New entrants and overcapacity: lessons from regional aircraft manufacturing

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Abstract: The commercial aircraft manufacturing industry has been largely dominated by the advanced economies in North America and Western Europe. During recent decades, several emerging economies have invested heavily in the commercial aircraft industry, notably in regional aircraft manufacturing. This paper describes the global regional aircraft industry by comparing the demand and available production capacity. A small number of companies are currently active in this industry and able to satisfy demand. Yet, a larger number of companies are starting or planning to start production. Under these conditions and forecasted demands, overcapacity is a likely result. Four propositions are developed to explain the behaviour of new entrants.

Keywords: regional jets; entry-decisions; overcapacity; mature markets; aircraft industry.

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1 Introduction

The regional aircraft segment has experienced several important changes in recent years. Regional aircraft are defined in this article as aircraft with a capacity of up to about 100 passengers. The upper limit is to some extent arbitrary but is generally accepted in the industry. About a decade ago, the main competitors in regional turboprop aircraft manufacturing were companies located in industrially developed countries. These companies included British Aerospace (BAe) (located in the UK), Fokker (The Netherlands), Fairchild-Dornier (Germany) and Saab (Sweden). These companies have since then ceased civil aircraft production; Fokker in 1996, Saab in 1999, BAe in 2001, and Fairchild-Dornier in 2002. There are currently two companies that are producing regional jets (Embraer from Brazil and Bombardier from Canada) and two companies that produce turboprops (Bombardier and ATR, a Franco Italian alliance). Other companies such as AVIC (China), Sukhoi (Russia) and Mitsubishi (Japan) are working on entering the regional aircraft market in the near future. Table 1 provides an overview of the different manufacturers and their products. This is adopted from Endres (2006), Francis (2007a) and Massy-Beresford and Kinsley-Jones (2007).

Table 1 Current regional jet manufacturers and new entrants

Company	*Aircraft*	*# passengers*	*Range in km*	*Entry into service*
Bombardier	CRJ 700/900	70/86	3121/2774	2001/2003
Embraer	E-170/190	70/98	3104/3200	2004/2005
AVIC	ARJ21-700/900	90/105	2230/2230	Expected 2009
Sukhoi	Superjet100	78/98	2900/2950	Expected 2009
Mitsubishi	MJ-70/90	70/90	3600/3600	Expected 2013
JADC (Kawasaki)	YPX	Several options are being considered	Unknown	Preliminary stage

With the number of companies that have ceased regional aircraft manufacturing and already several successful companies in place, the question is whether there is room for more players in the market.

This paper focuses on capacity development. If too many players are active on a market, a situation of overcapacity will be reached, which probably will place pressure on

profit margins. The fact that a number of companies have already ceased production in the regional aircraft segment can be interpreted as a previous overcapacity situation and the introduction of new companies in the near future can create a similar situation. Therefore, the purpose of this paper is to analyse the capacity situation in regional aircraft manufacturing and to determine the viability of the market for new players. This paper is set-up as follows. In Section 2, general background information is discussed on the specific industry to provide a context for the specific capacity issues. In Section 3, literature will be presented on capacity and specific research questions are posed. In Section 4, the methodology is described followed by Section 5 with a presentation of the results. In Section 6, the results are discussed and propositions are developed to explain the decisions by potential new entrants. Finally, the paper ends with a conclusion section.

2 Aircraft manufacturing industry context

Aircraft manufacturing has several characteristics that make it distinct from many other industries. In this section, a quick overview will be provided about some of the main characteristics to provide a context for the discussion.

The development of aircraft is extremely expensive. To design and develop a large aircraft such as the Airbus 380, a 525 plus seat aircraft, costs $11 billion or more (Sparaco, 2000). Smaller aircraft such as the regional jet family by Embraer (E170-family) with approximately 70–98 seats cost $850 million to design and develop (Lewis, 2003). The final product itself, i.e., the aircraft, is logically also expensive. For example, the Boeing 737-800, a 162–189 seat aircraft has a list price of over $70 million (http://www.boeing.com/commercial/prices/index.html). The lifecycle of an aircraft type can extend beyond 20 years. For example, the most successful commercial jet aircraft in number of sales, Boeing's 737, was first delivered in December of 1967 and Boeing 737's are still produced and sold in 2008 (Jet Information Services, 2008). In order to extend a product's lifecycle that long, many technological upgrades occur within that time, such as, for example, changing payload-range characteristics, installing better engines or making product design improvements that lead to performance improvements. An example of the latter is the addition of winglets at the end of the wings, which reduce drag and lead to fuel efficiency improvements. Therefore, a competitor in the aircraft manufacturing industry needs to have sufficient financial resources as well as sophisticated technological (design and development) capabilities.

The production of aircraft is characterised by a requirement for skilled labour, a long production throughput-time, low production rates, and often a low total production volume for a specific aircraft type (Steenhuis et al., 2007). Out of all the jet aircraft that have been produced, only ten aircraft types have had sales in excess of 1,000 units. The Boeing 737 has the highest aircraft deliveries record with 5,600 aircraft since 1967. This is followed by the Boeing 727 with 1,831 deliveries and the Airbus 320 with 1,827 deliveries (Jet Information Services, 2008). Boeing, one of the main competitors in aircraft production, delivered a total of 441 commercial aircraft in 2007 (Jet Information Services, 2008). To put this into perspective, as a comparison, General Motors, one of the main car manufacturers, produced 5,708,038 passenger cars in 2006 (http://oica.net/wp-content/uploads/2007/07/ranking06.pdf) .

The commercial aircraft manufacturing industry has been a challenging industry to compete in as can be deduced from the exit of well-known western companies such as

Lockheed (USA), McDonnel Douglas (USA), British Aerospace (UK) and Fokker (The Netherlands). Yet, despite these apparent challenges, there have been several attempts in the last decades by 'new' companies to enter the market, in particular for regional jets, although frequently this has led to failure. Examples are Fairchild-Dornier (Germany; regional jets), IAe (Indonesia; both turboprops and jets), and Romaero (Romania; jets). None of these new entries has been successful.

Fairchild-Dornier was an established turboprop manufacturer, which tried to enter the jet segment but ran into financial difficulties and filed for bankruptcy (Endres, 2007). IAe started in the 1970s from a nearly non-existent industry (Eriksson, 2003). IAe is currently still producing turboprop aircraft although it has stopped the production of commercial jets after 1998, the International Monetary Funds ordered that no more financial support and privileges were to be given to this state company (Stackhouse, 1998). Romaero is another state-owned company that eventually gave up producing jet aircraft due to financial constraints although it still produces turboprops (Steenhuis et al., 2007).

Despite the exit of several well-established companies in the recent past, and the failed attempts of Fairchild-Dornier, IAe and Romaero to enter the market, a new set of potential entrants has been identified which includes AVIC (China), MHI (Japan) and Sukhoi (Russia). The question is whether the market is economically viable to sustain that many players. Before analysing the economic viability, another characteristic should be pointed out. Lessons from IAe show that this was a government-supported initiative that eventually lacked a solid economic base and seems to have been more a matter of national prestige (Eriksson, 2003). Taiwan is a similar case where technological development motives played a role but where it was shown that the development of a civil aerospace industry is more difficult than expected (Eriksson, 2006). Todd and Simpson (1986) showed that the aircraft industry cannot be considered independently of the actions of the state and that for the civil market, government financing schemes are often relied upon. Eriksson (1995) provides more recent examples of, in particular, Asian countries and the influence of the government or national prestige. This is not limited to developing countries. Airbus is an example where a consortium received government support for a long period of time, which eventually led to a strong competitor. Japan is another country that has assigned strategic importance to aerospace and that has used technology transfer projects to increase technological skills (National Research Council, 1994). The lesson to draw from this is that economic motives are not always the only motives involved in the decision to manufacture aircraft. In other words, with regard to capacity, the decision to add capacity in this industry may not be based upon economic rationale. Concerns have already been raised about the motives of potential new entrants. For example, with regard to AVIC's plans for a 150-seat aircraft it has been stated that 'in 20 years' time they will have something that is competitive with a 2005 jet airliner built by Airbus or Boeing' and 'there will not be any meaningful revenue for decades and the time it will take to get a return means the private sector won't go near it' (Ionides and Kingsley-Jones, 2008).

3 Capacity

It is distinctly possible that with the introduction of new players in the regional aircraft segment, a situation of overcapacity will be created. Some industries, such as sectors of the chemical industry, are frequently dealing with situations of overcapacity (Young,

1999). Overcapacity may lead to a reduction in prices (Adams, 1999). When looking at the issue of capacity or overcapacity, it is noteworthy that capacity decisions are at the junction of industry data (market demand) and company decision-making. The literature on capacity deals with the two perspectives, i.e., capacity decisions are discussed for individual companies (3.1) and capacity (in particular overcapacity) has been discussed from an industry perspective (3.2).

3.1 Company capacity

Capacity is one of the important structural, or long-term, design parameters for an organisation (Hayes and Wheelwright, 1984; Hayes et al., 1996, 2005). Capacity decisions deal with the amount, the timing, and the type of capacity [Hayes and Wheelwright, (1984), p.31]. A capacity strategy is a longer-term sequence of capacity decisions, which are triggered by a capital authorisation request for an expansion of capacity [Hayes and Wheelwright, (1984), p.46]. A capacity strategy is based on a series of assumptions and predictions about long-term market, technology, and competitive behaviour. These include:

1 the predicted growth and variability of primary demand

2 the costs of building and operating different sized plants

3 the rate and direction of technological evolution

4 the likely behaviour of competitors

5 the anticipated impact of international competitors, markets, and sources of supply [Hayes and Wheelwright, (1984), p.46].

Hayes and Wheelwright (1984, p.47) state that it is sometimes difficult to define or measure capacity. For example, it can be physical space, equipment, output rates, human resource capabilities, materials, or a combination. Finch (2006, p.481) makes a similar statement and identifies several resource groups that contribute to capacity such as: labour capacity, equipment capacity, packaging capacity, equipment maintenance capacity, sales force capacity, inventory storage capacity, facility capacity, and material receiving capacity.

One of the main challenges in capacity decisions is to match capacity with demand, as Stevenson (2007, p.177) states 'the goal of strategic capacity planning is to achieve a match between the long-term supply capabilities of an organisation and the predicted level of long-term demand.' Unevenness in demand may lead to under utilisation or overcapacity. Some of the typical strategies discussed in capacity decision are to add capacity proactively, neutral or reactively (Davis et al., 2003; Russell and Taylor, 2006; Heizer and Render, 2004).

