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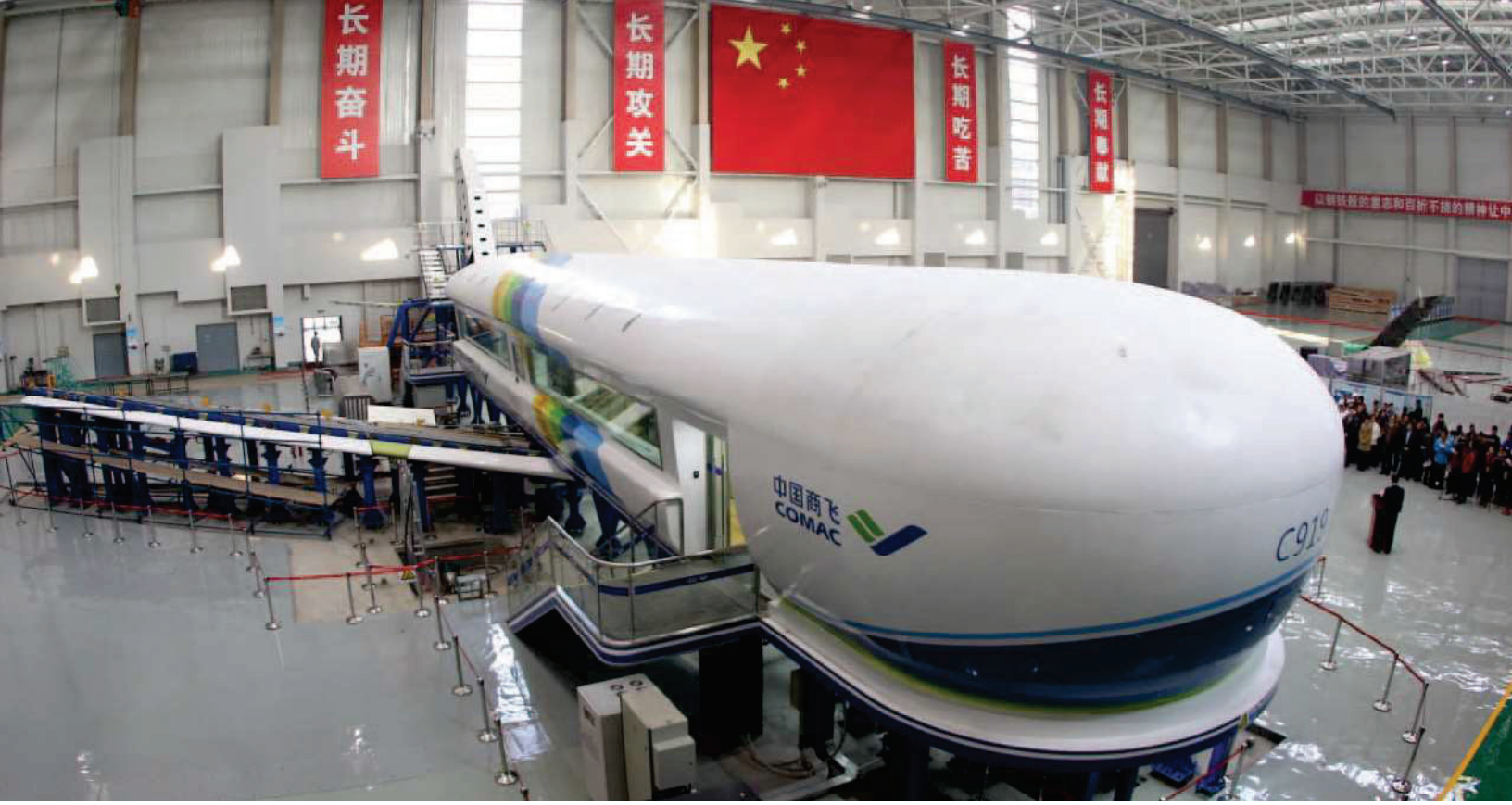


# The Effectiveness of China's Industrial Policies in Commercial Aviation Manufacturing

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*Cover image: The testing platform for China's C919 jumbo jet is pictured at the Shanghai Aircraft Design and Research Institute of COMAC (Commercial Aircraft Corporation of China) in Shanghai, December 30, 2013. (Shanghai Daily - Imaginechina / Associated Press).*



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# Preface

Since economic reforms began in 1978, China has enjoyed rapid growth in exports, which have contributed to the country's impressive economic growth. Improvements in the quality of China's workforce, manufacturing technologies, and materials have enabled the country to enter new, more technologically sophisticated industries. The Chinese government has denoted several such industries as strategic, and has employed industrial policies, formal and informal, to foster the development of "national champions." As part of this strategy, the Chinese government has attempted to induce the transfer of technologies from foreign manufacturers to Chinese companies. To the extent that these policies have been successful, they have accelerated shifts in production and employment from industries located in other countries to China.

The purpose of this report is to use a case study of the emerging commercial aviation manufacturing industry in China to:

- identify and evaluate the effectiveness of the policies and mechanisms the Chinese government has used to create national champions in this industry
- evaluate the effectiveness of the steps taken by foreign manufacturers to increase sales in the Chinese market while seeking to prevent transfers of key technologies to potential future Chinese competitors
- provide policy options that allow foreign governments to effectively respond to Chinese industrial policies in the commercial aviation manufacturing industry
- draw to the attention of Chinese policymakers the costs as well as the benefits of China's industrial policies.

The report should be of interest to policymakers and the public in China concerning the benefits and costs of using industrial policies to foster the growth of the commercial aviation manufacturing industry. It should also be of interest to policymakers and public audiences in North America, Japan, and Europe who are interested in the effects of China's industrial policies on international trade flows and the accompanying effects on shifts in employment and output from their high-technology industries to China. The report also provides options for policies to counter the effects of Chinese industrial policies on the output and employment in industries in other countries.

This research was funded by philanthropic contributions to RAND.

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The research reported here was conducted in the RAND Environment, Energy, and Economic Development Program, which addresses topics relating to environmental quality and regulation, water and energy resources and systems, climate, natural hazards and disasters, and economic development, both domestically and internationally. Program research is supported by government agencies, foundations, and the private sector.

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Questions or comments about this report should be sent to the project leader, Dr. Keith Crane, Keith_Crane@rand.org). For more information about the Environment, Energy, and Economic Development Program, see http://www.rand.org/energy or contact the director at eeed@rand.org.

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# Summary

Since economic reforms began in 1978, China has enjoyed rapid growth in exports, which have contributed to the country's impressive economic growth. Improvements in the quality of China's workforce, manufacturing technologies, and materials have enabled the country to enter new, more technologically sophisticated industries. The Chinese government has denoted several such industries as strategic, and has employed industrial policies, formal and informal, to foster the development of "national champions." As part of this strategy, the Chinese government has attempted to induce the transfer of technologies from foreign manufacturers to Chinese companies. To the extent that these policies have been successful, they have accelerated shifts in production and employment from industries located in other countries to China.

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- provide policy options that allow foreign governments to effectively respond to Chinese industrial policies in the commercial aviation manufacturing industry
- draw to the attention of Chinese policymakers the costs of China's current industrial policies.

## China's Commercial Aviation Manufacturing Industry

Although China's government has had a long-standing interest in manufacturing commercial aircraft, it has not had much success. Until recently, China's aircraft manufacturing industry's production was limited almost exclusively to serving the Chinese military. Consequently, almost all of China's commercial aircraft have been imported from foreign manufacturers. In 2008, the Chinese government consolidated its efforts to develop a commercial aircraft manufacturing industry by setting up a new state-owned commercial aircraft manufacturing company, the Commercial Aircraft Company of China (COMAC), to build two domestic aircraft: a regional jet, the ARJ-21, already under development, and a narrow-bodied aircraft, the C919.

## Chinese Policies for Commercial Aviation Manufacturing

### Goals

The Chinese government sees designing and manufacturing passenger jets as an important indicator of the nation's technological prowess. Aviation manufacturing more broadly is seen as driving economic growth and innovation, and as providing a key basis for national defense. To achieve the goal of creating a globally competitive commercial aviation manufacturing industry, the Chinese government has adopted a strategy of first engaging in domestic production and assembly using foreign designs, then developing its own designs with foreign assistance, culminating in completely independent local development of a commercial aircraft without foreign assistance.

### Policy Instruments

To create an indigenous commercial aviation manufacturing industry, the Chinese government has employed the following policy instruments:

- setting up national champions
- providing launch aid
- compelling state-owned airlines to purchase Chinese aircraft
- targeting orders to foreign manufacturers with assembly operations in China or who source from China
- stipulating that foreign suppliers enter into joint ventures with Chinese partners
- encouraging foreign countries to purchase Chinese aircraft through diplomatic persuasion and the provision of loans.

These policy instruments have contributed to an industry that has more than doubled output between 2005 and 2010 and now employs over 250,000 people. The industry has also become increasingly technologically sophisticated. However, industry output remains a very small share of China's total industrial output, just 0.17 percent in 2010. China's share of the world export market for commercial aviation products also remains small, just 1.3 percent in 2011. Consequently, China's industry has yet to displace substantial shares of output or employment from operations in other countries.

## Why Do Foreign Companies Invest in China?

### Reasons for Investing

Foreign companies engage in the manufacturing of commercial aviation products in China to:

- **provide support to Chinese customers.** China's commercial aircraft fleet currently accounts for 9.6 percent of the global fleet. In light of the size of China's market, aircraft manufacturers and suppliers of major aviation components need to have operations in China to provide service to their customers.
- **benefit from a competitive source of parts.** Foreign aircraft manufacturers and their suppliers have also turned to China for competitively priced parts. Chinese suppliers

have provided intricately machined components and other technologically sophisticated components, such as parts manufactured from composite materials, at competitive prices.
- **set up assembly operations to generate sales to Chinese airlines.** Manufacturers have found assembly operations in China, such as Airbus's joint venture in Tianjin, facilitate sales of aircraft to Chinese airlines.
- **purchase Chinese components as a marketing tool to encourage Chinese purchases of aircraft.**
- **participate in the C919 program.** A slew of manufacturers have recently set up joint-venture operations in China so as to be eligible to be a supplier for the C919 program.
- **enhance the company's image in China.** Foreign companies have found that a manufacturing presence in China provides goodwill, increasing the likelihood that Chinese customers will purchase their products.

### Challenges of Investing

Foreign aircraft manufacturers, like many companies, find investing in China challenging. All of the companies we interviewed had been active in China for years and had developed strategies and programs to safeguard their intellectual property and technologies. The most common approach is to manufacture key components outside of China; the joint venture then imports the component for final assembly. All materials and components used on aircraft must be certified by aviation regulatory agencies, such as the Federal Aviation Administration (FAA). This global regulatory system for the aviation manufacturing industry helps to lessen the theft of intellectual property in China. Because Chinese manufacturers must obtain international certification for their components even if components are to be used in Chinese aircraft, foreign companies that believe their intellectual property rights have been injured by Chinese companies are in a position to intervene to prevent the certification and hence sale of those products.

Foreign aviation product manufacturers underlined the importance of innovation in preventing the emergence of Chinese competitors. This is especially important in subcomponents where the barrier posed by certification is not as high. Many companies now design products specifically for China. A number of these companies noted that by focusing on quality, improving manufacturing efficiency, and distribution, they have been able to out-compete their Chinese competitors even at the lower end of the market.

## Net Assessment

### China

In our view, Chinese government policies pursued to support the creation of national champions in commercial aviation manufacturing have not yet borne fruit. Although industry output has grown rapidly over the last decade, the shares of China's industry in world exports and in gross industrial output in China remain very small and have not risen markedly. The ARJ-21 is constructed largely, if not entirely, from components manufactured by foreign companies; the C919 will also depend heavily on imported components. China's industry continues to struggle with systems integration: projected dates for the certification of the ARJ-21 have been postponed several times; the C919 is most definitely going to face delays. In short, COMAC has yet to show that it will be able to produce commercially viable aircraft, much less show that it can become commercially competitive.

All of our interlocutors believe that, in the coming years, Chinese manufacturers will continue to improve the quality and technological sophistication of their products. Almost all believe that COMAC will succeed in certifying the C919. Opinions differed concerning likely numbers of aircraft sold and delivered. One expert noted that current sales contracts are quite "soft" and that there are several ways by which buyers can avoid consummating the final sale, not least by canceling orders due to delays in deliveries. Moreover, by the time COMAC hits full production, the C919 will be technologically outdated compared to Airbus's and Boeing's new models, the A320neo and 737 Max, respectively. Most of our interlocutors felt that COMAC will not truly be able to break into the international commercial aircraft market until it manufactures another plane following the C919. To develop such an aircraft, COMAC will need another round of substantial financial support from the Chinese government over a relatively long period of time. Even then, many, if not most, of our interlocutors are skeptical that COMAC could compete successfully with Airbus and Boeing.

One area where China is likely to be more successful than in commercial aviation is general aviation, smaller aircraft used for private, charter, or corporate use. China has been buying its way into the international market. China Aviation Industry General Aircraft Company (CAIGA), China's state-owned enterprise active in general aviation, has acquired Cirrus, a U.S. manufacturer. It has also recently signed a joint-venture agreement with Cessna to assemble Cessna's Citation model in China.

### Foreign Companies

Most major international commercial aviation manufacturers now have joint ventures in China. Foreign companies have set up these operations for a variety of reasons, but Chinese pressure for purchases of components manufactured in China and stipulations that suppliers for Chinese domestic aircraft set up joint ventures in China have definitely played a role. It would be surprising if these facilities are not eventually fully integrated into the global manufacturing base of these companies. Although some facilities, like Airbus's assembly operation in Tianjin, may remain dedicated to serving the Chinese market, over the course of the next decade we expect to see more supplier facilities in China specialize in specific products or modules and supply these to the foreign partner's global operations.

Many of the managers of foreign manufacturers with whom we held discussions argued strongly that sales of products manufactured by joint ventures in China do not compete with imports from the United States or Europe. They argued that the joint ventures serve to create, not destroy, jobs in their home countries. Sales made by the joint venture would not have been made if the joint venture had not existed; imports of parts and components for assembly by Chinese joint ventures generate employment in the United States or Europe. However, in the long run, it is our view that more components are likely to be manufactured in China.

