduce the chances of any potential threat to its rule from being realized.[329]

China continued to devote much of its attention to economic development because the Party's continued existence is predicated upon improving the quality of life for its people. The government has embarked on a nationwide strategy for meeting the demands of the next phase of development, indigenous innovation. In China's Medium and Long-Term Plan for the Development of Science and Technology (2006-2020), the guidelines were set for channeling 2.5 percent of the nation's total GDP toward research and development in areas of strategic importance for future economic development and national security.[330] The government listed the development of an indigenous large passenger aircraft as one of those 16 key pillars industries for China's continued growth.

THE INTERMEDIATE STATE UNDER DENG

The intermediate state, as described by Peter Evans, is one that maintains a degree of both autonomy and embeddedness but at times falls prey to an imbalance that can take the form of excessive clientelism or isolated autonomy.[331] The state appears to possess autonomy and embeddness but has a tendency to disrupt that balance, thus complicating the developmental process because the degree of autonomy and embeddedness have not been fully legitimized within the state. The intermediate state is plagued by

[329] Barry Naughton, "China's Distinctive System: Can It Be a Model For Others?" *Journal of Contemporary China* 19, no. 166 (2010): 455.

[330] "Chinese Governments Official Web Portal," Chinese Government Web Portal, http://www.gov.cn/english/2006-02/09/content_183426.html (accessed September 27, 2010).

[331] Ibid., p60.

inconsistencies; it often reverts to solving problems in ways with which it is most familiar. China beginning under Deng Xiaoping began to exhibit the characteristics of the intermediate state.

Deng set the stage for great economic development that would span three decades by establishing precedent and introducing the country to the rule of law; China, however, still cannot be classified as an embedded and autonomous developmental state; though at times, it possesses those characteristics, it has on many occasions been overly autonomous, making it an intermediate state. China grew at an annual rate of about 10 percent for more than 30 years because of the changes it made beginning in the late 1970s toward a socialist market economy. It transitioned from a nation that placed a premium on serving the state before the individual to valuing individual interest over the collective under Deng. "The state's role in production was gradually curtailed and reliance on administrative commands was gradually replaced by fiscal, monetary and regulatory instruments."[332]

The state introduced a legal system that recognized private ownership and contracts. These reforms did diminish the state's importance and capacity, but by no means did they eliminate its ability to influence outcomes. Market forces did, nevertheless, play a greater role in the economy. "Despite China witnessing a degree of market liberalization, political liberalization did not occur at the same pace. They lagged consistently behind economic reform."[333] The state asserted its authority while casting

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[332] Thomas Bernstein and Xiaobo Lu, *No Taxation Without Representation in Rural China* (New York: Cambridge University Press, 2003), p2.

[333] Ibid., p3.

rule of law aside in various ways, which included the Tiananmen Square crackdown and its quest to nationalize private firms and force them to merge with State-owned enterprises.

The Tiananmen Square massacre on June 4, 1989, for example, showed how China's reputable leaders would circumvent established law and precedent and call upon its military to end nonviolent student protests by the use of force. The soldiers were instructed to fire on the students who were gathered at the square in the name of a modest form of democratic reform. The protesters were interested in rooting out corruption and opening the channels of communication between students and party officials within the state structure. It was estimated that as many as 2,000 students were killed that day so that order could be restored. Proper procedure was casted aside as Deng Xiaoping and other party elders, who did not hold Politburo positions at the time, made the decision to begin firing on the students.[334] This resulted in widespread condemnation, which included the imposition of sanctions, some of which are still in place today. Because of this incident, the U.S. issued a ban on the selling of certain arms to China.

A recent incident in which the state took advantage of a growing crisis occurred at the onset of the financial crisis in 2008. The Chinese government pumped about $1.5 trillion into SOEs, resulting in major bankruptcies of private enterprises. [335] It became increasingly difficult for private firms to compete with SOEs possessing unlimited capital

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[334] Normal procedure requires members of the Politburo to decide on important decisions related to important national and international issues.

[335] Michael Sainsbury, "Renationalisation of Private Coal Assets Gathers Pace in Shanxi," Australia, http://www.theaustralian.com.au/business/opinion/renationalisation-of-private-coal-assets-gathers-pace-in-shanxi/story-e6frg9if-1225823056579 (accessed July 15, 2009).

during troubled economic times. By eliminating private firms or forcing them to merge with State-owned enterprises, national firms would be in a better position to compete with foreign enterprises on a global scale. Without domestic competition, national firms would profit immensely by exploiting the large domestic market, giving them the opportunity to develop scale economies and channel profit toward research and development. “Many of China's State-owned enterprises (SOEs) have grown into giants, eclipsing the relatively young, private companies that have contributed heavily to the country's progress.”[336] In 2008 alone, more than 300,000 small and medium-sized firms either closed down or merged with State-owned enterprises.

The government also showed a blatant disrespect for private property in Shaanxi province when it forcefully took over many small firms because they violated state environmental regulations within 1 year.[337] Even though some coal-miner operators had implemented the environmental standards required by the state, they were still forced to sell their businesses to the state at a rate of 30 percent less than they were actually worth.[338] The Chinese government, has on various occasions bypassed the rule of law and asserted its authority, which has been predatory in nature. Without the respect for rule of law, entrepreneurs are discouraged from investing their money in projects when the state does not provide a stable set of rules which make returns on investment predictable. Under the current situation, firms have to be wary of governmental takeover.

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[336] Austin Ramzy, “Why China's State-Owned Enterprises Are Making a Comeback,” Time Magazine, http://www.time.com/time/world/article/0,8599,1894565,00.html (accessed June 1, 2009).

[337] Jason Ma, “Coal Mine Ownership in China Changes with Political Winds (and Whims),” Epoch Times, http://www.theepochtimes.com/n2/content/view/24424/ (accessed July 15, 2010).

[338] Micahel Sainsbury, “What's Yours Is Mine in the China Coalfields,” The Australia, http://m.theaustralian.com.au/OpinionNews/pg/0/fi175932.htm (accessed June 1, 2010).

ROLES PLAYED: DEMIURGE, CUSTODIAN, MIDWIFE AND HUSBANDRY

The intermediate state having the characteristics of both the predatory state and the developmental state utilizes at times all four policy roles mentioned in Peter Evans's framework. The Chinese intermediate state espouses the demiurge and custodial roles with respect to the launching of its large commercial aircraft because of its importance to national security and economic development. Innovative technologies are known to emanate from the development of commercial aircraft that could potentially spillover to other sectors of the economy and the military. Since the industry is naturally driven toward a monopoly, the Chinese government will not allow any private whether foreign or domestic firms to exploit China lucrative market. Over the next 20 years China's demand for large aircraft will constitute nearly 25% of the world's total demand Allowing private enterprise to enter such strategic industries are believed to create situations where personal greed can trump the interests of the country. Private firms could not only exploit the nation's scarce resources but they could potentially refuse to share its innovative technology with other sectors of the economy or the military if they feel it is not in their best interest. Private interest often runs counter to that of public interest or national security; therefore, it would prevent private firms from entering such industries.[339]

China does, however, espouse the midwifery by inviting foreign firms and capital to help develop aircraft subsystems, parts and components that their domestic enterprises

[339] Suisheng Zhao, "The China Model: Can It Replace the Western Model of Modernization?" *Journal of Contemporary China* 19, no. 65 (2010): 424.

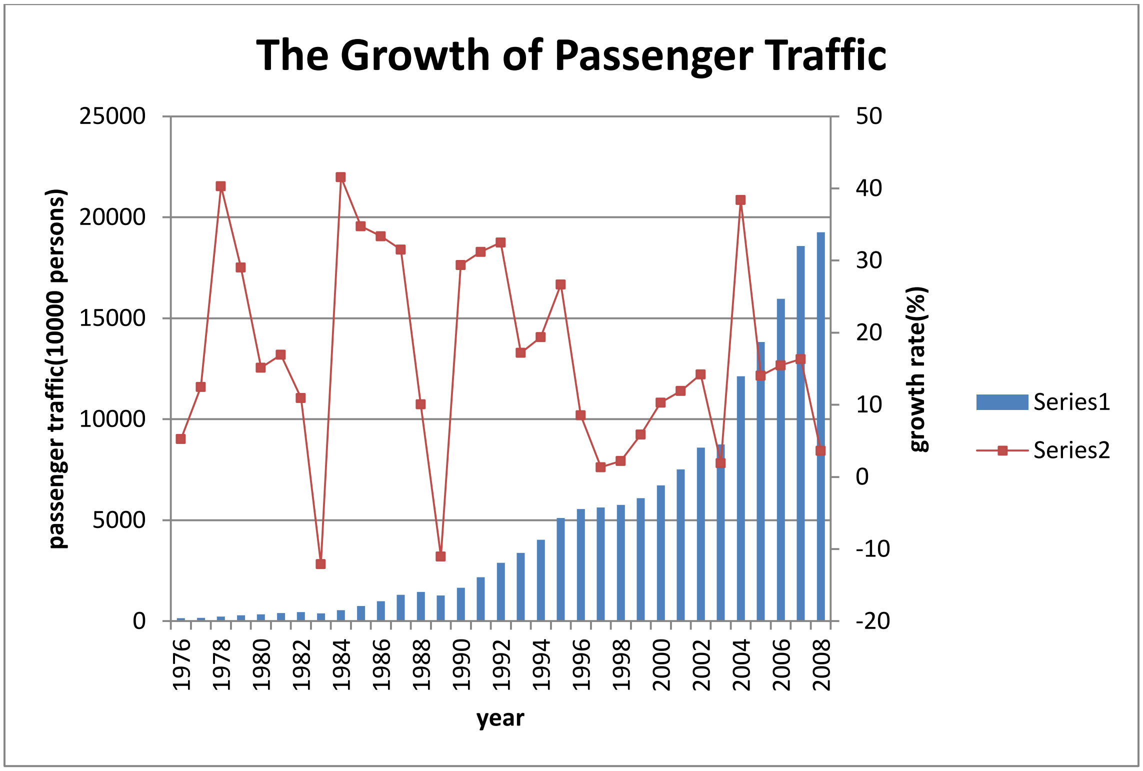
are not able to produce indigenously. The Chinese government offers incentives, including reserving a degree of the Chinese market for the foreign firm's products in exchange for entering into joint-venture arrangements with its state-owned. Once the foreign firm commits to entering a venture with the Chinese, the government may play the husbandry role by offering tax credits and allocating money toward the venture's research and development. These ventures are especially important for the Chinese because they gain access to world class manufacturing technology and infrastructure in addition to learning western managerial practices. These foreign companies are also welcomed because they employ many local people.

DEMAND FOR THE C-919

Passenger Traffic

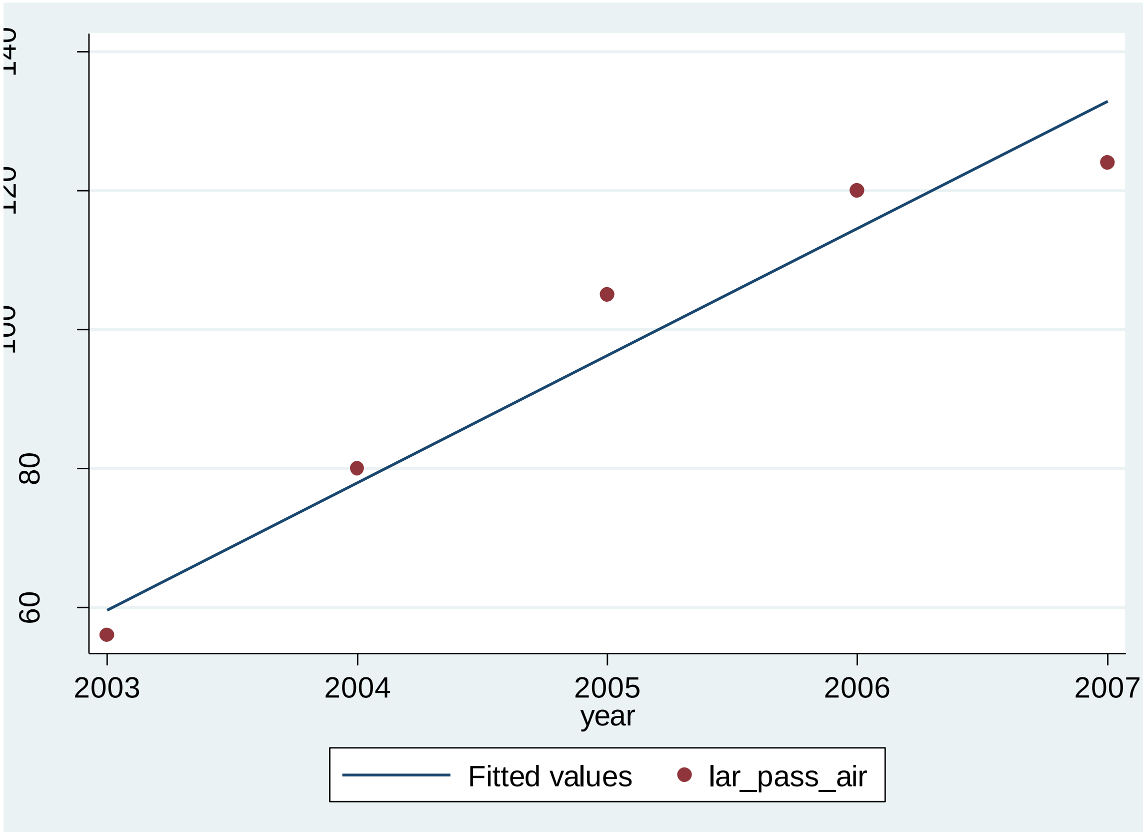
On May 11, 2008, the Commercial Aircraft Corporation of China (COMAC), a limited-liability company, was created to manage and oversee the development of its indigenous large passenger aircraft, the C919. The corporation was primarily created to satisfying China's growing demand for large passenger aircraft over the next two decades. China's domestic passenger volume grew at an astounding rate of 16.5 percent between 1976 and 2008; air passenger traffic jumped from 2.31 million people in 1978 to 192.5 million in 2008.[340]

[340] Department of Comprehensive Statistics of National Bureau of Statistics, (Guojia Tongjiju Guomin jingji Zonghe Tongjisi), *China Compendium of Statistic 1949-2008* (Xinzhongguo liushinian Tongji Ziliao Huibian) (China Statistics Press, January 2010), (Zhongguo Tongji Chubanshe, January 2010), p51.



Since China's economy is expected to grow at its current annual rate of 9 percent over the next two decades, China's air passenger traffic is also expected to continue to grow at a steady annual rate of 16.5 percent--we can expect more than 770 million passengers to travel by air in 2020. This would pay huge dividends for China if it is able to successfully manufacture an indigenous passenger aircraft. China will require over 3,560 airplanes (as revealed in the regression model below) with more than 60 percent in the 190-seat range worth $340 billion over the next 20 years.[341]

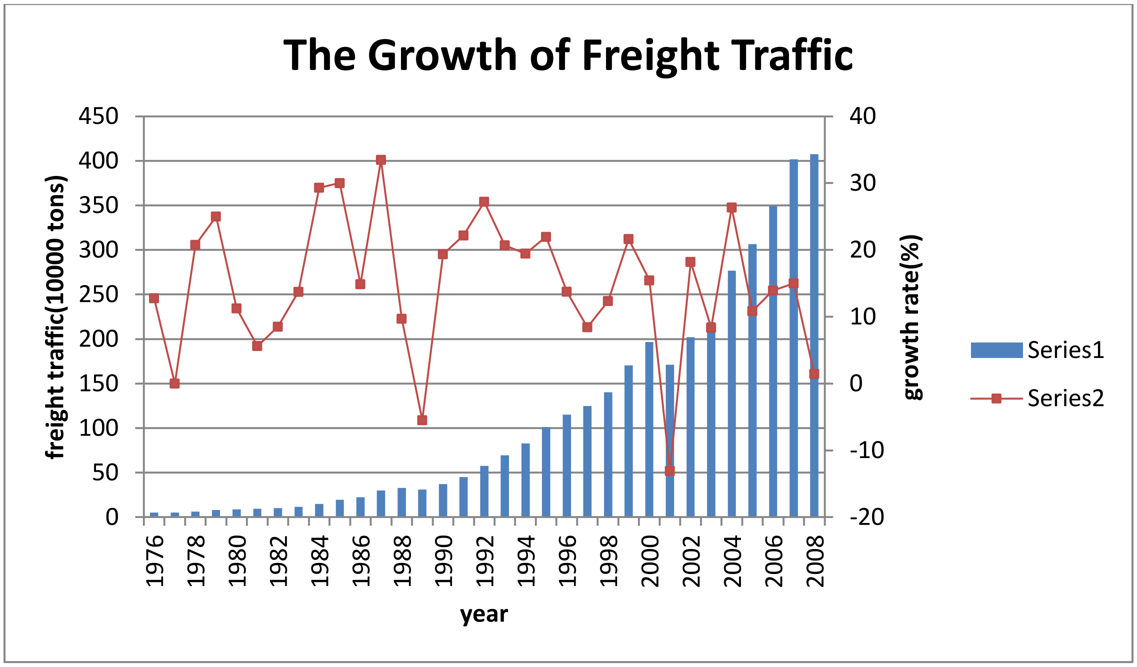
[341] Mark Stokes, "China's Commercial Aviation Sector Looks to the Future, Project 2049 Institute," Project 2049 Institute, www.scribd.com/.../Chinas-Commercial-Aviation-Sector-Looks-to-the-Future.com.



The slope of the line for the number of large passenger aircraft is 18. In 2007, the number of planes increased by 124 from the previous year. The regression chart predicted that, in 2008, there would be an increase of 142 (124+18), and that, by the end of 2010, it would rise to 178. We can then assume that the increase each year is fixed at 178; therefore, over the next 20 years, the total demand will be 178×20=3560.

Cargo and Freight Traffic

China today has the world's second-largest cargo market, right behind the U.S. In 1976 China's total freight constituted only 53,000 tons; by 2008 it had jumped to a staggering 4.07 million, increasing by 14.5 percent annually.[342] With the expectation that China's economy will continue to grow at an annual rate of 9 percent, we can project that cargo will also continue to grow at 14.5 percent annually; we can then forecast that, by 2020, cargo will exceed 12.7 million tons; it is reasonable to assume that China will be looking to add 300 freighters to its fleet by 2026.[343]



Reform as a Catalyst for Demand

This surging demand, which will literally require China to quadruple its fleet over the next two decades, can be attributed to the success of China's reform beginning with

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[342] Department of Comprehensive Statistics of National Bureau of Statistics, (Guojia Tongjiju Guomin jingji Zonghe Tongjisi), *China Compendium of Statistic 1949-2008* (Xinzhongguo liushinian TongjiZiliao Huibian) (China Statistics Press, January 2010), (Zhongguo Tongji Chubanshe, January 2010), p53.

[343] "Boeing Projects $340 Billion Market For New Airplanes in China," Boeing, http://www.boeing.com/news/releases/2007/q3/070918a_nr.html (accessed September 18, 2009).

Deng Xiaoping's four modernizations, consisting of paying special attention to certain sectors of the economy: agriculture, science and technology, industry, and national defense. Politics and ideology became less important than the overall development of the country. Market reform was also introduced by allowing small-scale private interest the ability to pursue its material desire by operating alongside, and to a limited degree competing with, the state sector in a system previously dominated and ordered around the principles of a command economy.[344] For the most part, newly established private firms competed in small- scale industries, while the large, bloated State-owned enterprises, continued to monopolize, the large-scale industrial sectors. As long as private firms did not grow so big that they can significantly affect market outcomes in sectors deemed vital for national security and important for overall continued economic growth, they were largely left alone.[345]

Allowing private firms to form and compete in the market against SOEs exposed the weaknesses of these government-owned firms. "The competitive market is one of the most important external forces that discipline a firm and force it to become more efficient."[346] This level of competition revealed how poorly managed State-owned enterprises actually were. For example, it was often unclear for employees in such enterprises to know who they had to answer to. Were they directly responsible to their superiors in the vertical state bureaucratic system or to their superiors under the local

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[344] Mark Dougan, *A Political Economy Analysis Of China's Civil Aviation Industry* (New York: Routledge, 2002), p66.

[345] Barry Naughton, *The Chinese Economy: Transitions and Growth* (Massachusetts: MIT Press, 2007), p300.

[346] Ibid., p297.

bureaucratic system? Having to answer to their superiors in both groups led to mass confusion, as one group would often contradict the other. Enterprise managers and other employees often complained that they had too many mothers-in-law claiming a share of the property and responsibility of the SOE.[347] Enterprise rights were not clear.

During the 1980s the government started to shift SOE orientation toward profitability, and since many of these state- owned enterprises were operating at a loss and were not considered vital to the function of the economy, they were allowed to go out of business or to be completely or partially sold off in the market. New laws began to surface protecting private property and the rights of both buyers and sellers when transactions took place. The introduction of a Property Rights law in 1994 led to a reduction in the overall number of SOEs and an increase in both jointly owned firms and privately owned firms. The number of State-owned enterprises fell to 21,300 in 2008 from 102,200 in 1994 as a result of the campaign known as "grasping the large and letting the small go."[348] The government was mainly concerned with holding onto large enterprises that were important for national security and economic development. They included energy, telecommunications, and natural resources.[349] With foreign and local businesses having entered the picture, consumers could choose between products that were made by private businesses and those made by the state; there was a more diverse

[347] Mark Dougan, *A Political Economy Analysis Of China's Civil Aviation Industry* (New York: Routledge, 2002), p74.

[348] Department of Comprehensive Statistics of National Bureau of Statistics, (Guojia Tongjiju Guomin jingji Zonghe Tongjisi), *China Compendium of Statistic 1949-2008*,(Xinzhongguo liushinian Tongji Ziliao Huibian), (China Statistics Press, January 2010), (Zhongguo Tongji Chubanshe, January 2010), p134.

[349] Barry Naughton, *The Chinese Economy: Transitions and Growth*, (Massachusetts: MIT Press, 2007), p302.

environment. By 1998 approximately 95 percent of industrial goods and services were traded in the market.[350]

In 1975, before the reform period began, 81 percent of all industrial output was produced by State-owned enterprises, with collectively owned firms managing only 18.9 percent, leaving private industry at 0.1 percent. By 1998, SOEs only produced 49.63 percent of total industrial output while collectively owned constituted 19.46 percent and individually owned 30.91 percent.[351] China's State-owned enterprises in 2008 accounted for 28 percent of total industrial output, while collectively owned consumed 1.76 percent and private and individual enterprise taking 70.24 percent, indicating a significant decline in SOE contribution to industrial output.[352] As China remained committed the principles of the market, incentive and motivation grew among private firms to increase production and produce better-quality items that consumers demanded. As firms continued to sell their products, they looked to expand, thus hiring more people, who would then earn money, enabling them to purchase more goods, thus contributing to the overall growth of the economy. In 1978 401.52 million people were employed in China; that number

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[350] Baohua Yuan, "Six Favorable Conditions For Soe Reform and Three Pieces of Advice On That, (gaohao Guoyou Qiye Gaige de Liuge Youli Tiaojian Ji Santiao Yijian)," *Truth Seeking* 8 (1998): 337.-338.

[351] Department of Comprehensive Statistics of National Bureau of Statistics, (Guojia Tongjiju Guomin jingji Zonghe Tongjisi*), China Compendium of Statistic 1949-2008 (Xinzhongguo liushinian Tongji Ziliao Huibian) (*China Statistics Press, January 2010), (Zhongguo Tongji Chubanshe, January 2010), p40.

[352] National Bureau of Statistics in China (ZhonghuarenmingongheguoTongjiju), *Chinese Statistical Yearbook 2010 (Zhongguo tongji nianjian 2010*) (Chinese Statistics Press 2010), (Zhongguo Tongji Chubanshe, 2010), p507.

limbed to 774.8 million by 2008 as a result of economic reform and Deng Xiaoping's Open Door policy.[353]

Open Door Policy

Beginning in 1978, China opened its doors to other nations, allowing them access to its large, virtually untapped markets. Foreign trade corporations and external trade channels popped up all over the country and revenue was generated as a result of foreign direct investment; it became an important component of the domestic economy. Before the 1970s, most of China's foreign trade was mainly between countries of Eastern European and the Soviet Union. In 1978, foreign trade was approximately 9.8 percent of China's total Gross Domestic Product (GDP); it skyrocketed to 30.4 percent in 1990 and 35.2 percent in 1996.[354] The open door policy has integrated China into the global economy, introducing it to some of the world's finest products, managerial techniques, and technology. China became the largest importer of foreign capital between 1992 and 1995, receiving 42 percent of all foreign direct investment going to developing countries round the world.[355] The stock of FDI in China rose to a record high of $92.4 billion in

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[353] Department of Comprehensive Statistics of National Bureau of Statistics, (Guojia Tongjiju Guomin jingji Zonghe Tongjisi), *China Compendium of Statistic 1949-2008* (*Xinzhongguo liushinian Tongji Ziliao Huibian)* (China Statistics Press, January 2010), (Zhongguo Tongji Chubanshe, January 2010), p7.

[354]Jiacheng, Zheng, *Statistical Yearbook of China*(*Zhongguo Tonji Nianjian*)(Beijing: China Statistical Publishing House, 1997), (Zhongguo Tongji Chubanshe, 1997), pp46, 588.

[355] H. Liew, "A Political Economy Analysis of Taiwan-Mainland Economic Relations," in C.L. Chiou and L. H. Liew, *Uncertain Future: Taiwan-Hong Kong-China Relations after Hong Kong's return to Chinese Sovereignty* (Aldershot, United Kingdom: Ashgate, 2000), p162.

2008.[356] Over 46 percent of this money went towards industrial manufacturing.[357]

With a greater number of Chinese people employed thanks to market reform and foreign direct investment, the quality of life among Chinese citizens improved immensely. Along with such improvements in the quality of life is a desire for material goods and enhanced comfort, especially when traveling. In 1985 the average disposable income for a city resident went from 653.62 Yuan (approximately $222) to 13,231 Yuan (approximately $1,945) in 2008 (see appendix B-1).[358] More Chinese during their national holiday have traveled by plane than ever before, demonstrating the rise in income and life quality. In 2009, during the 7-day National Holiday, 5.89 million people traveled by air, an 18 percent increase compared to 2008.[359] The development of an indigenous airliner will satisfy this growing demand.

C-919: FACTOR CONDITIONS

Porter's model stresses the importance of a merit-based and competitive education system for bringing the best out in students. A nation must make a commitment, not only to invest in its factor conditions, but to reinvest in or continuously upgrade their quality

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[356] Li Yangping, "Foreign Direct Investment Falls 5.7 Percent," Bloomberg, http://www.bloomberg.com/apps/news?pid=20601087&sid=atLCaoVsxERI&refer=home) (accessed March 24, 2010).

[357] "Sectoral Distribution of Fdi," FDI, http://www.fdi.gov.cn/pub/FDI_EN/Statistics/AnnualStatisticsData/AnnualFDIData/FDIStatistics,2008/t20100427_121020.htm (accessed June 1, 2010).

[358] "Statistics of Henan Province Network, (henan Nan Tong Ji Wang)," HA Stats, http//www.ha.stats.gov.cn/hntj/lib/tjnj/2009/html/1001.htm (accessed September 1, 2010).

[359] Hongmei Lin, "How to Travel Successfully by Air On the National Holiday? (shiyi Huangjinzhou Ruhe Shunli Chengfeiji Chuxing?" Xinhua net, http://www.chinataiwan.org/dlly/lykx/200909/t20090929_1011991.htm (accessed October 15, 2010).

vis-à-vis the competition.[360] Understanding this, Deng Xiaoping introduced a merit-based educational system in order to close gap with the West and for China to transition to high-income nation status. He understood that, for China to become a great world power, it must rely on future generations of intellectuals and experts who could create and develop advanced technology, which would in turn facilitate great economic development and trigger a higher living standard for the Chinese people. Even though China today has the second largest economy in the world, the living standard of its people is still relatively low compared to those of the world's most advanced countries; its per capita income equates to $3,000, less than 10 percent of that of the United States and the European Union.[361] With this in mind, Deng re-instituted the merit-based system in order to attract the best students into college, who in the future would be capable of making a valuable contribution to the economic development of the country.

Merit-Based System

The "GaoKao," (高考) a college examination equivalent to the SAT through which colleges select high school graduates based upon their scores in comparison to other students, was reintroduced in 1977. That year alone, 5.7 million students took the exam, and 270,000 students, a total of 4.7 percent of all test takers, were admitted into

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[360] Michael Porter, *The Competitive Advantage of Nations* (Free Press Court, 1990), p80.

[361] Fred Bergsten and Charles Freeman*, China's Rise: Challenges and Opportunities* (Washington DC: Peterson Institute for International Economics, 2008), p10.

college, demonstrating the competitiveness of the admissions process.[362] Universities began recruiting students based on merit after a nearly 12-year hiatus. Prior to these changes, only select students demonstrating a strong commitment to revolutionary goals had an opportunity to pursue higher education.