3.2 Industry and (over)capacity

The literature on overcapacity is very scarce and typically only at the industry level. To the best of our knowledge, there is no specific literature that deals with individual companies decision-making and industry overcapacity situations. Rather, the literature is more general about how overcapacity situations might occur, i.e., industry characteristics that make it susceptible to overcapacity.

Overcapacity is a situation where capacity exceeds demand. Overcapacity may result from forecasting errors. An example of overcapacity as a result of forecasting errors is the global chemical shipping at the end of the 1990s (Young, 1999). From 1982–1997, the marine chemical transportation growth rate was 5% a year worldwide. Then, in mid-1997, due to the Asia crisis, the industry faltered, seaborne trade in chemical products declined 1% in 1998. Prior to the crisis, chemical shipowners had anticipated continued demand growth and ordered new ships. 'It was a good market in 1995–96… Everyone thought it would continue into 1997–1998' [Young, (1999), p.45]. Shipbuilding had also become less expensive, attracting operators to an already overcrowded market. In 1998, the global fleet expanded by 6%. Also, fewer ships were being scrapped, many ships were not demolished after the typical 25 years of service. As Young (1999, p.45) states 'confident of continued growth, chemical tanker operators ordered ships years before scrapping decisions were due.' One owner of a fleet of chemical tankers stated

> "The world economy was growing so fast that we made sure our vessels were delivered before the older ships were scrapped… We all erred on the side of caution so that we would not lose market share by scrapping and then have to regain it with new ships. We have a great deal of replacement in mind, but the question is when to act [Young, (1999), p.45]."

The oversupply in the chemical shipping sector is estimated at 30%–35% and has caused a 10%–20% fall in freight rates on major routes (Young, 1999).This example not only shows how forecasting errors may cause overcapacity in an industry but also the effects that overcapacity can have on the companies that operate in such an industry.

Aside from the demand forecasting errors, the overcapacity situation in this example was exacerbated because old capacity, which was expected to be scrapped, was not scrapped. This may partly be caused by cautious capacity expansion decisions where new capacity is added before the old capacity needs to be scrapped. Another complicating factor may be that the decision to add capacity, due to the lead time of building the capacity, may have to be made (too) far in advance.

Therefore, industries with demand uncertainty and/or industries where capacity decisions are made far in advance may be more susceptible to overcapacity situations. Aircraft production is such a situation due to the long production lead-times.

Dearden et al. (1999) provide an example of overcapacity for markets where product differentiation is marginal. In these markets, prices are typically set by the supply-demand balance in the market place (Dearden et al., 1999). Dearden et al. (1999, p.59) state

> "The dynamics in many high capital investment markets produce cycles of various sorts… Firms, driven by the desire to capture new customers and to satisfy and retain existing customers invest in production capacity. When market demand fails to match production capacity, costs rise, prices fall and firms may selectively delete capacity. So, all competing firms simultaneously balance two objectives: they weigh their desire to capture market share through assurance of supply by building production capacity against their desire to keep capacity utilisation high by not building or even divesting production capacity. Although in a monopoly a firm might tune its production capacity to track demand cycles optimally, such coordination cannot occur naturally in an oligopoly when firms make decisions independently."

Dearden et al. (1999) argue that demand forecasts are a primary reason for cyclical behaviour and they built several scenarios for firm actions. They conclude that among other things flexible manufacturing systems, sharing or reallocating production capacity with other, countercyclical products can help. In other words, companies that face cyclical industries should strive to be flexible or offer additional countercyclical products. The aircraft industry has cyclical patterns and is therefore susceptible to overcapacity situations.

Porter (1980) discusses the industry tendency for overcapacity. According to Porter (1980, p.328) the risk of overbuilding capacity is most severe in commodity businesses for two reasons. The demand is generally cyclical; this not only guarantees overcapacity in downturns but also seems to lead to excessively optimistic expectations in upturns. Second, commodity products are not differentiated, this factor makes costs crucial to competition. Also, the absence of brand loyalty means that firms' sales are closely tied to the amount of capacity they have. Thus, firms are under great pressure to have large, modern plants to be competitive and adequate capacity to achieve their target market share. Porter (1980, pp.328–334) identified a range of factors that may contribute to overcapacity. Several important factors for aircraft production are:

- Capacity gets added in large lumps. To be able to produce more aircraft typically requires that a whole series of jigs has to be duplicated and a separate manufacturing line needs to be set up. Although when demand declines, producers can decide to use less labour, the fixed costs for these jigs remain and they cannot be sold or used for other types of production.

- There are significant exit barriers. This industry uses rather specific skill sets and equipment combined with huge investments, i.e., a high percentage of fixed cost. This makes it very hard to exit the industry other than by bankruptcy. As a consequence, capacity is not easily removed from the industry.

- There are political motives for employment, which may keep aircraft capacity in place much longer than would be warranted by free market principles. Since the number of people involved in aircraft production is high, the loss of employment by terminating an aircraft program or reducing production rates can be high. For example, during the downturn in the early 2000s, Boeing cut its workforce by more than 35,000 jobs (Daniel, 2003). With these types of job cuts, there is a lot of pressure to keep producing. For countries with more restrictive labour laws than in the US, it may also be more difficult to lay people off.

Overall, one key factor that tends to cause overcapacity in regional aircraft manufacturing is that the capacity for aircraft production is rather inflexible. A high capacity is needed in order to break-even but a lot of the tools for aircraft production are specific to a specific family of aircraft. Hence, an aircraft manufacturer does not have a lot of flexibility in times of low demand to move resources around aside from the fact that producers typically only produce a few aircraft types. Once an aircraft manufacturer has made the decision to produce, it is pretty much stuck with the decision and overcapacity is a continuous threat.

Porter (1980) also offers some solutions to prevent overcapacity to occur. These solutions are primarily preemptive strategies. It is questionable whether these preemptive strategies can work in regional aircraft manufacturing because there are

limited players and these players do not necessarily have flexibility to move into other types of businesses.

3.3 Conclusions

The literature review shows that although capacity decisions are discussed from an individual firm's perspective as well as from an industry perspective, the two streams have not been connected. In other words, although some industries are more prone to get into overcapacity situations, this is ultimately a result of a set of firms that make certain, often similar, decisions. Why firms make the decisions that lead to overcapacity and consequently poor performance is not clear. The discussion above also shows that aircraft manufacturing has a number of characteristics that make it susceptible to overcapacity situations. In this article, the focus will be on regional aircraft production and in particular, the 70–90 seat segment since this is the segment that is faced with potential new entrants. The key issue in this paper is whether there is room for new entrants in the market or whether that will cause an overcapacity situation. Since capacity is coupled with demand, the following three research questions are posed that together will provide insight into a potential overcapacity situation.

1 What is the forecasted demand?

2 What is the capacity of the existing two competitors?

3 What are the capacity plans of the potential new entrants?

4 Methodology

To address these research questions, it is necessary to determine the predicted demand (5.2) which is related to past demand (5.1). Furthermore, capacity determination of current regional jet manufacturers (5.3) and the estimated capacity of new regional jet manufacturers (5.4) are required. As indicated, this research is focused on regional jets. The focus will be on the 70–90 seat segment since this is where the new entrants are focusing their attention. Section 5.5 will include information on the 30–50 seat segment for illustrative purposes.

The analysis is based on secondary data, i.e., data that has been published on the aircraft industry from a variety of sources including manufacturers and industry data from industry publications such as *Flight International*, *Aviation Week* and *Space Technology*, are used for this purpose.

5 Findings

5.1 Past demand for regional jet aircraft

The historic demand for regional jet aircraft is provided in Table 2, which is adapted from O'Toole and Moxon (1996), O'Toole (1997, 1998), Kingsley-Jones (1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007a, 2008a). Table 2 includes the regional jet manufacturers that were active from 1994 until 2008. Fairchild-Dornier went bankrupt in 2002. AvCraft took over the 328Jet and Fairchild Dornier Industries the 728Jet production. Hence, all three names appear in the table.

Table 2 Net regional aircraft orders

Company	*Aircraft*	*Type*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*
30–50 seats																
ATR	ATR 42	Prop	14	24	14	20	4	13	6	5	0	10	1	17	3	16
Bombardier	Dash 8 Q100/200/300	Prop	20	34	60	26	23	27	34	6	6	11	19	12	14	17
	CRJ100/200/440	Jet	33	38	60	127	123	170	143	189	33	55	69	–58	–16	0
Embraer	135/140/145	Jet	13	5	63	129	192	109	358	38	13	12	10	–7	20	1
Fairchild Dornier	328	Prop	46	9	27	11	12	–7	0	0						
	328Jet	Jet			0	17	24	72	45	49						
	428Jet	Jet					0	40	–40							
AvCraft	328	Prop									0	0				
	328Jet	Jet									–52	11	18	–6	1	0
Fokker	Fokker 50/60	Prop	21	11	1	0										
Saab	Saab 340	Prop	4	16	32	21	0	0								
	Saab 2000	Prop	3	2	7	12	2	0								
Total			*157*	*139*	*264*	*363*	*380*	*426*	*546*	*287*	*0*	*99*	*117*	*–42*	*22*	*34*
70–90 seats																
ATR	ATR 72	Prop	18	26	11	34	17	15	18	20	14	–10	11	73	56	97
British Aerospace	ATP	Prop	3	0	0	3	3									
	Avro RJ85/100	Jet	25	37	21	32		2	17	–1	0	4				
Bombardier	Dash 8 Q400	Prop		0	15	17	2	31	7	6	4	23	13	49	24	80
	CRJ700/900	Jet			0	29	67	3	85	41	3	17	61	57	65	102
Embraer	ERJ 170/190	Jet					0	70	60	–8	6	127	98	97	179	145
Fairchild Dornier	728Jet/928Jet	Jet					0	60	58	4						
Fairchild Dornier Industries	728Jet	Jet									–124					
Fokker	70/100	Jet	29	47	6	0										
Total			*72*	*110*	*53*	*115*	*89*	*268*	*245*	*70*	*–97*	*161*	*183*	*276*	*324*	*424*
Total net orders for regional aircraft			*229*	*249*	*317*	*478*	*469*	*694*	*791*	*357*	*–97*	*260*	*300*	*234*	*346*	*458*

