Outsourcing of strategic resources and capabilities: opposing choices in the commercial aircraft manufacturing

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Abstract

Purpose – *This paper aims to address the questions of different outsourcing strategies between Airbus and Boeing and point out the theoretical limits of the resource-based view (RBV) approach that must be broadened with a finance perspective. Owing to the complexity of systems, the aircraft industry is nowadays structured around a well-organised value chain of product development and manufacturing. However, according to the RBV, capabilities attached to some systems and components are strategic resources and must be kept in house to maintain competitive advantage. In commercial aircraft avionics, critical systems such as flight controls fall directly under this rule, due to substantial risks of passenger safety they deal with.*

Design/methodology/approach – *This study is based on two comparative studies concerning the A330/340 and A350 programmes at Airbus and their equivalents at Boeing, the B777 and the B787. The data are both primary (financial and patent data) and secondary (semi-structured interviews and documentation.*

Findings – *The main result highlights the limits of the RBV model to understand why Airbus has chosen to re-internalise the development and production of flight control systems contrary to Boeing. For both, cost reduction is the main objective of outsourcing, but European firms are more careful with critical resources. The financialisation of aircraft manufacturers' strategies is another explanatory factor relevant to understand why Boeing outsources strategic resources such as flight controls.*

Research limitations/implications – *The authors demonstrate the potential of multiplication of research methods to address a question. Second, they try to bring together different theories in a preliminary effort, which gives them some promising stuffy perspective for future works.*

Practical implications – *By addressing both the RBV and the financialisation perspectives, the authors provide an interesting view of the COmplex Products and Systems (CoPS) challenges.*

Social implications – *The findings of this research must provide key of interpretation for business managers, which may consider the two faces, knowledge management and financial, to explain corporate performance.*

Originality/value – *Several originalities are relevant in this work. From a methodological point of view, the authors offer a comparison between the two main players of commercial aircraft manufacturing, an oligopolistic industry. Second, the data they choose to rely on are both qualitative and quantitative to strengthen the results. Third, at a micro level, this study is original in its approach of linking outsourcing to financialisation.*

Keywords *Outsourcing, Financial performance, Supply chain management, Aircraft industry*

Paper type *Research paper*

1. Introduction

One way of defining the boundaries of a company is to identify the capabilities and activities that it has to keep in-house and those that it has to outsource, thus defining an "inside" and an "outside". Together with the rising outsourcing in the years after the end of Golden Era of capitalism, two featured perspectives have especially dealt with questions around externalisation of corporate resources. The first belongs to a cost management and costs saving perspective, whereas the second deals mainly with the management of resources and capacities. Theorising the first perspective, transaction costs economics

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> **"One way of defining the boundaries of a company is to identify the capabilities and activities that it has to keep in-house and those that it has to outsource, thus defining an 'inside' and an 'outside'."**

(Williamson, 1985) suggests that, when the degrees of uncertainty, asset specificity and the frequency of exchanges are high, vertical integration is the main form of productive organisation due to the important transaction costs of contracting out the economic activity. Being the unit of analysis, transaction defines the organisational forms and choices. The second perspective on the question of contracting in our out is concurrently studied by the resource-based view (RBV) (Wernerfelt, 1984; Prahalad and Hamel, 1990; Barney, 1991). For this view, the ability of a company to build and develop a set of core or strategic capabilities is a guarantee of its competitive advantage. The view recommends keeping them in-house, and holding them is a further source of competitive advantage (Prahalad and Hamel, 1990; Barthélémy, 2007). For aircraft manufacturers, flight controls constitute strategic resources which necessitate capabilities that are also critical to deploy them. In particular, as the failure of an aircraft's flight controls puts at risk the lives of the passengers themselves, the level of certification required for this critical component is maximal. The pivotal nature of the system obliges, a priori, every aircraft manufacturer to retain total control of it, to maintain the confidence of the airlines that are its clients. Moreover, the technologies included in flight controls are highly specific, which make the system difficult to imitate. Nevertheless, it may be seen that, although Airbus has insourced this system, Boeing has adopted the opposite strategy of outsourcing it. How can one explain these opposing strategic choices made by two competitors in defining their boundaries? This paper aims to provide an answer to this question.

In our study, we have chosen not to restrict ourselves to the problem of the control of resources and capabilities. Although such control enters into the choice of whether or not to outsource, there are other criteria to be taken into account, in particular, the cost reduction that can be generated through outsourcing. In addition, in the case of the increasing financialisation of strategies and maximising shareholder value, where short-term financial performance and an increase in the share price are the primary objectives, this cost criterion becomes dominant. Thus, although the RBV enables us to understand the choice of Airbus, it must be broadened with a more financial perspective to explain Boeing's strategy, which is subject to these phenomena.

The paper is organised in three parts. In the first part, we use the VRIO (Value, Rarity, Imitability, Organisation) model to describe the unique and strategic nature of flight controls. In the second part, we show that Airbus and Boeing have developed opposing strategies in the case of flight controls; the former insources the system and the latter outsources it. These results are discussed in the third part where the financialisation of Boeing's strategy is demonstrated. We conclude by showing that it is necessary to go beyond the RBV to analyse corporate choices relating to outsourcing.

2. The VRIO model applied to flight controls

2.1 The VRIO approach

The source of competitive advantage for organisations has always been a major topic within the general discussion on organisational success among business scholars. Although the Harvard school (Porter, 1980) teaches us that the performance of a company results from the conditions of the industry of which it forms part and, in particular, from its competitive intensity, the RBV (Wernerfelt, 1984; Prahalad and Hamel, 1990; Barney, 1991) relates performance mainly to internal determinants. The development of the company thus depends on the way in which resources are cultivated, and their combinations improved, to forge capabilities (Prahalad and Hamel, 1990; Grandval and Soparnot, 2003, 2005).

Resources are specific tangible or intangible assets which can take financial, physical, human, technological, organisational or reputational (Grant, 1996) and relational forms (Dyer, 1996; Dyer and Singh, 1998). In particular, the ability of a company to maintain its knowledge base is an important resource, making the company into a catalyst of information and knowledge (Grant, 1996). Capabilities are considered to be the simultaneous deployment of several resources to carry out a given activity. They equate to capacity for coordination and a unique way of organising resources that is peculiar to the company that exploits them.