All our interlocutors stated that their partners were becoming more technologically sophisticated, but only a few voiced fears of losing their technological edge to Chinese companies, as long as their companies continue to innovate. Their companies' extensive marketing networks, incorporation of their products on aircraft manufactured by Airbus and Boeing, and manufacturing know-how provide them with strong incumbent advantages.

## Policy Options

### The United States and the European Union

Both the United States and the European Union (EU) face a conundrum. China's leadership appears convinced of the efficacy of industrial policies to foster new industries and expanding exports. In contrast, the United States and the EU have attempted to move away from industrial policies because of cost, lack of efficacy, and in the interests of creating a level playing field for international trade.

In both the United States and the EU, the "squeaky wheel" rule reigns. Trade issues are placed on bilateral agendas or brought to the World Trade Organization (WTO) only if a domestic company complains. Trade negotiators focus on other industries where competition from Chinese firms threatens to have immediate consequences, rather than markets like commercial aviation manufacturing, which U.S. and European firms still dominate. In a world in which immediate problems are given all the attention, what can and should the U.S. government and the EU do with regards to commercial aviation manufacturing?

- Engage in bilateral negotiations with the EU to discourage the use of purchases of components as a marketing tool by Airbus and Boeing.
- Push for more transparent tenders for purchases of aircraft by Chinese state-owned airlines.
- Ensure that Chinese aircraft components submitted for certification by the FAA or European Aviation Safety Agency do not incorporate intellectual property taken from other companies.
- Work with domestic companies with operations in China to voluntarily report whether and how investment decisions in China have been influenced by Chinese industrial policies.
- Continue to press the Chinese government in bilateral forums and at the WTO to dispense with industry-specific industrial policies.
- Monitor the development of the C919 and succeeding aircraft and intervene promptly through the WTO and bilateral forums in response to efforts to use subsidies or other supports to enter foreign markets.

Without a dramatic change in China's "national champions" policy, none of these measures are likely to create a level playing field in China for Western manufacturers. However, persistent efforts to reduce the trade distorting effects of China's industrial policies through countervailing duties or other measures may serve to mitigate some of the effects of China's policies.

### Implications for the Government of China

The Chinese government has aggressively pursued the development of a number of industries, including high-speed trains, wind turbines, and automobiles. In all three cases, the Chinese government has stipulated that to manufacture in China, foreign companies must enter into joint ventures with Chinese firms. In the case of wind turbines and high-speed trains, Chinese joint-venture partners developed their own products outside the joint venture and captured the vast majority of sales in China with these products. In both these cases, state-owned companies have been the principal purchasers of the final product. However, deficiencies in the technolo-

gies of Chinese manufacturers have limited their ability to export. Because China has been the largest market in the world for high-speed trains and one of the largest markets for wind turbines, China's industrial policy had an appreciable effect on the sales of foreign firms.

Foreign manufacturing companies must also set up joint ventures with Chinese partners in the automotive sector. In contrast to high-speed trains and wind turbines, joint-venture products continue to dominate the market. In the case of the automotive industry, the principal purchasers are individuals or private companies; joint-venture manufacturers do not face a single, state-owned client for their products.

In our view, the Chinese government would benefit from carefully reviewing its current policies of government support for commercial aviation manufacturing and making a considered decision whether this activity is a good use of China's resources. China is spending well over $7 billion for the C919; the ARJ-21 has also been expensive. Yet most of our interlocutors were skeptical that either the C919 or the ARJ-21 will ever be commercial successes. In light of the many hurdles facing COMAC, in our view this is an opportune time for the Chinese government to rethink its investments and policies targeting specific industries. Focusing its energies on creating a business environment friendly to all firms—private, foreign, and state-owned alike—will be much more likely to result in a higher payoff.

One of the lessons of the post–World War II era has been the importance of the free flow of ideas and people for technological advances. The rise of the modern multinational corporation has played a key role in these advances. These companies are adept at drawing on talent from across the globe in creating multinational teams to develop new products and processes. They have developed systems for developing and deploying new technologies and products.

One of the goals of China's leadership has been to put the country at the forefront of global advances in science and technology. China has talented engineers and scientists and has registered significant advances in a large number of industries, including space and telecommunications. It also has a number of successful multinational companies of its own. However, to the extent foreign companies are not given the same treatment as their Chinese counterparts, as has been the case in the wind turbine and high-speed rail industries, or are afraid that their intellectual property rights will not be safe, they will remain cautious about what technologies they bring to China. If China wishes to become fully integrated into the global commercial aviation manufacturing industry, China's government would be well advised to change its current policies to create a more equitable business environment for both foreign and Chinese commercial aviation manufacturers. The benefits of such a policy change for China would be considerable in terms of better allocation of investment, better integration into global technology supply chains, and the substantial savings of putting funds currently going to support national champions to better uses.

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## Abbreviations

| | |
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| ASC | American Superconductor Corporation |
| AVIC | Aviation Industry Corporation of China |
| CAIGA | China Aviation Industry General Aircraft Company |
| CASC | China Aviation Supplies Import and Export Group Corporation |
| CEO | chief executive officer |
| COMAC | Commercial Aircraft Company of China |
| EASA | European Aviation Safety Agency |
| EU | European Union |
| FAA | Federal Aviation Administration |
| GATT | General Agreement on Tariffs and Trade |
| GDP | gross domestic product |
| JCCT | U.S.-China Joint Commission on Commerce and Trade |
| JIE | RAND Justice, Infrastructure, and Environment |
| NDRC | National Development Reform Commission |
| PLAAF | People's Liberation Army Air Force |
| R&D | research and development |
| S&ED | U.S.-China Strategic and Economic Dialogue |
| SAIC | Shanghai Aviation Industrial Company |
| SAIC Motor | Shanghai Automotive Industry Corporation Motor |
| SAMC | Shanghai Aircraft Manufacturing Company |
| SCM Agreement | Agreement on Subsidies and Countervailing Measures |
| SASAC | State-owned Assets Supervision and Administration Commission of the State Council |
| WTO | World Trade Organization |
| XAIC | Xi'an Aircraft International Corporation |

CHAPTER ONE

# Introduction

In the 30-odd years since the beginning of economic reforms in 1978, China's economy has grown at a remarkable rate. In 1978, China's gross domestic product (GDP) was just $263 billion, placing it well below European economies such as France and Italy. Today, China has the second largest economy in the world. Although a large number of changes have been made in economic policy following the introduction of reforms in 1978, an about-face in Chinese attitudes toward foreign direct investment has been one of the most momentous. Initially concentrated in export zones, China has gradually opened up its economy to foreign investment in more regions and more sectors of the economy.

The influx of foreign direct investment has been accompanied by rapid growth in exports and new industries in China, which have contributed to this impressive economic growth. From manufacturing shoes, textiles, clothing, and toys, China has become one of the world's largest assemblers of motor vehicles and a major force in a wide range of medium and heavy industries that were formerly the province of the United States, Western Europe, and more lately Japan, South Korea, and Taiwan. Improvements in China's workforce, manufacturing technologies, and materials have enabled the country to enter new, more technologically sophisticated industries. Exports from plants in China, often wholly-owned subsidiaries of foreign corporations or joint-venture operations between Chinese state-owned companies and foreign companies, have supplanted production from plants in the European Union (EU), Japan, the United States, and other countries. The shift in global output in these industries has been accompanied by the closure of plants in competitor countries and associated declines in employment.

As foreign trade and foreign direct investment became more important for China's prosperity, China's leadership made a decision to resume its membership in the General Agreement on Tariffs and Trade (GATT). When GATT was replaced by the World Trade Organization (WTO), China applied for membership. After 15 years of negotiations with GATT and the WTO, China became a member of the WTO in 2001. Prior to joining the WTO, China made a large number of policy changes that improved foreign access to Chinese markets for goods and services. It also made a number of commitments to continue to open its markets following membership.[1] However, membership has been followed by continued trade frictions. More than a decade after China's accession to the WTO, neither the EU nor the United States recognize China as a market economy; the EU and the United States have frequently charged

[1] Directorate-General for External Policies for the Union, Policy Department, "EU-China Trade Relations," European Parliament, 2011, p. 21.

China with violations of WTO rules.[2] Differential access to markets for goods, services, and capital have been of great concern to policymakers in the home countries of companies that invest in China, as these countries have experienced losses in jobs and exports within sectors that compete with Chinese manufacturers.[3]

Under its accession agreement with the WTO, China may not make approval of foreign investment conditional upon the existence of domestic competitors or on any performance requirement including technology transfer or obligations to conduct research and development activities in China. Nonetheless, in several industries, often denoted as strategic, the Chinese government has adopted industrial policies, formal and informal, to induce the transfer of technologies from foreign manufacturers and increase output; many of these policies do not appear to be compliant with WTO rules. These policies have included a wide range of restrictions designed to steer foreign direct investment to sectors and areas of most interest to Chinese policymakers and in many instances to foster the growth of Chinese companies that it hopes will become "national champions," or global leaders in those industries. To the extent that these policies have been successful, they have accelerated shifts in production and employment to China from existing facilities in these industries in other countries.

## Purpose

The purpose of this study is to use a case study, the emerging commercial aviation manufacturing industry in China, to:

- identify and evaluate the effectiveness of the policies and mechanisms the Chinese government has used to create national champions in this industry
- evaluate the effectiveness of the steps taken by foreign manufacturers in the commercial aviation industry to increase sales in the Chinese market while seeking to prevent transfers of key technologies to potential future Chinese competitors
- provide policy options that allow foreign governments to effectively respond to Chinese industrial policies in the commercial aviation manufacturing industry
- assess the relative successes and failures of the Chinese government and foreign manufacturers to achieve their goals within the commercial aviation industry (As part of this assessment, we evaluate the extent to which the goals of the Chinese government and foreign manufacturers are mutually exclusive or can be pursued concurrently.)
- draw to the attention of Chinese policymakers the costs as well as the benefits of China's industrial policies.

We have chosen a single industry, the commercial aviation manufacturing industry, for this study, so that we could engage in a detailed evaluation of Chinese policy in an industry

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[2] U.S. and EU trade policymakers have yet to grant China market economy status, although China will automatically acquire this status in 2016 in accordance with the conditions under which it joined the WTO. Directorate-General for External Policies for the Union, 2011, p. 21; U.S. Trade Representative, *2012 Report to Congress on China's WTO Compliance*, Washington, D.C., December 2012.

[3] The most recent example of these effects has been in the photovoltaic panel industry, where Chinese manufacturers have contributed to sharp declines in output and exports from manufacturers in Europe, Japan, and the United States. See Keith Bradsher, "Chinese Solar Panel Giant Is Tainted by Bankruptcy," *New York Times*, March 20, 2013.

that has been singled out in recent Five-Year Plans for development.[4] The industry is of special interest because of the intent of Chinese industry leaders to create a competitor to Boeing and Airbus on the international market.[5] The Chinese state has provided substantial resources to achieve this goal. At the same time, because of the technological expertise needed to manufacture aircraft and aircraft components, Chinese companies face high hurdles to break into an international market where not only aircraft, but components and materials, need to be certified by U.S. or European aviation agencies before they can operate. Thus, this industry provides an excellent case study in a technologically challenging and advanced industry to examine the effectiveness of China's industrial policy.

## Approach and Organization of This Report

To complete this study, we employed a number of research techniques, drawing on a wide range of information sources.

### Assessing the Performance of China's Commercial Aviation Industry

In the next chapter, we assess the development of China's commercial aviation industry, drawing on Chinese-language accounts from newspapers and business journals, Chinese-language websites from major Chinese aviation manufacturers, and Chinese statistical data to describe the organization and growth of China's commercial aviation manufacturing industry. The statistical information includes data on foreign direct investment, output, exports, imports, and employment in this industry in China.

### Identifying Chinese Government Policies

In Chapter Three, we inventory the range of formal and informal policies and mechanisms that the Chinese government has used to induce growth in this industry. To do so, we drew on official policy statements, investigated the availability of policy instruments such as reductions in import permits, domestic content provisions, state procurement practices, and other measures, and interviewed managers from Chinese and foreign companies in the commercial aviation manufacturing industry to provide a comprehensive list of major policy instruments, formal and informal, that have been used to channel foreign direct investment and encourage the transfer of technologies from foreign manufacturers to the domestic Chinese industry. During the course of this research, we interviewed more than 50 company representatives and managers (Western and Chinese), journalists, lawyers, U.S. government officials, and consultants to and other individuals knowledgeable about the Chinese domestic commercial aircraft industry in China and the United States to gain their perspectives about China's domestic industry. In addition to interviews with industry personnel, we drew on previous studies and used information from the commercial press to describe Chinese government policies and policy instruments in this sector.

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[4] Ministry of Industry and Information Technology, "Middle and Long-Term Development Plan for the Civil Aviation Industry (2013–2020)," May 22, 2013.

[5] Zuoming Lin (林左鸣), "The Path of AVIC's Strategic Evolution (中航工业战略变革之道)," *China Aviation News*, April 17, 2012.

### Determining Foreign Company Strategies

In Chapter Four, using press accounts and other public sources, we identified all the major foreign commercial aviation manufacturing companies with operations in China. Drawing on articles from Western newspapers and business journals, corporate reports and other corporate information from the websites of these companies, previous studies, discussions with company executives and other knowledgeable individuals in China and the United States, and discussions with representatives of these manufacturers at the Zhuhai Air Show in November 2012, we detailed the steps taken by these foreign manufacturers to increase sales in the Chinese market while seeking to prevent transfers of their key technologies and other know-how to potential future Chinese competitors. In this stage of the research, we conducted more than two dozen interviews with managers of foreign and Chinese commercial aviation manufacturers. From one source or another, we obtained information on all Tier One suppliers (that is, suppliers of modules) for China's commercial aviation manufacturing industry. For reasons of confidentiality, we have not identified these individuals or the companies we interviewed in this report.

