Special Analysis

After two years of turbulence, the French aeronautical sector is ready to take off again

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France is the world's second largest exporter of aeronautical equipment after the United States: in 2015, it supplied almost a quarter of the world's exports of these products. Over the course of the last twenty years, French exports have become more specialised in aeronautical goods, much more so than those of the other main producer countries. In addition, the knock-on effect of the aeronautical branch on national activity is greater in France than for its partners. All in all, the French economy has proven to be the most sensitive of the large world producers to fluctuations in world demand for aircraft.

And yet, the French aeronautical sector does not seem to have benefited as much as it might have from the tremendous surge in air traffic over the last few years. Indeed air traffic has risen sharply since 1995, and even more markedly since 2010, driven by the rise in passenger numbers in Asia. However, although the aeronautical industry boosted French growth between 2000 and 2013, it fell back in 2014 and 2015. The trade surplus in aeronautical equipment has eroded since 2014 and is expected to fall again on average in 2016. This erosion is due to problems on both supply and demand sides. Producers of business aircraft and helicopters are suffering from a sharp fall in demand, particularly from the oil producing countries. In the commercial airliner industry, manufacturers and equipment manufacturers are struggling to keep up with new demand as they are at the limit of their production capacity. Thus, French manufacturers have been faced with particularly acute procurement issues since 2014, and this has interfered with production and delayed deliveries. Finally, recent aircraft contain more and more foreign technology, in particular for the engines, which mechanically erodes the trade balance of French aeronautics, due to increased importation of parts and equipment.

However, in 2016 these supply and demand problems seem to be resolving themselves. Production capacity is expected to expand, as the recovery in investment in the aeronautical sector has been confirmed in 2016. The business climate remains favourable and the order books are still full, in particular for a new generation of engines partly produced in France, which went into service in summer 2016. The aeronautical branch's production and exports are therefore expected to rise sharply by mid 2017, if only to catch up on delayed deliveries.

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After two years of turbulence, the French aeronautical sector is ready to take off again

Aeronautics: a sector that is benefiting from strong growth in air passenger traffic

World air traffic has seen momentum build since 2010, particularly in Asia

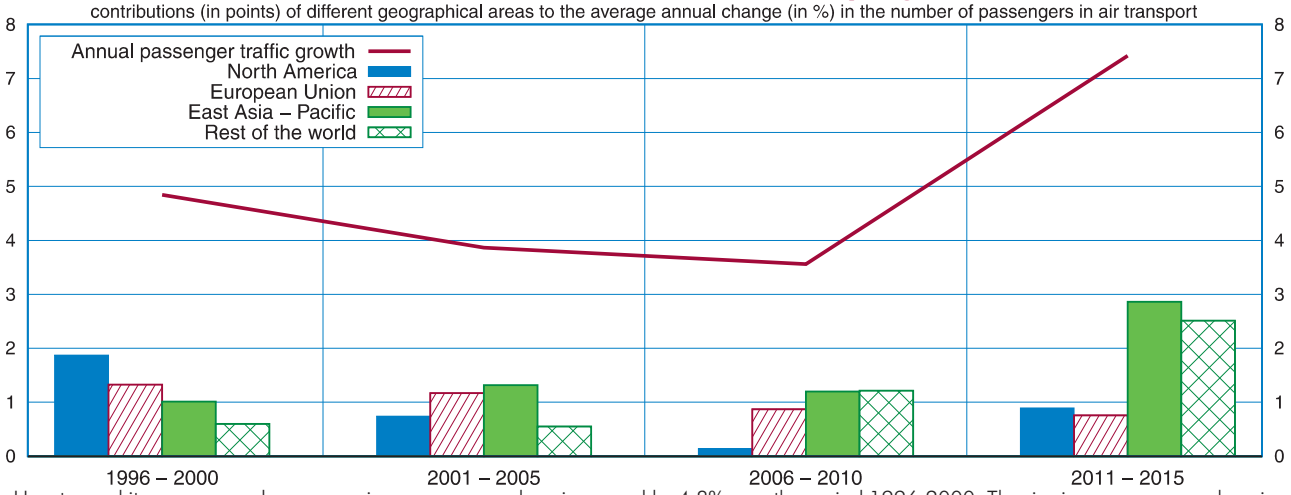
Final demand for the aerospace industry corresponds mainly to purchases of civilian aircraft and airlines' maintenance expenditure; these two items far outweigh purchases of military equipment and other civilian equipment. The industry has thus benefited from the strong growth in air traffic, which has grown faster (+5.0% a year on average since 1995) than overall world growth (+3.8% a year). The momentum in air traffic even accelerated between 2010 and 2015: +7.4% a year on average (*Graph 1*), compared to a global growth rate of +3.5%. This boom has been largely sustained by the development of air traffic in Asia-Pacific region: since 1995, air traffic in this region of the world has increased by 7.2% a year on average (+11.6% between 2010 and 2015). Air traffic has also increased considerably in Latin America, the Middle East and North Africa. In Europe on the other hand it slowed until 2005; since then it has been growing steadily, by 3.7% a year. Similarly, in North America, air traffic slowed between 1995 and 2010, and has been growing since 2010 at a rate of 2.7% a year. All in all, Europe and America are no longer the main zones driving the growth in air traffic and their share of global air traffic fell from 62% in 1995 to 45% twenty years later.

The aeronautical industry remains concentrated in North America and Europe, with contrasting trade balances

Although a first twin-engine jet airliner has just been entirely assembled in China (Chinese manufacturer AECC's C919) and Airbus is building an assembly plant there, the aeronautical industry has actually relocated very little in response to changes in demand. Indeed, the development costs of these new programmes are very high, which limits the appearance of new players in the industry; furthermore, the construction of new production units requires massive investments while the costs of transporting the finished products are relatively low. This is why aeronautical production remains essentially concentrated in North America and Europe, both for commercial airliners — with the dominance of the Airbus/Boeing duopoly — and engines, which represent up to 30% of the total price of a plane. The engine market is dominated by a small number of American firms (GE Aviation, Pratt & Whitney) and European companies (Rolls-Royce, Safran Aircraft Engines). This situation explains the recent changes in the balance of trade (*Graph 2*): the large Asian countries are the main net importers of aircraft and their trade deficit in aerospace goods has widened considerably over the last few years in favour of the six main producing countries.

1 - Asia has become the main contributor to the vitality of global air traffic

contributions (in points) of different geographical areas to the average annual change (in %) in the number of passengers in air transport



How to read it: as an annual average, air passenger numbers increased by 4.8% over the period 1996-2000. The rise in passenger numbers in North America contributed +1.9 points to this increase.

Source: International Civil Aviation Organization

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The French economy is the most specialised in aeronautics

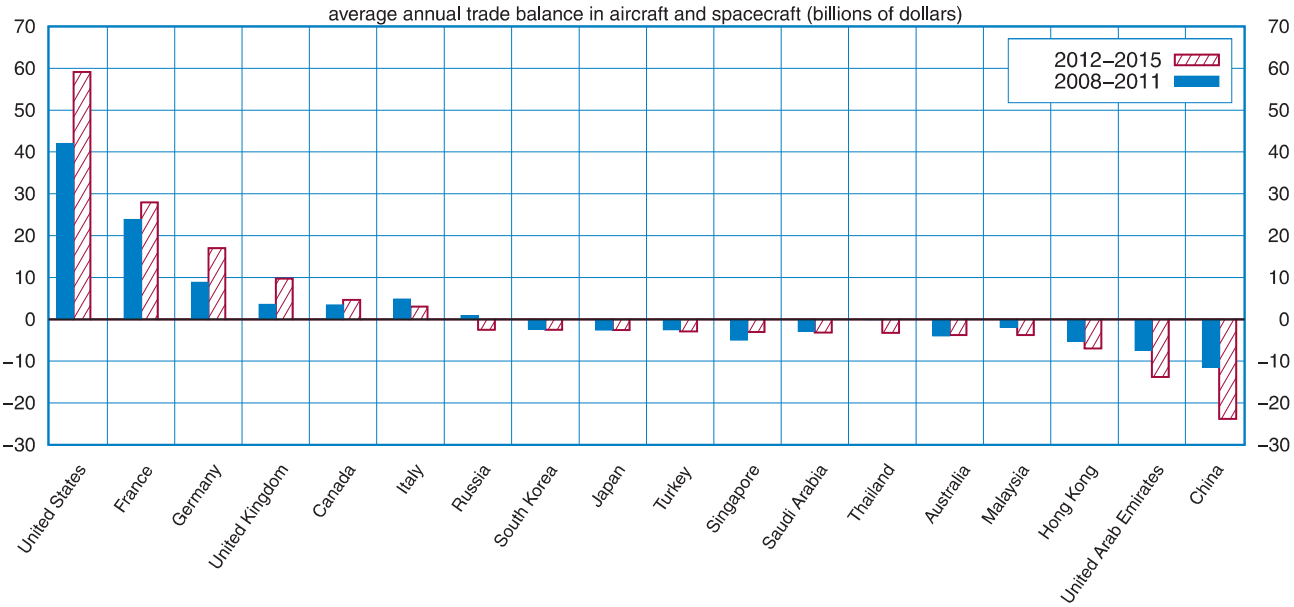
Aeronautical production is concentrated in six countries in North America and Europe, which account for almost 80% of world exports: the United States (29% of world exports in dollars in 2015), France (22%), Germany (12%), the United Kingdom (9%), Canada (4%) and Italy (2%). These countries are distinguished from each other both by the level of their aeronautical trade balance and their industrial specialisation in the sector.

