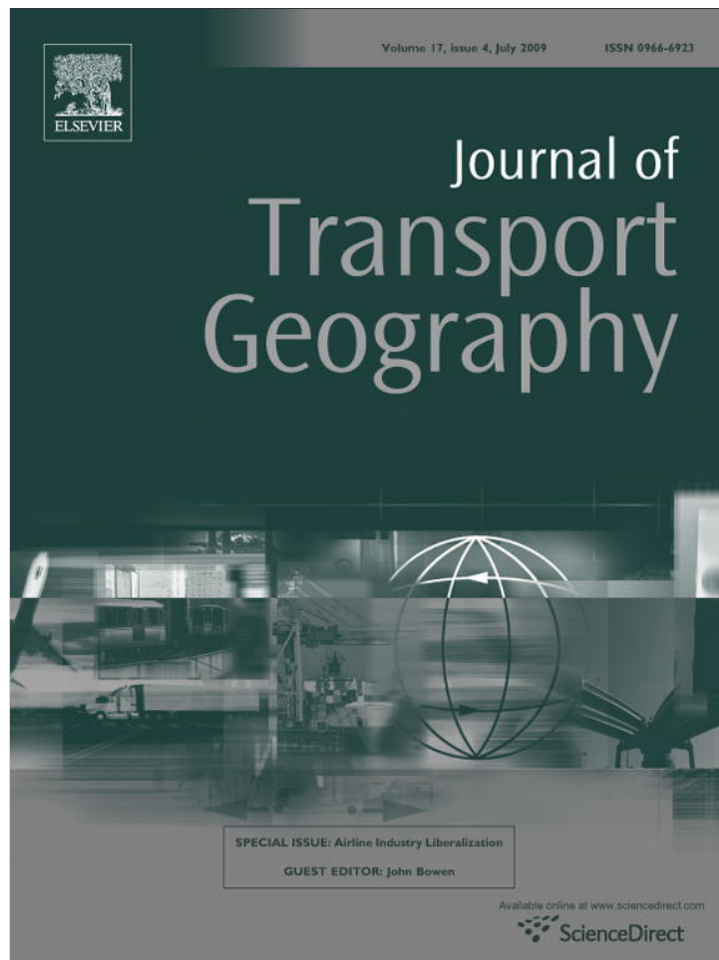


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## Journal of Transport Geography

journal homepage: [www.elsevier.com/locate/jtrangeo](http://www.elsevier.com/locate/jtrangeo)

# China's airline consolidation and its effects on domestic airline networks and competition

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## ARTICLE INFO

## Keywords:

Airline consolidation  
 Liberalization  
 Network  
 China

## ABSTRACT

Air transportation in China has experienced tremendous growth and major reforms in the past three decades. While there is a large literature on airline liberalization, publications about China are limited. As China transforms from a centrally planned economy to a market economy, how closely has China followed the practice of liberalizing the airline industry seen in other countries around the world? This paper offers a review of air transportation development in China and compares China's approach with other countries. In particular, this study examines the impact of the government-led airline consolidation of 2002 upon domestic network structure and competition.

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## 1. Introduction

Today's airline industry is in a very different environment than it was a few decades ago. Many economic, technological, and political factors (e.g., economic and population growth, new aircraft technology, globalization and liberalization) have contributed to the unprecedented changes experienced by the airline industry over the past few decades. Among these factors, the Airline Deregulation Act (ADA) passed by the US Congress in 1978 was undoubtedly one of the most significant events that started the transformation of airline industry. The ADA ended 40 years of tight regulation under the Civil Aeronautics Board (CAB) and aimed at transforming the US airline industry into a freely competitive environment driven by market forces. The passage of Airline Deregulation Act was soon followed by the Staggers Rail Act (1980), the Motor Carrier Regulatory Reform and Modernization Act (1980), and the Bus Regulatory Reform Act (1982) that essentially created a liberalized inter-state transport market in the US (Button, 1991). This trend of moving towards liberalization was not confined to the United States. Many other countries followed suit and began their liberalization efforts (e.g., Button, 1991; Kasper, 1988; Williams, 1994).

Many scholars, including geographers, have studied various aspects of airline liberalization. They include topics such as the spatial effects of deregulation on connectivity and accessibility (Chou, 1993; Ivy et al., 1995; Bowen, 2000, 2002; O'Connor, 2003), market competition and consolidation (Debbage, 1993; Graham, 1993; Goetz and Sutton, 1998; Goetz, 2002), network structures (Shaw,

1993; Shaw and Ivy, 1994; O'Kelly, 1998; Jin et al., 2005), airfare pricing (Oum et al., 1996; Stavins, 2001; Vowles, 2006), and airline alliances (Youssef and Hansen, 1994; Vowles, 2000; Fan et al., 2001; Oum et al., 2001). Mixed findings regarding the effects of airline liberalization have been reported. While some positive effects like increased air passenger volumes and lower average fares have been observed, many negative effects also have surfaced. This has led some researchers to conclude that "deregulation is a failure" (Dempsey and Goetz, 1992, p. xvi).

When other countries around the world followed the US in liberalizing their airline industry, they adjusted the policies and the practices according to the unique characteristics of their own economic, political, and physical conditions. For example, European countries are much smaller than the United States in terms of the land size and must face the challenge of developing an open air transport market across national borders. Canada and Australia are similar to the US on the land size, but their population is far smaller than the US. Asian countries, on the other hand, often have different political systems and business cultures from the western countries. They therefore all have to find their own ways of liberalizing the airline industry. A number of studies that examine airline liberalization in Europe (Dennis, 1994; Ivy, 1995; Graham, 1997, 1998; Thompson, 2002; Goetz and Graham, 2004; Fan, 2006), in Canada (Oum, 1991; Williams, 1994), in Australia (Forsyth, 1991; Hooper, 1998), and in Asia (Bowen and Leinbach, 1995; Bowen, 2000, 2004) have been published.

Although many important changes have occurred to air transportation in China due to rapid economic growth and major reforms over the past three decades, one interesting observation is that relatively few studies of the airline industry in China have been published in the mainstream geography and transportation

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journals. Jin et al. (2004) examine the changes of geographic patterns of air passenger transport in China from 1980 to 1998 with respect to its economic growth, regional inequality, and network development. Wang and Jin (2007) investigate the uneven spatial distribution of airports and the hierarchical pattern of air passenger flows in China. Ma and Timberlake (2008) use longitudinal air passenger flow data to analyze the leading cities in China at both the national and global levels for the period of 1990–2005. Zhang and his associates (1998, 2003, 2008) have published several articles about China's air transport development and reform in transportation journals.

China is the most populous country in the world with 1.31 billion people in 2006 (National Bureau of Statistics of China, 2007). It has experienced remarkable changes and growth since the beginning of economic reforms in 1978. China's per capita gross domestic product (GDP) increased from 381 yuan (RMB) in 1978 to 16,084 yuan in 2006, a 42-fold increase in 28 years. Accompanying the economic growth, transportation in China gained an impressive eight-fold growth of total passenger volume from 2.54 billion in 1978 to 20.2 billion in 2006. Measured by the total passenger-kilometers, the growth is 11 times from 1978 to 2006. Among the different transportation modes, highways accounted for 58.5% of total passenger flow, followed by railways (32.1%), waterways (9.1%), and civil aviation (0.1%) in 1978. By 2006, the market shares changed to highways (91.9%), railways (6.2%), waterways (1.1%), and civil aviation (0.8%). Highways clearly gained the dominant role in terms of the number of passengers carried. If we measure the market shares by passenger-kilometers, a different picture emerges. Railways had a market share of 62.7% in 1978, followed by highways (29.9%), waterways (5.8%), and civil aviation (1.6%). By 2006, highways became the dominant mode at 52.8% market share, while railways' share dropped to 34.5%. In the meantime, civil aviation's market share grew from 1.6% in 1978 to 12.4% in 2006. According to the percentage of growth in passenger volume for each travel mode, civil aviation increased 69.4 times from 1978 to 2006, followed by highways at 12.5 times, railways at 1.5 times, and a negative growth of waterways (−4%). Civil aviation therefore is the fastest growing travel mode in China, although highways carry more passengers. China ranked second among the members of the International Civil Aviation Organization (ICAO) in terms of the total revenue passenger-kilometers in 2005.<sup>1</sup> In 2006 alone, China's air passenger volume grew 15.5%, passenger-kilometers increased 16%, and freight tonnage went up by 13.9% compared to the previous year. These growth rates are far above most countries, including the United States (0.1% growth of air passengers in 2006, 4.6% growth of passenger-miles in 2005, and −1.3% growth of freight tonnage in 2006).<sup>2</sup>

As China continues to transform from a centrally planned economy to a market economy, policy liberalization and a shift of power from the central government to local governments have been observed in many sectors, including the airline industry (Zhang, 1998). With its large population size, strong economic growth, and increasing international trade, we can expect that air transport in China will continue to grow both domestically and internationally. It therefore is important to examine the changes in China's airline industry and compare them with the changes observed in the US, Europe, and other Asian countries. The objectives of this paper are twofold. First of all, we will provide an overview of the key transformations of the airline industry in China since the economic reforms in 1978. We then offer an analysis of the domestic passenger airline networks in China before and after the airline

consolidation of 2002. This airline consolidation plan was designed and implemented by the Civil Aviation Administration of China (CAAC) and represents the most recent major policy that has significant and long-lasting impacts on the airline industry in China. A study of the changes caused by this policy can shed light on the current status and future prospects of China's airline industry.