### Assessing Shifts in Output in the Global Commercial Aviation Manufacturing Industry

In Chapter Five, we assess the effects of the growth of the Chinese industry on the U.S. industry and the global industry as a whole. Utilizing statistical information from the United Nations' Foreign Trade database (Comtrade) and Chinese, U.S., and European data on the commercial aviation manufacturing industry, we measured changes in output, exports, and employment in China and the United States as well as output and exports in other countries that are major manufacturers of commercial aircraft and aviation components.[6] We also drew upon previous studies, the commercial press, discussions with industry managers, expert evaluations, and a visit to the Zhuhai Air Show in November 2012 to chart changes in China's technological capabilities in this industry. Drawing on this statistical information on the Chinese market and industry and similar information from the countries from which the foreign direct investment came, we contrasted changes in output, exports, and global market share in the case of China with the evolution of this industry in the home countries of foreign investors in China. Drawing on these data, we assessed relative changes in output and sales, market share, and the relative positions of Chinese and foreign manufacturers in the Chinese market and in the global market.

### Evaluating the Relative Effectiveness of Chinese Policies and Foreign Manufacturers' Strategies

In Chapter Six, we provide a net assessment of the effectiveness of China's industrial policies and foreign manufacturers' strategies to protect their proprietary technologies while also selling into the Chinese market. Drawing on the statistical and analytical sources previously discussed, we contrasted the goals of the Chinese government with the achievements of the commercial aircraft manufacturing industry in terms of mastery of technologies as measured by certification of aircraft and expert evaluations, and growth in output of commercial aircraft and components and modules for the commercial aircraft industry. The evaluation benefited from our attendance at the Zhuhai Airshow in November 2012, where we were able to discuss products, operations, and strategies with representatives of a large number of foreign and some

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[6] *China Civil Aviation Industrial Statistical Yearbook*, Beijing: China Statistics Press, 2007–2011.

Chinese companies in this industry. We also sought to ascertain the financial and other costs of Chinese endeavors to develop a commercial aircraft manufacturing industry drawing on interview data and analogous costs for developing aircraft by Boeing and Airbus.

We evaluated the success of foreign investors in terms of growth of sales within China and protection of intellectual property. As part of this assessment, we contrasted the achievement of the goals of the Chinese government with those of foreign manufacturers, determining where they have been at odds with each other or where they have been compatible. In this section, we drew on analogous developments in other high-technology industries where China has sought to master new technologies and expand output, to identify factors that are similar and different from those in the commercial aviation manufacturing sector.

### Policy Implications for Foreign Governments and China's Government

Chapter Seven draws out policy implications from this analysis for both foreign governments and China's government. Drawing on reports and policy statements, we first contrast Chinese industrial policies with rules issued by the WTO governing foreign trade, foreign investment, and protection of intellectual property rights. We then discuss U.S. and EU approaches to addressing trade and commercial issues with China, focusing on the commercial aviation manufacturing sector. Subsequently, we identified various policy options available to the U.S. government and the EU to address trade issues stemming from Chinese policies to encourage the growth of its domestic commercial aviation manufacturing industry. We discussed these policy options and existing policies with civil servants in the United States and elsewhere to ascertain realistic potential policy responses, including employing safeguards available through the WTO. We conclude with a discussion of the costs and results of employing industrial policies to foster the growth of new industries, contrasting the costs with the potential benefits for the Chinese government.

CHAPTER TWO

# China's Commercial Aircraft Manufacturing Industry

This chapter provides an overview of the structure of China's commercial aviation manufacturing industry. It then charts the development of the industry since the beginning of the People's Republic of China. It concludes with an assessment of the industry's strengths and weaknesses.

## Structure of China's Commercial Aviation Manufacturing Industry

In the past, China's aircraft manufacturing industry produced aircraft almost exclusively for the Chinese military, especially the People's Liberation Army Air Force (PLAAF). Aside from the production of smaller (often propeller-driven) planes based on modified Soviet designs, China's role in the global commercial aviation manufacturing industry consisted of providing parts for foreign aircraft manufacturers. More recently, China has embarked on developing two domestic commercial aircraft: a regional jet designated the ARJ-21, and a narrow-bodied aircraft that has been designated the C919. We describe the enterprises that form the core of this industry: the Aviation Industry Corporation of China (AVIC) and the Commercial Aircraft Company of China (COMAC).

### Aviation Industry Corporation of China (AVIC)

AVIC (中国航空工业集团公司) is by far the largest company engaged in aircraft manufacturing in China. All military aircraft and all major aviation components such as engines and avionics are manufactured by either its subsidiaries or joint ventures between its subsidiaries and foreign companies. It is much more vertically integrated than other participants in the global aircraft manufacturing industry, manufacturing a very large share of the materials, components, subassemblies, and modules it uses rather than sourcing from outside suppliers.

Shortly after the creation of the People's Republic of China, the Chinese government made aircraft production the responsibility of the Ministry of Heavy Industry, with operations managed by the Civil Aviation Administration of China under the supervision of the PLAAF. Subsequently, the Ministry of Aerospace Industry was set up, and enterprises engaged in the aerospace industry were transferred to the new ministry. AVIC was created in 1993 from enterprises that manufactured aircraft and aircraft components. These enterprises had fallen under the former Ministry of Aerospace Industry. The creation of AVIC was designed to improve the operations and technological sophistication of China's aviation manufacturing industry by making enterprises more responsive to their primary client, the PLAAF. Under both the Ministry of Heavy Industry and the Ministry of Aerospace Indus-

try, enterprises were reportedly more responsive to their immediate superiors in the industrial ministries than to the PLAAF.[1]

Despite the creation of AVIC, the PLAAF remained unhappy with the quality and technological capabilities of Chinese aircraft. In the 1990s, the PLAAF imported jet fighters from Russia rather than purchase the domestic alternative because of the technological and quality deficiencies of Chinese military aircraft.[2] In 1999, the Chinese government split AVIC into two corporations, AVIC I and AVIC II, in an effort to rectify these problems by introducing more competition into this industry.[3]

The creation of AVIC I and AVIC II did little to stimulate competition among Chinese enterprises for government military contracts, as the two firms were specialized in different areas, with AVIC I focusing on military aircraft and medium-sized commercial planes, while AVIC II focused on smaller civilian airframes, transport aircraft, and helicopters. In response to this failure, the Chinese government re-merged the two companies in 2008. According to AVIC chief executive officer (CEO) Lin Zuoming, the re-merger of AVIC was motivated in large part by the aviation industry's desire to create a national champion of sufficient heft to compete against the established companies in the global aviation market.[4] AVIC's management has adopted the goal of becoming one of the world's leading aviation companies, explicitly benchmarking the company's performance against Airbus Group and Boeing, the global industry leaders. AVIC's overall strategic vision, laid down soon after the 2008 re-merger, is summarized in the eight-character directive "*liangrong* (两容), *sanxin* (三新), *wuhua* (五化), *wanyi* (万亿)," or "two integrations, three new's, five transformations, and one trillion."[5] The "one trillion" refers to AVIC's total revenue target in renminbi for the year 2020. Using 2012 exchange rates, that Figure translates into roughly $160 billion. For comparison, Boeing reported $69 billion in total revenue in 2011, while Airbus and AVIC each reported roughly $40 billion. The other six characters of the directive lay out the strategies by which growth is to be achieved. The "two integrations" refer to "integration within the global aviation production chain, and integration within the regional economic development sphere." The "three new's" refer to the three new emphases of "brand value creation, business model innovation, and integrated network construction." Lastly, the "five transformations" refer to "market-oriented reforms, specialized consolidations, capitalized operations, globalized development, and commercialized growth." This strategic vision represents an ambitious plan to place AVIC on a more market-oriented footing, while making the company a major player within the global aviation industry.

As of 2012, AVIC employed some 400,000 employees in more than 200 subsidiary units—including 34 research institutions, such as the China Aeronautical Research Institute. In 2011, total revenues ran $40.8 billion, nearly double the $21.7 billion recorded in 2008, and

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1 Evan S. Medeiros, Roger Cliff, Keith Crane, and James C. Mulvenon, *A New Direction for China's Defense Industry*, Santa Monica, Calif.: RAND Corporation, MG-334-AF, 2005, p. 157.

2 Institute of International and Security Studies, "China," *The Military Balance*, 2001.

3 Shen Bin, "AVIC to Be Split into Two Groups," *China Daily* (Business Weekly Supplement), January 31–February 6, 1999, p. 1.

4 Lin, 2012.

5 Lin, 2012, pp. 4–5.

more than quadruple the combined $10 billion revenues of AVIC I and AVIC II from eight years earlier in 2003 (see Table 2.1).

As can be seen in Table 2.1, value added from commercial aviation in recent years has accounted for 8 to 10 percent of AVIC's total revenues. Because China's two new domestic commercial aircraft, the ARJ-21 regional jet and the C919 narrow-bodied jet, have faced repeated delays in development, AVIC subsidiaries and the joint ventures in which they are engaged have yet to generate much in the way of revenues from these projects. For the time being, most of AVIC's revenues from commercial aviation still come from subcontracts to Boeing, Airbus, and other foreign companies—as well as joint ventures with Airbus and Embraer for the final assembly of designated aircraft models in China.

The vast majority of AVIC's revenues come from sales of products other than commercial aircraft or aircraft components or sales of military aircraft. In the late 1990s, roughly 80 percent of AVIC I's and AVIC II's combined revenues came from the sale of products outside aviation, such as cars, motorcycles, and automotive components.[6] As of 2012, the proportion of aviation-related revenues in total revenues appears to have risen, but it is probably still below 50 percent. Such a broad range of businesses runs counter to current Western management principles, which maintain that firms should concentrate on "core competencies."[7] However, AVIC appears to be in no hurry to divest itself of these subsidiaries. Over the last few decades, non-aviation products appear to have been more profitable than aviation products. AVIC management regards these "non-core" activities as a key source of profits to invest in its aviation businesses, not as distractions from its core business.[8] Moreover, as growth in manufacturing components for the commercial aviation industry is constrained by competition for contracts with Boeing and Airbus from existing suppliers and the absence of demand from China's nascent industry, AVIC managers pursue business outside aviation manufacturing because of better prospects for bonuses tied to increasing profits and sales.

**Table 2.1**
**AVIC Revenues and Operating Profits**

| | 2003 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|
| Year | | | Millions of Dollars | | |
| Total revenue | $10,000 | $21,738 | $25,189 | $31,006 | $40,835 |
| Value added from civil aviation | $1,907 | $2,134 | $2,515 | $2,640 | $3,215 |
| Value added from civil aviation (% of revenues) | 19.1% | 9.8% | 10.0% | 8.5% | 7.9% |
| Net profit | | $568 | $767 | $704 | $930 |
| Profit margin (% of revenues) | | 2.6% | 3.0% | 2.3% | 2.3% |
| Fortune Global 500 ranking | | 426 | 330 | 311 | 250 |

SOURCES: Compiled from the AVIC corporate websites, annual reports, media reports, and *China Civil Aviation Industrial Statistical Yearbook*, Beijing: China Statistics Press, 2007–2011.

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[6] Ye Weiping, "Challenges and Opportunities for Ordnance Industry Following China's Entry to WTO (Part 2 of 2)," *Ta kung pao* (Internet version), April 26, 2000.

[7] Michael E. Porter, *Competitive Strategy: Techniques for Analyzing Industries and Competitors*, New York: The Free Press, 1980.

[8] Lin, 2012.

On the corporate level, AVIC functions as a holding company whose primary role is allocating capital, coordinating activities among subsidiary companies, managing relations with the central government, and acting as an interface between the subsidiary companies and foreign business partners. AVIC corporate does make all key personnel appointments at the subsidiaries. However, the Chinese Communist Party approves all key appointments to management positions at AVIC. Local Communist Party leaders have a say in appointments within their jurisdictions.

Historically, the various AVIC subsidiaries have operated largely independently of each other, despite their nominal relationship within the same corporate family. The enterprises have been responsible for their own finances and management practices.[9] In contrast, the research institutes were funded by the state budget and were engaged only in research and development (R&D) and design. More recently, the institutes have become focused on generating revenues and have diversified into different businesses, frequently with a technological bent. Some have set up subsidiaries to which they have transferred inventions and other intellectual property so as to capitalize on these assets. Some of these subsidiaries have been listed on China's stock markets through initial public offerings.

Despite some attempts at coordination from corporate headquarters in Beijing, there has been little synergy between the member firms in general. At times, especially in non-aviation activities, there has been a great deal of duplication. In the words of AVIC CEO Lin Zuoming, it is a pressing challenge for the company to evolve beyond "a pile of potatoes, held together in a burlap sack."[10]

In an effort to rationalize the firm's organizational structure, the 2008 AVIC reorganization introduced a "three-tier management system" under which an intermediary layer of "direct subsidiaries" was established.[11] These units are separately incorporated holding companies, one for each of the conglomerate's major lines of business. The spectrum of businesses covered range from military aviation to general aviation, from cars and motorcycles to finance and real estate. Individual member firms are grouped under the "direct subsidiaries" according to their areas of activity, though a great deal of functional overlap probably still exists since most of these enterprises are highly diversified. Figure 2.1 shows the organization of AVIC's aviation units.