From 1976 to 2007, over 60 million students took the "GaoKao" (高考) exam, with only one-sixth of that number entering college, demonstrating just how fierce the competition is to get into college.[363] However, in recent years, the odds of getting into college have dramatically improved. In 2007, for example, there were 10.1 million students taking the college entrance exam, with 5.67 million (approximately 56 percent) entering college.[364]

Many students still face the harsh reality that they may not get accepted into college, so they spend most of their adolescence preparing for the exam. It is not knowledge that is most in demand but test-taking strategies that play a larger role in Chinese society. If students do not score high enough to get admitted into college and still wish to attend college, they must repeat the last year of high school in order to retest the following year. Some students are fortunate to come from wealthy families and bypass the GaoKao exam (高考) and study abroad. Still, many students with high GaoKao (高考) scores may wish to study abroad in pursuit of a higher quality of education than they would receive in China; the higher education system in China has many deficiencies.

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[362] Benjamin Siegel, "Stressful Time For Chinese Students," Time, http://www.time.com/time/world/article/0,8599,1631854,00.html (accessed June 11, 2009).

[363] "10 Million Sit Two Day Exam," China Daily.com (accessed June 2, 2010,.http://www.chinadaily.com.cn/china/2007-06/07/content_889597.htm.

[364] Ibid.

While Porter's model emphasizes the importance of having a high-quality and competitive education system that will train its intellectuals, scientists, and engineers to be creative and innovative in order to create a world-class economy, he doesn't specifically provide a detailed blueprint of the kind of education conducive to such development. Although he does mention the importance of nation of to continually invest in upgrading its factor conditions, but exactly how to do so is absent.

China's higher education system has hardly produced world-class scholars and experts who have consistently made valuable and innovative contributions to the world.[365] There have been very few Chinese Nobel Prize laureates in the last century. Recognizing the sharp differences in educational quality between China and the West, between 1978 and 2008 more than 1.39 million Chinese students went abroad for further education, and only 389,100 came back, making China the top brain-drain in the world.[366]

These students do not come back for several reasons. The most prominent is that there are better opportunities to earn a higher salary and enjoy a better quality of life in the West than if they returned to China. The starting yearly salary for students abroad in

[365] Recent studies have shown that China has taken the lead on the world's fastest and most powerful supercomputer with its unveiling of its Tain-ha-1A. However, the computer could not have been built without American microchips or the Linux operating system. Eric D. Isaacs, "Why America Must Win the Supercomputing Race?" ComputerScience.org (accessed January 2012), http://www.computerscience.org/?p=62.

[366] "The number of Chinese students studying abroad over the past thirty years was near 1.40 million and less than 3 percent of them came back to China," ("30nian Chuguo Liuxue Renshu jin 140wan Huiguo Renshu Buzu 3 percent"), Morning News, (Xinwen Chenbao), (accessed January 15, 2010), http://edu.ifeng.com/abroad/200909/0929_6979_1369986.shtml.

American is approximately $40,000, compared to 10,000 ($1,510) Yuan in China.[367] Someone with a college degree living in the West is likely to earn eight times more than he or she would in China, even though the cost of living is four times that of China.

Also, students who are intellectually curious are likely to stay in the countries where they studied because they have the ability to conduct research and carry on their work using state-of-the-art facilities and equipment; they may also have the opportunity to work with some of the world's leading scholars in their respective fields; this is not available in China, and, with the censoring of the internet, accessing pertinent information for their research may be troublesome. Others do not return because they admire the American healthcare system, considered the best in the world.[368]

Students are more likely to return to China during times of economic crisis--100,000 of the total number of students returning to China came back last year because of the financial crisis, up 56 percent from 2007.[369] Most students coming back have either had trouble finding employment in the country where they studied or had good career prospects or jobs lined up before they left China.

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367 Zewen Hu, "Latest report, Average Starting Salary for Bachelor Graduates, 2,321 Yuan per Month," ("Diaocha Xianshi 2010nian Benke Biyesheng Pingjun Qixin Meiyue 2321Yuan"), Xinhua News, (Xinhua Wang), (accessed January 2011), http://www.chinanews.com/gn/2010/12-25/2746379.shtml.

368 "China News:With an Improved Living Condition in China, High-Level Talents Studying in the U.S. will Come Back to China," ("zhongguo Xinwen Wang: Huiguo Shenghuo zhiliang Genggao Liumei Gaoxueli Rencai Zaixian Huiguochao"), (accessed December 15, 2009), http://www.chinanews.com/cn/lxsh/news/2009.10-20/1919205.shtml.

369 "1,000 students returned last year," People's Daily Online, (accessed April 19, 2010), http://english.people.com.cn/90001/90776/90883/6925012.html, p1.

Engineers and Scientists

Since the year 2000, there has been great cause for alarm in the West as China has been graduating more than 600,000 engineers annually, twelve times the number reached in the United States (70,000). [370] Contrary to what many scholars think, there is less cause for concern than might be imagined, especially when we look at the differences in educational quality between engineers trained in China and those trained in the West. China's educational system exhibits clear-cut deficiencies in the system that discourage and stifle student innovativeness and creativity. A nation that doesn't focus on training students to think creatively is less likely to produce technologically advanced goods and services.

The Chinese educational system overemphasizes the importance of knowledge rather than understanding the productive system that lies behind creating it.[371] The system prioritizes memorization over reasoning. Students become capable of storing and spreading knowledge but don't have the ability to create it. Academia is not interested in getting its students to explore deeper questions of philosophical thought for

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[370] In China the word engineer does not translate well into different dialects and has no standard definition. A motor mechanic or a technician could be considered an engineer. Also the numbers included all degrees related to information technology and to specialized fields such as shipbuilding. It seems that any bachelor's degree with engineering in its title was included in the ministry's statistics regardless of the degree's field or associated academic rigor. Also the Ministry includes short-cycle degrees typically completed in 2 or 3 years making them equivalent to associate degrees in the U.S.. Nearly half of China's reported degrees fall into this category These statistics put out by the Ministry of Education could therefore be misleading. For more information see VIivek Wadhwa, "Where the Engineers are," Issues In Science and Technology, (accessed November 16, 2010, http://www.issues.org/23.3/wadhwa.html, p2.

[371] Jun Fu, The Dao Wealth of Nations (Guo Fu Zhi Dao) (Beijing: Peking University Press, 2009), (Beijing Daxue Xinwen Chuban She, 2009), p11.

understanding and explaining the world; it is more focused on teaching practical information to deal with world realities.[372]

But philosophical thought is an important component of education, which ought not to be primarily concerned with mere factual information but focus on how and why knowledge is and was created. The Chinese educational system trains its students to be experts; there is a huge difference between experts and scholars.[373] The former are limited to knowing empirical information related to fields of study. Their focus tends to be narrow and is not interdisciplinary in nature. The latter are primarily concerned with understanding and explaining knowledge and how it was arrived at, for the purpose of creating new knowledge; they seek to create generalities, or law-like regularities, with applications beyond the scope of their study; they seek to make the world more intelligible, so as to improve life quality. This is one reason why China has been less creative and innovative than its American counterparts over the past 100 years.[374]

Critical and analytical thinking today takes a back seat to expertise mainly because many of the professors themselves are a product of the China's education system. Chinese professors do not, for example, clearly understand the difference between the Humanities and the Social Sciences. Many believe they are doing Social Science research when they are in fact doing Humanities.[375] Scholars in China predominately publish articles and books that are descriptive rather than theoretical in

[372] Ibid., p15.

[373] Ibid., p15.

[374] Ibid., pp284-293.

[375] Ibid., p30.

nature, hindering the possibility of reaching beyond the narrow confines of their study. Chinese scholars also don't adhere to a strict academic standard like those in the west. Academia in China is known for plagiarism, cheating, and falsified academic works.[376]

Cheating is clearly pervasive when International Relations Professor Jiangyong, of Qinghua University, had to make announcements on several occasions, during the course of the semester, to graduate students in his Analysis of International Strategy class promising that, if students wrote a publishable final paper, he would not take credit for the work and publish it under his own name.[377] He also mentioned on a regular basis that Qinghua now has very expensive computer software that can detect plagiarism and warned his students not to try it.[378] Announcements of that sort lead one to believe that academic integrity in China clearly leaves something to be desired.

Culture and Education

Inherently absent from Porter's model, which is important for understanding why the Chinese lack creative ability, is the Confucian culture. The Confucian Philosophy provides for the ethical and moral foundation governing social relationships for maintaining social harmony and order in society. In order to achieve these goals, the Confucian tradition places a strong emphasis on hierarchical relationships where individuals completely subject themselves to the complete subordination and respect for

[376] Ibid., p15.

[377] Qinghua University is considered the top Engineering school in the country, which recruits the country's best and brightest students.

[378] Personal Interview with Ryan Fraiser Lowell, a student of Professor Jiangyong's Master's level "Analysis of International Strategy" class at Qinghua University on January 2, 2011.

higher authority.[379] For example, a son must commit to the unquestioned obedience of his father, a wife to her husband, and an employee to his boss. Confucianism guides and dictates how individuals behave toward others of similar or different ranking in social hierarchies.

The Confucian culture is believed to be a major driving force for why the Chinese have not been creative or innovative, which is especially important for the aviation industry. Within the Confucian culture, students must never challenge and always respect their teachers. Teachers control what students learn and how they learn it. Seeking out information independently or exploring intellectual curiosity is frowned upon and is a violation of the traditional cultural norms of Confucianism. This denies students natural freedom of expression and a sense of individuality.[380] Students are not expected to actively think out problems and employ their critical and analytical thinking skills for problem solving. For example, even if a teacher commits an error while working out a mathematical equation on the board, students would not dare to speak out, for fear the teacher might lose face, or “mianzi” (面子), or feel embarrassed. It is important to be aware of one’s place in society. If one point’s out the teacher’s mistake, that person would be stepping out of line; they would not be adhering to the strict hierarchical order that, to some degree, still persists in China: Children must respect their teachers as a higher authority.

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[379] Kyung Hee Kim, “Exploring the Interactions between Asian Culture (Confucianism) and Creativity.” *Journal of Creative* Behavior 41, no.1 (2007): pp30-35.

[380] Ibid., p40.

While voicing differences of opinion in a college classroom is frowned upon in China, it is encouraged in the United States. America is widely known to have the best higher-education system in the world. It attributes its success largely to ethnic, cultural, and racial diversity, for this improves the quality of a student's overall educational experience. Students with unique experiences and diverse backgrounds will share their views and opinions in class and will open the minds of other students in one of two ways: either what they say will change their minds by introducing them to a line of thinking (perspective), or evidence, they haven't considered before, or it will force them to think deeply and critically to defend their own positions in the light of criticism. This element of education is largely missing in China. Classroom discussions and debates sharpen one's critical thinking and analytical abilities in the West. In China, a typical class is taught by the teacher straight out of a book.[381] Information that is conveyed is hardly ever challenged or opened for discussion, and is often accepted as scientific fact rather than a scholarly viewpoint.

Unlike the Chinese education system, there is a greater emphasis in independent thought and reasoning in the American system; for example, it is very common, after a lecture, for students to be asked to grapple with course materials; they are expected to independently formulate opinions, either for writing research papers or for preparing class presentations. In China, independent thought and creativity are stifled.

The Chinese educational system leans towards conformity mainly because the system is test centered. Teachers in primary, middle, or high school, or even in college,

[381] Guoliang Li, "The Negative Influence of Confucian On Innovation, (rujia Wenhua Dui Chuangxin de Fumian Yingxiang," *Contemporary Education Forum, (Dangdai Jiaoyu Luntan)* no. 1 (2003): 53-54.

are trained to teach students how to score high on exams rather than emphasize the importance of learning. If students were to offer their opinions in class, they could expect their teachers to point out that their opinions do not matter because they will not appear on the test, so they needn't waste their time thinking about such opinions, but rather draw the conclusions that the teacher wants them to draw, so they can score high on the exam. In fact, at every level of their education, exams will determine whether they have mastered enough of the material to go on to the next level. If a student doesn't score high enough, he or she won't have an opportunity to go on and may be forced to enter a vocational school.

Mono-disciplinary Study

Most students in China must decide within their first or second year of high school whether they will choose a career in the natural sciences or the social sciences; their education will then primarily follow the track they have chosen, with limited exposure to the discipline they didn't choose. They would take the GaoKao (高考) either following a natural science or social science track. In the United States, students are required to take a multitude of classes within both the social science and natural science tracks. It is very difficult for children 15 years of age to decide on a career path when they haven't taken enough classes in different disciplines, or had enough life experiences, to determine where their passions lie. It is common for parents in China, by contrast, to choose the career path their child will take.

It is also extremely difficult in China to change a major once it has been decided upon. You will enter college taking mostly, if not all, of the classes related to your field of study. Students have little experience taking classes in a range of other fields, as their American counterparts do who are trained in a system that tries, not just to create experts in a given field, but students who are learned and well-rounded. Creative inspiration partly comes from piecing together and drawing information from unrelated fields, which often results in coming up with something entirely new, an element missing from the entire Chinese education system.

These limitations are not problematic for job seekers after graduation. Unlike Americans, who seek to acquire the necessary skills and knowledge in college to succeed and find jobs in the fields of study, it is known among college students in China that, if you don't have any interest in furthering your education beyond the undergraduate level, doing the bare minimum to earn your degree is sufficient, because it is the reputation of the university you've graduated from that will get you the job; your own your individual skills and abilities count for much less.[382]

In fact, many Chinese students do not see the limitations in the education system within their respective fields or disciplines as a major problem, because many students, after graduation and regardless of their majors, aspire to work in government-affiliated jobs. They value job security and benefits over a higher salary that could be taken away should the economy take a turn for the worse.[383] State-owned enterprises rank first, because they are more stable and provide medical insurance and pensions for their

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[382] Personal interview with Rita Ma, Director of Study Abroad Program at New Channel English School on September 24, 2009.

[383] "ChinaNews: Mircrosoft, IBM No Longer Best Options, University Graduates tend to choose SOEs," ("Zhongguo Xinwen WeiYuan, IBM Renqi Jianshuai, Daxue Xuesheng Xuan Guzhu Guoqi Shouchao Waiqi"), (accessed January 15, 2010), http://www.chinanews.com.cn/edu/edu-qzjy/news/2009/08-05/1805564.shtml.

employees. During economic crises, private enterprises and joint ventures may cut jobs, as they have done in amid the current global financial crisis. SOEs, however, often expand during rough times as the government tries to assert greater control over the economy. "Number of applicants for 2010 national civil service exam reached 1.46 million people which is 16 times the number in 2003."[384]

Obtaining a job in a State-owned enterprise seems to be very popular, as 34.1 percent of college graduates choose to work in SOEs; 23 percent of college graduates seek to pursue a career in foreign-invested enterprises, 17.5 percent in joint ventures, and another 25 percent choose public institutions, private enterprises, or non-for-profit organizations.[385] There is less of a desire to be innovative or creative in a State-owned enterprise, because there is never a threat that the enterprise will go out of business. Private enterprises need to sell their products in order to profit to stay in business.

The 863 Program

The shortcomings of China's educational system have resulted in a lack of creativity and innovativeness on the part of its professionals. Still to date, the Chinese have had a hard time producing state-of-the-art advanced technologies and acquiring technologies that certain countries refuse to sell to because of fear that they might make

[384] "The number of applicants for National civil exam has increased by 16 times in 7 years,"(Guojia GongwuYuan Kaoshi Baoming Renshu Qinianjian Zengzhang Jin Shiliubei"), Shenzhen Xinwen net, (Shenzhen Xinwenwang), (accessed December 15, 2010), http://www.sznews.com/education/content/2009-11/03/content_4156405.htm.

[385] ChinaNews: Mircrosoft, IBM No Longer Best Options, University Graduates tend to choose SOEs," (Zhongguo Xinwen WeiYuan, IBM Renqi Jianshuai, Daxue Xuesheng Xuan Guzhu Guoqi Shouchao Waiqi), (accessed January 15, 2010), http://www.chinanews.com.cn/edu/edu-qzjy/news/2009/08-05/1805564.shtml.

their way into China's military. In order to get around these shortcomings, China launched the 863 program, followed by the 968 program, designed to trigger indigenous innovation. Not only has Porter's model shown us why China has not produced world-class intellectuals and scholars, it also directs our attention to understanding why its national research programs have not been successful. Research programs were not chosen on their merits but on what advanced the careers of low- to mid-level government officials. Therefore, a lot of money, talent, and resources were channeled to unproductive areas of the economy. The projects that the country could have benefitted from were largely ignored. This led to the country's scholars and experts creating research projects that satisfied the interests of bureaucrats rather than what the country really needed.

In 1986, four prominent scientists--Wang Daheng, Wang Ganchang, Yang Jiachi, and Chen Fangyun--who were all previously involved in China's strategic weapons program wrote a letter to Deng Xiaoping suggesting that China develop a national indigenous technology program to keep pace with the rapid technological development taking place around the world. In 1983, for example, the United States had already begun work on the Strategic Defense Initiative (SDI); an inter-government initiative was formed among European nations called EURICA of Europe, which formulated a Comprehensive Outline of Science and Technology Progress for the year 2000; at the same time, Japan launched policies for the promotion of science and technology over a 10-year period.[386] All these programs had impacted the growth and the development of technology throughout the world.

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[386] "HIGH TECH RESEARCH AND DEVELOPMENT (863) PROGRAMME," EMBASSY OF THE PEOPLE'S REPUBLIC OF CHINA IN IRELAND, (accessed January 1 2011), http://ie.china-embassy.org/eng/ScienceTech/ScienceandTechnologyDevelopmentProgrammes/t112844.htm.

In order to reduce the growing technological gap between China and foreign countries, Deng responded to the scientists' letter by approving a strategic national science and technology program. This high-technology research development program became known as the 863 Program, with the government channeling 10 billion RMB into seven key fields: biotechnology, space technology, information, lasers, automation, energy, and new materials; these fields were further divided into 15 subfields, with each having a chief scientist and a committee of experts who were responsible for organizing, selecting projects and participants, and allocating funds.[387]

Since the main goal of the 863 program was to keep pace over the next 15 years with the rest of the world in technological development, and to strive for scientific breakthroughs wherever possible,[388] it was imperative to attract China's best and brightest scientists nationwide to work on critical projects related to the development of the national economy and the military. Some of the critical projects undertaken by scientists included high temperature, superconductivity, non-linear science, important chemical problems in life process, and brain function and its cell and molecular basis.[389] Complementing the 863 program, the 973 program was established in 1998 with the creation of the State Basic Research and Development Program, which would support interdisciplinary scientific research endeavors.

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[387] Cao Cong, *China's Scientific Elite* (London: Routledge Curzon, 2004), pp30-32.

[388] "HIGH TECH RESEARCH AND DEVELOPMENT (863) PROGRAMME," EMBASSY OF THE PEOPLE'S REPUBLIC OF CHINA IN IRELAND, (acessed January 1, 2011), http://ie.china-embassy.org/eng/ScienceTech/ScienceandTechnologyDevelopmentProgrammes/t112844.htm.

[389] Cao Cong, *China's Scientific Elite* (London: Routledge Curzon, 2004), pp30-32.

The program originally called for the channeling of 2.5 billion RMB ($300 million) over 5 years, 1998-2002, to projects falling within six categories relevant to the country's economic and social development and funded by the Ministry of Science and Technology (MOST). These were: population and health, information, agriculture, resources and the environment, energy, and new materials; each selected project would receive on the average of 30 million RMB ($3.6 million).[390] "Between 1998 and 2001, 108 projects were selected with the total funding of 1.8 billion ($217 million)."[391]

MASSIVE CORRUPTION IN AWARDING LARGE-SCALE RESEARCH GRANTS

While there were some modest breakthroughs stemming from the 863 and 973 programs, which included high-performance computers, third-generation mobile communications, deep-sea robots, hybrid rice, and genetically engineered medicine, etc., this program was for the most part judged highly corrupt and inefficient.[392] Most of these problems related to the Communist Party's top-down structure, which lacks transparency, thus inviting massive and systemic corruption. Smaller-sized grants, such as those offered from China's National Natural Science Foundation, were for the most part awarded based on scientific merit; however, that was not the case for large-scale grants awarded by

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[390] "Profile of the 973 Program," National Basic Research Program of China, (September 9, 2010), http://www.973.gov.cn/English/Index.aspx.

[391] Cao Cong, China's Scientific Elite (London: Routledge Curzon, 2004), p31.

[392] 863 (accessed February 16, 2009), http://www.863.gov.cn/1/1/index.htm.

government funding agencies that ranged from tens to hundreds of million Yuan.[393]

Each year the government, along with its team of scientists, lays out the guidelines of research areas and project types, based on the needs of the nation, which will receive funding. These projects are so narrowly defined that there is much skepticism over whether these needs are actually national in scope; it is clear that the scientists sitting on the committee that devise these guidelines adhere to the personal interests of bureaucrats who are overseeing or managing project distribution.[394] These bureaucrats are not interested in seeking the advice of scientists, but use their scientific knowledge and expertise to support projects that they would like to undertake that will score them the most political points. Bureaucrats are often short-sighted and have only their political interests in mind, approving projects that will win favor with their superiors and improve their possibilities of getting promoted.

Many scientists in pursuit of a large-scale grant will tailor their research to meet the needs of the agenda created by the scientists and bureaucrats, whether they believe it is the correct course of action to take or not for meeting the national need. Most scholars and university professors are paid approximately 2,000-5,000 Yuan ($307-$769) per month.[395] A famous professor at Peking University once revealed that his income, combined with the research funding he received from the government, amounted to 4,786

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[393] Yigong Shi and Yi Rao, "China's Research Culture," *Science* 329, no. 599 (2010): 1128.

[394] Ibid., p1128.

[395] Personal Interview with Guangbin Yang, Professor of international Studies Remin University on March 25, 2008.

RMB ($736) monthly.[396] Scholars are paid so little that they need to surrender their research interests to the needs of politicians and bureaucrats to get more money. If they receive the grant money, their salaries increase immensely and the government supplies their labs with state-of-the-art resources. They therefore must kowtow to the interests of the bureaucrats.

For example, water shortages have threatened several villages in China--Qinghai and Ningxia. Due to limited rain fall, people did not even have enough water for drinking. Some villages have disappeared and their residents have been forced to relocate. Other villages in those areas are still in danger, but migration is not a viable solution for these poorer residents and communities. These villages could benefit immensely from the creation of research programs that focused on climate change; however, such research is seldom supported. Since the research funds are allocated by government officials, many of which are engineers, from their perspective, research exploring and explaining climate change and drought is meaningless, for it doesn't result in direct outcomes or show any political achievement while being very expensive.[397]

They would ask their team of scientists to demonstrate the rationality of certain engineering aims like dam projects. Scholars in the research field of water resources all turned to suggesting dam projects to get research funds; they would demonstrate how all

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[396] Personal interview with Yijun Zhou, Associate Professor, School of Journalism and Communication, Peking University on March 29, 2010.

[397] Personal Interview with Ph.D candidate Mr.Liu , Water Resource department at Qinghua University on November 15, 2010.

government solutions were reasonable when, in fact, dams could cause great damage to water systems, especially under conditions of water scarcity.[398]

This top-down approach is highly corrupt and suppresses creativity and independent thought. In order to become a recipient of large-scale grant in China, the decision is not based on one's scholarship or credentials but on the connections that one has made with bureaucrats and a few powerful scientists; for obvious reasons, scholars and researchers spend a significant amount of their time on building connections, "Guanxi" (关系), instead of attending conferences, conducting research, or educating students; it is, for example, common in China for professors to use their students as laborers in their laboratories because their time own is better spent on developing social relationships. [399]

Also, decisions on research grants are often made according to how much money one can offer the scientists in charge of making such decisions. Scientists are often bribed by scholars, so that they can receive prestigious research grants. When corruption happens, as long as the supervisor is satisfied with the subordinate's work, the actual quality of that work is largely ignored. Culturally, and in a non-transparent society, people in China are only responsible to their supervisor. Getting the job done is most important. The end result matters more than the process it took to get there. Additionally, it is also hard to expose corruption, especially in a government that suppresses civil society and controls the media.

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[398] Ibid.

[399] Yigong Shi and Yi Rao, "China's Research Culture," *Science* 329, no. 599 (2010): 1128.

Many professors, scholars, and researchers adamantly oppose the way this system operates but choose to remain silent because they fear the possibility of losing grant opportunities or other resources the government might allocate to them in the future.[400] They do understand that such corruption squanders the innovative potential of China. Many scholars therefore will adopt a wait-and-see attitude, hoping that, as China continues to develop and modernize, so will its political institutions. This unhealthy culture discourages future generations from entering academia or research institutes.

COMMERCIAL ESPIONAGE

What doesn't fit into Porter's model but is very important for understanding how China has acquired state-of-the art technology other than from developing its factor conditions and research facilities is commercial espionage, which poses the single greatest threat to the security of U.S. technology."[401] Nowadays, with obtaining classified information as easy as hacking into a computer system, economic espionage is on the rise, and has cost a thousand of the largest U.S. companies more than $45 billion in losses annually; China is now the world's worst offender. [402] Although there is no hard evidence that exists that the Chinese government has been committing acts of espionage to gain technology and information for building its large passenger aircraft, the possibility,

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[400] Ibid., p1128.

[401] "China Spying biggest U.S. Threat," BBC News,(accessed June 24, 2010), http://newsvote.bbc.co.uk/mpapps/pagetools/print/news.bbc.co.uk/2/hi/americas/7097296.htm.

[402] John R. Wilke, "Two Silicon Valley Cases Raise Fears of Chinese Espionage," Wall Street Journal online, (accessed June 24, 2010), http://www.economicespionage.com/WSJ.htm.

however, can't be overlooked from the proof that it has in other sectors of the economy and the military.

To commit industrial espionage, China has organized and developed a well-coordinated campaign targeting western governments and companies by covertly stealing military and industrial secrets in pursuit of shortcut routes to bolstering economic and military modernization.[403] Committing acts of espionage produces results in a shorter amount of time while using significantly less capital. China would have otherwise spent 10 years and $10 million on research and development if it did not attempt to steal secrets and bribe competitors and foreign nationals at the rate of about $1 million apiece, and get the same if not better results.[404]

Given China's one-party rule and the unique overlap of its political and economic institutions, U.S. law enforcement has been ineffective at stopping this commercial espionage using the counterintelligence strategy it refined during the Cold War. Unlike the Russians, who were then restricted from entering the United States, the majority of PRC nationals who have acquired technologies illicitly have come to the U.S. legally.[405] The Chinese government has been quite efficient at enlisting a wide range of people, organizations, and collection operatives to acquire military and industrial technologies; these threats are also coming, not solely from Chinese intelligence operatives, but from

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403 "US Worried about China Industrial Espionage Activities during World's Expo," Homeland Security Newswire, May 3, 2010 on web 27 September 2010, (http://homelandsecuritynewswire.com/us-worried-about-china-industrial-espionage-activities-during-worlds-expo).

404 Sheo Nandan Pandey "China's Economic Espionage Prowess," ISPSW, (accessed June 11, 2010) (www.ispsw.de).

405 "U.S. National Security/Commercial Concerns with the People's Republic of China," United States House of Representatives,(accessed September18, 2010), http://www.house.gov/coxreport/, p2.

ordinary people who, along the way, were coerced, bribed, or directly employed by the Chinese government--including working scientists, students, business people, and bureaucrats. Because the PRC technology acquisition is not centrally controlled or coordinated, the difficult challenge of combating it is made even harder.[406] There is clear case for concern; the U.S. could suffer severe loses to its economy, and the espionage could pose a grave threat to its national security as well.

Methods Used To Acquire Military Technology

China's two professional intelligence agencies, which have traditionally been prominent in acquiring technologies illicitly, are the Ministry of State Security (MSS) and the PLA General Staff's Military Intelligence Department (MID). However, nowadays these professional intelligence agencies account for only a small percentage of the PRC's foreign science and technology collection; most U.S. technology losses have occurred during commercial, scientific, and academic exchanges between the United States and China. [407] In fact, much of the data collection is done by non-professionals, including PRC officials, bureaucrats, students, scientists, researchers and other visitors to the west. These individuals are often coerced into working on behalf of the MSS or MID or other PRC-controlled organizations, scientific bureaus, commissions, research institutes and enterprises. The Chinese government relies more on developing non-centralized, non-professional networks such as research institutes and military- owned

[406] Ibid., p2.

[407] Ibid., p19.

industrial companies to collect sensitive technology and information, rather than intelligence agencies.