Table 3 Backlog

Company	*Aircraft*	*Type*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*
30–50 seats																
ATR	ATR 42	Prop	12	24	9	9	5	6	6	6	1	8	4	16	11	20
Bombardier	Dash 8 Q100/200/300	Prop	24	38	61	31	22	23	40	21	17	11	21	23	19	17
	CRJ100/200/440	Jet	46	43	49	118	166	253	297	366	263	163	124	19	0	0
Embraer	135/140/145	Jet	13	18	59	142	272	276	479	364	256	181	103	45	53	46
Fairchild Dornier	328	Prop	65	45	21	21	8	2	1	0	0					
	328Jet	Jet				17	44	82	76	61	6					
	428Jet	Jet						40	0	0						
AvCraft	328	Prop										7	2			
	328Jet	Jet										12	11	0	0	
Fokker	Fokker 50/60	Prop	14	14	2	0	0									
Saab	Saab 340	Prop	42	43	31	26	3	0	0							
	Saab 2000	Prop	34	16	11	12	4	0	0							
Backlog 30–50 seat			*251*	*241*	*243*	*376*	*524*	*682*	*899*	*818*	*543*	*382*	*265*	*103*	*83*	*83*
70–90 seats																
ATR	ATR 72	Prop	13	12	12	26	22	14	18	23	23	7	10	73	113	173
British Aerospace	ATP	Prop	5			0	1	0								
	Avro RJ85/100	Jet	31	46	32	42	31	10	12	0	0	0	0			
Bombardier	Dash 8 Q400	Prop		0	11	32	30	61	50	27	12	23	26	57	57	90
	CRJ700/900	Jet				29	96	99	184	203	160	111	105	84	76	116
Embraer	ERJ 170/190	Jet						60	120	112	118	245	297	322	410	430
Fairchild Dornier	728Jet/928Jet	Jet						60	118	122	0					
Fairchild Dornier Industries	728Jet	Jet														
Fokker	70/100	Jet	54	60	4	0	0									
Backlog 70–90 seat			*102*	*118*	*59*	*129*	*180*	*304*	*502*	*487*	*313*	*386*	*438*	*536*	*656*	*809*
Total backlog for regional aircraft			*353*	*359*	*302*	*505*	*704*	*986*	*1401*	*1305*	*856*	*768*	*703*	*639*	*739*	*892*

In Table 2, a distinction is made between the roughly 30–50 seat aircraft and the roughly 70–90 seat aircraft. This distinction is made because the aircraft in these two segments are typically distinct aircraft types whereas a manufacturer typically has several aircraft in a segment based upon derivatives. Derivates are aircraft that are typically shortened or lengthened versions of a base-model. For example, Embraer offers the ERJ 135/140/145 series with respectively 37, 44 and 50 seats in the 30–50 seat range while it offers the ERJ 170/175/190/195 series with respectively 70, 78, 98, 108 in the 70–90 seat range. Another distinction is made between turboprop aircraft and jet aircraft. Table 2 does not separately identify Embraer's cooperation with Harbin Aircraft Industries (part of AVIC II). Harbin and Embraer have a joint venture in China. This joint venture is producing the ERJ-145 family. Table 2 shows that the total demand (net orders) for regional aircraft over the last 14 years was 5,085 aircraft, i.e., 2,792 in the 30–50 seat segment and 2,293 in the 70–90 seat segment.

Table 3 provides an overview of the historical development of the backlog in this sector. This table is based on the same sources as Table 2. Backlog exists because airlines typically start their aircraft purchasing decisions up to four years in advance and delivery of the last aircraft from an order can take place six or more years after the order is placed. Consequently, aircraft manufacturers need to know well in advance of delivery dates how many aircraft are required to be able to schedule their production. For example, Boeing decided to close its 757 production line in October 2003 when the order backlog was 12 aircraft of which the last were expected to manufactured by the end of 2004 (Norris, 2003). Similarly, Boeing decided to close its 717 production line in January 2005 because its order backlog was only 32 and these were due to be delivered by early 2006 (Wastnage, 2005).

The appearance of backlog can be interpreted as a situation of insufficient capacity, that is, the producers don't have enough capacity and therefore a backlog is created. However, in this industry this does not apply. The backlog is a consequence of the lead times involved in ordering and producing aircraft. In a sense, rather than inventories of finished aircraft, manufacturers use 'inventories of orders' (backlog) to adjust capacity to changing demand patterns.

5.2 Forecasted future demand

Both current competitors provide forecasts for demand for regional jets for the next 20 years, i.e., 2008–2027 (Bombardier Market Forecast, Pre-Farnborough Media Briefing and 2008-2027 Embraer Market Outlook) and Embraer (2008). These companies do not distinguish the exact same market segments. Bombardier's forecast probably includes the higher range segment of 100–150 seats because it is working on a new jet, the C-series (Kirby and Kingsley-Jones, 2007). It is also planning the CRJ1000, a 100–104 seat aircraft that is a stretch from the CRJ900 (Kirby and Kingsley-Jones, 2007). Table 4 provides Bombardier's forecast, Table 5 provides Embraer's forecast.

Table 4 Bombardier's forecast

Period	*20–59 seat*	*60–99 seat*	*100–149 seat*	*Average demand per year (for roughly 70–90 seat segment)*
2008–2027	500	6,100	6,300	305

Table 5 Embraer's forecast

Period	*30–59 seat*	*61–90 seat*	*91–120 seat*	*Average demand per year over 20 years (for roughly 70–90 seat segment)*
2008–2017	275	1,075	1,800	130
2018–2027	825	1,525	1,950	
2008–2027	1,100	2,600	3,750	

Although the identified segments from Bombardier (60–99) and Embraer (61–90) are not exactly identified as a 70–90 seat segment, in this article their identified segments will be identified as the roughly 70–90 seat segment since the aircraft that both manufacturers are currently offering aircraft that fit into that category.

It is noticeable that the two forecasts are quite different and that for the next 20 years, Bombardier expects almost 2.5 times as much demand on an annual basis in the 70–90 seat segment than Embraer. This leads to an additional remark about aircraft demand forecasts. In the aircraft industry, there are frequent adjustments to forecasts and many times new aircraft models are proposed that are never developed. Examples of forecasting adjustments are; due to slackening of sales, Bombardier had to trim its CRJ200 production in 2004 (Flight International, 2004). Embraer, cut back its two year delivery forecast by 12% in 2004 (Shannon, 2004) and AvCraft cut its forecast from between 700 to 1,200 aircraft to between 250–350 aircraft (Norris, 2004). In other words, the forecasts from Bombardier and Embraer are subject to change. Another example is that in 2007, Bombardier estimated the market for 60–99 seat aircraft at 4,300 units (Bombardier Aerospace, Commercial Aircraft Market Forecast 2007-2026) so it increased its forecast by more than 40% in the last year whereas Embraer's forecast for this segment in 2007 was the same as the 2008 forecast (2007-2026 Embraer Market Outlook). It was noted by de Bruijn and Steenhuis (2004) that aircraft demand forecasts may be influenced by the manufacturer's product development plans. This may indeed be the situation for Bombardier, which is planning the C-series aircraft (above 100-seat regional aircraft) and therefore may be more optimistic about regional aircraft demand in general. Note that based on Table 2, the average demand for the 70–90 seat segment over the last 14 years was 164 aircraft per year.

With this history of frequent forecast changes in mind and with the discrepancy between Bombardier's forecast and Embraer's forecast, and in addition with the much higher forecasted demand by Bombardier compared to the average net orders over the last 14 years, it is questionable whether the forecast by Bombardier is not too optimistic.

5.3 Capacity of current manufacturers

In this paper, capacity is viewed from an output perspective, i.e., capacity is determined by how many products are produced. Stevenson (2007, p.179) distinguishes two types of capacity. Design capacity is the maximum output rate or service capacity an operation, process, or facility is designed for. Effective capacity is the design capacity minus allowances such as personal time, maintenance, and scrap. Design capacity is the maximum rate of output under ideal condition.

Table 6 Regional aircraft deliveries

Company	*Aircraft*	*Type*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*
30–50 seats																
ATR	ATR 42	Prop	19	12	28	19	10	12	7	5	5	3	5	5	8	7
Bombardier	Dash 8 Q100/200/300	Prop	29	20	38	34	30	25	17	25	11	7	9	10	17	19
	CRJ100/200/440	Jet	26	41	51	61	75	82	99	126	134	155	108	47	1	0
Embraer	135/140/145	Jet	0	0	4	31	60	97	157	153	121	87	88	48	12	7
Fairchild Dornier	328	Prop	18	29	22	11	13	7	1	1						
	328Jet	Jet			0	0	0	15	33	31						
	428Jet	Jet					0	0	0							
AvCraft	328	Prop									0	0				
	328Jet	Jet									8	7	8	6	1	0
Fokker	Fokker 50/60	Prop	17	11	5	3										
Saab	Saab 340	Prop	9	15	26	26	24	3								
	Saab 2000	Prop	5	20	11	8	10	4								
Total			*149*	*169*	*185*	*193*	*222*	*245*	*314*	*341*	*279*	*259*	*210*	*116*	*39*	*33*
70–90 seats																
ATR	ATR 72	Prop	32	27	11	20	21	23	15	15	14	6	8	10	16	37
British Aerospace	ATP	Prop	1		0	3	3									
	Avro RJ85/100	Jet	26	21	26	22	20	23	15	10	0	4				
Bombardier	Dash 8 Q400	Prop		0	0	0	0	0	18	30	18	12	10	18	31	47
	CRJ700/900	Jet			0	0	0	0	0	22	46	66	67	78	63	62
Embraer	ERJ 170/190	Jet					0	0	0	0	0	0	46	72	86	123
Fairchild Dornier	728Jet/928Jet	Jet					0	0	0	0						
Fairchild Dornier Industries	728Jet	Jet									0					
Fokker	70/100	Jet	30	41	17	5										
Total			*31*	*68*	*54*	*50*	*44*	*46*	*48*	*77*	*78*	*88*	*131*	*178*	*196*	*269*
Total regional aircraft delivered			*180*	*237*	*239*	*243*	*266*	*291*	*362*	*418*	*357*	*347*	*341*	*294*	*235*	*302*

Effective capacity is usually less than design capacity owing to the realities of changing product mix, the need for periodic maintenance of equipment, lunch breaks, coffee breaks, problems in scheduling and balancing operations, and similar circumstances. Furthermore, Stevenson (2007, p.179) states that the actual output cannot exceed effective capacity, and is often less because of machine breakdowns, absenteeism, shortages of materials, and quality problems, as well as factors that are outside of the control of the operations managers.