These "direct subsidiaries" serve as "profit centers and commercialization centers," whereas individual member organizations—which include various research and educational institutes—are "cost centers and specialization centers." For aviation-related subsidiaries, AVIC headquarters exercises "strategic oversight," which involves setting strategic objectives, technological benchmarks, and financial goals, among other targets. For non-aviation-related subsidiaries, AVIC exercises only "financial oversight" to ensure these subsidiaries stay profitable.[12] The exact relationship, including financial oversight, between the direct subsidiaries and their member units is not clear. These intermediary holding companies are responsible for setting strategic objectives for their respective areas of operations; identifying short-, medium-, and long-term goals for the implementation of those objectives; providing marketing and sales

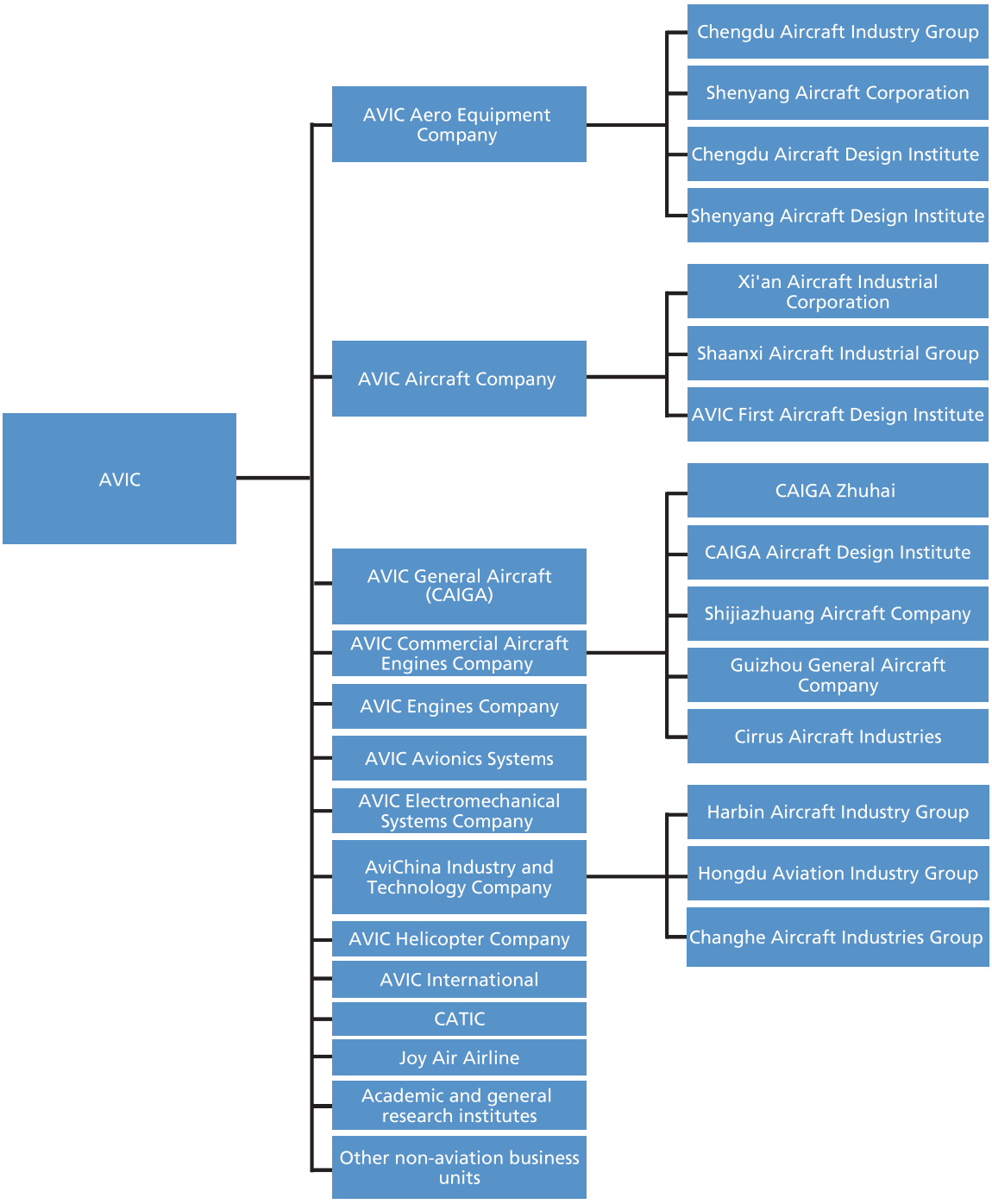
[9] Medeiros et al., 2005, p. 176.

[10] Lin, 2012.

[11] Lin, 2012.

[12] Lin, 2012.

**Figure 2.1**
**Organizational Chart of AVIC's Aviation Units**




SOURCES: Compiled from various subsidiary company websites, AVIC annual reports, and media reports.

support for member enterprises; and integrating the research and development and production capabilities of member units to achieve greater operational efficiency.[13]

The more established and successful member enterprises tend to jealously guard their operational autonomy from headquarters. In the West, successful integration of companies typically occurs through mergers and acquisitions that establish new lines of authority through changes in ownership; it remains to be seen whether the attempt to achieve integration while preserving the organizational parity of all member units will be successful. We next describe some of the most important "direct subsidiaries" shown in Figure 2.1. A more complete listing is provided in Appendix A, Table A.1.

***AVIC Aero-Equipment Company, Ltd. (***中航航空装备有限责任公司***)***

The AVIC Aero-Equipment Company, formerly known as AVIC Defense, is the division of AVIC that specializes in the development and production of advanced jet fighters. As such, the company boasts some of China's most technologically sophisticated aviation assets, including the Chengdu Aircraft Industry Group, the Shenyang Aircraft Corporation, the Chengdu Aircraft Design Institute, and the Shenyang Aircraft Design Institute. Although Chengdu and Shenyang are both known primarily for their fighter lineups, both Shenyang Aircraft and Chengdu Aircraft have established subsidiaries to handle subcontract work for Boeing and Airbus: Chengdu Commercial Aircraft Company and Shenyang Aircraft Commercial Company. AVIC and its subsidiaries have bundled some of these commercial aerospace manufacturing entities and listed them on Chinese stock exchanges. Chengdu is the contractor for the nose section of China's ARJ-21 regional jet, while Shenyang is the contractor for its tail assembly.

***AVIC Aircraft Company, Ltd. (***中航飞机有限责任公司***)***

The AVIC Aircraft Company is the AVIC division that specializes in large transport aircraft, both civil and military. The two major airframe manufacturers in this group are the Xi'an Aircraft Industrial Corporation and the Shaanxi Aircraft Industrial Group. Xi'an Aircraft Industrial Corporation began as a manufacturer of bombers; it continues to produce the H-6 series of medium bombers developed from the Tupolev Tu-16 of 1950's vintage and the JH-7 series of fighter-bombers. In recent years, it has set up a subsidiary to work as a subcontractor for Boeing and Airbus, supplying complete wing assemblies for the Airbus A320; it was also chosen to manufacture the fuselage and wings for the ARJ-21 project and has an ownership stake in an airline, Xinfu Airlines.

Xi'an Aircraft Industrial Corporation manufactures AVIC's only noteworthy indigenous commercial aircraft, the MA-60, a turbo-prop airliner in the 60-seat class, originally developed from the Soviet Antonov An-24 transport. The plane was certified by the Chinese government in 2000. Since then, 66 aircraft have been delivered, but the number of deliveries has consistently fallen below target.[14] The plane has a list price of $14 million to $15 million. Based on these prices, revenues from the MA-60 have never accounted for much more than 10–15 percent of Xi'an Aircraft Industrial Corporation's annual revenues (See Table 2.2).

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[13] Zhou Lu (陆洲), "Wang Yawei: Defense Subsidiary to Concretize (汪亚卫:防务分公司实体化)," *China Securities Journal*, September 21, 2009.

[14] Lin, 2012.

**Table 2.2**
**Xi'an Aircraft International Corp. Revenue and Production Figures**

| Revenue and Production | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|
| Total revenue ($millions) | 285.2 | 1,347.4 | 1,203.9 | 1,556.1 | 1,372.3 |
| Net profit ($millions) | 13.8 | 66.1 | 59.2 | 63.9 | 16.6 |
| Revenue from aviation products ($millions) | 220.2 | 1,270.6 | 1,124.0 | 1,473.7 | 1,268.2 |
| As a % of total | 77.2 | 94.3 | 93.4 | 94.7 | 92.4 |
| Revenue from domestic market ($millions) | 193.9 | 1,220.6 | 1,050.7 | 1,384.9 | 1,184.6 |
| As a % of total | 68.0 | 90.6 | 87.3 | 89.0 | 86.3 |
| Number of MA-60s delivered | (14 to date) | 10 | 8 | 18 | 8 |
| MA-60 delivery target | | 22 | 20 | 20 | 10 |
| Number of ARJ-21 fuselages delivered | 0 | 0 | 0 | 0 | 2 |

SOURCES: Compiled from Xi'an Aircraft International Corp website, annual reports, and media reports.

The other major airframe manufacturer in the group, the Shaanxi Aircraft Industrial Group, produces the Y-8 series of turboprop medium transports, derived from Ukraine's Antonov An-12 series of military transports. Other members of the group include the Xi'an Aviation Braking Technology Company, the AVIC Landing Gear Advanced Manufacturing Company, and the Xi'an-based AVIC First Aircraft Design Institute.

In November 2009, AVIC Aircraft became the first AVIC "direct subsidiary" to be listed in its entirety on an equity market when its unlisted assets were injected into the Xi'an Aircraft International Corporation (XAIC), a holding company created for listing on the Shenzhen Stock Exchange in 1997. As of 2009, 70 percent of XAIC's revenues were generated from aviation manufacturing; 30 percent were generated from other activities.[15]

### *China Aviation Industry General Aircraft Company, Ltd. (中航工业通用飞机公司)*

China Aviation Industry General Aircraft Company (CAIGA) is the AVIC division that specializes in general aviation aircraft: smaller aircraft for personal or business use. Its major aviation-related assets in China include the CAIGA Zhuhai Manufacturing Base, the Shijiazhuang Aircraft Industry Group, the Guizhou General Aircraft Company, and the CAIGA Aircraft Design Institute in Zhuhai, Guangdong. CAIGA has built up its general aviation capabilities by purchasing a U.S. manufacturer of small aircraft, Cirrus,[16] and signing a recent agreement with Cessna to assemble a model of Cessna's Citation in China.[17]

Unlike many other AVIC direct subsidiaries, CAIGA is not merely a holding company. Created as a joint venture between AVIC and the Guangdong Provincial Government in July 2009, organizationally it may be the most modern of the AVIC direct subsidiaries. Headquartered in Zhuhai, the company is building a large corporate campus that includes a design center, a marketing center, a manufacturing facility, and a customer service facility, as well as its own charter aviation service. In addition to its aviation assets, AVIC injected non-aviation assets into the new company, the most important of which include AVIC Sanxin (an

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[15] Ying Xu and Zhongrong Liang (徐英, 梁钟荣), "AVIC Aircraft to Be Listed in Entirety (中航飞机整体上市)," *21st Century Business Herald*, November 7, 2009.

[16] James Fallows, *China Airborne*, New York: Pantheon Books, 2012, pp. 142–144.

[17] Molly McMillin, "Cessna, CAIGA Complete Contract for Joint Venture to Assemble and Sell Citation XLS+ Jets in China," *The Wichita Eagle*, November 14, 2012.

architectural-glass manufacturer), AVIC Heavy Machinery (castings and forgings, hydraulics, and alternative energy), AVIC ZEMIC (electronic measurement instruments), and the Guihang Automotive Components Company. These "non-core" businesses generate a substantial share of total revenues and profits, which can be used to invest in aviation manufacturing as well as non-aviation activities.

CAIGA's greatest challenge may be its lack of experience in the general aviation sector. Outside of Cirrus and the new joint venture with Cessna, the company's lineup of general aviation aircraft is modest. The only CAIGA aircraft with a substantial service record is the Shijiazhuang Y-5B, an aircraft based on the ancient An-2 biplane design. The four aircraft types under development at the Zhuhai complex—the Starlight 100 and 200 ultralight business jets and the Primus 100 and 150 ultralight business turboprops—are designs purchased from bankrupt Oregon kitplane maker Epic Aircraft for $4.3 million; these planes are sold to enthusiasts who assemble the plane themselves from disassembled kits.[18] As uncertified amateur kit planes, these designs require substantial development before they can enter commercial service.

### Commercial Aircraft Company of China

At the same time that AVIC I and AVIC II were re-merged, COMAC was spun off from AVIC in an effort to create a commercial aviation manufacturer that more closely mirrors the commercial operations of Boeing and Airbus Group.[19] COMAC is an independent corporation responsible for the design, assembly, testing, and marketing of China's forthcoming indigenous commercial airliners, the ARJ-21 and C919. It was created from the former AVIC Commercial Aircraft Company, which was itself created from the Shanghai Aircraft Manufacturing Company (SAMC) in 2002. In addition to SAMC, COMAC has a customer service center and two research and design centers in Shanghai and Beijing. It is also a shareholder in Chengdu Airlines, a publishing house, and the Shanghai Aviation Industrial Company (SAIC), which is a holding company that controls businesses in non-core areas such as air freight, logistics, machine building, catering, and automotive components.[20] Figure 2.2 shows key features of COMAC's organizational structure.

COMAC has the express mission of focusing on commercial aviation development; it will not be engaged in producing military aircraft.[21] COMAC was split off from AVIC to make it easier for foreign companies to provide components for COMAC's two commercial aviation projects, the ARJ-21 and the C919. The Chinese government hoped or believed that Western (especially U.S.) strictures on exports of technologies would be looser if foreign companies were dealing with an exclusively commercial aircraft manufacturer rather than with AVIC or its subsidiaries. COMAC was also set up in an attempt to address shortcomings in China's commercial aviation manufacturing industry that stemmed from AVIC's focus on military aircraft. (As already noted, AVIC's problems extend deeper than commercial aviation manufacturing; historically, the PLAAF and PLA Navy were also dissatisfied with AVIC's product performance and service; the situation has improved in recent years.)[22] Because the requirements

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[18] Matt Thurber, "Chinese Firm to Buy Epic Assets," *AINonline*, April 30, 2010.

