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The Changing Landscape of the Aircraft Industry

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Summary points

- Asia's economic growth will exert a significant 'pull' effect in terms of manufacturing location for the aerospace industry and more Western firms will partner with Chinese firms, in particular.
- China has specific advantages not enjoyed by other challenger states, notably its large domestic aircraft market and exceptionally large pool of labour.
- Aerospace is different from other manufacturing sectors where latecomer strategies have been employed – and suggestions that Western producers will be supplanted may be misguided. Technological interdependence is increasing, making it more difficult for states to pursue autarkic technology policies.
- Aerospace is very reliant on other sectors for key technologies, and few emerging states show signs of having significant capabilities across a range of supporting sectors. Challenger states are thus using elements of national champion strategies while at the same time engaging in collaborative ventures with Western suppliers.
- These trends suggest that incumbent producers will continue to enjoy significant competitive advantages for some time.

Introduction

Arguably no other technology-rich sector has been so dominated by Europe and the United States as aerospace. While Japan and, recently, other Asian economies have developed significant innovative capacity in areas such as electronics and renewable energy technologies, aerospace has remained largely the domain of the same set of European and American companies (or their direct ancestors) that dominated that landscape five decades ago. Only in recent years has this dominance been eroded – with Canada and Brazil carving out important positions in the regional jet market. Over the years, several states, including South Africa and Indonesia, attempted to gain market share – but to little effect. In the past five years a renewed effort has been made to break the 'Euro-American' dominance of the sector; Japan, China, India and Russia have all announced significant new efforts aimed at developing an indigenous civil airliner. China has announced a series of production arrangements with major manufacturers in the United States and Europe, using the immense promise of its internal air-travel market as a bargaining chip. Why has regional dominance in this sector proved so durable, and is it now finally being eroded?

On the face of it, the Euro-American dominance of the sector does seem to be slipping. Market 'pull' forces suggest that production will follow large customers. All major aircraft manufacturers agree that the fastest-growing regional market is Asia, and a number have concluded that placing production facilities in Asia is a necessary step to maintain competitive position. As Asia emerges as the new, dominant region in the global economy it seems likely that production will follow customers. Offset arrangements – where production is outsourced to a customer in exchange for orders – has long been a feature of the industry. However, Asia's emerging economic weight suggests that offsets will be the minimum expectation of the region's governments. Asia's demographics and geography strongly suggest that air travel will become the dominant mode of travel in the region. High levels of GDP growth will increase the supply of comparatively price-insensitive customers. Moreover, the region's geography – unlike Europe's – makes air travel the only viable option for international travel. China in particular stands out as an emerging giant, with an expected demand for new aircraft that is simply extraordinary. UK Trade and Investment estimates that China will need to triple the size of its existing civil aircraft fleet by adding almost 3,800 large (that is, over 100-seat) airliners.[1]

> 'All major aircraft manufacturers agree that the fastest-growing regional market is Asia'

Any erosion of the competitive position of the United States or Europe would have consequences for those economies. In the United States, aerospace is one of the very few manufacturing sectors where the domestic industry generates trade surpluses. In 2009, the US balance of trade exceeded £55 billion.[2] The European industry generated a surplus of €34 billion on export sales that accounted for a third of the EU's manufacturing exports.[3] In both Europe and the United States employment in the aerospace sector has remained relatively stable for a decade after a significant reduction during the 1990s, when the post-Cold War era saw significant cuts in defence expenditure and a wave of consolidation throughout the aerospace sector. Although this indicates that considerable gains in productivity have been achieved, it also raises questions about the long-term ability of the industry in the EU and US to expand employment at a time when unemployment of skilled workers is politically sensitive. For some basic components where

1 Trade and Investment (2010).
2 Aerospace Industries Association (2010).
3 Aerospace and Defence Industries Association of Europe (2010).

labour costs are key, it is difficult to see how EU and US firms can compete with Asian suppliers. Mexico too has established an interesting niche as a low-cost and conveniently located supplier.[4] Higher-skilled and research and development jobs may well stay in Europe and America for some time, and there is evidence that the depreciation of the US dollar and moderate wage expectations by non-union labour in US southern states are tempting firms to move some production to the US. Embraer, for example, builds executive jets at a plant in Melbourne, Florida.[5]

This paper explores the drivers underlying this process of globalization. The aerospace industry presents a particular puzzle: it is at once very globalized and centralized. Few other industries are as reliant on a complex and spatially dispersed supply chain, yet few other sectors have as concentrated a structure at the apex of the industry. Systems integration capability seems to present incumbent firms with a particularly strong source of competitive advantage. It is also the case that the long life-cycles and the complex international regulatory regime for aircraft favour firms with significant access to financing – both for product development and sales – and the necessary technical and government affairs functions to manage after-sales support. The Boeing 787 programme was envisaged as a revolutionary departure from the traditional, pyramidal structure of the industry with the very extensive subcontracting of design and manufacturing tasks. Yet by 2010, the troubled programme had to be re-centralized under Boeing management, demonstrating the need for strong programme management.[6]