## 2. Development of air transportation in China since 1978

China's civil aviation went through four major development phases since the founding of the People's Republic of China in 1949. The first phase (1949–1978) was characterized by a fully regulated environment under tight military control. In fact, the Civil Aviation Administration of China was initially established as a unit under the Central Military Commission. It became a branch of the Ministry of Transport in 1958 and then was placed under the State Council in 1962. Regardless of the changes in the administrative organization, the CAAC was directly managed by the People's Liberation Army (PLA) Air Force during this phase. Civil aviation in China was tightly controlled in all aspects such as entry, exit, fares, schedules, and routes. The CAAC at this phase served as not only an administrative and regulatory agency but also an entity that directly managed the operation of airports and airlines. Under the CAAC, there were six regional civil aviation bureaus located at Beijing, Shanghai, Guangzhou, Chengdu, Lanzhou (moved to Xi'an later on), and Shenyang. In addition, 23 provincial bureaus and 78 local civil aviation stations were established. Civil aviation in China was under the complete monopoly of the CAAC. There was no competition in the market and efficiency was not a priority during this period. Air transportation mainly served people who worked for government agencies or state-owned enterprises (Zhang, 1998). The airline industry therefore had persistent losses during this phase and experienced a total loss of 360 million yuan during the period of 1968–1974 (Shen, 1992).

The launch of economic reforms in 1978 marked the beginning of the second phase (1978–1987) of civil aviation development in China. A major goal of this phase was to transform the air transport sector from a state-owned operation to a profit-seeking enterprise. As a first step towards this goal, the CAAC was separated from the military in 1980. The central government then announced an incentive policy in 1981 that made the CAAC responsible for any losses incurred and allowed the CAAC to retain part of the revenues. This was an important step towards transforming the airline industry into a profit-seeking enterprise. Nevertheless, the CAAC remained as an agency that regulated the air transport industry and in the meantime operated airports, airlines, and other air transport services. In 1985, airlines funded by local governments and the private sector were permitted to enter the passenger airline market. This phase began the initial transformations of the airline industry in China, but it was far from achieving a deregulated environment.

The third phase (1987–2002) began with a policy announcement in January 1987 by the State Council to separate the administrative role and the operational role of the CAAC. As a result, six state-owned trunk airlines (Air China, China Eastern Airlines, China Southern Airlines, China Southwest Airlines, China Northwest Airlines, and China Northern Airlines) were established between 1987 and 1991. These airlines were made responsible for their own losses/profits and were given power to make decisions on staff hiring, flight frequency, and some other operational tasks (Zhang, 1998). In addition, the CAAC transferred the operation of airports to local governments and made the local governments responsible for the losses/profits of running the airports. The CAAC therefore was no longer involved in airline and airport operations and became an administrative agency only. Another important change

<sup>1</sup> Announcement by the Civil Aviation Administration of China (CAAC), <<http://www.caac.gov.cn/>>.

<sup>2</sup> Bureau of Transportation Statistics, <[http://www.bts.gov/publications/national\\_transportation\\_statistics/](http://www.bts.gov/publications/national_transportation_statistics/)>.

since mid-1980s was the relaxation of regulations on market entry and route entry (Zhang and Round, 2008). A number of new carriers funded by local governments or government-owned enterprises entered into the market between mid-1980s and early 1990s. For example, Xiamen Airlines was established in 1984 by CAAC Shanghai Bureau and government-owned enterprises in Fujian province. The Shanghai municipal government founded Shanghai Airlines and began operations in 1985. Sichuan Airlines owned by the Sichuan provincial government started its operations in 1988. Hainan Airlines was initially established as Hainan Province Airlines in 1989. Shenzhen Airlines and several other new carriers began their services in early 1990s. Many of the new carriers however were too small to achieve economies of scale and were losing money. This situation is similar to the wave of new entrant carriers entering the market during the first few years after the airline deregulation of 1978 in the United States. Between 1983 and 1988, a number of US airlines were in financial difficulty and many bankruptcies, mergers, and acquisitions were observed in the US airline industry (Goetz and Sutton, 1998). In response to the deteriorating financial situation caused by competition among the airlines, the Chinese State Council released a new policy announcement in 1993 that called for reexamining the qualification of existing carriers and stopping the approval of new carrier applications (Zhang and Chen, 2003). This announcement signaled an important policy shift from encouraging new entrants to encouraging mergers and consolidation.

With the new non-CAAC airlines and easier approval of new routes, the number of domestic and international routes increased significantly during this phase. Table 1 indicates that the number of domestic routes (excluding routes connecting Hong Kong and Macao) increased from 233 routes in 1985 to 990 routes by 2000 (a 4.25-fold growth). During the same period, the number of civil aviation airports grew from 82 to 139 and the number of civil aviation aircraft doubled from 472 in 1985 to 982 in 2000. The increased number of carriers and routes created a competitive market that was new to the airline industry in China. In 1997, the CAAC permitted airlines to offer different levels of discount to the airfares set by the government. Some airlines offered up to 70% discount rates on selected routes. This caused serious fare wars among the airlines and led to a total loss of 2.1 billion yuan to the airline industry in 1998 (Zhang and Chen, 2003). The CAAC subsequently adjusted its fare-setting policy several times. Nevertheless, these fare-setting policy changes failed to create a fair, competitive environment driven by free market forces (Wang, 2005). The financial downturn experienced by the Chinese airlines in late 1990s was similar to the record loss of nearly \$13 billion by the US airlines between 1990 and 1993 (Goetz and Sutton, 1998). In short, the third phase introduced some important changes to the airline industry in China that moved it closer to a competitive market.

The beginning of the fourth phase (2002–present) was marked by the implementation of a CAAC-led airline consolidation in 2002. On October 11, 2002, the CAAC announced the founding of three major airline groups – China National Aviation Holding Company (core business is Air China), China Eastern Air Holding

Company (core business is China Eastern Airlines), and China Southern Air Holding Group (core business is China Southern Airlines). This was the outcome of a multiple-year effort by the CAAC to consolidate the CAAC-owned airlines into three roughly equal major airlines. Other non-CAAC-owned carriers were encouraged to participate on a voluntary basis. Table 2 shows the basic data of individual airlines in 2001 and in 2004, respectively. This table is organized to illustrate the groups of member airlines that were consolidated with the major airlines by 2004. For example, China National Aviation and China Southwest Airlines became part of Air China's network by 2004. Although Sichuan Airlines and Xiamen Airlines were partially owned by China Southern Airlines, they operated as independent carriers in 2004 and therefore are treated as separate airlines in this study. The "Big Three" airlines – Air China, China Eastern, and China Southern – clearly dominated the airline industry in China after the consolidation. The three-firm concentration ratios were 62.8% in 2001 and 78.7% in 2003 based on passenger-kilometers (Wang, 2005). With respect to total number of passengers, the three-firm concentration ratios were 51.5% in 2001 and 77.4% in 2003. These numbers confirm the increased dominance of the Big Three after the consolidation of 2002. The airline industry as a whole has continued to experience growth during this phase. The number of domestic routes grew from 971 routes in 2002 to 1,025 routes in 2006 (5.6% growth) while the number of international routes increased by 66.5% during the same period (Table 1). In the meantime, the number of aircraft jumped from 1,112 in 2002 to 1,614 in 2006 (45% growth).

Although China started its reform of airline industry in 1978 (coincidentally the same year when the US Congress passed the Airline Deregulation Act), China has gone through a very different path of liberalizing its airline industry compared to the US. Bowen (2000, 2002) points out that both privatization and deregulation are used in different countries around the world to liberalize the airline industry. China has implemented policies to separate airline operations from the CAAC and to encourage new airlines entering the market. These efforts certainly have created a more market-oriented and competitive environment, with several Chinese airline companies now traded on the stock market. Nevertheless, this is very different from the private airline market in the US. The majority share of many airlines in China is owned by entities with close financial ties to the governments or government-owned businesses. China also implemented policies of relaxing regulations on entry, pricing, flight frequency, and routes. These policies often reflect the thinking behind a centrally planned economy rather than that of a free market economy. Several airfare-setting policy changes announced by the CAAC during the late 1990s and early 2000s indicate the government's intention to control competition and the financial losses in the airline industry. The airline consolidation plan designed and implemented by the CAAC is another case in point.