The actual output will be used as an 'estimate' of the effective capacity. The actual output is a 'conservative' indicator for the effective capacity since the effective capacity is equal to or higher than the actual output. Therefore, if an analysis of actual outputs indicates that overcapacity exists, then this is only compounded by looking at effective capacity instead of at actual output. Table 6 provides an overview of the output by assessing the history of aircraft deliveries. It is adapted from the same sources as Table 2. Table 6 shows that over the last 14 years, a total of 4,112 regional aircraft were delivered, i.e., 2,754 in the 30–50 seat segment and 1,358 in the 70–90 seat segment. That is, in the 70–90 seat segment the average annual delivery was 97 aircraft.

To determine capacity of an individual producer, the maximum production rate achieved in the last ten years (see Table 4) is taken as an indicator for what the company can achieve as a minimum with regard to production, i.e., its capacity. Table 7 provides an overview of the capacity for the current competitors in the 70–90 seat regional jet aircraft segment.

Table 7 Capacity of current 70–90 seat jet manufacturers

Manufacturer	*Aircraft*	*Maximum output rate*
Bombardier	CRJ 700/900	78
Embraer	ERJ 170/190	123
Total 70–90 seat capacity		201

The annual capacity of 201 aircraft is much higher than the average annual demand for 97 aircraft over the last 14 year. Based upon Table 7, Bombardier and Embraer have a combined capacity to deliver 4,020 aircraft over the next 20 years. Comparing Table 7 with the market forecasts of Bombardier and Embraer, it can be concluded that when the 'most optimistic' market forecast is used, there is production room for an additional 104, i.e., 305–201, aircraft per year, or 2,080 aircraft over a 20-year period. This assumes that Bombardier and Embraer will try to utilise their capacity optimally. In Section 6, this assumption will be discussed. This leads to the question whether the production of 2,080 aircraft is a sufficient amount for one or more companies to successfully enter this market segment. If the 'average' of the forecasts of Bombardier and Embraer is used, i.e., average annual demand of 218 aircraft per year, then there is room for an additional 17 aircraft per year, or 340 aircraft over a 20-year period. If the 'most pessimistic' forecast, i.e., Embraer's 2008 forecast, is used then the current competitors can already more than fulfil the demand. It should be pointed out that the most pessimistic forecast, i.e., Embraer's 2008 forecast, still forecasts an average growth of roughly 35% for the 70–90 seat segment compared to the last 14 years, i.e., demand for 130 aircraft per year versus 97 aircraft per year.

Sales of 500–700 aircraft are taken as a measure that the product is successful, i.e., profitable [US Department of Commerce, (1986), p.24]. This equates volume of sales

with the profitability of a program. However, although a small volume typically means that a program is not profitable, a large sales volume does not necessarily lead to a profitable program. This depends on the cash-flow, the amount of money invested, the cost of capital, the cost of production, the experience gained (learning curve effects) and the speed with which these are gained. This last aspect is particularly important for late entrants since a part of the market has already been captured. This gives the initial entrants opportunities to move faster down the learning curve leading to reduction of cost. If a company has a low market share, i.e., it only delivers a small number of aircraft per year, then it will not only take longer to reach a pre-determined break-even point but in effect, the break-even point will go up because interest cost etc., will influence it. In this case, the total cost of the program will increase.

Based on these considerations, it can be established that the average measure of an additional 340 aircraft over a 20-year period is not a sufficient quantity for additional manufacturers to be able to survive. If the most optimistic forecast of Bombardier is used, then the additional 2,080 aircraft over a 20-year period is probably a sufficient quantity for one additional manufacturer but it remains questionable whether two additional companies can survive due to the advantages of early entrants as explained above. First, due to higher cost the earlier estimate of 500–700 aircraft as a break-even quantity may go up and second, due to higher cost the aircraft may be less competitive so the ability to reach the higher required sales level goes down. For one new entrant to survive, that still assumes that the new entrant will be able to capture a significant part of the market.

The above is based upon the estimates of production capacity as provide in Table 7. Note that Table 7 is a 'very conservative' estimate for the effective capacity of Bombardier and Embraer. This is because both manufacturers have already demonstrated that they can achieve this production quantity. The capacity may go up due to shifts in emphasis between product lines. Figure 1 shows how market demand in general has shifted from the 30–50 seat segment to the 70–90 seat segment.

Figure 1 Net regional aircraft orders

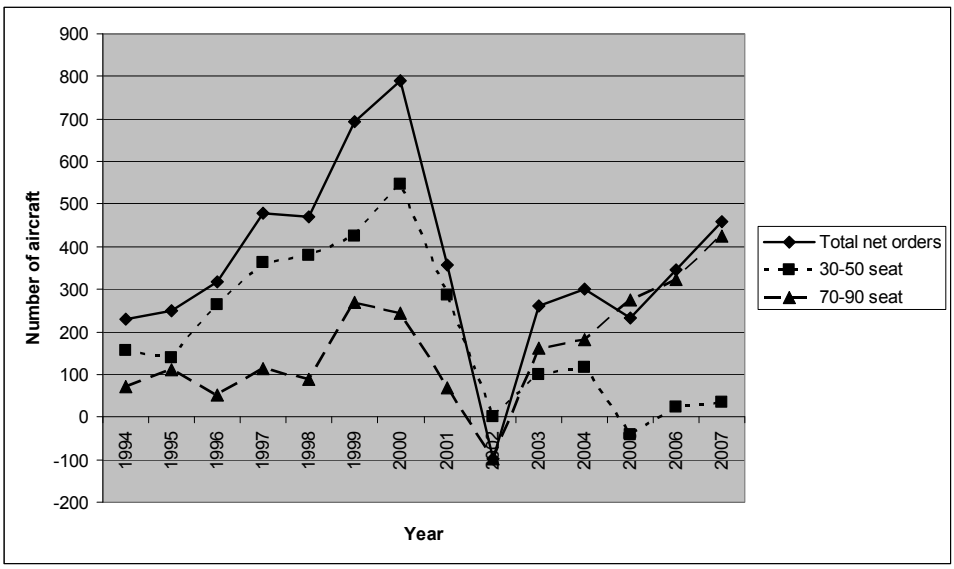
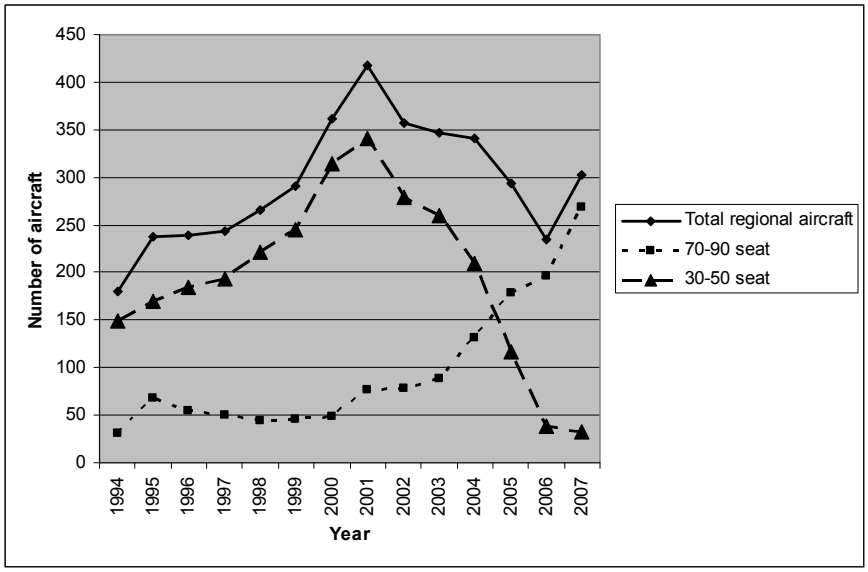


Figure 2 shows the response of regional aircraft manufacturers in the number of deliveries.

Figure 2 Regional aircraft deliveries



Figures 1 and 2 show that a shift in demand has occurred from the 30–50 seat segment to the 70–90 seat segment. The two main regional jet manufacturers Bombardier and Embraer show a similar pattern as shown in Figures 3 and 4.

Figure 3 Capacity shifts at Bombardier

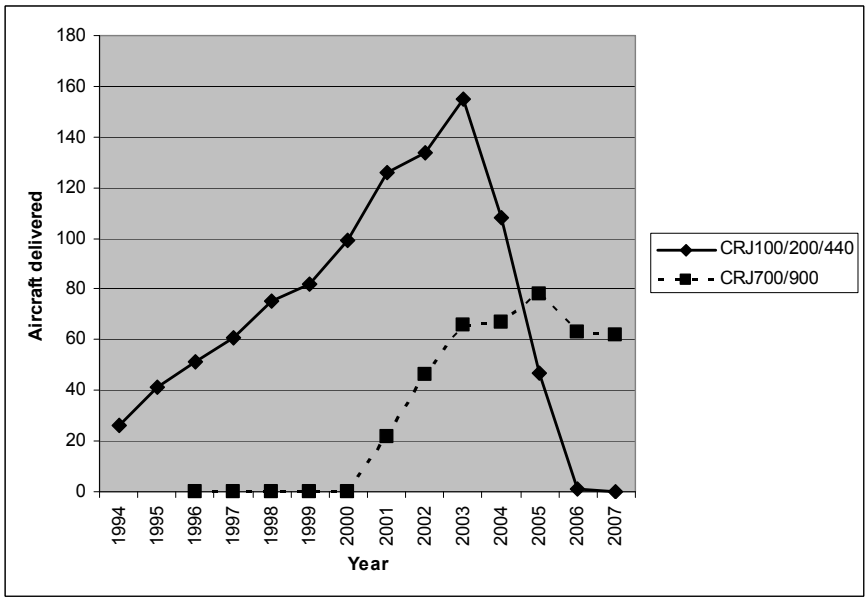
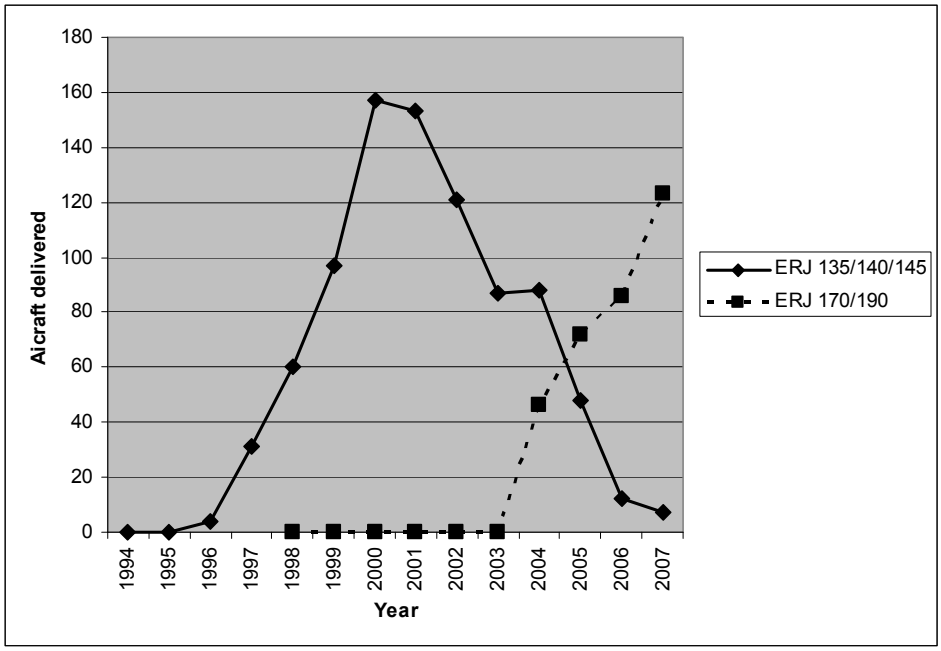