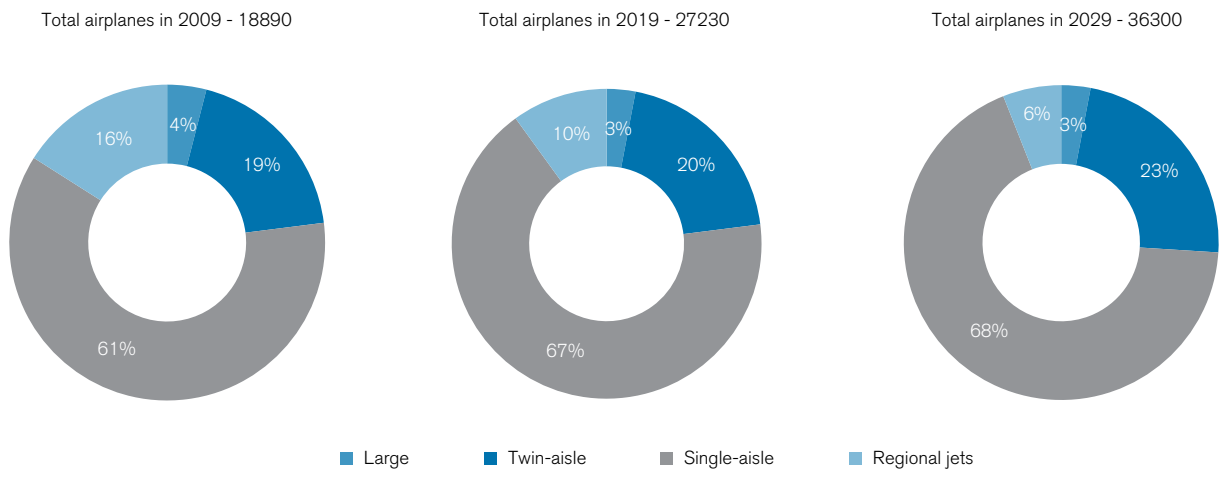
Market growth

All major forecasts agree that passenger growth will continue rising ahead of global GDP growth for the next 10–15 years. The main driver of this growth is the economic advance of emerging markets, which has driven an increase in air travel. Boeing calculates that 60–80% of the increase in demand for air travel is directly related to economic growth and the consequent need for business and cargo air services.[7] In addition, the fruits of economic growth have underpinned a dramatic increase in tourist travel. Airbus notes that since 2007 passenger growth in emerging markets has been increasing over twice as quickly as in developed economies. Tourism-related travel has been increasing at an average annual rate of 4% (long-term growth in air travel averaged approximately 4.4% for over a decade).[8] In Asia a newly affluent middle class has joined Western consumers as keen travellers, and tourism in Asia grew by 5.5% in 2010.[9] Moreover, much of this growth is in premium traffic, where leisure travellers pay for business-class seats, with yields growing by 40% since 2007.[10]

Five years ago, it was said that Boeing and Airbus had fundamentally different conceptions of the airliner market of the future. Airbus was then offering its superjumbo A380 in the expectation that airline passenger growth would be concentrated in major global hubs; Boeing forecast a world of smaller aircraft operating on direct routes between a much greater variety of cities. Yet, in another way, both manufacturers are in agreement: a large proportion of the increasing passenger numbers of the future will travel in medium-sized aircraft, operating on domestic or short-to-medium range international routes. Even allowing for some differences in methodology, both major manufacturers forecast that over two-thirds of new aircraft deliveries in the next decade will be of small and medium-sized jets. This expectation of the dominance of smaller aircraft is evidently shared by emerging market players in Russia, Japan and China, all of which are developing products in the 100–130-seat category. There they will face direct competition from new generations of the

4 Aerostrategy (2009).
5 Embraer (2008).
6 Ostrower (2011).
7 Boeing (2010b), p. 8.
8 Ibid., p. 4.
9 World Tourism Organization (2011).
10 Airbus Industrie (2010).

Figure 1: Predicted demand for airliners



Source: Boeing (2010b)

Airbus A320 and Boeing's 737 range. These smaller aircraft are the mainstay of the production lines of both major manufacturers. Moreover, both Canada's Bombardier and Brazil's Embraer also have aircraft of this capacity for sale, with the Brazilian firm contemplating a new jet to meet expected demand in Asia.[11] Thus the competitive environment in at least one market segment looks very challenging for all involved. Although the market is potentially large, existing and emerging manufacturers are concentrating on the same competitive space.

To capture part of this market, several Western firms have entered into extensive subcontracting arrangements with Chinese partners. In one sense, these activities are not new: US dominance of the Japanese airliners market has been ascribed to the willingness of Boeing to grant special status to Japanese firms in relation to subcontracting work – including responsibility for elements of wing design on the 787.[12] Airbus now has an A320 assembly line in China, and Bombardier and Embraer both make extensive use of Chinese manufacturing partners as a means to gaining aircraft orders. Nonetheless, as Eriksson notes, many Western firms regard relations with Chinese manufacturers as a risky but necessary step, and concerns about technology transfer and loss of competitive advantage remain.[13]

Technology, industrial structure and barriers to entry in aerospace

For many politicians, managers and academics, aerospace is the quintessential 'strategic' economic sector and this particular nature of the sector has justified a range of government support programmes for the industry in many countries. What, however, is a strategic industry? Common usage among policy-makers suggests that strategic industries are highly profitable 'industries of the future' which have to be maintained within a country for their contribution to overall economic growth and prosperity. The OECD identifies a small set of five high-technology manufacturing sectors (2007 global value in brackets): communications and semiconductors ($445 billion), pharmaceuticals ($319 billion), scientific instruments ($189 billion), aerospace ($153 billion), and computers and office machinery ($114