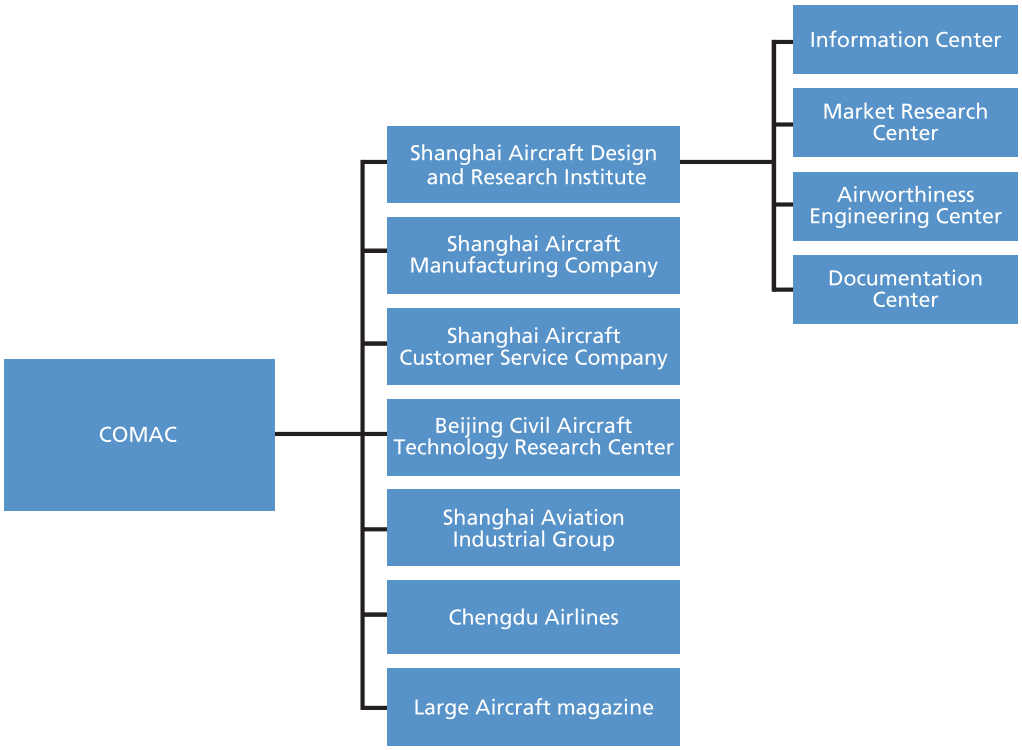
[19] Lin, 2012, p.1.

[20] Bradley Perrett, "Chinese Advances," *Aviation Week and Space Technology*, Vol. 170, No. 4, January 26, 2009, p. 313.

[21] Discussions with industry experts in China in the fall of 2012.

[22] Medeiros et al., 2005, pp. 182–183.

**Figure 2.2**
**Abbreviated Organizational Chart of COMAC's Aviation Units**




SOURCES: Compiled from the COMAC company website, COMAC annual reports, and media reports.
RAND *RR245-2.2*

for producing a military rather than commercial aircraft are very different and AVIC had not been successful in producing and marketing commercial aircraft, Chinese policymakers felt that a new corporation that would focus solely on commercial aircraft was needed, especially as AVIC and its subsidiaries have not been sensitive to market forces. The decision to set up COMAC was also driven in part by the perception that a new organization was needed to manage the program. This perception was driven in part by the success of the Chinese space program, which set up a new organization to spearhead the manned space program. That approach has been quite successful.

As of 2012, COMAC had 6,000 employees, many of whom are employed in businesses not related to aviation. Its aviation activities are focused on producing the ARJ-21 and designing and manufacturing the C919.[23] Given the differences in size and market focus between COMAC and AVIC, AVIC will remain the backbone of the Chinese aviation industry. It will also be a major Tier One supplier to COMAC.[24]

[23] Baidu Online Encyclopedia, "COMAC," web page, undated.

[24] Suppliers in manufacturing industries are often categorized as Tier I, Tier II, and Tier III. Tier I suppliers provide complete modules to original equipment manufacturers for final assembly into the product. Tier II suppliers provide components or submodules to Tier I suppliers. For example, a Tier II supplier might provide the hydraulic assemblies for landing gear manufactured by a Tier I supplier. A Tier III supplier provides parts to Tier I or Tier II suppliers rather than subassemblies or modules.

***Shanghai Aircraft Manufacturing Company, Ltd. (上海飞机制造有限公司)***

The SAMC is COMAC's assembly and manufacturing center. It is responsible for the final assembly and systems integration of the ARJ-21 regional jet and the C919 narrow-bodied commercial jet projects. SAMC (formerly the Shanghai Aircraft Manufacturing Factory) established itself as China's leading builder of large commercial jets when it successfully developed China's first jet airliner, the Y-10, in the early 1980s. Between 1986 and 1994, it partnered with McDonnell Douglas to assemble the MD-80 series of narrow-body jets. Today, it is a subcontractor for Boeing and Airbus.

SAMC's new assembly facility in Shanghai's Pudong New District was completed in 2009. By 2010, the facility reportedly had the capacity to assemble up to 30 ARJ-21s per year; the capacity was scheduled to expand to 50 by 2012.[25]

## The Development of China's Commercial Aviation Manufacturing Industry

### History

From the beginning of the People's Republic of China, the Chinese government has sought to develop China's capacity to produce capable military aircraft. Commercial aircraft manufacturing and operations in China were given a lower priority. In fact, the commercial aviation sector got its start under the management of the Chinese military. As one aviation industry expert noted, the military background of China's civilian aviation sector is "an origin that shapes the development of the industry down to the present . . . including a number of bad habits that make it less market-oriented and less competitive."[26]

In the 1970s, China made the first of several attempts to build a commercial jet. SAMC developed the most successful of these—the Y-10 jet transport, an aircraft broadly similar to the Boeing 707. Although a number of test flights conducted in the early 1980s were apparently successful, the plane cost significantly more than Western planes; Chinese airlines found it more profitable to purchase aircraft from Boeing and Airbus. The program was discontinued due to design and cost problems.[27]

Following the cancellation of the Y-10 program in 1983, Chinese planners formulated a "three-step plan" for the development of a commercial jet industry. According to this plan, China would proceed from local production and assembly of foreign designs to local development with foreign assistance, then to completely independent local development without foreign assistance by 2010.[28] The target date would prove optimistic, but "step one" of the plan got off to a quick start in 1985, when SAIC reached an agreement with McDonnell Douglas to assemble the MD-82 narrow-body airliner in Shanghai from kits. Between 1986 and 1994, a total of 35 MD-82/83 jets were assembled, including five MD-83s that were exported back to the United States. The two partners planned to assemble 40 MD-90s, an upgraded deriva-

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[25] GlobalSecurity, "Shanghai Aviation Industry (Group) Co., Ltd.; Shanghai Aircraft Manufacturing Factory (SAMF); COMAC Final Assembly Center," web page, undated b; COMAC, "COMAC Final Assembly Center," web page, undated b.

[26] Interview with aviation industry expert in China.

[27] Medeiros et al., 2005, p. 174.

[28] Mark Dougan, *A Political Economy Analysis of China's Civil Aviation Industry*, London: Routledge, 2002, pp. 102–105.

tive of the MD-80 series, but Boeing stopped producing the aircraft following its merger with McDonnell Douglas, and the program was discontinued.[29]

Following the termination of the MD-80/90 venture, in 1997, China persuaded a consortium that included Airbus and Singapore Technologies to join AVIC in the development of a 100-seat regional jet, dubbed the AE-100. This program ended in 1999, when Airbus pulled out in the wake of the Asian financial crisis. Airbus concluded that the program no longer fit into its strategic plan in light of the altered economic outlook.[30]

Subsequently, Chinese planners focused on smaller regional jets in the hope of gradually working their way up to larger aircraft as the industry gained experience. In 2000, Xi'an Aircraft Company, Chengdu Aircraft Industry Group, Shenyang Aircraft Corporation, and the Shanghai Aircraft Manufacturing Company formed a consortium in Shanghai to develop and produce a regional jet, designed for flights of less than three hours and seating 70 to 105 passengers, known as the ARJ-21. Although launched in 2002, the plane was first flown in November 2008, but has not yet been certified. Its design is based on the MD-90. Ukraine's Antonov Design Bureau has provided help with the final design. The airframe is being manufactured by a consortium of AVIC companies; major subsystems are sourced from various American and European companies, including GE, Rockwell Collins, Honeywell, Liebherr, and Safran.[31] Deliveries were originally scheduled to begin in late 2011. However, as of 2013, the project was still contending with various manufacturing issues, and the aircraft is unlikely to get Chinese regulatory approval before 2014.[32] The partners hope for a total production run of some 850 planes through 2030.[33]

In December 2002, another Chinese aircraft manufacturer, the Harbin Aircraft Industries Group, formed a joint venture with Brazil's Embraer to assemble Embraer's ERJ-145 family of 30- to 50-seat regional jets in Harbin.[34] The Embraer Harbin facility made its first delivery in February 2004. However, the venture struggled from the start. Despite a production capacity of 24 aircraft a year, the facility delivered a total of only 41 ERJ-145 aircraft over seven years before production ended in April 2011. Production at the facility will now reportedly switch to the Legacy family of business jets.[35]

More recently, the Chinese industry appears to have shifted its focus to larger aircraft in the 130- to 170-seat class that currently account for the bulk of China's commercial air fleet. In September 2008, a joint venture between Airbus and a Chinese consortium was set up in Tianjin to perform final assembly of the Airbus A320. The venture delivered its first A320 in June 2009, and delivered its 100th in 2012.[36] Because of low volumes, unit production costs

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[29] International Trade Administration, *Flight Plan 2010: Analysis of the U.S. Aerospace Industry*, 2010, pp. 56–57.

[30] Dougan, 2002, p. 108.

[31] Roger Cliff, Chad J. R. Ohlandt, and David Yang, *Ready for Takeoff: China's Advancing Aerospace Industry*, Santa Monica, Calif.: RAND Corporation, MG-1100-UCESRC, 2011, pp. 26, 45.

[32] Perrett, 2012.

[33] Cliff et al., 2011, pp. 26–27.

[34] Andrea Goldstein, "A Latin American Global Player Goes to China: Embraer in China," *International Journal of Technology and Globalisation*, Vol. 4, No. 1, 2008, p. 63.

[35] "Harbin Embraer Aircraft Delivers Last ERJ 145 to Tianjin Airlines," *What's On Tianjin*, May 27, 2011.

[36] Kurt Hofmann, "Airbus Tianjin Factory to Deliver 100th A320 in September," *ATW Daily News*, June 15, 2012.

are higher than those in Europe.[37] Costs may fall over time, but volumes will be constrained because the facility is intended to produce aircraft only for the Chinese market.[38]

China's indigenous commercial jet project in this class, the C919, was launched in 2009.[39] COMAC had hoped for the maiden flight to be in 2014 and first deliveries by 2016,[40] but observers of the Chinese industry now believe the first flight will not take place until the second quarter of 2015, and the first deliveries are unlikely before 2018.[41] COMAC's SAMC will produce a small-partition airframe to be manufactured by a consortium of Chinese firms; as with the ARJ-21 program, Xi'an Aircraft will manufacture most of the C919's aerostructures, including most of the fuselage. Hongdu Aviation/Nanchang Aircraft will produce the aft fuselage, Harbin Aircraft will produce the fairings (parts of the aircraft that reduce drag) and moving surfaces, Shenyang Aircraft will produce the tail assembly, and Chengdu Aircraft will manufacture the nose.[42] As with the ARJ-21 program, major systems are to be sourced from international suppliers; however, in the case of the C919, all international systems-suppliers to the C919 project have had to set up joint-venture manufacturing sites in China with Chinese partners as part of supplier contracts. In general, the Chinese partner is to have a majority stake of at least 51 percent.[43] COMAC has set ultimate production goals for the C919 of 150 aircraft per year, which would supply one-third of China's domestic demand and account for 10 percent of the international market. At present, the project is clearly the top priority for the Chinese commercial aviation industry; many of the senior personnel on the ARJ-21 program are said to have been reassigned to the C919 program.[44] As of May 2013, the total number of domestic and foreign orders for the C919 is said to have reached 380, although it is not clear how many of these consist of nonbinding options.[45] Individuals we interviewed in China stated that purchasers have yet to put money down and that prices have yet to be negotiated.[46]

China has engaged in the production of parts and subassemblies for Western aircraft manufacturers for many years; most major Chinese enterprises in the industry are engaged in some subcontracting production. The value of subcontracting production in the sector was

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[37] Interview with aviation industry expert in China.

[38] Yuan Ma, "First A320 Assembled in China Makes Maiden Flight (中国组装A320首飞)," *International Aviation*, June 2009, p. 42.

[39] Philip Butterworth-Hayes, "China's Short March to Aerospace Autonomy," *Aerospace America*, February 2010, p. 27.

[40] Tu Lei, "Aviation Industry Gets Landmark 8-Year Road Map: MIIT Plans for Competitive Future," *Global Times*, May 24, 2013, p. 23.

[41] Bradley Perrett, "Further Delays On COMAC C919 Program Push First Flight to 2015," *Aviation Week*, May 24, 2013b.

[42] "COMAC Reveals Local Supply-Chain Plan," *Flight International*, September 29, 2009.

[43] Cliff et al., 2011, p. 43; interviews with U.S. government officials, managers of international aircraft manufacturing companies in China.

[44] Sabrina Zhang, "Indonesia Halts US$1.2 Billion ARJ Order," *World Civil Aviation Resource Net*, May 22, 2012a; interviews in China with managers working on the project.

[45] Lei, 2013, p. 23; Sabrina Zhang, "Chinese-Made C919 to Be Launched in 2016," *World Civil Aviation Resource Net*, August 9, 2012b; interviews in China with managers knowledgeable about the project.

[46] Interviews in China with managers knowledgeable about the project.

estimated to be roughly $350 million in 2010, and year-on-year growth rates have generally been in the double digits.[47]

### Output and Employment

Output and employment in China's commercial aviation manufacturing industry have been increasing. Between 2005 and 2010, total industry sales increased from $6.8 billion (as measured in 2005 U.S. dollars) to $16.0 billion in 2010. Output rose 134 percent over this period, at an average annual rate of 18.6 percent (Table 2.3). Growth has been volatile, with output falling 4.9 percent in 2008 while rising 53.6 percent in 2006. Compared to aviation manufacturing industries in other countries, sales remain concentrated on the domestic market: Cumulative exports ran 17.3 percent of cumulative output from 2005 to 2010, exports as a share of output has fluctuated between 13 and 21 percent. China's industry has been growing, but domestic sales, not exports, have been the primary driver.

Total employment in commercial aviation manufacturing has increased from 234,390 in 2005 to 254,844 by 2010, a 9 percent overall increase and numbers that rival employment in this industry in the United States and other major countries with a large commercial aviation manufacturing industry (Table 2.4). The absolute numbers and shares of employees who are engineers/technicians or are recorded as working in research and development activities have increased in recent years.