Figure 4 Capacity shifts at Embraer



Analysing Figures 3 and 4, it can be assumed that both Bombardier and Embraer have more available capacity in the 70–90 seat segment than the estimate from Table 7. This is due to some flexibility to move capacity from the production of 30–50 seat aircraft to the production of 70–90 seat aircraft. Table 8 provides an indication of the capacity of Bombardier and Embraer in the 30–50 seat segment. This capacity is significantly higher than their capacity in the 70–90 seat segment.

Table 8 Capacity of current 70–90 seat jet manufacturers in the 30–50 seat segment

Manufacturer	*Aircraft*	*Maximum output rate*
Bombardier	CRJ100/200/440	155
Embraer	ERJ 135/140/145	157
Total 30–50 seat capacity		312

There is some flexibility to switch capacity to the other aircraft segment. For example, flexibility occurs by switching personnel although this may involve training. The general production techniques/tools can also be used to some extent for other aircraft. However, this is not a straight relationship, i.e., the capacity for regional jet production is not simply a sum of the capacity in the 30–50 seat segment (Table 8) and the capacity in the 70–90 seat segment (Table 7) because not only did the output for these segments peak at different times, the capacity flexibility is also limited due to aircraft specific production items such as jigs etc. that can not be used for different aircraft types. In aircraft production, these types of specific production capacity form a high fixed cost and large part of the production process. Also, some shifts, such as in personnel between 30–50 seat aircraft production and 70–90 seat aircraft production may already have appeared in

the past. Nevertheless, based upon the above, it can be concluded that Bombardier and Embraer have potentially more capacity available than indicated in Table 7.

To conclude, at best, with Bombardier's most optimistic forecast, it seems that there is room for one additional competitor to add capacity in the market. If the most pessimistic forecast (Embraer) is taken or if Bombardier's forecast from 2007 is taken and also if the average of Bombardier's 2008 forecast and Embraer's 2008 forecast is taken, there is no room for an additional competitor in the market since Bombardier and Embraer are capable of delivering most of the anticipated demand.

5.4 Capacity plans by new entrants

Five potential new entrants in the 70–90 seat market have been identified: Sukhoi, AVIC I, Mitsubishi, JADC (Kawasaki) and Rekkof. The first three of these are determined new entrants where either production is already taking place or a program has officially been launched. The last two companies have publicly made statements but at this point, it is uncertain or doubtful that they will enter the market. The last two are included in the discussion to illustrate additional 'plans'.

- Sukhoi

  A Sukhoi led consortium is working on the SuperJet100. This will be the first Russian aircraft designed from scratch to meet Western certification standards. Sukhoi is also working on a stretched 120-seat version (Turner, 2007a). Alenia took a 25% stake in Sukhoi Civil Aircraft in 2006 (Turner, 2007a), illustrating western involvement. The first SuperJet100 is expected to be delivered in 2009 (Ranson, 2008). Sukhoi expects to capture about 20% of the market, which it translates into about 800 aircraft (Massy-Beresford and Kingsley-Jones, 2007). Although Sukhoi does not give any time-period, if a 20-year period is assumed for the forecast (this is used by the main aircraft manufacturers such as Bombardier, Embraer but also Airbus and Boeing) then this means that Sukhoi expects demand for roughly 4,000 aircraft, which is somewhere between Embraer and Bombardier's forecast. As pointed out in Section 5.3, Embraer and Bombardier have the capacity to deliver this number of aircraft.

- Mitsubishi

  Mitsubishi Heavy Industries (MHI) is currently developing the MRJ family consisting of the MRJ90 (90-seat class) and the MRJ70 (70-seat class). After receiving an initial 15 aircraft order from ANA, MHI formally launched their program in April 2008. The entry into service is expected in 2013 (Francis, 2008). The expected cost for developing the aircraft is $1.5 billion (Kingsley-Jones, 2008b) and MHI projects demand for about 1,000 of these aircraft (Govindasamy, 2008), this is a 20% share of MHI's forecast for 5,000 aircraft in the 70–90 seat segment (Kingsley-Jones, 2008b). MHI did not provide a specific time-period for the forecast but if a 20-year forecast is assumed then this means that MHI expects to sell 1,000 aircraft, which is roughly the difference between MHI's forecasted demand of 5,000 units and the roughly 4,000 units that Bombardier and Embraer have capacity for as shown in Section 5.3.

- AVIC

  AVIC I is currently producing the ARJ21 prototype, it started cutting the first metal in January 2004 and final assembly was started in March 2007 (Francis, 2007c). Chinese certification is expected in the second half of 2007 (Endres, 2006). AVIC I and Bombardier disclosed at the Paris air show in 2007 that they will be partners. Bombardier will invest $100 million to work with AVIC on a 105-seat stretched version of the ARJ21. AVIC I will invest $400 million into its aircraft factories to prepare them to work on the planned Bombardier C-series, a 110–130 seat aircraft (Francis, 2007a). China is also planning an additional 70-seat turboprop, the MA700. The first flight is expected in 2013 or 2014 (Francis, 2007b). No data could be found on AVIC's expected demand or sales.

- JADC

  JADC from Japan is at an earlier stage. Currently, it carries out feasibility studies for an indigenous regional jet. The Japanese Government has been focusing on regional jets for a longer time. Approximately ten years ago, it was looking into the YS-X, a 100-seat regional jet, but it gave up these plans in 1998 to focus more on components and subsystem technologies (Flight International, 1998). In 2002, JADC again initiated studies on a 30-seat regional jet (Doyle, 2002) and a 150-seat regional jet (Sobie, 2003). Both of these fall outside of the 70–90 seat segment but the 150-seat jet falls into the highest number of seat segment mentioned in Bombardier's forecast hence, it is mentioned here. As part of JADC, Kawasaki revealed at the 2006 Farnborough air show that it has plans for the YPX, a 110–130 seat aircraft but a final decision has not yet been made (Flight Daily News, 2006). Another interpretation has been that Kawasaki might be working on an aircraft that is similar to the Embraer E-190 (Endres, 2006).

- Rekkof

  Rekkof is included as a potential new entrant although it is highly unlikely at this time that it would become a competitor. It is mentioned because although Fokker went bankrupt in 1996, Rekkof has expressed its intention in continuing the production of Fokker 70 and Fokker 100 aircraft. India expressed interest in the Rekkof production of Fokker aircraft. 'Talks are continuing on possible license production of revamped versions of the Fokker regional jet types in India' (Ionides, 2006). 'There is some interest in Fokker aircraft in India… we would have to make it for the overseas market as well to be viable and improvements would have to be made to the original design to reduce operating costs' (Ionides, 2006). Estimated production rates for Rekkof are based on past available data from Rekkof's website (http://www.rekkof.nl).

To put the plans of the potential new entrants into perspective, a couple of remarks will be made. First, when assuming a 20-year forecast, then the new entrants have more optimistic forecasts than Embraer but less optimistic forecasts than Bombardier. Second, currently Bombardier and Embraer together hold a 100% market-share. Therefore, any company that plans to enter the market and considering that demand will not exceed the current combined capacity of Bombardier and Embraer assumes that it will be able to take marketshare away from these two companies. An example above is Sukhoi. Third, if

market growth is forecasted, i.e., demand will exceed current combined capacity of Bombardier and Embraer, then it might be possible to take advantage of the growth. An example above is Mitsubishi. However, this assumes that Bombardier and Embraer will not expand their capacity. Lastly, the points above illustrate the challenges for a new entrant in competing with Bombardier and Embraer. What has not even been taken into consideration is the possibility of two or more new entrants and how they will have to compete not only with Bombardier and Embraer but in addition with the other new entrants.

Table 9 provides an overview of the planned production rates for new entrants.

Table 9 Expected capacity of potential entrants and entry timing

Manufacturer	*Aircraft*	*Estimated output rate per year*	*Expected entry into service*
Sukhoi	SuperJet 100	70 by 2011 (Karnozov, 2007)	2009
AVIC I (ARJ21)	ARJ21	30 by 2011 (Francis, 2007a)	2009
Mitsubishi	MRJ	Not yet available	2013
Rekkof (Fokker)	Fokker 70/100	45	Unknown
JADC	YS-X	Not yet available	Unknown

Section 5.3 showed that in the 'most optimistic demand scenario' there is room for an additional 104 aircraft per year and that this was based on 'very conservative estimates for existing production capacity' of Bombardier and Embraer. Table 9 shows that there are five potential new entrants of which, three are serious and the bottom two are uncertain. When the new entrants are taken together, they will add more than 104 aircraft per year in capacity. Even if only Sukhoi, AVIC and MHI are included it will add more than 104 aircraft per year since MHI will have to produce more than four aircraft per year. Furthermore, in Section 5.3 it was concluded that with the most optimistic forecast there was probably room for one new entrant. In addition, if the more pessimistic forecasts were used there was barely any necessity for additional capacity, i.e., no room for additional new entrants. Overall then, it can be concluded that three to five new entrants would lead to overcapacity and that two or even one new entrant (dependent upon the forecast used) will likely lead to an overcapacity situation.