11 Polek (2011).
12 McGuire (2007).
13 Eriksson (2010).

billion).[14] Aerospace is seen as a key driver of technology, as well as an employer of highly skilled graduates. To listen to some policy-makers, then, aerospace would surely be a very profitable, very knowledge-generative (and -consumptive) industrial sector. Viewed another way, however, the aerospace industry is rather average. In 2010 the average return on assets for major aerospace companies was 6.1%; respectable, but just over half that of the global pharmaceutical industry (11.5) and much less than the return earned in mining, oil and consumer foods.[15] In the UK, the pharmaceutical industry conducts nearly 25% of all business-related research and development. The UK aerospace sector accounts for approximately 10%.[16]

The rise of emerging markets as locations for production has thus far followed a predictable path; early manufacturing was concentrated in products that were relatively easy to manufacture and technologically unsophisticated. Now, however, emerging markets have been expanding their research and development capabilities, and the globalization of R&D activity is rapidly becoming a reality. This globalization, however, has two important characteristics. First, there is a spatial dimension, with more research and activity taking place in countries such as Brazil and China that used to have little indigenous research capability. There is, however, another important dimension, namely the increasing interdependence of the research process. The OECD notes an increasing percentage of patents resulting from international collaboration.[17] The spread of R&D activity thus cannot be viewed simply in zero-sum terms where one state's increased activity comes at the expense of another. Increased collaborative knowledge creation also raises an interesting question as to whether modern technologies are so complex and interdependent that state technology policies premised on autarkical principles are completed misguided. In a world of technological interdependence, leadership may no longer mean the domination of the final stage of production but rather the production of key subsystems. Yet many governments still seem interested in developing technology policies whose aim is to capture the final, integrative stage of the sector.

Complex systems, cascades and specialization

Products and services can be placed on a continuum relating to their technological characteristics. On one end are complex products and services (CoPS) – highly intricate, customized and costly – while commodified products sit at the other end. CoPS entail the creation of a highly specialized set of arrangements among suppliers, customers and political authority; the complexity of the system demands high levels of coordination and co-creation among suppliers, contractors and customers, while the bespoke nature of the CoPS implies a specific relationship to political power, whether regulators or legislators.[18] This is a somewhat more elaborate version of the sectoral systems of innovation, which emphasizes the specific qualities of key technologies in a product and their implications for company strategy. The implication of the argument is that CoPS can confer on firms an incumbency advantage through the erection of significant barriers to entry. A challenger firms needs to surmount not just technological barriers, but obstacles that arise from regulatory compliance, marketing and customer support and outright political influence in the purchasing decisions of buyers.

Aircraft manufacturing features a relatively standardized product, so there is some disagreement about whether aircraft are CoPS, though major studies of high-technology sectors have tended to categorize them as complex systems.[19] But the sector is CoPS-like in most other respects: the product is immensely complicated with major subsystems being technologically complex in themselves, and some aerospace subsystems, notably engines and avionics packages, are

14 National Science Foundation (2010), Chapter 6, p. 17. McGuire (2007).
15 Fortune 500 (2009).
16 McGuire (2007).
17 OECD (2010).
18 Hobday (1998).
19 Eriksson (2010).

regarded as CoPS.[20] The implication of complex systems for industrial structure is twofold. First, it underpins the dominant position of system integrators, as only these 'top-of-the-tree' firms possess both the technical and regulatory expertise to bring these systems to market. This is known as the cascade effect: the durability of the competitive position of leading systems integrators through dominance of the top tier of subsystem suppliers.[21] Challenger firms simply lack the necessary resources to organize, integrate and produce a CoPS. The second implication of complexity for aerospace is greater technological specialization as firms outside the small circle of prime contractors seek other ways to compete National aerospace networks had become more specialized after 1945, with the development of identifiable niche strategies among smaller aerospace nations such as Argentina, China, Brazil and Canada – the implication being that participation in the full spectrum of aerospace activities would elude all but the existing, dominant powers of Europe and the United States.[22]

The apparent barriers to entry erected in complex systems suggested to some scholars that states (and, by extension, their firms) would adopt particular strategies in an effort to catch up with leading nations. The existing literature on technological catch-up can be said to describe three phases. First, economies gain their initial exposure to technology by using foreign direct investment to expose indigenous workforces to foreign-owned technologies. At this stage, the recipient economy does little more than implement a particular technology, usually as an element in a global supply chain of a Western multinational.[23] With experience, domestic firms come to understand the technology, including not just codified knowledge but any associated tacit knowledge. This process, by which technicians and other skilled personnel come to understand the basic workings of a technology, represents the second stage.[24] The final stage of the process sees indigenous firms in possession of sufficient technical expertise (usually embodied in scientists, engineers and technicians) to be capable of manipulating the technology to create either incremental or dramatic improvements. Although terminology differs, there is widespread agreement about the stages described, with indigenous firms gradually attaining higher levels of technological sophistication through a process of learning. The process is usually conceptualized as linear, where follower firms seek to catch up with established leaders. In the case of aerospace, early stages see firms involved in the manufacturing of simple, commodified parts for aircraft, or carrying out simple services such as maintenance.[25] At later stages, the use of offsets and other production agreements allows latecomer industries to gain experience in the integration of subsystems. What is interesting in the case of aerospace is how, until very recently, few states have attained the final stage, where their indigenous aerospace firms learn to design and produce an assembled airliner.

