ECONOMIC CONTRIBUTION AND PRODUCTIVITY OF ATM

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Abstract

This paper estimates the economic contributions of ATM to GDP and to employment in selected countries, as well as to provide some measures of ATM-related investment and economic productivity. Its focus, driven in part by availability of data, is on the European and North American economies. Incomplete information and estimates along parallel lines are also provided for small groups of States in Central and South America, South Asia and South Africa.

The total impact of ATM (including direct, indirect and induced effects) on North American and European GDP in 2002 was estimated to be of the order of $22 billion, with total direct, indirect and induced employment at approximately 230,000 jobs. In these two regions, ATM capital investment amounted to approximately 20% ($2.6 billion) of revenue in 2002. Considering only direct values, worldwide ATM revenues were estimated to be in the range of $16-20 billion in 2002. Numerous other estimates of a similar nature are provided.

Comparisons with other European data, confirm the view of ATM as a sector in which jobs have high skill content. Productivity appears to be comparable to that in other technologically advanced sectors of the economy. The findings of this study should be treated as preliminary, in view of data limitations and the diverse economic characteristics of the countries and regions examined.

Introduction

Beginning with the mid-1930s, air traffic management (ATM) has played an essential role in the dramatic growth of the aviation sector around the world. Throughout these years, air navigation service providers have been continuously improving, managing and operating a truly global infrastructure system that enabled the safe and expeditious transportation of more than 1.8 billion passengers and 450 billion ton-kilometers (including freight and mail) in 2004 [1].

Research on the economic contribution of aviation has either ignored ATM or simply attributed this contribution to other aviation sectors. This might be due to two reasons: first, ATM services have historically been provided as one of an array of services offered by government, thus reducing interest in a separate economic analysis of the sector; and, second, ATM's relatively small economic size is not conducive to an input-output analysis, a method often used for other larger sectors. In general, from the economic point of view, ATM is popularly regarded as a necessary service to be paid for through various charges on airspace users, rather than as a part of the broader aviation sector with its own added value and economic characteristics. This leads to a situation where investment in ATM is often viewed with considerable skepticism by governments and other stakeholders.

This paper is the first, to our knowledge, to focus on the economic value and role of ATM on its own. Based on European, US, and ICAO figures, it addresses some basic economic questions such as: What is the contribution of ATM to GDP and to employment? How does its economic productivity compare with that of other sectors? And what is the size of investment and R&D expenditures in the sector?

The contents of the paper can be summarized as follows: The next section reviews recent literature assessing the economic impact of aviation in general, and extracts from earlier studies values for impact multipliers that are used later in the paper. We then identify data sources, specify the scope of our analysis, and define the variables and quantities of interest. The contributions of ATM to GDP and employment in Europe and North America are estimated next, in a section that also includes partial information on other parts of the world based on incomplete ICAO data. We subsequently provide corresponding estimates of investment and productivity associated with ATM. A final section summarizes our conclusions and suggests directions for further research.

Contributions of the Aviation Sector

Previous research on the economic value of aviation has looked mostly at the value added by the air transport sector as a whole, with occasional emphasis on the specific sub-sectors of airlines, airports and aviation manufacturers. The role and economic value of ATM have largely been ignored. This brief review of previous research will concentrate on a few recent studies in this area and will retain elements that will be of use for this paper, such as the estimates of economic multipliers. For a more comprehensive review of previous studies see [2, 3].

Two of the recent studies deal with the economic impact of the aviation sector in the United States. The first, by DRI-WEFA [4] is motivated by the widespread concern about air traffic delays. The study uses estimates of the national economic impact of the sector to argue for more investment into aviation infrastructure. The following sub-sectors were considered:

- airlines;
- general aviation (including business aviation and air taxi);
- aircraft manufacturing and maintenance;
- airports;
- the Federal Aviation Administration (FAA) and the National Aeronautics and Space Administration (NASA);
- travel and tourism activity generated by aviation.