On the other hand, we can find many similarities between China and the airline industry in other Asian countries. In a study of newly industrializing countries and regions in East Asia (including South Korea, Taiwan, Singapore, Hong Kong, Philippines, Malaysia, Indonesia, and Thailand), Bowen and Leinbach (1995) identify two

**Table 1**  
Growth of civil aviation in China, 1985–2006.

	1985	1990	1995	2000	2001	2002	2003	2004	2005	2006
No. of civil aviation airports	82	94	139	139	143	141	126	133	135	142
No. of civil aviation aircraft	472	499	852	982	1031	1112	1160	1245	1386	1614
No. of civil aviation routes	268	437	797	1165	1143	1176	1155	1279	1257	1336
–International routes	27	44	85	133	134	161	194	244	233	268
–Domestic routes (excluding HK/Macao routes)	233	385	694	990	967	971	918	990	981	1025
–Hong Kong/Macao routes	8	8	18	42	42	44	43	45	43	43

Source: China Statistical Yearbooks, compiled by National Bureau of Statistics of China, <<http://www.stats.gov.cn/tjsj/ndsj/>>.

**Table 2**  
Basic data of individual airlines, 2001 and 2004.

2001				2004			
Carrier	Registered capital <sup>a</sup> (mil. Yuan)	No. of aircraft <sup>a</sup>	No. of staff <sup>a</sup>	Carrier	Registered capital <sup>a</sup> (mil. Yuan)	No. of aircraft <sup>a</sup>	No. of staff <sup>a</sup>
Air China (CA)	1500	69	11,050	Air China (CA)	6500	150	28,120
China National (F6)	113	11 <sup>b</sup>	600				
China Southwest (SZ)	547	37	8300				
China Eastern (MU)	4867	70	10,900	China Eastern (MU)	5720	172	34,454
Air Great Wall (G8)	–	3 <sup>b</sup>	350				
China Northwest (WH)	320	29	5200				
Wuhan Airlines (WU)	180	12	600				
Yunnan Airlines (3Q)	533	22	4300				
China Southern (CZ)	3374	111	12,800	China Southern (CZ)	5304	232	30,392
China Northern (CJ)	1063	52	7900				
Xinjiang Airlines (XO)	429	20	4780				
Hainan Airlines (HU)	471	25	3500	Hainan Airlines (HU)	730	33	8389
Changan Airlines (ZZ)	745	13	400				
Shanxi Airlines (8C)	320	9	150				
Xinhua Airlines (XW)	1830	12	1230				
Shandong Airlines (SC)	400	21	820	Shandong Airlines (SC)	400	22	2345
Shanghai Airlines (FM)	521	21	2000	Shanghai Airlines (FM)	721	36	5025
Shenzhen Airlines (ZH)	300	12	850	Shenzhen Airlines (ZH)	300	26	2311
Sichuan Airlines (3U)	125	14	1500	Sichuan Airlines (3U)	350	22	1843
Xiamen Airlines (MF)	550	23 <sup>b</sup>	4100	Xiamen Airlines (MF)	550	26 <sup>c</sup>	4556

<sup>a</sup> Statistical data on Civil Aviation of China, Civil Aviation Administration of China Press, 2002 and 2005. General aviation aircraft are excluded in the statistics reported here.

<sup>b</sup> Civil Aviation Resource Net of China, <<http://www.carnoc.com/mhzi/hkgszl.htm>>.

<sup>c</sup> Aircraft Data of Chinese Civil Aviation, <<http://www.xmyzl.com>>.

important modes of state involvement in the airline industry: state ownership of carriers and government regulation of airline competition. Both practices are evident in the above review of air transportation development in China. Bowen and Leinbach (1995, p. 472) further suggest that the Asian governments “have been careful to limit the pace and scope of liberalization so that ultimate control of the industry remains firmly with the state.” Again, the evolution of Chinese airline industry reviewed in this section clearly supports Bowen and Leinbach’s argument. While the Chinese government has demonstrated its intention of transforming the Chinese airline industry into a market-oriented and competitive environment, the removal of state controls in the Chinese airline industry is far from complete. Although air transportation in China is widely recognized for its remarkable growth in the past three decades, it is important to recognize the unique characteristics of the Chinese airline industry and the differences between the state-led partial deregulation and privatization carried out in China and the more strongly market oriented deregulation implemented in the US.

### 3. Data and methods for analysis of domestic network change and competition

The airline consolidation implemented by the CAAC in 2002 caused profound changes to the airline industry in China. Many research questions could be raised about this consolidation. As geographers, we are interested in how this consolidation changed the spatial structure of airline networks and the extent to which the consolidated networks have affected competition among the airlines. To examine the passenger airline networks before and after the consolidation of 2002, this study selects 2001 and 2004 as the study years. For the geographic coverage, we choose the cities to be included in the analysis based on the following criteria<sup>3</sup>:

<sup>3</sup> Population and economic data are based on the 2003 *China City Statistical Yearbook* (China Statistics Press). The world heritage list is derived from <<http://whc.unesco.org/en/list>>.

- *Population size*: includes the 50 most populous cities in China;
- *Economic status*: covers the top 50 cities based on per capita GDP data;
- *Administrative status*: includes the capital city of all provinces and the autonomous regions (excluding Hong Kong, Macau, and Taiwan), plus the municipalities under the direct control of the Chinese Central Government; and
- *Major tourism sites*: covers the cities with cultural/natural heritage sites on the UNESCO world heritage list.

The above criteria take into account the population, economy, administration, and tourism of all candidate cities. There exist significant overlaps among the cities selected by each of the above four criteria. Sixty cities met at least one of the criteria and comprise our sample; many of the 60 cities met several criteria. Fig. 1 shows the geographic distribution of these 60 cities. These 60 cities collectively account for 96% of the total air passenger volume of 2001 in China. This reflects a significant gap between the cities selected for this study and other smaller and less-developed cities in China, which lag far behind in economic development and therefore are not attractive markets to the airlines. In fact, most carriers in China operate very few regional aircraft that are suitable for serving cities with a low passenger volume. For example, only 4 out of the 69 aircraft operated by Air China in 2001 were BAE 146-100s (maximum 88 seats) and all other aircraft were B747s, B777s, B767s, B737s, or A340s. The smallest aircraft operated by China Eastern and China Southern in 2001 was B737-200s. With respect to smaller airlines, Shanghai Airlines operated three CRJ-200s (50 seats) and the remaining 16 aircraft were B737s, B757s, or B767s in 2001. All 12 aircraft operated by Shenzhen Airlines in 2001 were B737s. By 2004, Shanghai Airlines operated five CRJ-200s among its 36 aircraft (the remainder were B737s, B757s, or B767s) and Shenzhen Airlines operated 26 B737s as its entire fleet in 2004. In addition, China has not developed an integrated hub-and-spoke network operation with a close cooperation between a major carrier and its regional commuter carriers. The above characteristics make China different from the US and most European markets with regard to air services to small cities. The 60 cities selected for this



Fig. 1. Geographic distribution of the 60 cities selected for this study.

study therefore are considered a good representation of the air passenger market in China.

For the creation of individual airline networks, we use the scheduled flights published in the *Timetable of Chinese Air Carriers* of 2004 and 2001 (April–October edition). Any domestic flight, which has origin and destination cities among the 60 cities selected for this study, is included. The 2004 database covers 575 city pairs with flight services in both directions and another four city pairs with flights in one direction only. They account for 98% of the domestic routes with 200,000 or more passengers and 90% of the total domestic flights in 2004. These numbers again indicate that the cities and the flight routes included in this study reflect well the airline passenger services in China. The same data coding procedure is followed to create a 2001 database that represents the passenger airline networks before consolidation.

The 2001 *Timetable of Chinese Air Carriers* lists 20 Chinese carriers offering scheduled passenger flights. The number of Chinese carriers with scheduled passenger flights drops to nine in the 2004 *Timetable of Chinese Air Carriers*. Table 3 shows the number of cities and the number of nonstop routes for each carrier in 2001 and in 2004, respectively. Air China gained additional 16 cities (from 37 cities in 2001 to 53 cities in 2004 – a 43% growth) and 220 routes (from 103 routes in 2001 to 323 routes in 2004 – a 214% growth), compared to 13 additional cities (34% growth) and 291 routes (130% growth) for China Eastern Airlines, and seven additional cities (15% growth) and 194 routes (55% growth) for China Southern Airlines during the same period. The airline consolidation of 2002 clearly created three dominant airlines with respect to the network coverage. Hainan Airlines, through its own acquisition and merger efforts, gained 10 new cities (27% growth) and 159 routes (91% growth) from 2001 to 2004. It became the fourth largest airlines in China. Table 3 also lists the total number of unique

cities and nonstop routes served by the primary carrier and its member carriers if they were consolidated in 2001. For example, Air China and its two member carriers (China National and China Southwest) collectively would serve 51 different cities and 366 nonstop routes. Ninety-two percent of the 26 cities served by China National and 67% of the 42 cities served by China Southwest overlapped with the cities served by Air China in 2001. On the other hand, only 12% of China National's routes and 11% of China Southwest's routes were redundant to the nonstop routes in Air China's network of 2001. Similar statistics are observed for China Eastern and China Southern. This pattern suggests that the CAAC purposely identified individual airlines with complementary route structures to be consolidated with each of the Big Three carriers. As a result, the Big Three carriers gained a significant number of new nonstop routes while having only a modest increase in the number of cities served after the consolidation. Hainan Airlines clearly followed the same strategy implemented by the CAAC in order to remain competitive with the Big Three carriers.