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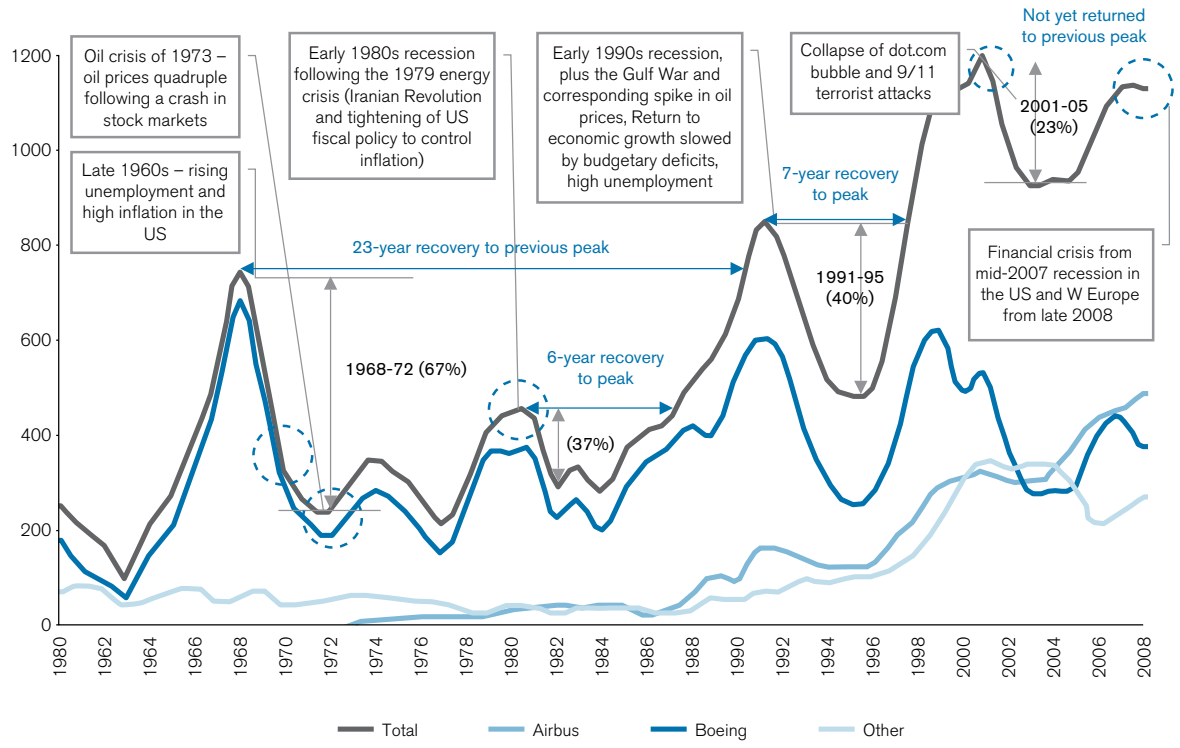
Aside from being complex, the aerospace sector has other characteristics that militate against market entry, particularly by newcomer firms from developing economies. First, the aircraft industry is prone to violent swings in demand (see Figure 2). It is also very capital-intensive, with long

20 Hobday (1998): 690.
21 Nolan et al. (2008).
22 Frenken (2000).
23 Vertesy and Szirmai (2010).
24 Ibid.
25 Aerostrategy (2009).

Figure 2: Western-built aircraft deliveries, 1960–2008



Source: UK Trade and Investment, from Ascend Online Fleet, 2010.

payback periods that dampen investor enthusiasm for the sector. These characteristics have long been used to justify extensive government support for the sector, drawing on a market-failure argument that, notwithstanding the importance of aerospace, its high-risk nature militates against private-sector investment. The pattern that has developed in many states in recent years has been to create a *de facto* national champion aerospace systems integrator, then use that firm as a focus for broader efforts in the market. Arguably, Embraer of Brazil set the pattern for emerging economies. The company benefited from extensive government support in the form of protectionist tariffs, government procurement policies and access to R&D support.[26] In the absence of strong government support, market entry in aerospace is exceptionally difficult.[27]

Another – often under-appreciated – barrier is the extensive regulatory regime for aerospace products. In other sectors, latecomers seeking to enter the market can do so by offering cheaper and simpler products and so avoid direct competition with incumbent producers. Experience gained at the low end of the product range can, in time, be leveraged in more high-quality offerings. This practice was used successfully in consumer electronics by Japanese firms and, more recently by Korean car producers.[28] Federal Aviation Administration (FAA) and European airworthiness certification authorities require certification of any aircraft, wherever manufactured, to conform to standards. The requirement to conform to international standards at the outset renders any low-end entry impossible. Indonesia found this out to its cost when

26 Teitel (2006).
27 McKinsey and Company (2008).
28 Vertesy and Szrimai (2010), p. 7.

its licensed production arrangement of Bell 412 helicopters foundered on regulatory compliance issues raised by the FAA and Indonesian regulators themselves.[29]

Latecomer strategies

This suggests that shifts in industrial structure in aerospace will not, in fact, follow patterns seen in other industries but rather will be characterized by more circuitous routes to participation in the full range of activities in the sector. One study suggests that aerospace is characterized by a process of interrupted innovation whereby latecomer firms can take advantage of exogenous shocks to the sectoral innovation system. These shocks disturb stable relationships among participants and technologies within a sectoral innovation system, presenting opportunities for new entrants to gain share. Latecomer firms must nonetheless possess sufficient skills in existing technologies to have gained some experience with incumbent firms but must also be agile enough to seize the opportunity presented by the exogenous shock.[30] The Japanese aerospace industry presents an example of this process. Japanese firms lead the world in the development and application of composites in a range of industrial uses, including load-bearing components for aircraft. Composites are stronger than steel or aluminium, lighter (hence fuel-saving) and more durable. Long established as a subcontracting partner for the American aerospace industry, leading Japanese firms such as Mitsubishi have used their independently developed expertise in composite technologies to gain key roles in the development of Boeing aircraft, notably the 787. It has also allowed Mitsubishi to explore the launch of its own regional jet.[31]