A resource or a capability is said to be strategic if it gives the company a long-term competitive advantage. To achieve this long-term competitive advantage, several conditions must be met (VRIO model) (Barney, 1991, 1995; Peteraf, 1993; Barney and Hesterly, 2006):

- The resources and capabilities that offer the greatest value are those that give access to a great number of markets and give a product its value in the eyes of the client. They can also enable the company to exploit an opportunity offered by the environment or to protect itself against a threat (Value).
- The resources and capabilities must not be held by a large number of companies (Rarity).
- The resources and capabilities must be difficult and/or very expensive for competitors to imitate. Causal ambiguity, which indicates that the company has poor control over the causality between resources and competitive advantage, the path-dependence of the organisation's history, the difficulty of replicating internal social relationships and the filing of patents all inhibit imitation (Dierickx and Cool, 1989) (Imitability).
- The company must be able to exploit the resources and capabilities, which pre-supposes an efficient organisation of processes and of its structure (Organisation).

The resources and capabilities defined as strategic are thus a major asset of the company and contribute to the definition of its boundaries. The company can derive a long-term competitive advantage from resources and capabilities that meet the above-mentioned conditions. By adopting this logic, the company should not outsource them because they are part of its core business (Prahalad and Hamel, 1990; Barthélémy, 2007) and offer a long-term competitive advantage (Quinn and Hilmer, 1994). This is the case for flight controls.

2.2 Electric flight controls: a strategic resource according to the VRIO model

Electric flight controls constitute a major component of avionics systems of an aircraft. A handful of researchers (Hobday *et al.*, 2000; Acha *et al.*, 2007; Acha and Brusoni, 2008) have shown that the design and production of these *complex product systems* (CoPS) call

> **"We have shown that Airbus has progressively brought the computer element, the core of the flight control system, back in house during successive programs whereas Boeing outsources this critical, strategic component in an accelerated fashion."**

"... we demonstrate the potential of multiplication of research methods to address a question."

for very specific physical, technological and intellectual resources like industrial processes to track components or highly skilled workforce capable to follow specific certification rules as examples. Increasing complexity of aircraft systems and sub-systems and the importance of controlling such technologies also influence this special feature. Additionally, technological risks emerging through the rapid evolution of electronic component technologies and the increasingly systemic relation between flight controls and other sub-systems (wings, structures) reinforce the particular character of flight control systems. In his case study research on knowledge management strategies of engine manufacturers, Prencipe (1997, 2000) utilised CoPS framework to show the evolution of production strategies of these suppliers towards extended outsourcing, while they update other crucial capabilities required for the production of the entire system of aircraft engines.

Flight controls belong to the category of on-board systems known as "critical real time"[1], with very strict reactivity and safety requirements for the equipment. Three types of equipment make up the sub-system. *Pilots' controls* (control column, speed brake lever and rudder pedal) transmit information in the form of signals to *computers* which process it and send instructions to the *actuators* on the rudders. A system of intelligent sensors distributed over the whole aircraft analyses the flight data (anemometer, gyrometer, *etc*.) which are then processed by dedicated computers and displayed on the pilots' instrument panel. The computer transmits the data and guarantees the ability of the equipment to reproduce the movement of the pilot (manoeuvring of the cables). Flight control computers are interesting case study subjects regarding past works on CoPS in the avionics industry for two reasons. First, the research on them which also crosses CoPS literature offers another window for knowledge management research field. Second, engine and flight control computing systems constitute the most critical systems for certification requirement. With a focus on flight controls, we chose to address Airbus/Boeing's rivalry on the management of critical resources. To the best of our knowledge, flight controls are a very specific case of knowledge re-appropriation and resource re-internalisation which are not equally observed in two players. Airbus follow a progressive and long-term re-internalisation strategy since the A340 arguing the technological challenges on flight control computers and still outsources some other critical components such as engine controls, structures, etc.

This system may be considered as a strategic resource as described by the VRIO model.

2.2.1 Electric flight controls: indispensable on modern aircraft. The design of an aircraft is based on the assembly of complex systems and sub-systems. Avionics now occupy a central position with the widespread introduction of electric controls and electronics into the systems which aim to reduce costs by making the aircraft lighter and to make it more secure with regard to rapidly increasing air transport globally.

For the past 20 years, airlines have insisted on electric flight controls before purchasing a civil airliner with more than 100 seats. Until the 1960s, military and civil aircraft were equipped with hydraulic and mechanical flight controls where the pilot manipulated a control column linked by cables to actuators placed on the wings and rudders. The Concorde and Mirage 2000 programmes were the first to include – even partially – electrical controls (Fly by Wire), the objectives being to improve the manoeuvrability of the aircraft and to facilitate the introduction of new functions and equipment (Sghairi Haouati, 2010). Later, electric flight controls became progressively generalised in civil aviation starting with the A320 programme for Airbus and the B777 for Boeing. Their presence has been a source of value for the client, determines (although it does not ensure) commercial success and represents a barrier to entry for potential competitors.

Today, successive innovations that have enabled the progressive electrification of flight controls continue this trend, the electric version bringing a reduction in mass (and thus in fuel consumption) of approximately 17 per cent compared to the hydro-mechanical version (Thillois, 2006), as well as a reduction in maintenance costs.

2.2.2 A system that is complex to manufacture and to imitate. The criteria of Rarity and Imitability may be considered simultaneously, given the critical nature of flight controls. There are three reasons for this:

1. Any problem with the flight controls will lead to the return of the aircraft to the maintenance site and its immobilisation for several days; thus, supplementary costs are often high (Delehelle, 2008).
2. Any technical failure of the flight controls imperils the safety of the passengers. In this case, the safety and security of flights directly influence technological orientations, in particular for systems known as critical real time such as flight controls. The field of avionics is structured into several major groups defined by the Air Transport Association[2]. RTCA DO-178B lists them according to their level of criticality or DAL (Design Assurance Level). Flight control systems are classified at the maximal level A: any failure of the system may lead to a catastrophic problem.
3. This system includes more and more components that are not dedicated to aeronautical applications, and whose use may, a priori, not satisfy the certification criteria of the aeronautical industry.

More generally, the electrification of avionic systems has led to the creation of very strong technological links between the aerospace and electronics industries, which manifests itself today in the dependence of the former on the latter. In fact, following the democratisation of electronics for the general public, production dedicated to the aeronautical and defence industries represents only 7 per cent of worldwide semi-conductor production (Decision, 2012). As a result, the semi-conductor industry no longer supplies components specifically adapted to the needs of architect-integrators.