Aeronautical manufacturing accounts for a large part of French exports

In export terms, the French economy has become more and more specialised in aeronautics: in 1995 the weight of the sector in total exports was already 60% higher than the average in the main producing countries (*Graph 3*); in 2015, it was 130% higher: the difference with the average of the main producer countries has therefore more than doubled in twenty years. The United States remains the word's largest exporter, but aeronautics has become less predominant in its exports: in 1995, the weight of the sector in total American exports was 60% higher than it was on average in the main producer countries, as it was in France at the time; by 2015, it was only 40% higher. In Germany, Canada and Italy, the relative importance of aeronautics in total exports has remained stable: since 1995 its share has remained at a level 40% below the average of the main producer countries in Germany and Canada and 80% lower in Italy. These relative differences in exports are accompanied by differences of a comparable scale in terms of activity, that is, in terms of the relative share of aeronautics in the value added of industry.

Thus aeronautical exports represented 3.2% of GDP in France in 2015, or a proportion four times higher than twenty years ago, compared to 1.3% in Germany and around 0.7% in the United States, the United Kingdom and Canada.

2 - Six exporting countries are meeting the increased demand from Asia and the Middle East



Note: annual average trade balance for the years 2008-2011 and 2012-2015, the twelve biggest deficits and six biggest surpluses over the second period are shown.

Sources: US Census Bureau for the United States, UNComtrade and International Trade Center for the other countries

After two years of turbulence, the French aeronautical sector is ready to take off again

The French economy is the most sensitive to foreign final demand in aeronautics

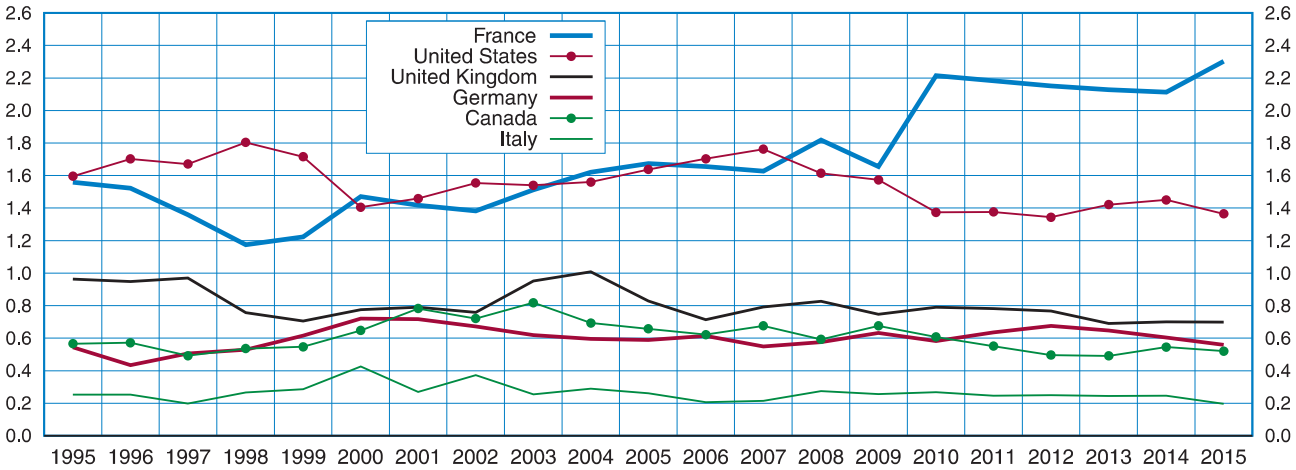
As well as its economic weight, the aeronautical branch[1] also produces very substantial knock-on effects. Indeed, the aircraft production process involves not only plane manufacturers, engine builders, equipment manufacturers and subcontractors but also service providers ranging from the financing or aeroplanes to design and research services. Thus a shock affecting the aeronautical industry in a country will have an impact amplified by the knock-on effects on other sectors of the economy. These effects are measured by the "value added multiplier". This is a ratio that provides, for one unit of extra aeronautical value added, the number of units of value added produced overall in the economy.[2] It is all the higher as production uses a large quantity of intermediate consumptions and as the content of the latter represents more domestic activity than imports. The input-output tables provided for each country by the OECD allow the multipliers to be calculated for different years.

The knock-on effects on aeronautical manufacturing are greater in France than in other countries

It is in France that the knock-on effects of the aeronautical branch are the greatest: in 2011, €1 of value added generated by the aeronautical branch was translated into €3.6 of value added generated in the rest of the economy (*Table 1*). This is explained by the sector's high level of vertical specialisation in France and therefore the large share in the production of intermediate consumptions, mainly produced domestically. The knock-on effects are also very high in Italy, in spite of its limited specialisation: here the value added multiplier was 3.4 in 2011. In the other countries, the multiplier has generally been stable at around 2.

1. For reasons of simplification, in this part, the aeronautical branch is included in the "other transport equipment" branch, which covers other branches including car, boat and train building and military land vehicles. This is because some data are only available at this aggregate level. In France, aerospace manufacturing represents approximately 80% of the branch, whether in value or employment terms (see *box 1*).
2. For details of the method, see *appendix 1*.

3 - Development of trade specialisation in the aerospace branch for the main producer countries



How to read it: the specialisations indices used are Hoover-Balassa indices, which compare the ratios of one country (in this case exports) with average observations across a reference sample (in this case the six main producer countries in the aeronautical sector). These indicators have the advantage of being easier to exploit than direct comparisons of national ratios, which can mask very significant differences in absolute value (Le Blanc, 2007). A company's trade specialisation corresponds to the ratio of its aerospace exports to its total exports, compared to the average ratio calculated for all the countries in the sample. A high specialisation index means that aerospace exports account for a larger portion of the country's exports than the average for the six producer countries. For example, a value of 1.6 for the French index means that in France the aeronautical sector accounts for a share of exports that is 60% higher than that represented by the the entire branch in the total exports of the six countries.

Sources: US Census Bureau, UNComtrade and International Trade Center, INSEE calculations

The French economy is the most dependent on world final demand for aeronautical goods

The knock-on effects, greater than elsewhere, and the higher degree of specialisation of the aeronautical branch in exports make France the country most sensitive to foreign final demand in this sector (*Appendix 2*). The OECD's international input-output tables allow a calculation of the sensitivity of countries' activity to a shock in global demand in the aeronautical sector. Thus in 2011, the weight of value added (all sectors combined) generated by world demand for aeronautical goods in total value added was higher in France than in the other producer countries. With unchanged partnerships and market shares, a 10% increase in global aeronautical demand would contribute +0.11 points of growth to French GDP. The effect would be approximately 30% less on United States GDP, approximately 20% less on German GDP and 50% less on Italian growth (*Graph 4*).

French activity is more specifically dependent on demand from the emerging countries

The French economy depends more than other exporting economies on aeronautical demand from other countries, in particular the emerging countries, including China: 0.53% of its value added in 2011, compared to 0.43% in Germany and 0.23% in the United States. Furthermore, it is also particularly dependent on final aeronautical demand from Germany and the United States: in 2011, demand from these two countries generated 0.30% of total French value added (0.17% from German demand and 0.13% from American demand). By comparison, final domestic aeronautical demand — mainly orders from French airlines — represented 0.22% of French value added.

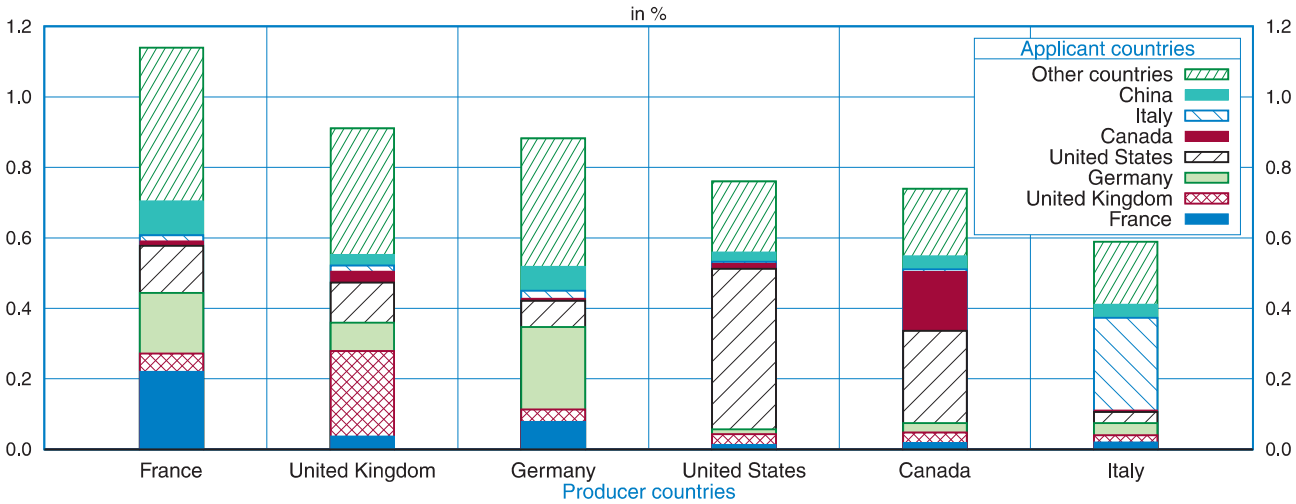
Table 1 - Value added multiplier for the "other transport equipment" branch in the main producer countries

Year	France	Italy	United Kingdom	United States	Germany	Canada
1995	3.4	2.9	2.0	2.3	2.4	1.5
2000	3.1	2.6	2.0	1.9	2.1	1.5
2005	3.4	3.1	2.1	2.1	2.0	1.7
2011	3.6	3.4	2.4	2.1	2.1	1.8

How to read it: in France in 2011, when the "other transport equipment" produces €1 of value added, it generates €3.6 of value added in the total general economy through the intermediate consumptions produced domestically. For France, these figures are close to those calculated for the aerospace sector using "symmetrical" IOTs estimated at a detailed level by INSEE. The difference with the aerospace multiplier calculated in the *Conjoncture in France* of March 2012 (4.8 based on the IOT for the year 2009) is explained in particular by the change in the national accounts base made since this publication and by the level of detail in the IOT used.