That said, in other respects latecomer strategies employed by Russia and China are similar to those employed by Brazil. Both states have abandoned extensive internal competition among several aircraft companies in favour of a single (or very few) national champions. This concentrates technical and scientific skill. Second, like Brazil, both Russia and China make use of co-production and licenced production arrangements. Whether these states can attain the final stage and develop radical innovations for the sector remains to be seen. One key difference is that overt trade protection of the type used by Brazil is now rendered extremely difficult under World Trade Organization rules, to which China is subject, although Russia's path to WTO accession is not yet complete.

Russia

The Russian aerospace industry virtually collapsed in the wake of the Soviet Union's demise. Although very advanced in terms of theoretical understandings of a range of aerospace technologies, Soviet manufacturing capabilities never allowed the country to develop the necessary process technologies in areas such as composites and avionics. In the Soviet era, the government contrived competition among several design bureaus, such as Mikoyan and Sukhoi, as a mechanism for encouraging innovation. After the collapse of the Soviet Union, many of the design bureaus incorporated themselves and sought to compete in international markets – mainly in military aerospace. Though the newly private Russian industry was technologically advanced, lack of capital to finance purchases and concerns about after-sales service limited its success. The decline of the civil aerospace sector was particularly marked. In 2005, the output of the entire Russian civil sector was 10 aircraft.[32] That year marked a watershed in the industry, and the Russian government instigated a dramatic consolidation of the sector such that the post-communist Russian aerospace industry is now a state-controlled national champion. In 2006 President Putin announced the creation of the United Aircraft Building Corporation (UAC), which amalgamated the major Russian design bureaus under a single corporate structure. After an initial flotation and the issuance of new shares in 2010, the Russian federal government controls 82% of the corporation, with private investors, including

29 Eriksson (2003). See also Goldstein (2003).
30 Vertesy and Szrimai (2010).
31 McGuire (2007).
32 International Trade Administration (2010).

the European Aeronautic Defence and Space Company (EADS), controlling the remaining 14%.[33]

Russia's principal civil aircraft offering is the Sukhoi Superjet 100, designed for the 75–100-seat market, as are virtually all other new entrants' products. Though drawing heavily on Sukhoi's own rich design resources, the jet makes extensive used of Western suppliers for major subsystems, including the French firm SNECMA for the engine.[34] Moreover, Alenia Aeronautica was engaged as a strategic partner in 2007 to oversee foreign sales and support for the aircraft.[35]

China

No other emerging market has attracted as much attention as China. This is partly because it is unique among emerging competitor nations in having a significant domestic market for aircraft, which in theory would allow it to adopt more autarkic development policies for the sector, safe in the knowledge that national-champion firms could sell to a large, captive domestic market. In fact, Chinese policies for the sector have to a large extent mirrored those seen in other manufacturing industries such as automobiles, with Beijing using access to the huge domestic market as a lever to encourage foreign firms to invest in joint production arrangements with domestic manufacturers. While China's openness to FDI and other forms of collaboration with Europe and North American firms has generally been welcomed, there remain some concerns that the technology transfer that will inevitably take place between foreign and Chinese partners will, over time, present problems for incumbent firms.

China's interest in civil aviation – and its willingness to partner with foreign companies – dates from the 1980s, when McDonnell-Douglas agreed to produce MD-80 passenger planes in the country. The arrangement eventually collapsed as McDonnell's survival as an independent airliner manufacturer became increasingly unviable. Indeed, McDonnell's interest in China may well have stemmed from a growing perception within the company of its cost-competitive weakness *vis-à-vis* Boeing and Airbus, and the resultant interest in dramatic efforts to regain its position. McDonnell's partner in the failed venture was the predecessor of Aviation Industries of China (AVIC), which was formed in 2008 by a state-sponsored merger of two large state-owned enterprises AVIC I and AVIC II. In one sense, the merger in 2008 returned the industry to the state of affairs that had existed ten years earlier, when the AVIC companies were created in an effort to spur competition.[36] AVIC is essentially a holding company, overseeing 20 listed subsidiaries across all subsectors of civil and military aerospace. It is in addition a large (30%) shareholder in the Commercial Aviation Company of China (COMAC), which was also created in 2008 with the specific aim of developing a medium-range, 100–150-seat civil airliner.[37] The Chinese cite Airbus' complex corporate structure as inspiration for AVIC's complicated arrangement of specialist subsidiaries: 'Airbus has already proved that one of the best frameworks for building large aircraft is one made up of business segments and centres of excellence.'[38]

China has opted to make extensive use of foreign firms in the development of civil aircraft. The new C919 medium-range jet will utilize Honeywell's avionics systems as well as GE technologies in a range of subsystems.[39] In addition, it will use Western-designed engines from CFM International.[40] COMAC also announced a potentially wide-ranging collaborative agreement with Bombardier in March 2011, which would see the firms cooperating on marketing and product development.[41] Aside from allowing

33 United Aircraft Corporation (2010).
34 McHale (2010).
35 Sukhoi Aircraft Company (date accessed?)
36 Forbes (2008).
37 UK Trade and Investment (2010).
38 VIC President Hu Xiaofeng, quoted in Perrett (2010).
39 Honeywell, (2010).
40 Perrett (2010).
41 Bombardier (2011).