6 Discussions

The purpose of this paper was stated as analysing the capacity situation in regional aircraft manufacturing and to determine the viability of the market for new players. The observation was made that when looking at past demand data as well as forecasted demand data in combination with current and expected future production capacity in the 70–90 seat segment, a situation of overcapacity is likely to occur when too many new entrants enter the market. An important question is: why are companies planning on entering this market segment under those conditions? There are several possible answers to that question. This will be explored by looking at the matching of (forecasted) demand and (forecasted) capacity. Logically, misunderstandings about forecasted demand, forecasted capacity or not basing decisions on economic criteria can explain the plans of new entrants. This leads to five possible scenarios:

1 The demand forecasts are correct and there is room for more than one additional competitor. That is, the conclusion reached above is incorrect, there will be no overcapacity or companies are able to survive by producing fewer aircraft than assumed necessary in the discussion above.

2 The conclusion reached above, i.e. there is overcapacity, is currently correct. However, this situation will change because future demand will exceed the discussed demand forecasts and therefore there will be room for additional capacity (new entrants).

3 The conclusion reached above, i.e. there is overcapacity, is currently correct. However, the new entrants have other reasons to assume that they can flourish. That is, their capacity will have to replace some of the capacity of the current competitors.

4 The conclusion reached above, i.e. there is overcapacity, is correct. The potential entrants are underestimating the situation and there is not enough room to add capacity (new entrants) in a financially viable way.

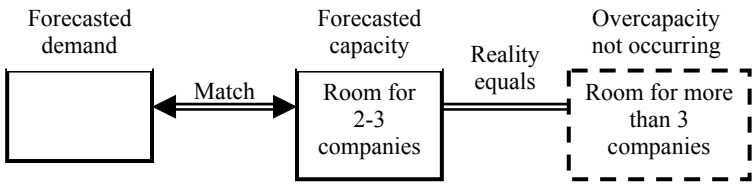
5 The conclusion reached above, i.e. there is overcapacity, is correct. However, the new entrants have other, non-financial motives, which do not require economic survival in the market.

Each of these five possible explanations will be discussed in the following four sections leading to a proposition for each scenario.

6.1 Overcapacity is not occurring

A possibility is that the forecasted figures are correct but that this situation is not a situation of overcapacity or at least it means that more than three regional aircraft manufacturers can survive together. This is depicted in Figure 5, where it shows that the forecasted capacity is similar to the forecasted demand yet more companies can survive together.

Figure 5 Overcapacity does not occur



This explanation might be correct because it might be possible that a manufacturer needs to produce a minimum number of aircraft in order to survive that is much lower than their effective capacity. For example, when taking Bombardier's forecast of 6,100 aircraft and if a break-even point of roughly 700 aircraft were used for a manufacturer, then this would lead to a potential market for almost nine manufacturers. However, in this case,, almost nine manufacturers would break-even, and not make a profit. Secondly, it is possible that the break-even point for manufacturing is lower than the 500–700 aircraft that was used in Section 5.3. This would allow more new entrants. Sukhoi has stated that its expected break-even point is 300 units (Turner, 2007b), but several months later it was

stated as 350 units (Bonnassies, 2007). Because of the changes in what Sukhoi announced, these figures were not used in the previous analysis because of reliability issues. Furthermore, as was pointed out in Section 5.3, the break-even point is connected to the learning curve and the speed of deliveries. When production rates are low, then it will not only take longer to reach the break-even point but the break-even point will also shift upward and the cost of aircraft will remain longer at a higher level. A complicating factor for new entrants is that both Bombardier and Embraer at the beginning of 2008 have already delivered respectively 342 and 204 aircraft in the 70–90 seat segment. This means that they have learning advantages, i.e., lower production costs, which makes them more competitive. Later entrants might have to sell their aircraft for lower prices than initially anticipated leading to yet an even higher break-even point. Although there are some logical arguments against the possibility of multiple new entrants, the following proposition is formulated so that at least the possibility is not ignored.

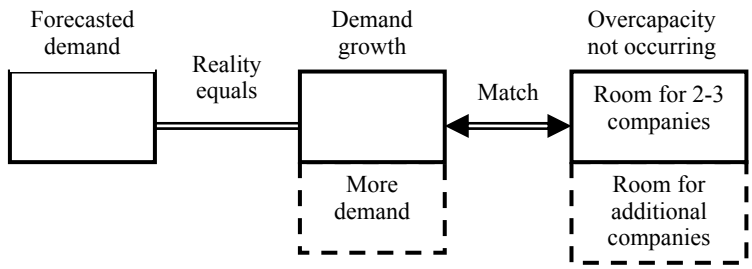
Proposition 1 Actual demand for regional jets is as indicated in published forecasts. The market is large enough for the current competitors and new entrants to survive together.

This proposition can be tested by following the 70–90 seat regional jet segment over the next decade or so to determine whether market forecasts have indeed been correct and whether new entrants are able to survive.

6.2 Overcapacity is occurring but demand will grow

The new entrants might be using different forecasts that are higher than the published forecasts by Bombardier and Embraer. Demand is therefore expected to grow beyond the current forecasts resulting in an adjustment in the forecasts. These forecasts might indicate to the new entrants that there is enough demand for their products. This is depicted in Figure 6.

Figure 6 Demand will grow



The data for past aircraft orders and deliveries are available from different sources and checks indicate that these sources report similar data. The past orders and deliveries figures are therefore deemed reliable. The published forecasts have typically been too high and therefore have been adjusted downward (see Section 5.2) but an adjustment upward is also possible. This leads to the following proposition:

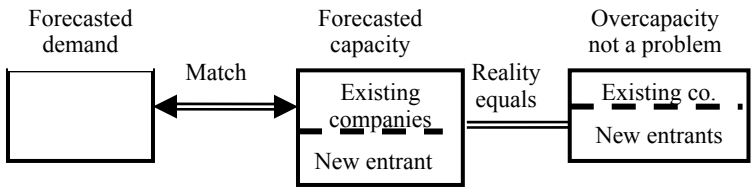
Proposition 2 Actual demand for regional jets is higher than indicated in published forecasts. The market is large enough for the current competitors and new entrants to survive together.

This proposition can be tested by following the 70–90 seat regional jet segment over the next decade or so to determine whether market forecasts have indeed been adjusted upward and consequently new entrants were able to survive.

6.3 Overcapacity not a problem

Another possible explanation for the decision-making of new entrants is that although they are aware of the numbers as presented in Section 5 (that is that overcapacity exists), they sense that the overcapacity situation will not apply to them. In this situation, the new entrants are expecting to operate in the market but expect to change the current status of competition. This is depicted in Figure 7.

Figure 7 Overcapacity not a problem



For example, when Bombardier and Embraer developed their regional jets in the 30–50 seat segment, they introduced a new product that replaced the existing turboprops. Although the overall demand for regional aircraft may not have changed much, the 30–50 seat regional jet manufacturers replaced the 30–50 seat regional turboprop manufacturers. Therefore, whether overcapacity existed for the turboprop segment could be viewed as an irrelevant factor for Bombardier and Embraer's decision making to enter the 30–50 seat market. In order to be able to capture a piece of the market regardless of the existing overall capacity, a new entrant will have to introduce a new product that will attract sufficient customers and/or the new entrant needs a protected market that is significant in size.

One strategy might be to close of the domestic market to sell enough units in that closed market and/or to gain production experience, i.e., become more internationally competitive. Both China and Russia might be able to close their domestic markets for outside manufacturers but in both cases, this is deemed insufficient as a sole factor for survival by ACAC and Sukhoi. A total market for 500 ARJ21 is foreseen in China but the focus is also on Southeast Asia and South-America for exports (Endres, 2006). For Sukhoi, the domestic market is also not considered sufficient. Sukhoi expects to sell 800 aircraft over the next 20 years, of which 250–300 from airlines in Russia and the CIS (Kingsley-Jones, 2007b; Massy-Beresford and Kingsley-Jones, 2007).

It appears therefore, that the new entrants will have to sell their aircraft in international markets and they will need to introduce a product that is attractive to customers to take market share from Bombardier and Embraer. Export is a challenge for a new entrant due to the need to meet western standards, certification issues and the need to provide a global sales and support network (Steenhuis et al., 2007). To deal with this problem, both AVIC I and Sukhoi have used western companies to provide them with advice (Francis, 2007a; Turner, 2007a). In September 2007, AVIC I had firm orders for 35 aircraft from Chinese airlines and memorandums of understanding for another 28

aircraft of which two for its first international customer from Laos (Francis, 2007a). Sukhoi currently has a backlog from Russian customers for 61 aircraft (Kingsley-Jones, 2007a). According to Sukhoi, it has also an international customer: ItAli Airlines has ordered ten Superjet 100/95 in a long-range version 98-passenger, with options for ten additional aircraft (http://www.sukhoi.superjet100.com/mediacenter/news/00026/). Table 10 provides some insight into how the new entrants think that they can distinguish themselves, i.e., be attractive to part of the market.

Table 10 Distinguishing features new entrants

Company	*Claims*
AVIC	No specific claims found that make the aircraft more appealing than existing aircraft from Bombardier and Embraer.
Sukhoi	'SSJ will have significantly lower operating costs [than Bombardier and Embraer] – our target is to be 10–15% better – and its wider cabin will offer more comfort.'
	'Sukhoi says the SSJ's catalogue price is $27.8 million, undercutting its direct rivals, the Embraer 190 and 195, by 18–22%.' (Massy-Beresford and Kingsley-Jones, 2007)
Mitsubishi	'MRJ is the next generation regional jet made with cutting-edge technology. The aircraft will achieve the best combination of operating economy and cabin comfort' (http://www.mrj-japan.com/) and 'the aircraft will burn 20% less fuel and emit less noise than its competitors' (Flight International, 2007)
Rekkof	'The Fokker 70 NG and the Fokker 100 NG will have the lowest purchase price of any aircraft in their class' and 'on an average 500 nm trip, the total direct operating costs of the Fokker 70/100 NG will be 10% less than the present day Fokker 70/100 and compared to the nearest competitor the DOC advantage will be 15%' (http://www.rekkof.nl/bannerframes/frame_the_operation.htm)
JADC	No specifics provided

In this particular situation, the new entrants expect to capture a piece of the market, which means that there will be less of the market available for their competitors. Whether the new entrants will be competitive depends upon a range of factors, see for example (Steenhuis et al., 2007) and goes beyond the scope of this article. If market demand overall is correctly forecasted (as in number of aircraft) and if the new entrants are successful in capturing a significant part of the market, then this must result in a loss of market share for either Bombardier and/or Embraer. This may lead to a displacement of one or both of these manufacturers.

