Catching up in aeronautics: introduction to the special issue

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1 Introduction

The evolution of the aircraft manufacturing industry follows some of the contours of the product and industry lifecycle models (PLC-ILC). The industry was born at the beginning of the 20th century in the richest countries of Europe (France, Germany and the UK) and the USA; a few decades later, companies in many second cohort countries entered the industry in Europe and elsewhere[1]. However, in a decade after the emergence of the first dominant design, the DC-3 in 1935, the industry experienced a shakedown with fast industrial and geographic concentration. The USA, France and the UK became the leading countries; Canada caught up in certain niches (business and regional jets), Germany and Japan left the industry after their defeat in WWII and most of the other countries were relegated to the production of modules or subsystems for the few main producers situated in one or the other of the three leading countries.

The aircraft segment of the aerospace industry is now in its maturity phase. Calling it a mature industry does not mean that invention and innovation have slowed down. The industry is as innovative as it ever was. Yet, some other traits of maturity are evident: it shows high barriers to entry, and consequently few new entrants, as well as incremental technological change in modules and materials, and some architectural novelties.

With the dissolution of the Soviet Union in 1989, Russia almost entirely abandoned the civilian segment of the industry, and concentrated in some successful military models. Since the mid-2000, Russia is making efforts to re-enter the commercial segment, in competition with other developing or developed countries. Spain has seen the revival of its industry through its association with Airbus. Thus, in the last decade one has seen the emergence of a handful of countries that are either entering or re-entering the sector. The most conspicuous include Brazil, China, Japan, India, Russia, and Singapore. Are any of these countries catching up? Such is the subject of this special issue. The introduction starts by defining catching up (Section 2), then analyses the types of catching up in aeronautics (Section 3), presents figures for the production, employment and exports for the main countries (Section 4), and draws conclusions and policy implications from the analysis (Section 5).

2 What is catching up

The term catching up in economics has historically been associated with a growth in total factor productivity, one that brings the country that is catching up tangentially closer to the world leader in terms of productivity. Catching up is another word to make reference to the convergence hypothesis, the idea that poor countries have the potential to grow faster than advanced ones, because they find available technologies ready that they only need to adopt. However, history shows that some countries are catching up, and many others are not. Yet some authors such as Sachs and Warner (1995) suggested that the necessary conditions for catching up were just open international trade and the strong protection of private property.

An alternative institutional explanation of catching up has been associated with the name of Moses Abramovitz (1986) since the last quarter century. Abramovitz suggested that it was not free trade or the protection of private property that was key, but 'social capabilities', institutions, that allowed backward countries to absorb, master and use advanced science and technology, whatever the trade regime. The late 1990s and early 2000s brought massive support to Abramovitz approach as many of the 'open trade' activist countries went bankrupt including Argentina and Russia. Also, the Asian financial crises showed that trade liberalisation could have disastrous consequences to developing countries (Stiglitz, 2002).

Following the path opened by Abramovitz, the systems of innovation approach suggested that catching up required the development and fine-tuning of institutions (public research organisations, research universities and innovative companies) able to adopt, develop and use modern science and technology (Freeman, 1987; Lundvall, 1992; Nelson, 1993). An open trade regime, strong private property institutions and political democracy may or may not be present for catching up. But a major effort in human capital formation, research organisations and in-ward technology transfer are the key ingredients. Catching up thus, is less a process that automatic market forces produce, but more the result of an effort to build national, regional and sectoral innovation systems (Niosi, 2010).

Furthermore, the definition of catching up as being a macro-economic process is somewhat misleading. Today the median country has a total population of 4.5 million. Thus, productivity in most countries depends on just one or two industrial sectors. In Finland, it is telecommunication equipment and forest industries. In Singapore, it is microelectronics and pharmaceutical products. The productivity gap between the European Union and the USA is often explained by the slow emergence of the knowledge-based industries in Europe (Van Ark et al., 2008). Similarly, Jorgenson et al. (2008) attributed the rise of US productivity between 1995 and 2004 to the growth of the information-technology-producing industries as well as the information-technology-using sectors. In other words, total factor productivity is strongly affected by the performance of key sectors of each individual national economy. Some authors have gone even further: a quarter of US productivity growth is linked to the retail sector, most precisely organisation al innovation brought forward by Wal-Mart's innovation in retail trade (Freeman et al., 2011). Similarly, in Canada, Baldwin and Gu (2011) suggested that retail trade had contributed by 28% of the overall Canadian labour productivity growth between 1990 and 2008.