Chinese technicians and engineers an opportunity to learn from Western companies, the use of existing suppliers and major subsystems is almost certainly designed to facilitate the long and complex airworthiness certification processes in Europe and the United States.

Potential constraints on growth

As more and more consumers pile onto planes to travel for business or pleasure, increasing competition for the resources necessary for the aircraft to take off is intensifying. Political turmoil in the Middle East in 2011 produced a sharp spike in the price of oil, and the underlying price trend for oil has been in an upward climb since 2007. Of the four major aircraft manufacturers, only Embraer clearly modelled the impact of higher oil prices on demand, and it forecast little impact on demand at an assumption of $80 per barrel.[42] One of the major effects of rising oil prices could be to reverse the tendency for far-flung supply chains in many industries. A reversion to 'near-shoring' would have an important impact on the cargo market.[43] Competition for supplies of a range of rare earth metals, as well as bauxite, has also sharpened and increased prices. China's *de facto* embargo of rare earth exports to Japan in 2010 – in connection with a territorial dispute between the two states – provided support for the view that a dangerous element of neo-mercantilism has crept into international economic relations. The aircraft industry is a key consumer of oil in the form of kerosene fuel for the engines, and every aircraft is packed with electronics, fixtures and fittings made from a range of products ranging from lanthanum to titanium to cotton – all commodities whose price has rocketed in the past three years. As the number of significant and developed economies increases, so too will competition. Over the longer term, the growth and expansion of technological capabilities suggest that globalization will increase the opportunities to generate solutions to these issues, but the short-term impact is negative.

Air travel also faces social constraints, although their impact may vary according to region. Noise and the general impact of airline industry infrastructure on quality of life as an area of dispute can be seen most easily in Europe. In western and northern parts of the continent, population densities and the proximity of large airports to metropolitan centres have long made the expansion of air travel more difficult than elsewhere. The availability of high-speed rail not only provides competition for airlines in Europe, it also provides environmental lobbies with a powerful argument that alternatives to aircraft use exist. In other regions, these socially generated pressures do exist, but perhaps not to the same extent. In parts of Asia, the fact that policy-makers have been able to build airports in anticipation of rapid economic growth has obviated some of the problems seen in Europe, where airport expansion is widely opposed. And in Asia, as in North America, South America and Africa, rail travel is not a serious competitor, particularly for international journeys.

The aircraft industry has made important incremental improvements in the economic and environmental impact of its products. Nonetheless, it can be argued that it still works to the same 'template' of metal construction, wings and turbine engines that existed in the 1950s. Unlike computing, it has not undergone a dramatic, 'game-changing' innovation.[44] In the management literature, it has been suggested that radical innovations that overthrow incumbent firms typically come from 'left field' and represent a decisive shift in product or service. However, some empirical work in technology-rich fields suggests otherwise. It has been argued that most radical innovations are built on existing knowledge to a greater extent than previously realized.[45] Similarly, other work suggests that new product development in aerospace is facilitated by the rich technical resources available to dominant Western firms. Access to technology-rich adjacent industries and extensive links with university research were positively

42 Embraer (2008), p. 9.
43 Blackden (2011).
44 McGuire (1999).
45 Schoenmakers and Duysters (2010).

associated with the ability of UK aerospace companies to develop composite technologies.[46] It is unclear whether newcomer firms possess this kind of extensive and rich network. Incumbent firms expend large amounts of money on R&D: Boeing spent $4.1 billion in 2010,[47] while EADS, Airbus' parent company, spent €2.9 billion that same year (excluding government contracts). EADS is undertaking a series of research programmes in airframes and engine technologies that suggest it is pursuing the type of 'game-changing' innovation that would allow it to maintain competitive advantage over emerging competitors.[48]

> "Few industries demand the range of corporate competencies expected of an aircraft manufacturer"

Conclusion

Barring major social upheaval and economic collapse, Asia is poised to become the dominant market for the civil airliner industry in the coming decades. It is perfectly true that, as in other sectors, market expansion has been used as a lever to get existing firms to invest in plant and other facilities. All major Western aircraft manufacturers have expanded their presence in Asia in recent years, with Airbus being particularly willing to open final assembly operations in China. It seems very likely that Japan, China and Russia will all take advantage of the expansion of global air travel to launch a range of aircraft designed principally to meet demand for medium-sized airliners in Asian markets. They will join offerings by incumbents Airbus, Boeing, Bombardier and Embraer. All of these aircraft will share major subsystems, perhaps demonstrating that a key competitive niche in the aerospace market is as a major supplier, not a systems integrator. At the Paris Air Show in June 2011, executives at both Airbus and Boeing conceded that their duopoly – at least in the smaller, medium-range aircraft – was over, with several companies selling competitive products.[49]

However, new challengers face obstacles that either do not exist or are not as significant in other sectors. Few industries demand the range of corporate competencies expected of an aircraft manufacturer. The need to conform to international regulatory standards gives existing integrators and major subsystem suppliers an important lever in commercial negotiations. They also possess access to innovation networks in the form of research institutions and other technologically advanced sectors that – at least for now – cannot be replicated by emerging economies. At the same Paris Air Show where its management spoke of the erosion of its competitive position, Airbus announced a world record sale of 200 150-seat aircraft to Air Asia: Airbus' orders at the show were for 720 aircraft worth $72 billion.[50] Bombardier sold 50 aircraft worth $1.4 billion at the same show and lost an important sale to Airbus because of the latter's greater resources in arranging financing and offering engine choices.[51]

In short, while Asia and other players like Russia will take a greater share of production in the aircraft industry the sector does not seem poised for a major 'break' in technological trajectories that would open up opportunities for new entrants to offer dramatically new products. The rules of the game in aerospace remain those written by Europe and the United States in the wake of the Second World War, and both Airbus and Boeing have significant resources available to meet the current wave of competition.