Front companies

A common method by which the PRC acquires technology is through the use of front companies, which are enterprises that are set up and controlled on the behalf of another. This is done so it masks the organizations true intentions to the public. In other words, the organization was set up to do one thing, but in actuality it does another. Overseas governments or state bureaucracies will set up front companies to circumvent laws that prevent sensitive technology transfers and acquisitions between companies of different nations. Setting up shop in a foreign nation and masking your true identity so that the public believes that you are a local company seeking profit, would rid anyone of suspicion that you might transfer technology back to your home country. According to the 1999 Cox report, there are more than 3,000 PRC corporations in the U.S., many of which are connected with the PLA, a state intelligence service or technology acquisition roles. This is particularly troublesome for law enforcement to monitor because the Chinese government, and possibly intelligence services, have become savvy at blurring the lines between their commercial seeking-profit enterprises and those enterprises established to commit espionage.[408]

In the past many, front companies would have recognizable names linking them directly to the PRC, like NORINCO and Poly Technologies. The boards of directors of

[408] U.S. National Security/Commercial Concerns with the People's Republic of China," United States House of Representatives, (accessed September 18, 2010), http://www.house.gov/coxreport/, p13.

these companies did not conceal their true identity and were easily identified as former PLA officers, thus drawing a lot of negative publicity and media attention. In order to avoid attracting such attention, Chinese companies no longer used names similar to those of their parent companies; they use American names instead. They have also brought in people who were unrecognizable to sit on boards of directors in order to avoid media attention that would otherwise draw law enforcement to closely monitor their activities. On many occasion, the PRC has also forced former dissidents to establish companies in the U.S. and to commit acts of espionage by throwing them in jail or harming their families if they did not consent to do so.

In June 1993, a former Chinese philosophy professor, Bin Wu, and two other Chinese nationals, were caught trying to smuggle third-generation night-vision equipment to the Chinese government.[409] The Chinese government first learned of such technology when the Americans used it in the first Gulf War in 1991. Wu and the two other PRC nationals relocated to the U.S. and set up small front companies in Norfolk, Virginia. It was then relatively easy for Wu and his cohorts to purchase sensitive technology from a number of U.S. companies in the names of their front companies and ship it to the MSS through a middle man in Hong Kong.

Wu was not a typical intelligence officer; he actually had good cover, and U.S. law enforcement would never have expected him to commit acts of espionage, for he was a pro-Western dissident in China, a strong proponent of democracy who had been involved in the protests at Tiananmen Square. He was given the choice of relocating to

[409] William Glaberson, “Spy, Citing Fears. Fights Return to China,” New York Times, (accessed April 13, 2009), http://query.nytimes.com/gst/fullpage.html?res=9903E4D6113DF930A35751C1A9679C8B63.

the United States to help MSS acquire technology or facing a stern prison sentence. In fear of what might be done to his family, and to avoid going to prison, he chose the former and was sent to the U.S. to establish himself in the political and business community. The MSS told Wu he would serve as a sleeper agent and could be called upon any time to complete a task.[410]

Civilians

Another significant source of the PRC's technology acquisition comes from Chinese businessmen who have relocated to the United States but still show their loyalty to the PRC. Many businessmen that have immigrated to the United States have done so for monetary gain. The Chinese government believed that since these individuals were predominately motivated by financial incentives, they could easily be bribed with the right amount of money to commit acts of espionage; they would basically be inclined to sell their interest to anyone posing an offer.[411] The Chinese government would contact these PRC nationals and offer them large amounts of money for stealing sensitive technology and shipping it back to their motherland.

Peter Lee was a Chinese-born naturalized U.S. citizen who had worked at the Los Alamos and Lawrence Livermore National Laboratories. Having worked at the laboratories, Lee had access to classified information, which he passed to the Chinese government between 1985 and 1997. In 1985, Lee stole classified information for the

[410] U.S. National Security/Commercial Concerns with the People's Republic of China," United States House of Representatives, (accessed September 18 2010), http://www.house.gov/coxreport/,p36.
[411] U.S. National Security/Commercial Concerns with the People's Republic of China," United States House of Representatives, (accessed September 18, 2010), http://www.house.gov/coxreport/,p38.

PRC about how to use lasers to create nuclear explosions on a miniature scale.[412] In 1997, Lee passed classified information to the PRC on very sensitive detection techniques that could result in threats to U.S. national security. They would have information and knowledge on how to threaten or possibly destroy U.S. nuclear submarines.[413] The Lee case illustrates how PRC Nationals with no prior intelligence experience are bribed by the PRC to commit acts of espionage. The PRC uses Chinese nationals hired by U.S. firms for the purpose of data theft.

Another example of such a case was of Chinese Canadian Xiaodong "Sheldon Meng," who was employed at Quantum 3D Inc in San Jose California. "He was caught in 2003 for misappropriating company secrets, including a product known as nVsensor a corporate night vision technology product used exclusively in military applications for training and simulation applications."[414] In a government issued report, Meng's theft was intended to benefit the PRC Navy Research center in Beijing. He was also charged with trying to sell the military application secrets to the Malaysian and Thai Air Force. The recipient of this secret information would be the country that offered him the most money.

[412] Ibid., p38.

[413] Ibid., p38.

[414] Jonathan Eric Lewis, "The Economic Espionage Act and the Threat of Chinese Espionage in the United States," (accessed June 28, 2010), jip.kentlaw.edu/.../8 percent20Chi-Kent percent20J percent20Intell percent20Prop percent20189.pdf.

Spy Posing as a Civilian

Another case receiving nationwide media attention involved Dongfan "Greg" Chung, a Chinese spy who was convicted on July 29, 2010, of misappropriating sensitive aerospace and military information from his employer, Boeing.[415] Dongfan, who had a high-level security clearance, kept over 300,000 pages of Boeing company secrets at his California home, which clearly violated company policy. He sent much of this secret information on the U.S. space shuttle, booster rockets, and military troop transports to China with the help of another spy, Chi Mak.[416] It is believed that Chung had been sending sensitive information to China over a 30-year career working as an aeronautical engineer for Boeing and Rockwell International. The extent of what was sent to China, and the adverse impact it may have on U.S. national and economic security, is not known.[417]

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415 "United States of America Plantiff vs. Dongfan "Greg" Chung Defendant," United States District Court Central District of Californina Southern Division, (Case No. SACR o8-00024-CJC), (accessed November 20, 2010, http://www.fas.org/irp/ops/ci/chung071609.pdf, p2.

416 Chi Mak was employed by an American Defense Contractor, Power Paragon for nearly two decades; he was given a security clearance and therefore had access to sensitive information regarding Navy Ships, weapons and submarines. He secretly copied sensitive information on Quiet Electric Drive propulsion systems for the next generation of U.S. nuclear submarines, details on the Aegis Radar System, and information on next-generation stealth ships being designed for the U.S. Navy and sent it via courier to China. He was tried and convicted to 24 ½ years in a federal prison. For more information see Carrie Johnson and Jody Warwick, "Chinese Spy Slept in U.S. for Two Decades," Washington Post, (accessed May 5,2009), http://www.washingtonpost.com/wp-dyn/content/article/2008/04/02/AR2008040203952.html.

417 Gillian Flaccus, "Chinese Spy Gets more than 15 years in Prison," ABC News, (accessed July 24, 2010) http://abcnews.go.com/Business/wireStory?id=9774665&page=1, p1.

Joint ventures

According to federal officials, stealing of industrial secrets appears to be most prevalent in California's Silicon Valley, where much of the country's advanced research and technological development within the high-tech sectors of the economy take place. China has began flooding its scientists and engineers to the valley in pursuit of these commercial secrets by establishing business ventures with American companies where its staff members may have access to secret technology.[418] Stealing company secrets nowadays, does not require advanced and sophisticated methods for acquiring it; in fact, is as easy as the click of a mouse. Foreign intelligence services have learned that U.S. government and private sector information that would require years of expensive technology or human assets to acquire can be accessed easily, or stolen using computer networks. Sensitive documents can be downloaded easily onto a USB Flash drive, small enough to conceal. The losses that a company can accrue from having its secrets stolen are devastating.

The software company 3DGeo fell victim to this kind of theft. In 2000, the company set up a venture with one of its major customers, China's National Petroleum Company. The venture called for sending Chinese staff members to Californian for training.   However, one employee, Yan Ming Shan while training on the software at 3DGEO Development Inc. copied company secrets onto his personal laptop; he illegally copied the secret design and source code of one of the world's most powerful software

[418] "Operations," Global security.org,(accessed January 15 2011), http://www.globalsecurity.org/intell/world/china/mss-ops.htm.

tools for locating oil and gas deposits.[419] FBI agents were tipped off by another employee at 3DGEO who noticed something suspicious taking place. Yan Ming Shan was apprehended as he attempted to board a flight to China. "The boss of 3DGeo says if Shan had succeeded, 'he'd be getting some technology that we keep guarded out into the industry and revealing secrets. '"[420]

Professional Visits

Another technique the PRC employs for technological and data acquisition is its reliance on the use of professional scientific visits, delegations, and other scholarly exchanges. In 1996 more than 80,000 PRC nationals visited the U.S. as part of 23,000 delegations.[421] During conferences and symposiums, many U.S. scientists accidently reveal sensitive information during heated professional discussions and debates. This often occurs when sensitive questions are asked. Another strategy the Chinese employ in order to get scientists to reveal secret information is to plan a really busy itinerary for their invited guests while PRC intelligence agents break into the visitor's hotel room and steal sensitive information and data. The Chinese have also been known to employ another technique, which involves subjecting the visitor to a long and grueling itinerary

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[419] John R. Wilke, "Two silicon Valley Cases Raise fear of Chinese Espionage," BBC News,(accessed February 15, 2010), http://www.economicespionage.com/WSJ.htm.

[420] "U.S. fear China's Industrial Spies," BBC News, (accessed October 12, 2010) http://news.bbc.co.uk/2/hi/programmes/newsnight/5102358.stm,p32.

[421] "U.S. National Security/Commercial Concerns with the People's Republic of China," United States House of Representatives, (accessed September 18, 2010), http://www.house.gov/coxreport/,p39.

while providing a continuous flow of alcoholic beverages to the guest to lower his resistance to answering sensitive questions.[422]

Students

The number of PRC nationals attending academic institutions in the United States presents another method through which the PRC can collect sensitive information and technology. "During any given year there are over 100,000 PRC nationals who are either attending U.S. universities or have remained in the United States after graduation."[423] These PRC nationals are often targeted by the Chinese government and the PRC intelligence services. The former is interested in enlisting PRC scholars who remain in the U.S. and have established strong networks in their respective fields. They could potentially be an asset, for they may have access to important scientific technology and classified data once employed in the States. Wen Ho Lee, for example, was born in Taiwan, educated in the United States, and employed by Los Alamos. He was accused of giving the PRC classified information on the W-88 warhead in the mid 1980s and information on nuclear weapons in the 1990s. He was later set free when insufficient evidence was assembled to convict him for committing espionage. He did plead guilty to downloading classified information onto an unsecured computer. He was placed under house arrest and assisted the FBI with related cases. [424]

[422] Ibid., p39.

[423] Ibid., p41.

[424] "Four Chinese Espionage Investigations,"(accessed January 18, 2009), http://www.pbs.org/wgbh/pages/frontline/shows/spy/spies/four.html.

Purchasing technology

PRC representatives who have previously worked in high-technology companies in China, or were government officials, have been able to purchase sensitive technologies, including electronic equipment. The PRC has mainly been able to purchase these goods because of the carelessness of the Department of Defense, who was probably in rush to get rid of excess property. Without properly checking codes indicating that the material in quiestion was advanced military equipment, which would have prevented the sale of such equipment to certain parties, the D-o-D enabled PRC buyers to purchase such equipment. Many PRC companies bid on military equipment and technologies using American-sounding names to avoid suspicion and to conceal their relationship with the Chinese government. The PRC was, for example, able to purchase a multi-axis machine tool profiler used to build wing spans for the F-14 fighter for under $25,000 when the original price is over $3 million.[425]

Purchasing of American Companies

Other tactics the PRC has employed to gain state-of-the-art technology include the outright purchase of American companies. In 1996, to take one case, the Chinese purchased Sunbase Asia, an American company that produced ball bearings for the U.S. military, in California. Information on the extent of sensitive technology transfer to China has not been made public.[426] With the purchase of certain high-tech companies, China

[425] Robert Greenberger, "Let's Make a Deal: Chinese Find Bargains in Defense Equipment as Firms Unload Assets," *Wall Street Journal*, October 21, 1998.

[426] "U.S. National Security/Commercial Concerns with the People's Republic of China," United States House of Representatives, (September 18, 2010), http://www.house.gov/coxreport/,p46.

could easily gain access to technology that could strengthen their economy and military.

C-919: SUPPORTING AND RELATED INDUSTRIES

The supporting and relating industries determinant in Porter's model lends great insight into how China plays the midwifery role by offer foreign firms a piece of their large market for entering cooperative ventures with Chinese companies. In exchange for share of the market, the Chinese would gain technological know-how with respect to assembling, manufacturing and designing aircraft. "The size of China's domestic has provided a powerful magnet to Western aircraft manufacturers for many years. The government can make such offers to foreign companies because it controls the CAAC, the institutional body that is responsible for all purchases of aircraft. The government decides how much of the market a particular firm can and will occupy. Although Porter's fails to discuss the differences between production technology from design technology, his model does focus our attention on China's strategy for developing a competitive advantage by creating innovative technology.

Despite the lessons of the Y-10, China has still embarked on strategy where it would acquire state-of-the-art technology from entering joint-ventures with western firms. These firms however remain reluctant to educate the Chinese on how to develop their latest generation of aviation technology because they could be grooming a future competitor. Relying solely on the technology from entering ventures or serving as a supplier for an airplane manufacturer could not help China realize its dream of developing an internationally competitive large passenger aircraft. This could happen only if the other variables in Porter's diamond model are satisfied.

China's Three Step Plan

The Ministry of Aviation originally devised a three step "take off plan," with the goal of developing a 190 seat indigenous plane that was originally expected to be realized by 2010; the plane is now pushed back to 2016 due its lack of independent design experience. The first step of the plan was to cooperate with a foreign partner to assemble a medium-sized aircraft. To realize that goal, it was important for China to become familiar with the manufacturing process of an aircraft. It would have to start out supplying parts and components for aircraft manufactures and once they become familiar with the process of manufacturing, they could then team up with a partner to co-assemble an aircraft.

The second phase of the three step plan was to co-operate with a leading airplane manufacturer to jointly design a state of the art 100 plus seat aircraft. It believed using its large market as bargaining chip will entice manufacturers to want to work with them. Lastly, China after having learned all of the relevant technologies in the areas of manufacturing and design, it would seek to develop a 190 seat large aircraft, the third and final step of its three-step plan.

Contracting for Main Aircraft Manufacturers

Boeing, Airbus, and McDonnell Douglass, to name a few firms, have benefitted immensely from contracting the manufacture of airplane parts to China. The importance of China as an aircraft purchaser has in fact attracted an increasing number of Western companies to set up shop in China. The Chinese hoped that, in exchange for this market share, those manufacturers would pass along technology and help it adopt the managerial practices needed to produce an indigenous aircraft. While aircraft manufacturers sought cooperation with China so that they could exploit China's abundance of cheap labor, they also understood that, in exchange for educating and outsourcing the manufacturing of aircraft to China, state-controlled airlines would be more inclined to purchase their aircraft and products as well. Also, because of China's low labor costs, these aircraft manufacturers were be able to sell their airplanes cheaper worldwide than if they had been manufactured in the U.S. or their other home countries.

Most of the work that has been contracted to China through the aircraft manufacturers themselves or their suppliers have been limited to structural assemblies rather than making and assembling major components for the plane including systems and integration packages.[427] China has not yet been able to transition from supplying components and parts to supplying major aircraft subsystems which include fuel, pneumatic, electrical and environmental control systems; these markets are very lucrative and are still dominated mainly by U.S. companies such as Goodrich, GE, and Parker.[428] Even though some of these companies have started to source some components to the Chinese, they are very careful at what they teach them.

Profits for supplying major aircraft subsystems are very lucrative. For example, while Chinese companies have sold approximately $700 million worth of components and structural work to North American and European airliner programs in 2007, Parker earned approximately $3.5 billion in July 2008 for a single contract to supply Bombardier

[427] Ibid., p11.

[428] Ibid., p11.

with a fly-by-wire control system for its C Series airliner.[429] Western companies are hanging on to the most lucrative areas of their aircraft- manufacturing programs; they are unlikely to give up their source of competitive advantage to the Chinese, which would lead to Chinese companies eventually competing with them in these areas.

China's indigenous skill set has been developed against the backdrop of an ever-increasing presence of European and American aviation manufacturing companies that have entered China in pursuit of a share of the market. After years of supplying work and joint-venture agreements to these companies, China's civil aircraft industry has acquired the basic capability of civil aircraft design, manufacturing, testing, and certificate verification. Many of China's technological advances stem from cooperative agreements and investments made by these aerospace companies. There are six main aviation factories in China (Shenyang, Xian, Chengdu, Shanghai, Harbin, and Shaanxi) that are still currently involved in the production of parts for Airbus, Boeing, Bombardier, and Embraer and will also contribute to the C919 based on what they have learned from their experience working with foreign aviation manufacturers.

Shenyang Aircraft Corporation

The Shenyang Aircraft Corporation (SAC), a subsidiary of AVIC, was founded in 1953 and is the oldest and probably the most important of all of China's aircraft factories, as it employs over 30,000 people and designs and manufactures all of its fighter planes for its military, beginning with the J-5 and going all the way to the first Chinese carrier, the J-15. The SAC is divided into four departments: civilian aircraft, ancillary equipment,

[429] Ibid., p3.

military aircraft, and civilian products (non-aviation related, from construction materials to passenger buses.)[430]

Shenyang is currently the only supplier of the emergency hatch for the A320 and had delivered more than 10,000 of them by October 2010; it also manufactures spare ribs, sliding ways, and fixed advanced edges of airfoils for the A320 series, and doors for the A330/A340 cargo aircraft.[431] It is the only supplier of leading edges of vertical tails for the B787 cargo door for the B757, and is providing parts for the B737 empennage.[432] SAC has imported all parts and raw materials from U.S. suppliers in order to ensure that its components meet the required quality control standards of the FAA. Shenyang also signed an agreement with Bombardier in 2008 to produce the center fuselage for the Q-400 series. The general manager of SAC, Pang Zhen, has stated that, for the C919 project, his company will produce the aft fuselage, vertical tail, engine bracket, APU Department doors, and other body structures.

Xian Aircraft Corporation

The Xian Aircraft Corporation, a subsidiary of AVIC I, was established in 1958 and has over 20,000 employees. XAC has been responsible for developing more than 20 types of major military and civilian aircraft. The XAC mainly focuses on the production

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[430] "Shenyang Aircraft Corporation," Global Security.org, (accessed July 15, 2010), http://www.globalsecurity.org/military/world/china/sac.htm.

[431] "Industrial Cooperation and Technology Transfer," ("Gongye Hezuo yu Jishu Zhuanraang"), Airbus, (accessed January 2, 2010), http://www.airbus.com.cn/industrial-co-operation/.

[432] "The representatives of Chinese aircraft corporations talk about their experiences while participating in the manufacturing of the Boeing 787," ("Zhongguo Feiji Changjia Daibiao tan Canyu Boyin787 Zhizao Jingli"), Sina Military, (Xinlang junshi), (accessed July 15, 2010), http://mil.news.sina.com.cn/2007-06-10/1211448873.html, pp.1-6.

of bombers and transports, which include the JH-7 and the H-6. It also produces a number of large- and medium-sized civilian airplanes, including the Y-7 and the MA-60. The Xian Aircraft Company was the first in China to establish international cooperation. Some of its supplier cooperation agreements include making the vertical tail for the B737-700 and parts for the B747, including the tail piston and the forward boarding gate.[433] Xian delivered the first inner wing flap for the B747 to Boeing, and is supposed to become the only supplier of this part by 2012. The official contract for the project was signed on October 13, 2009, and will expire on December 31, 2024.[434] It is the biggest and most sophisticated part of the plane that China supplies for Boeing aircraft.

In 1999, XAC began supplying parts for Airbus, which include the wing and the electronics compartment access door for the A320 and A330/A340 series. XAC is also responsible for the A320 caisson, air conditioner pipe, and brake block for the A330/A340 series.[435] "In May 1997 Airbus signed a contract for the manufacturing by Xian Aircraft Company for the rear section of the fuselage for the ATR 72 twin-turboprop 74-passenger aircraft."[436] Xian is also one of the four main suppliers for the

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[433] "Investment from Boeing in China," ("Boyin Zai Zhongguo de Touzi"), Boeing, (accessed February 4, 2010, http://www.boeingchina.com/ViewContent.do?id=37732.

[434] The announcement of the Xi'An Aircraft International Corporation's contract signing agreement for the production of the vertical tail for the Boeing 747 series," ("Xian Feiji Guoji Hangkong Zhizao Gufen Youyan Gongsi Guanyu Qianshu Shengchan Meiguo Boyin747 Xilie Feiji Chuizhi Weiyi Xiangmu Hetong de Gonggao"), Securities Times, (Zhengquan Shibao), (accessed August 17, 2010, http://epaper.stcn.com/paper/zqsb/html/2009-10/15/content_123837.htm.

[435] "Industrial Cooperation and Technology Transfer," ("Gongye Hezuo yu Jishu Zhuanrang"), Airbus, (accessed January 2, 2010), http://www.airbus.com.cn/industrial-co-operation/.

[436] "Xian Aircraft Company," Global Security.org, (accessed January 15, 2010), http://www.globalsecurity.org/military/world/china/xac.htm.

large aircraft and regional project. It is responsible for developing the fuselage and the wing for the ARJ-21, taking more than 60 percent of the entire aircraft manufacture.

In 2009 Xian acquired a 91.25-percent stake in Fischer Advanced Composite Components (FACC), the largest Boeing supplier in Australia. The former Australian company had already produced wing parts and interior components and systems for China's regional aircraft ARJ-21-700 aircraft. With all of the technology, machinery, and automation at its disposal from the acquisition, its responsibilities for development of the C919 have increased. According to the agreement between XAC and COMAC, the former will supply six working packages for the C919, which include the middle of the body, outboard wing box, aileron trailing edge flaps, leading edge slates, and spoilers.[437]

Harbin Aircraft Manufacturing Corporation (HAMC)

The Harbin Aircraft manufacturing Corporation was founded in 1952 and currently has more than 16,000 employees, who are mainly responsible for the development of light helicopters and light general aviation aircraft.[438] Harbin Aircraft manufactures the H-5 bomber, the Z-5 and Z-9 helicopters, and the Y-11 and Y-12 multipurpose air transports. Harbin and Airbus have established a joint venture focusing on high-grade composite materials, in which Harbin holds an 80-percent share. It has developed China's most advanced technology on composite materials. HAMC is the only

[437] Huanqiu Wang, "AVIC Shoulders Alone: Detailed Explanation on the level of localization of C919," ("Zhonghang Gongye Yijian Chengdan: Xiangjie C919 Feiji Guochanhua Shuipin"), Global Times, (January 3 2011), http://mil.huanqiu.com/china/2010-11/1258289.html.

[438] "Harbin aircraft Manufacturing Corporation," Global Security.org, (January 15, 2010), http://www.globalsecurity.org/military/world/china/hamc.htm.

supplier for the A350XWB rudder and manufacturer elevator. It manufactures the composite nose rib of the tail piston for the A320, the composite tailfin torque box, and spare fittings for the A330/A340.[439] In September 2010, Harbin became the only supplier of B787 wide-body fairing panels. With 30-40 percent of the C919 to be made of composite materials, Harbin is expected to become the main supplier of those related parts.[440]

Chengdu Aircraft Industry Corporation

The Chengdu Aircraft Industry Corporation (CAC) was established in 1958 and is involved in designing, developing, and producing aeronautical systems as well as non-aviation products. The CAC follows a business development strategy known as "Main Body With Two Wings," which entails the production of military aircraft as a main body and the supply of parts, components, and electrical work the two wings.[441] CAC is the second-largest producer of fighter aircraft in China. The company was established during the first Five Year Plan with the help of the Soviet Union. It was one of the 156 industrial projects that warranted support of the Russians in 1956. Aircraft built at CAC include the J-7/f fighter, which was based on the MIG-21 and FC-1, which went into production in

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[439] Yuequn Sun, "Look forward to successful cooperation with the Chinese—Interview with Barron, the President of Airbus China Company Limited," ("Qidaizhe yu Zhongguo Yiqi Tengfei—Fang Kongke Zhongguo Youxian Gongsi Zongcai Bolong,"), (accessed August 15, 2010), (http://www.hljjjb.com/jjyw1.asp?ArticleID=13366.

[440] Shanshan Chen, ""Preserving technology, Harbin Aircraft establishes composite aircraft parts manufacturing center," (Wei Dafeiji Chubei Jishu, Hafei Xie Kongke Jian Fuhe Cailiao Feiji Lingbujian Zhizao Zhongxin"), (accessed April 15, 2010), http://business.sohu.com/20080717/n258193932.shtml.

[441] "Chengdu Aircraft Industry Corporation," Global Security.org, (January 20, 2010), http://www.globalsecurity.org/military/world/china/cac.htm.

early 1991 as a replacement for the aging J-7.

Chengdu Aircraft serves as a major supplier for Boeing, as it is producing composite rudders for the B787 (it is the only supplier of rudders for this plane), and the tail for the B757. Its supply work for the B747-8 mainly consists of horizontal stabilizers, ailerons, spoilers, and sub-assemblies. CAC has been responsible for producing main parts and components for Airbus as well. It produces the gate for the Airbus A320/A330 and has a contract with Airbus under which it will supply 5 percent of the body work for the A350WXB airplane.[442] It also supplies the nose sections and parts of the rear passenger door for the A320 and A330/A340. It will manufacture the nose of the C919 airplane as well.

Shaanxi Aircraft Company

The Shaanxi Aircraft Company was established after the severing of ties between the Chinese and the Russians in the early 1960s. It is known for modifying civilian versions of aircraft for use in other applications. For example, when it developed the Y-8 civil airplane it was used as a patrol plane, a helicopter carrier, and an unmanned aerial vehicle for the military. Most civilian planes that are produced at this location are either changed or modified for military purposes. This company's most important contribution to military development is the E-2000, the Chinese AWACS (Airborne Warning and

[442] "Chengdu Aircraft participate in the manufacturing of newest Airbus aircraft A350WXB" ("Chengfei Minji Canyu Zhizao Kongke Zuixin A350WXB Kuanti Feiji"), (accessed December 15, 2010) http://mil.news.sina.com.cn/s/2010-09-15/1613610969.html.

Control System), the PRC's essential Air Force in a possible conflict with Taiwan.[443] We can assume that, when the development of the C919 is officially launched, a military version of this plane will be built by the Shaanxi Aircraft Company.

Guarding Core Technology

There has been a growing fear among manufacturers such as Boeing and Airbus that, if they pass along sensitive technologies to the Chinese, they will become less relevant in the Chinese market once China's aircraft manufacturers become more adept at working with such sophisticated technologies. However, aircraft manufacturers, beginning in the 1970s and continuing to the present day, have outsourced parts of the aircraft, protecting any sensitive technology from falling into the hands of a potential future competitor. [444]

Western firms can protect intellectual property rights by limiting the amount of information and knowledge they share with Chinese industrial partners. "You can organize yourself in such a way that even if you are cooperating, people don't have access to sensitive information."[445] Also, companies have created encryption software in order to protect their sensitive technology from being accessed by current or future competitors. They were especially worried about China, because it has a history of violating

[443] "KongJing-2000 Airborne Warning & Control System," sinodefence.com, (January 17, 2010), www.sinodefence.com/airforce/specialaircraft/kj2000.asp.

[444] Personal Interview conducted with Dr. Baichun Zhang (expert on technology transfer and innovation), Scholar at the Institute for the History of Natural Science at the Chinese Academy of Sciences on August 20, 2009.

[445] China special: Opening doors- China's growth market for aircraft," Aircraft Defense Security, (accessed October, 10, 2004), http://www.sbac.co.uk/community/cms/content/preview/news_item_view.asp?i=14610&t=0, p1.

intellectual property laws and reverse- engineer aircraft, as they suspect it did with Y-10, given its similarity to the B-707.

Negotiations with McDonnell Douglas

As more and more types of airplane parts and components have been subcontracted to China, it has nonetheless come to master the technologies and methods for doing so; it has become more interested in doing more sophisticated and advanced work in the design and assembly of aircraft. "Using access to its potentially huge aviation market as a bargaining chip, China has succeeded in getting foreign aircraft manufacturers to involve China in the design and production of commercial airliners."[446] This was especially true when aircraft manufacturers faced stiff competition from rivals and wished to gain an edge over the competition by gaining a share of the Chinese market.

In the late 1970s, competition among aircraft manufacturers (Boeing, Lockheed, McDonnell Douglas, etc.) in the large and medium transport range had been growing fiercely. McDonnell Douglas's DC-10 was virtually indistinguishable from Lockheed's L-1011, which led to the two companies splitting their sales almost evenly, making it impossible for either to profit. In order to stave off bankruptcy, McDonnell Douglas entered a cooperative agreement with China on production of its MD 80 aircraft, hoping

[446] Roger Cliff, The Military Potential of China's Commercial Technology (California: RAND, 2001), p25.

that it would lead to a large share of China's virtually untapped market.[447] Consuming a decent share of which would ensure the firm's survival on the commercial side of the industry. In the process, they taught elements of design to the Chinese, even if it had profound effects in the future. Survival was their immediate goal.