Companies developing avionic systems have thus had to develop capabilities to adapt to the regulatory and technological constraints explained above. The R&D effort has to bear on the whole system, while respecting the precise specifications for each sub-system to guarantee their conformity during certification. The very strict reactivity and safety requirements of the normalisation and certification authorities have led to the imposition of "dissimilarity" of equipment. The principle of dissimilarity means that, for each piece of equipment, its hardware and software design must have been carried out by two different teams, and it must exhibit redundancy to prevent any simultaneous failure of the equipment. This pre-supposes that there are sufficient actors in the market and opens the way to competition. Despite this principle, owing to the complexity of the systems, the heavy constraints on their production (dissimilarity) and the requirements of the certifying bodies, fewer than ten companies throughout the world are capable of designing and producing such equipment (see Table I for a list of the companies involved with the programmes considered in this paper).

Very high level of technological specificity of this type of system means that to date, it has not been possible to redeploy it on other products. The rare companies that are capable of designing and producing electric flight controls are following their own, specialised technological pathways. They benefit from the effects of experience built up over a long time that are, in fact, difficult to imitate or to redeploy. The intrinsic complexity of the system (hardware, software, systems engineering), itself linked to other systems, extends the knowledge base necessary for the creation of the system, each technology having to be mastered and combined with the others. This assembly of technological elements explains

Table I Companies per system

Aircraft programs	*Computers*	*Flight controls* *Flight management*	*Actuators*
B777	GEC Avionics	Honeywell	Parker
A330/340	Thales	Honeywell Thales	Liebherr
B787	GE-Smith (CCS) Honeywell (Comp)	Honeywell	Moog
A350	Airbus	Honeywell	Moog

Source: The authors

the diversity of the patents filed by the prime contractors for the system (see below), which can only be copied in its entirety and not partially.

2.2.3 Exploiting resources and capabilities. The last criterion of the VRIO model is that, to qualify its resources as strategic, the company must be organised to exploit those resources and capabilities (Organisation). The idea of the boundary of the company makes full sense in terms of this last dimension because it deals with the question of whether the firm will design and produce a resource itself or entrust it to a partner. Over the past 20 years, a lot of consideration has been given to new architectures for electronic systems that will affect flight controls. Up to now, aircraft have been designed using "federated" architecture, where the computers have been allocated to a single function. The new architectures, known as "modular" or "distributed"[3], lead to the distribution of the computers throughout the whole aircraft and support the inclusion of several functions in one computer. The impact of these architectural changes calls for a strong implication of architect-integrators in their design because they call into question the whole way in which aircraft have been designed up to now. Flight control computers are concerned because their critical nature means that their architecture remains independent of the others, raising questions about architectures for future programmes. In concrete terms, the creation by Airbus of an innovation organisation (EADS IW), including a Competence Center dedicated to electronics and the integration of systems such as flight control computers, illustrates the desire to exploit strategic resources and capabilities related to this equipment. Moreover, specific, constrained organisational processes are deployed in companies developing DAL A equipment. Among these processes, we can cite the obligation to produce documents tracing the development of the software, to verify and justify each point in the specification, to verify the code and supply the results of all the verification tests of the software. All in all, more than 70 points and objectives must be justified and must conform to the standard to obtain certification (Table II).

If flight controls appear to be, a priori, a strategic resource inasmuch as they represent a major asset in the design of an aircraft, and should thus logically be maintained within the

Table II VRIO model applied to flight control computers

Conditions	*Flight control computers*
Value	Presence demanded by airlines Reduction of operation and maintenance costs Airlines' confidence in Airbus and Boeing for their thorough knowledge of this critical system ("critical real time", "general public" component)
Rarity	No more than ten design and production companies throughout the world
Imitability	Specific technological pathways Large increase in the number of patents filed by Airbus and Boeing
Organisation	Competence Center dedicated to electronics and systems integration Process of traceability of equipment from design to maintenance

Source: Authors' work

boundaries of the company, studies in the field show disparities between aircraft manufacturers' strategies. Our study will illustrate the differences in perception between the actors in respect of their own boundaries.

3. Case study: Airbus and Boeing, opposing strategies

3.1 Research methods and data

This qualitative research uses two comparative studies concerning the A330/340 and A350 programmes of Airbus and their equivalents at Boeing, the B777 and the B787. In each case two sources, primary and secondary, have been used: semi-structured interviews and documentation (Yin, 1989). More precisely, this paper has benefitted from information collected during ten semi-structured interviews (lasted between 60 and 90 minutes) carried out between October and December 2013 with engineers/experts in electronic technologies and engineers/managers of systems in this field. During these face-to-face interviews, two main themes were discussed. First, we asked for technical information on flight controls systems and technological challenges since the 1980s as the introduction of fly-by-wire systems (electrical flight control). Engineers provided us a better understanding of the flight control technologies and their technical challenges (with new electronics technologies) for both developments and integration with other avionics systems and aircraft integration as a whole. Second, we asked programme development engineers and marketing managers about customer relations for each programmes studied. The evolution of the task distribution for the control of both system design and production was targeted in the second topic. Press releases of the firms and published speeches of several chief executive officers and programme managers were added for a better understanding of the gradual outsourcing or insourcing strategies.

As a whole, these elements are particularly relevant to consider flight controls as a critical system in the aircraft, first, for the major technical challenges hosted in each programme, second, for the centrality of the system in the safety certification requirements and, finally, for the importance attached by these firms to the strategic production of the system, as both chief executive officers confirmed after their companies' excessive outsourcing with their latest programmes (Gates, 2010; *CNN*, 2013).

The financial data were collected from primary sources like companies' annual reports and press releases and secondary sources like newspaper articles, interviews given to journalists by managers of the companies and the industrial and financial databases Airframer and Capital IQ.

We associate this information with a research on patent data. Patents are generally considered to be an output of a company's research and development process, and the company protects its output to survive by using an extensive intellectual property system that aims to prevent copying (Dierickx and Cool, 1989) and, before all, to ensure an exclusivity of its use (Granstrand, 1999). Although the complexity of the system and its multiple connections that generate technological interdependence already form a barrier to copying, patents exist to provide strategic protection for key elements.

