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Preconditions, windows of opportunity and innovation strategies: Successive leadership changes in the regional jet industry

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ABSTRACT

We analyse the drivers of two successive leadership changes in the regional, or mid-sized jet market, a particularly dynamic segment of the commercial aircraft industry. In the first instance, Bombardier, a Canadian newcomer, assumed leadership over the incumbents, BAe and Fokker, in 1995. In 2005, the Brazilian firm, Embraer, became the market leader in terms of number of regional jet deliveries. Our theoretical framework considers discontinuities in the building blocks of sectoral innovation systems as windows of opportunity for which challenger firms can devise strategic responses allowing them to assume market leadership. It also considers preconditions as necessary capabilities limiting the number of potential challenger companies. The analysis of leadership change shows that more efficient engines and technological improvements in subsystems, changing oil prices, business cycles, liberalization of air transport services, scope clauses and government interventions provided technological, demand and regulatory windows of opportunity. Launching new aircraft families (an architectural innovation), targeting the 50- and the 100–120-seat niche markets gave first Bombardier's CRJ family and later Embraer's E-Jet family the leadership. The fate of failed challengers and incumbents point to the importance of incumbent traps, technological and financial capabilities, the timing of windows of opportunity, speedy strategic response, a proper evaluation of future demand and sheer luck, as long lead times and sunk costs entrap incumbents and other inadequately responding companies.

1. Introduction

Schumpeterian dynamics constantly change companies' market shares. A handful of successful innovators may become industry leaders, until new challengers arise to "dethrone" them (Mowery and Nelson, 1999; Schumpeter, 1934, 1942). Successive leadership changes have characterized the regional jet (RJ) manufacturing industry since its emergence. This highly turbulent segment of the aerospace industry has witnessed the entry of firms from advanced and emerging economies, and the exit of long-established producers (Steenhuis, 2015).

Studies on industrial dynamics in aircraft manufacturing have primarily focused on producers of large civil aircraft (LCA) (Frenken and Leydesdorff, 2000; Golich, 1992; Moran and Mowery, 1991; Pavcnik, 2002). The market for mid-sized jets, unlike the consolidated LCA market, is in continuous turmoil. Some companies had a long tradition in designing and producing aircraft (i.e., Fokker, Canadair or British Aerospace (BAe) and its predecessors), others were relative newcomers (i.e., the Brazilian Embraer or the Chinese Comac). Companies' motivations to gain technological competence in RJs vary; some consider this market as a stepping-stone towards the more challenging LCA market, others aim to maximize profit from RJs.

This paper explores the history of catch up and leadership changes that took place in the global RJ industry from the late 1980s to 2010, by studying the co-evolution of technology, the competitive landscape, and the strategies of firms and governments. It aims to explain what triggered periods of catch-up and instances of leadership change, and why incumbents lost their leading positions.

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Section 2 provides a background on the industry, its emergence and the account of two instances of leadership change. Section 3 presents the theoretical framework and key arguments to test in case studies. Sections 4 and 5 offer in-depth analyses of leadership change from the early leaders to Bombardier, and subsequently from Bombardier to Embraer, by discussing windows of opportunity, strategic responses and the preconditions with respect to all relevant companies. Finally, Section 6 synthesizes the conclusions.

2. The regional jet industry and the record of leadership changes

2.1. About the industry

We define RJs as turbofan-engine-powered aircraft carrying typically 30 to 120 passengers at a range of up to 2000-2500 M.[1] Their size, range and operational costs on shorter distances distinguish RJs from LCA, while both share many technological and operational commonalities. The upper boundary of the regional segment is elusive as the smallest members of the Boeing 737 or Airbus 320 families show certain similarities to the largest Embraer E-Jets. Propulsion, rather than seating capacity, distinguishes RJs from turboprop-powered commuters. Turboprops may be more economical to operate on short distances than RJs, but are noisier and offer limited cruising altitude, speed and range. Based on our definition, many smaller jets of preceding decades would qualify as RJs.[2] However, those aircraft served different markets (connecting main airports rather than extending service to regional airports) and were not optimized for shorter routes, which were typically flown by turboprop commuters. RJs show commonalities with larger business jets. They may be identical from a technological perspective but serve different customers, so demand patterns differ. Nevertheless, the various similarities allow commercial aircraft producers to enter the RJ market relatively easily (Steenhuis, 2015).