After several years of negotiations, on March 31, 1985, an agreement was reached between McDonnell Douglas (MD), the Chinese Aviation Supplies Company, and the Shanghai Aviation Aircraft Company. The agreement stipulated that over a 12-year period, China and McDonnell Douglas would produce 30 to 45 jetliners in Shanghai, and 25 aircraft would be purchased by the CAAC to be used to service domestic and some overseas routes.[448] The remaining aircraft would be sold in the United States. Thirty-five in total were actually produced, with five sold to TWA in the U.S. market.[449] This would be the first time in history that in U.S. history that one of the airline's commercial jets would be assembled in another country.

MD Cooperation Agreement

"Chinese factories provided an increasing proportion of the components used to construct the aircraft, going from 15 percent at the beginning of the program to 50 to 60

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[447] "The plane is the company's fuel-efficient, twin-engine MD-82, designed to carry up to 172 passengers on flights of up to 2,360 miles." See Louis Kraar "Selling How One Man Landed China's $1 Billion," August (accessed September 18, 2010), http://money.cnn.com/magazines/fortune/fortune_archive/1986/08/18/67924/index.htm.

[448] Jihe Bian, Liangyu Guo and Jineng Shi, "The Chronicles of the Shanghai Aviation Industry," (Shanghai hangkong Gong Yezhi), Shanghai Academy of Social Science Press: November 1996, (Shanghai Shehui KexueYuan Chubanshe, November 1996)), (accessed December 15, 2009), http://www.shtong.gov.cn/node2/node2245/node64983/node64990/node65041/userobject1ai59511.html.

[449] Roger Cliff, *The Military Potential of China's Commercial Technology* (California: RAND, 2001), p25.

percent at the end."[450] MD was responsible for the more sophisticated components and parts of the plane, which included the engine, propulsion, hydraulics, avionics, etc. The Shanghai Aviation Industry was responsible at the outset for riveting the mid part of the body, connecting half wings, and running air tightness tests.[451] As the engineers became more skilled and familiar with the equipment and the processes, the amount of responsibility increased. They would produce such components as the main landing gear doors, the front landing gear doors, rear service doors, electronic compartment access door, inner flap-slide bracket cargo door, horizontal stabilizers, rear service door frame, and so forth.[452] They also test-flew the plane and delivered it in accordance with the engineering drawings and technical standards of MD. In all, China produced a total of 2,000 processing parts for the MD82 project.[453] The first step of China's three step plan had been officially completed.

How Did China Benefit from the MD Venture?

The Chinese not only acquired advanced technologies but learned the importance of quality assurance engineering and standard management practices as well from the project. Prior to it, they had a very superficial understanding of airworthiness; although

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[450] Ibid., p25.

[451] Jihe Bian, Liangyu Guo and Jineng Shi, "The Chronicles of the Shanghai Aviation Industry," (Shanghai hangkong Gong Yezhi), (Shanghai Academy of Social Science Press: November 1996), ("Shanghai Shehui KexueYuan Chubanshe November 1996)," (accessed December 15, 2009), http://www.shtong.gov.cn/node2/node2245/node64983/node64990/node65041/userobject1ai59511.html.

[452] Ibid.

[453] Liangyu Gao, "The Chinese Trunk Airliner Program Being Carried out China and McDonnell Douglas Co-produce MD-90 Airplane," ("Zhongguo Minhang Gongye de Xianzhuang Jiqi Wenti –yi MD90 Ganxian Feiji Xiangmu Weil"), (*Air Research*, Vol.1, 2001), (Hangkongshi Yanjiu Vol.1, 2001), p32.

they were able to build an aircraft on their own, as proven by the Y-10, they were not capable of building it in accordance with airworthiness standards that ensured the safety and security of the aircraft and its passengers. The joint venture helped China's aviation industry to acquire modern assembly technology and facilities in line with FAA regulations and international standards, which laid the foundation for future aircraft development.[454] The work the Chinese had done with MD also offered sufficient proof to other aircraft manufacturers that China was capable of assembling a plane a plane that incorporated such critical standards, which encouraged them to consider doing business with the nation. China had certainly learned more about aircraft development and management from the MD joint venture than from any other cooperative agreement to date.

CULTURE DIFFERENCES MAKE COOPERATION WITH M.D. TOUGH

Porter's model suggests the benefit of having world class suppliers and related industries in your home market because cultural similarities will foster a strong work relationship. On the other hand, cultural differences can create high levels of distrust and serve as a roadblock to accomplishing common objectives, even though the paths to realizing those goals were different. Confucianism was designed to maintain social harmony where the collective good of the country is prioritized over the individual. On the other hand, western culture gives prominence to the individual over the collective. In the joint venture between MD and China, a working relationship eventually developed,

[454] "The large Aircraft Dream," (Dafeiji Zhi Meng), CCTV, (December 12, 2010), http://news.sina.com.cn/s/2008-03-03/182515066250.shtml.

not as a result of respect for one another's culture, but because China's conformed to MD's methods and culture.

Because of China's unique history, it was very difficult at first for the Shanghai Aviation Factory to work with McDonnell Douglas. A lot of time and effort was invested in cementing a formable and working relationship despite the totally different styles of thinking and cultural perspectives. In the early 1980s, the Chinese still remained distrustful of foreigners. In fact, most people, whether they worked on farms or in the Danwei (State-owned factory) had never seen foreigners before. They had spent entire lives exclusively with people with whom they were familiar. It was unheard of to work with people you didn't know.

Before a working relationship can develop, there needs to be a series of confidence and trust-building measures must be taken between two parties that set them on a track toward friendship. In the Chinese cultural framework, if you are friends, you may have a strong binding working relationship, but such a relationship will not develop between mere acquaintances. Identities, which stem back to its Confucian traits, were still very important in Chinese society. Having to work with strangers did not accord with Chinese culture. It is not easy to trust people you do not know. If you want to do business, it is important to work on the relationship. Guanxi (关系) must be developed. All the Chinese knew about "Laowai" (老外), foreigners, was what they had heard from friends and family, and at school. As avid students of their own history, they remained highly suspicious of foreigners because of the humiliation and embarrassment their country suffered under the Qing dynasty era occupation and thereafter.

Chinese society under Mao Zedong trained and indoctrinated individuals to believe that a person who is motivated by financial gain possesses few of the morals and values that are essential for the development of a country. Foreigners were such people. They were selfish and would lie, cheat, and deceive in pursuit of material ends.

The Chinese were patriotically sensitive and, in their hearts, would give up economic benefits to protect the nation and its core values. This sense of nationalism made cooperation with McDonnell Douglas quite difficult. The Chinese believed that, if a company entered its homeland, it ought to follow rules and regulations in line with Chinese culture. McDonnell Douglas was very vocal about entering a joint-production agreement with China under which they expected the Chinese to follow its methods and rules of production for creating state-of-the-art products with the sole intent of making money. To the host country, this seemed rude and selfish. McDonnell Douglas failed to understand that the venture was not about business for the Chinese but about developing the nation. Despite Deng Xiaoping's desire to change the thought of Chinese people and imbue them with the notion that to be rich was glorious, 30 years after the abolition of the free market the Chinese people still felt social stigmatization in pursuing individual interests instead of looking out for the greater good.

There also is a face-saving gesture in Chinese culture that does not exist in the West. When they dislike something or have a problem with something one says or does, they say so in an indirect way that is not offensive. You don't directly criticize or praise people. If you praise an individual on a team, others will feel they have done a poor job. If a boss gives one of four employees an award, for example, the others will feel ashamed.[455] It is expected in Chinese culture that everyone should perform well. Giving praise is a roundabout way of saying that the others didn't fulfill the expectations of the company.

But a system that does permit rewarding individual achievement stifles creativity and innovation. If a young person is promoted faster than older colleagues in a company, they lose face. The older, more experienced colleagues will feel humiliated. Younger colleagues aware of such feelings, therefore, choose not to to distinguish themselves. In Western culture, by contrast, employees will usually be proud of their colleagues' accomplishments. Like most Western enterprises, (e.g., McDonnell Douglas) encouraged its employees to devise ways to improve the production system. Promotions and bonuses were given based on merit. In China, bonuses were awarded to everyone for their time and effort; there was no distinction between their best and worst employees.

Upon completion of the co-production agreement on March 3, 1985, McDonnell Douglas slowly introduced a handbook known as "the Bible" to the Shanghai Aviation Factory, which systematically laid out guidelines and procedures for the production and assembly of the aircraft from the factory floor all the way to the plane's test flight.[456] There was a learning curve for Chinese colleagues to internalize MD methods because of the vast cultural differences just mentioned between the two labor forces. The Shanghai Aircraft Factory was intended to mirror, in image and operation, the MD factory in Long Beach, California.

[455] Zheng Fan, "Cross-cultural management in the joint ventures—the MD Practice of Culture integration in Shanghai," (Zhongwai Hezi Qiye de Kuawenhua Guanli –Jianxi Maidao Gongsi zai Shanghai de Wenhua Ronghe Shijian), International Economic Cooperation, (Guoji Jingji Hezuo), (October 2002), p47.

[456] Ibid., pp45-46.

The handbook set the responsibilities of each department in the factory, how it should be run, and how it might specifically coordinate others. The Bible defined the responsibilities of every factory, person, and department involved in the process. The standards were so specific and meticulous that MD actually calculated that the average assembly cycle was to take 245 days from start to finish. A total of 6,200 standard working hours are required to produce one airplane; testing the aircraft at Long Beach required 8 hours, and they calculated an additional 20 hours for troubleshooting.[457] McDonnell Douglas, in fact, set the exact room temperature for testing the plane, which the Chinese were expected to follow. MD believed that it was important for the Chinese to adhere to these guidelines and procedures so the finished product could receive an FAA airworthiness certificate, which alerts potential customers that the plane is both safe and reliable. The FAA authorized an MD representative to ensure Shanghai's compliance with its regulations on a consistent and regular basis.

In order to achieve that goal, a team of McDonnell Douglas experts, in conjunction with Shanghai Aircraft Factory staff, set up a quality-audit chamber to assess factory worker and management methods.[458] The chamber's purpose was to ensure that procedures were being followed at all levels, that company goals were being met, and that the work complied with FAA regulations. In addition to identifying problems and inconsistencies, the unit was empowered to fix them. The process of carrying out quality audits actually strengthened the awareness, and standardized the behavior, of all

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[457] Ibid., p47.

[458] Zhang Xiangsheng, "The Practice of Standard Program in Joint Production with MD," (Yu Maidao Gongsi Hezuo Shengchanzhong de Guanbiao Shijian), (*Shanghai Standardization*, Vol.3, 1997), (*Shanghai Biaozhunhua*, Vol.3, 1997), p11.

employees. Holding employees accountable for their actions forces them to develop good habits in accordance with mandated procedures and standards.[459]

MD management standards were, nevertheless, quite troublesome for the Chinese to follow, for they were so different from what the Chinese were used to. It took time to internalize the procedures. Although Chinese State-owned enterprises had been created with the intent of both workers and management following standard operating procedures, those procedures were completely ignored.[460] There was no clear delegation of responsibility among departments in an enterprise; having defined responsibilities would have meant holding individuals accountable for their work in situations in which praise or punishment could result in a loss of face. The result was a huge and predictable waste of time and resources that, in some respects, is difficult for a Western mind to grasp. For example, in a typical State-owned enterprise there are many departments. Usually, one is responsible for the manufacturing of a product that another employs. Without a clear delineation of responsibility, when the part is made, it can sit in the department for days, since no one knows whether the manufacturing department is supposed to deliver it to the department that uses the product, or the latter is supposed to pick it up.[461] It is safe to assume that few Westerners could anticipate encountering problems of this nature.

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[459] Ibid p12.

[460] Zheng Fan,“ Cross-cultural management in the joint ventures—the MD Practice of Culture integration in Shanghai,” (Zhongwai Hezi Qiye de Kuawenhua Guanli –Jianxi Maidao Gongsi zai Shanghai de Wenhua Ronghe Shijian), *International Economic Cooperation*, (Guoji Jingji Hezuo), (October 2002), pp46-47.

[461] Ibid., p48.

The only time employees really worked hard in China before their collaboration with Western firms was when their factory received a "red-head file," a document highlighted in red, sent by the central government, and addressed to the factory manager that indicated a sense of urgency regarding the completion of an assigned task or project.[462] The manager then delegated responsibility to each employee, and they would work diligently night and day until the job was completed. When there were no such red-head files to trigger action, many employees slacked off; they felt no need to work hard when employment and raises were guaranteed regardless of work performance and standing out was thought of an insult to others. McDonnell Douglass tried to implement a system that boosted worked performance by issuing bonuses based on merit.

State-of-the-Art Technology and Infrastructure

To ensure that their aircraft would receive U.S. Federal Aviation Administration certification, McDonnell Douglas helped the Chinese renovate factories in Shanghai where the planes were being assembled, providing massive amounts of technical data, and tools and training, required to assemble the aircraft. The Chinese were provided with 1,837 technical and design drawings of the MD 82/85, which were translated into Chinese in 370,000 standard pages; they were given 699 process standard documents, which translated into 14,000 standard pages, and 8 compensation trade products with 561

[462] Ibid., p46.

drawings that resulted in 80,000 pages in Chinese.[463]

MD helped China upgrade its technology at over 17 facilities at a cost over 82 million RMB.[464] These facilities included spray painting workshops, digital control processing workshops, computer laboratories which could meet the advanced technical request. Shanghai changed their workshop organization from 4 workshops which were riveting, general assembly spray painting and test flight to 10 stations which were mid-body riveting, body connection, body air tightness test, general assembly, function tests, spray painting and test fly and deliver. The total construction area was 28,673 square meters.[465]

MD trained thousands of Chinese technicians for the program and issued 7,951 certificates to those who were trained. McDonnell Douglas even sent a team of Chinese engineers to the United States to educate them in technical training in engineering, tooling, and other technology-intensive areas for assembling a state-of-the-art aircraft.[466] Among the 132 staff from Shanghai sent abroad, 26 received training in quality assurance, 25 in liaison engineering, 45 in manufacturing, 16 in tooling, 7 in process planning, and 6

[463] Jihe Bian, Liangyu Guo and Jineng Shi, "The Chronicles of the Shanghai Aviation Industry," (Shanghai hangKong Gong Yezhi), (Shanghai Academy of Social Science Press: November 1996,) ("Shanghai Shehui KexueYuan Chubanshe, (accessed December 15, 2009), http://www.shtong.gov.cn/node2/node2245/node64983/node64990/node65041/userobject1ai59511.html.

[464]Zheng Fan," Cross-cultural management in the joint ventures—the MD Practice of Culture integration in Shanghai," (Zhongwai Hezi Qiye de Kuawenhua Guanli –Jianxi Maidao Gongsi zai Shanghai de Wenhua Ronghe Shijian), International Economic Cooperation, (Guoji Jingji Hezuo), (October 2002), pp46-47.

[465] Ibid.

[466] Roger Cliff, *The Military Potential of China's Commercial Technology* (California: RAND, 2001), p25.

in production control.[467] Through its work for MD, China was able to master state-of-the–art technologies that included numerical control machining, CNC machining,[468] and mirror-like skin-stretch-forming parts, etc.[469]

MD-90 Agreement

Based on the success of the first cooperative arrangement, the China Aviation Corporation signed another contract agreement with McDonnell Douglas in 1992. This was not a supplier task for China but a cooperation venture in which the two parties would co-assemble the MD-90 aircraft--and of which China would have full intellectual property rights upon the plane's completion. It would be the first time China had cooperated with a foreign country to produce 150-seat main-line aircraft incorporating the state-of-the-art technologies of the 1990s, in which 70 percent-- consisting of 40,000 parts and components--were to be produced indigenously in China. Shanghai invested

[467]Weijia Sun, 'The Breakdown of the AE-100 Aircraft Project," ("Zhong'ou 100 zuo keji Yanzhi Xiangmu Yanzhe qianhou"), (*China Profiles*, Vol.1, 1999), pp12-17.

[468] Digital or numerical controls, direct machine tools automatically through a programmed sequence of operations (drilling, milling, boring, etc.) with the aid of computerized control tapes. Machine feed, speed, distance and direction, flow of coolant as well as selection of tools are performed automatically. The change of instructions happens easily by replacing the control tape with another program. For information see Arnold Heinrich, The Recent History of the Machine Tool Industry and the Effects of Technological Change, (University of Munich, Institute for Innovation Research and Technology Management, November 2001), (accessed December 5, 2010, www.bwl.uni-muenchen.de/forschung/diskus_beitraege/workingpaper/1833.pdf, p11.

[469] The skin is the material that covers the wings and the fuselage. In order to produce light-weight that would be tough enough to form close tolerance among aluminum parts the material needs to be able to stretch. Stretch forming is a metal forming process in which a piece of sheet metal is stretched and bent simultaneously over a die in order to form large contoured parts. Stretch forming is performed on a stretch press in which a piece of sheet metal is securely gripped along its edges by gripping jaws. The gripping jaws are each attached to a carriage that is pulled by pneumatic or hydraulic force to stretch the sheet. For more information see Arnold Heinrich, The Recent History of the Machine Tool Industry and the Effects of Technological Change, (University of Munich, Institute for Innovation Research and Technology Management, November 2001),(December 15, 2010), www.bwl.uni-muenchen.de/forschung/diskus_beitraege/workingpaper/1833.pdf, p11.

approximately 635 million Yuan in new equipment, technology, and upgrading its facilities.[470]

McDonnell Douglas provided the Chinese with 21 tons of blueprints and technical files. Shanghai translated and followed 600 thousand engineering drawings, 7 million words of function-test documents, and 8.6 million words of technical standards. [471] China basically received all the manufacturing technology, and part of the design blueprints, for the MD-90.

Aside from MD supplying the drawings and raw materials, engines, airborne equipment, and some other subsystems, China was responsible for parts manufacturing, assembly, and test- flight quality control in accordance with FAA regulations, to accomplish which China assigned approximately 10,000 people across four departments in Shanghai, Xian, Shenyang, and Chengdu to the project. More than 400 of them were trained in the U.S., while others were trained several times by MD staff locally.[472]

For the first time, the Chinese employed the main manufacturing company–supplier management model, accepted as the international standard for managing such a project. Since there were more than 40,000 parts and components produced in four factories in China, quality control was very important. Shanghai was responsible for the management and coordination among these factories. It made copies of all the technical data and blueprints provided by MD for the three others, and was responsible for

[470]Jihe Bian, Liangyu Guo and Jineng Shi, “The Chronicles of the Shanghai Aviation Industry,” (“Shanghai hangKong Gong Yezhi”), (Shanghai Academy of Social Science Press: November 1996), (Shanghai Shehui KexueYuan Chubanshe),” (accessed December 15, 2009), http://www.shtong.gov.cn/node2/node2245/node64983/node64990/node65041/userobject1ai59511.html.

[471] Ibid.

[472] Ibid.

delivering and tracking technological information, coordination of different technologies, evaluating the quality systems of the other facilities, following their progress, and helping them to finish their work in a timely manner. Shanghai was also responsible for meeting FAA requirements.[473]

The Chengdu Aircraft Manufacturing Company was responsible for producing the nose section and forward passenger doors and stairs of the aircraft; the Xian Aircraft Manufacturing Company built components for the wing and cabin interior; the Shenyang Aircraft Manufacturing Company was responsible for the main components of the vertical tail; and the Shanghai Aircraft Factory itself took care of the large sections of the fuselage and wings, in addition to final assembly and flight-testing the craft.[474]

Despite the increased responsibility on part of the Chinese, the MD-90 project came to an abrupt halt in 1996 when Boeing merged with MD and closed all of its production lines in China. Boeing wanted those lines shut down because, during the reform period, Chinese airlines and government institutions had more autonomy to choose what they wished to purchase, and many airline managers--in return for purchasing aircraft from abroad --received trips abroad as well, on which they would stay in five-star hotels. When aircraft were domestically built, Boeing could easily offer such pampering, because a link existed between the pampering and the sale of airplanes.[475] The Chinese produced only two aircraft before the production line stopped. The two proved, however, that the Chinese were capable of developing aircraft in accordance with

[473] Ibid.

[474] Mark Dougan, *A Political Economy Analysis of China's Civil Aviation Industry* (New York: Routledge, 2002), p140.

[475] Ibid., p128.

FAA airworthiness regulations, while using a modern technology and a management system in line with the international standard. The MD-90 project's most important achievement for the Chinese was assembling completed sets of advanced materials, techniques, quality control, airworthiness, and production management, and putting them into practice through four major aviation companies producing aircraft.[476]

Air Express 100

During these years of cooperation with MD, Chinese officials continued to seek out other foreign manufacturers that would provide the Chinese with a more comprehensive co-production project; they wanted a larger role in the process where they could play a more active part in designing new aircraft.[477] Although China on many occasions tried to draw prominent aircraft manufacturers into such cooperative agreements, most efforts failed to get past the initial memorandum-of-understanding phase. One notably did in the early 1980s when an agreement was reached between President Jiang Zemin and South Korean President Kim DaeJung to cooperate in building a 100-seat aircraft.[478] They also decided that they would seek a third partner for this endeavor with experience in designing and building commercial aircraft. In 1996, negotiations reached a stalemate, as the two partners could not come to terms on where

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[476] Liang Gao, "The Chinese Trunk Airliner Program Being Carried out China and McDonnell Douglas Co-produce MD-90 Airplane," (Zhongguo Minhang Gongye de Xianzhuang Jiqi Wenti –yi MD90 Ganxian Feiji Xiangmu Weil,), (*Air Research*, Vol.1, 2001), (*Hangkongshi Yanjiu* Vol.1, 2001), p.33.

[477] Mark Dougan, *A Political Economy Analysis of China's Civil Aviation Industry* (New York: Routledge, 2002), p108.

[478] Weijia Sun, 'The Breakdown of the AE-100 Aircraft Project," ("Zhong'ou 100 zuo keji Yanzhi Xiangmu Yanzhe qianhou"), (*China Profiles*, Vol.1, 1999), pp12-17.

final assembly of the airplane would take place. South Korea insisted the general-assembly line be located in Korea. Because the two sides couldn't see eye-to-eye on this issue and on their respective shares of the partnership, South Korea opted out of the agreement in 1996.

China reached out to Singapore (STPL) to replace South Korea as a potential partner in the project; STPL agreed to the partnership and to China's request for having final assembly rights in Xian. As for the third partner, China was more interested in recruiting Airbus than an American company, because of the technology restrictions that had been set in place after the Tiananmen Square incident on June 4, 1989.[479] In April 1996, China's Li Peng visited France and met with President Chiraq about having members of the Airbus consortium (France, Britain, and Italy) join the partnership with South Korea to build an aircraft in the 100-seat range. Chiraq accepted, and an agreement was reached under which China would own 46 percent of the company, Singapore 15 perent, and Airbus 39 percent.[480] Final assembly would take place in Xian, at the Xian Aircraft Company. Airbus did feel somewhat uneasy about China's insistence on full access to all core technologies related to the project, and to acquire the plane's intellectual property rights, with which it could produce derivatives of the original model.[481] These issues Airbus believed could be worked out over time.

The agreement nevertheless broke down in 1998, 2 years after the AE-100 endeavor was officially announced to the public. The cancellation of the project was

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[479] Ibid., pp12-17.

[480] Mark Dougan, *A Political Economy Analysis of China's Civil Aviation Industry* (New York: Routledge, 2002), p108.

[481] Ibid., p108.

largely attributed to management and other internal changes taking place within Airbus, whose new chief executive officer, Noel Forgeard, was not in favor of the project.[482] Prior to 1988, Airbus had not been listed as a single company, but as a series of companies that would cooperate with one another on manufacturing projects of similar interests. Forgeard turned it into a single company, a legal entity in which members would have to vote on whether to undertake a project.

On September 3, 1998, Airbus canceled the AE-100 project on the grounds that it was not economically viable, arguing that it would cost over $2 billion in R&D alone, whereas R&D for an upgrade of its A320 model would cost less than half that amount.[483] There wasn’t enough market share in the existing 100 seat range to warrant the development of entirely new aircraft at such outlays.

Airbus found it wise to produce the A318, a derivative of the A320 aircraft, intended to replace older editions of the B737 and DC-9 planes. Another important reason Airbus opted out of the AE-100 agreement was that Boeing had committed to developing its B717 plane and was expecting to deliver its first 100-seat plane to AirTran in 1999.[484] If the Airbus consortium went ahead with the AE-100, which would not have entered service until 2002 barring any unforeseen delays, it would be forfeiting

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[482] Julian Moxon, “Airbus Industrie and AVIC abandon AE31X,” Flight Global, (accessed November 15, 2010, http://www.flightglobal.com/articles/1998/07/08/39195/airbus-industrie-and-avic-abandon-ae31x.html.

[483] Weijia Sun, ‘The Breakdown of the AE-100 Aircraft Project,” (“zhong’ou 100 zuo keji Yanzhi Xiangmu Yaozhe qianhou”), (*China Profiles*, Vol.1, 1999) , pp12-17.

[484] “Boeing Delivers First 717-200 Jetliner To AirTran Airways,” Boeing, September 23, 1999 on web 10 February 2010 (http://www.boeing.com/news/releases/1999/news_release_990923b.html).

approximately 3,000 aircraft to Boeing.[485] Stage two of China's three-step plan was, thus, not realized.

Germany and the MPC 75

In 1985, China sought an equal partnership with a major aircraft manufacturing company on the development of an entirely new aircraft; jointly designing an original airplane with a major aircraft manufacturer would be a fundamental and crucial step for the future development of its own indigenous aircraft. China's Aviation Technology Import Export Company, and the AVIC, found such a partnership with the Federal Republic of Germany's Deutsche Aerospace's company, (MBBB) which was interested in jointly developing a 70-passenger regional jet equipped with two propfan engines.[486]

In 1985, MBBB and CATIC signed a memorandum of understanding and began conducting a feasibility study. In December 1987, it was decided that the major designing of the aircraft would take place at the Xian Aircraft Design Institute, and that the plane would be produced and assembled at Xian Aircraft Company (XAC). In August 1988, CATIC and MBB of Germany officially signed a general agreement for the development for what was called the "MPC-75 project"; the agreement laid out the fundamental technology and data transfers that Germany would supply to China.

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[485] Paul Lewis, "Airbus urges AE31X speed-up to compete with Boeing," *Flight Global*, (accessed March 4, 2010, http://www.flightglobal.com/articles/1998/02/04/32353/airbus-urges-ae31x-speed-up-to-compete-with-boeing-717.html.

[486] "MMB MPC-75," Flight International, (accessed September 21, 2010), http://www.flightglobal.com/pdfarchive/view/1987/1987 percent20-percent200879.html?search=MBB+aircraft+project).

During the initial pre-development stage, MPCA organized and outlined the strategy for the joint development of the aircraft. More than 30 technicians and engineers flew to Germany to participate. They discussed detailed information regarding the technologies that would be used in the aircraft and the tentative design and preparation for airworthiness assessment, along with marketing and sales activities and strategies and so forth.

During the pre-development, with the help of German technology, China organized a supporting team and finished designing the plane's landing gear, air conditioner, oxygen supplier, and successfully made SCCH mode, in addition to making over 60 tool kits for the plane's assembly.[487] In cooperation with the Germans, China participated in research and joint cooperation on 14 fields of engineering technology and management expertise. They included general, aerodynamics, pneumatic flight physics, structure, systems, project control, planning, marketing, quality guarantee, and cost control for the plane.[488]

By 1993, more than 200 Chinese engineering experts and professionals had gone to Germany for on-the-job training and technical transfer. They established the MPC-75's technical program during the detailed engineering design and development phase. Technical transfer consisted of 11 types of computer software including ASSCOS, weight and balance, scientific database, and 73 other applications.[489] The experience and files of

[487] Qiang Huang, "The Exploration for the Rise of China's Civil Aircraft Industry," ("Zhongguo Minji Chanye Jueqi Zhi Tansuo"), Aviation Industry Press, April 1, 2007 (Hang Kong Gong Ye Chu Ban She,), (accessed January 15, 2010 http://vip.book.sina.com.cn/book/chapter_60895_42501.html.

[488] Ibid.

[489] Ibid.

technical transfer were collected into books. Many of the technology transfers, which included advanced management and design techniques, and verification standards, would be put into practice when designing other models, including China's Y-7 aircraft.[490]

The MPC-75 aircraft design and level of technology were expected to be on par with the A320 aircraft. It used the advanced engine and featured low fuel consumption, low noise, low pollution, etc. The plane's lifting surface was to be built out of composite material to reduce the plane's weight. The plane was designed, in short, to possess a strong competitive advantage.

The project was eventually canceled in 1993, however, because, with the establishment of Airbus as a limited liability company, each of its member nations had to act in accordance with the conglomerate as a whole; the company had to speak with one voice. The decision had already been made to invest Airbus's financial resources in the A319 model. Secondly, due to China's commitment to its trunk liner with McDonnell Douglas, its funding for the project was limited. It therefore sought a third partner, which it could not find.