46 McAdam et al. (2008).
47 Boeing (2010a), p. 3.
48 The Economist (2011); EADS (2010)
49 Odell (2011).
50 Hotakainen and McMillin (2011).
51 Keenan (2011).

References

Aerospace Industries Association (2010), *Aerospace Foreign Trade*, Series 31 and 32, http://www.aia-aerospace.org/economics/aerospace_statistics/, accessed 26 March 2011.

Aerospace and Defence Industries Association of Europe (2010), *Facts and Figures 2009*.

Aerostrategy (2009), *Globalization 2.0: The Next Stage*, September 2009.

Airbus Industrie (2010), *Global Market Forecast 2010-2029*, Blagnac, December.

Blackden, Richard (2011), 'Rising Oil Prices Loom Over Future of Delivery Giant UPS', *Sunday Telegraph*, http://www.telegraph.co.uk/finance/newsbysector/supportservices/8409808/Rising-oil-prices-loom-over-future-of-delivery-giant-UPS.html?sms_ss=email&at_xt=4d9088b87b4bae44%2C0.

Boeing (2010a), *2010 Annual Report*.

Boeing (2010b), *Market Forecast 2010-2029*, Boeing Corporation.

Bombardier (2011), 'COMAC and Bombardier Sign Strategic Agreement on Commercial Aircraft' 24 March, http://www.bombardier.com/en/corporate/media-centre/press-releases/details?docID=0901260d80167ce7, accessed 27 June 2011.

EADS (2010), *2010 Annual Report*. http://www.eads.com/eads/int/en/investor-relations/financials-guidance/key-figures.html.

The Economist (2011), 'Plane Truths', 12 March 2011, p. 89.

Embraer (2008), 'Embraer Chooses Melbourne Fl as for Executive Jet Plant, http://www.embraerexecutivejets.com/english/content/customer-services/newsletter_8_7.asp, accessed 8 June 2011.

Eriksson, Sören (2010), 'China's Aircraft Industry: Collaboration and Technology Transfer – the Case of Airbus', *International Journal of Technology Transfer and Commercialisation*, 9(4): 306–25.

Eriksson, Sören (2003), 'Indonesia's Aircraft Industry: Technology and Management Impediments', *International Journal of Technology Transfer and Commercialisation*, 2(2): 207–26.

Eriksson, Sören (2000), 'Technology Spill-Over from the Aircraft Industry: the case of Volvo Aero', *Technovation*, 20: 653–64.

Forbes (2008), 'China Reorganises Aerospace Industry', http://www.forbes.com/2008/12/03/china-aerospace-comac-cx_1204oxford.html, accessed 16 March 2011.

Fortune 500 (2009), Return on Assets, http://money.cnn.com/magazines/fortune/global500/2009/index.html, accessed 12 March 2011.

Frenken, Koen (2000), 'A Complexity Approach to Innovation Networks: The Case of the Aircraft Industry (1909-1997), *Research Policy*, 257–72.

Goldstein, Andrea (2003), 'The Political Economy of High-Tech Industries in Developing Countries: Aerospace in Brazil, Indonesia and South Africa', *Cambridge Journal of Economics*, 26: 521–38.

Hobday, Michael (1998), 'Product Complexity, Innovation and Industrial Organisation', *Research Policy*, 26: 689–710.

Honeywell, (2010), Honeywell Helps Drive Chinese Aerospace Growth With Four Major Systems For New Passenger Aircraft http://www51.honeywell.com/honeywell/news-events/press-releases-details/11.19.10C919.html, 19 November, accessed 16 March 2011.

Hotakainen, Bob and Molly McMillin (2011), 'Boeing Suffered Setbacks at Paris Air Show, but Analysts Debate Outlook', *Los Angeles Times*, 27 June, http://www.latimes.com/business/la-fi-boeing-20110627,0,3945684.story, accessed 27 June 2011.

International Trade Administration (2010), 'Russia: Consolidation of the Aerospace Industry', US Department of Commerce, trade.gov/static/aero_rpt_russian_industry_consolidation.pdf, accessed 1 March 2011.

Keenan, Greg (2011), 'Airbus Takes Shine Off Bombardier's Party in Paris', *Globe and Mail*, 24 June, http://www.theglobeandmail.com/globe-investor/airbus-takes-shine-off-bombardiers-party-in-paris/article2073901/. Accessed 27 June 2011.

McAdam, Rodney, Tom O'Hare and Sandra Moffatt (2008), 'Collaborative Knowledge Sharing in Composite New Product Development: An Aerospace Study', *Technovation*, 28: 245–56.

McGuire, Steven (2007), 'The United States, Japan and the Aerospace Industry: From Capture to Competitor? *Pacific Review*, 20(3): 329–50.

McGuire, Steven (1999), 'Sectoral Innovation Patterns and the Rise of New Competitors: The Case of Aerospace in Asia', *Industry and Innovation*, 6(2): 153–70.

McHale, John (2010), 'Russian Aircraft Industry will Benefit from Strategic International Partnerships', *Avionics Intelligence*, 11 August.