The academic literature has long debated the use of patents as a tool for analysing the technological dynamics of companies, in particular, because of the bias caused by the differences in intellectual property practices between states, by the unequal propensity of different industries to file patents, and their actual use by companies (Laperche, 2004; Ben Lakhdar and Foucault, 2004; Gallini, 1992; Arundel and Kabla, 1998). Despite these limits, in a little-studied industry like avionics, patents would appear to be a useful tool for understanding the technological dynamics of the actors. The analysis of the industry carried out by Acha and Brusoni (2008) has already shown, through a study of patents, a change in technological governance leads to an explosion in demand for electronics for the general public. In the VRIO approach, the use of patents makes it possible to account partially for the structuring of the knowledge bases of Airbus and Boeing relating to flight controls, a complex system to be understood in terms of the technological combination necessary for its production. Prencipe (1997, 2000) shows how technological innovations in the electronic field for engine control systems lead engine manufacturers to choose different strategies and improve their strategic skills to keep the system development under control, and their competitive advantage.

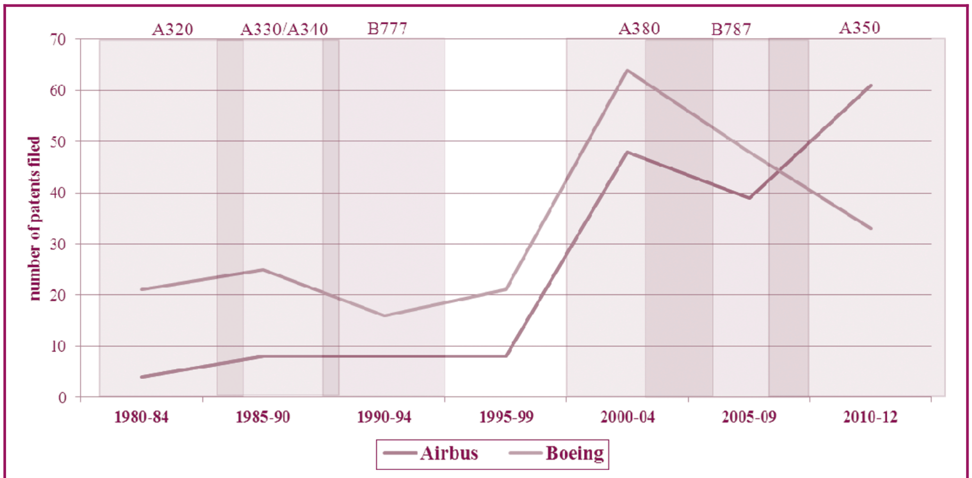
The patents we analysed were extracted from the FamPat (Questel) database using the Orbit programme. A search combining IPC codes, key words and expert analysis (three key technological experts in charge of system developments were asked for assistance) enabled 176 patent families to be identified for Airbus and 228 for Boeing, over a period of 30 years corresponding to the periods of development and launching of the aeronautical programmes studied (1980-2010)[4]. To reach such a result, an initial extraction using experts' key words was followed by another one with IPC codes. Finally, each patent portfolio was confirmed by these experts. As shown in Figure 1, breaking down the period into six sub-periods allowed the analysis of the technological dynamics to be refined while taking into account the long development cycles (five to seven years) of the commercial aircraft industry.

3.2 Airbus: partial return to insourcing of resources and capabilities

Increasing complexity of products, rapid technological change and multiplication of required capabilities to create a system with more than one industry involved fostered the organisational development of supply chains (Johnson, 2003; Lonsdale and Cox, 2000). Companies do not need any more to keep each specific knowledge or capability required to devise and produce every element of a system, and they resort to outsourcing as part of a product development policy. In aerospace, a new industrial organisation has also emerged since the 1980s. From a knowledge management perspective, this new structure is bringing together groups of firms with their capabilities and different forms of knowledge around a supply chain or network which is necessary to develop new products and put them on the market (Prencipe *et al.*, 2003).

Also, from a knowledge management perspective, the introduction of new technologies drove industrial actors to involve in R&D in a greater scale. Given the increasingly widening knowledge paths to devise and develop more and more complex aircrafts, manufacturers do not have any more the capacity to keep all competencies in house. Changing design requirements between different programmes, continuous introduction of new technologies

Figure 1 Patents filed by Airbus and Boeing since 1980 in the field of flight controls (mean n° of patent families per period)



Source: Authors' calculations from the Qpat database also for existing programmes and the pressures of customers to develop highly innovative products with cutting-edge technologies induce substantially higher R&D and production costs.

Hobday *et al.* (2005) emphasise, thus, the similarity of the systems integration concept and the knowledge management approach developed by Cohen and Levinthal (1989). On the one hand, internal activities of research and development allow firms to acquire knowledge required to introduce new programmes as well as managerial capabilities to coordinate suppliers. On the other hand, the integration of systems developed or produced outside the walls of the final product manufacturer helps them to gain new knowledge coming through collaborating firms. Eventually, an increasing specialisation of certain firms towards the management of such networks in response to new forms of competition is observed (Pavitt, 2003).

Additionally, manufacturers resort now to divide aircraft development process in work-packages to distribute costs and risks among suppliers. The size of these packages and their technological complexity has continuously increased in time (McGuire, 2007; Doerfler *et al.*, 2012). The aim is to cut off development costs and to reduce production lead time. Design, development and production of an aircraft through work-packages entail a global network of suppliers which has to be effectively coordinated. Such integration is to be understood as a capability to coordinate knowledge trajectories of suppliers which are complex and diversified by nature (Dosi *et al.*, 2003). Even though manufacturers develop such managerial capabilities to coordinate such networks, they do not completely unload their knowledge repositories necessary to realise these systems.

Airbus and Boeing have increasingly concentrated their activities at the beginning (design, R&D) and end of the value chain (final assembly, sales and associated services in training and technical assistance) and, thus, fulfil the roles of architect or integrator (Brusoni and Prencipe, 2001; Brusoni *et al.*, 2001; McGuire, 2007). Beyond these common characteristics, one can observe significant differences between Airbus and Boeing in relation to the design and industrialisation of structural elements and strategic systems. This is the case for flight controls.

For early Airbus programmes launched in the 1970s, such as the A300 and the A310, the division of labour was structured, and it was corresponded essentially to national industrial policies, organised around nationalised companies. These programmes were designed to be technologically conservative to control costs by placing the emphasis on standardised components. The idea was to convince potential clients of the similarity of their new purchases with their existing fleets (Thornton, 1995). Nevertheless, Airbus concentrated its efforts on developing a few cutting-edge technologies such as fly-by-wire electric flight controls. The A320 was the first aircraft in the Airbus range to be equipped with these systems.