The study estimated three types of impact of each of these sub-sectors on Gross Domestic Product (GDP)[1] and employment:

- direct: the value added and the employment generated directly by the sector;
- indirect: the impact on the activities providing inputs to aviation;
- induced: the additional impact that results from the income generated directly or indirectly by civil aviation.

The study concluded that the combined direct, indirect and induced economic impact of the aviation sector (as defined above) in 2000 amounted to 9.2% of the US GDP, or $903 billion, and more than 11 million jobs. If the travel and tourism impacts are not included, this estimate is reduced to 4.8% of the US GDP and almost 6 million jobs.

The DRI-WEFA study [4] estimated that FAA and NASA together contributed $10.6 billion to GDP and 113000 jobs. Of these, the direct impact amounted to $7 billion and 75000 jobs. An estimate of the indirect impact was not provided, while the induced impact was $3.6 billion and 38000 jobs. The study did not attempt to isolate the contribution of air traffic management alone. In the case of NASA, ATM-related programs constitute a relatively small part of overall aeronautical activities, while the FAA, in addition to ATM, provides other services, such as regulation and certification and airport technical assistance and improvements.

To obtain the indirect and induced impact of the aviation sector, the study used economic multipliers. The indirect (or "production") multiplier, i.e., the ratio of the sum of direct and indirect impacts to the direct impact alone, was estimated to be 1.7 – lower than in other industries, due to the high labor content of aviation. The total multiplier, which is the ratio of the sum of direct, indirect and induced impacts to the direct impact, was 2.6.

The second study by Wilbur Smith Associates [5], assessing the economic impact of civil aviation on the US economy in 2000, arrived at significantly lower figures for the impact of aviation on GDP: it was estimated to be $503 billion or 5.1% of the GDP. The study appears to cover the same aviation sectors as DRI-WEFA [4], but its estimate of direct contribution to GDP was $197.6 billion vs. $343.4 billion in the DRI-WEFA study.

In 2003, the Advisory Council for Aeronautical Research in Europe (ACARE) released the findings of a study aimed at estimating the current size of the "air transport system" in the EU-15[2] economy and

[1] The GDP of a country or a region is the total market value of goods and services produced in that country or region within a given period after deducting the cost of goods utilized in their production.

[2] EU-15 includes the 15 countries of the European Union before its 2004 enlargement to 25 countries. The 15 countries are: Austria, Belgium, Denmark, Finland, France,

how it may evolve up to 2020 under different scenarios [2, 3]. It covered the direct, indirect and induced impact of three air transport sectors: airlines, airports and civil aircraft manufacturing.

An input-output model was used to derive the multipliers for indirect and induced economic impact. Econometric models were then applied to estimate the changes in the economic impact of air transport over a 20-year time horizon, under the different scenarios. The study estimated that the total contribution of air transport to EU GDP, including the direct, indirect and induced impacts, was 221 billion Euros or 2.6% of EU-15 GDP. The total number of jobs related to air transport was estimated at 3.1 million or 1.9% of total EU employment.

The study did not include ATM in the definition of the air transport sector, which, as noted, was confined to airlines, airports and civil aircraft manufacturers. The multipliers obtained and utilized for each of these three sub-sectors are shown in Table 1. The "value added" multipliers are greater than the ones in [4] for the US (1.7 and 2.6, respectively, for "indirect" and "total"). However the DRI-WEFA study included tourism, a sector with high labor content, and, of course, addressed a different economic environment. It should also be noted that multipliers do not account for economies of scale, unused capacity or technological change in the industry and, thus, are bound to change over time.