Another interesting pattern exhibited by the statistics in Table 3 is that the total number of unique cities and the total number of unique nonstop routes served by the primary carrier and its member carriers in 2001 match very well with their corresponding numbers in 2004. For example, if China National and China Southwest were merged with Air China in 2001, their combined network would serve 51 unique cities and 366 unique nonstop routes after removing the redundant cities and routes served by more than one carrier. These numbers are very close to the number of cities (53) and the number of nonstop routes (323) served by Air China in 2004. Similar patterns are observed for China Eastern (49 cities and 510 routes in 2001 versus 51 cities and 515 routes in 2004) and China Southern (52 cities and 568 routes in 2001 versus 53 cities and 544 routes in 2004). The above statistics suggest that the

**Table 3**  
Network data of individual airlines, 2001 and 2004.

2001			2004		
Carrier	No. of cities served	No. of non-stop routes	Carrier	No. of cities served	No. of non-stop routes
Air China (CA)	37 (51) <sup>a</sup>	103 (366) <sup>c</sup>	Air China (CA)	53	323
China National (F6)	26 (92%) <sup>b</sup>	78 (12%) <sup>d</sup>			
China Southwest (SZ)	42 (67%) <sup>b</sup>	233 (11%) <sup>d</sup>			
China Eastern (MU)	38 (49) <sup>a</sup>	224 (510) <sup>c</sup>	China Eastern (MU)	51	515
Air Great Wall (G8)	20 (85%) <sup>b</sup>	44 (14%) <sup>d</sup>			
China Northwest (WH)	34 (88%) <sup>b</sup>	150 (32%) <sup>d</sup>			
Wuhan Airlines (WU)	40 (83%) <sup>b</sup>	132 (13%) <sup>d</sup>			
Yunnan Airlines (3Q)	38 (87%) <sup>b</sup>	92 (22%) <sup>d</sup>			
China Southern (CZ)	46 (52) <sup>a</sup>	350 (568) <sup>c</sup>	China Southern (CZ)	53	544
China Northern (CJ)	42 (88%) <sup>b</sup>	262 (36%) <sup>d</sup>			
Xinjiang Airlines (XO)	33 (91%) <sup>b</sup>	80 (24%) <sup>d</sup>			
Hainan Airlines (HU)	37 (48) <sup>a</sup>	175 (314) <sup>c</sup>	Hainan Airlines (HU)	47	334
Chang'an Airlines (ZZ)	32 (75%) <sup>b</sup>	76 (8%) <sup>d</sup>			
Shanxi Airlines (8C)	13 (77%) <sup>b</sup>	26 (0%) <sup>d</sup>			
Xinhua Airlines (XW)	23 (87%) <sup>b</sup>	57 (11%) <sup>d</sup>			
Shandong Airlines (SC)	41	158	Shandong Airlines (SC)	40	159
Shanghai Airlines (FM)	31	67	Shanghai Airlines (FM)	45	100
Shenzhen Airlines (ZH)	29	73	Shenzhen Airlines (ZH)	38	94
Sichuan Airlines (3U)	37	118	Sichuan Airlines (3U)	24	72
Xiamen Airlines (MF)	39	153	Xiamen Airlines (MF)	38	162

<sup>a</sup> Number of unique cities served by the primary carrier and its member carriers if they were merged in 2001.  
<sup>b</sup> Percentage of cities served by the member carrier that overlaps with the cities served by the primary carrier.  
<sup>c</sup> Number of unique nonstop routes served by the primary carrier and its member carriers if they were merged in 2001.  
<sup>d</sup> Percentage of nonstop routes served by the member carrier that overlaps with the nonstop routes served by the primary carrier.

CAAC-led consolidation plan simply merged the airlines together without attempting to make major adjustments to the merged networks. It also is interesting to note that Hainan Airlines, which was not part of the CAAC-led consolidation plan, exhibits the same pattern (48 cities and 314 routes in 2001 versus 47 cities and 334 routes in 2004). Regarding other smaller carriers, Shanghai Airlines and Shenzhen Airlines both expanded their networks between 2001 and 2004, while Sichuan Airlines experienced a noticeable reduction in both the number of cities and the number of nonstop routes. In the meantime, Shandong Airlines and Xiamen Airlines maintained their status quo. These variations among the smaller carriers in China are similar to the finding of a study that shows considerable variation in the strategies adopted by the US low-cost carriers in developing their networks in the 1990s (Reynolds-Feighan, 2001). We will further examine and discuss the variations among these smaller carriers in China when individual airline networks are evaluated in the next section.

Fig. 2 presents the maps of individual airline networks in 2001 and in 2004. Among the Big Three, Air China's geographic coverage expanded significantly to the west and the south after its consolidation with China Southwest and China National. China Eastern Airlines broadened its coverage in the northwest and the southwest. China Southern Airlines, on the other hand, intensified its coverage in the north and the northwest. These maps clearly illustrate that the airline networks of the Big Three became very similar to each other in terms of geographic coverage after the consolidation. These geographic patterns of network coverage are different from the network structures of US major carriers after the deregulation. Although the major carriers in the US also expanded their networks through mergers and acquisitions after the deregulation, they developed their hub-and-spoke networks with distinct geographic orientations (Shaw, 1993). For example, Delta Airlines developed its network with an emphasis on the South while Northwest Airlines focused its network mainly on the Midwest. On the other hand, United Airlines established a network with a strong east-west orientation.

In order to compare the accessibility level at each city on individual airline networks, this study employs two network nodal accessibility measures to systematically examine each airline

network before and after the consolidation of 2002. The first measure is based on the number of direct connections that each node has with other nodes in the same network. In this study, we compute the *direct connection* (DC) index as follows (Shaw, 1993):

$$DC_i = \sum_{j=1}^N C_{ij} / (N - 1) \tag{1}$$

where  $C_{ij}$  equals to 1 if nodes  $i$  and  $j$  have direct, nonstop flight connections and 0 otherwise, and  $N$  indicates the total number of nodes in the given network. Since different airline networks often consist of different number of nodes, the DC index is standardized by taking the ratio of the sum of  $C_{ij}$  to  $(N - 1)$ , where  $(N - 1)$  represents the minimum number of direct, nonstop flights required to connect a given node with all other nodes in a network. This direct connection index, which ranges from 0 (no direct connection with any other nodes in a network) to 1 (directly connected with all other nodes in a network), can help us examine the level of connections at each city on individual airline networks. As a result, we can use the DC index to assess changes in nodal accessibility before and after the consolidation and to identify the contribution of individual member carriers to the consolidated network. This index is similar to the measures of connectivity, including number of cities and routes served, used in Fan's analysis of intra-European inter-city flight connectivity (Fan, 2006).

To take into account both direct and indirect connections between cities, we also compute the *shortest-path connection* (SPC) index using the Shimbel shortest-path matrix method, which calculates the number of flight segments along the shortest-path between each origin-destination pair (i.e.,  $D_{ij}$ ) (Shimbel, 1953; Taaffe et al., 1996). Specifically, the SPC index is computed by the equation below (Shaw, 1993).

$$SPC_i = \sum_{j=1}^N D_{ij} / (N - 1) \tag{2}$$

Again, the SPC index is standardized by taking the ratio of Shimbel shortest-path measure to  $(N - 1)$ . When the SPC index equals to 1, it suggests that a city has direct, nonstop flight connections with all other cities on the network. If a city receives an SPC index