### Technological Capabilities of China's Commercial Aviation Manufacturing Industry

Since the first Chinese-assembled MD-82 rolled out in Shanghai in 1986, the Chinese commercial aviation industry has greatly improved its overall industrial capabilities. The production of components, subassemblies and final assemblies for foreign commercial aircraft makers has required many of China's aircraft producers to build modern factories, purchase more technologically sophisticated manufacturing equipment, provide better training for personnel, and improve quality assurance. Computer-integrated manufacturing systems and automation tools such as computer-aided design software, computer-aided process planners, and digitally controlled machine tools have become widespread in leading Chinese aviation factories.[48] Chi-

**Table 2.3**
**Sales and Revenue of China's Commercial Aviation Industry by Year**

| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|
| Sales and Revenue | (Millions of U.S. Dollars in Constant Prices of 2005) | | | | | |
| Output | $6,847 | $7,475 | $11,482 | $13,377 | $12,728 | $16,043 |
| % change over previous year | Not available | 9.2% | 53.6% | 16.5% | –4.9% | 26.0% |
| Exports | $995 | $1,262 | $2,003 | $2,775 | $1,779 | $2,107 |
| % change over previous year | 26.8% | 58.8% | 38.5% | –35.9% | 18.4% | 26.8% |
| Exports as a share of sales (%) | 14.5% | 16.9% | 17.4% | 20.7% | 14.0% | 13.1% |

SOURCE: *China Civil Aviation Industrial Statistical Yearbook*, 2007–2011.

NOTE: Dollar figures deflated by the U.S. GDP deflator.

[47] China Economic Information Network, *2009 China Aircraft Manufacturing Industry Annual Report*, Beijing: China Economic Information Network, 2009, p. 38.

[48] Medeiros et al., 2005, pp. 182–183.

**Table 2.4**
**Employment in China's Commercial Aviation Industry, by Year**

| Employees | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|
| Total employees | 234,390 | 230,547 | 251,390 | 246,736 | 241,609 | 254,844 |
| Engineers and technicians | 36,709 | 38,166 | 52,005 | 49,250 | 48,383 | 54,397 |
| Engineers and technicians as % of total employees | 15.7% | 16.65% | 20.7% | 20.0% | 20.0% | 21.4% |
| R&D personnel | 22,278 | 25,616 | 23,653 | 27,233 | 26,812 | 28,050 |
| R&D personnel as % of total employees | 9.5% | 11.1% | 9.4% | 11.0% | 11.1% | 11.0% |

SOURCE: *China Civil Aviation Industrial Statistical Yearbook*, 2007–2011.

nese aerospace enterprises have received AS9100 and NADCAP certification (international quality-control standards).

However, not all aircraft design and manufacturing in China are state of the art. Chinese analysts admit that many enterprises are not operated according to modern management principles. We were informed by some companies that some of the AVIC subsidiaries to which they subcontract have asked for increases in prices to cover rising labor and other costs. Company managers said AVIC has been less willing to cover losses of its subsidiaries stemming from losses from subcontracting. In the past, AVIC's focus had been on improving manufacturing capabilities so the subsidiaries could manufacture more sophisticated components, and the corporation had been willing to cover losses associated with providing more sophisticated components so as to acquire these capabilities. However, now that the technological sophistication of the subsidiaries has risen, AVIC management has been under pressure to reduce losses.[49]

China has yet to certify an indigenously designed and developed large commercial jet. As noted, the COMAC ARJ-21 has run into repeated delays.[50] A key problem has been a lack of systems integration skills. Boeing and Airbus have moved to using a "distributed airframe manufacturing process," whereby subcontractors are responsible for manufacturing major sections of the airframe, which Boeing and Airbus then assemble. According to a source familiar with the project, "[different parts are] indeed produced by different manufacturers. However, most of the time, the lack of communication and coordination is causing the manufacturers to be working on their own. The finished products are having compatibility issues during final assembly."[51] Quality has also been a problem. Certain parts of the aircraft have failed to meet quality requirements, and the difficulties are only being slowly overcome.[52]

In addition to integration challenges, China's industry still struggles to integrate the development of new designs into manufacturing. Traditionally, China's research and design institutes had been completely funded by the state through annual budgetary allocations. The institutes still receive partial support through annual budgetary outlays, but now depend on contracts for the remainder of their funding. Historically, after an institute completed a design, the designers reportedly simply handed over the blueprints and design data to the manufacturing enterprise without compensation. This state of affairs has changed: Aircraft design

[49] Interview with Western analyst of China's aviation industry.

[50] Bradley Perrett, "ARJ21 Certification Delayed To 2014," *Aviation Week and Space Technology*, October 26, 2012.

[51] Zhang, 2012a.

[52] Zhang, 2012a.

institutes now face greater financial incentives to develop designs in collaboration with manufacturers and better attuned to the needs of the final customer, but the separation of research and design into separate institutes detached from manufacturers still makes the integration of R&D into the final products more difficult than it is in Western companies.[53]

[53] Information provided by Western aircraft component manufacturer with operations in China.

CHAPTER THREE

# China's Industrial Policy and Its Commercial Aircraft Manufacturing Industry

## Chinese Government Policy Goals

The Chinese government uses technological successes, such as the launch of manned spacecraft and the production of stealth jet fighters, as manifestations of the country's rise as a great power. To date, all of China's commercial aircraft have been imported from foreign manufacturers or produced domestically under license from foreign firms. In keeping with these measures of success, the Chinese government sees designing and manufacturing a passenger jet as an important indicator of a nation's technological prowess. The Chinese government also sees a vibrant commercial aircraft manufacturing industry as a source of economic growth and technological spin-offs. To achieve the goal of creating a commercial aviation manufacturing industry, as already noted, the Chinese government has adopted a strategy of first engaging in domestic production and assembly using foreign designs, then developing its own designs with foreign assistance, culminating in completely independent domestic development of a commercial aircraft without foreign assistance.[1]

The importance and priority given the development of a commercial aviation manufacturing industry is reflected in China's last few Five-Year Plans. The development of a high-technology transportation equipment manufacturing sector has been listed as a goal in the tenth (2001–2005), 11th (2006–2010), and 12th (2011–2015) Five-Year Plans.[2] Within these broad, published plans (usually described at the national level as "outlines" rather than detailed "plans"), the commercial aviation manufacturing industry was specifically listed as a priority in the 10th Five-Year Plan, mentioned (once) in Section 2 of Chapter 10, "Promoting High-Tech Research," where aircraft manufacturing was listed at the end of a list of key technologies to promote, from super computers to biotechnology to robotics.[3] In the 11th Five-Year Plan, Chapter 10 ("Accelerating the Development of High-Tech Industries") contains a one-paragraph section on "Promoting the aviation and space industries." Half of this paragraph is devoted to commercial aviation; the other half to space. The paragraph calls for the "development of new regional jets, large jets, helicopters, and advanced aircraft engines and avionics; the expansion of subcontracting production, and the promotion of commercialization (of aviation technology) (发展新支线飞机、大型飞机、直升机和先进发动机、机载设备，扩大转包生产，推进产)."[4]

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1 Lin, 2012, pp. 4–5.

2 National People's Congress, *China's 10th (2001–2005) Five-Year Plan*; *China's 11th (2006–2010) Five-Year Plan*; *China's 12th (2011–2015) Five-Year Plan*.

3 National People's Congress, *China's 10th (2001–2005) Five-Year Plan*.

4 National People's Congress, *China's 11th (2006–2010) Five-Year Plan.*

The *12th Five-Year Plan* also cites the importance of developing a high-technology transportation equipment manufacturing industry. However, commercial aircraft manufacturing was not mentioned explicitly in the national document. To rectify this omission, in 2011, AVIC's director for science and technology, who at the time was a delegate to the National People's Congress, submitted a proposal to add the "vigorous development of the aircraft industry" to the *12th Five-Year Plan*. His proposal was not adopted.[5] In May 2013, however, China's Ministry of Industry and Information Technology issued the "Middle- and Long-Term Development Plan for the Civil Aviation Industry (2013–2020)."[6] The plan lays out China's goals for the industry in much more detail.

A number of other indicators point to the importance of the commercial aircraft manufacturing industry to the Chinese government. In mid-2012, the State Council reconfirmed commercial aviation manufacturing as a goal when it included it as one of seven "new strategic industries" that would serve as an engine of economic growth fueling the country's economy over the next several decades. Since these announcements were made, all nine members of the Chinese Communist Party's Politburo's Standing Committee have reportedly "given important directions" supporting the development of COMAC, and prominent members of the full Politburo have paid visits to COMAC exhibitions to show support.[7] As one analyst argued to us, China's move into commercial aviation is "not a commercial program, this is a program about national face and the greatness of the Chinese nation" in the eyes of the top leaders of the Chinese Communist Party.[8]

The management of AVIC has explicitly argued for the importance of developing a commercial aviation manufacturing industry in China. In the words of AVIC CEO Lin Zuoming, "large multinational corporations are an important form of strategic power for the reflection of the national will. For a large country such as China, its comprehensive national power must be supported by well-diversified, large-scale, multinational corporations . . . Only then will we have a say in the world."[9]

## Chinese Policy Instruments

The Chinese government has employed several policy instruments in its efforts to create an indigenous commercial aviation manufacturing industry. These fall into the following categories:

- setting up national champions
- providing launch aid
- compelling state-owned airlines to purchase Chinese aircraft

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[5] Hongbiao Zhang, "Proposal for Including Aviation Industry in the *Twelfth Five-Year Plan*, 张洪彪：关于航空产业列入"十二五"规划的提案, 2011.

[6] Ministry of Industry and Information Technology, 2013.

[7] Chengbin Yajie Li Sun and Zhenghong Li, "New Waves Surging on the Banks of the Huangpu River, Scientific Development Raising Its Sails – Secretary General Hu Jintao on Work Inspection Tour in Shanghai (浦江两岸涌新潮,科学发展扬风帆—记胡锦涛总书记在上海市考察工作)," *People's Daily*, January 18, 2010.

[8] Interview with manager from Western aircraft component supplier.

[9] Lin, 2012.

- targeting orders to foreign manufacturers with assembly operations in China or who source from China
- stipulating that foreign suppliers enter into joint ventures with Chinese partners
- encouraging foreign countries to purchase Chinese aircraft through diplomatic persuasion and the provision of loans.

These measures are intended to result in the emergence of an independent domestic champion in the commercial aircraft manufacturing industry that China hopes will eventually be competitive with Boeing and Airbus.[10]

### Setting Up National Champions

The Chinese government merged AVIC I and AVIC II back into a single company in 2008, and it created COMAC, a state-owned company dedicated to producing commercial aircraft designed and manufactured in China. In contrast to AVIC, which is focused on military aviation, COMAC's mission is to produce commercially viable jet aircraft, a mission no previous Chinese state-owned company has had. In a sign of how important the COMAC initiative is within the leadership, COMAC's first Chief Executive Officer and Party-Secretary outranked the Party-Secretary of AVIC—while the former had been a full member of the Chinese Communist Party's Central Committee since 2002, the latter did not become a full Central Committee member until 2012. However, COMAC's current CEO ranks below the CEO of AVIC in terms of Party ranking.[11]

### Providing Launch Aid

One of the greatest hurdles facing any aircraft manufacture is obtaining the financing needed for the long, expensive process of developing a new airplane. For example, Airbus's A380 cost 11 billion euros (more than $13 billion) and took over a decade to develop.[12] Designing and developing a new commercial jet is an especially difficult challenge for a company like COMAC that has not previously designed and built a new aircraft and has no existing models to generate revenues and profits to sustain the company while the costs of developing a new plane are incurred.

Like all other major investment projects in China, the C919 project first had to be approved by the National Development Reform Commission, formerly the State Planning Commission. As part of the approval process, the NDRC first requested the Ministry of Industry and Information Technology to conduct a technical review of the proposed project before giving COMAC approval to proceed.[13] The technical review is a precondition before the NDRC can give its approval to launch a project.

After the C919 project was approved in 2009, COMAC was able to draw on its 19 billion renminbi ($2.8 billion) in paid-up capital to begin development. The capital had been injected into the company in 2008 to provide funding for the launch of the C919. In addition to 6 billion renminbi in capital from the central government held by the State-owned Assets Supervi-

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[10] Lin, 2012, p. 1.

[11] National People's Congress, "Roster of the 16th Central Committee of the Chinese Communist Party."

[12] Guy Norris and Mark Wagner, *Airbus A380: Superjumbo of the 21st Century*, St. Paul: Zenith Press, 2005.

[13] Interviews with individuals engaged in C919 project.

sion and Administration Commission of the State Council (SASAC), other government entities and state-owned enterprises also invested in the company, including 5 billion renminbi from the Shanghai Municipal Government's Guosheng Investments Group, 1 billion renminbi from Aluminum Corporation of China (Chinalco), 1 billion renminbi from Baosteel Group, and 1 billion renminbi from Sinochem.[14] AVIC's equity investment of 5 billion renminbi in COMAC was primarily made through the transfer of assets: Commercial Aircraft Co., Shanghai Aircraft Manufacturing Factory, and the Shanghai branch of First Aircraft Institute, as well as the intellectual property rights to the ARJ-21.[15]

Once the NDRC approved the project, COMAC also became eligible for a variety of state-supported funding, including loans from state-owned banks. In 2009, China's Bank of Communications provided a credit line of 30 billion renminbi ($4.4 billion) for the development of the C919. Coupled with the equity investments, COMAC had initial resources of more than $7 billion for the development of the C919.[16] In addition, COMAC can ask investors such as the state-owned companies and the Shanghai Municipal Government to provide guarantees on loans made to COMAC.