Thus, several authors have redefined catching up, and centred it on specific sectors. Perez and Soete (1988) were among the first ones to highlight sectoral catching up. They

suggested that developing countries could leapfrog more advanced nations if they invested early in new industries not yet taken over by companies based in North America, Western Europe or Japan. Lee and Lim (2001) proposed a sectoral definition of catching up based not on total productivity or labour productivity but on market share in the world economy. They suggested that countries that were catching up and a traded industry should exhibit increasing world market share of exports. Reviewing the industrial history of South Korea in the past half century, they found that some industries have caught up while others have remained backward and still others have fallen behind. They also define three different patterns of catching up: path-following catching up (when backward countries pursue the same steps as the leading country in the development of a specific sector, 'path-creating' catching up when the latecomer firms launch a new development path, and path-skipping catching up, that occurs when latecomers bounce over some phases in the development of the industry.

3 Catching up in aerospace

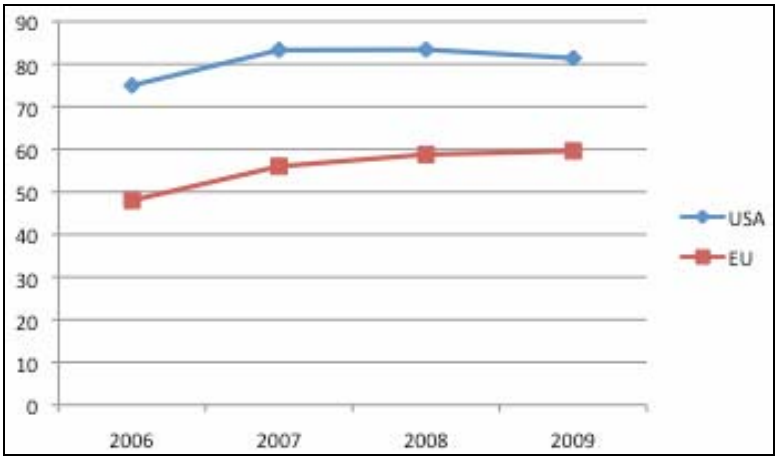
During a century of industrial development, aircraft production has moved through different major stages, over which it became a complex product. During the first two decades, aircraft manufacturers were integrated concerns, producing all parts of aircraft. Soon, the sector was divided between airframe and engine manufacturers. Such companies as General Electric and Rolls Royce Plc had started producing engines before WWI. Pratt & Whitney joined them in 1925. Later on, since the mid-1920s, US engineers discovered that fixed landing gear was responsible for a large percentage of the drag. Thus, landing gear became also an independent module, as retractable landing gear started to be used, and became more complex over the years with the adoption of the jet engine in the 1940s and 1950s.

As aircraft became a complex product with at least ten major sub-systems or modules[2], some companies abandoned the production of entire planes and concentrated on one or a few subsystems. Aircraft integration was left for a reduced number of firms. Catching up thus may occur not at the integration level, but at the level of one or two a subsystems. Also, some countries export both entire aircraft; the largest of them are the USA, France, the UK, Canada, Germany, and Brazil, but they also include China, Israel, Italy, Russia, Spain and Sweden, most often for defence products. Other countries export mainly subsystems, including Austria, the Czech Republic, Denmark, the Netherlands, and Poland (European Commission, 2009).

Catching up thus means different things. The aerospace industry is a global one; it is extensively traded, which makes it a very different sector from such domestic industries as retail trade. In this paper, catching up would mean, moving closer to the total export sales of the leading country, the USA. The question thus, is which countries, if any, is catching up with the USA?