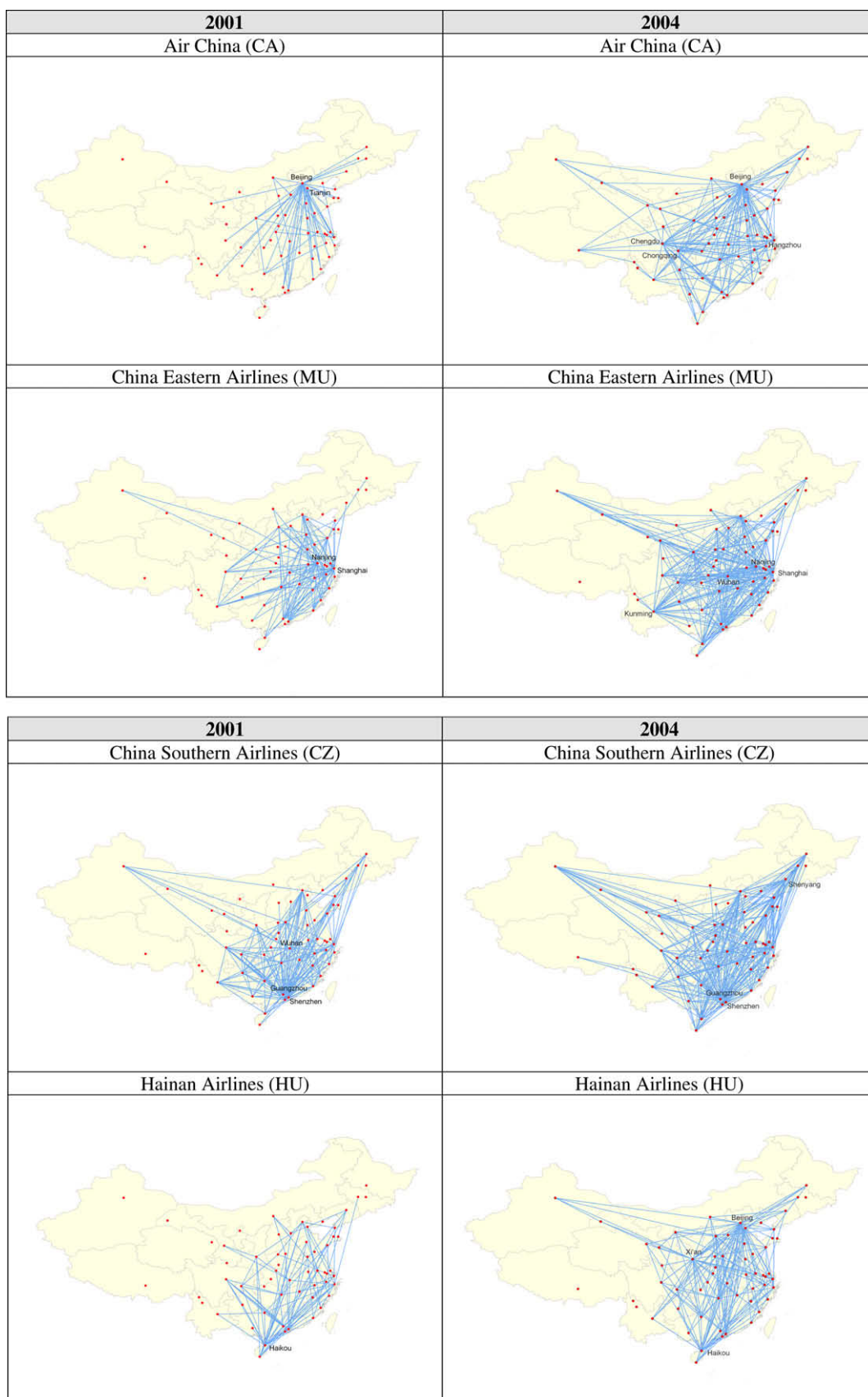


Fig. 2. Individual airline networks of 2001 and 2004.

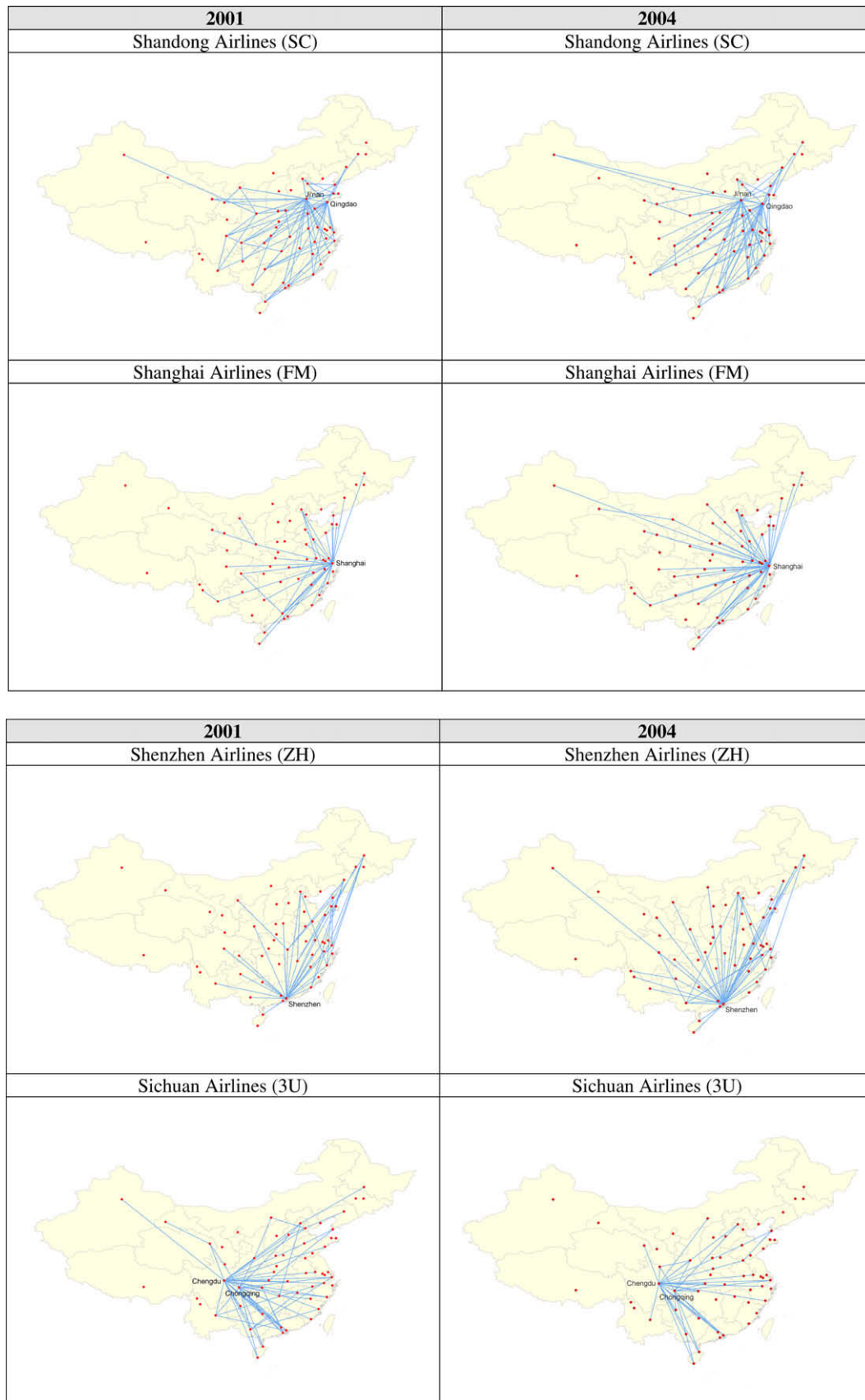


Fig. 2 (continued)

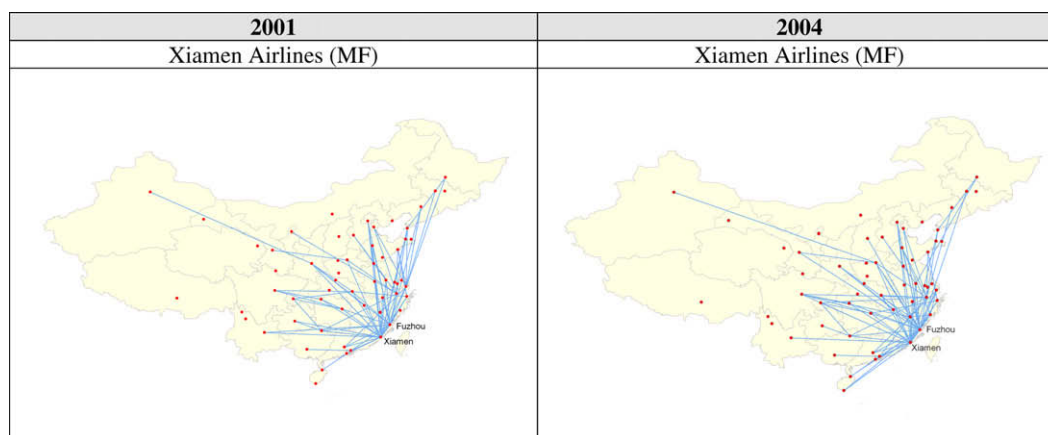


Fig. 2 (continued)

of 2, it means that passengers at this city on average are required to make one transfer (i.e., two flight segments) to reach any other city on the network. With the network structures illustrated in Fig. 2 and Table 3, we anticipate that the SPC index would generate rankings of top cities similar to those derived from the DC index. We include both DC index and SPC index in this study in order to identify any major deviations between these two sets of rankings, which would indicate the cities with high overall direct connections and low overall indirect connections or vice versa.