The Shanghai Municipal Government's equity stake in and support for COMAC is not unusual. Local governments have played a major role in promoting the growth of the commercial aviation manufacturing sector. Regional, provincial, and local governments have all provided financial and other support to joint ventures with and subsidiaries of AVIC and other manufacturers of aviation components and modules. As a high-technology industry, aviation manufacturing is considered prestigious and worthy of government support. Managers of the manufacturers of components and subsystems in the aviation industry frequently pursue a strategy described as 'two fusings' (*liang rong*), fusing themselves to foreign firms with advanced technologies and to local governments with the financial resources, land, and powers over tax policy to subsidize investment by joint ventures and companies and create a favorable environment for company operations.[17] Chinese news media have described how local governments have supported the aviation industry by setting up industrial parks for aircraft manufacturing, reserving plots for manufacturers, providing financial assistance, engaging in workforce training, and offering other forms of support, with the aim of inducing aircraft manufacturers to settle in their localities.[18] According to one of our interlocutors, local officials find that supporting the construction of a new plant for manufacturing aviation components highly attractive.[19] The plants result in increased economic output in the local community, a key indicator for judging the success of the local leadership. Because aviation is considered a high-technology industry, these plants are looked on favorably by the government and Chinese Communist Party hierarchy, which contributes to career advancement for local officials. Local

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[14] Anil Gupta and Haiyan Wang, "COMAC: China's Challenge to Airbus and Boeing," *Bloomberg BusinessWeek*, June 30, 2010.

[15] GlobalSecurity.org, "Commercial Aircraft Corporation of China (COMAC)," web page, undated a.

[16] Gupta and Wang, 2010.

[17] Interview with Western expert on China aviation manufacturing industry.

[18] "Domestically Manufactured Large Aircraft—The Making of China's Aviation Manufacturing Industrial Cluster," *High Tech Science and Technology Review* (高新技术科技导报), July 30, 2010.

[19] Interview with Western expert on China aviation manufacturing industry.

officials are also able to leverage the national program to obtain loans and other forms of support, as well as personal advancement.

The plants also provide opportunities for graft. Because the plants are often built on land that had been farmland, local governments can requisition this land and lease it to companies for new plants. Construction companies benefit from contracts to build the new facility. Local and higher-level government officials may benefit from kickbacks provided by developers and construction companies who are awarded the contracts.[20] The costs of these economic zones are paid by local communities, which receive less than the market value of the land, and by the national government and state-owned banks, which pick up losses from zones that fail to cover their costs.

### Compelling State-Owned Airlines to Purchase Chinese Aircraft

Chinese carriers are virtually the only customers for both the ARJ-21 and C919.[21] As of April 2013, Chinese domestic airlines accounted for 251 of the 267 orders (94 percent) for the ARJ-21.[22] COMAC states that it now has 380 orders for the C919s, but only ten have been ordered by customers other than Chinese airlines—an order by GE Capital Aviation Services, a leasing firm that will lease the aircraft to Chinese carriers.[23] Without these orders, the C919 could not be launched. ABCDlist, an airline information website, only reported 150 firm orders and 55 options for the C919 as of December 20, 2012 (Table 3.1).

The Chinese government is able to pressure China's airlines to order these aircraft through a variety of mechanisms. First, the Civil Aviation Administration of China has to approve all purchases of aircraft by Chinese airlines.[24] Through the approval process, the Civil Aviation Administration can pressure airlines to purchase Chinese-designed and manufactured airplanes. Second, China's three largest airlines are all state-owned companies. The CEOs of these state-owned companies are appointed by SASAC, but must be approved the Central Organization Department of the Chinese Communist Party. Job retention and career advancement depends upon how well these CEOs pursue the Chinese government's strategic goals, along with how well their companies perform financially.[25] Third, these three airlines have relied on financial support from the state to finance their operations and expand their fleets. For example, in 2009, China Southern received a $1.5 billion capital injection that helped cover procurement and other costs. These airlines also rely on loans from state-owned banks provided at lower-than-market interest rates to finance their operations and purchase aircraft. These loans

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[20] Information provided by Western expert on China aviation manufacturing industry.

[21] Aubrey Cohen, "COMAC C919 Lands Orders from Six Customers for 100 Jets," *Seattle Post-Intelligencer*, November 16, 2010.

[22] ABCDlist, "COMAC ARJ21 Production List," ABCDlist website, February 13, 2013a.

[23] Gordan G. Chang, "China's Aviation ABCs: Airbus, Boeing, and COMAC," *Forbes*, November 25, 2012.

[24] Andrea Goldstein, "The Political Economy of Industrial Policy in China: The Case of Aircraft Manufacturing," William Davidson Institute Working Paper Number 779, the University of Michigan Business School, Ann Arbor, Mich., July 2005.

[25] Andrew Szamosszegi and Cole Kyle, "An Analysis of State-Owned Enterprises and State Capitalism in China," *U.S.-China Economic and Security Review Commission Report*, October 26, 2011, p. 73.

**Table 3.1**
**Orders for COMAC Aircraft**

| Purchaser | ARJ-21 Sales | ARJ-21 Options* | C919 Sales | C919 Options* |
|---|---|---|---|---|
| ABC Financial Leasing | | | 45 | |
| Air China | | | 5 | 15 |
| BOC Aviation | | | 20 | |
| Bocom Leasing | | | 30 | |
| CCB Leasing | | | 50 | |
| CDB Leasing | | | 10 | |
| Chengdu Airlines | 30 | | | |
| China Aircraft Leasing | | | 20 | |
| China Eastern Airlines | | | 5 | 15 |
| China Southern Airlines | | | 5 | 15 |
| GECAS | 5 | 20 | 10 | 10 |
| Hainan Airlines | | | 5 | 15 |
| Hebei Airlines | | | 20 | |
| Henan Airlines | 100 | | | |
| ICBC Leasing | | | 45 | |
| Joy Air | 50 | | 20 | |
| Lao Airlines | 2 | | | |
| Merkukh Enterprises | 9 | | | |
| Shandong Airlines | 10 | | | |
| Shanghai Airlines | 5 | | | |
| Shanghai Financial Leasing | 30 | | | |
| Shenzhen Financial Leasing | 20 | | | |
| Sichuan Airlines | | | 20 | |
| Xiamen Airlines | 6 | | | |
| Totals | 267 | 20 | 150 | 55 |

SOURCES: ABCDlist, 2013a; ABCDlist, "Commercial Aircraft Sales," ABCDlist website, April 2013b.

* Options or Letters of Intent.

are often provided in accordance with government-directed investment policies: in this case, to make purchase decisions in accordance with government policy.[26]

In some instances, airline executives have reportedly been unhappy about these orders. An aviation insider reports that one CEO of a Chinese airline referred to the ARJ-21 as "that stupid airplane," while another expressed the view that there are "no prospects for regional jets in China."[27] As noted by Cliff et al., China has constructed a large high-speed rail network. Regional jets, which are designed for shorter hauls, compete directly with high-speed rail. The higher per-seat costs of regional jets will make it difficult for airlines to compete against high-speed trains.[28] In general, orders appear to be soft. One interlocutor stated that no money has

[26] Szamosszegi and Kyle, 2011, p. 46.

[27] Information provided by Western expert on China aviation manufacturing industry.

[28] Cliff et al., 2011, p. 17.

exchanged hands for most orders; purchase price, guarantees, and delivery times have not yet been determined.[29] Some of the "orders" are only letters of intent or options to buy.

### Targeting Orders to Foreign Manufacturers with Assembly Operations or Suppliers in China

Not only does the Chinese government use the Civil Aviation Administration's approval process to pressure state-owned airlines to make purchase decisions in accordance with government policy, it also uses this power to encourage foreign commercial aviation product manufacturers to purchase Chinese components and to set up joint ventures in China. As part of its strategy to develop a commercial aviation manufacturing industry, the Chinese government has encouraged Western commercial aircraft manufacturers to establish joint ventures with state-owned corporations for final assembly of aircraft as well as components. Companies that have set up assembly operations have benefited from sales. As already noted, McDonnell Douglas, which at the time was the weakest of the three major manufacturers of large commercial aircraft, set up an assembly operation with SAIC in Shanghai to sell to the Chinese market, and was able to sell 30 planes to Chinese airlines from this assembly operation before a merger with Boeing led to the assembly operation being closed.[30]

Airbus and Embraer have also set up joint ventures to assemble some of their models for sale in China; currently, these operations serve the Chinese market only. The opening of Airbus's assembly operation coincided with a dramatic increase in sales of Airbus aircraft to Chinese airlines. In 2005, Airbus reached an agreement with China to establish Airbus's first final assembly line outside of Europe (in Tianjin), and also secured an order for 150 A320 airliners from China.[31] Over the course of the next four years, Airbus won contracts for another 432 aircraft.[32] By comparison, Boeing sold 287 airliners during the same period (2006–2010).[33] Prior to the opening of Airbus's joint venture in Tianjin, Boeing dominated the Chinese market. Since this assembly operation has been up and running, Airbus has more or less split the market with Boeing. Embraer's operation has been much less successful, in part because regional aircraft have not found much of a market in China.

The Chinese government sees procurement of components by foreign aircraft manufacturers as helpful for introducing modern management and production practices to Chinese partners.[34] Consequently, offsets, or purchases of Chinese-manufactured components by aircraft manufacturers like Boeing and Airbus, have been a factor in Chinese decisions on purchases of aircraft. Both Airbus and Boeing track purchases of components from Chinese companies; more than half of all Airbus planes contain components manufactured in China.[35] These purchases are seen as important for continued sales. In addition to signing contracts

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[29] Information provided by Western expert on China aviation manufacturing industry.

[30] Alexis Haakensen, "Country Studies: China," International Trade Administration, undated; Dominic Gates, "Boeing's China Hand Guides Strategy to Beat Back Airbus," *Seattle Times*, Tuesday, April 11, 2006.

[31] Airbus, "Airbus in China: Aircraft Operations in China," Airbus website, undated b.

[32] Helene Fouquet and Gregory Viscusi, "Airbus, Areva, Total Gain in $22.7 Billion China Contract Haul," Bloomberg.com, November 4, 2010.

[33] Boeing, "Orders and Deliveries," February 13, 2013.

[34] Interviews in China with managers of foreign companies who participate in joint ventures with Chinese firms.

[35] Airbus, undated b.

with Chinese suppliers to supply components, Airbus has set up joint ventures to manufacture modules for some of its aircraft. The Harbin Hafei Airbus Composite Manufacturing Center, opened in February 2011, is a joint venture located in Harbin, China, that will produce composite parts for the A350 XWB jetliner.[36]

Boeing sources a large variety of components and modules from China. Every one of Boeing's commercial aircraft incorporates Chinese-manufactured components or modules. For the 787 program, Chinese manufacturers are the sole source providers of a number of parts made of composite materials, including the rudder, the fin, and fairings. According to Boeing's website:

> Boeing equity investment in China is considerable, and Boeing procurement from China is significantly greater than other aviation companies. In fact, Boeing is China's aviation manufacturing industry's largest foreign customer.[37]

Political winds have a large impact and influence on Chinese orders from Boeing and Airbus. In the past, the Chinese government has suggested that large orders for Boeing planes hinged on the U.S. renewal of China's "Most Favored Nation" trading status.[38] The Chinese government has also suggested that Boeing's success in China might be jeopardized by political friction over Taiwan.[39]

#### Stipulating That Foreign Suppliers Enter into Joint Ventures with Chinese Partners

Chinese aviation industry leaders have made no secret of their desire to trade market access for technology; joint ventures are their vehicle of choice to acquire advanced foreign technologies. Since the late 1990s, the Chinese government has encouraged joint ventures between Chinese manufacturers of aircraft components and their foreign counterparts. Such joint ventures are designed to help Chinese firms acquire technologies, managerial know-how, and production experience. In a manufacturing joint venture, the foreign partner typically supplies the production design and management expertise, while the Chinese partner provides the facility and labor. Thus, the Chinese partner has an opportunity to learn how to efficiently produce a line of products it did not previously have the capability to produce. A drawback to manufacturing joint ventures can be that they are often effectively controlled by the foreign partner, which limits the Chinese partner's ability to steer the venture toward product areas of interest to the Chinese parent company. An R&D joint venture provides an opportunity for the Chinese partner to learn not just how to produce a specific line of products, but how to design and develop entirely new product lines. From the perspective of the Chinese partner, R&D joint ventures provide a better opportunity to improve the production capabilities.[40]

Earlier on, the goal of spurring technology transfer through joint ventures was achieved only in part. In most cases, aviation joint ventures established in China consisted of assembly operations and involved older systems. Since the advent of the ARJ-21 and the C919 projects,

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[36] Airbus, undated b.

[37] Boeing, "Boeing in China," web page, undated a.

[38] John Newhouse, *Boeing Versus Airbus*, New York: Vintage Books, 2007, pp. 182–183.

[39] Kristi Heim, "Boeing Stumbles in Race for China," *Seattle Times*, June 20, 2005.

[40] Cliff et al, 2011, p. 36.

other goals have been given more prominence, especially the goal of establishing a commercial aviation manufacturing industry in China.[41] Chinese government officials have clearly communicated to foreign firms in the commercial aviation manufacturing industry that their business in China would be much more likely to enjoy success if they are seen as a "friend of China." Companies can demonstrate this by setting up local production facilities, bringing in technologies, or participating in the C919 project. Even firms that declined to participate in the C919 have made considerable efforts to ensure that their decision not to participate is not seen as inflicting a loss of face for the Chinese side.[42]

The CEOs of both COMAC and AVIC are aware of the technological limitations facing their companies. To be successful, COMAC must ensure its aircraft will be certified by the Civil Aviation Administration of China to fly within China and by the Federal Aviation Administration (FAA) and the European Aviation Safety Agency (EASA) so that its aircraft can be flown outside of China. Because of the respect accorded the FAA and EASA for their procedures, and the importance of the United States and Europe as destinations, aircraft that have not been certified by the FAA and EASA cannot, for all intents and purposes, fly internationally. The primary means COMAC has employed to reach this goal is to incorporate only modules and components that have already been certified by the FAA and EASA into the C919. In other words, the components and modules used in the C919 will incorporate the same technologies as Boeing's 737 and Airbus's A320. As a recent congressional report notes:

> To overcome the reputation issue, . . . Chinese-owned COMAC have sought well established international joint venture partners that will be involved in the design, manufacture, marketing, and maintenance of commercial aircraft manufactured by those state-owned companies. Their expectation is that such partnerships will increase credibility and reduce the risk to airlines that purchase or lease such planes—especially if the partnerships help those companies establish a reputation for product safety, performance, quality, comfort, and price competitiveness.[43]

To encourage the development of a Chinese industry, COMAC has stipulated in its tender documents that modules and major components used in the aircraft be assembled in China by joint ventures, especially in high-technology areas such as advanced materials and flight control systems where Chinese technology is lagging.[44] According to COMAC Deputy General Manager Wu Guanghui, local production is a requirement for foreign suppliers to the C919 program.[45] In areas of less concern, the Chinese are content with traditional subcontracting or other work-share arrangements.