Sources : OECD, input-output tables (IOT) by countries and INSEE calculations (see appendix 1)

4 - For each producer country, weight in the value added of the activity generated by final demand for "other transport equipment" from the demanding countries



How to read it: in France, over 0.2% of total national production in value added is connected to final domestic demand for aeronautical goods. In Germany, 0.1% of national activity is connected to this French final demand for aeronautical goods.

Sources: OECD, international input-output table (IIOT) of 2011 and INSEE calculations (see appendix 2)

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Box 1 - The largest part of the fluctuations in "other transport equipment" stems from aeronautical manufacturing

Several factors (volatility of results, significance of trends, statistical confidentiality) prevent the publication of all the short-term indicators at a sufficiently detailed level to analyse the trends in aerospace manufacturing industry alone.

In particular, the quarterly national accounting results are published grouping together all the sectors manufacturing transport equipment (level "A17" in the aggregate classification 2008),that is to say the automotive industry included. Today the latter only represents half of transport equipment: 49% of production in 2014 (compared to 70% in 1999); 49% of value added (63% in 1999) and 58% of employment (67% in 1999).

In the annual national accounts for production by branch and the business tendency survey in industry, results are published at a more detailed level, that of "other transport equipment". However, this remains a relatively broad category as it includes, as well as aerospace manufacturing, shipbuilding, railway equipment, military combat vehicles and finally the manufacturing of other vehicles (in particular two-wheeled vehicles). According to the weighting used for the industrial production indices (IPI, *Table*), aerospace manufacturing represents 82% of production of "other transport equipment" whereas according to the detailed administrative employment data ("DADS", administrative and social data) it represents 75% of salaried jobs and 79% of pay.

As for customs data and the industrial production index (IPI), these are short-term sources that enable sub-sectors of "other transport equipment" to be separated out. However, at all events, no short-term statistics are published for aeronautical manufacturing as the construction of spacecraft is systematically included, without being identified separately.

These sources show that the weight of aerospace manufacturing is such that its contribution explains the great majority of the variations in the production indices for other transport equipment: since 2000 it has accounted for 93% of its monthly volatility. The heterogeneity of "other transport equipment" does not mean that the trends in its production (*Graph*) do not share some common characteristics: these are all sectors that have seen strong growth since 1990 (unlike manufacturing industry overall), with current production substantially exceeding the pre-crisis levels.

Finally, aerospace manufacturing represents an even greater share of the foreign trade of the "other transport equipment" sector overall (in the customs data by value, 95% of exports and 89% of imports in 2015). ■

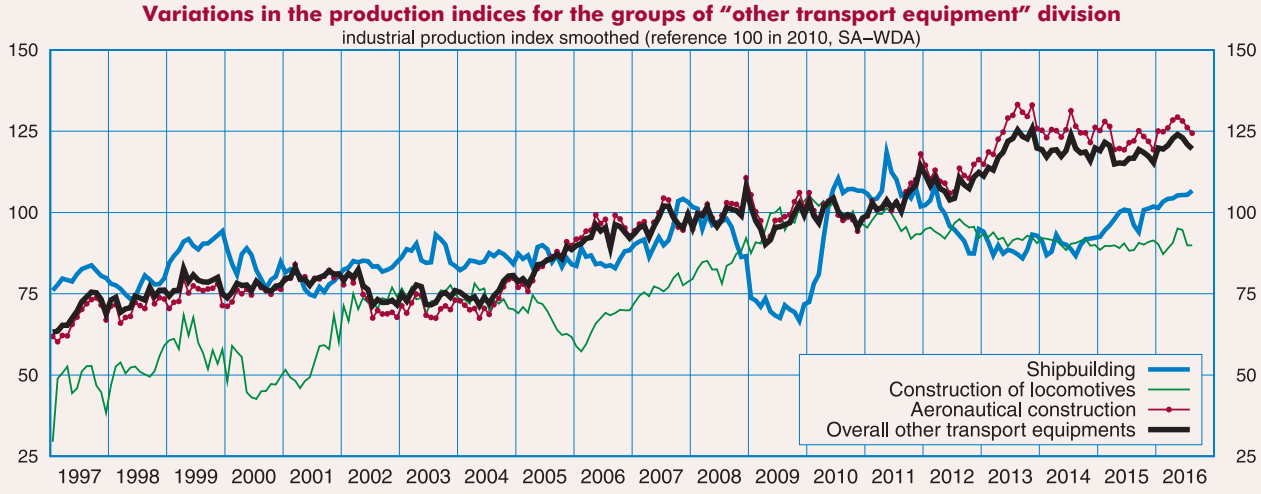
Weight of different groups in the "other transport equipment" division

in %

	Shipbuilding	Railway equipment	Aerospace manufacturing	Manufacturing of other vehicles
Production measurements (weighting IPI, 2010 base)	8	8	82	2
Employment (DADS base, 2013)	13	9	75	2
Wage (DADS base, 2013)	10	9	79	1
Exports (2015, in value)	2	1	95	1

Sources: INSEE, General Directorate for Customs and Indirect Taxes

Variations in the production indices for the groups of "other transport equipment" division



Source: INSEE

Reciprocally, Germany profits more from final demand for aeronautical goods from France and the United States than from each of the other countries, but it depends less than France on its two main partners. In the United Kingdom, national valued added depends more on American final aeronautical demand than that of its European partners. Furthermore, Canada's total valued added benefits much more from final aeronautical demand from the United States than from its own demand. The United States and Italy, on the other hand, are much more closed: the weight of their own final demand for aeronautical goods far outstrips that of the demand from each of the other countries.

The aeronautical industry contributed to French growth until 2013, but fell back in 2014 and 2015

Aeronautical activity more buoyant than the rest of industry until 2013

In France from 2000 to 2013, the aerospace industry was substantially more buoyant than the rest of manufacturing industry. Over this period, the production index of the aerospace industry increased at an annual rate of 4.4% compared to an average drop of 1.3% a year for the rest of manufacturing industry (*Graph 5*). Thus the weight of the manufacture of "other transport equipment" in the valued added of industry increased over the same period, reaching 5.0% in 2013 compared to 3.1% in 2000. At the same time "other transport equipment" represents a growing share of exports of industrial goods (13.1% in 2013, or an increase of 4.5 points since 2000). Given the knock-on effects, the sector's average contribution to GDP growth was +0.1 points a year over the period 2003-2013.

Aeronautical activity fell back in 2014 and 2015

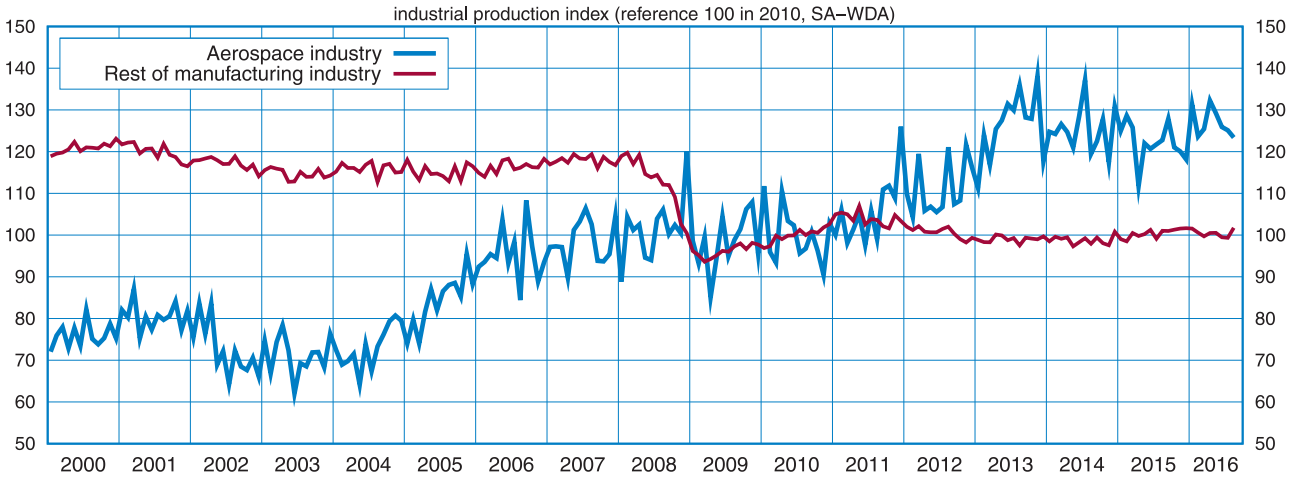
However, in 2014 and 2015, activity in the aerospace sector decreased by 3.2% overall over these two years. This drop is in contrast to industry overall, which picked up by 1.2% between 2013 and 2015. At the beginning of 2016, activity in the aerospace sector began to recover, but its average level over the first three quarters was barely any higher than its 2013 level.