#### 4. Effects of airline consolidation on domestic network structure and airline competition

##### 4.1. Network changes based on direct connection measures

Tables 4–8 present the direct connection (DC) measures by individual airlines before and after the airline consolidation. There are

**Table 4**  
Direct connection measures of Air China, 2001 and 2004.

2001				2004			
Rank	City	# of DC <sup>b</sup>	DC Index <sup>c</sup>	Rank	City	# of DC <sup>b</sup>	DC Index <sup>c</sup>
<i>Air China (CA) N<sup>a</sup> = 37</i>				<i>Air China (CA) N<sup>a</sup> = 53</i>			
1	Beijing	31	0.86	1	Beijing	43	0.83
2	Tianjin	8	0.22	2	Chengdu	31	0.60
3	Shanghai	5	0.14	3	Chongqing	21	0.40
4	Xi'an	5	0.14	4	Hangzhou	17	0.33
5	Wuhan, Shenzhen, Hohhot	4	0.11	5	Tianjin	15	0.29
<i>China Southwest (SZ) N = 42</i>							
1	Chengdu	30	0.73				
2	Chongqing	21	0.51				
3	Guiyang	15	0.37				
4	Beijing	11	0.27				
5	Kunming	11	0.27				
<i>China National (F6) N = 26</i>							
1	Hangzhou	19	0.76				
2	Wenzhou	10	0.40				
3	Beijing	4	0.16				
4	Changsha	4	0.16				
5	Chengdu, Dalian, Harbin, Kunming, Nanchang, Qingdao	3	0.12				

<sup>a</sup> Total number of cities, among the 60 cities included in this study, served by the airline.

<sup>b</sup> Number of other cities that have direct, non-stop flight connections with the given city.

<sup>c</sup> Direct connection index.

two approaches to comparing networks before and after mergers. One approach is to combine the soon-to-be-merged airlines into a single network before mergers actually take place. This allows us to compare the combined networks before and after mergers (e.g., Shaw and Ivy, 1994). A shortcoming of this approach is that we cannot assess the contribution of individual carriers to the merged network, especially if we have multiple carriers that are combined into a single network. We therefore choose to analyze

**Table 5**  
Direct connection measures of China Eastern Airlines, 2001 and 2004.

2001				2004			
Rank	City	# of DC <sup>b</sup>	DC Index <sup>c</sup>	Rank	City	# of DC <sup>b</sup>	DC Index <sup>c</sup>
<i>China Eastern (MU) N<sup>a</sup> = 38</i>				<i>China Eastern (MU) N<sup>a</sup> = 51</i>			
1	Shanghai	27	0.73	1	Shanghai	41	0.82
2	Nanjing	19	0.51	2	Wuhan	30	0.60
3	Guangzhou	14	0.38	3	Nanjing	28	0.56
4	Beijing	11	0.30	4	Kunming	26	0.52
5	Qingdao, Taiyuan	11	0.30	5	Xi'an	24	0.48
<i>Wuhan Airlines (WU) N = 40</i>							
1	Wuhan	33	0.85				
2	Yichang	8	0.21				
3	Guilin	6	0.15				
4	Zhangjiajie	6	0.15				
5	Changsha and four other cities	4	0.10				
<i>Yunan Airlines (3Q) N = 38</i>							
1	Kunming	28	0.76				
2	Chongqing	5	0.14				
3	Shanghai	3	0.08				
4	Changsha	3	0.08				
5	Huangshan, Nanning	3	0.08				
<i>China Northwest (WH) N = 34</i>							
1	Xi'an	18	0.55				
2	Lanzhou	14	0.42				
3	Nanjing	13	0.39				
4	Beijing	10	0.30				
5	Changsha, Wuhan	9	0.27				
<i>Air Great Wall (G8) N = 20</i>							
1	Ningbo	11	0.58				
2	Chongqing	4	0.21				
3	Changsha	3	0.16				
4	Wuhan	3	0.16				
5	Guilin and six other cities	2	0.11				

<sup>a</sup> Total number of cities, among the 60 cities included in this study, served by the airline.

<sup>b</sup> Number of other cities that have direct, non-stop flight connections with the given city.

<sup>c</sup> Direct connection index.

**Table 6**  
Direct connection measures of China Southern Airlines, 2001 and 2004.

2001				2004			
Rank	City	# of DC <sup>b</sup>	DC Index <sup>c</sup>	Rank	City	# of DC <sup>b</sup>	DC Index <sup>c</sup>
<i>China Southern (CZ) N<sup>a</sup> = 46</i>				<i>China Southern (CZ) N<sup>a</sup> = 53</i>			
1	Guangzhou	37	0.82	1	Guangzhou	42	0.81
2	Shenzhen	24	0.53	2	Shenzhen	26	0.50
3	Wuhan	22	0.49	3	Shenyang	24	0.46
4	Beijing	16	0.36	4	Dalian	22	0.42
5	Changsha	16	0.36	5	Changsha	22	0.42
<i>China Northern (CJ) N = 42</i>							
1	Dalian	19	0.46				
2	Shenyang	17	0.41				
3	Harbin	15	0.37				
4	Changchun	14	0.34				
5	Shenzhen	13	0.32				
<i>Xinjiang Airlines (XO) N = 33</i>							
1	Urumqi	13	0.41				
2	Xi'an	10	0.31				
3	Beijing	5	0.16				
4	Lanzhou	4	0.13				
5	Zhengzhou	4	0.13				

<sup>a</sup> Total number of cities, among the 60 cities included in this study, served by the airline.

<sup>b</sup> Number of other cities that have direct, non-stop flight connections with the given city.

<sup>c</sup> Direct connection index.

individual airline networks before and after the consolidation in order to illustrate the contribution of individual carriers to the consolidated network. The direct connection measures presented in Tables 4–8 indicate several distinct patterns and interesting changes before and after the consolidation of 2002. First of

**Table 7**  
Direct connection measures of Hainan Airlines, 2001 and 2004.

2001				2004			
Rank	City	# of DC <sup>b</sup>	DC Index <sup>c</sup>	Rank	City	# of DC <sup>b</sup>	DC Index <sup>c</sup>
<i>Hainan Airlines (HU) N<sup>a</sup> = 37</i>				<i>Hainan Airlines (HU) N<sup>a</sup> = 47</i>			
1	Haikou	23	0.64	1	Beijing	35	0.76
2	Shenzhen	11	0.31	2	Xi'an	31	0.67
3	Ningbo	11	0.31	3	Haikou	24	0.52
4	Guangzhou	8	0.22	4	Tianjin	16	0.35
5	Changsha	8	0.22	5	Taiyuan	16	0.35
<i>Changan Airlines (ZZ) N = 32</i>							
1	Xi'an	18	0.58				
2	Yinchuan	7	0.23				
3	Chongqing	6	0.19				
4	Wuhan	4	0.13				
5	Xi'ning, Zhangjiajie	3	0.10				
<i>Xinhua Airlines (XW) N = 23</i>							
1	Beijing	15	0.68				
2	Tianjin	7	0.32				
3	Kunming	3	0.14				
4	Xi'an	3	0.14				
5	Guangzhou	3	0.14				
<i>Shanxi Airlines (8C) N = 13</i>							
1	Taiyuan	7	0.58				
2	Tianjin	3	0.25				
3	Zhengzhou	3	0.25				
4	Yinchuan	2	0.17				
5	Qinhuangdao, Dalian	2	0.17				

<sup>a</sup> Total number of cities, among the 60 cities included in this study, served by the airline.

<sup>b</sup> Number of other cities that have direct, non-stop flight connections with the given city.

<sup>c</sup> Direct connection index.

**Table 8**  
Direct connection measures of other airlines, 2001 and 2004.

2001				2004			
Rank	City	# of DC <sup>b</sup>	DC Index <sup>c</sup>	Rank	City	# of DC <sup>b</sup>	DC Index <sup>c</sup>
<i>Shandong Airlines (SC) N<sup>a</sup> = 41</i>				<i>Shandong Airlines (SC) N<sup>a</sup> = 40</i>			
1	Ji'nan	24	0.60	1	Ji'nan	23	0.59
2	Qingdao	20	0.50	2	Qingdao	22	0.56
3	Xi'an	6	0.15	3	Nanjing	8	0.21
4	Chongqing	5	0.13	4	Yantai	8	0.21
5	Zhengzhou, Shenzhen, Hefei	5	0.13	5	Xiamen, Shenzhen	7	0.18
<i>Shanghai Airlines (FM) N = 31</i>				<i>Shanghai Airlines (FM) N = 45</i>			
1	Shanghai	25	0.83	1	Shanghai	41	0.93
2	Guangzhou	5	0.17	2	Nanjing	4	0.09
3	Xi'an	3	0.10	3	Guangzhou	4	0.09
4	Beijing	3	0.10	4	Beijing	3	0.07
5	Kunming and four other cities	2	0.07	5	Hangzhou	3	0.07
<i>Shenzhen Airlines (ZH) N = 29</i>				<i>Shenzhen Airlines (ZH) N = 38</i>			
1	Shenzhen	22	0.79	1	Shenzhen	34	0.92
2	Wuhan	4	0.14	2	Nanning	6	0.16
3	Nanchang	4	0.14	3	Beijing	5	0.14
4	Wenzhou	4	0.14	4	Wuxi	3	0.08
5	Shenyang, Harbin	4	0.14	5	Wenzhou	3	0.08
<i>Sichuan Airlines (3U) N<sup>a</sup> = 37</i>				<i>Sichuan Airlines (3U) N<sup>a</sup> = 24</i>			
1	Chengdu	27	0.75	1	Chengdu	22	0.96
2	Chongqing	15	0.42	2	Chongqing	12	0.52
3	Nanning	5	0.14	3	Jiuzhai	3	0.13
4	Zhangjiajie	5	0.14	4	Xi'an	3	0.13
5	Beijing, Kunming	4	0.11	5	Beijing and eleven other cities	2	0.09
<i>Xiamen Airlines (MF) N = 39</i>				<i>Xiamen Airlines (MF) N = 38</i>			
1	Xiamen	25	0.66	1	Xiamen	23	0.62
2	Fuzhou	17	0.45	2	Fuzhou	23	0.62
3	Shanghai	9	0.24	3	Hangzhou	13	0.35
4	Hangzhou	9	0.24	4	Wuyishan	11	0.30
5	Wuhan	6	0.16	5	Zhengzhou	6	0.16

<sup>a</sup> Total number of cities, among the 60 cities included in this study, served by the airline.