Brazil Embraer

While China still remains stalled on the second step of its three-step plan, it saw potential advantages in cooperating with Brazilian aircraft manufacturer Embraer when it expressed interest in early 2002 in having its ERJ-145, a 50-seat regional aircraft, assembled in China. Brazil was facing tough competition from Canadian airplane manufacturer Bombardier's CRJ series in the regional market, and it believed that forging

[490] Ibid.

better relations with China would pay huge dividends. Better relations with the Chinese would win it a greater share of the Chinese market, especially when, over the next 20 years, China's demand is expected to reach 950 regional jets.[491] Because competition was fierce and Brazil needed to gain an advantage over Bombardier, China believed that Brazil, a developing country, would be more inclined to transfer technology than an assembly license.[492] At the very least, China would import the newest state-of-the-art manufacturing technologies used by world aircraft producers in the 21st century.

An agreement between Embraer and China was reached in December 2002 with the establishment of the Harbin Embraer Industry Group (HEAI), with a registered capital of $25 million[493] According to the agreement, final assembly of the 50- seat regional aircraft was to take place at China's Harbin Aircraft Industry. Embraer would, moreover, own 51 percent of the company, and China 49 percent.[494] It was the first time Embraer had ever assembled a plane outside Brazil.

The Harbin plant would receive supplies and ready-made parts and components from Embraer's vast global network and would be responsible for assembling, testing, and marketing the plane, which was to be built primarily for the Chinese market. At the start of the venture, production capacity was expected to reach 24 per year, at $19.5

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[491] Allison Leung, "Embraer Sees China Buying 950 Regional Jets Over 20 years," Reuters, (accessed on web July 5, 2010, http://www.reuters.com/article/idU.S.LNE6AF02M20101116.

[492] Andrea Goldstein, "The Political Economy of Industrial Policy in China: The Case of Aircraft manufacturing," The William Davidson Institute, (Working paper 779, July 2005) (accessed February 15, 2009), http://ideas.repec.org/p/wdi/papers/2005-779.html, p21.

[493] "Boeing, Airbus fuel China's emerging aircraft industry," En.AVBuyer.com.cn, (accessed July 4, 2010), (http://www.avbuyer.com.cn/e/2007/18652.html).

[494] Andrea Goldstein, "The Political Economy of Industrial Policy in China: The Case of Aircraft manufacturing," The William Davidson Institute, (Working paper 779, July 2005) (accessed February 15, 2009) http://ideas.repec.org/p/wdi/papers/2005-779.html, p22.

million each.[495] There was much skepticism over how much could be produced and sold in China from the very beginning. Despite the fact the plane took its maiden flight in December 2004, a few months behind schedule, Embraer needed to sell at least 20 aircraft per year for the venture to be considered financially viable.

The most accurate assessment of why, during the course of the 7-year period, the joint venture was only able to sell a total of 50 aircraft was that Embraer truly did not understand the workings of the Chinese market. It did grasp the nature of Chinese culture and the importance of developing “Guanxi” (关系) in order to gain access to China’s vast markets. Additionally, local production had traditionally helped foreign companies to avoid paying import duties of 24 percent, but those were cut by WTO agreements beginning in 2006, thus reducing the price advantage Embraer may have previously had.[496]

What Did China Learn?

Through the joint venture with Embraer, China became acquainted with the company’s management philosophy, which had enabled the company to grow into such a huge success in regional aircraft development. “The process of manufacturing and the production of ERJ145 aircraft is performed on the basis of dividing process interfaces by workstation instead of by a system in which other aviation products are produced.” In order to ensure a smooth transition of the ERJ145 from its previous assembly location in Brazil to Harbin, Embraer set up intensive training programs in both China and Brazil,

[495] Ibid., p22.

[496] Ibid., p23.

which entailed theoretical training and teaching, and familiarizing Chinese engineers and technicians with the various state-of-the-art technologies used in aircraft assembly, quality assurance, and customer support, all in accordance with Embraer standards.

In order to make certain that company regulations and standards were being followed during the initial stage of the joint venture, Embraer furthermore sent a team of engineers, specialists, and technicians to Harbin to serve as on-site supervisors and to offer technical support and assistance. During the first year of the joint venture, about 54 Embraer representatives helped the Chinese assemble the first airplane. The number decreased to four representatives by the time the fifth aircraft was produced in 2004. By 2005, China was able to assemble 97 percent of the plane on its own in accordance with company's established rules, regulations, and processes.

China's ability to adhere to Embraer's strict standards was rewarded on May 3, 2006, when HEAI earned its AS9100B Certificate; it was now included in the online aerospace supplier information system (OASIS), and officially became part of the International Aerospace Quality Group. HEAI also was the first aircraft manufacturer Asia recognized by the NQA in the U.S.[497]

Before assembling the ERJ-145 in China, the Chinese were only able to produce regional, propeller-driven airplanes. The ERJ-145 has brought the Chinese regional plane into the jet age. China learned advanced techniques in assembly, flight test delivery, and other turbojet technologies through the drawings and documents transferred in the joint venture, including commercial aircraft sealing drill riveting technology, structure sealing technology, aircraft spray technology, steam navigation and other electronic test

[497]Ibid.

technology system integration testing techniques, and cabin pressurization flight test and receive.

From this venture, China has also learned how to manage global partners and suppliers. The Harbin Embraer Aircraft Industry Company had 20 people contracting and monitoring more than 200 suppliers and was in charge of purchasing more than 5,000 different kinds of parts. The process was supervised via internet and advanced computerized software. The aircraft produced ERJ145 had reached the standard of Embraer produced airplanes.

Airbus 320

In Tianjin, on May 18, 2009, China also played host to the first Airbus aircraft that had ever been assembled outside Europe. On June 28, 2007, the joint-venture contract for the Family Final Assembly Line (FAL) of the A320 airplane, to take place in Tianjin, was signed between China and Airbus in which Airbus holds 51 per cent of the shares, while the Chinese hold 49 percent.[498] Since China had had no prior experience assembling an aircraft in the 150-to-180-seat airplane prior to this agreement, the Tianjin project will not only provide a model to learn from but will train and educate Chinese engineers and technologists in the latest manufacturing technologies, processes, and techniques in the large passenger aircraft range. Aircraft assembly requires high-end manufacturing technology employed by the original aircraft manufacturer. "The FALC is the first final assembly line outside of Europe however it is almost identical to the state-

[498] "West Air Becomes a New Airbus Operator," Airbus, (accessed January 15, 2010) http://www.airbus.com/presscentre/pressreleases/press-release/detail/west-air-becomes-a-new-airbus-operator/news-browse/4/.

of-the-art Airbus single aisle final assembly line in Hamburg, Germany."[499] The FALC employs the same processes, tools, and procedures used in Europe. The agreement worked out with China is that the A320 final assembly venture includes putting together the fuselage, wings, engines, tails, noses, and doors that are shipped from Europe.[500] Also included in the arrangement are technology transfers to the Chinese including the famous Airbus wing structure-manufacturing technology, which is very important for a country developing its own large indigenous aircraft. All 480 employees who work at FALC have received extensive training in Europe.[501] This ensures that the aircraft delivered in China adheres to the same assembly standards that prevail in Europe.

Airbus was primarily interested in setting up such a venture in China in order to develop a better relationship there, which it believes will translate into gaining a stronger foothold in the market, as it has done in the past. Airbus does not gain much with respect to cutting costs by having final assembly taking place in Tianjin. Airbus pays 800,000 Euros for each plane, and has to pay much higher salaries to engineers sent to China to assemble aircraft in Tianjin. For example, the average annual salary for Airbus employees in Europe is about 60,000 Euros, compared about 250,000 Euros for employees sent to China.[502]

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499 Wang Yu, "Airbus jets out the tenth A320 from China," China Daily, (accessed June 29, 2010), http://www.chinadaily.com.cn/regional/2010-05/27/content_9901336.htm.

500 Ambrose Evans-Pritchard, "Airbus rides the Chinese dragon," Telegraph, (accessed October 15, 2010), http://www.telegraph.co.uk/finance/economics/5700337/Airbus-rides-the-Chinese-dragon.html.

501 Wang Yu, "Airbus jets out the tenth A320 from China," China Daily, (accessed June 29, 2010), http://www.chinadaily.com.cn/regional/2010-05/27/content_9901336.htm.

502 Libing Wei, ""Southern Weekly: How high could Airbus Tianjin fly?" ("Nanfang Zhoumo: Tianjin Kongke Neng Fei Duogao?"), Southern Weekly, (accessed December 29, 2010), http://news.qq.com/a/20070524/002264_1.htm.

By the end of November 2010, there were 643 Airbus aircraft in operation in China, which accounted for 44 percent of the entire market share.[503] With the production line in operation in China, Airbus expects to acquire more than half the Chinese market in the coming years. Its foothold in that market has grown exponentially since it first produced aircraft for China in 1995. There were only 29 aircraft operating in China then, which accounted for a mere 7 percent of the total market. It is expected that 80 to 90 A320-series aircraft will be delivered to Chinese airlines on average annually.[504] This will boost Airbus market share in a market in which their indigenous plane will consume a share.

AVIATION-RELATED INDUSTRIES AND SUPPLIERS

Building an entire commercial aircraft requires the integration of technologies from unrelated fields. It is virtually impossible to cover all industries important for aircraft development; therefore, this section pays special attention to the major roadblocks with respect to technological obstructions China must surmount in order to successfully create a large state-of-the-art civilian air transport.

One major obstacle China's aviation industry faces to building an entire civil airplane has been its inability to create a turbofan engine technology. It has not yet mastered jet engine technology**.** China, however, has engaged in a multitude of joint ventures to expand its knowledge and gain the requisite technology needed to assemble a

[503] "Airbus in China," ("Kongzhong Keche Zai Zhongguo,"),(accessed January 3, 2011), http://www.airbus.com.cn/corporate-information/airbus-in-china/.

[504] Baokang Xie, "Airbus A320 Tianjin General Assembling line starts," ("Kongke A320 Tianjin Zongzhuangxian Kaigong"), China Economic Times, (Zhongguo Jingji Shibao), (accessed January 8, 2010), http://news.sohu.com/20070517/n250060831.shtml.

jet engine by 2020. To date, however, it still has to import engines for its commercial aircraft**.**

According to experts in this area, the main problem for Chinese engineers is that they are unable to produce an acceptable nozzle for the engine; if the main combustion nozzle is not built to sufficient tolerances, the engine will have limited capability and a short life span. While a nozzle of lesser precision may be sufficient for military endeavors, because the plane would only need to fly a limited number of hours, commercial airlines require their planes to fly at least 8 hours per day, and such an engine would not hold up under those conditions. The Chinese have simply not been able to build enough power and thrust into their engines. Besides the lack of this core-hardware technology, there are also clear quality and control requirements that China can't meet in machining processes and in fabricating the hundreds of components and parts used in turbofan engines.[505] It lacks the technology and associated functions to test the engine and ensure its safety. So China it cannot meet airworthiness standards for powering a commercial aircraft.

Chengdu Aero-Tech Company

Though there are many foreign engine companies operating in China today, only a few to date have launched co-production ventures in which the Chinese gain access to state-of-the-art manufacturing facilities, processes and assembly, equipment, and tooling for aero-engine production. Other arrangements were predominately supplier-based and have not moved beyond contract work agreements. China only makes components that

[505] Personal Interview with aero-engineer Zhi Gang Jiang of Air China on May 15, 2010.

are transported back to Europe and North America for final assembly.[506] One noteworthy exception is the Chengdu Aerotech Company, which was established in 1996 between Pratt and Whitney, which owns 78.3 percent of the company; the Chengdu Engine Corporation, which owns 13.5 percent; and the China Aviation Industry Corporation (AVIC II), which owns 8.2 percent. The company has a registered capital of $19.7 million, with more than 200 employees.[507]

The joint venture was established to produce commercial aircraft engines components and parts, for both China's domestic market and world airline customers, using state-of-the-art manufacturing technology and standards. At the start, the company produced parts for Pratt and Whitney, and as its Chinese partner became more experienced with P&W's manufacturing standards, procedures, and product line, it took on more sophisticated tasks, which included producing advanced components for high-tech turbine engines. The company now produces precision sheet metal and machined components for aircraft engines and industrial gas turbines. The final products made at this facility are shipped to the U.S. and Canada, Hamilton Sundstrand, Kawasaki, Eldim, etc.[508]

To carry out such tasks, Pratt and Whitney built state-of-the-engine manufacturing facilities in Chengdu, which also included advanced engine-manufacturing equipment, processes, and tools. Its production facilities are equipped with

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[506] Mark Dougan, *A Political Economy Analysis Of China's Civil Aviation Industry* (New York: Routledge, 2002), p110.

[507] "Chengdu Aerotech Manufacturing Co., Ltd," Easy China Supply.com, (accessed January 27 2011), http://www.easychinasupply.com/producttrade/last_pt_com/163847.html.

[508] Ibid.

a broad range of advanced computer-controlled machining, forming, and welding equipment. The special processes include vacuum brazing, vacuum furnaces, plasma spray, rubber application, NDT, MPI, FPI, EDM etc. The production capabilities include large machining, small machining, and airframe ECS (environment control system) components and sheet metal fabrication.[509]

Xian-Aero-engine Corporation

Another noteworthy venture that has put China on track toward developing its own state-of-the-art jet engine was the Xian Aero-engine Corporation (XAE), which was established in 1997 in partnership with Rolls Royce. Rolls Royce helped to build a state-of-the-art facility in Xian that included advanced technologies, equipment, and tooling. XAE was responsible for producing steel and light alloy ring components made for Rolls Royce engines.[510] As the Chinese become more experienced with Rolls Royce practices, standards, and procedures, the company's responsibilities increased; it began to cast and machine turbine nozzle guide vanes (NGV) for use in the BR710 for the Gulfstream V and Bombardier Global Express, and in the BR715 for the Boeing 717.[511] The company also makes NGVs for the Tay engine, the power plant for the Gulfstream IV and Fokker

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509 Ibid.

510 "Rolls-Royce signs U.S.$10 Million Agreement," PR Newswire, (accessed January 5, 2011), http://www.prnewswire.co.uk/cgi/news/release?id=59712.

511 "Working Together," Rolls Royce, (accessed February 17, 2010), http://www.rolls-royce.com/china/en/partners/default.htm.

100. The Chinese were trained for these tasks by German technicians onsite and at the BMW Rolls-Royce Dahlewitz factory in Germany.[512]

S-FA Engine

The AVIC established a commercial aircraft engine corporation in 2009 for the purpose of researching and developing an engine of C919, a model known as SF-A. The Chinese were interested in an engine that brought together the strengths of both American-style and Russian-style jet engines while avoiding their weaknesses. Americans engines are high tech but tend to be very fragile; they are quite expensive to repair and protect. They also tend to need servicing often, which can also be very costly. The Russian engine, by contrast, is much cheaper but consumes more fuel and is very noisy. China's aero-engine should be cheaper than American and Russian models yet easier to repair, and should offer lower fuel consumption.[513] The goal for 2020 is to produce an engine that is cheaper than its competitors' to purchase and that is low in fuel consumption, yet is easy and cost-effective to repair.[514]

To realize this goal, aside from having learned engine technology from a multitude of joint ventures, AVIC signed a cooperation program in 2008 with Cranfield University in England under which China would send 150 airplane engineers and engine

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[512] Roger Cliff, *The Military Potential of China's Commercial Technology* (California: RAND, 2001), p26.

[513] Personal interview conducted with Rui Zhang, Managing Director at the Chengdu Aircraft Industrial Group October 18, 2009.

[514] Yin Yiliang, Wei Zhimin, "Competence and International Cooperation— Courses Required before Large Aircraft Flight," ("Jingzhengli yu Guoji Hezuo: Dafeiji "Qifei" Qian de Bixiuke"), China Industry News, July 9th, 2008, (Zhongguo Gongye Bao, July 9, 2008), pA02.

designers to learn development.[515] Most of China's experience with engine development had been for the military--the Russian AL-21 engine, used in the SU-27; and the WS10A engine, used in the J-10 aircraft. Until the S-FA is built and issued FAA airworthiness certification, China has signed an agreement with CFM International, a 50-50 joint venture between General Electric of the U.S. and Snemca of France, to employ its Leap-X to power the C-919.

Composites

The most advanced materials currently in use by aircraft manufacturers and expected to be employed in greater percentages in the future for manufacturing airframes are composites, known their light weight (which reduces fuel consumption) and greater resistance to fatigue and corrosion (so the aircraft can be serviced less frequently) along with higher strength-weight ratios.[516] Aircraft usually need to be serviced every 6 years; however, if a plane is built of composite materials, it needs to be maintenanced only once in 12 years, reducing repair fees by 32 percent.[517] Planes have traditionally used aluminum in the structure of the aircraft, which weighs 40 percent more than composite materials and is not as strong and durable. Carbon-fiber composites are about four times

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515 "UK university cultivate design talents for Chinese big aircraft and engine," ("Yingguo Daxue Wei Zhongguo Peiyang Dafeiji He Fadongji Sheji Rencai"), Business Week of UK, (accessed July 4, 2010), http://news.163.com/08/0411/10/4989V0K500011MTO.html.

516 "Airbus Harbin JV plant delivers 1st work package," China Daily,(August 4, 2010), http://www.neworiental.org/publish/portal0/tab1127/info535122.htm.

517 Du Shanyi, Guan Zhidong, "Strategic Considerations for Development of Advanced Composite Technology for Large Commercial Aircraft in China," (Woguo Daxing Keji Xianjin Fuhe Cailiao Jishu Yingyong Celue Sikao"), (*Acta Materiae Compositae Sinica*, Vol. 25, No. 1, Feb., 2008), (*Fuhe Cailiao Xuebao*, Vol.25, No.1 February 2008), pp1-10.

stronger than aluminum.[518] Both Airbus's A350 and Boeing B787 are now using quite a large amount of composite materials in the airframes of their planes. Composites have a strong capacity to prevent cracks and other damage. Overhaul is much easier as well when aircraft are fabricated from composites because damage is visible to the naked eye, thus making it easier to find and repair.[519]

Understanding the importance of composite materials for the future of airframe building, China has managed to secure contracting work from companies such as BHA, that supply such materials to aircraft manufacturers. A joint venture was formed in 2002 between Hexcel owning 40%, Boeing 40 and China's AVIC owning 20% BHA.[520] Boeing, which now owns 80 percent of BHA, having bought out Hexcel for $22.3 million in July 2008, remained reluctant to enter a venture with China working on composites, because helping China to learn, understand, and possibly develop high grades of composite material will help them with building a state-of-the-art passenger aircraft that could potentially pose a serious challenge to its own. Boeing's main competitive advantage rests on the percentage and quality of composite materials used in its airframes. Despite Boeing's skepticism over passing along technology and information that could groom a potential competitor, China has in fact, developed a significant level

518 Irene Shen, "Hafei Rises to Six-Month High on Airbus Parts Venture (Update1)",(accessed January 4, 2010), http://www.bloomberg.com/apps/news?pid=newsarchive&sid=aB2JDEgQKoYY&refer=china.

519 Du Shanyi, Guan Zhidong, "Strategic Considerations for Development of Advanced Composite Technology for Large Commercial Aircraft in China," (Woguo Daxing Keji Xianjin Fuhe Cailiao Jishu Yingyong Celue Sikao," (*Acta Materiae Compositae Sinica*, Vol. 25, No. 1, February, 2008), (*Fuhe Cailiao Xuebao*, Vol. 25 No.1 February, 2008), pp1-10.

520 "Boeing expands its China venture," China Daily, (accessed November 1, 2010), http://www.chinadaily.com.cn/china/2008-11/19/content_7221208.htm.

of expertise in composites from working for several years with Airbus sister company Eurocopter.

China gained such expertise from jointly developing and producing carbon-fiber helicopter cockpits with Eurocopter.[521] Nowadays, China is able to develop it independently. Although the Chinese have the capacity to produce low-grade composite materials for commercial use, aircraft manufacturers, such as Boeing and Airbus, require a more advanced type that must pass a rigorous testing and certification process for approval, which is long and expensive.[522] It is not cost-effective for the Chinese. "The cost and time involved to certify production processes, materials tools modes would be cost prohibitive to customers."[523] This is the main reason why China has made it a priority to be able to develop the necessary machines and tools for the industry. China is still approximately 15 years behind Western countries in the use of such technologies.[524]

Boeing has, then, since found a way to benefit from the venture while avoiding transferring technology that could potentially put their state-of-the-art aircraft at risk. The composite materials for the venture are laid by hand, so Boeing does not have to give the Chinese access to controversial automation technology it needs for developing high grades of composites that are cost-effective on its own. The joint venture produces

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[521] "Composite Materials in the Aerospace Industry in China," AMCham Export Compliance Working Group,(accessed May 8, 2009, http://web.resource.amchamchina.org/news/ECWGCrossSectorReportAttachmentA.pdf, p126.

[522] Interview with President James Liu of Grand-Pacific Enterprises, specializing in the production of Composite materials on January 12, 2010.

[523] Ibid., p136.

[524] Zhang Xingjin, Deng Zhonglin, "The Discussion on Carbon Fiber Composite and Passenger-carrying Aircraft of China," ("Qiantan Xianwei Fuhe Cailiao yu Zhongguo Dafeiji"), (*Fiber Composites*, No. 2 June 2009), (*Xianwei Fuhe Cailiao*, No.2 June 2009), pp24-26.

composite secondary structures and interior parts instead for the Boeing B737 NG, B747, B767, and B777, which include the flight deck close panels, dorsal fin, wing to body fairing, cover panels wing fixed trailing edge, and wing fixed leading edge interior panels.[525]

Airbus Composites

In January 2009, Airbus and a group of Chinese industrial partners signed a contract to establish a Joint Venture Manufacturing Centre in Harbin, China, for the purpose of manufacturing and developing composite material parts and major components for the Airbus A350 XWB programme (it will actually manufacture 5 percent of the A350 airframe) and the Airbus A320.[526] These components will be manufactured using the latest composite-manufacturing technology and equipment based on Airbus procedures, standards, and processes. The joint venture, known as the Harbin Hafei Airbus Composite Manufacturing Centre Company Limited, has Hafei Aviation Industry Company Ltd. (HAIG) holding a 50-percent share, Airbus China holding 20 percent, and both AviChina Industry and Technology Ltd.(AVIChina) and Harbin Development Zone Heli Infrastructure Development Company Limited (HELI) each holding a 10-percent share.[527]

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[525] "Moving South: A series of reports examining in outsourcing aircraft manufacturing Trends outsourcing manufacturing to low wage acres of the world," Media Ltd, (accessed July 9, 2010), http://pmi-media.com/downloads/low-wage-global-aerospace-study.pdf, p16.

[526] "Joint Venture to Establish a Manufacturing Centre for A320/A350 Composite Parts in China," Deagal.com, (accessed January 5, 2011), http://www.deagel.com/news/Joint-Venture-to-Establish-a-Manufacturing-Centre-for-A320A350-Composite-Parts-in-China_ aspx.

[527] Ibid.

The factory first started its production at the end of 2009, working on developing composite work packages for the A320, including elevators, rudders, and horizontal tail plane spars.[528] The partners agreed to begin production while in the midst of building the state-of-the-art manufacturing facility in Harbin, which was officially completed at the end of 2010. The company further plans to branch out into maintenance repair and overhaul in the near future.

Maintenance

China, which has thus far lacked experience with maintenance and repair, was compelled to establish a venture in those areas with Boeing. Providing customer service and repair is deemed especially important for China in the run-up to the launch of its indigenous aircraft in 2016. In 2006, The Boeing Shanghai Service Co. was officially established, with Boeing holding a 60-percent share and Shanghai Airport Authority and Shanghai Airlines holding 24 percent and 15 percent, respectively.[529] The joint-venture company is primarily responsible for providing heavy maintenance checks, repairs and upgrades to interiors, avionics, and in-flight systems for five major airlines and for the Boeing 737NG. With its new hangar facility, the MRO is able to service four narrow bodies or two wide body aircraft at any one time. “A clear advantage of the facility is its ability to combine the skills, quality and knowledge of an airframe manufacturer, an

[528] Hu Yang and Lu Haoting, “Airbus Harbin JV plant delivers 1st work package”, China Daily, (accessed Jan 2, 2011),http://www2.chinadaily.com.cn/business/2010-07/03/content_10054176.htm.

[529] Henry Canaday, “Asia Pacific,” Aviation week,(accessed January 2, 2011), http://www.aviationweek.com/aw/jsp_includes/articlePrint.jsp?storyID=news/om1207fac.xml&headLine=New percent20And percent20Expanded percent20Maintenance percent20Facilities.

airline and a component logistics specialist to provide a world-class service."[530]

C-919: FIRM STRATEGY, STRUCTURE AND RIVALRY

Porter's model draws our attention to the structure and strategy of COMAC, the corporation responsible for developing its large indigenous aircraft. Although on the surface it appears that the company is organized around meeting the current demand, this is misleading. The company is primarily controlled by the state through the State Council's State Assets Supervision and Administration Commission (SASAC), and the state-run airlines will be forced to purchase the airplane. As Porter's model indicates, such a level of subsidization will not inspire a company to produce state-of-the-art aircraft that the market demands, and motivation will be lost to continuously improve the product when sales are guaranteed through China's large domestic market. The company is not going to organize in a way conducive to competing with other manufacturers.

COMAC (LLC)

In 2008, the National People's Congress officially approved the plan for the establishment of the limited liability company, the Commercial Aircraft Corporation of China (COMAC), which is directly responsible to the State Council's State Assets Supervision and Administration Commission (SASAC), which is its largest shareholder

[530] "Boeing Shanghai Aviation Services Agrees Component Support Contract With AJ Walter Aviation," AJW Aviation,(accessed November15, 2010), http://www.ajw-aviation.com/communications/latest-news/176-boeing-shanghai-aviation-services-agrees-component-support-contract-with-a-j-walter-aviation.html.

owning 31.6 percent of the company, worth $2.7 billion; the other major shareholders include the Shanghai Municipal Government via Guosheng Group, which has a 25-percent stake in the company ($700 million), and the AVIC, which has just under 25 percent; three other shareholders, each holding a 5-percent ($150 million) stake in the company are the Baosteel Group Corp., the Aluminum Corporation of China (Chinalco), and Sinochem Corp.[531] The estimated total investment on the C919 project is expected to be more than 200 billion Yuan, comparable to that of the Three Gorges Dam project.[532]

In accordance with company law, COMAC follows a modern corporation system in which it has an association of stockholders, a Board of Supervisors, and a Board of Directors. The Board of Supervisors is made up of party members from the central government, which includes members from the Central Military Commission, the CAAC, the Department of Commerce, etc. This board represents the national interest of the country and makes sure that any business decisions decided by the Board of the Directors aren't in conflict with the state's interest. Whatever is deemed in the national interest takes precedence over all commercial business. Before any major decisions are made, including the devising of company strategies, goals, plans, and their execution, the Board of Directors must consult with the Board of Supervisors in order to make sure that they are in line with national goals and interests.

The Board of Directors for COMAC thus focuses on the business aspect of the operation, while the Supervisory Board will balance that with political interest. For

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[531] Mark Stokes, "China's Commercial Aviation Sector Looks to the Future," Project 2049 Institute, May 8, 2009, p2.

[532] Yali Zhang, "Total investment on the C919 project is expected to be more than 200 billion Yuan, comparable with the Three Gorges Dam project." ("Zhongguo Dafeiji Zongtouru Jiang Da 2000 Yi, Yu Sanxia Gongcheng Xiangdang,"),(accessed March 15, 2010), (http://news.qq.com/a/20090508/001026.htm.

example, the Board of Supervisors may make decisions regarding the selection of companies with which China may enter into a joint venture and an agreement can be made for the exchange of technology and market share. China has increasingly required that very exchange in joint ventures as a prerequisite and a condition for awarding manufacturing contracts. The intention seems to be for China to develop the requisite knowledge and the domestic expertise in subsystems in addition to airframes.

Board of Directors

The State-Owned Assets Commission, because it is the largest shareholder of the company, has the main responsibility for supervising the operation. The Board of Directors is chosen by the shareholders. Since the SASAC maintains the largest share of the company, it chooses the representatives sitting on the Board of Directors. The SASAC has unmatched power to control the business aspect of all decision making. As one can readily see, this modern corporation system that was created to imitate a modern company with a formal separation of power is rather illusory.