Table 1. Multipliers from ACARE study [2, 3]

Value Added Multipliers	**Indirect**	**Total**
Airlines	1.85	3.00
Airports	2.15	3.53
Aerospace Manufacturers	1.73	2.81
Employment Multipliers	**Indirect**	**Total**
Airlines	2.02	3.82
Airports	1.63	2.56
Aerospace Manufacturers	2.06	2.86

Another recent study, performed on behalf of Airports Council International-Europe [6] considered not only the direct, indirect and induced economic impacts of European airports but also their "catalytic" impact. Catalytic impact can be interpreted as the dynamic effect that air transport and airports can have on the demand and supply sides of the economy. For example, on the demand side, it includes the benefits (and costs) that result over time from airports attracting trade and tourism and, on the supply side, the dynamic impact on business investment, labour supply and business productivity. Initial results of a more recent study for the EU-25 [7] suggest that air transport can indeed have a sustained positive impact over time on both business investment and productivity: through these channels it can increase GDP by approximately +3.8% in the long run. Considering the smaller size of ATM, evidence on this effect would be difficult to isolate. Therefore, catalytic impact is not considered in this paper.

The significant differences among the estimates of the economic impact of aviation obtained by the studies outlined above are not atypical. They highlight the fact that analyses of this type are difficult, in the first place, and that the results are highly sensitive to scope (e.g., EU-15 vs. EU-25), and especially to the many necessary assumptions underlying the analysis, as well as its level of detail, and adopted methodology. In order to minimize the possibility of inflating our estimates of the contributions of ATM, the most conservative of the multiplier values identified above will be used in this paper.

Scope of the Analysis

According to ICAO's definition, ATM comprises the functions of Air Traffic Services (ATS), Airspace Management (ASM) and Air Traffic Flow Management (ATFM), with ATS being the primary component in terms of resource requirements. To capture the economic contribution of ATM this paper estimates the employment, revenues and costs associated with the provision of ATS, ASM and ATFM in the United States, Canada and Europe. For an indication of relative sizes, it also includes revenue and added value figures for a few groups of countries in other parts of the world, as well as a rough estimate of the worldwide revenue of ATM service providers. "Europe" includes[3] the 31 air navigation services providers (ANSP) for which data are available through EUROCONTROL's most

Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the UK. The 10 countries that joined the EU in 2004 are the Czech Republic, Cyprus, Estonia, Hungary, Latvia, Slovak Republic, Malta, Lithuania, Poland and Slovenia.

[3] Countries covered are Spain, Czech Republic, Sweden, Bulgaria, Austria, Norway, Belgium, Croatia, Cyprus, Germany, Turkey, France, Estonia, Italy, Finland, FYROM, Hungary, Ireland, Latvia, Slovak Republic, Netherlands, Malta, Moldova, Albania, UK, Portugal, Denmark, Lithuania, Romania, Switzerland, and Slovenia.

recent Air Traffic Management Cost-Effectiveness report [8].

The following aspects of ATM's economic characteristics are examined:

- revenue;
- direct value added and direct employment;
- indirect value added and indirect employment;
- induced value added and induced employment;
- annual investment and R&D expenditures;
- productivity.

The estimates rely on publicly available data. *Added value* for a year is the value of the goods and services produced less the cost of inputs purchased such as materials, components and services during that year. As the costs of all ATM inputs are not readily available, the direct added value can be obtained by adding the costs of the ATM factors that add value to the inputs. These factors include depreciation (the cost of using equipment and other durable goods during a year), interest (the cost of capital) and staff costs[4]. Therefore, value added was computed as follows:

Value added = staff costs + depreciation + interest (1)

To estimate the indirect and induced impacts of ATM, conservative multipliers from other aviation sub-sectors are used, as noted earlier. From our literature review and Table 1, we have that, for contribution to the GDP, indirect multipliers range between 1.7 and 2.1 and total multipliers between 2.6 and 3.5. For employment, indirect multipliers range between 1.6 and 2 and total multipliers between 2.6 and 3.8. The lowest values (1.7, 2.6, 1.6 and 2.6, respectively) have been used in every case to compute the relevant values shown in Table 2 below.

ATM Value Added and Employment

Data relevant to the value added, employment, investment and productivity of ATM are dispersed through several different documents both in Europe and in North America. For FY2002, on which we concentrated, the data had to be culled from the following sources:

- For Europe, the EUROCONTROL'S Performance Review Commission's reports on ATM Cost-Effectiveness (ACE) [8] and the EUROCONTROL's reports on ATM R&D activities in Europe (ARDEP) [9].
- For the United States, the FAA's budget reports [10], National Aviation Research Plans (NARP) [11] and Performance and Accountability reports [12, 13, 14].
- For Canada, the 2001 and 2002 annual reports of NAV CANADA [13, 14] and ICAO data [15].
- For other regions, ICAO data collected through Form K (Financial Data) [15]; only 35 of the 188 ICAO contracting states provided these data in 2002.