The trade balance has deteriorated since 2014

The trade balance of the aeronautical industry has shown a surplus of about $25bn[3] a year since 2010. It climbed regularly, reaching a peak of $32.5bn in 2013. Since then, the trade surplus has fallen to $26.0bn in 2015; it is expected to fall again in 2016, to $20.8bn (*Graph 6*). All in all, the trade surplus is thought to have eroded by approximately $11.7bn in three years.

3. According to the customs service, 85% of commercial contracts and foreign trade in the French aeronautical sector are in dollars (see Études et éclairages issue n°. 62, published by the General Directorate for Customs and Indirect Taxes, December 2015). For international comparisons, it is therefore more appropriate to express trade flows and balances in dollars.

5 - Aerospace activity was very buoyant until 2013, but fell back in 2014 and 2015



Source: INSEE

However, the United States' trade surplus has not dipped since 2013 and reached a record level of $63.5bn in 2015. Over the same period, the German trade balance fell from 2012 to 2014, but recovered in 2015, limiting the overall drop to $3.6bn since its peak in 2012.

The reduction in the French trade balance is due to specific difficulties in different sectors of the French aircraft construction industry, on both the supply and the demand side, which led to lower exports and pushed up imports.

The recent erosion of the aeronautical trade balance stems from specific issues with supply and demand

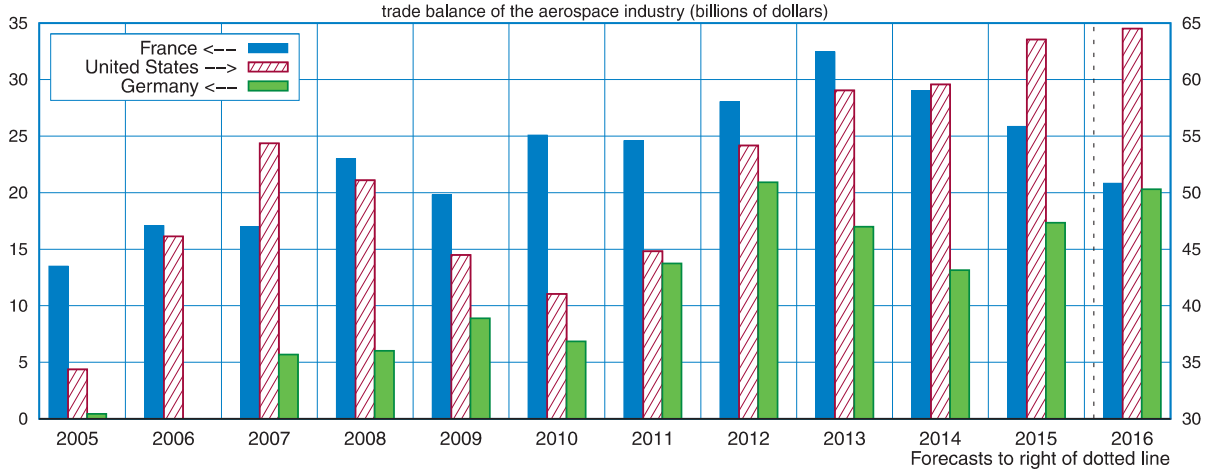
Exports of commercial airliners fell markedly from 2014 onwards

Deliveries of planes and helicopters account for the majority of French aerospace exports (almost 65%). Indeed, in the global aeronautical industry, France's role is that of an assembler. It is a net exporter of planes and helicopters, but an importer of components and equipment. In civil aviation, there are three main markets: commercial airliners, business aircraft and helicopters. These three markets have followed very different trajectories. First of all, in spite of growth in global air traffic that remains strong (+6.5% in 2015), French exports of airliners slowed in 2014 and in 2015, contributing –1.6 points on average to the fall in exports of civilian aircraft over those two years, compared to +7.5 points on average between 2008 and 2013 (*Graph 7*). In 2016, sales are expected to recover on average over the year, with a contrast between a clear decline in the first half of the year, which is probably attributable mainly to delivery delays concerning components and equipment entering into the manufacturing of new models of aircraft (see below), and a distinct recovery in the second half-year.

Sales of helicopters and business planes have suffered from the sharp fall in oil prices

Next, the business aircraft and helicopter markets have a specific business cycle which can differ from that of commercial airliners. First of all, the almost 60% fall in oil prices since mid-2014 has led to a sharp fall in investments in business helicopters on the part of the hydrocarbon extraction sector, which normally has a very high level of demand. The slump in helicopter sales also had a negative effect on aeronautical deliveries in 2015 (contribution of –1.5 points to the overall variation in the sector) and will likely continue to do so in 2016 (–1.2 points). Secondly, the slowdown in world demand, in particular from emerging countries, has hit sales of business planes (contributions of –1.5 points in 2014 and –0.8 points in 2015). However, deliveries are expected to improve in 2016 (+1.5 points).

6 - The trade surplus of the aeronautical sector has eroded since 2014



Sources: General Directorate for Customs and Indirect Taxes, INSEE calculations

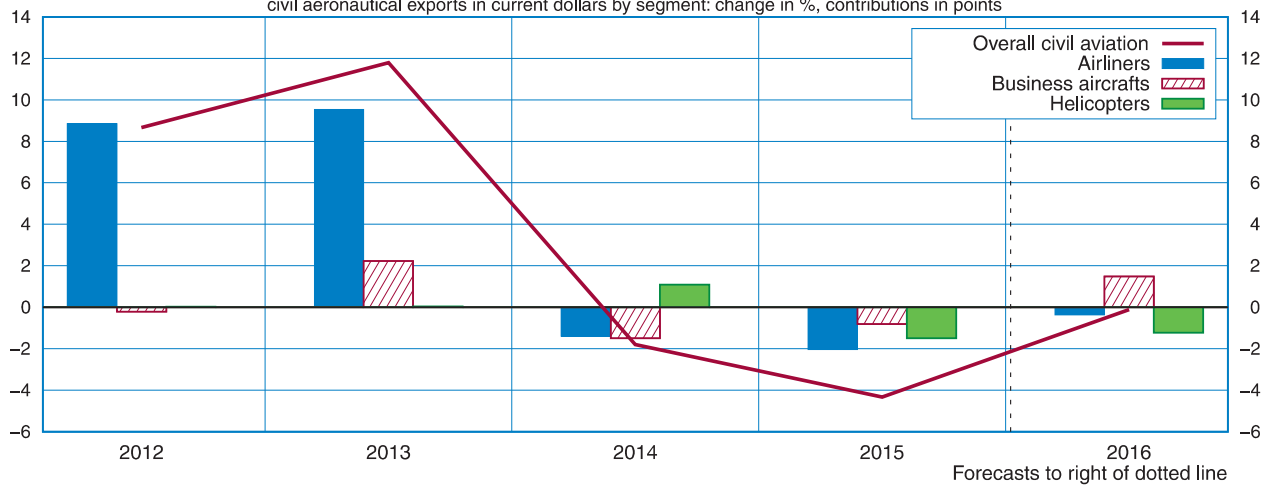
The lower demand for business planes and helicopters has resulted in a sharp fall in production for the main companies concerned (Airbus Helicopter, Dassault's civil aviation branch and indirectly the equipment manufacturers that supply engines and various parts). This decline has had a negative effect on the entire French aerospace industry, contributing approximately –4.2 points in 2014 and 2015 to the overall decline (–3.4% in total over these two years). In 2016, the total production of these two sectors is expected to fall again, negatively contributing to the overall development of the aerospace sector by about –3.0 points.

Imports have been buoyant since 2014, mainly parts and equipment imports

In 2014, aeronautical imports gathered pace substantially (+12.7% in dollar value, after an increase of 1.6% in 2013 and an average of +4.8% since 2008, *Graph 8*). Purchases of parts and equipment were particularly vigorous in 2014, contributing +17.6 points overall; they were consolidated slightly in 2015, but they are expected to grow sharply in 2016 (+13.8%). Technological choices concerning models of engines explain this buoyancy to a large extent, as new models of planes are using foreign engine technologies more and more. This therefore means that there is a growing trend towards planes equipped with a

7 - Since 2014, exports of commercial airliners have fallen considerably, whilst sales of helicopters and business planes are also down

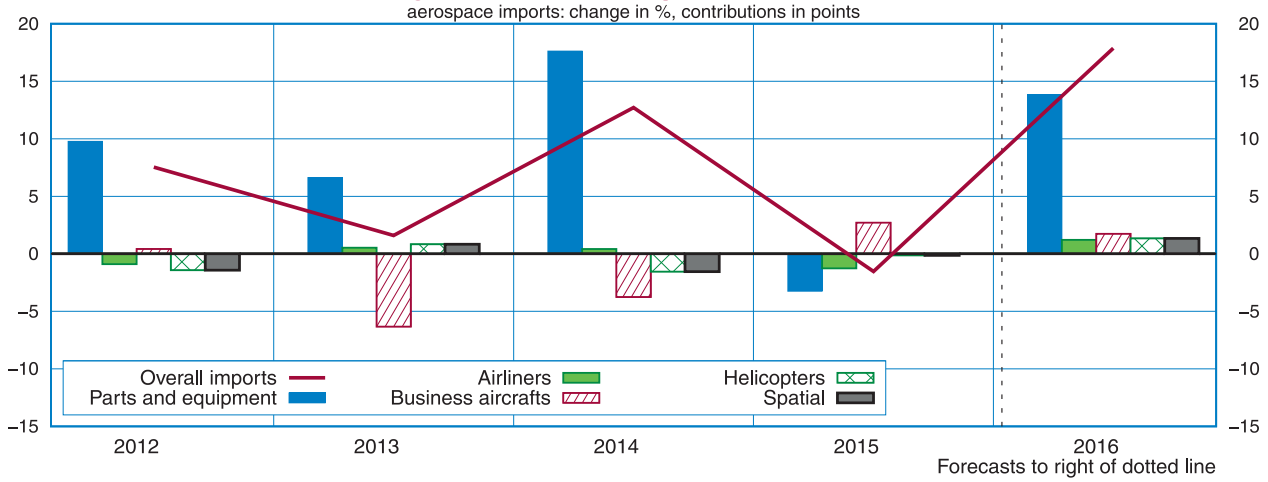
civil aeronautical exports in current dollars by segment: change in %, contributions in points



How to read it: in 2015, civilian aeronautical exports fell 4.4%. Business and short-haul regional airliners contributed –0.9 points to this fall, helicopters –1.5 points, airliners –2.0 points.
Sources: General Directorate for Customs and Indirect Taxes, INSEE calculations

8 - Imports of parts and equipment have contributed to vigorous aeronautical purchase since 2014

aerospace imports: change in %, contributions in points



Sources: General Directorate for Customs and Indirect Taxes, INSEE calculations

foreign engine in Airbus's deliveries: 85% in 2015 compared to 82% in 2013 and 75% in 2007 (*Graph 9*), to the detriment of French engine manufacturers.