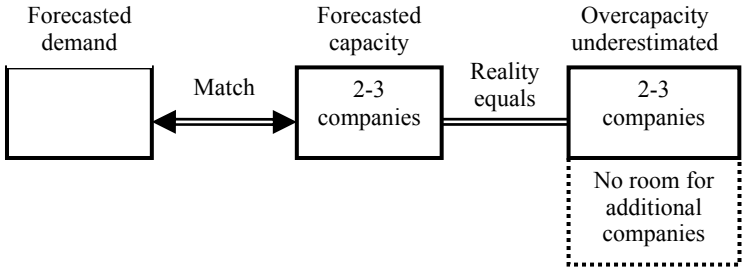
Proposition 3 Actual demand for regional jets is similar to that indicated in published forecasts. The market is not large enough for the current competitors and new entrants to survive together. The new entrants offer a distinctly new and attractive product that replaces the current competitors leading to a displacement of one or both of the current competitors.

This proposition can be tested by following the 70–90 seat regional jet segment over the next decade or so to determine whether the market forecasts by Bombardier and Embraer have indeed been correct and whether new entrants have been able to capture a significant part of the forecasted demand.

6.4 Underestimating overcapacity

Another possibility is that the new entrants are underestimating the overcapacity or that they are overestimating their ability to become successful. This is depicted in Figure 8.

Figure 8 Overcapacity underestimated



Lovallo and Kahneman (2003) describe how many managers make decisions based upon delusional optimism. Over-optimism can be traced to cognitive biases as well as organisational pressures. It is likely that this optimism is occurring in the new entrants in regional jet manufacturing as well. Lovallo and Kahneman (2003, p.63) state 'it is in the planning of such de novo efforts (entering an entirely new market) that the biases toward optimism are likely to be great.' As an example, Mitsubishi estimates that demand for 70–90 seat aircraft for the next 20 years will be over 5,000 units. This is 92% more than Embraer's forecast and 16% more than Bombardier's forecast even though Bombardier used a smaller category (that is from 60–99 seats).

In addition to over optimism, Comino identified that a market entry decision typically involves uncertainty and that companies use different types of information to deal with this uncertainty. One of those is information externalities, that is information inferred from the behaviour of other investors (Comino, 2006). The implication is that when one company decides to enter the market, others might do the same because they perceive the entry of the initial company as a signal of profitability; otherwise, the initial company would not have entered the market. This kind of decision-making underestimates capacity issues. Reid and Zyglidopoulos (2004) studied failed investments in China and found similar explanations. Key issues were failure of understanding and failure of anticipation. Failure of understanding can be found when companies mirror the actions of competitors. Failure of anticipation is for example a significant overestimation of demand and/or facing an unforeseen level of competition (Reid and Syglidopoulos, 2004). Both create an over optimism situation as mentioned by Lovallo and Kahneman (2003).

It is quite possible that this situation is also occurring in the 70–90 seat regional jet segment. As explained in Section 2, the regional jet market may have characteristics that encourage overcapacity on a structural basis. This lends support for an explanation of new entrants behaviour based on optimism of new entrants. This leads to the following proposition:

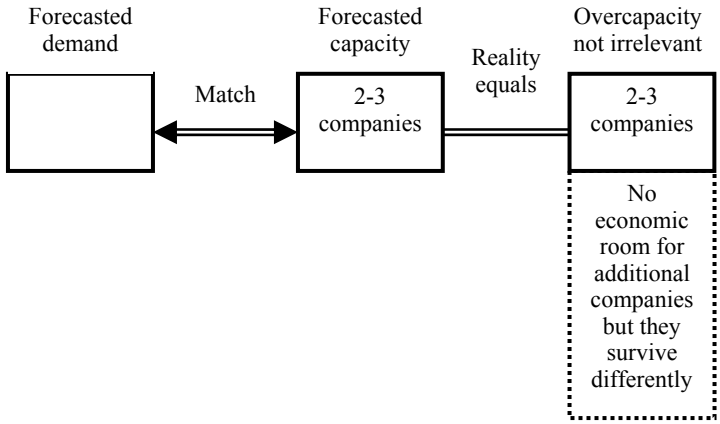
Proposition 4 Actual demand for regional jets is similar to that indicated in published forecasts. The market is not large enough for the current competitors and new entrants to survive together. The new entrants have been too optimistic and do not offer a distinctly new and attractive product that replaces the current competitors. Therefore, the new entrants cannot survive in the market.

This proposition can be tested by following the 70–90 seat regional jet segment over the next decade or so to determine whether the market forecasts by Bombardier and Embraer have indeed been correct and whether new entrants have not been able to survive.

6.5 Non-economic motives

The last possibility is distinctly different from the previous four. The previous four propositions were all based on rational economic decision making from companies. The decision to enter is therefore dependent upon the perceived probability of being able to financially survive in the market. Another possibility is that the new entrants have other, non-economic motives, as has been illustrated in the past, see Section 2. This is depicted in Figure 9.

Figure 9 Non-economic motives



For example, they may want to manufacture aircraft as part of a technological development strategy even if this is not economically beneficial. It may also be a matter of national prestige or creating employment. This leads to the following proposition:

Proposition 5 Actual demand for regional jets is similar to that indicated in published forecasts. The market is not large enough for the current competitors and new entrants to survive together. The new entrants have been too optimistic and do not offer a distinctly new and attractive product that replaces the current competitors. Therefore, the new entrants cannot economically survive in the market. However, the new entrants have other, non-economical, motives that keep them active in the market.

This proposition can be tested by following the 70–90 seat regional jet segment over the next decade or so to determine whether the market forecasts by Bombardier and Embraer have indeed been correct and whether new entrants have not been selling a significant number of aircraft (around 500) but remain active in the market.

7 Conclusions

In this paper, the regional aircraft industry has been analysed from a capacity perspective. In the recent past, a number of experienced western manufacturers have ceased regional aircraft production. Additionally, several companies have attempted to enter this market but have failed. Despite these histories, currently, a number of non-western manufacturers are planning to enter the 70–90 seat regional jet segment. The question raised in this paper is whether there is room in this market for these additional new entrants based upon a capacity viewpoint. The literature review showed that the regional jet manufacturing industry has characteristics that make is susceptible to overcapacity situations. Findings from this industry may also apply in other industries with similar characteristics. The analysis in this paper of past demand, forecasted demand, and available capacity indicate that there is probably not enough room for all new entrants to coexist with current manufacturers and that an overcapacity is likely to occur.

Despite the publicly available data on forecasted demand and available capacity in this market, several of the new entrants are in advanced stages of introducing their products. In the literature, the capacity decision has been described from an individual firm perspective and overcapacity has been treated from an industry perspective. The linkage of individual firm decisions related to overall industry data is limited. In this paper, this last aspect has been explored by looking at explanations for the behaviour of new entrants that have forecasting data available to them. Information on market expectations from the new entrants shows that they implicitly either expect to take advantage of market growth, i.e., fill the demand that is in excess of the capacity of current manufacturers, or they implicitly or explicitly expect to take market share away from the current manufacturers. One factor that is unclear in the expectations of new entrants is the role of other new entrants.

Based upon the functioning of existing manufacturers and the formulated intentions of the potential new entrants five propositions were developed to explain the potential outcome of the decisions. Four propositions were developed based upon rational-economic motives. These four propositions relate to different interpretations about

1 what is necessary with regard to capacity in order to survive

2 higher forecasts then what is publicly stated

3 the possibility that new entrants take market share away from existing manufacturers

4 a situation of over-optimism from the new entrants.

A fifth proposition was developed, which did not assume a rational-economic motive. This last aspect may be more specific to the particular industry that was studied. Previous experiences of some of the failed attempts to enter the regional jet manufacturing industry has shown that non-economic considerations such as prestige or local development can be included in the decision-making of potential new entrants.

The analysis and development of propositions highlights an important characteristic of capacity decision making. A firm's capacity decision-making relates to matching its forecasted demand with capacity. It is possible that forecasted demand is over-optimistic. This is maybe even more so in markets with relatively few competitors where there is a perceived opportunity for capacity in addition to that of the main competitors. This type of situation resembles the prisoner's dilemma. That is, each of the potential new entrants

faces an attractive situation to enter the market because there is room for an additional competitor. However, if all potential new entrants enter the market, it is likely that all potential new entrants will suffer because there is not enough room for all of them to be economically viable. Add to this that some of the new entrants may have other, non-economic motives, and the probability increases that too many new entrants will try to enter the market, which results in a situation of overcapacity. This raises an important challenge in capacity decision making: although the capacity decision is at the firm level, the demand forecast is at the industry level and influenced by other players. Overcapacity, in particular, might occur when there is a lot of uncertainty in the market forecast that relates to activities of other competitors or potential new entrants. Tracking the regional aircraft industry for the next decade will have to show which of the propositions will be confirmed which would contribute to the understanding of the relationship between firm-level capacity decisions and the uncertainty in industry-level forecasts.

References

2007–2026 Embraer Market Outlook, 4th ed., available at www.embraer.com (accessed on 4 September 2007).

2008–2027 Embraer Market Outlook, 5th ed., available at http://www.embraercommercialjets.com/hotsites/market-outlook-2008/english/content/home/ (accessed on 21 May 2008).

Adams, J. (1999) 'Prices suffer from rising overcapacity', *Chemical Week,* February 17, p.51.

Bombardier Aerospace, Commercial aircraft market forecast 2007-2026, available at http://www.bombardier.com, retrieved from September 4, 2007.