McKinsey and Company (2008), *The Growing Role of Emerging Markets in Aerospace*, April.

National Science Foundation (2010), *Science and Engineering Indicators*.

Nolan, Peter, Jin Zhang and Chunhang Liu (2008), 'The Global Business Revolution, the Cascade Effect and the Challenge for Firms from Developing Countries', *Cambridge Journal of Economics*, 32: 29–47.

Odell, Mark (2011), 'Airbus and Boeing Call End to "Duopoly"', *Financial Times*, 21 June, p. 21.

OECD (2010), *Research and Technology Indicators, 2009*, Paris: OECD.

Ostrower, Jon (2011), 'Cost of a Tarnished Dream', *Flight International*, 4–10 January, pp. 6–7.

Perrett Bradley (2010), 'In For the Long Haul', *Aviation Week and Space Technology*, 172(41): p. 65, 15 November.

Polek, Gregory (2011) 'Embraer to Decide on Next Commercial Project Next Year', *Aviation News International*, 25 March, http://www.ainonline.com/news/single-news-page/article/embraer-to-decide-on-next-commercial-project-this-year-29195/, accessed 26 March 2011.

Schoenmakers, Wilfrid and Geert Duysters (2010), 'The Technological Origins of Radical Innovations', *Research Policy*, 39: 1051–59.

Sukhoi Aircraft Company, http://sukhoi.org/eng/planes/projects/rrj/, accessed 20 March 2011.

Teitel, Simón (2006), 'On Semi-Industrialised Countries and the Acquisition of Advanced Technological Capabilities', *Economics of Innovation and New Technologies*, 15(2): 171–94.

United Aircraft Corporation (2010), 'Shareholders of UAC Approve Additional Shares Issue', http://www.uacrussia.ru/en/press/news/index.php?from4=2&id4=530, accessed 15 March 2011.

UK Trade and Investment (2010), *Aerospace Supply Chain in China*, Department of Business, Innovation and Skills, HM Government.

UK Department for Business, Innovation and Skills (2010), *Annual Innovation Report*.

Vertesy Daniel and Adam Szirmai (2010), 'Interrupted Innovation: Innovation System Dynamics in Latecomer Aerospace Industries', UNU-MERIT Working Paper 2010-059.

World Tourism Organization (2011), *World Tourism Barometer, 2011*, 9(1), February.

International Economics at Chatham House

International Economics at Chatham House produces policy-oriented research and analysis of the challenges facing the global economy today. It maintains links with policy-makers and researchers around the globe to ensure that our independent analysis of global economic issues translates into practical and timely policy insight on the challenges facing the world economy today. The main themes include the changing world economy and the G20 framework, reform of the international monetary system, growth of emerging market financial centres, and international competitiveness and growth.

A changing world economy and the G20 framework

In the wake of the recent financial crisis, the G20 has played an important role in facilitating international economic policy cooperation. It has yet to be seen, however, if the group can move beyond its roots as a crisis committee and play a more institutionalized role in confronting the array of challenges facing the global economy today.

The International Economics team has focused its research to explore the future prospects for the G20 and set out an ambitious schedule for international economic policy cooperation (*Preventing Crises and Promoting Economic Growth: A Framework for International Policy Cooperation*). In addition, current research explores the role of G20 observer countries and those outside the G20 process in international economic policy cooperation.

Reform of the international monetary system

The international monetary system is in flux – no longer meeting the needs of an increasingly unbalanced global economy, but not yet ready to move beyond the dollar as the world's reserve currency. Current research explores the future of the international monetary system, and assesses the prospects for a range of proposed reforms.

Recent work has explored the prospects for a multi-currency reserve system (*Beyond The Dollar: Rethinking the International Monetary System*) and investigated China's ambitions for the renminbi as an international reserve currency (*'One Currency, Two Systems': China's Renminbi Strategy*).

Currently, a Chatham House taskforce is leading a review of the role of gold in the international monetary system, often the subject of heated debate. Chatham House is exploring the issue from different angles and perspectives, to focus on reform of the international monetary system..

Growth of emerging market financial centres

As the epicentre of global economic growth continues to shift towards emerging markets, Chatham House International Economics has embarked on a series of studies into the specific challenges and opportunities facing financial centres in emerging economies.

Recent work has focused on the strengths and weaknesses of the Gulf as a global financial centre (*The Gulf Region: A New Hub of Global Financial Power*) and the outlook for the Japanese financial sector in the light of recent international trends (*The Outlook for Tokyo: New Opportunities or Long-Term Decline for Japan's Financial Sector?*).

Current research explores the prospects for financial centres in the Greater China region, including Hong Kong, Taipei and Shanghai, as well as the challenges and opportunities that shifting global financial influence may pose for Singapore's role as an established Asian financial centre.

International competitiveness and growth

The past quarter-century has seen massive changes in the world economy. Trade integration and the globalization of value chains, with more and more manufacturing now taking place in emerging economies, have created new challenges together with new opportunities. As we move forward into the next decade, it is critical to address the issue of how the industries of the future will look, and which sectors/industries will lead future growth.

International Economics is undertaking a series of projects to examine the outlook for key global industries over the next decade. These include a series of research study groups on the changing industrial landscape and industry case studies identifying emerging 'global champions'.

Chatham House is also partnering with the University of Warwick's Centre for Competitive Advantage in the Global Economy (CAGE) to explore how markets, institutions, and public policy interact to create and sustain competitive advantage in response to these global changes.

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