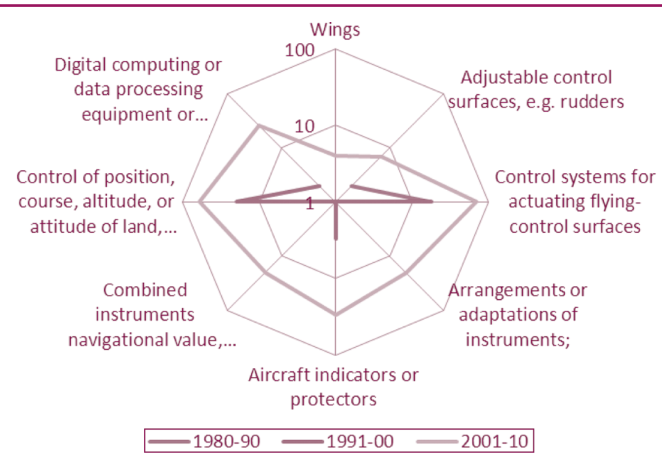
In effect, Airbus initially chose to outsource its electric flight controls, entrusting the design and production of the computers to the SFENA[5] which had the necessary capabilities (in particular, the thorough knowledge of flight control laws) to create the sub-system. Subsequently, the decrease in the availability of government finance led Airbus to use partners to share the risks and control development costs, while continuing to draw on the technological capabilities of its suppliers. With the A330/340, Airbus adopted a new purchasing policy which led to the outsourcing of systems to companies from countries that were not partners in the European consortium, on condition that they contributed to research and development costs[6]. With the A380, Airbus pursued its search for new partners throughout the world. The cost of the programme, estimated at more than $10 billion, largely explains this strategy of increased outsourcing. Thus, certain Asian companies were promoted from the rank of sub-contractor to that of partner, sharing the risks. Considering the commercial potential of this new aircraft in relation to Asian airlines, numerous contracts were signed with Chinese, Japanese and Korean companies.

Outsourcing was also orientated towards American companies because of their strength in relation to cutting-edge technologies, and also due to expected sales to American airlines and for certain financial motives, such as covering exchange-rate risks (McGuire, 2007). Airbus sells its aircrafts overwhelmingly in US dollars, whereas it pays for a major part of its purchases in Euros. The A350 programme has provided the occasion to develop this strategy further by consolidating the network of suppliers as part of its "New System Policy" of procurement. To do this, bigger and more integrated work-packages are offered to equipment manufacturers that are part of the development process (Doerfler *et al.*, 2012). In addition, Airbus has established several joint-ventures with its global partners, especially in China. The decision taken in 2012 to construct a new assembly factory in the USA (Mobile) also shows the ambition of the European company to become a worldwide enterprise. Airbus' outsourcing strategy has been determined by a combination of market prospects, control of production costs and the possibility of acquiring technological capabilities from suppliers.

Nevertheless, in a context favourable to outsourcing, starting with the A330/340 programme Airbus began a process of bringing progressively the design and production of equipment back in house, even if secondary computers were still outsourced to Sextant Avionique. The complete return to insourcing of computers finally occurred in the 2000s with the A380 and A350 programmes. Airbus is the only manufacturer to have carried out such a return to insourcing for the flight control sub-system (Table I).

To understand this process of bringing flight controls back under in-house control, we have analysed the structure of the portfolio of patents held by Airbus (Figure 2) in detail. Two types of development may be observed. On the one hand, Airbus deepened its knowledge of the technologies related to this critical system. In fact, the number of patents filed by the European manufacturer increased considerably from the middle of the 1990s, which corresponds to the preparation of the A380 programme for which the research and development related to the flight control system was considerable (Figure 1). The issues were, in particular, related to the ability to control the aircraft in flight (ultra-high-capacity aircraft) and the reduction in the weight of the equipment by replacing hydraulic circuits and actuators with electrical solutions. On the other hand, and more generally, Airbus improved its knowledge of the command process for the equipment (in particular, digital calculation) to control the aircraft functions (navigation, transmission, etc.). This sheds light

Figure 2 Changes in technological knowledge bases at Airbus for the period 1980-2010 (number of patents filed per technology)



Source: Authors' calculations from the Qpat patent database on Airbus' desire to control completely the development process and thus prevent any failure of a supplier.

3.3 Boeing: from controlled to accelerated outsourcing

From the 1970s, Boeing sought new partners by opening up its production to Italian Finmeccanica and a consortium set up by the Japanese Government including three major actors of Japanese aerospace (Mitsubishi, Kawasaki and Fuji). Each equipment manufacturer participated in the financing of the programme via risk-sharing. Thanks to this approach of sharing costs and risks, Boeing encouraged its partners to become involved in the operation of the production and thus improved the quality and price of the different elements. To adapt to the contraction of the American and European Governments' defence budgets and to the intensification of the competition with Airbus, with the launch of the B777 programme, Boeing placed the emphasis on an acceleration of production rates and on the consolidation of its markets, pushing back the development of new products to the following decades. The trend towards outsourcing was further accentuated with the B787 programme that 70 per cent of its value outsourced, against 50 per cent for the A350 (Fingleton, 2005; MacPherson and Pritchard, 2007; Sorscher, 2011). Cost- and risk-sharing contracts were signed with not only historical partners but also with many new suppliers from all over the world. The criteria for the selection of these suppliers were the ability to develop the required capabilities, to meet the quality requirements, to finance R&D and to bear other costs. The suppliers are responsible for a major part of the design and for the management of their intellectual property on the programme.

As far as electric flight controls are concerned, the American company only introduced them for the B777 programme, sub-contracting, for example, the design and manufacture of the computers to GEC Avionics. This is an example of "controlled" outsourcing by the manufacturer, which sought in this manner to retain the possibility of insourcing this element again or to have control over the standards and the compliance of sub-systems. However, with its latest programme B787, Boeing let its suppliers to design, build and integrate sub-systems after a decision to divest Boeing Commercial Electronics in 2004, a major unit to integrate systems components and to control over systems suppliers (Gates, 2013).