<sup>b</sup> Number of other cities that have direct, non-stop flight connections with the given city.

<sup>c</sup> Direct connection index.

all, the Big Three carriers all kept their main hub (i.e., Air China at Beijing, China Eastern at Shanghai, and China Southern at Guangzhou) as the top ranking hub before and after the consolidation. However, only Shanghai on China Eastern's network experienced an increase of its DC index from 0.73 in 2001 to 0.82 in 2004. Beijing of Air China and Guangzhou of China Southern both experienced a slight decrease of their DC index values. It also is worth noting that the Big Three all share an almost identical DC value at their respective main hub in 2004 (0.83 for Air China, 0.82 for China Eastern, and 0.81 for China Southern). A close examination of Table 5 indicates that the growth of Shanghai's dominant role in China Eastern's network after consolidation is not due to the other member carriers in the China Eastern Air Holding Company, which do not offer many direct connections with Shanghai. This suggests that the CAAC-led consolidation plan helped China Eastern to enhance the level of hubbing at its main hub to become comparable with the other two major airlines. Such a consistent level of hubbing at the main hubs among the major carriers is difficult to find in a deregulated market that is driven by free market forces instead of a government-led consolidation plan. For example, the DC index values of the top hub for six major US airlines (i.e., American, Continental, Delta, Northwest, United, and USAir) ranged from 0.61 to 0.86 in early 1990s (Shaw, 1993). This difference again highlights a fundamental difference between the network structures of major airlines in China versus their counterparts in the US.

Another pattern observed across the Big Three is the heavy influence of their member airlines on the consolidated network of 2004. For example, the major hubs of China Southwest Airlines (Chengdu and Chongqing) and China National Aviation (Hangzhou) replace the secondary hubs in Air China's network of 2001 and become the second, the third, and the fourth places in Air China's network of 2004 (Table 4). For China Eastern Airlines, Wuhan (top hub of Wuhan Airlines), Kunming (top hub of Yunan Airlines), and Xi'an (top hub of China Northwest Airlines) occupy the second, the fourth, and the fifth places, respectively, in China Eastern's network of 2004 (Table 5). Shenyang and Dalian (top two hubs of China Northern Airlines) take the third and the fourth places in the China Southern's network of 2004 (Table 6). This pattern supports our previous argument that the CAAC-led consolidation plan of 2002 merged the networks without attempting to make major adjustments to the consolidated networks, which would normally be expected if the mergers were driven by free market forces.

Table 4 also shows that Air China operated a single-hub network centered at Beijing in 2001. After the consolidation, Air China became a multiple-hub network with a gradual transition of the level of hubbing, measured by the DC index, among the major hubs. On the other hand, China Eastern and China Southern exhibited gradual transitions of hubbing levels among their top hubs in both 2001 and 2004 (Tables 5 and 6). As a result, the consolidation had a bigger impact on the network structure of Air China than those of China Eastern and China Southern. Another important pattern observed among the Big Three is that the top five hubs on their 2004 networks do not overlap at all. This is very different from the situation in their 2001 networks in which Beijing, Shanghai, Guangzhou, Wuhan, and Xi'an show up as the major hubs in multiple networks. This is a very interesting finding. As discussed in the previous section, the CAAC-led consolidation plan created three roughly equal major airlines with similar geographic coverage among their networks. We would expect that their overlapping geographic coverage would lead to stronger competition among the Big Three after the consolidation. Tables 4–6 however inform us that the Chinese government strategically designed the consolidation plan such that each of the Big Three carriers would have its own distinct set of major hubs in order to minimize direct competition among the Big Three.

Hainan Airlines, which went through its own mergers and acquisitions independent of the CAAC-led consolidation plan, shows a change pattern that is both similar to and different from the Big Three. The original leading hub at Haikou in 2001 dropped to the third place in 2004. Beijing (top hub of Xinhua Airlines), Xi'an (top hub of Changan Airlines), and Tianjin and Taiyuan (top two hubs of Shanxi Airlines) took the first, the second, the fourth, and the fifth places in Hainan's network of 2004 (Table 7). Comparing the top five hubs served by Hainan Airlines in 2004 with those served by the Big Three, we notice that Beijing, Xi'an, and Tianjin on Hainan's network overlap with the top five hubs of Air China and China Eastern. This suggests that Hainan Airlines was prepared to compete with the Big Three at their major hubs, which is different from the strategy of avoiding head-to-head competition among the Big Three under the CAAC-led consolidation plan.

The other five smaller airlines exhibit quite different strategies of adjusting their network structures in response to the consolidated networks of the Big Three (Table 8). Shandong Airlines and Xiamen Airlines in general maintained the status quo of their dual-hub networks with very minor adjustments to their networks between 2001 and 2004. Fig. 2 clearly shows that the network structure of Shandong Airlines and Xiamen Airlines remained basically the same with only minor changes to the cities and the routes served by them. This is a sensible strategy because their leading hubs do not directly compete with the Big Three. In other words, the consolidation plan did not introduce any major

**Table 9**  
Shortest-path measures of all airlines, 2001 and 2004.

2001			2004		
Rank	City	SPC Index <sup>b</sup>	Rank	City	SPC Index <sup>b</sup>
<i>Air China (CA) N<sup>a</sup> = 37</i>			<i>Air China (CA) N<sup>a</sup> = 53</i>		
1	Beijing	1.14	1	Beijing	1.17
2	Shanghai	1.89	2	Chengdu	1.40
3	Xi'an	1.89	3	Chongqing	1.60
4	Hohhot	1.92	4	Hangzhou	1.71
5	Wuhan	1.94	5	Guiyang	1.77
<i>China Eastern (MU) N<sup>a</sup> = 38</i>			<i>China Eastern (MU) N<sup>a</sup> = 51</i>		
1	Shanghai	1.32	1	Shanghai	1.18
2	Nanjing	1.57	2	Wuhan	1.40
3	Guangzhou	1.65	3	Nanjing	1.44
4	Beijing	1.73	4	Kunming	1.48
5	Taiyuan	1.76	5	Xi'an	1.52
<i>China Southern (CZ) N<sup>a</sup> = 46</i>			<i>China Southern (CZ) N<sup>a</sup> = 53</i>		
1	Guangzhou	1.18	1	Guangzhou	1.17
2	Wuhan	1.53	2	Shenyang	1.58
3	Shenzhen	1.62	3	Changsha	1.60
4	Changsha	1.69	4	Dalian	1.62
5	Beijing	1.69	5	Haikou	1.62
<i>Hainan Airlines (HU) N<sup>a</sup> = 37</i>			<i>Hainan Airlines (HU) N<sup>a</sup> = 47</i>		
1	Haikou	1.36	1	Beijing	1.24
2	Ningbo	1.72	2	Xi'an	1.35
3	Shenzhen	1.83	3	Haikou	1.50
4	Sanya	1.92	4	Taiyuan	1.67
5	Chongqing, Guilin, Changsha	1.94	5	Tianjin	1.67
<i>Shandong Airlines (SC) N<sup>a</sup> = 41</i>			<i>Shandong Airlines (SC) N<sup>a</sup> = 40</i>		
1	Ji'nan	1.43	1	Ji'nan	1.46
2	Qingdao	1.65	2	Qingdao	1.46
3	Hefei	2.00	3	Shenzhen	2.05
4	Zhengzhou	2.03	4	Nanjing	2.05
5	Chengdu, Yinchuan, Yichang	2.05	5	Xiamen	2.08
<i>Shanghai Airlines (FM) N = 31</i>			<i>Shanghai Airlines (FM) N = 45</i>		
1	Shanghai	1.17	1	Shanghai	1.07
2	Guangzhou	1.93	2	Guangzhou	1.95
3	Xi'an	2.00	3	Beijing	1.98
4	Beijing	2.00	4	Hangzhou	1.98
5	Chongqing, Wenzhou	2.03	5	Yinchuan and four other cities	2.00
2001			2004		
<i>Shenzhen Airlines (ZH) N = 29</i>			<i>Shenzhen Airlines (ZH) N = 38</i>		
Rank	City	SPC Index <sup>b</sup>	Rank	City	SPC Index <sup>b</sup>
1	Shenzhen	1.21	1	Shenzhen	1.08
2	Wuhan	1.96	2	Nanning	1.89
3	Nanchang	2.00	3	Beijing	1.92
4	Beijing	2.00	4	Wuxi	1.97
5	Wenzhou	2.00	5	Wenzhou and five other cities	2.00
<i>Sichuan Airlines (3U) N = 37</i>			<i>Sichuan Airlines (3U) N = 24</i>		
1	Chengdu	1.25	1	Chengdu	1.04
2	Chongqing	2.00	2	Chongqing	1.52
3	Naming	2.03	3	Ji'nan	1.91
4	Zhangjiajie	2.06	4	Jiuzhai	1.91
5	Beijing	2.06	5	Xi'an, Xuzhou	1.91
<i>Xiamen Airlines (MF) N = 39</i>			<i>Xiamen Airlines (MF) N = 38</i>		
1	Xiamen	1.34	1	Fuzhou	1.38
2	Fuzhou	1.61	2	Xiamen	1.38
3	Hangzhou	1.89	3	Hangzhou	1.70
4	Shanghai	1.97	4	Wuyishan	1.78
5	Guilin, Wuhan	2.05	5	Zhengzhou	1.95