Bombardier Market Forecast, Pre-Farnborough Media Briefing, available at http://www.bombardier.com/en/0_0/0_0_1_7/0_0_1_7_8/pdf/20080507_Market_Forecast_Pre-Farnb_FNL.pdf (accessed on 21 May 2008.

Bonnassies, O. (2007) 'Sukhoi expects Superjet to break even by 2012', *Flight International,* Vol. 172, No. 5111, p.9.

Comino, S. (2006) 'Entry and exit with information externalities', *Journal of Economic Behavior & Organization*, Vol. 60, pp.85–99.

Daniel, C. (2003) 'Boeing to cut another 5,000 jobs', *Financial Times,* 18 July, p.13.

Davis, M.M., Aquilano, N.J. and Chase, R.B. (2003) *Fundamentals of Operations Management,* 4th ed., McGraw-Hill Irwin, Boston.

Dearden, J.A., Lilien, G.L. and Yoon, E. (1999) 'Marketing and production capacity strategy for non-differentiated products: winning and losing at the capacity cycle game', *International Journal of Research in Marketing,* pp.57–74.

de Bruijn, E.J. and Steenhuis, H.J. (2004) 'Freedom of choice in technology strategy? An analysis of technology strategy in the large commercial aircraft industry', *Technology Analysis & Strategic Management,* Vol. 16, No. 3, pp.381–393.

Doyle, A. (2002) 'Japan to sound out manufacturers on indigenous 30-seat regional jet', *Flight International,* September, Vol. 24–30, p.6.

Endres, G. (2006) 'Back to stay', *Flight International*, Vol. 170, No. 5060, 31 October–6 November, pp.37–66.

Endres, G. (2007) 'A fine balance', *Flight International,* Vol. 172, No. 5111, pp.24–37.

Eriksson, S. (1995) *Global Shifts in The Aircraft Industry, A Study of Airframe Manufacturing with Special Reference to the Asian NIEs,* Department of Human and Economic Geography, University of Gothenburg, Series B, No. 86.

Eriksson, S. (2003) 'Indonesia's aircraft industry: technology and management impediments', *International Journal of Technology Transfer and Commercialization*, Vol. 2, No. 2, pp.207–226.

Eriksson, S. (2006) 'Cluster creation and innovation within an emerging Taiwanese high-tech sector', *International Journal of Technology Transfer and Commercialization*, Vol. 5, No. 3, pp.208–236.

Finch, B.J. (2006) *OperationsNow, Profitability, Processes, Performance,* 2nd ed., McGraw-Hill Irwin, Boston.

Flight Daily News (2006) 'Kawasaki plans civil version of P-X patrol', *Flight Daily News*, July 18, p.5.

Flight International (1998) 'Japan moves away from YSX', *Flight International,* 26 August–1 September, p.6.

Flight International (2004) 'Bombardier sees sales of regional jets slacken', *Flight International,* 1–7 June, pp.7.

Flight International (2007) 'MHI offers roomier MRJ', *Flight International*, Vol. 171, No. 5093, p.31.

Francis, L. (2007a) 'Building a future', *Flight International*, Vol. 172, No. 5102, pp.38–41.

Francis, L. (2007b) 'China to follow ARJ21 with all-new 70-seat turboprop', *Flight International*, Vol. 172, No. 5099, p.12.

Francis, L. (2007c) 'ARJ21 assembly starts in Shanghai', *Flight International,* Vol. 171, No. 5078, p.9.

Francis, L. (2008) 'MRJ takes off with 15-aircraft ANA order', *Flight International,* Vol. 173, No. 5132, p.10.

Govindasamy, S. (2008), 'Mitsubishi takes aim for 1,000 sales', *Flight International,* Vol. 173, No. 5133, p.21.

Hayes, R., Pisano, G., Upton, D. and Wheelwright, S. (2005) *Operations, Strategy and Technology, Pursuing the Competitive Edge,* Wiley.

Hayes, R.H. and Wheelwright, S.C. (1984) *Restoring our Competitive Edge, Competing Through Manufacturing,* John Wiley & Sons, New York.

Hayes, R.H., Pisano, G.P. and Upton, D.M. (1996) *Strategic Operations, Competing Through Capabilities,* The Free Press, New York.

Heizer, J. and Render, B. (2004) *Operations Management,* 7th ed., Pearson Prentice Hall, Upper Saddle River, NJ.

Ionides, N. (2006) 'Indian reincarnation on cards for Fokker regional jet types', *Flight International*, Vol. 170, No. 5055, p.12.

Ionides, N. and Kingsley-Jones, M. (2008) 'China's big-time ambitions', *Flight International,* Vol. 173, No. 5139, p.14.

Jet Information Services (2008) *World Jet Inventory, Year-end 2007*, Jet Information Services, Utica, NY.

Karnozov, V. (2007) 'OAK puts Russion vision into action', *Flight International,* Vol. 172, No. 5112, p.11.

Kingsley-Jones, M. (1999) 'Jet there soon', *Flight International,* 10–16 February, p.30.

Kingsley-Jones, M. (2000) 'Regional jets steal output lead', *Flight International,* 15–21 February, p.32.

Kingsley-Jones, M. (2001) 'Jets soar as prop sales slump', *Flight International,* 13–19 February, p.33.

Kingsley-Jones, M. (2002) 'Regional orders plummet as jet output growth slackens', *Flight International,* 26 February–4 March, p.31.

Kingsley-Jones, M. (2003) 'Cancellations exceed orders', *Flight International,* 4–10 February, p.18.

Kingsley-Jones, M. (2004) 'Surge in jet sales brings back boom', *Flight International,* 3–9 February, p.12–13.

Kingsley-Jones, M. (2005) 'Turboprops turn the corner', *Flight International,* 1–7 February, pp.14–15.

Kingsley-Jones, M. (2006) 'Cancellations in sub-90-seat sector push regional jet orders into red', *Flight International,* Vol. 170, No. 5053, p.6.

Kingsley-Jones, M. (2007a) 'Regional appetite returns', *Flight International*, Vol. 171, No. 5077, pp.12–13.

Kingsley-Jones, M. (2007b) 'Russian revolution', *Flight International*, Vol. 171, No. 5073, pp.36–39.

Kingsley-Jones, M. (2008a) 'Props drive regional boom', *Flight International,* Vol. 173, No. 5129, pp.12-13.

Kingsley-Jones, M. (2008b) 'Will MRJ change the game?', *Flight International,* Vol. 173, No. 5133, p.20.

Kirby, M. and Kingsley-Jones, M. (2007) 'CRJ1000 takes on Embraer 190', *Flight International,* Vol. 171, No. 5076, p.12.

Lewis, P. (2003) 'Changing circumstances', *Flight International*, 13–19 May, p.60.

Lovallo, D. and Kahneman, D. (2003) 'Delusions of success, how optimism undermines executives' decisions', *Harvard Business Review,* Vol. 81, No. 7, p.56–63.

Massy-Beresford, H. and Kingsley-Jones, M. (2007) 'Export driven', *Flight International*, Vol. 171, No. 5073, pp.44–45.

National Research Council (1994) *High-Stakes Aviation: US-Japan Technology Linkages in Transport Aircraft,* National Academy Press, Washington D.C.

Norris, G. (2003) 'Sales drought takes 757's scalp', *Flight International,* 21–27 October, p.4.

Norris, G. (2004) 'AvCraft 'flat wrong' as it cuts 328Jet outlook', *Flight International,* 16–22 November, p.12.

O'Toole, K. (1997) 'In search of the new jet age', *Flight International,* 5–11 March, pp.25–26.

O'Toole, K. (1998) 'Regional revolution', *Flight International,* 11–17 February, pp.27.

O'Toole, K. and Moxon, J. (1996) 'Regional dilemma', *Flight International,* 7–13 February, pp.26–27.

Porter, M.E. (1980) *Competitive Strategy,* The Free Press, New York.

Ranson, L. (2008) 'Sukhoi finally ready to start Superjet flight testing', *Flight International,* Vol. 173, No. 5138, p.17.

Reid, D.M. and Zyglidopoulos, S.C. (2004), 'Causes and consequences of the lack of strategic foresight in the decisions of multinational enterprises to enter China', *Futures*, Vol. 36, pp.237–252.

Russell, R.S. and Taylor III, B.W. (2006) *Operations Management, Quality and Competitiveness in a Global Environment,* 5th ed., John Wiley & Sons, Hoboken, NJ.

Shannon, D. (2004) 'Embraer cuts back two-year delivery forecast', *Flight International,* 26 October–1 November, p.9.

Sobie, B. (2003) 'Japan targets regionals for manufacturing return', *Flight International,* 19–25 August, p.12.

Sparaco, P. (2000) 'Europeans remain upbeat about A3XX', *Aviation Week and Space Technology*, 14 February, p.64.

Stackhouse, J. (1998) 'IMF bring IPTN down to earth', *Interavia*, February, p.32.

Steenhuis, H.J., de Bruijn, E.J. and Heerkens, J.M.G. (2007) 'Technology transfer and catch-up; Lessons from the commercial aircraft industry', *International Journal of Technology Transfer and Commercialization*, Forthcoming.

Stevenson, W.J. (2007) *Operations Management,* 9th ed., McGraw-Hill Irwin, Boston.

Todd, D. and Simpson, J. (1986) *The World Aircraft Industry,* Croom Helm, London.

Turner, A. (2007a) 'Sukhoi advances composite use for stretched SSJ', *Flight International,* Vol. 172, No. 5095, p.8.

Turner, A. (2007b) 'New start for Sukhoi', *Flight International,* Vol. 172, No. 5100, pp.33–35.

US Department of Commerce (1986) *A Competitive Assessment of the US Civil Aircraft Industry,* Westview Press, Boulder and London.

Wastnage, J. (2005) 'German carrier holds torch for 717', *Flight International,* 15–21 March, p.11.

Young, I. (1999) 'Chemical shipowners grapple with overcapacity', *Chemical Week,* 16 June, pp.45–46.

Websites

http://oica.net/wp-content/uploads/2007/07/ranking06.pdf, retrieved.

http://www.mrj-japan.com/, retrieved July 22, 2008.

http://www.rekkof.nl/bannerframes/frame_the_operation.htm, retrieved April 1, 2005.

http://www.rekkof.nl/bannerframes/frame_the_operation.htm, retrieved April 1, 2005.

http://www.sukhoi.superjet100.com/mediacenter/news/00026/, retrieved July 22, 2008.