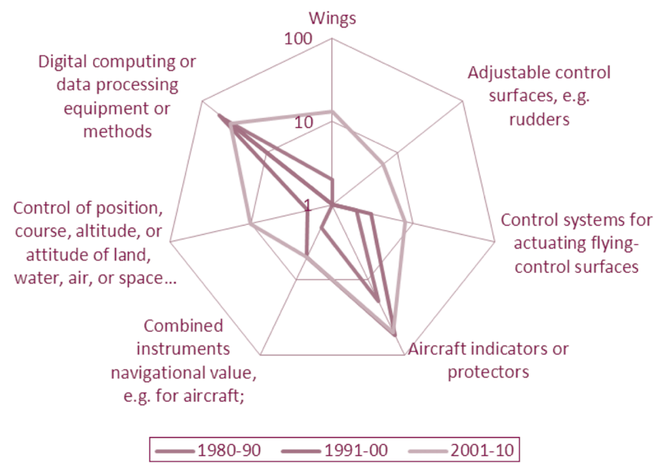
The analysis of the technological orientations adopted by the company reveal a different strategy to that of Airbus. Although the patent clearly show the desire of Airbus to control and develop its capabilities to produce the flight control system itself, those filed by Boeing reveal a desire to control the integration of such systems into the aircraft, placing greater emphasis on their impacts on the wings, the fuselage (positioning of the actuators) and the links with other on-board equipment (transmission).

In addition, Figure 3 shows, from the beginning of the 2000s, that Boeing, contrary to Airbus, has less extended its knowledge base and was no longer seeking to maintain a strong technological base in flight controls but in wings and aircraft flight indicators, marking a strategic divergence with Airbus. In this way, Boeing indicated its intention to concentrate on the role of integrator rather than an investor in new technologies. However, an analysis of the organisation of the Group shows an awakening of consciousness to the importance of controlling capabilities in-house with a reorganisation of its Research and Development Centers in 2013, in particular, opening a specialised research centre on Flight Sciences, Electronics and Networked Systems, Structures in Southern California.

4. Outsourcing induced by financial motives

Our analysis has shown so far that, although the VRIO model explains Airbus bringing its flight control computers back in-house, it does not provide an analysis of the outsourcing choice made by Boeing. Two types of explanations can be proposed. The first one is the qualitative difference of two companies' outsourcing strategies which took shape along

Figure 3 Changes in technological knowledge bases at Boeing for the period 1980-2010 (number of patents filed per technology)



Source: The authors, from the Qpat patents database

their historically distinct partnership strategies, and the second one is diverging financial motives behind their productive reorganisation efforts.

4.1 Acting differently: system or prime integrator?

In the first instance, two companies appear to have similar integration strategies considering increased outsourcing for both of them with their latest programmes. However, this quantitative convergence does not correspond to a qualitative similarity. At the level of knowledge management and the control over strategic resources, the level of investment on knowledge base, the historical course of outsourcing and the relations with suppliers exhibit crucial differences, which correspond to distinct forms of productive activity. The idea of systems integration that has been embraced by both firms in their latest programmes leads us to multiple interpretations. In effect, systems integration, at the level of knowledge management, assumes a full control over the work-packages either developed or produced by suppliers for an aircraft programme as long as the *systems integrator* is directly involved in design of work-packages at the beginning of the innovation process and it is fully responsible for the entirety of the certification procedure at the end. In our case, Airbus fulfils the role of systems integrator to a full extent. The same process is qualitatively different in the case of Boeing that the company only performs the preliminary design of work-packages that are largely handled by suppliers. The main task as the final assemble of systems, which has been substantially reduced by the company compared to its previous programmes, gives the company a role of a *prime integrator* of a supply chain focused only on the latest stages of the integration process (A.T. Kearney, 2008). Certification files are contributed and submitted together by the supplier of the systems and their final integrator. The question asked for the next section is explicit. Why does Boeing progressively act like a prime integrator while Airbus sticks on its role of systems integration?

4.2 The impact of financial motives

Since the early days of globalisation, corporations all over the world increasingly resort to outsourcing and offshoring for multiple reasons extensively discussed by several lines of economics and business literature. However, the analyses over the financial determinants of outsourcing decisions remained largely limited (Smith, 2012; Froud *et al.*, 2014). On the contrary, although globalisation has a compelling impact over corporate strategies to mimic one another, efforts to explain firm-level differences in outsourcing decisions and corresponding disparity in knowledge management strategies should take into account such forces like the concurrent rise of finance-oriented corporate strategies over the past few decades next to increasing outsourcing during the same period. In other words, finance should be taken as an explanatory variable to identify firm-level differences. To do so, we propose to take into account the financialisation of corporate strategies which makes cost reduction a primary objective to increase shareholder value that becomes, alongside an RBV, an explanation for outsourcing strategies (Milberg, 2008; Milberg and Winkler, 2010).

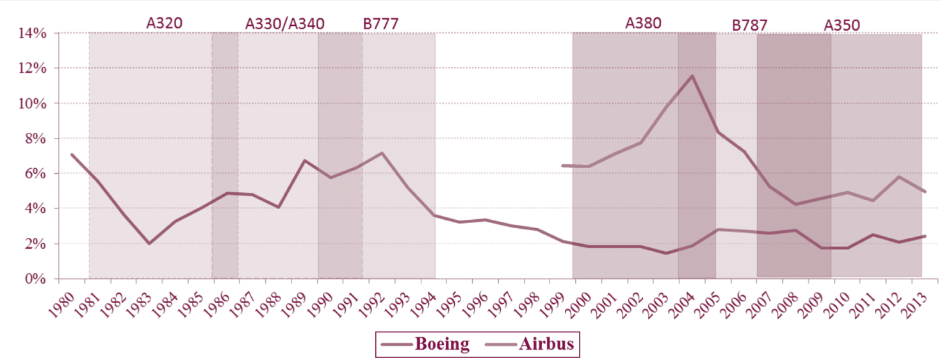
Although the conservation of strategic resources and capabilities is a primary factor in explaining the choice between insourcing and outsourcing, the reduction of production costs is another. Increasing outsourcing towards international suppliers is a response to this search for cost reduction, in this case, R&D and capital investment costs. Although both manufacturers share this concern[7], it is particularly significant at Boeing also because of its orientation towards shareholder value maximisation and the impact of financialisation over its production strategies. Thus, the underlying link between cost-cutting and financialisation has to be explained by the structural change in the meaning of corporate performance and resulting consequences.

A financialised company is perceived by its directors as a financial asset from which value may be removed, rather than as a productive asset through which value may be created (Lazonick, 2010). From this point of view, the directors must maximise shareholder value by aligning their own interests with those of the shareholders (Lazonick and O'Sullivan, 2000). The performance of a company is increasingly based on short-term financial criteria and on share prices (Christensen *et al.*, 2008) and shifted capital from production to financial assets in search of superior returns (Krippner, 2005).