This increase in imports of aeronautical equipment mainly benefits engine manufacturers in the United Kingdom and the United States, which account for 6 percentage points in the increase in aeronautical imports between 2013 and 2015. A large proportion of these engines concerns both new models of plane and engine replacements in existing aircraft; they are engines that are more and more fuel-efficient. Above all, no French new-generation engine was approved by the aircraft safety authorities for entry into service before 2016. This loss of domestic market by French engine manufacturers has not been offset on foreign markets, and exports of engines and equipment fell sharply in 2015.

Furthermore, purchases of commercial airliners also contributed to the increase in imports in 2015 (+2.7 points) and again in 2016 (+1.7 points), whereas it contributed negatively between 2008 and 2014 (–6.2 points per year on average). These purchases correspond to investments by French airlines, which are acquiring foreign planes, from the United States in particular.

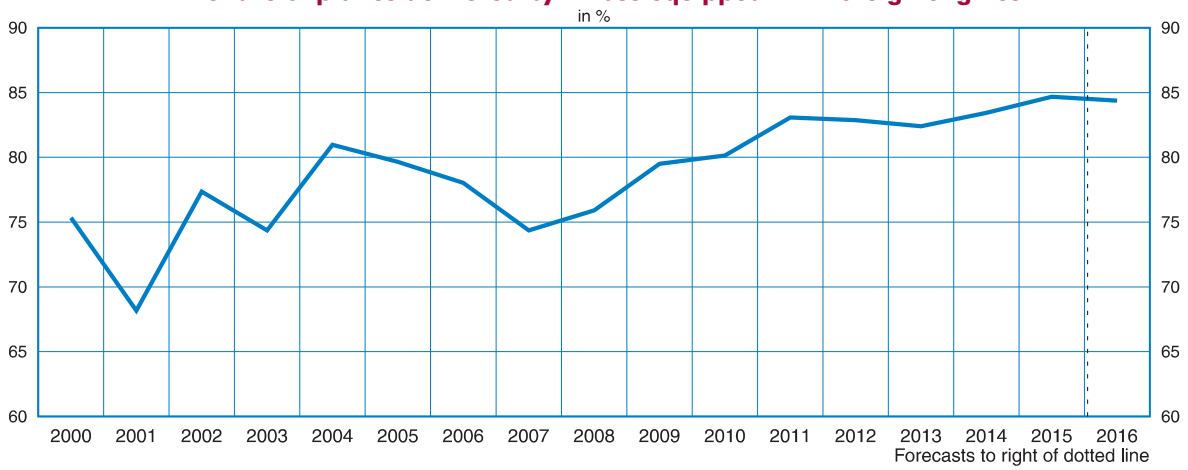
Constraints on production, capacity issues in particular, have affected production by both equipment and aircraft manufacturers

Demand-side difficulties encountered by the manufacturers of business planes and helicopters therefore do not seem to be representative of the economic situation of the "other transport equipment" sector overall. In fact business tendency survey indicate rather that it is supply-side issues that explain the dip in aeronautical activity since 2014.

Production in the sector seems to be limited by equipment shortages

The aeronautical sector seems to be suffering from a lack of production capacity. Since 2012 the production capacity utilisation rate (CUR) in the "other transport equipment" industry has indeed remained considerably higher than its average between 1994 and 2007 (84.7%; *Graph 10*). In 2016, the CUR has increased again (to 92.1% on average) coming close to the maximum level reached in 2007 (94.1%), which leaves little room for extra production. The situation is similar for the supply chain of South-West France's aerospace industry in general. For these manufacturers that include subcontractors, suppliers and service providers as well as aircraft and engine manufacturers (*Box 2*), the CUR also reached a very high level in 2015 (88.2%). It is equivalent to its pre-crisis level, whereas it has remained below this level in the rest of manufacturing industry.

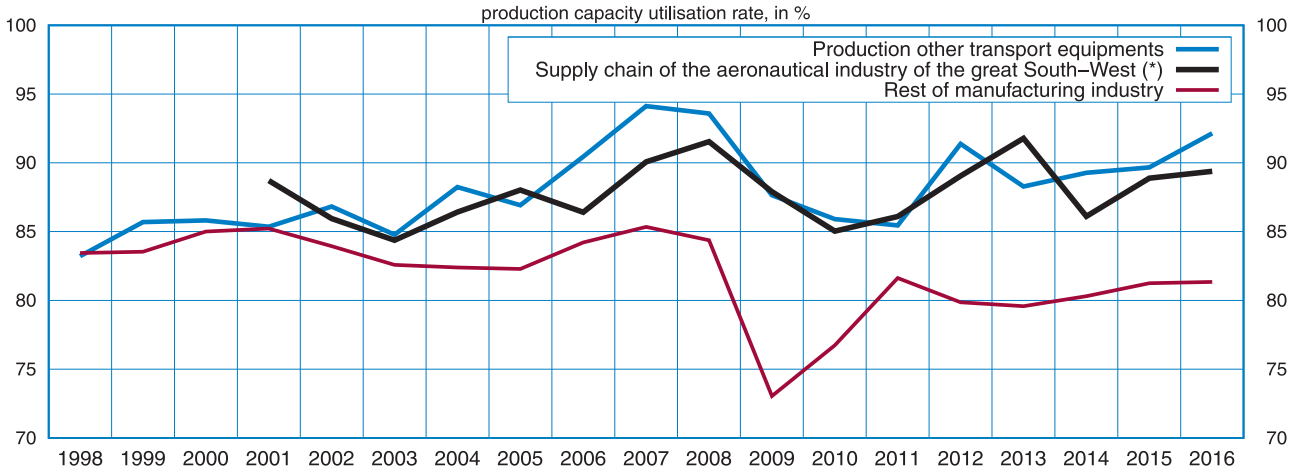
9 - Share of planes delivered by Airbus equipped with foreign engines



Note: this ratio was constructed using the number of annual deliveries of planes by type, and for each type, Airbus's technological choice regarding the engine (supplied by a resident firm or not), taking into account the market share of the different models of engine when several engines could equip the same aircraft. Only Airbus deliveries from France were counted, and not the company's total sales.
Sources: manufacturers, General Directorate for Customs and Indirect Taxes, INSEE calculations

Production therefore seems to be limited by shortages of equipment to meet demand. In fact, among the factors that have limited their production, firms in the "other transport equipment" sector mention supply-side more often than demand problems compared to companies in the rest of industry (*Table 2*): since 2013, the proportion of companies considering that they have insufficient orders has been below its long-term average; conversely, equipment bottleneck problems have been mentioned more frequently than on average since 2014. Subcontractors, and suppliers in the aeronautical industry are also faced with lower demand problems than normal; however, the proportion of them reporting equipment bottlenecks has fallen back below its average in 2016.

10 - Spare capacity are small in aeronautics



* Indicator calculated from the responses to surveys of the aeronautical industry in South-West France; the calculation includes the responses from industrial firms and service providers.

Sources: INSEE, quarterly business survey in industry, Space-Aeronautical surveys (2001 to 2012) and Aerospace industry surveys in Aquitaine and Midi-Pyrénées (2013 to 2015)

Table 2 - Supply difficulties are easing, but some equipment bottlenecks persist

Proportion of companies concerned by different factors limiting their production (annual averages in %)

Sector	Average 1994-2016	2013	2014	2015	2016
Manufacture of "other transport equipment"					
Insufficient orders	54	26	29	25	30
Difficulties of demand only	49	22	22	18	23
Equipment bottlenecks	9	18	28	24	34
Difficulties of sourcing	10	28	28	9	12
Recruitment difficulties	30	42	27	25	34
Supply chain of South-West France's aerospace industry					
Insufficient orders	33	23	37	29	20
Difficulties of demand only	25	11	23	19	14
Equipment bottlenecks	13	7	10	20	10
Difficulties of sourcing	9	19	16	21	3
Recruitment difficulties	27	49	44	26	21
Rest of manufacturing industry					
Insufficient orders	52	63	60	53	49
Difficulties of demand only	43	51	48	42	40
Equipment bottlenecks	7	4	5	4	4
Difficulties of sourcing	9	7	6	6	5
Recruitment difficulties	28	26	26	28	31

Forecast

* Statistics calculated from the responses of industrial companies in the aeronautical industry in the South-West of France to the industry business tendency survey.