Plan and Strategy

The Commercial Aircraft Corporation of China's (COMAC) plan is to develop a 190-seat large indigenous commercial aircraft to satisfy its 17.5-percent annual growth in air transportation. The aircraft is known as the COMAC 919. The C represents "China" as well as "COMAC," the number 9 in Chinese culture represents "forever," and the number 19 means the aircraft will contain 190 seats.[533]

The plane is expected to develop a competitive advantage by reducing fuel consumption by 15 percent and operating costs by as much as 12 percent as a quarter of the plane is expected to be made with composite materials; it is also expected to be more environmentally friendly than its competitors with a 50- percent reduction in CO2 emissions.[534] The plane's cost is also expected to be 20 percent cheaper than those of its foreign competitors. COMAC also claims that the cabin will be more comfortable for its passengers, as the seats will be larger and the cabin more spacious. This will eliminate the overcrowding feeling that passengers' experience. There will be larger observation windows and larger overhead bins to accommodate passenger carry-on luggage as well.

To meet these objectives, COMAC will be responsible for carrying out aircraft research and development, producing components, final assembly, marketing, customer service and repair, airworthiness certification, and financial leasing.[535] The plane is expected to profit after its sells somewhere between 300 and 400 aircraft.[536] Before then, the project will depend on the government to primarily fund the plane's development. China itself will build 30 percent of the entire aircraft, relying greatly upon foreign

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533 Rob Vogelaar, "China First Jumbo Jet C-919 to Take off in 8 Years," Aviationnews.eu, (accessed October 9, 2009), http://www.aviationnews.eu/2009/03/11/chinas-first-jumbo-jet-c919-to-take-off-in-8-years, p1.

534 "China's large aircraft will launch customer next year, initial order can number as many as 90 aircraft," ("Zhongguo Zao Dafeiji Mingnian Qidong Dingdan, Shoupi Mubiao Shi 90 Jia,") Beijing Morning Post, , (Beijing Chenbao) ,(accessed September 27, 2009),http://news.xinhuanet.com/tech/2009-09/23/content_12099669.htm, p1.

535 Mark Stokes, "China's Commercial Aviation Sector Looks to the Future," Project 2049 Institute, May 8, 2009 pp4-5.

536 Qianming Shang, "Chinese Big Airplane Started with being Proud," ("Zhonguo Dafeiji Haomai Qicheng,") *Outlook Weekly*, (*Liao Wang Xinwen Zhou Kan*), Vol. 20, 2008, (accessed March 8, 2010) http://lw.xinhuanet.com/htm/content_3245.htm.

suppliers (see appendix B-9). COMAC is planning to manufacture up to 3,000 aircraft in total, approximately 150 a year, to satisfy its domestic demand.[537] It will count on its state-controlled domestic airlines to buy the majority of these planes. China will require 3,560 aircraft worth $340 billion, of which 1,400 are expected to be large-size commercial airplanes, over the next 20 years.[538] As of November 2010, COMAC announced that it has already received 145 orders for its C919 airplane from four Chinese domestic airlines--Air China, China Southern, China Eastern, and Hainan Airlines, as well as from the U.S.-owned GE Capital Aviation Service.[539]

COMAC Board of Directors

COMAC shareholders and supervisory board have appointed a team of China's most senior aviation leaders to senior board of director's positions in the company. The only task the central leaders and their Board of Supervisors have given to the Board of Directors, aside from finishing the project successfully, is to build the plane with domestic suppliers whenever possible; if Chinese suppliers lack the technological capability, the group may seek out foreign partners to fill the void. They are to gain access to the best materials and suppliers in the world to help build the plane if need be. Guaranteeing the plane's quality will take precedence over anything else. Even though

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[537] Mark Stokes, "China's Commercial Aviation Sector Looks to the Future," Project 2049 Institute, May 8, 2009 p4.

[538] Lei Hou, "First Jumbo Jet to take Off in 2014," China Daily, (accessed July 15, 2009) http://www.chinadaily.com.cn/china/2009-03/12/content_7573588.htm.

[539] "China Wins 100 C919 Orders Breaks Airbus-Boeing Grip," Bloomberg.com, (accessed December 19, 2010, http://www.businessweek.com/news/2010-11-16/china-wins-100-c919-orders-breaks-airbus-boeing-grip.html.

the SASAC put together a team of Board of Directors capable of managing this very important task, they do have limited experience with respect to developing an airliner for the market.[540]

Many of these leaders are young engineers who formerly played prominent roles in China's defense industry. Zhang Qingwei, assigned the position of Chairman of COMAC, is well known his leading role in the success of China's space program. He is also a member of the Central Committee[541] (204); therefore, he is very well respected within the government and can wield significant influence over the Shareholders and Board of Supervisors when they are developing grand strategic decisions.[542]

Prior to joining COMAC, Zhang was the Director of China's Aerospace Science and Technology Corporation (CASC) and brought some of the most senior and respected managers within the space and missile industry to serve with him on the Board of COMAC. Jin Zhuanglong is an alternate member of the Central Committee (204 +176); that is, if for some reason some of the current members fall ill or step down, when his number is called, he will serve.[543] Jin served under Zhang as Deputy Director of Commission of Science, Technology, and Industry for National Defense (COSTIND) and was appointed General Manager of COMAC. The new COMAC Deputy Director He

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540 Personal Interview with Richard Jones, Consultant for the C919 Project and former General Manager of the Marketing Department Airbus, China on April 15, 2010.

541 The Central Committee consists of over 300 of the country's most prominent party members in the country.

542 "Resume of Zhang Qingwei," ("Zhang Qingwei Jianli"), Xinhua.net, (accessed January 31, 2011), http://news.xinhuanet.com/ziliao/2007-08/31/content_6636882.htm.

543 "Resume of Jin Zhuanglong", ("Jin Zhuanglong Jianli") xinhuan.net, (accessed January 15, 2010), http://cn.chinagate.cn/politics/2008-05/12/content_15160513.htm.

Dongfeng previously managed the CASC's China Academy of Launch Technology's 211 Factory before becoming CASC Deputy Director, where he worked under Zhang.[544]

COMAC decided that, based on China's prior experience working with the most prominent aircraft manufacturers, it should be able to develop 30 percent of aircraft while enlisting the help of international suppliers through a standard bidding process for the remaining 70 percent. Priority will go to those foreign companies willing to enter joint ventures with Chinese companies and to share state-of-the-art technology. More than 47 different domestic and foreign firms, contracted to work on this project in China and abroad, will be in the supply chain for the C-919.

Delegation of Shareholder Responsibility

The plane will be designed, manufactured and assembled in Shanghai. Shanghai was delegated this responsibility because of its prior experience with working on the Y-10 and its co-production agreement with McDonnell Douglas. The Shanghai Aircraft Design and Research Institute, which is responsible for the plane's design, was created in the 1970s, when Mao Zedong approved the Y-10 project. The Shanghai Aircraft Manufacturing Corporation is in charge of both producing and assembling the C919 aircraft. This factory was where the joint venture between MD and China for the development of the MD80 and MD90 took place. The Shanghai Aircraft Consumer Services Corporation will be mainly in charge of providing related services for

[544] Ibid., p3.

consumers.[545] It was set up by COMAC with a registered capital of 100 million Yuan. It will carry out life-long consumer services, which includes maintenance and repair, as well as possess responsibility for selling and leasing aircraft to both domestic and foreign customers.[546]

The Aluminum Corporation of China (Chinalco) will provide all of the aluminum and titanium material for the C919. Chinalco, the third-ranking aluminum company in the world, is capable of developing the world's most advanced grade of aluminum alloy. It has already invested 5 billion RMB and is will develop advanced aluminum and other important materials for the C919 project. It has assigned over 100 engineers to work on this task. Since the company is a shareholder, it has a priority over all other aluminum-producing companies; whatever metals it can produce will be used in the C919. If for some reason it is not able to adequately develop advanced aluminum for the aircraft, it will partner up with A-Alcoa Inc., the largest U.S. aluminum producer; together they will study and manufacturer aluminum structural concepts, designs, and alloys for the C919. The Aluminum Corporation of China is currently working toward achieving the goal of developing the first C919 aircraft with 30-percent aluminum alloy.

On December 29, 2009, Baosteel signed with its COMAC partners to carry out comprehensive cooperative research and development on aviation-use steel, raw material supplies for aircraft parts, and components for the C919. In September 2010, COMAC managers visited Baosteel, and an agreement was reached that enables Baosteel, since it

[545]"The consumer service center," ("Kehu Fuwu Zhongxin"), COMAC, (Zhongguo Shangfei Gongsi), (accessed January 9, 2010), http://www.comac.cc/main/sdzx/200912/29/t20091229_315657.shtml.

[546]Ibid.

is also a major shareholder, to develop steel on its own for use by COMAC in the aircraft. Like Chinalco, it will have priority over all other foreign and domestic manufacturers of steel. This, it was believed, would motivate Baosteel management to invest heavily in new research and technology. The only way COMAC can refuse original BaoSteel products is if they are not made efficiently.

The AVIC has been designated the responsibility of supplying equipment, factories, and manufacturing technology for this project and forging joint ventures with international companies; it will also work on developing its first successful indigenous commercial engine. Sinochem will be responsible for production of composites material. If it is not able to do it well on its own, it will seek international cooperation.

CONCLUSION

Peter Evans's framework proved to be very important for showing us the policy choices available to China following its transition toward an intermediate state for the development of the C919 airplane. Under the predatory state, it had relied on state institutions for economic development while at the same time restricting the emergence of an entrepreneurial class and foreign investment in the economy for fear that their greed would allow them to exploit the country's limited resources for personal gain, which might in fact run counter the interest of the nation as a whole. With the abolishment of a market economy, important decisions regarding economic development were made by Chinese central leaders calling on the many state bureaucracies to execute their vision.

In 1978, Deng Xiaoping set out to correct the deficiencies in the system by also playing the midwifery and husbandry roles; he allowed the establishment of private firms to compete in the economy and stimulate demand. China at this time opened up to the world, allowing foreign companies to relocate and invest in the country. The newfound openness stimulated an economy that had suffered at the hands of Mao Zedong. With the emergence of private enterprise came products and processes that people wanted and needed. As businesses become successful, they expand, and hire more people. The newly employed then have the ability to purchase goods and products, thus further stimulating the economy. The Chinese economy was soon growing steadily at a pace of about 9 percent per year, lifting millions out of poverty. As more and more people entered the middle class, disposable income has risen immensely, and by 2008 it had reached 15,780 Yuan ($2,300) for urban residents and 4760 Yuan ($696) for rural residents, creating a greater demand for air travel.[547]

Michael Porter's framework proved to be very useful for showing us what China has and hasn't done to build a competitive and successful aircraft. As demand rose for air travel, China correctly set out to once again develop an indigenous large passenger aircraft. When there is a growing demand in a society, firms look to satisfy it by developing a product based on close collaboration with buyer needs. Products will improve over time as wants and needs change and as the customer base alerts firms to the existing shortcomings in products; likewise, new interests emerge when new technology becomes available from other sectors of the economy and can diffuse into aircraft development. The continuous desire to create and innovate comes when there is stiff competition in the market. When rivals are present, firms try to outdo one another for

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[547] Statistics of Henan Province Network, (Henan Nan Tong Ji Wang), (accessed July 15, 2010) http//www.ha.stats.gov.cn/hntj/lib/tjnj/2009/html/1001.htm.

current and new business. Without such competition, firms are likely to remain stagnant. In China's case, the desire to continue to innovate may perhaps be lost because the government will protect its market and guarantee that its State-owned firms will purchase its aircraft. As Porter notes, without such competition, the desire to create and innovate is lost.

Just as important, as Porter notes in his Factor conditions variable, if a potential demand for a product or service arises, a nation must possess an educated population that has an advanced and specialized skill set capable of designing and creating new and innovative products. Even though there has been growing concern among nations that China has been consistently graduating twice as many engineers than they do yearly, Porter's determinant paved the way for looking deeply into the actual nature of China's education system. Although the model falls short of explaining what type of education is required for having the distinct population to design and create new products, it does force us to determine what type of education is most conducive to achieving such goals.

Our research has shown how China's educational system has served as a hindrance to developing innovative and indigenous aircraft. The system trains experts rather than scholars; Chinese students are skilled at knowing information but not at understanding how that knowledge is created. It is more important for scientists and engineers to understand how knowledge is created, and how to expand upon it, than merely possess the descriptive information. China's mono-disciplinarian education also contributes immensely to this problem, as innovative thoughts and ideas stem from bringing together or drawing on information from unrelated fields.

What is absent from Porter's model and an important tool for learning and gaining access to new technology is China's commitment to commercial espionage. It has devised a multitude of new methods through which it calls upon Chinese nationals, students, and former dissidents--through bribes or fear--who either study or work abroad to acquire sensitive technology and send it back to China. Government officials also set up front companies, under American names in the United States, to acquire sensitive technology. This has proven to save both a lot of money and the time it would take to develop the technologies on its own, and poses the single greatest threat to U.S. national and economic security. Although it is extremely difficult to prevent, the United States has channeled exorbitant amounts of money to preventing such espionage from occurring.

Over the years, China has employed a strategy of using its large market as a bargaining chip for gaining access to advanced technology. It has continuously set up ventures with aircraft manufacturing companies such as Embraer, Boeing, and Airbus, which all seek to gain an advantage over the competition by gaining a foothold in the large Chinese market. China has gained access to state-of-the-art manufacturing and production technologies from these companies although most of them are unwilling to hand over design technology or their most sophisticated technology and components to the Chinese because they fear they will lose their competitive advantage and possibly groom another competitor in the industry.

Still, the cooperative arrangement with McDonnell Douglas most enabled China to learn management, production, and aircraft development. With MD's survival at stake, it wished to gain access into the largely untapped Chinese market, so it was willing to generously offer China state-of-the art technology. It was extremely difficult at first for

China and MD to work together due to their vast cultural differences, but once the Chinese had conformed to the leadership and strategies of McDonnell Douglass, they learned how to develop, organize, and manage the operation and the development of aircraft. What had also previously served as a roadblock to aircraft development and is absent from Porter's model is culture, which in China, for example, prohibited praise or reward of individuals for their hard work, thus reducing incentives to work hard. When the Chinese began to offer these incentives and changed its system of management and structure, they learned how to develop a plane to meet FAA standards.

Looking at Porter's variable Structure, Rivalry and Organization, we can see that China has implemented changes from when it developed the Y-10. However, their new system is not without problems. COMAC, as a limited liability corporation, is predominately government owned. The new system does improve the overall management process in terms of being structured and well coordinated; however, the government is still calling the shots, not private interests. It still employs the demiurge role, as it was the government's decision to push forward with the development of the C919 and put together a team including Zhang Qingwei at the helm of its Board of Directors to carry out the government's vision. But it is a very different system from that that was in place when the Y-10 was developed, because COMAC has enlisted foreign suppliers to supply components and parts that China cannot produce on its own. The state also put a Board of Supervisors in place to ensure that any company decisions made do not run counter to the national security interests.

Because COMAC is government owned, there is little fear that the company will be deprived of capital or ever go out of business. It doesn't feel the sense of urgency, or necessity to continue to build state-of-the-art airplanes, because the government under CAAC controls domestic purchasing of aircraft and has ensured that its state-run airlines will purchase the aircraft. This removes an immense amount of pressure on the one hand but, on the other, weakens the company's ability to compete with Boeing and Airbus, which face such pressures. COMAC doesn't have the desire to organize and structure the company to compete with Boeing or Airbus in the free market when its home market will account for 25 percent of total world demand. The guaranteed sales do not encourage hard work from the company and its employees.

CHAPTER FIVE

CONCLUSION

China has made remarkable progress in the development of its commercial aviation industry. It has gone from relying on the Soviet Union for aircraft and for helping it to develop the industry, to standing on the threshold of competing with industrial giants: Boeing and Airbus. The case studies utilized in this study demonstrates the value and the insightfulness the theoretical framework, which combines the work of Peter Evans and Michael Porter has on determining how successful a nation/firm is likely to be in building an internationally competitive industry. However, the framework is not without weaknesses, which can in fact be tweaked to make its value stronger when applied to other important industrial sectors.

The framework illuminated the reasons why China was unsuccessful at developing a large commercial aircraft in the late 1970s. As Evans notes, the predatory state has severe limitations in the policy choices available to manipulate the important societal variables captured in Porter's model in order to build a competitive aircraft. The country became completely reliant on the state for economic development as large state institutional bureaucracies were responsible for carrying out the goals of development.

The nation was confined only to the role of demiurge, because it did not possess the dense networks of legitimate rule-based ties among societal members who were primarily motivated by profit, which in turn will produce goods and services for the greater good of society. Mao inherently believed the capitalism possessed high levels of greed, and that private firms were more interested in profit than improving the country as a whole. Going hand in hand with the demiurge impulse, in which the state is in charge of producing or developing virtually all industrial sectors of the economy, is the custodial role, which prevents domestic and foreign entrepreneurs from exploiting, creating, or taking advantage of potential market opportunities.

Demand and the Y-10

As articulated in Porter's model, aircraft development should have been pursued in accordance with societal demands; this impulse was absent in China. The society gains as whole when societal demands are met. For example, companies able to satisfy societal demands with products and or services are likely to generate greater profits, while societal members and potential consumers gain by having access to products they want or need, thus making life more comfortable and satisfying. As demand grows in new or up-and-coming industries, new and existing firms will try to compete in them, seeking to meet the needs of the people by introducing their own unique amalgam of products and services. This, in turn, forces existing companies to constantly seek to refine and improve their products, should they wish to sustain or expand their share of the market. Competition forces firms to find ways to make their products more cheaply, add new features to existing products, or develop an entirely new product to stimulate and satisfy customer interest. Without a demand, there is no niche to satisfy--nor is there any reason for competitors to enter an industry that appears to be profitable.

There was certainly no case to be made for the development of an indigenous airliner in the 1970s to the average citizen, barely having enough food, earning 605 Yuan per year. The decision to launch the Y-10 program was not based on societal need but on Chinese leaders' desire to project an image of modern industrialized country abroad by being able to travel on a Chinese-made aircraft. However, as Porter's model exemplifies, without a demand for a product, there is limited opportunity to achieve success in an industry. In communist China, the existence of private industry was forbidden, so enterprises were not allowed to freely enter an industry. Success was thus unachievable, since there was no incentive to produce a competitive product or sell enough of it to achieve economies of scale.

Factor Conditions and the Y-10

Porter's model also correctly notes that, in order to satisfy or create a niche in the market, a nation must have a highly trained pool of advanced factor conditions. Nations must develop their educational system so as, not only to train students in advanced and specified areas of science and engineering, but to devote a portion of their curriculum to research and development.

Absent from Porter's model is what must be taught to in schools that stimulates creativity. A solid education conducive to stimulating creativity and innovativeness begins with being interdisciplinary. It arms the student with more knowledge through which he or she could challenge current ways of thinking and offer better ideas or solutions for resolving current and future problems. Society must allow access to information and allow students to grapple with what they are learning. In Mao's China, students were not only denied access to information perceived to be threatening or contradictory to revolutionary goals and ideas, but made to understand that challenging what was taught was forbidden. Students had to accept whatever was taught as scientific truth, which stifled independent thinking.

Colleges and universities were also closed down intermittently over a 12-year period, during and after the Cultural Revolution, resulting in a loss of a generation of scholars, intellectuals, and students that were denied the opportunity to learn, conduct research and development, and train the next and future generations of Chinese in their respective fields. This significantly hurt China's quest at developing an advanced jet aircraft.

Supporting and Related Industries and the Y-10

While Porter's supporting and related industries determinant discusses the value a nation can acquire from working with world-class suppliers and related industries (preferably domestic suppliers and industries), he doesn't specifically distinguish between the two types of technological knowledge a firm can gain from working with suppliers and industries: manufacturing and design. Under Mao's predatory state, the Russians provided the Chinese with blueprints, technology, and equipment for imitating and replicating their aircraft. The Chinese relied so heavily on copying Russian aircraft that they received minimal experience in designing and creating innovative aircraft. The importance of being able to design aircraft cannot be understated.

This technical information provided by the Russians was useful predominantly for teaching the Chinese how to manufacture and assemble an aircraft. Without the ability to design, you are limited to developing aircraft with only the level of technology you have been given. You don't possess the ability to go beyond, because you lack structural information about the aircraft that can explain why it was made the way it was. Being unable to design an original aircraft makes it difficult to create a competitive product. You will always remain at the same level as the aircraft you are able to duplicate.

Structure, Rivalry, and Organization and the Y-10

The framework presented in this study also highlights the lack of motivation and the vast waste of resources that the predatory state witnessed during production of the Y-10 project, which hindered China's ability to develop a competitive airline. The organizational structure of the work unit under Mao offered workers lifetime employment and health benefits, regardless of how productive they actually were; these benefits were not linked to work performance, which actually discouraged factory employees from working hard. In fact, it was rather difficult to monitor work performance because bureaucrats and factory directors were given lifetime employment no matter how efficient their subordinates were, and the system did not encourage those in charge to monitor or encourage workers to achieve factory goals. From managers all the way down to factory workers, people had little incentive to work beyond the bare minimum. Additionally, factories were predominantly over-staffed, and most workers were confused about what their responsibilities actually were. There was no clear-cut delineation of responsibilities for each worker; therefore, it was difficult to hold anyone accountable for completing specific assignments.

Under that bureaucratic organizational structure, workers would work moderately hard when the factory manager received an order from his bureaucratic superior urging him to complete a task of central importance right away. On the spot, the factory managers would create a division of labor among his employees to complete the task at hand as soon as possible. Most workers cared about completing the task with little regard for the quality of finished product. In fact, in most cases, though factories were given orders from their superiors, they didn't possess the right tools, materials, or resources for the task at hand, and workers had to improvise, using materials and tools they had instead of what they needed, resulting in poorly made and/or damaged products. Their bureaucratic superiors were actually far removed from knowing what resources their subordinates had available or could obtain.

This problem played a role in the failure of the Y-10. Mao Zedong called for its development with little knowledge of whether China possessed the technological capability to succeed at it. Mao called for the development of the airliner in the 1970s, just after many of China's scientists and engineers were forced into penal camps during the Cultural Revolution. He didn't realize how severe the shortage of talent really was.

There was also a lot of confusion during the production of the Y-10, since there was no clear delineation of responsibility among central administrative bureaucracies, resulting in overlaps in responsibility. When a particular department sent an order to a factory, it would often be the case that the factory received different requirements for the same task from other, superior, administrative departments, resulting in mass confusion and a lot of wasted resources. Factories would be forced to pick and choose which department to satisfy and which to defy. With the central government financing the entire project, a lot of money and resources were wasted, and duplication of tasks and products was common. Because the government controlled the purse strings, it decided to discontinue the project upon the return of Deng Xiaoping and his cohort, who had been sent to the countryside to be re-educated during the Cultural Revolution. Deng and the others discontinued all projects that had been started during, or were associated with, the Cultural Revolution, which included the Y-10 project.

THE INTERMEDIATE STATE

Deng Xiaoping saw it as imperative to reinstitute methods of governance, which entailed legitimizing the constitution and rule of law in order to restore faith in the Communist Party and to bring the country out of financial ruin. The need for rule of law, predictability, and property rights were essential for triggering both domestic and foreign investment in the economy.

With laws created that protected private and intellectual property, people began to strive for material wealth and happiness. As predictability began to surface as a result of the reinstitution of norms, procedures, and routines in line with socialist free-market principles, investors began tapping into China’s large unexploited market. China was able to grow at an annual rate of about 10 percent for more than 30 years because of such changes and investor confidence in the system. This translated into huge economic growth for China through which it would gain advanced technology and managerial experience from foreign enterprises.

As the government established a rule-based network respecting private enterprise, China had begun to demonstrate traces of a developmental State. On the other hand, as with most states in transition, during times of uncertainty and crisis, China has reacted in an overly autonomous fashion (where rule of law was ignored), especially in cases that were potentially threatening to one-party rule, making China an intermediate according to Evans's state categorization. As described by Evans, the intermediate state possesses both autonomy and embeddedness in adequate amounts but at times falls prey to an imbalance that can take the form of excessive clientelism or isolated autonomy.[548]

One case in particular was the Tiananmen Square Crackdown in 1989, where soldiers were ordered to fire on students protesting in the name of modest democratic reform. As many as 2,000 students were killed as a result. Proper procedure was cast aside, and the rule of man became the way forward as party elders, who were no longer part of the Politburo, including Deng, made the decision to open fire.

Another example of the state asserting control beyond what it had been authorized to do according to rule of law occurred during the onset of the financial crisis in 2008. To the disadvantage of entrepreneurs and private businesses, the central government instructed banks to pour over $1.5 trillion into SOEs that were on the verge of bankruptcy. At the same time, banks were restricted in what they could lend to private enterprise. This resulted in many private firms going bankrupt. Eliminating private firms, or forcing them to merge with SOEs, was part of the national strategy to create public enterprises capable of competing against the world's best internationally. Additionally, it was politically expedient to allow private firms, rather than SOEs, to go out of business

[548] Ibid., p60.

because they employ far fewer people; high levels of unemployment could have posed a grave threat to the legitimacy of the party.

ROLES UNDER THE INTERMEDIATE STATE

As an intermediate state, China utilized all four policy choices at its disposal. The Chinese intermediate state plays the demiurge and custodial roles with respect to the launching of its large commercial aircraft. This industry is considered importance for national security and for further economic development. Therefore, because of the government's great distrust for the private sector, it restricts it from occupying or monopolizing the industry.

China does through its policies of midwifery and husbandry invite foreign firms and their capital to enter joint-ventures with its domestic enterprises to help develop aircraft subsystems, parts and components that they can't produce themselves. In exchange for entering joint ventures with Chinese companies and for introducing them to state-of-the-art technologies, the government will its foreign partners tax credits, greater access to capital, financial incentives and reserve a portion of its large market for the venture's products.

Demand for the C-919

In line with Porter's demand variable, China in 2003 committed to the development of its indigenous aircraft, mainly for satisfying a domestic demand that is expected to amount to 25 percent of the world's market. This demand grew out of China's commitment to strengthen the rule of law and the development of a socialist market economy, which provided incentive and motivation for private and foreign firms, not only to invest in China, but to increase production and to produce better-quality items to satisfy customer desires. When businesses prosper, they look to expand, thus hiring more people, who will then earn a salary, enabling them to purchase more goods as well, which contributes to the overall growth of the economy. In 1978, 401.52 million people were employed in China. That number climbed to 774.8 million in 2008, as result of Deng's reforms and "open-door" policy.[549] In 1985, the average annual disposable income in the Beijing was 653.62 Yuan ($222); it climbed to 13, 231 ($1,945) in 2008.[550] With a greater number of people now on the employment rolls in China, the market for consumer goods and services has increased immensely. The desire for material possession and air travel has grown exponentially. As people earn more money, their tastes begin to expand, and they desire better-quality items and more luxurious services--3.431 million Chinese traveled by air in 1980, and the number of passengers flying has continued to grow since then at an annual rate of 16.5 percent. At this pace, China can expect there to be more than 770 million passengers traveling by air domestically by 2020. The amount of cargo shipped within the country has grown at an annual rate of 14.5 percent and is expected to reach 12.7 million tons by 2020.[551] Demand is essential

[549] Ibid., p7.

[550] Statistics of Henan Province Network, (Henan Nan Tong Ji Wang), (accessed July 15, 2010), http//www.ha.stats.gov.cn/hntj/lib/tjnj/2009/html/1001.htm.

[551] Department of Comprehensive Statistics of National Bureau of Statistics, (Guojia Tongjiju Guomin jingji Zonghe Tongjisi), *China Compendium of Statistic 1949-2008*, (*Xinzhongguo liushinian Tongji Ziliao Huibian*), (China Statistics Press, January 2010), (Zhongguo Tongji Chubanshe, January 2010), p53.

for business to exploit potential niches and produce advanced products of which enough can be sold domestically and internationally to achieve scale economies.

Factor Conditions for the C-919

The competition in China for receiving a university education has typically been fierce. Between 1976 and 2007, over 60 million students took the GaoKao (高考) exam, with one-sixth of that number entering college. However, these statistics have improved dramatically in the past few years; in 2007 alone, 10.1 million students took the college entrance exam, with 56 percent (5.67 million students) of all test-takers admitted into college.[552]

Along with this increase in the number of students entering college, China has also been able to produce 12 times as many engineers than the U.S. annually. Porter's factor condition variable places a lot of emphasis on training engineers and scientists, illuminating the idea that they are vital for society because they find innovative ways to enhance economic development, especially in the areas of high technology that spill over to the military and other sectors of the economy. However, the framework remains deficient in explaining what type of engineering education is most conducive to training engineers to be creative and innovative. Engineers in China have faced immense troubles when it comes to producing state-of-the-art technology, and the state has been obliged to rely on foreign enterprises to supply its developmental needs.

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[552] "10 Million Sit Two Day Exam," China Daily.com, (accessed June 2, 2010), http://www.chinadaily.com.cn/china/2007-06/07/content_889597.htm.

Students in China are heavily discouraged from exploring their individuality or being innovative and creative. Their system overemphasizes the importance of knowing knowledge rather than creating knowledge. It prioritizes memorization over reasoning. The education is also harmed by forcing students to choose a social-science track or the natural-science track on which they will only take classes in that area, from the second year of high school all the way to the end of college. The system is anything but interdisciplinary in nature, which is important for facilitating the critical and analytical thinking needed for enhancing creativity.