Thus, this change in production strategies translates into a reduction in investment to increase short-term values, for example, earnings per share. Different actors of discourse building and transmitting it such as business consultants replaced their strategy consultancy with value-based management, aiming primarily at the increase in financial returns and delivering them to shareholders (Froud *et al.*, 2006). The growing literature over the impact of financialisation in developed economies, however, has shown that there is a negative correlation between productive investment and financial distribution of corporate resources (Bens *et al.*, 2002; Stockhammer, 2004; Orhangazi, 2008; Bhargava, 2013). There is a growing tension between the investments over internal productive resources including knowledge and the asset mentality which sees such resources to be bought and sold on the market in a continuous manner in the form of acquisitions and divestments (Salento *et al.*, 2013). Another implication of the financialisation era and an increasing use of corporate funds is the merger and acquisition activity of corporations, which has reached record levels during the same period (Stockhammer, 2004; Milberg and Winkler, 2009). Decisions over knowledge retention and further investment on existing knowledge have been attached to the value extraction logic of financialised corporation, especially in the US case (Hopkins and Lazonick, 2014). The changing institutional framework in Western economies also facilitated the motives of financial accumulation and shareholder value orientation. A series of studies have outlined the impact of financialisation on national institutional setting, and vice versa (Stockhammer, 2004; Aglietta and Reberioux, 2005; Morin, 2006; Batt and Appelbaum, 2013). The degree of change in such settings may help explain the differences between corporate strategies depending on home country institutional framework differences. Such an effect is especially important in the case of commercial aircraft manufacturing that Airbus and Boeing operate under distinct rules of corporate organisation, even though their global sourcing strategies exhibit remarkable similarities.

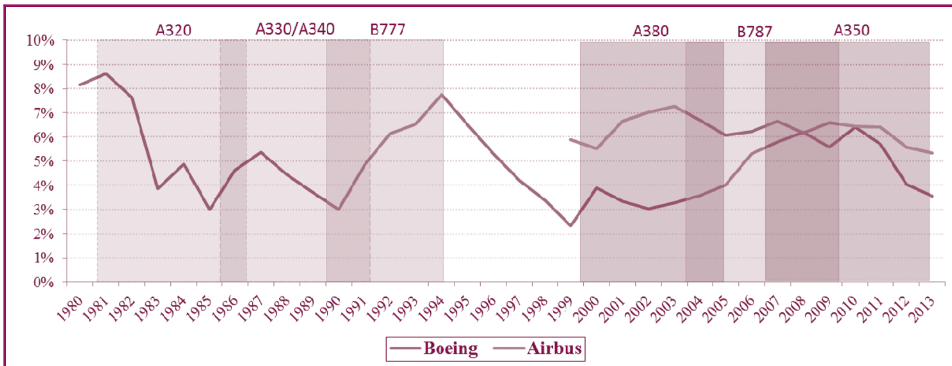
Contrary to the imperatives of financialisation including shareholder value maximisation and quick returns from short-term investments together with substantial cost-cutting, aircraft companies have to mobilise substantial amounts of financial resources to cover the spending on new machinery and tooling, new assembly lines or manufacturing plants and design and development costs. A comparison between Airbus and Boeing shows that Boeing's investment has decreased since the 1990s and still remains inferior to that of Airbus (Figure 4). The rapid increase in capital expenditures in their earlier programmes of B777 and A380 did not have the same extent in their latest programmes B787 and A350 which are outsourced in unprecedented levels by Boeing and Airbus. Finally, this concentration on share performance and short-termism induced by financialisation also has a negative impact on R&D (Christensen *et al.*, 2008; Lazonick, 2010). Despite the introduction of new technologies during the latest American and European programmes, the increase in the proportion of R&D expenditure remained modest compared to the increases during previous programmes, although Airbus invested more in R&D than Boeing during the 2000s. In effect, for Boeing, the rise of the R&D expenditures along the B787 programme were unplanned and mostly due to missteps of the company (Gates, 2011) (Figure 5). Since the late 1990s, Boeing has gone under a substantial corporate transformation which has taken its final shape in the organisation of B787 programme. The orientation towards project management and final integration as company's official core competencies has gone hand in hand with its focus on maximising shareholder value explicitly stated by the company[8] as the ultimate aim of a twenty-first century American

Figure 4 Capital expenditures as a percentage of turnover at Airbus and Boeing between 1980 and 2013



Source: Authors' calculations based on company annual reports

Figure 5 R&D expenditures as a percentage of turnover at Airbus and Boeing between 1980 and 2013



Source: Authors' calculations based on company annual reports enterprise. The decision over the relocation of headquarters from the historical manufacturing centre of Washington State to Chicago in 2000 to be closer to financial community (Muellerleile, 2009) is another example of the difference over strategic choices. In contrast, Airbus, as a predominantly production-oriented company, has moved its headquarters from Paris to Toulouse in 2013 where its main assembly sites are located. Such strategic shifts continue to have important impact over the industrial architecture as well as the persisting differences between two companies.

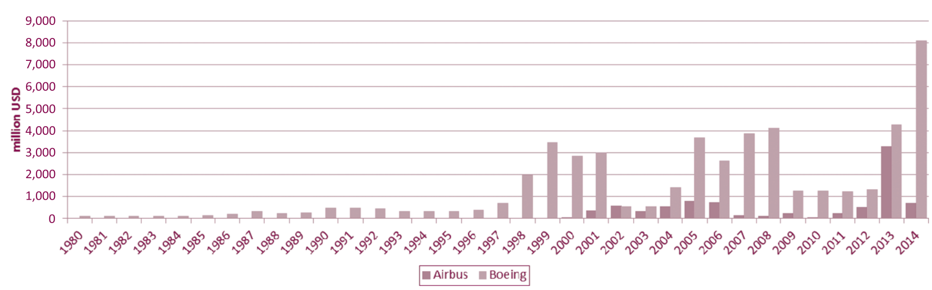
On the other hand, in a financialised company, the creation of shareholder value should be reinforced through the distributions of returns to shareholders as major principals according to mainstream view. Two main forms of value distribution to shareholders are dividends and share repurchases, and especially in the USA, share repurchases became "systemic and massive" in the past 20 years and together with dividends they reached around 80 per cent of net income on average among large US corporations (Lazonick, 2013). Share repurchases which has negative impact on long-term R&D and other investment expenditures (Orhangazi, 2008; Bhargava, 2013) are the main form of distribution for many large US companies including Boeing, while their utilisation remained very limited in the Airbus case so far. Between 1999 and 2014, in aggregate, Boeing distributed five times more cash in the form of dividends and share repurchases to its shareholders than Airbus. The focus on such value extraction activities instead of redirecting financial resources to other areas like capability development through productive investment has long been undermining the productive capabilities of the US manufacturing. Any imitation of such practices by European firms would also have destructive effects which can arise even faster. Different than the USA, institutional framework in European countries is based on the delicate balance of power among different stakeholders, and it is much less open to flexible modifications (Figure 6).