Sources: INSEE, quarterly business survey in industry and Aerospace industry surveys in Aquitaine and Midi-Pyrénées linked to the quarterly business survey in industry

After two years of turbulence, the French aeronautical sector is ready to take off again

Box 2 - How is aeronautical production measured in France and what is its impact on inventory volatility

One of the industrial production indices (IPI) is dedicated to tracking the trend in "manufacture of air and spacecraft". This branch covers, in accordance with the Statistical classification of economic activities in the European Community (NACE), the manufacturing of aeroplanes, helicopters, spacecraft, launchers and satellites, etc.

This rather wide scope, representing approximately 5% of the value added of French manufacturing industry, is broken down for the purposes of constituting indices into four "sub-branches": engines for aircraft (22% of the index), helicopter airframes1 (9% of the index), aeroplane airframes (47% of the index) and finally launchers, spacecraft and ballistic missiles (21% of the index). Associated with each of these four sub-branches there are also "elementary" indices, i.e. indices based directly on the production data submitted on a monthly basis by the companies concerned, whose aggregation, via weightings corresponding to turnover in these, forms the "manufacture of air and spacecraft" index.

For the elementary index relating to aeroplane airframes, production is measured in "quantities produced", i.e. the number of finished planes coming off the different assembly lines in the world (France, Germany, China) in any given month. Simply counting the aircraft produced nonetheless would require supposing that only one type of plane is produced, and only in France. To get round the differences in production locations, in the quantity of work needed, in price or technology between the different models of plane, the planes are aggregated based on a reference model, the Airbus A320 to be specific, combined with equivalence tables. Equivalence factors are therefore defined by Airbus for all the other models; these correspond to the ratio of the value added created in France in the production of the model in question to that created on France on production of an A320.

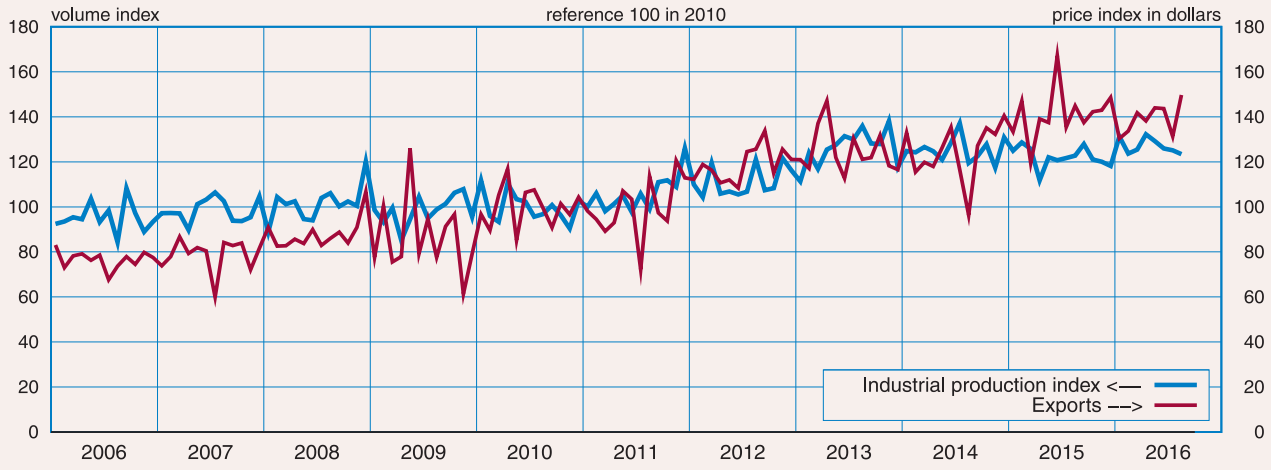
A similar method is used to produce the index for helicopter airframes and aircraft engines. However, trends in the production of spacecraft and ballistic missiles are determined based on those in the hours worked (hours actually worked by personnel directly attached to production) declared on a monthly basis by companies in the branch. The volumes of hours declared are then corrected for the changes in productivity to produce the elementary production index for "spacecraft and ballistic missiles".

The production measurements are marked by fits and starts due to the irregular pattern of planes coming off the assembly line. However, final demand for the aeronautical industry, and exports in particular (which in 2013 represented approximately 60% of final uses), is even more volatile: this is the case at aerospace manufacturing level (*Graph*) with customs data that are much more volatile than the IPI at the "other transport equipment" level of aggregation. In the quarterly accounts, the volatility of exports is three times greater than that of production over the period 1990-2015. A first factor of this difference in volatility may be due to the fact that, whereas production counts finished planes, exports are counted at the time of delivery. In addition, unlike production, exports do not only count assembled planes, but also planes in the course of manufacturing once they have crossed the border, with these flows of unfinished planes also occurring in fits and starts. Finally, if only the part of the finished plane attributable to French production is counted, the production measured is necessarily lower than counting an entire plane exported, as long as it is delivered in France, and whatever the share of domestic value added; this difference can amplify the irregularity in the patterns of production.

For the national accounts, the differences between patterns of production and exports show up mainly in changes in inventories. Over the period 1990-2015, these changes accounted for a little under a third of the volatility in the variations in inventory of all goods and services, which is substantially higher than the weight of the sector in production (8% on average over this period). ■

The term «airframes» refers to all the fuselage and wing structures.

Production indice in the "manufacture of air and spacecraft" and exports



Sources: INSEE (for Industrial Production Indice, ref. 100 in 2010, SA-WDA), customs service for the exports in products of manufacture of air and spacecraft

Business leaders report a reduction in supply difficulties in 2016

Aeronautical activity has also been limited by supply difficulties: companies judged them serious in 2014 and 2015, in the aeronautical sector as well as in the rest of the industry. However, manufacturers consider that they have been less so in 2016.

In concrete terms, final aircraft assembly, as well as the aeronautical industry, have been faced with serious supply difficulties. Airbus in particular has spoken publicly about the issues it has faced in order to justify certain delivery delays. The effect on the industrial production index (IPI) is all the greater as this statistic corresponds to a number of "finished" planes (*Box 2*).

However, supply-side issues do not seem to be connected to the problem with finding qualified personnel, as hiring difficulties are not considered substantially greater than in the rest of manufacturing industry; in 2016, this criterion was mentioned by 34% of industrial companies in the "other transport equipment" sector and by 31% of other firms in the manufacturing industry. In 2014, hiring difficulties were nevertheless often mentioned by subcontracting firms and suppliers in the aeronautical industry, but this problem seems to have become less pressing since 2015.

After being rather disappointing in 2014 and 2015, the recovery in investment in the aeronautical industry has been confirmed in 2016

To reduce production constraints, companies may choose to acquire new equipment. Over the last few years, investments have been forecasted to rise more often by companies in the aeronautical industry than in the rest of manufacturing industry (*Table 3*), but in hindsight the actual investments made in 2014 and 2015 have turned out to be lower than expected. In 2016, the balance of opinion on the expected trend in investments has increased considerably once again, both for large companies in the "other transport equipment" sector and for subcontractors in the aerospace sector in South-West France. For this group of companies, the provisional figures on growth in investments in 2016 seem to confirm a sharp increase. The new investments are being used not only to renew capital, but also to increase production capacities: the balance of opinion on growth in production capacity is substantially higher than its average for firms in the "other transport equipment" sector and for aerospace industry subcontractors.

Table 3 - Aeronautical industry subcontractors and suppliers confirm the acceleration in investment in 2016

Changes (in %) and balances of opinion (annual averages in %)

Sector	Average 2002-2016	2013	2014	2015	2016
Manufacture of "other transport equipment"					
Annual variation of investments in value	4	9	5	7	3
Expected half-year variation of investments	12	22	19	27	40
Past half-year variation of investments	4	9	9	14	
Observed and expected variation of capacities of production	36	55	32	56	56
Supply chain of South-West France's aerospace industry					
Annual variation of investments in value	5	3	9	6	17
Expected half-year variation of investments	18	21	8	25	47
Past half-year variation of investments	11	20	6	4	
Observed and expected variation of capacities of production	29	40	58	67	62
Rest of manufacturing industry					
Annual variation of investments in value	0	–5	3	2	4
Expected half-year variation of investments	3	–4	0	6	4
Past half-year variation of investments	5	2	4	10	
Observed and expected variation of capacities of production	31	19	12	22	28

Forecast

* Statistics calculated from the responses of industrial companies in the aeronautical industry in the South-West of France to the industry business tendency survey (investments).