COMMERCIAL ESPIONAGE

Absent from Porter's framework and equally important for understanding a common way in which China has learned to acquire technology is commercial espionage. The Chinese government has called upon Chinese nationals, students, and former dissidents who have either studied or worked abroad--through bribes or fear--to acquire sensitive technology and send it back to China. Government officials also set up front companies in the United States under American aliases, so they can acquire sensitive technology to send back to China. This has saved the Chinese money and the time it would take them to develop such technologies on their own. The nation has developed spy rings in which Chinese nationals work in companies like Boeing or Cisco, from which stolen technology makes its way into the Chinese military-industrial complex. Although no specific evidence exists that the Chinese government has been committing acts of espionage to gain technology and information for building its C-919 large passenger aircraft, we can't overlook the possibility because of the proof that it has in other sectors of the economy and the military. Commercial espionage poses the single greatest threat to U.S. national and economic security. Although it is extremely difficult to prevent, considering China's vast network of spies, the United States has channeled money into protecting our nation and economy.

Supporting and Related Industries for the C-919

Because of China's backwardness in the production of state-of-the-art technologies, the government has been instrumental in helping local enterprises work out cooperative arrangements with foreign companies by offering them a piece of their large market share in exchange for technology and managerial expertise. China has lured foreign manufacturers to long-term cooperative arrangements by guaranteeing a large portion of their market as long as those manufacturers are willing to educate local companies in how to produce such products and familiarize them with the equipment, technology, and management needed to do so. Porter's model advocates greater cooperation with suppliers and related industries where relevant technologies and manufacturing processes can be learned.

Since 2008, the government, the largest shareholder of COMAC, has been responsible for enlisting foreign enterprises, and joint-ventures when possible, to service the complex parts and components of the plane that China doesn't possess the ability to build on its own. China hasn't thus far been able to transition from supplying components and parts to supplying major subsystems, some of which include the engine and the pneumatic, electrical, and environmental control systems; these markets are every lucrative and still dominated by U.S. companies such as Goodrich, GE, and Parker.[553] As stated earlier, Porter's model doesn't identify the types of technologies firms will acquire from cooperative arrangements. Boeing and Airbus, the current industrial leaders, are certainly not willing to give up their competitive advantage, even though they have committed to joint ventures with the Chinese; they are willing, however, to educate them on some advanced technologies and equipment, and to some degree on how to develop such complex systems and products, but they will not be so foolish as to give away company secrets or their most advanced and most prominent technologies so as to groom a future competitor for their product.

One notable joint venture that China has been able to capitalize on in technology acquisition, production, and aircraft development was with McDonnell Douglas in the 1990s. MD was on the verge of bankruptcy and believed that gaining access to the Chinese market would give it the life support it needed to continue to compete in the commercial aircraft industry. Porter's model does little to address the role of how cultural differences may serve as a roadblock or may even to a nation's approach to learning new technologies, approaches, and procedures. It was extremely difficult at first for China and MD to work together due to the vast cultural differences between them, but once the Chinese had abandoned their cultural practice of serving the collective before the individual, they were able to gain from the partnership. Porter's model doesn't specifically say so, but it implies that nations seeking a competitive advantage in an industry must conform to Western cultural business practices.

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[553] "Moving South: A series of Reports Examining Trends in Outsourcing Aircraft to Low Wage Areas of the World," *PMI Media Ltd*, September 2009, p11.

Firm Strategy, Structure, and Rivalry for the C-919

Porter's model advocates allowing firms to establish, structure, and organize themselves around the nature of the free market. COMAC, the limited liability company responsible for the development of the C919, was expected to operate and function as if it were a legitimate private business. However, the status of the Commercial Aircraft Corporation of China is misleading: COMAC is directly responsible to the State Council's State Assets Supervision and Administration Commission (SASAC), the largest shareholder in the company, owning 31.6 percent of the company, worth $2.7 billion; the other shareholders include the Shanghai Municipal Government through the Guosheng Group, which has a 25-percent stake in the company, amounting to $700 million, and the AVIC, which has just a little below 25 percent; the three other shareholders, each holding a 5-percent ($150 million) share in the company, are the Baosteel Group Corp., the Aluminum Corporation of China (Chinalco), and Sinochem Corp.[554] In fact, the AVIC, Baosteel, Chinalco, and Sinochem Group are all centrally owned, so the central government is in fact pulling the strings and making the key decisions in COMAC. The central government will channel money toward the project as needed and faces no direct competition from other airliners.

In accordance with company law, COMAC follows a modern corporation system in which it has an association of stockholders, a Board of Supervisors, and a Board of Directors. The Board of Supervisors is made up of party members from the central government from the Central Military Commission, the CAAC, and the Department of

[554] Mark Stokes, "China's Commercial Aviation Sector Looks to the Future," Project 2049 Institute, May 8, 2009, p2.

Commerce. This board represents the national interest of the country and can overrule any corporate or business-related decisions. What is deemed in the national interest of the country trumps any commercial business interest.

Although this company is considered a limited liability company with a multitude of shareholders, the central government holds the majority share and therefore makes all decisions regarding the direction and strategy of the company, all the way down to management. The central government hand-picked Zhang Qingwei to serve as the chairman of the board, and selected candidates for other key management positions as well.

What China hasn't learned from the Y-10 experience is that individuals need to be held accountable for the success or failure of the aircraft's development Problems can in fact emerge that are beyond management's control because factory workers responsible for producing parts for the plane still remain unmotivated. Although it is true that the workers will receive an additional bonus should the plane profit, they still know the government will set aside a portion of the market for the C919. Therefore, they assume that the plane will profit anyhow, and that their bonuses will automatically come without having to work extremely hard. Just as during production of the Y-10, it still remains difficult to fire unproductive factory workers, as they for the most part they are still guaranteed lifetime employment.

COMPETING WITH THE C-919

With China expected to consume 25 percent of the world's aircraft large aircraft demand by 2020 and the size of the entire large passenger and freight aircraft market expected to grow even greater--projections argue that, by 2029, the world will require a total of 26,000 new passenger and freight planes worth over $1.3 trillion--foreign aircraft manufacturers (in Canada, Russia, and possibly Brazil), in addition to China's COMAC, have now committed to production of their own large passenger aircraft in the 150-190 seat range in pursuit of a share of the pie, which will make will make it far more difficult for manufacturers to profit without distinguishing themselves from the competition.[555] The central government's firm control over all aircraft purchases through the CAAC will certainly set a portion of the market for the C919 regardless of the plane's performance vis-à-vis the competition.

Both Airbus and Boeing however have decided to compete in this market by producing derivatives of their current 150-190 seat planes: the A320NEO and the B737 MAX. A major reason for why Airbus has chosen to reequip its A320 aircraft aside from being cash strapped is that it believes the technology for creating an entirely new narrow-bodied aircraft in the 190 seat range is that the technology will not be ready or perfected for at least another two decades; therefore it wouldn't make sense to develop a new plane. Designing another aircraft from scratch would cost somewhere in the ballpark of $7 to $10 billion; that is a hefty price to pay when technology is not advanced enough to gain a significant competitive advantage over its rivals. Refitting its A320 aircraft will cost $1.31 billion dollars and will save airlines hundreds of millions of dollars each year,

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[555] Airbus Ups Aircraft Demand Forecast," Dec 13, 2010, Euronews, (accessed April 15, 2011), http://www.euronews.net/2010/12/13/airbus-ups-aircraft-demand-forecast/.

considering current fuel prices.[556] Airbus does realize that there will be guaranteed C919 orders in China, and that it will be competing mainly with Boeing for the share of the market that is unreserved. Airbus can also benefit should the C919 delay its launch and airlines are in desperate need of aircraft.

The A320NEO will be equipped with a new engine that will reduce oil consumption by nearly 15 percent, placing it on par with, and is expected to debut at the same time as, the C919 in 2016.[557] The A320NEO will also have 95- percent airframe commonality with other Airbus airplanes, which will serve as another strong selling point for choosing this plane over its competition. It will be able to share and alternate parts among Airbus planes in different ranges. Its main competitive advantage, however, lies in the reputation and the reliability of its products that have developed over the years, and it is confident that its airplane will debut on time.

Originally, Boeing believed the best course of action to stay ahead of the competition was to produce an entirely new, technologically advanced aircraft, despite the great risk involved. If unsuccessful, the company can avoid forfeiting a great deal of the market to the competition over the next 10 years by realizing several years into the development of a new aircraft, that the project simply isn't feasible. It can then switch its production line toward equipping its B737 with a new engine, to avoid relinquishing as much as it can of the market to its competitors. If successful, Boeing will have great

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[556] "Airbus A320 NEO Alters Narrowbody Market," Aviation Week, (accessed February 2, 2011),http://www.aviationweek.com/aw/generic/story.jsp?channel=comm&id=news/awst/2010/12/06/AW_12_06_2010_p25-273552.xml&headline=null&next=10.

[557] "Airbus A320 NEO Alters Narrowbody Market," Aviation Week, (accessed February 2,2011), http://www.aviationweek.com/aw/generic/story.jsp?channel=comm&id=news/awst/2010/12/06/AW_12_06_2010_p25-273552.xml&headline=null&next=10.

potential to consume the lion's share of the world's single-aisle market. A new successful Boeing aircraft will pose a great risk to Airbus customers, because those who opt to buy the A320Neo will have invested billions of dollars in a plane that will be obsolete in just a few years. Airbus would then try to seek parity with the new B737. This may in fact discourage airlines from buying the A320 NEO.

However, with the trouble that Boeing had encountered with nearly a three year delay in the debut of the B787, it fears that launching a new technologically advanced aircraft would be very risky. The Airbus NEO has secured more than a 1,000 orders for its plane, thus far. After conducting market research, Boeing had come to the conclusion, that there is an expectation that airlines within this decade will be looking to replace their old MD80/90, B737 and A320 planes with newer more-fuel efficient planes as their current fleet reaches their 25 year-retirement limit. Some reports indicate that the world-wide demand for new aircraft in this range is over 7,000.[558] Boeing stands to lose a lot should a new aircraft be delayed. This will leave airlines with no choice other than to purchase a more reliable fuel-efficient airplane from another manufacturer.

Therefore in August 2011, Boeing decided to launch its B737Max aircraft, which is expected to debut in 2017 and to provide a 4% lower fuel burn and 7 % reduction in operating costs compared to the AirbusNEO. The engine for this plane will be provided by CFM International, a joint venture between General Electric and Snecma.

[558] "Airbus sees demand for over 27,800 aircraft in the next 20 years," (accessed September 19, 2010), http://www.airbus.com/newsevents/news-events-single/detail/airbus-sees-demand-for-over-27800-aircraft-in-the-next-20-years/.

A NEW STRATEGY FOR COMPETING IN COMMERCIAL AVIATION

A more viable strategy for both Airbus and Boeing--to ensure that aircraft manufacturers' profit and loss is tied to the market economy and not to the massive quantities of subsidies channeled into production, launch costs, and or guaranteed purchases of homegrown aircraft--will be to work out an agreement in the WTO that puts into law restrictions and caps on the amounts of direct and indirect subsidies that can be channeled toward aircraft manufacturers. This agreement should also include unfairly reserving a portion of a home market for domestically made aircraft.

A collective body representing the WTO members should monitor and subject manufacturers and their respective governments to close scrutiny, and if a nation's firm is found in violation of the agreement, other member governments should disqualify their domestic airlines from purchasing the violator's aircraft. Together the host countries involved in the agreement would possess leverage as they would constitute possibly more than 60% of the world market share so such restrictions influence a firm's ability to profit. This would clearly set the tone for future aircraft manufacturers who wish to enter the fray; should they not comply, punitive measures will be imposed on them.

POTENTIAL IMPACT ON BOEING

If such an agreement or a new American industrial policy is not worked out, Boeing stands to lose immensely Although the U.S. government placed Boeing in a category of too big to fail because it remains the sole commercial aircraft manufacturer in the U.S. and is a major supplier of weaponry and weapon systems to the military, the company downsizes when business is not good or because of the anticipation that business will not be good in the future. The American government will let Boeing eliminate jobs so it can cut costs and operate as an efficient business, however it will allow everything short of failing; they will bail the company out if the potential for bankruptcy exists.

As in all profit-seeking entities, when businesses are doing well, they expand and increase their number of employees, and when they're floundering, they downsize, laying off workers, which clearly affects state and local economies. For example, during the height of the Cold War in 1983, Boeing hired over 50,000 workers in the Puget Sound Area of Seattle, Washington.[559] However, when the Cold War was winding down in the early 1990s, President Bush announced a plan to unilaterally reduce the American military budget by $50 billion over a 5-year period, resulting in a reduction of the American nuclear arsenal and eliminating several categories of weaponry.[560] These cuts, along with the completion of the 747-400 production line, which entailed such startup jobs as flight testing, issuing certifications, and production work that usually took five people were no longer needed.

Also, because of a slowdown in commercial airplane orders as result of a heavy competition from the heavily subsidized European Consortium Airbus, Boeing cut more than 28,000 jobs in 1995, which amounted to 13 percent of its workforce.[561] With the

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[559] Charles Pope and Paul Nyhan "Boeing to lay off 20,000 to 30,000," Seattle Post-Intelligencer Reporters, (accessed March 15, 2010), http://www.seattlepi.com/business/39369_boeingweb.shtml.

[560] "COMPANY NEWS; Moog to Reduce Work Force 27 percent," New York Times, (accessed March 5, 2011), http://www.nytimes.com/1992/02/12/business/company-news-moog-to-reduce-work-force-27.html.

[561] "COMPANY NEWS; AIRCRAFT MAKER SAYS WORK FORCE WAS CUT 13 percent IN 1993," New York Times, (accessed March4, 2011), http://www.nytimes.com/1994/01/15/business/company-news-aircraft-maker-says-work-force-was-cut-13-in-1993.html.

majority of workers earning around $37,400 per year, the local economies in Puget and Kansas City were set to lose hundreds of millions of dollars in business revenue. There were further cuts in 2001, following the terrorist attacks on September 11, resulting in a Boeing loss of 38,180 jobs.[562] When jobs are lost, engineers are not creating new and innovative products that consumers need, want, and desire. This could place Boeing at a strategic disadvantage against companies that are heavily subsidized and could retain their workforce.

POTENTIAL IMPACT ON AIRBUS

Unlike Boeing, Airbus's strong unions ensure that, regardless of the nature of the economy, its employees remain hired; Airbus maintains such a capability because it is heavily subsidized by a consortium of European nations. It particularly dislikes laying off workers, because the countries that make up the consortium are socialist in nature; however, when business is bad, it has in the past offered incentives to its employees, such as favorable early retirement packages, that they would have trouble refusing. During troubled economic times, the company has overextended itself, committing to the development of aircraft within multiple ranges, thus limiting its leeway to fill a gap in the market whenever one appears. Airbus, with the demands of the A350 and A380 programs, does not possess the manpower or the financial capital at this juncture to launch a new narrow-body aircraft if that was what the market demanded.

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562 David Bowermaster, "Boeing Warns 1,140 More Workers of Possible Layoffs," Seattle Times (June 4, 2008) http://www.lexisnexis.com/hottopics/lnacademic/.

STRENGTH AND WEAKNESSES OF THE FRAMEWORK

After conducting this study, the author began to unravel the usefulness of this theoretical framework that combines the work of Peter Evans and Michael Porter. The framework's strengths lie in pinpointing what the state could do to increase the likelihood of developing an international competitive industry. We see that certain institutional arrangements as articulated by Evans are more conducive to implementing sound policy capable of satisfying the important variables Porter suggests are important for developing an international competitive industry. Through this framework, we can clearly point to the areas in which the state has or has not to the best of its ability put itself in a position to compete and sustain an advantage. This framework also can point to the source or the reasons for why the state has not been able to satisfy a particular variable. It might be that, given the state's institutional arrangement with society, it is limited in to what types of policies it could implement. The problem may not lie in the state-societal configuration, and the source of the problem may be the state's neglect of a certain area. Whatever the case, the framework allows us to not only locate the problem but suggest how to fix it.

This framework is particularly useful for states wishing to develop or strengthen their indigenous capabilities, particularly in the high-technology field, which is important because of the benefits and spillovers to the overall economy and the military. Success in such sectors often translates into major improvements in the overall economy and the living standard of the people. Unlike other industries, high technologies are unique in that they are normally driven toward a natural monopoly and require the employment of highly skilled engineers and scientists to continuously upgrade and sustain their products.

However, after utilizing this framework, it is apparent that the framework does have inherent weaknesses. Evans's embedded autonomy model, for example, does not clearly specify how much autonomy or societal embeddedness must be present for the state to be considered predatory, intermediate, or developmental. This did pose a problem for the Chinese cases used in this study, because the evidence of China under Mao being predatory, or intermediate under Deng, was more than obvious. In analyzing less-obvious cases, it might not be as easy to categorize.

Secondly, this theoretical framework might be considered limited in its explanatory power when it come assessing how to produce a favorable diamond for increasing the probability of developing or sustaining a competitive advantage, because individual state diamonds do not acknowledge that large portions of a company's operations may lie outside its home country; it is not correct to assume, or suggest, that a nation's competitive advantage rests solely upon the strength of its diamond in its home country.[563] This did not pose a problem for the cases used in this study; however, perhaps the theoretical framework can be revised to include supranational diamonds. For example, when assessing the competitive advantage of the U.S., Mexico, or even Canada, it might not be wise to look just at one country in particular, because, due to their close proximity to one another, they draw on each other's resources, factor bases, competition, demand, and supporting and related industries, etc.[564] Firms can rely on the diamonds of other nations for their success; this framework fails to take that into consideration.

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[563] Paul Ellis and Howard Davies, "Porter's Competitive Advantage of Nations: Time for the Final Judgment," *Journal of Management Studies*, (Vol.37: Issue 8, 2000) p1203.

[564] Ibid., p1204.

Airbus serves as another litmus test for the framework's limitations. The theoretical framework falls short in its ability to collectively determine a group of States' institutional arrangements with society, enabling us to categorize the member states as a developmental, intermediate, or predatory state. It then becomes rather difficult to determine the best, or most likely, policy options available for influencing important societal variables in the development of an industry. The theoretical framework, that is, lacks the ability to collectively categorize member states as embedded or autonomous, or to look at a collective diamond to pinpoint where there are areas for gaining a competitive advantage.

It is possible, however, to identify the largest shareholder of a company--which usually is not only devising company strategy and goals, but building the fundamental parts and components of the aircraft (engine, aircraft design, propulsion, etc.), which is where the competitive advantage traditionally lies. We can classify the State-industry arrangement of that member country and then determine from a normative perspective how best it can manipulate its societal variable. Nevertheless, the framework has the weakness of not being able to draw on the diamonds of its member countries.

Additionally, Porter's Diamond Model fails to take in to account alternative ways in which a nation might acquire technology, such as through commercial espionage. Many countries, such as China, have devoted an exorbitant amount of money to acquiring technology through spying. Many other countries, like the United States, have yet to figure out a way to combat this espionage without placing limits on foreign nationals' ability to study, work for high technology companies, or open businesses in the United States, yet not compromise economic and national security interests. It hasn't found a way to balance the talent that foreign nationals contribute to American society as a whole with a program to battle theft of corporate and/or national secrets.

Another way in which the framework can be modified is to include a cultural variable to better understand why certain countries or firms have had trouble applying, and adapting to, techniques learned from joint ventures and their relations with successful firms because their unique culture doesn't adapt easily to the management style, processes, and techniques of their more advanced partners. The variable should also include ways and means in which a nation or firm could best incorporate, or adapt to, the culture and methods of advanced partners in a joint venture.

THE FRAMEWORK AND HIGH-SPEED RAIL

It would be interesting to look at the high-speed rail industry through the lens of the modified framework. The Chinese were once junior partners with Japan's Kawasaki Heavy Industries, Siemens AG, Alstom SA, and Bombardier, Inc. and are now competing with them internationally.[565] China claims to have a high-speed rail capability that has advanced beyond the technological level of the very foreign firms that have served as its mentors in the field. The Chinese developed a rail network that extends from Shanghai to Hangzhou and has the capacity to sustain cruising speeds of more than 245 mph. The fastest European and Japanese trains were clocked at 199 mph.

The successful strategy China claims to have employed in order to exceed the competition was that the central government channeled funds to its State-owned

[565] Norihiko Shirouzu, "Train Makers Rail Against China's High-Speed Designs," The Wall Street Journal, on (January 15, 2011), http://online.wsj.com/article/SB10001424052748704814204575507353221141616.html.

enterprises for obtaining, and learning how to create and use, advanced foreign technology. Many companies that have wished to tap into China's large market have been willing to give up large amounts of advanced technology. By handing over such technology to the Chinese, they have groomed another competitor in the global marketplace. China does acknowledge that its trains have been partially developed with foreign technology, but, at the same time, officials from the China South Locomotive and Rolling Stock Industry (Group) Corp. (CSR) claim that they have further advanced the product through their own research and development. The Chinese claim to have made an indigenous Chinese product by systematically compiling all of the technologies and resources gained from various foreign companies and tweaking them to meet China's needs.[566] In doing so, they have, they argue, created something original.

Many Japanese companies, including Kawasaki, have said on the record that China did in fact not develop an indigenous model; all it did was reverse-engineer existing Japanese trains and sell them overseas, which is in clear violation of the original agreement Japan made with China that prevented the latter from selling trains possessing Japanese intellectual property abroad. According to Kawasaki, China merely copied the Japanese design and used exactly the same technology in its train, changing only the exterior paint scheme and interior trims, along with providing a stronger propulsion system to reach higher speeds.[567] Utilizing the refined framework will pinpoint the strengths and weaknesses of what the Chinese are doing, and carve a path forward for enhanced competitiveness.

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[566] Ibid.

[567] Ibid.

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APPENDICES

APPENDIX A

Starter questions that I asked interviewees in order to open the dialogue

1. What effect did the Cultural Revolution have on the aviation industry and what damages were served to other high technology industries in general?
2. How did Mao's shutting down of Universities for over a 4 year period factor into China's troubles with developing its high technology sectors?
3. As relations began to improve with the United States in the late 1970's and early 1980's, did the desire for creating an indigenous aircraft decrease?
4. As confrontation with the United States began to diminish and economic relations between the two countries began to grow, did the absence of powerful enemy, diminish the need for creating an airliner that can contribute to its air defenses?
5. What role did Nixon's historic visit to China have on the government's decision to not pursue the manufacturing of an indigenous airliner?
6. Did the availability of Boeing aircraft for purchase factor in to not pursuing the building of an indigenous aircraft?
7. Was it realized that it was far cheaper to buy planes than produce an indigenous aircraft when there was no immediate threat of war?
8. What goes into the process of reverse engineering an airplane? How difficult is it? What problems did the Chinese encounter when trying to copy Soviet and American aircraft?
9. What has China learned from copying Soviet Aircraft (Yun 5, 8, 12 etc.) and what of that has been incorporated into the ARJ-21 and COMAC 919?
10. What role did the Tiananmen Square Massacre and its aftermath have on China deciding to once again work on building an indigenous aircraft?
11. What new technologies was pertinent to China's development of an indigenous aircraft but was off limits as a result of Tiananmen Square?
12. As relations with the United States began to improve several years later, how did the joint ventures that the Chinese government set up with Boeing, Airbus and McDonnell Douglas help it to acquire and learn about state-of-the- art technologies needed for aircraft development?
13. What does and how does China plan on overcoming its inability to develop engines for aircraft?
14. What strategies has China employed to continue to gain state-of-the-art technologies from foreign manufacturers? What strategies has the government employed to produce state-of-the-art technologies on its own?
15. How did China assess the need for aircraft development following the 1996 Taiwan Strait Crisis?
16. Why in the past were Chinese airlines not willing to purchase Chinese made aircraft?

17. Why did the Ministry of Aviation Industry (MAI) and the Aviation Industries of China (AVIC) have trouble meeting the FAA standards for certification of its copied planes?
18. Why did the AVIC originally doubt that China's building of a large passenger aircraft could ever meet FAA standards? Has it changed its views since and if yes, why?
19. Why was the Yun 12 able to get this certification and others were not?
20. What is China doing to make sure that that its indigenous aircraft will be able to get this certification?
21. Has China employed any former scientists or engineers that have previously worked for Boeing, Airbus and McDonnell Douglas? How have they contributed to China's production of its indigenous aircraft?
22. Why will domestic airliners purchase China's indigenous large commercial aircraft (COMAC 919)
23. How does the COMAC 919, distinguish itself from its competitors?
24. What features and advanced technologies does the COMAC 919 possesses that its competitors do not have?
25. Is there any domestic and international demand for these innovative technologies? What is China's marketing strategy to entice domestic and international airlines to buy the COMAC 919?
26. How did China come up with the innovative technologies for their aircraft?
27. Why will American airlines purchase this plane?
28. How much money has gone in to the COMAC 919 project?

APPENDIX B-1

Units of Yuan										
Year	Per Capita Annual Income and Expenditures of Urban Household					Per Capita Annual Income and Expenditures of Rural Household				
	Disposable Income	Disposable Income Index	Living Expenditur	Food	Engel's Coefficien (%)	Net Income	Index of Net Income	Living Expenditur	Food	Engel's Coefficie (%)
1978	315.00		274.00	163.00	59.5	104.71		81.70		
1979	361.04	114.3	302.98	177.21	58.5	133.56	127.6		67.32	60.7
1980	413.80	108.1	335.02	192.66	57.5	160.78	120.5	135.51	78.49	57.9
1981	436.90	103.1	363.23	205.18	56.5	215.57	133.4	165.57	89.08	53.8
1982	462.24	103.9	382.47	214.17	56.0	216.74	99.7	177.90	101.18	56.9
1983	483.21	101.6	405.00	232.07	57.3	272.00	124.5	196.35	113.71	57.9
1984	537.28	108.8	431.68	244.37	56.6	301.17	110.3	219.64	122.46	55.8
1985	653.62	114.2	556.72	277.74	49.9	328.78	107.0	260.19	145.83	56.0
1986	790.04	113.2	653.83	333.59	51.0	333.64	99.7	292.48	159.88	54.7
1987	893.28	104.9	711.27	379.57	53.4	377.72	110.1	309.90	164.03	52.9
1988	946.10	87.2	896.55	465.99	52.0	401.32	98.2	346.73	179.42	51.7
1989	1,111.46	102.2	963.97	533.19	55.3	457.06	102.5	390.05	199.99	51.3
1990	1,267.73	113.5	1,067.67	585.27	54.8	526.95	105.5	437.73	240.93	55.0
1991	1,384.81	103.9	1,199.95	644.26	53.7	539.29	102.3	454.68	242.83	53.4
1992	1,608.03	107.8	1,342.58	716.99	53.4	588.48	104.9	472.61	264.02	55.9
1993	1,962.75	110.4	1,609.26	798.78	49.6	695.85	109.0	564.93	334.52	59.2
1994	2,618.55	104.7	2,155.15	1,074.18	49.8	909.81	103.4	731.78	426.17	58.2
1995	3,299.46	107.8	2,673.95	1,338.93	50.1	1,231.97	109.5	929.39	544.26	58.6
1996	3,755.44	103.9	3,009.35	1,439.32	47.8	1,579.19	113.8	1,206.43	670.89	55.6
1997	4,093.62	106.4	3,378.02	1,506.25	44.6	1,733.89	107.4	1,270.52	693.09	54.6
1998	4,219.42	105.3	3,415.65	1,454.99	42.6	1,864.05	106.5	1,240.30	700.78	56.5
1999	4,532.36	111.2	3,497.53	1,427.65	40.8	1,948.36	106.4	1,163.98	617.46	53.0
2000	4,766.26	106.1	3,830.71	1,386.76	36.2	1,985.82	103.9	1,315.83	654.13	49.7
2001	5,267.42	108.8	4,110.17	1,424.90	34.7	2,097.86	104.9	1,375.60	668.77	48.6
2002	6,245.40	114.2	4,504.68	1,517.04	33.7	2,215.74	105.1	1,451.51	697.02	48.0
2003	6,926.12	109.0	4,941.60	1,662.30	33.6	2,235.68	99.6	1,508.67	726.57	48.2
2004	7,704.90	105.5	5,294.19	1,855.44	35.0	2,553.15	108.1	1,664.09	808.27	48.6
2005	8,667.97	110.2	6,038.02	2,067.51	34.2	2,870.58	107.5	1,891.57	858.97	45.4
2006	9,810.26	111.9	6,685.18	2,215.32	33.1	3,261.03	112.1	2,229.28	911.48	40.9
2007	11,477.05	111.0	7,826.72	2,707.44	34.6	3,851.60	112.2	2,676.41	1,017.43	38.0
2008	13,231.11	108.3	8,837.46	3,079.82	34.8	4,454.24	107.2	3,044.21	1,165.81	38.3

a) Data on disposable income of urban household are calculated on basis of income of living in 1978-1991.

Source: Statistics of Henan Province Network, (Henan Nan Tong Ji Wang), (15, July 2010(www.ha.stats.gov.cn/hntj/lib/tjnj/2009/html/1001.htm).