To answer this question, we studied the export figures of countries that are potential candidates to move closer to the leader, in terms of exports, and thus catch up. The first data show US aircraft export in billion USD from 2006 to 2009. Figure 1 compares US data with EU exports outside Europe. The figure shows that EU still trails behind the USA but is tangentially approaching the leader, thus catching up.

Figure 1 US and European Union (out of Europe) aeronautics exports, 2006–2009 (billion of current USD) (see online version for colours)



Yet no European country comes closer to the USA, if they are taken individually. Table 1 shows that the three European leaders (Britain, France and Germany) are way behind the USA.

Table 1 Aeronautics exports by country, 2000-09 (billion of current USD)

	2000	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*
USA	54.7	58.5	56.9	51.1	52.9	62.6	75.0	83.3	83.4	81.4
France	20.66	22.35	21.92	23.45	27.23	30.04	35.77	39.54	48.16	44.02
Germany	20.09	23.57	22.63	23.34	26.35	27.92	34.77	32.98	37.58	41.26
Canada	8.94	11.22	10.43	10.08	9.78	10.94	12.06	14.13	14.36	13.69
Japan	3.48	4.28	3.03	2.63	3.20	3.85	4.77	5.57	5.81	6.43
Brazil	3.69	3.73	2.84	2.11	3.48	3.70	3.75	5.21	6.05	4.47
Singapore	0.74	0.96	1.10	1.35	1.50	2.01	3.66	4.36	5.48	5.80
China	0.64	0.53	0.60	0.60	0.79	1.10	1.99	2.07	2.69	2.10
Mexico	0.91	1.13	1.20	1.07	1.03	1.28	1.57	2.02	2.24	1.65
Russian Federation	0.74	0.89	2.80	3.46	3.21	1.36	1.06	1.13	1.15	1.09
India	0.06	0.08	0.11	0.09	0.09	0.12	0.68	0.35	1.44	1.13
Rep. of Korea	0.84	0.67	0.48	0.55	0.51	0.62	0.84	0.93	0.91	0.90
Argentina	0.28	0.20	0.10	0.19	0.03	0.08	0.30	0.37	0.79	0.64

Note that tiny Singapore has moved ahead of Brazil in terms of total aeronautics exports. Also, France and Germany are moving closer to the USA, but they are the two main exporters of Airbus products. Finally, Mexico has entered the industry with the same strategy it used to enter the automobile industry: by attracting foreign direct investment and assembling aircraft subsystems.

4 The issue

This special issue contains papers about the major actual countries involved in catching up: France and the European Union, Brazil, Canada, China, India, Mexico, Russia and Singapore. France, which in the early decades of the 20th century was competing for the top with the USA, is back in the position of world number two, and main follower. France has taken the leadership in organising the European Union aircraft industry, through its initiatives and investments in Airbus, EADS, Eurocopter and SAFRAN (engines). The paper by Med Kechidi shows the rise of Airbus as the world's second producer of large commercial aircraft.

Canada has been a consistent catcher up in the civil aerospace industry. Since it entered the industry in 1927 and particularly since it launched the world's first regional jet, in 1992, it has evolved into a series of business jets, regional turboprops, civilian helicopters, small aircraft engines, and other types of aircraft. Its consistent progress is explained, in Majlinda Zhegu's paper, by learning processes in the federal government capacity to frame such a complex, costly, and risky sector.

Brazil's rise in the aircraft industry is almost miraculous. Embraer, a company founded in 1967, was able to manage its conversion from the military to the civilian segments, its privatisation in 1994, and its rapid growth ever since, somehow imitating Bombardier in regional jets, then entering in the production if business jets. Its accomplishments are even more dramatic because Embraer does not conduct much R&D and has specialised in the design and assembly of both types of jets, importing almost all its subsystems. The paper by Anne-Marie Maculan shows the rise of Embraer as well as the thin path it is following.

The paper by Irina Boyko shows the rise and fall and eventual comeback of the Russian aerospace industry. Russia was at the leading edge of the industry before WWI, but the October Revolution gave a first devastating blow to the sector as several major aerospace engineers left the country. During and after WWII the industry revived, but the fall of the URSS and the economic chaos that followed the fall of the Berlin wall, destroyed the industry. In the last ten years, the industry is trying to catch up again, particularly through alliances with Western companies and through the design of the new regional jet, Sukhoi.