Sources: INSEE, quarterly business survey in industry, Space-Aeronautical surveys (2004 to 2012) and Aerospace industry surveys in Aquitaine and Midi-Pyrénées (2013 to 2015)

After two years of turbulence, the French aeronautical sector is ready to take off again

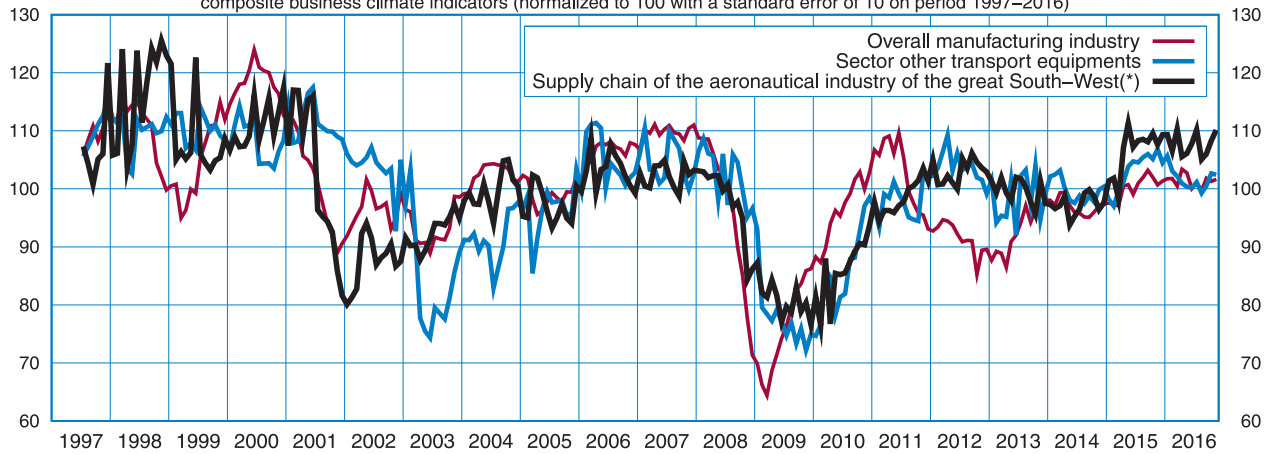
The prospects for demand remain optimistic

Over recent years, the business climate has been more positive in the aeronautical industry than in the rest of industry; over the whole of 2016, this indicator has seen a dip, but remains above its long-term average (*Graph 11*). The outlook for industrial companies in the supply chain has remained higher than its average since mid-2015. The outlook is also very favourable for the service companies in this sector (*Box 3*). The dip in the outlook for aeronautics is due to the fall in the balance of opinion on order books and more particularly on foreign orders, although these balances remain above their long-term average. Nonetheless, this fall in the order books must be put into perspective as the two main players in the French aeronautical industry both have particularly large order backlogs. For airframes, Airbus recorded 279 new orders with a value of €35bn at the Farnborough air show in 2016: at the end of October 2016, Airbus therefore has a total of 6,700 orders to deliver over the next twenty years. Although its rate of production of A380s (assembled in Toulouse) is to be reduced because of a lack of demand, the company seems to be enjoying considerable success with its new models in the A320 Néo family. It is precisely for this type of single-aisle plane that Safran Aircraft Engines developed with GE Aviation (within the company CFM international) a new engine (the "Leap") which passed the 10,000 order mark even before it went into service in summer 2016. However, production of this engine is not entirely located in France: it also involves factories in the United States.

Finally, for military aeronautics, the difficulties encountered by Airbus Helicopters (which lost out on a contract for Poland) must also be put into perspective given the export successes of Dassault Aviation, which has just doubled the size of its order book by signing a contract for the sale of Rafale planes to India, after the contracts with Qatar and Egypt.

11 - The business climate for "other transport equipment" has slowed, but remains favourable for other firms in the aeronautical industry

composite business climate indicators (normalized to 100 with a standard error of 10 on period 1997–2016)



* Statistics calculated from the responses of industrial companies in the aeronautical industry in the South-West of France to the industry business tendency survey.

Sources : INSEE, quarterly business survey in industry and Aerospace industry surveys in Aquitaine and Midi-Pyrénées linked to the quarterly business survey in industry

Box 3 - Survey of the aerospace industry in South-West France and the business tendency surveys

The survey of the aerospace industry in South-West France is an annual survey conducted by INSEE in conjunction with the Aerospace Valley competitiveness cluster. It measures the economic weight of the industry in the former Aquitaine and Midi-Pyrénées regions: these two regions account for 45% of the jobs in establishments in the aerospace manufacturing sector. The aerospace industry encompasses all the companies whose activity is partly or totally dedicated to the manufacturing of aeroplanes, engines, spacecraft, whatever their use (civilian, military, etc.).

The survey covers almost 1,700 firms in the aerospace manufacturing sector, but also in the sectors partially involved in the industry (*Table 1*): for example, sectors such as explosives manufacturing (used for rockets), mechanical engineering, the manufacturing of navigational equipment or the repair and maintenance of air and spacecraft.

Table 1 - Sector of activity of firms in the aeronautical industry in South-West France

in %

	Whole survey	Enterprises in the "business survey in industry"	Enterprises in the "business survey in services"
Basic metals and manufacturing of other metal products	18	15	0
Manufacturing of computer and electronical products	13	20	0
Manufacturing of electrical equipments	8	13	0
Manufacturing of transport equipments	25	37	1
Repair and installation of machinery	7	6	1
Rest of industry	3	4	0
Trade - Repair of motor vehicles and motorcycles	4	0	0
Computer activities and information services	4	0	22
Other activities (including engineering)	16	4	72
Research and scientific development	1	0	0
Rest of trade and services	2	1	3

Note: distribution obtained by weighting their turnover eventually destined for aerospace manufacturing.
Sources: INSEE, Aerospace industry survey in the South-West of France (2015) and business tendency surveys in industry and services

The results of the industry survey presented in this report do not concern the aircraft manufacturers themselves, nor project managers and engine manufacturers, which are not in the scope of the survey. It only concerns suppliers, subcontractors and service providers who work for these large companies. For the industry side, the survey questions mainly subcontractors and equipment manufacturers, whilst in services, most of the activity concerns engineering firms and technology consultancies (*Table 2*).

Table 2 - Functions of firms in the aeronautical industry in South-West France

in %

	Whole survey	Enterprises in the "business survey in industry"	Enterprises in the "business survey in services"
System integrator	9	13	0
Component supplier	24	36	2
Engineering and technology consultancy	13	7	49
Industrial subcontractor	31	33	3
Design subcontractor	3	0	12
Hardware and software component supplier	3	2	1
Hardware and software tool supplier	4	1	12
Maintenance company	7	5	4
Service provider	6	3	16

Note: distribution obtained by weighting their turnover eventually destined for aerospace manufacturing.
Sources: INSEE, Aerospace industry survey in the South-West of France (2015) and business tendency surveys in industry and services

After two years of turbulence, the French aeronautical sector is ready to take off again

The business tendency surveys on activity and investments in the industry and the survey on activity in services cover the entire scope of the survey on the industry. Pairing these two types of surveys provides, in the business tendency surveys, a sample of subcontractors, suppliers and service providers in the aeronautical sector, some 70 firms for the industry survey and 55 for the services survey on average each quarter. Across this precise scope, the usual estimates resulting from the business tendency surveys were made, in particular the calculation of a business climate and a production capacity utilisation rate.

In the service companies connected with the aeronautical sector, in 2016 many more business leaders than in 2015 announced an increase in their activity and demand (*Table 3*). Numerous balances of opinion reached levels unseen since 2005. This optimism on the current and future level of activity also makes them more optimistic about recruiting new people and correlatively, the proportion of companies stating that they are experiencing recruitment difficulties has once again gone above its long-term average. A survey was also done in 2014 to measure the weight of the aerospace industry in the Provence-Alpes-Côte d'Azur region: it is concentrated around the Airbus Helicopters and Thales Alenia Space sites in Marignane and Cannes respectively (Artaud & Ettouati, 2015). ■

Table 3 - Dynamic service companies

balances of opinion (annual averages in %)

	Average 2005-2016	2013	2014	2015	2016
Supply chain of South-West France's aerospace industry					
Turnover expected in the next three months	17	11	24	14	34
Expected demand	12	6	18	12	18
Expected investments	3	5	2	9	4
Situation of the enterprise	12	4	7	10	35
Exploitation result expected	11	16	13	1	9
Difficulties of accounts	1	–10	–6	–9	1
Demand limiting production	37	45	42	42	38
Workforce limiting production	12	4	2	16	25
Expected employment	22	3	27	38	57
Recruitment difficulties	34	6	5	26	36

Forecast

Note: statistics calculated from the responses of companies in the aeronautical industry supply chain in the South-West of France to the industry business tendency survey.

Sources: INSEE, Monthly business survey in services, Space-Aeronautical surveys (2004 to 2012) and Aerospace industry surveys in Aquitaine and Midi-Pyrénées (2013 to 2015)

By mid-2017, production and exports could make up for the delays accumulated since the beginning of the year

The demand prospects still look favourable for commercial airliners and could be less negative than they seemed for business planes and helicopters, given the stabilisation of oil prices since spring 2016. In addition, both the business tendency surveys and the announcements made by manufacturers suggest that the supply-side problems are gradually easing; vigorous imports of aeronautical equipment also confirm this diagnosis and seem to indicate that activity will be sustained in the coming months (*Box 4*).

All these factors combine to suggest that the aeronautical branch's production and exports will probably rise sharply by mid-2017, if only to catch up on delays accumulated since the beginning of the year.