RJ manufacturing does not differ from the structure of the mature commercial aircraft manufacturing industry. By the 1990s, this had transformed into a pyramid-shape hierarchy, with system assemblers on top, followed by primary structures and system suppliers, and component producers on lower tiers. Aerospace companies with multiple competencies can be competitors and collaborators at the same time (Niosi and Zhegu, 2005). Competitiveness in the global aircraft industry is affected by many interrelated factors, including access to capital and risk-sharing partners, government support, design capabilities and production capacity, internal organization of corporations and markets, and the characteristics of aircraft programmes. These include price and operation costs, which can benefit from commonality with other models and maintenance arrangements (USITC, 1998). The complexity of factors implies that leadership change is best analysed from a co-evolutionary perspective, considering technology, firms, markets and institutions (Bonaccorsi and Giuri, 2000; Frenken, 2000).

2.2. The take-off of regional jets and the early innovators

We date the emergence of the RJ industry to the introduction of the BAe-146 family and the Fokker F-100 in the early 1980s. RJs won the battle against turboprops due to a combination of factors. Rapidly increasing oil prices in the 1970s triggered the development of new, fuel-efficient aircraft (Fig. 1). The introduction of a new generation of turbofan (jet) engines with a relatively higher bypass ratio rendered RJs profitable even on shorter routes. The liberalization of US air transport services in 1978 opened new markets for smaller jets offering direct connections between regional airports, and connecting regional airports with hubs. Congested hubs discouraged slower and turbulence-sensitive turboprop commuters that carried fewer passengers but used similar or more airspace compared to LCAs. A subsequent decline in kerosene prices in the 1980s ensured that the newly introduced RJs gained market share. Passengers preferred jets that offered a modern alternative to replace aging turboprops (Ramsden, 1989b). In conjunction, these developments radically changed the market. Airlines could now select smaller jets as a strategic choice, rather than due to technological constraints.

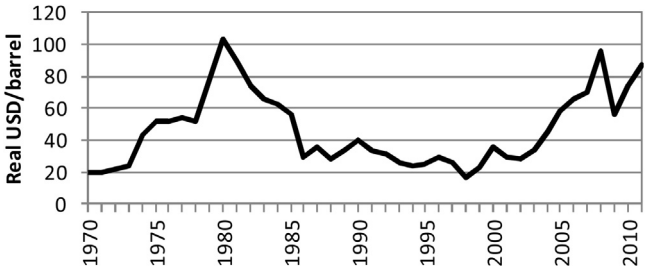

Fig. 1. Average annual crude oil prices in real terms (1970–2011). Source: US Department of Transport

RJs emerged in Europe, while the US was the overall leader in aerospace. McDonnell Douglas (MDD) and Boeing chose to target the apparently more lucrative LCA and abandoned the regional market. The aircraft industry was rather advanced in the UK and in the Netherlands, with companies benefiting from strong linkages with governments. BAe and Fokker could exploit their experience of producing and selling various types of aircraft, and their established networks of suppliers[3] (Broekel and Boschma, 2012; Cooke and Ehret, 2009).

Many of BAe's and Fokker's strategic choices on design and marketing were emulated by subsequent leaders. Both companies recognized that cost-efficiency was crucial in the regional market, which necessitated efficient product design and large production capacity. Both companies designed their aircraft in-house. The BAe-146 109-seater jet was based on an earlier shelved project of a predecessor company, but was equipped with four modern engines (Hewish, 1982). BAe intensified collaborations both in-house and with external partners, including one sharing the risks of development and production. Fokker's F-100 twinjet was a fundamentally upgraded derivative of its F-28 model.[4] The F-100 was produced in partnership with British and US-based firms. The BAe-146 design utilized the family concept to maximize commonalities and reduce costs, and was offered in three sizes catering for individual airline needs, covering seating capacities from 70 to 128. Fokker also aimed to launch a family, but only managed to introduce a smaller derivative (the F-70), due to liquidity problems. Both aircraft differed substantially from other available models. The BAe-146 family offered a wide cabin, relatively low noise and versatility in its operations. The F-100 offered relatively lower structure-weight per seat, due to using composite materials for control surfaces and inte-

[1] Given the multitude of definitions, we apply a comprehensive one based on Steenhuis (2015), Wikipedia, Jane's and various articles of *Flight International*, *Aviation Week & Space Technology* and BAe, Bombardier and Embraer publications.

[2] I.e. the SE-120 *Caravelle*, the BAC-111 or the DC-9-10.

[3] For a complete list of successful commercial aircraft programs and firms of the UK following World War II, see "Post-war UK civil aircraft production" *Flight International*, 19 Dec 2006. The Dutch commercial aircraft industry was virtually monopolized by Fokker.

[4] Experts debate whether the Fokker's F-28 *Fellowship* was the first RJ, 240 of which were produced from the late 1960s until the mid-1980s.

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