China has entered the industry only after the birth of the popular Republic of China. It grew a military aircraft industry with the support of the URSS, but the Sino-Russian split left the country without any source of foreign technology. The Great Leap Forward completed the disorganisation of the industry. After the Sino-American rapprochement in the early 1970s, China started to grow a new aircraft industry based on technology imported from the West. Through foreign direct investment, alliances and joint ventures, as well as massive public investment, China may reshape the industry in the decades to come. The paper by Jorge Niosi and Jing Yuan Zhao tells the story of China's catching up.

India is also making efforts to catch up in aerospace. In the first decades as an independent nation, it put the emphasis on the space segment of the industry (mainly satellites and rockets) as well as military aircraft. Yet in the last ten years it has been growing new capabilities in the civil aircraft industry where – like China – international alliances and public investment may accelerate the catching up process. The paper by Sunil Mani explains the contours of the Indian entering in the industry.

Daniel Vertesy analyses the emergence and rapid growth of the Singapore aerospace industry, active at both the manufacturing and maintenance levels. Since the early 1970, Singapore followed a consistent path of industrialisation targeting non-traditional industries such as microelectronics and pharmaceuticals for the world market. Its entry in the aircraft industry took place through maintenance repair and overhaul of the fleets of Singapore Airlines and the Singapore Air Force. From these specific competencies, Singapore added manufacturing and soon overcame Brazil in terms of both value added and labour productivity.

Mexico developed its won strategy to enter the industry: attracting foreign direct investment in the production of entire subsystems. Like in the case of automobiles, and at the very opposite of its Asian competitors, Mexico did not try to create a national champion or increase the R&D activities of these subsidiaries; it jet took advantage of the fairly skilled but inexpensive labour to create a series of small clusters in Northern and Central Mexico that wooed both US and European firms, and lately some Canadian producers also. Javier Martinez Romero tells the story of Mexican entry in aerospace.

5 Conclusions and policy implications

Our data suggest that the catching up of countries like Brazil, Canada, India or Russia is somewhat exaggerated. May be Brazil has caught up with Canada in one segment (regional aircraft) and is catching up in business jets.

Our figures tend to suggest a few countries may catch up in the industry as a whole (as systems integrators). It may happen that only China will shake this stable industrial pecking order. China may also disturb the stable close match between Brazil and Canada in regional aircraft. In both cases, the entry of China will take one or two decades at the very early.

Two general conclusions seem evident. The first one is that catching up has very different paths, from ‘industrialisation by invitation’, the less costly and risky way to catching up, but also the one that may bring smaller returns. At the other extreme, China and Russia are aiming at designing, producing and marketing their own aircraft, a much more expensive and uncertain trail to catching up, but one that may produce higher returns.

The second is that the institutional framework is key to any type of catching up, and its roles are variegated. The aerospace sector is and has always been heavily supported by the state, both in military and civilian applications, in space as well as in aircraft. In order to understand the development of this industry, one needs to examine, as the authors in this special issue have done, the institutions that fund the sector, as well as those that provide advanced human capital and technology. It is to be noted that in some countries such as China and Russia (but also in India, Israel and Singapore, as in other emerging countries) the state not only funds and supports, but produces and sells aerospace equipment: the industry is basically a state owned and controlled one. In other countries such as Brazil and Canada, the state has temporarily owned aerospace-producing organisations. In Mexico, the state has the minimal role: it simply attracts foreign investors and provides them with land and tax rebates, and eventually invests in specialised education and training. The results would be in line with the specific institutional framework and path that the catching up country has chosen.

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Notes

1 The list includes at least Argentina, Australia, Austria, Belgium, Brazil, Canada, Czechoslovakia, Hungary, Italy, Japan, the Netherlands, Russia, Spain, Sweden, and Switzerland.

2 Including avionics, engines, fuselage, tails, nacelles, tires, landing gear, and wings.