As regards production, after a year 2016 which is expected to see production bounce back (+3.9% expected on average over the whole of the year) and to exceed its 2013 level, the carry-over effect into 2017 is expected to reach +2.7% by mid-year. On the export front, after seeing a substantial recovery from summer 2016 onwards, exports are expected to remain vigorous until mid-2017. Thus the carry-over effect to the middle of 2017 is expected to be +5.6%, after +0.5% over the whole of 2016. ■

Box 4 - Predicting production from imports of components and equipment

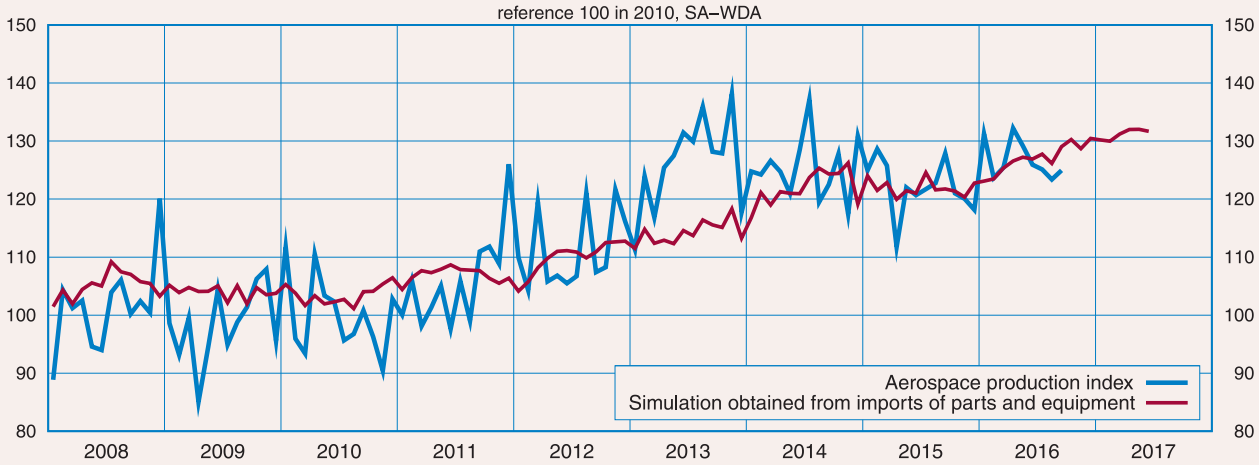
The business tendency surveys make it possible to estimate production in "other transport equipment" for Q4 of 2016, but they do not provide enough information to predict production through to mid-2017.

To make such forecasts, it is possible to use a simple relationship between recent imports of aeronautical components and equipment (i.e. engines, propellers, rotors, seats and other aeroplane parts) and aerospace production measured using the industrial production index (IPI). The model based on monthly production data is the given by this equation:

$$\Delta\log(IPI_t) = \underset{(4.5)}{0.8} - \underset{(-4.5)}{0.4}(\log(IPI_{t-1}) - \underset{(4.5)}{0.4}\log(import_{t-1})) - \underset{(3.0)}{0.3}\Delta\log(IPI_{t-1}) + \varepsilon_t$$

(in brackets Student's t-distribution)
Period of estimation 2006Q1-2015Q1
R^2 adjusted in the model: 38%

Estimation of the trend in aeronautical production based on imports of components and equipment



Sources: INSEE (for the industrial production index), use of data from the Directorate-General for Customs and Excise, adjusted by INSEE to calculate the limited data series

Bibliography

Artaud D. and **Ettouati S.** (2015), "18 100 emplois dédiés à la filière aéronautique et spatiale en 2013", *INSEE Analyses Provence-Alpes-Côte d'Azur*, n° 20.

Cachia F., **Gallot P.**, **Tallet F.**, "L'activité d'Airbus dans les statistiques de l'Insee", *Conjoncture in France*, INSEE, March 2007, p. 25-29.

Cambon G., "La chaîne d'approvisionnement aéronautique et spatiale du grand Sud-Ouest - Un dynamisme plus modéré en 2014", *INSEE Analyses Occitanie*, n° 3, February 2016.

Decret V., "La chaîne d'approvisionnement aéronautique et spatiale du grand Sud-Ouest - L'industrie aéronautique tourne à plein régime", *INSEE Analyses Nouvelle-Aquitaine*, n° 5, Fabruary 2016.

Dutheil G. (2016), "Airbus enregistre 129 commandes fermes au Salon de l'aéronautique de Farnborough", *Le Monde*, 12 July 2016.

Le Blanc G. (2007), "La France souffre-t-elle d'une mauvaise spécialisation industrielle ? Enquête sur les profils comparés de spécialisation des principales puissances industrielles (1999-2002)", *Les notes de l'Institut*, Institut de l'entreprise, March.

"Aeronautic construction and automobile construction, two sectors with a pronounced spill-over effect on the rest of the economy" *Conjoncture in France*, INSEE, March 2012, p. 89-92.

"Presque la moitié des échanges extracommunautaires de la France est facturée en euros", *Études et éclairages* n° 62, direction générale des douanes et droits indirects, December 2015. ■

Appendix 1 - Calculation of the value-added multipliers

The value-added multiplier for aeronautical production can be estimated from the input-output tables provided by the national accounts. For each branch of the economy, the "intermediate inputs table" part of the input-put table details the intermediate consumptions used (imported or produced domestically) and the valued added of the branch. The supply and use balance provides for each product its total offer, its domestic production and the volume imported.

Let n be the number of products in the economy. Let IC be the square matrix size $n*n$ that details for each product unit (columns) its consumption of intermediate products (rows). Let IC_{imp} and IC_{dom} be the square matrices size $n*n$ that detail for each production unit (columns) its consumption of imported and domestically produced intermediate products (rows). Finally, let row vector size n consisting of 1, e be the column vector size n whose component corresponding ro the aeronautical sector equals 1 and the others 0 and Id be the identity matrix.

A production unit in the aeronautical sector can be broken down as follows:

$$1 = \underbrace{a \times IC \times e}_{\text{Intermediate consumption}} + \underbrace{VA_1}_{\text{Value added at the 1st step of production}}$$

$$1 = \underbrace{a \times IC_{imp} \times e}_{\text{Part of imported IC}} + \underbrace{a \times IC_{dom} \times e}_{\text{Part of IC domestically produced}} + \underbrace{VA_1}_{\text{Value added at the 1st step of production}}$$

The breakdown of domestic production into value added and intermediate consumption, then into intermediate consumptions produced in the country and imported, is repeated at every stage of production. The value-added content of a production unit in the aeronautical sector, in other words the sum of the value added for each of the production stages, is therefore:

$$1 - a \times IC_{imp}\left[Id - IC_{dom}\right]^{-1} \times e$$

The value-added multiplier is obtained by dividing the value-added content of a production unit by the share of value added in the first production stage (VA_1). This multiplier is all the greater when the production involves intermediate consumptions with high valued added and few imports. ■

Appendix 2 - Calculation of the origin of the value added contained in final demand

The OECD's inter-country input-output (ICIO) tables describe the intermediate consumption necessary for production for 62 countries and 34 industries. There are therefore 2108 different industry-country pairs. The sum of the items in column *j* is the sum of the intermediate consumptions to produce $Prod_j$, the production of the j^{-th} industry-country pair.
By dividing each item in column *j* by $Prod_j$, we obtain the share of $Prod_j$ in the intermediate consumption of each industry-country pair. We obtain the matrix *IC* where:

$$IC_{ij} = \frac{ICIO_{ij}}{Prod_j}$$

To obtain the final production, there has been a succession of production stages. In fact, final production, at the final stage, $Prod_0$ is equal to:

$Prod_0 = VA_0 + IC_0$

Where VA_0 is the value added in the final stage and IC_0 the intermediate consumption in the final stage.

Now, IC_0 is also production:
$IC_0 = Prod_1 = IC \times Prod_0$

Likewise, in the second production stage:
$Prod_2 = IC_1 = IC \times Prod_1 = IC^2 \times Prod_0$
$Prod_\infty = 0$ (because $IC^\infty = 0$)

Thus, $Prod_{tot}$, the total production produced to produce $Prod_0$ is the sum of the $Prod_i$ productions produced at each stage *i*:

$$Prod_{tot} = \sum_{i=0}^{\infty}(Prod_i) = Prod_0 + Prod_1 + ... + Prod_\infty = (\sum_{i=0}^{\infty} IC^i) \times Prod_0 = (Id - IC)^{-1} \times Prod_0$$

To calculate VA_{tot}, the total value added generated by the production of $Prod_0$, we multiply $Prod_{tot}$ by the diagonal matrix *V* where the γ_j items are the share of valued added in the production of the j^{-th} pair.

Thus:

$$\gamma_j = \frac{VA_j}{Prod_j} = 1 - \sum_{i=1}^{i=2108}(IC_{ij}) = \frac{Prod_j - \sum_{i=1}^{i=2108}(ICIO_{ij})}{Prod_j}$$

$$VA_{tot} = V \times (Id - IC)^{-1} \times Prod_0$$

At each production stage *i*, we have:
$VA_0 = Prod_1 - Prod_0 = (IC - Id) \times Prod_0$
$VA_1 = Prod_1 - Prod_2 = IC \times (Id - IC) \times Prod_0$
$VA_2 = Prod_3 - Prod_2 = IC^2 \times (Id - IC) \times Prod_0$
$VA_n = IC^n \times (Id - IC) \times Prod_0$

Hence:

$$VA_{tot} = \sum_{i=0}^{\infty} VA_i = (\sum_{i=0}^{\infty} IC^i) \times (Id - IC) \times Prod_0 = (Id - IC)^{-1} \times (Id - IC) \times Prod_0 = Prod_0$$

Finally, with *i* the line number of the vectors:

$$\sum_{i=1}^{i=2108}(VA_{tot})_i = \sum_{i=1}^{i=2108}(V \times (Id - IC)^{-1} \times Prod_0)_i = \sum_{i=1}^{i=2108}(Prod_0)_i$$

The sum of the items in the vector $Prod_0$ is equal to the sum of the value added generated by production $Prod_0$.

In this study, the centre of interest is global final demand in the aeronautical sector. By constructing a vector with 2108 lines where all the items are nil except those corresponding to the aeronautical sector which are equal to the final demand of each country in the aeronautical sector, and by multiplying this vector by the matrix $V \times (Id - CI)^{-1}$, we obtain the details of the origin of the value added produced to meet this final demand. ■