COMAC prefers that the Chinese partner in these joint ventures own 51 percent or more of the operation. Although this level of Chinese ownership was stipulated in the tender docu-

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[41] Discussions with Western commercial aviation component manufacturers in China.

[42] Discussions with Western commercial aviation component manufacturers in China.

[43] Glenn J. Harrison, "Challenge to the Boeing-Airbus Duopoly in Civil Aircraft: Issues for Competitiveness," *Congressional Research Service Reports*, July 25, 2011, p. 11.

[44] Michael Mecham and Joseph C. Anselmo, "A Big Bet on China for Suppliers," *Aviation Week and Space Technology*, September 6, 2010.

[45] Zhengguo Zhang, (张正国), "C919 Finalizes Selection for Five Major Sub-Systems (C919 选定五大系统供应商)," *International Aviation*, May 2010, p. 34.

ment, not all the winning bidders have had to comply with this stipulation.[46] Moreover, key technologies and components, such as engines or avionics, are still manufactured in the West and imported into China for assembly.

### Acquisitions of Foreign Companies and Foreign Technologies

In recent years, Chinese companies have acquired some foreign firms as a way of also acquiring their manufacturing technologies, products, R&D capabilities, and markets. In December 2009, Xi'an Aircraft Industry Company and a Hong Kong-based private equity firm Advanced Treasure Limited acquired 91.25 percent of Future Advanced Composite Components, an Austrian company specializing in manufacturing parts and modules from composite materials. This was the first acquisition of a large Western aircraft manufacturing company by a Chinese aerospace company. The XIAC CEO at the time of the acquisition, Meng Xiangkai, said the company was actively "joining into the global aviation industry chain."[47] Reflecting the apparent financial difficulties of the Austrian firm, the stake was purchased for $58 million.[48] Subsequent to the acquisition, XIAC and Future Advanced Composite Components created a joint venture in Zhenjiang (in Jiangsu province) to provide composite components for the C919 airframe, including interiors. The venture is also planning to conduct R&D on composite manufacturing techniques.[49]

In March 2011, CAIGA became the first Chinese company to acquire a foreign aircraft manufacturer when it acquired 100 percent ownership of the Duluth, Minnesota-based Cirrus Aircraft Corporation.[50] The deal was approved by U.S. regulators after Cirrus gave assurances that production would remain in the United States, and that Cirrus did not possess any unique technology with military implications.[51] As of 2014, Cirrus Chief Executive Officer Dale Klapmeier remains at the helm. CAIGA appears to have taken a hands-off approach, while the injection of Chinese capital is said to have "re-energized" the company.[52] In November 2012, CAIGA took an additional step toward expanding production of personal and business aircraft by signing a joint-venture agreement with Cessna Aircraft Company, a subsidiary of Textron, to assemble the Citation CLS+ business jet in China.[53]

So far the technologies acquired have not been extraordinarily advanced. Moreover, there are challenges to transferring capabilities to the Chinese parent, including technology export restrictions in the home country of the foreign firm. But as AVIC CEO Lin Zuoming explains,

> [The acquisition of foreign firms] is akin to the hiring of a foreign coach for "one-on-one" training to elevate our R&D level and capabilities. Therefore, the basic objective of foreign acquisitions is not the amount of economic benefits or profits that can be generated in the

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46 Discussion with manager of Western supplier to the Chinese aviation industry.

47 "FACC Acquired by Chinese Aircraft Company," Xinhua News Agency, 2009.

48 Doris Li, "2009—Chinese Enterprises Turned Abroad to 'Buy the Dips'," *Chinese Intellectual Property*, Issue 36, April 2010.

49 "AVIC's FACC to Establish Chinese Branch on Passenger Plane R&D," Xinhua News Agency, 2010.

50 Fallows, 2012, p. 141.

51 Mary Grady, "Cirrus Updates on Jet, China Deal," *AVweb*, March 30, 2011.

52 Russ Niles, "One Year Later: Cirrus Upbeat under Chinese Ownership," *AVweb*, July 22, 2012.

53 McMillin, 2012.

> short term. Rather, the basic objective is to elevate our comprehensive aviation industrial capabilities and research levels . . . so that even greater economic benefits can be generated in the future.[54]

COMAC has also sought to obtain expertise and technologies by hiring knowledgeable individuals and consultants. It has made a concerted effort to staff the company with "overseas turtles," Chinese nationals who left China to study abroad in the 1980s and 1990s and then stayed there to work for foreign companies. COMAC has also hired Western consultants with expertise in aircraft design and system integration, including a former FAA employee with expertise in certification, as well as test flight program managers and pilots.[55]

### Encouraging Foreign Countries to Purchase Chinese Aircraft Through Diplomatic Suasion and the Provision of Loans

The Chinese government has employed both the Chinese diplomatic corps and offers of loans in pursuit of sales of its commercial aircraft. While agreements by overseas airline operators to purchase COMAC's airframes have been few, they carry the potential to give greater credibility to the ARJ-21 and C919 than purchases by domestic Chinese airlines, because they have the appearance of independent commercial validation rather than being a political response to central government pressure to purchase, as Chinese domestic air carriers face.

Chinese diplomats have worked with COMAC to encourage foreign airlines, especially in poorer countries that look to China for development assistance, to agree to purchase COMAC aircraft. Chinese diplomats have informed decisionmakers in those countries that orders are a sign of their support for China's commercial aviation sector.

To date, this strategy to support COMAC has had only limited success. Laos has ordered two of COMAC's ARJ-21 (Table 3.1); Myanmar had options for two, but appears to have canceled the orders.[56] However, industry observers believe that the prices that have been quoted to these countries have been steeply discounted and that financial terms are subsidized.[57]

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[54] Lin, 2012.

[55] Comments provided by manager of Western aviation component manufacturer with subsidiary in China.

[56] ABCDlist, 2013a.

[57] Discussions with Western commercial aviation component manufacturers in China.

CHAPTER FOUR

# The Role of Foreign Companies in China's Commercial Aircraft Manufacturing Industry

In this chapter, we first describe the operations of foreign companies that have invested in the commercial aircraft manufacturing industry in China. We then investigate the reasons why those companies have invested. Finally, we review the challenges these companies face in retaining control over their intellectual property, protecting their investments, and staying competitive with domestic Chinese companies.

## Foreign Companies

Because almost all aircraft manufactured in China have been for the PLAAF, both the Chinese government and foreign companies were initially wary about foreign investment in this industry. The first joint venture in the aviation industry was set up in 1996, when Pratt & Whitney and the Chengdu Engine Group Company established a production facility to manufacture components for aircraft engines and industrial gas turbines.[1] Compared to other industries in China, this investment was fairly late. Since 1996, the numbers of foreign investments in China's aviation manufacturing industry have expanded rapidly; most major foreign commercial aircraft manufacturers and aviation subsystems suppliers now have facilities in China. Table 4.1 shows some of the larger such joint ventures as of 2010. As can be seen, equity in these operations remains small, reflecting the modest size of many of these ventures.

Investments by foreign companies in China range from wholly owned operations or joint ventures manufacturing components and subcomponents for export to joint ventures with Chinese airlines for support services. For example, Boeing owns 88 percent of Tianjin Composites Co., Ltd., a joint venture with an AVIC subsidiary, which assembles composite structures and interior parts for Boeing planes.[2] Boeing also owns a 60 percent share of Boeing Shanghai Aviation Service Co., Ltd., a joint venture with China Eastern Airlines and the Shanghai Airport Authority, which provides line and heavy maintenance, materials management services, component repair and overhaul, and runs a training school.[3]

Airbus has been active in China as well. As already described, Airbus in September 2008 set up a joint venture, Airbus (Tianjin) Final Assembly Company Limited, with a Chinese con-

[1] "Chengdu Aerotech Manufacturing Co., Ltd.," EasyChinaSupply.com website, undated.

[2] "Boeing Tianjin Composite Materials Facility Undergoes Expansion (波音天津复材工厂扩建)," *International Aviation*, December 2008, p. 9.

[3] Boeing Shanghai website, undated.

**Table 4.1**
**Selected Joint Ventures in China**

| Company in China | Foreign Investor | Capital ($million) |
|---|---|---|
| Final Assembly Line China | European Aeronautic Defence and Space Company N.V. | NA |
| The Tianjin Boeing Composites Co., Ltd. | Boeing International Holding Ltd. | $55.0 |
| Qing'an Group Co., Ltd. | Japan Daikin Corporation | $20.2 |
| Xi'an Aero Engine Group Co., Ltd. | Rolls-Royce | $11.0 |
| Zhuhai MTU Aerospace Engine Maintenance Co., Ltd. | MTU Aero Engines | $4.7 |
| Shenyang Liming Aero-Engine Group Co., Ltd. | GE | $1.4 |
| Shanghai Pratt & Whitney Aircraft Engine Maintenance Company | UTC's Pratt & Whitney unit | NA |

SOURCES: *China Civil Aviation Industrial Statistical Yearbook*, 2011; Pratt & Whitney, "Pratt & Whitney Presence in China," news release, undated.

sortium involving the Tianjin Free Trade Zone and AVIC, for final assembly of the A320.[4] Like Boeing, Airbus has also invested in a joint venture, Hafei Airbus Composite Material Manufacturing Center, located in Harbin, to supply composite components for Airbus.[5] Airbus also has a majority stake in Airbus (Beijing) Engineering Centre, a joint venture between Airbus and AVIC that employs Chinese engineers to work on design packages for new Airbus programs.[6]

Over the past few years, the stipulation that suppliers to the C919 assemble their modules in China and in joint ventures with Chinese companies triggered a new round of joint ventures between winners of the supply competition for the C919 and subsidiaries of AVIC. Table 4.2 shows a list of foreign companies that have been designated suppliers for the C919. All of these companies had agreed to set up joint ventures in China to provide modules for the C919.

After winning the competition to be sole suppliers, Nexcelle, Goodrich, Parker Aerospace, Rockwell Collins, and Liebherr set up their first joint ventures in China. In June 2011, CFM International, a joint venture between GE and Snecma of France, signed a Memorandum of Understanding to study local assembly of the LEAP-X1C engine for the C919 in Shanghai. However, in July 2013, Chaker Chahrour, CFM's executive vice president, stated that CFM was unlikely to proceed with assembly in China unless the business case becomes much stronger. He also ruled out a joint venture with AVIC Commercial Aircraft Engines Co. to assemble the engines, even though the latter has reportedly already built an R&D center in Shanghai.[7] GE has also set up a joint venture between GE Aviation and AVIC that will create and market commercial integrated avionics systems around the world. The joint venture will not only provide the avionics for COMAC's C919, but also for aircraft manufactured by Boeing, Airbus, Bombardier, and Embraer. The joint venture's initial focus is to provide integrated avionics systems for the C919 and to build a global customer and product support infrastructure.[8]

At least 19 U.S. and European firms are supplying major components of the ARJ-21, including the engines (GE), avionics (Rockwell Collins), flight control systems (Honeywell,

[4] Airbus (Tianjin) Final Assembly Company Limited, "Where We Operate," EADS, undated.

[5] "Airbus Harbin JV Plant Delivers 1st Work Package," *China Daily*, July 3, 2010.

[6] Airbus, "Airbus in China (空中客车在中国)," Airbus website, undated a.

[7] Greg Waldron, "CFM Cool on Possible Leap-1C Assembly in China," *Flight Global*, July 24, 2013.

[8] "GE's China Avionics Deal: A Q&A with Lorraine Bolsinger," GE website, January 19, 2011.

**Table 4.2**
**International Suppliers for the C919 Program that Have Joint Ventures in China**

| U.S. Partners | Contribution |
|---|---|
| Eaton Corp. | Pipelines for fuel and hydraulic systems |
| GE/Safran | Propulsion (CFM International), engine nacelle, thrust reversers (Nexcelle), avionics system core processing and displays, onboard maintenance and flight data recording |
| Goodrich Corporation | Exterior lighting, landing gear, and engine nacelle components |
| Hamilton Sundstrand | Electric power generation and distribution, cockpit pilot controls |
| Honeywell International | Flight control system; auxiliary power unit, wheels, braking system |
| Kidde Aerospace (Hamilton Sundstrand subsidiary) | Fire and overheat protection systems |
| Parker Aerospace | Fuel and hydraulic systems |
| Rockwell Collins | Communications and navigation systems, integrated surveillance system, cabin core system |
| Zodiac | Interiors |
| **Other International Partners** | |
| Fisher Advanced Composite Components (Austria) | Cockpit, cabin interior, kitchens, restrooms |
| Liebherr Aerospace Toulouse | Air management system |
| Liebherr Aerospace Lindenberg | Undercarriage system |
| Meggitt | Engine interface control unit |
| Safran | Aircraft wiring |

SOURCES: Cliff et al., 2011, p. 46; COMAC, "Suppliers" web page, undated c; Meggitt, "COMAC Chooses Meggitt's Engine Interface Control Unit," November 15, 2012; Safran, "Safran and COMAC Launch Aircraft Wiring Joint Venture," June 20, 2011; Aircraft Interiors International, "Monogram to Supply Water and Waste Systems for C919," undated.

Parker Aerospace), and landing gear (Lieberherr Aerospace). A list of international partners in the ARJ-21 program is provided in Table A.2 in the appendix.

## Why Do Foreign Companies Invest in China?

Through our discussions with representatives of foreign manufacturers of aircraft and aircraft equipment in China, we identified the following reasons why foreign companies engage in the aircraft manufacturing business in the country:

- provide support to Chinese customers
- benefit from a competitive source of parts
- generate sales to Chinese airlines
- purchase Chinese components as a marketing tool to encourage Chinese purchases of aircraft
- participate in the C919 program
- enhance the company's image in China.