APPENDIX B-2

Year	Total	Railway	(%)	Highway	(%)	Water	(%)	Civil Aviation	(%)
1952	245.18	163.5	66.7	45.6	18.5	36	14.7	0.02	0
1957	638.21	312.6	48.9	237.7	37.2	87.8	13.7	0.04	0.01
1962	122.54	750	61.4	307.4	25.1	163.9	13.4	0.17	0.01
1965	963.34	412.5	42.8	436.9	45.3	113.7	11.8	0.27	0.02
1970	1,300.56	524.6	40.3	618.1	47.5	157.6	12.1	0.22	0.01
1975	1,929.69	704.6	36.5	1,013.50	52.5	210.5	10.8	1.39	0.07
1978	2,539.63	814.9	32	1,492.30	58.7	230.4	9	2.31	0.09
1980	3,417.85	922.1	26.9	2,228.00	65.1	264.4	7.7	3.43	0.1
1985	6,202.06	1,121.10	18	4,764.90	76.8	308.6	4.9	7.47	0.12
1988	8,095.92	1,226.40	15.1	6,504.70	80.3	350.3	4.3	14.4	0.17
1990	7,726.82	957.1	12.4	6,480.80	83.8	272.2	3.5	16.6	0.21
1992	8,608.55	996.9	11.5	7,317.70	85	265	3	28.8	0.33
1994	10,928.83	1,087.40	9.9	9,539.40	87.2	261.6	2.3	40.3	0.36
1996	12,447.22	941.5	7.5	11,221.10	90.1	228.9	1.8	55.5	0.44
1998	13,772.52	936.2	6.7	12,573.30	91.2	205.4	1.4	57.5	0.41

Appendix B-2: Passenger Traffic by Mode of Transport (1,000,000 persons and percentage of total).

Source: Jiacheng, Zheng, Statistical Yearbook of China, (Zhongguo Tonji Nianjian), (Beijing: China Statistical Publishing House, 1999), (Beijing Zhongguo Tonji Nianjian Chubanshe, 1999).

APPENDIX B-3

(Units of 100 million)

Year	Gross national income	Agriculture	Industry	Building industry	Transport	Commercial	National income per person (Units of Yuan)
1952	589	340	115	21	25	88	104
1953	709	374	156	28	29	122	122
1954	748	388	174	26	32	128	126
1955	788	417	179	30	33	129	129
1956	882	439	212	55	37	139	142
1957	908	425	257	45	39	142	142
1958	1,118	440	401	68	59	150	171
1959	1,222	376	527	76	78	165	183
1960	1,220	332	565	79	84	160	183
1961	996	432	345	25	48	146	151
1962	924	444	303	32	38	107	139
1963	1,000	448	337	40	39	96	147
1964	1,166	549	422	50	44	101	167
1965	1,387	641	505	53	58	130	194
1966	1,586	692	606	58	66	164	216
1967	1,487	703	505	55	52	172	194
1968	1,415	714	449	44	49	159	183
1969	1,617	722	587	60	62	186	203
1970	1,926	778	789	80	74	205	235
1971	2,077	808	891	91	80	207	247

1972	2,136	808	942	88	84	214	248
1973	2,318	886	1,020	92	89	231	263
1974	2,348	922	1,015	99	85	227	261
1975	2,503	946	1,152	113	96	196	273
1976	2,427	940	1,106	120	92	169	261
1977	2,644	913	1,263	124	106	238	280
1978	3,010	986	1,487	125	118	294	315
1979	3,350	1,226	1,628	130	121	246	346
1980	3,688	1,326	1,804	185	126	247	376
1981	3,941	1,509	1,840	193	131	268	397
1982	4,258	1,723	1,948	209	147	231	422
1983	4,736	1,921	2,136	259	166	254	463
1984	5,652	2,251	2,516	303	205	377	545
1985	7,020	2,492	3,163	409	259	697	668
1986	7,859	2,720	3,573	514	320	732	737
1987	9,313	3,154	4,262	637	384	876	859
1988	11,738	3,818	5,416	783	460	1,261	1,066
1989	13,176	4,209	6,241	774	547	1,405	1,178
1990	14,384	5,000	6,610	839	787	1,148	1,267
1991	16,117	5,269	7,703	1,055	850	1,240	1,401

Note: data is calculated by the current price

Appendix B-3: National Income

Source: Jiacheng, Zheng, Statistical Yearbook of China, (Zhongguo Tonji Nianjian), (Beijing: China Statistical Publishing House, 1999), (Beijing Zhonggup Tonji Nianjian Chubanshe, 1999), p32.

APPENDIX B-4

Year	How many flights	distance 10,000km	Hours	Volume of passenger traffic /ten thousand	Passenger kilometer 10,000	Cargo (tons)	Cargo (kilometers)	Freight (10,000 tons per kilometer)	On Time (Arrival & Departu res)
1950	1,086	155	6,345	1.04	978	767	82	157	69.5
1951		294	13,013	2.39	2,261	1,670	168	349	73.5
1952	2,242	357	14,474	2.22	2,409	2,047	243	435	69.8
1953	3,021	469	18,812	2.84	3,322	3,608	447	712	79.9
1954	4,077	636	25,495	4.21	5,107	4,734	560	969	79.7
1955	5,687	769	31,195	4.86	5,685	4,711	514	1,012	72.5
1956	7,816	1,066	41,302	8.84	10,352	7,925	826	1,733	80.8
1957	7,076	990	36,084	6.85	7,987	7,976	825	1,534	76.5
1958	12,369	1,273	46,696	12.35	11,881	15,099	1,331	2,290	81.1
1959	18,264	1,677	62,317	15.96	14,264	25,659	2,233	3,393	86.4
1960	21,414	1,815	69,657	20.73	16,188	31,788	2,649	4,045	87.7
1961	21,740	1,749	67,903	20.2	13,805	29,255	2,398	3,586	85.5
1962	16,606	1,309	50,673	16.88	11,724	18,469	1,544	2,561	81.2
1963	17,645	1,462	54,326	17.6	14,011	20,700	1,720	2,935	78.6
1964	19,019	1,626	57,608	23.58	19,948	22,458	1,957	3,672	67.9
1965	20,287	1,776	61,221	27.21	24,835	27,163	2,510	4,662	73.4
1966	19,858	1,798	61,061	26.29	21,889	33,261	3,237	4,965	71.9
1967	21,462	1,888	64,041	30.56	24,357	38,511	3,802	5,568	74.3
1968	16,741	1,617	52,528	24.97	20,657	30,383	3,167	4,664	71.8
1969	16,788	1,580	50,637	21.64	17,132	32,745	3,275	4,528	63.9
1970	16,890	1,619	52,638	21.73	17,924	36,891	3,520	4,822	63.3
1971	18,950	1,743	56,077	33.63	29,520	33,171	3,206	5,373	68
1972	19,120	1,849	58,138	46.48	41,918	29,633	2,944	6,089	71.1
1973	20,546	2,009	59,176	60.01	57,275	28,149	3,004	7,228	71.6
1974	26,150	2,728	69,624	94.19	93,191	35,307	4,180	11,062	56.8
1975	32,535	3,550	85,351	138.99	153,854	46,556	6,016	17,181	58.9
1976	35,504	3,714	87,622	146.31	157,441	53,179	7,255	18,681	58.9
1977	38,068	3,765	87,837	164.57	183,449	53,019	7,592	20,801	63.9
1978	46,776	4,829	108,790	230.91	279,191	63,816	9,705	219,866	66.4
1979	5,770	5,943	127,130	297.98	349,927	79,873	12,341	375,36	64
1980	60,676	6,442	131,483	343.12	395,552	88,866	14,060	429,35	63
1981	62,907	6,880	130,954	401.29	501,602	94,206	16,966	53,583	63.1
1982	67,433	7,669	142,573	445.23	595,053	101,675	19,809	63,249	64.4
1983	58,776	7,071	127,683	391.45	589,633	115,926	22,860	65,903	66.4

Year	How many flights	distance 10,000km	Hours	Volume of passenger traffic ten thousand	Passenger kilometer 10,000	Cargo (tons)	Cargo (kilometers)	Freight (10,000 tons per km)	On Time (Arrival & Departu res)
1984	69,876	8,764	151,146	554.17	831,576	1,850,439	31,086	92,249	66.8
1985	85,030	11,119	185,310	746.79	1,157,163	195,059	41,513	127,102	68.2
1986	102,907	13,636	219,641	996.41	1,460,028	224,341	48,077	154,801	64.5
1987	130,545	17,075	278,745	1,246.57	1,860,634	292,063	65,236	202,833	66.1
1988	139,303	18,877	309,207	1,442.47	2,169,087	328,052	73,081	231,212	67.2
1989	136,267	18,568	302,902	1,283.06	1,867,691	309,698	69,341	205,602	59.5
1990	167,190	21,962	357,345	1,659.61	2,304,797	369,722	81,824	249,951	58.9
1991	204,895	26,263	431,780	2,178.12	3,013,185	451,985	100,954	320,663	63.8
1992	236,975	31,908	496,369	2,886.38	4,061,204	575,269	134,240	428,456	64.2
1993	287,228	39,797	603,097	3,383.15	4,776,045	693,935	166,139	511,820	58.4
1994	356,798	47,464	694,702	4,039.39	5,515,802	829,434	185,766	584,122	56.8
1995	437,877	56,232	826,373	5,117.13	6,813,036	1,011,145	222,981	714,385	58.8
1996	486,995	63,768	1,032,104	5,555.39	7,478,419	1,149,715	249,325	806,078	59.2
1997	513,164	68,983	1,102,041	5,629.66	7,735,168	1,246,590	291,024	866,771	57.1
1998	566,817	78,095	1,241,734	5,754.82	8,002,444	1,400,556	334,505	929,736	53.3
1999	598,932	83,879	1,327,894	6,093.81	8,572,818	1,704,296	423,427	1,061,127	55.6
2000	631,017	92,439	1,443,387	6,721.66	9,705,437	1,967,123	502,683	1,225,007	57.3
2001	707,272	104,950	1,639,940	7,524.28	10,913,539	1,709,814	431,750	1,411,918	58.5
2002	792,523	117,816	1,835,564	8,594.17	12,687,022	2,020,620	515,515	1,649,267	60.7
2003	833,428	119,797	1,837,129	8,759.22	12,631,853	2,190,416	578,976	1,707,946	61.9

Appendix B-4: (Main index of air transport from 1950-2003)

Source: Planning & Development Department of Civil Aviation Administration, (Zhongguo Minyong Hangkong Zongju Guihua Fazhan Si), (Statistical Data on Civil Aviation of China (2004)), (Cong Tong Ji Kan Min Hang (2004)), pp2.

APPENDIX B-5

Units of Per Person	Total	Engine-ering	Agricul-ture	Fores-try	Medi-cine	Teach-ing	Liberal Arts	Scie-nce	Fina-nce	Polit-ics and Law	Physi-cal Educa-tion	Arts
The highest year before libera-tion	154,612	27,555	10,147	…	11,849	20,818	15,794	9,929	17,698	37,682	594	254
1949	116,504	30,320	9,820	541	15,234	12,039	11,829	6,984	19,362	7,338	282	275
1950	137,470	38,462	11,435	1,833	17,414	13,312	10,147	9,845	24,084	6,984	297	365
1951	153,402	48,517	9,564	2,436	21,356	18,225	11,936	7,801	25,300	4,225	180	386
1952	191,147	66,583	13,262	2,209	24,752	31,551	13,511	9,563	21,974	3,830	325	358
1953	212,181	79,975	12,852	2,567	29,025	39,958	14,246	12,382	13,472	3,908	1,096	270
1954	252,978	94,991	12,805	3,090	33,919	53,112	18,346	17,096	11,153	4,017	1,900	254
1955	287,653	109,598	17,264	4,002	36,472	60,657	17,950	19,994	11,395	4,801	2,283	223
1956	403,176	149,360	30,718	5,755	45,902	98,821	22,468	24,930	12,803	7,108	2,699	261
1957	441,181	163,026	33,823	6,065	49,107	114,795	19,643	28,660	12,048	8,245	3,252	251
1958	659,627	257,277	58,192	9,702	77,079	157,278	25,965	41,123	14,322	7,114	7,278	421
1959	811,947	325,556	67,445	12,484	93,680	192,285	31,340	58,106	11,881	5,674	8,023	547
1960	961,623	388,769	80,402	14,839	116,925	204,498	33,905	83,608	14.297	5,271	9,086	1,005
1961	947,166	371,560	82,932	15,873	120,410	186,841	33,430	97,194	15,026	6,126	9,029	874
1962	829,699	345,247	66,863	13,862	108,470	137,561	40,098	88,433	12,096	3,796	6,334	693
1963	750,118	319,524	60,531	12,673	96,140	114,296	39,548	79,522	13,388	3,571	5,329	555
1964	85,314	296,831	55,603	10,352	85,195	97,462	41,205	71,164	14,540	3,725	4,561	4,567
1965	674,436	295,273	53,447	9,793	82,861	94,268	46,038	62,232	18,118	4,144	4,026	423
1966	533,766	233,750	43,008	8,134	64,129	72,003	39,017	48,218	15,324	3,527	3,382	32
1967	408,930	187,679	31,552	6,188	50,648	48,776	28,482	37,165	10,992	2,643	2,395	24
1968	258,736	127,845	18,509	3,697	32,065	25,078	16,791	24,728	5,863	1,431	1,282	14
1969	108,617	61,480	5,654	935	17,874	2,516	6,217	12,507	647	123	—	6
1970	47,815	11,623	1,090	330	13,235	9,140	7,240	4,357	90	—	—	7
1971	83,400	23,700	4,850	670	18,060	16,840	10,610	6,420	220	80	1,000	9
1972	193,719	69,918	11,372	1,601	38,340	33,557	19,819	15,002	1,134	—	1,656	13
1973	313,645	118,396	20,514	1,213	57,203	56,365	28,412	22,019	2,836	36	4,016	26
1974	429,981	168,348	25,246	3,824	73,226	78,544	36,111	30,055	5,340	329	5,646	33
1975	500,993	186,298	36,137	6,085	86,336	97,362	37,115	33,888	7,092	269	6,880	35
1976	564,715	198,079	50,529	8,612	98,381	109,731	42,879	39,285	6,569	410	5,843	43
1977	625,319	209,004	53,631	7,194	93,822	165,105	35,038	41,817	7,992	576	6,357	47
1978	856,322	287,648	53,712	7,915	112,990	249,940	46,153	64,170	18,190	1,299	8,643	56
1979	1.019.950	345.430	58.399	10.997	127.400	311.168	57.244	70.036	21.597	3.315	9.048	53
1980	1,143,712	383,520	70,494	11,681	139,569	338,197	58,054	83,651	37,082	6,029	9,412	65
1981	1,279,472	461,265	78,837	13,618	158,986	321,444	69,076	99,840	47,895	9,944	11,241	73

Appendix: B-5: Undergraduate Students Enrollment

Source: China Education Yearbook Editorial Department (Zhong Guo Jiao Yu Nian Jian Bian Ji Bu), China Education Yearbook (1949-1981), Zhong Guo Jiao Yu Nian Jian(1949-1981), (Encyclopedia of China Publishing House, 1984), (Zhong Guo Da Bai Ke Quan Shu Chu Ban She, 1984), p967.

APPENDIX B-6

Units of 10,000	Number of schools	Number of classes	Number of students	Students enrollment	Graduates
The highest year before liberation	28.93	66.4	2,368.30	…	118.5
1949	34.68	61	2,439.10	680	64.6
1950	38.36	73.9	2,892.40	696.6	78.3
1951	50.11	111.8	4,315.40	1,086.20	116.6
1952	52.7	126.3	5,110.00	1,149.30	149
1953	51.21	132.1	5,166.40	819.5	293.5
1954	50.61	131.6	5,121.80	1,054.50	332.5
1955	50.41	133.8	5,312.60	1,182.00	322.9
1956	52.9	148	6,346.60	1,592.30	405.1
1957	54.73	156.7	6,428.30	1,249.20	498
1958	77.68	201.9	8,640.30	3,000.50	606.3
1959	73.74	201.9	8,640.30	3,000.50	606.3
1960	72.65	…	9,379.10	2,494.30	734
1961	64.52	204.8	7,578.60	1,647.10	580.8
1962	66.83	199.5	6,923.90	1,586.30	559
1963	70.8	207.7	7,157.50	1,698.20	476.8
1964	106.6	267	9,294.50	2,968.90	567.4
1965	168.19	341.6	11,620.90	3,296.00	667.6
1966	100.7	…	10,341.70	1,879.20	900.5
1967	96.42	…	10,244.30	1,402.50	899.5
1968	94.06	…	10,036.30	1,753.20	1,489.50
1969	91.57	…	10,066.80	2,205.70	1,489.50
1970	96.11	…	10,528.00	2,831.80	1,652.50
1971	96.85	…	11,211.20	3,387.50	1,376.00
1972	100.92	…	12,549.20	3,603.60	1,414.90
1973	103.17	…	13,570.40	3,369.30	1,349.00
1974	105.33	413.9	14,481.40	3,249.50	1,521.00
1975	109.33	433.1	15,094.10	3,352.10	1,999.40
1976	104.43	439	15,005.50	3,161.10	2,489.50
1977	98.23	427	14,617.60	3,111.50	2,573.90
1978	94.93	423.7	14,624.00	3,315.40	2,287.90
1979	92.35	427.5	14,662.90	3,101.70	2,087.90
1980	91.73	427.9	14,627.00	2,942.30	2,053.30
1981	89.41	420.1	14,332.80	2,749.20	2,075.70

Appendix: B-6: Primary School Education: Number of students, classes and schools

Source: China Education Yearbook Editorial Department, (Zhong Guo Jiao Yu Nian Jian Bian Ji Bu), China Education Yearbook (1949-1981), Zhong Guo Jiao Yu Nian Jian(1949-1981), (Encyclopedia of China Publishing House, 1984), (Zhong Guo Da Bai Ke Quan Shu Chu Ban She, 1984), p1021.

APPENDIX B-7

Units of 10,000	Number of Students			Students Enrollment		Number of Graduates	
	Total	High School	Middle School	High School	Middle School	High School	Middle School
The highest year before liberation	149.59	31.79	117.8	…	…	…	…
1949	103．90	20．72	83．18	7.1	34.1	6.1	21.9
1950	130.49	23.8	106.69	10.8	50.1	6.1	21.9
1951	156.81	18.44	138.37	9.1	80.6	5.9	22.5
1952	249.01	26.02	222.99	14.1	124.2	3.6	18.5
1953	293.26	36	257.26	16.1	81.8	5.6	39.8
1954	358.67	47.8	310.87	19.5	123.6	6.8	57.6
1955	389.96	57.98	331.98	22.1	128.2	9.9	87
1956	516.47	78.41	438.06	37.4	196.9	15.4	78.5
1957	628.13	90.43	437.7	32.3	217	18.7	111.2
1958	852.02	117.88	734.14	56.2	378.3	19.7	111.6
1959	917.87	143.57	774.3	65.6	318.3	29.9	149.1
1960	1,026.01	167.49	858.52	67.8	364.8	28.8	142.2
1961	851.76	153.3	689.46	44.7	221.8	37.9	189.2
1962	752.8	133.91	618.89	41.7	238.3	44.1	158.4
1963	761.61	123.53	638.03	43.4	263.5	43.3	152.3
1964	854.03	124.68	729.35	43.8	286.6	36.7	138.6
1965	933.79	130.82	802.97	45.9	299.8	36	173.8
1966	1,249.80	137.28	1,112.52	20.7	272.7	28	162
1967	1,223.70	126.46	1,097.24	13.6	198.3	26.8	186.4
1968	1,392.26	140.79	1,251.47	63	648.5	79.4	519
1969	2,021.49	189.14	1,832.35	103.6	1,023.40	38	361.4
1970	2,641.85	349.7	2,292.15	239	1,176.30	67.6	618.9
1971	3,127.61	558.69	2,568.92	321.3	1,234.90	100.4	835
1972	3,582.44	858.03	2,724.41	479	1,247.10	215.9	1,035.50
1973	3,446.43	923.28	2,523.15	452	1,139.00	349.4	1,129.40
1974	3,650.36	1,002.74	2,647.62	541.1	1,345.10	417.9	1,060.60
1975	4,466.11	1,163.68	3,302.43	633.1	1,810.50	447	1,047.70
1976	5,836.58	1,483.64	4,352.94	861.1	2,344.30	517.2	1,206.00
1977	6,779.90	1,800.01	4,979.89	993.1	2,367.70	585.8	1,558.60
1978	6,548.25	1,553.08	4,995.17	692.9	2,006.00	682.7	1,692.60
1979	5,904.96	1,291.67	4,612.99	614.1	1,727.80	726.5	1,657.90
1980	5,508.08	969.79	4,538.29	383.4	1,550.90	616.2	964.8
1981	4,859.56	714.98	4,144.58	327.8	1,412.70	486.1	1,154.20

Appendix B-7: Number of students, student enrollment and number of graduates in High School and Middle School from 1949 to 1981.

Source: China Education Yearbook Editorial Department (Zhong Guo Jiao Yu Nian Jian Bian Ji Bu) China Education Yearbook (1949-1981), Zhong Guo Jiao Yu Nian Jian(1949-1981), (Encyclopedia of China Publishing House, 1984), (Zhong Guo Da Bai Ke Quan Shu Chu Ban She, 1984), p1000.

APPENDIX B-8

Units of per person	Total (Technical and Normal)	Technical College									Normal School
		Total Technical Only	Engineering	Agric-ultural	Forestry	Medicine	Financial	Physical Education	Arts	Other	
Total	6,402,587	3,478,501	1,387,228	650,890		947,580	382,526	15,793	42,333	52,151	2,924,086
1949	71,769	23,769	6,327	6,718	430	3,803	5,769	----	……	722	48,000
1950	74,826	21,972	5,513	4,397	331	5,834	5,493	——	66	338	52,854
1951	56,905	22,222	4,619	2,702	203	9,589	4,929	——	60	120	34,683
1952	68,146	40,758	9,498	4,361	347	15,840	10,535	——	96	81	27,388
1953	118,154	58,138	17,025	9,651	869	20,020	10,357	——	169	47	60,016
1954	169,503	71,717	23,377	13,038	2,208	19,460	13,483	84	67	——	97,786
1955	235,142	96,796	40,768	20,422	3,067	23,192	9,253	37	57	——	138,346
1956	173,595	74,734	44,983	7,618	2,605	10,386	8,723	——	419	——	98,861
1957	146,100	95,707	50,753	12,258	2,512	22,984	6,247	681	272	——	50,393
1958	190,960	101,292	50,711	21,027	2,609	20,008	5,520	927	490	——	89,668
1959	288,947	170,837	80,528	43,504	5,142	30,147	7,167	1, 871	1,601	877	118,110
1960	267,852	163,111	81,743	33,859	7,345	32,601	1,870	1,462	1,673	2,558	104,741
1961	339,508	215,970	106,515	53,996	6,233	42,525	2,494	1,522	2,003	691	123,529
1962	304,895	159,100	72,361	29,149	3,786	44,264	5,524	1,540	2,033	443	145,795
1963	196,089	107,058	49,092	14,262	2,073	32,660	6,582	540	1,656	193	89,031
1964	164,699	102,967	53,011	14,569	2,295	23,926	7,147	428	1,591	——	61,732
1965	91,388	73,359	40,750	6,409	1,376	12,927	8,835	174	2,283	605	18,029
1966	118,986	80,393	23,545	13,334	2,166	20,218	16,937	86	3,061	1,046	38,593
1967	170,329	118,138	44,425	17,380	2,657	31,374	18,111	188	2,769	1,277	52,191
1968	197,431	135,201	60,675	13,382	1,916	35,651	20,036	266	2,469	806	62,230
1969	102,845	81,841	53,827	8,399	1,841	9,023	5,236	447	2,614	454	21,004
1970	28,131	16,815	3,126	3,908	782	4,690	2,345	156	1,652	156	11,316
1971	88,970	37,960	6,820	12,640		9,680	……	…	…….	8,820	51,010
1972	94,935	36,210	14,113	4,221		10,094	……	……	…….	7,782	58,725
1973	122,067	38,031	11,109	3,348		19,737	3,428	……	…….	409	84,036
1974	166,265	78,315	21,984	7,720		40,788	6,202	……	786	835	87,950
1975	247,709	123,328	39,606	18,548		46,133	15,524	405	1,369	1,738	124,381
1976	338,629	190,213	62,341	31,865		68,361	22,331	1,255	1,675	2,403	148,398
1977	339,706	178,678	56,562	28,067		65,485	24,737	785	1,489	1,553	161,028
1978	231,990	119,335	31,294	27,055		43,884	13,924	248	2,221	709	112,655
1979	180,859	78,518	24,175	11,397	1,572	25,220	12,924	387	1,912	931	102,341
1980	410,337	201,187	57,769	29,083	3,237	53,523	47,060	1,006	2,125	7,384	209,150

1981	604,920	364,804	138,283	58,803	6,198	93,548	53,803	1,298	3,698	9,173	240,116

Appendix B-8: Number of Graduates in Secondary Vocational School from 1949 to 1981.

Source: China Education Yearbook Editorial Department, (Zhong Guo Jiao Yu Nian Jian Bian Ji Bu), China Education Yearbook (1949-1981), Zhong Guo Jiao Yu Nian Jian(1949-1981), (Encyclopedia of China Publishing House), (Zhong Guo Da Bai Ke Quan Shu Chu Ban She), 1984, p984.

APPENDIX B-9

B-1 Joint Venture Suppliers:

Foreign Company	Domestic Company	To supply
Parker	AVIC Electromechanical Systems (AVIC EM)	Fuel, inverting, and hydraulic systems
Goodrich	Jiangsu Tongming Auto Lamp Co.,Ltd	External lighting system
Honeywell	AVIC Harbin Dongan Engine (Group) Co., Ltd	APU
Liebherr	AVIC Electromechanical Systems (AVIC EM)	Air management systems
GE	AVIC	Open-architecture, integrated modular avionics core processing system, flight deck large-area display system, on-board maintenance system and the flight recording system
Eaton Corporation	Shanghai Aircraft Manufacturing Co., Ltd.	Fuel and hydraulic conveyance systems
Rockwell Collins	AVIC's Shanghai Aero Measurement-Controlling Research Institute	In-flight entertainment system, cabin core system
Thales	China Electronics Technology Avionics (CETCA)	In-flight entertainment

Honeywell	AVIC's Flight Automatic Control Research Institute	Fly-by-wire flight control system
Liebherr	AVIC Landing gear Advanced Manufacturing Co.	Landing gear
Honeywell	Hunan Boyun New Materials Co., Changsha Xinhang Wheel and Brake	Wheel and brake system
Rockwell Collins	AVIC's China Leihua Electronic Technology Research Institute	Communication, navigation and surveillance systems
Honeywell	AVIC Chengdu CAIC Electronics Co.	Inertial reference and air data systems
Parker	AVIC's Flight Automatic Control Research Institute	Flight control actuation
Moog	AVIC Qingan Group Co.	High Lift System
Liebherr	AVIC Jincheng Co.	Environment Control System
Parker	AVIC Jincheng Co.	Hydraulics system, fuel tank systems
Honeywell	AVIC Dongan	Auxiliary power unit
Hamilton Sundstrand's Kidde Unit	AVIC Tianjin Aviation Electro-Mechanical Co.	Integrated fire and overheat protection systems
FACC	Danyang Xin Mei Long	Interiors: ceiling panels, luggage compartments, windows, lavatories and galleys etc

Hamilton Sundstrand	AVIC Electromechanical Systems (AVIC EM)	Electric power system
Goodrich	Xi'an Aircraft International Corporation (XAIC)	Landing gear and engine nacelle components

B-2 Foreign Suppliers:

Company Name	To Supply
CFM [Joint Venture by Snecma (SAFRAN Group), and GE]	Engine: LEAP-X1C

B-3 Domestic Suppliers:

Company Name	To Supply
Xizi UHC	Not air-tight door, APU Door
Wuhan Hangda Aero Science & Technology Development Co.	Water systems
The Research Institute for Special Structures of Aeronautical Composite (RISAC) AVIC	Radome
AVIC Chengdu Aircraft Co.	Prow
AVIC HONGDU Aviation Industry Group	Fore fuselage, Mid-after fuselage
Xi'an Aircraft Industry (Group) Co.	Fuselage (including center wing), outer wing caisson, leading edge slot, trailing edge flap,

	aileron and spoiler
AVIC Shenyang Aircraft Co.	after fuselage, tail cone, vertical tail, engine hanger and APU door
AVIC Changhe Aircraft Industries Group Co.	leading edge slot and trailing edge flap
AVIC HAIG	vertical tail, front landing gear door, main landing gear door and wing fuselage fillets
Shanghai Aircraft Manufacturing Co.	Mid fuselage-center wing
Aerospace Research Institute of Materials & Processing Technology (ARIMT)	tail cone, aileron and spoiler