<sup>a</sup> Total number of cities, among the 60 cities included in this study, served by the airline.

<sup>b</sup> Shortest-path connection index.

impact on the networks of Shandong Airlines (with routes heavily concentrated on the two hubs of Ji'nan and Qingdao in Shandong province) and Xiamen Airlines (with routes heavily concentrated on the two hubs of Xiamen and Fuzhou in Fujian province). Shang-

**Table 10**  
Route-level competition among the airlines in 2004.

	Air China	China Eastern	China Southern
Air China	–	45%	46%
China Eastern	28%	–	42%
China Southern	27%	40%	–
Hainan Airlines	36%	46%	43%
Shandong Airlines	14%	42%	34%
Shanghai Airlines	37%	88%	43%
Shenzhen Airlines	26%	32%	60%
Sichuan Airlines	81%	42%	39%
Xiamen Airlines	27%	26%	38%

hai Airlines and Shenzhen Airlines, on the other hand, expanded their single-hub network by adding new cities and routes with direct connections to their respective leading hubs (0.93 for Shanghai and 0.92 for Shenzhen in 2004) (see Table 8 and Fig. 2). It is obvious that both airlines enhanced their main hub in order to compete directly with their Big Three rival (i.e., common leading hub at Shanghai between China Eastern Airlines and Shanghai Airlines and common major hub at Shenzhen between China Southern Airlines and Shenzhen Airlines).<sup>4</sup> Since both Shanghai Airlines and Shenzhen Airlines are local airlines and cannot easily shift their major hubs, they have no choice but to compete directly with their Big Three rivals.

The above analyses reveal many interesting changes and patterns for the Big Three as well as for the smaller airlines. The government-led consolidation plan created three roughly equal major airlines with similar geographic coverage among their networks. In the meantime, the consolidation plan strategically chose the airlines to be merged such that each of the Big Three carriers had a distinct set of leading hubs that did not overlap with other major airlines. These subtle designs embedded in the consolidation plan clearly reflect that the airline consolidation in China was a government-led liberalization rather than a market-driven liberalization as observed in the US. It appears that the consolidation plan had different levels of impact on the smaller carriers. For those smaller carriers with hubs that did not engage direct competition with the Big Three, they were not affected much by the consolidation and generally maintained their status quo. For smaller carriers that shared common hubs with the Big Three, they could either choose to enhance their network and compete directly with the Big Three or they could choose to reduce their network coverage and focus on the routes and cities where they were competitive. It is important to note that some of the smaller carriers in China could establish a partner relationship with a major carrier to develop an integrated hub-and-spoke network structure and operate like the regional commuter airlines in the US. This is another possibility for the future of smaller carriers in China.

#### 4.2. Network changes based on shortest-path connection measures

The top hubs derived from the shortest-path connection measures (Table 9) are very similar to the top hubs based on the direct connection measures for all airlines. This indicates that the major hubs are well connected with each other on the networks. Consequently, the shortest-path connection measure, which considers both direct and indirect connections among the cities on a network, gives similar results as those computed from the direct con-

nection measure. However, two major hubs identified by the direct connection measure dropped their rankings significantly when they are evaluated by the shortest-path connection measure. These two cities are Tianjin in Air China's network (Table 4) and Shenzhen in China Southern's network (Table 6). The low ranking of these two cities based on the SPC index is caused by their close spatial proximity to the leading hub (i.e., Tianjin–Beijing in Air China's network and Shenzhen–Guangzhou in China Southern's network) and there is no nonstop flight connection with the leading hub. Since these two cities cannot reach many other cities through the leading hub, they are penalized on the shortest-path connection measure although they have a relatively high direct connection index value. The shortest-path connection measure therefore is very useful to highlight the cities that experience a “traffic shadow” effect with respect to the leading hubs.

#### 4.3. Route-level competition among the airlines

While the nodal accessibility measures presented above help shed light on the competition among airlines at their major hubs, it is equally important to examine the competition on network routes among the airlines. We compute the degree to which each carrier's network overlaps with the networks of the Big Three in 2004. Table 10 indicates that the Big Three share less than 50% of the routes in their networks. Only 28% of China Eastern's routes and 27% of China Southern's routes overlap with Air China's routes. These statistics again confirm that the consolidation plan of 2002 attempted to minimize direct competition among the Big Three. On the other hand, 88% of Shanghai Airlines' routes overlap with China Eastern's network because they both have Shanghai as the main hub. Sichuan Airlines also has a high percentage of routes (81%) competing with Air China due to their common major hubs at Chengdu and Chongqing. Shenzhen Airlines competes with China Southern due to their common hub at Shenzhen. Xiamen Airlines and Shandong Airlines enjoy the lowest percentages of overlapping routes with the Big Three. These findings are consistent with the analysis results discussed in Section 4.1. In addition, the relatively low percentages of overlapping routes between the smaller carriers and the Big Three suggest that these smaller carriers have identified their niche markets serving particular routes among the 60 major cities included in this study. This could be a reason why smaller carriers in China have not focused on expanding their networks to serve small cities in China like some low-cost carriers have done in western countries (e.g., Fan, 2006).

## 5. Conclusions

Since the passage of the Airline Deregulation Act of 1978 in the United States, airline liberalization has become a widespread phenomenon across the world. Many developed as well as developing countries have implemented their own version of airline liberalization. China, which has experienced remarkable economic growth since it began economic reforms in 1978, also transformed its airline industry over the past three decades. This study finds that China employs a state-led reform approach that is very different from the free-market liberalization approach implemented in the United States. The implementation of airline liberalization in China has been similar to the experience in other Asian countries where the state remains a strong influence on the airline industry.

This paper also examines the airline consolidation of 2002 in terms of its effects on network structure and airline competition. The analysis results reveal the changes experienced by individual carriers and the strategies employed by individual airlines in response to the government-led consolidation. The changes observed

<sup>4</sup> Due to intense competition between China Eastern Airlines and Shanghai Airlines, there have been reports about a possible merger of these two airlines (for example, see <<http://www.chinesestock.org/show.aspx?id=22672&cid=28>>, <[http://big5.xinhuanet.com/gate/big5/news.xinhuanet.com/fortune/2008-09/09/content\\_9867061.htm](http://big5.xinhuanet.com/gate/big5/news.xinhuanet.com/fortune/2008-09/09/content_9867061.htm)>, last accessed on November 18, 2008).

with the Big Three carriers strongly suggest that the CAAC had a pre-set goal of creating three roughly equal major airlines while trying to minimize direct competition among them. This is very different from the airline deregulation in the US which was based on strong free market assumptions. It is fair to say that the airline industry in China has been shaped by government-led reforms rather than free market forces.

With its strong economic growth and large population size, China is becoming a major player in air transportation. It is important for the research community to study the economic, political, social, and geographic aspects of air transportation in China. The Chinese government has made many changes and will continue to make changes to the airline industry in China. There are many interesting research questions waiting to be tackled. For example, is gradual reform controlled by government a better approach than the free market liberalization approach for countries such as China? What should be the next step after the airline consolidation? Should the Chinese government protect the Big Three or encourage other airlines to compete with the Big Three? To what extent will air transportation expand its market share in China? With the traditional dependence on railways for medium- and long-haul passenger traffic and the recent policy of moving towards high speed rail, how would air transport and rail transport compete in the passenger travel market? We hope this paper will encourage other researchers to pursue these and other interesting and challenging research questions.

### Acknowledgments

The authors would like to acknowledge the research support received from the Knowledge Innovation Project of the Chinese Academy of Sciences (Grant No. KZCX2-YW-308) and the Chinese Hi-Tech Research and Development Plan Project (Grant No. 2006AA12Z209).

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