Conclusion

We have shown that Airbus has progressively brought the computer element, the core of the flight control system, back in house during successive programmes, whereas Boeing outsources this critical, strategic component in an accelerated fashion. The RBV is useful to understand Airbus' strategy, which seeks, as shown by the study of its technological bases, to extend and enrich its knowledge. At the same time, Boeing remains focused on technologies which deal with the integration of the equipment into the overall architecture of the aircraft. In terms of the number of patents filed in the field of flight controls, Airbus is clearly more dynamic, as it has developed an approach aimed at controlling these strategic resources and capabilities.

If the RBV, in general, and the VRIO model, in particular, are relevant to the analysis of the choices of the European company, they do not explain those made by its American

Figure 6 Annual shareholder value distribution of Boeing and Airbus (dividends + share repurchases), current prices



Source: Authors' calculations based on company annual reports counterpart. The financialisation of strategies, which makes cost reduction the primary objective to be attained, is the other explanatory factor to be taken into account. We have underlined the fact that, from this viewpoint, the company is perceived by its directors as a financial asset from which value may be removed, rather than a productive asset through which value may be created. Reduction in investment expenditures, an increase in the distribution of profits in the form of dividends and share repurchases, and a reduction in R&D efforts are main indicators of this phenomenon which have been highlighted in a broader context of the US economy (Bhargava, 2013; Stockhammer, 2004; Orhangazi, 2008; Lazonick, 2013). In each case, although the financialisation and shareholder value orientation certainly affect Airbus, all the indicators show a more significant impact of this phenomenon at Boeing.

Our analysis has several managerial implications. First, we demonstrate the potential of multiplication of research methods to address a question. Second, we try to bring together different theories in a preliminary effort, which gives us some promising stuffy perspective for future works. By addressing both the RBV and the financialisation perspectives, we provide an interesting view of the CoPS challenges. Third, the findings of our research must provide key of interpretation for business managers, which may consider the two faces, knowledge management and financial, to explain corporate performance.

In the end, the RBV and the VRIO model make the control of strategic resources and capabilities the first criterion of choice between insourcing and outsourcing. Airbus adopts this approach, favouring long-term technological control. Boeing, by favouring the outsourcing of a strategic, critical component, has opted differently. There are thus two opposing visions. However, Airbus has announced that in the future, it wishes to improve its immediate financial performance and shareholder value management. One piece of future empirical work would, therefore, be to make a dynamic study of the phenomenon of financialisation in the case of the European manufacturer. From a theoretical viewpoint, we have underlined the fact that the financialisation of strategies, in particular, and financial considerations, in general, should be used to complement RBVs. A theoretical development would be to offer a framework that includes these teachings.

The approach known as systems integration may also prove to be a fertile avenue. It deals with the organisation set up by companies in the electronics and aeronautics industries to develop complex products affected by rapid technological advances. Unlike the VRIO approach, it has the advantage of taking into account the characteristics of the environment, to put it differently, external dynamics. For example, the analysis includes the effects of the coordination of actors around a complex value chain. Often, the actors concerned by the development of such systems have a mode of industrial organisation which involves the sharing of knowledge and capabilities, whereas the complexity and highly technical nature of the systems requires the use of highly specialised companies (Prencipe *et al*., 2003). The fact that systems have become more complex has rendered such sharing necessary, a single actor no longer being able to bear alone the costs related to such projects. The final product manufacturer maintains overall control and determines for which sub-systems complete control will guarantee competitive advantage, the latter often being related to a financial gain. However, the concerns over costs and financial returns cannot be considered independently from the impact of financial motives and financial orientation of the same companies and related understanding over the sharing of the gains of innovation. Thus, although the production of a system might occupy the same strategic location for two projects, the manufacturers responsible for those projects will make different choices in relation to keeping the design in-house or outsourcing it, depending on their corporate strategies, and they will favour the short-term financial performance and value extraction over the maintenance of long-term capabilities and value creation.

Notes

1. In systems known as "critical real time", adherence to task execution cycles and sequencing are important. The computer must execute the tasks within a precisely defined time frame and must simultaneously take into account all the variables affecting the flight in real time. Non-adherence to these conditions can lead to a system failure that has catastrophic consequences for the flight.

2. Among other major groups may be found autoflight (ATA 22), communications (ATA 23), electrical power (ATA 24), flight controls (ATA27), navigation (ATA 34), integrated modular avionics (ATA 42), diagnostic and maintenance system (ATA 45) and charts (ATA 91).

3. The distributed architectures developed by the two aircraft manufacturers are known as IMA (*Integrated Modular Avionics*) for Airbus, and CCS (*Common Core System*) for Boeing.

4. Key words such as flight controls, aircraft control surface, aircraft control, embedded computer, flight control unit and (aeronautic OR avionics OR aircraft OR avion OR aerospace) were used with IPC codes in the B64C, G01P, G05B, G06F and G11B.

5. Established in 1947, The SFENA (*Société Française d'Equipements pour la Navigation Aérienne* – French Company for Air Navigation Equipment) became part of Sextant Avionique in 1989, which brought together the avionics divisions of Aerospatiale, Crouzet and Thomson CSF. Since 2001, Sextant Avionique has been called Thales Avionics, a subsidiary of the Thales group.

6. For example, BAE outsourced the production of part of the wing structure to the American company Textron Aerostructures, and Aerospatiale outsourced the production of components to the Canadian company Bombardier.

7. At the beginning of the 2000s, Airbus introduced three successive cost-reduction plans (Route 06, followed by Power8 and Power8+).

8. Boeing started to use shareholder value measurement techniques to decide over its corporate investments as early as late 1990s and explicitly stress the focus on maximizing shareholder value as the main cause of the company.

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