Table 2 shows our best estimates based on the analysis of the data in these sources. Many of the figures shown for the United States were obtained indirectly, because the FAA provides other services in addition to ATM, but FAA documents often do not report separately costs or other data that are specific to ATM. Consider the following example: In FY2002, the total payroll costs of the FAA amounted to $5.157 billion [10]. During the same year, 63.7% of all FAA employees [10] performed ATM-related functions[5]. A *pro rata* calculation then suggests that the FAA's ATM payroll expenditures were $3.285 billion. This was the value used for the "staff costs" component of "Value added" in Equation (1) for the United States. Similar inferences were made from the data to compute the depreciation[6] and interest[7] components in Equation (1), using [12], [13] and [14] as the primary information sources.

[4] Value added also includes "profit," but this is not applicable to the current not-for-profit mode of operation of ATM service providers practically everywhere.

[5] The FAA uses the term "air traffic services" (ATS) to denote the totality of services that we defined here as ATM, namely "ATS, ASM, and ATFM" in ICAO terminology.

[6] At the end of FY2002 the FAA had almost $14 billion in property, plants, equipment, inventory, and related property. The depreciation of these assets for FY2002 reached $835 million. Considering that in FY2002 ATS represented 58.2% of the FAA's cost of operations, a *pro rata* calculation resulted in $484 million to ATS depreciation cost.

[7] At the end of FY2001, the FAA Trust Fund had $13.66 billion. The following year (FY2002) the average interest rate for certificates issued through this fund was 5.125%. Thus, the account generated approximately $699.7 million in interest. We used the *pro rata* approach (58.2% share of ATS, Footnote 6) to obtain $407 million in interest for FY2002.

Table 2 – Contribution of ATM to GDP and Employment in 2002

	Revenue (M USD)	Value Added (M USD)				Employment			
		Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total
Europe	5643	4139	2897	3725	10762	47675	28605	47675	123955
US[a]	6228	4178	2925	3760	10863	34521	20713	34521	89755
Canada[b]	598	449	314	404	1167	5200	3120	5200	13520
North-America and Europe	12469	8708	6096	7837	22641	87396	52438	87396	227230
Mexico, Brasil[c], Peru and Ecuador	567	449[d,e]	314	404	1168	n/a	n/a	n/a	n/a
India[f], Thailand[a] and Bangladesh[g]	600	401[d]	280	360	1041	n/a	n/a	n/a	n/a
South Africa[f] and Tanzania	39	28[d]	20	25	73	n/a	n/a	n/a	n/a
World	*16000-20000*								

Notes: a) fiscal year to 30 September 2002; b) fiscal year to 31 August 2002; c) figures of 2001; d) staff cost was estimated using the staff cost as % of revenue in Europe and North-America, 53%; e) interest expenses n/a for Ecuador; f) fiscal year to 31 March 2003; g) fiscal year to 30 June 2002

The rough estimate of revenues from ATM worldwide shown in Table 2 was derived by extrapolating from the incomplete ICAO financial data, considering that (a) the total revenues from Europe, North America and the other groups of States listed in Table 2 amounted to about $13.6 billion in FY2002 and (b) we do not have revenue data for some major providers of ATM services (Japan, China, Russia, Australia, New Zealand) along with many other States are missing.

Table 2 indicates that ATM is clearly a much smaller sub-sector of aviation than airlines or airports (as estimated by the recent studies we outlined earlier), when it comes to the magnitude of both value added and employment. However, it is also clear that the true economic importance of ATM is not fully captured by the measures of Table 2 alone. ATM is indispensable to ensuring flight safety and to managing the flow of air traffic. In this sense, ATM's role is analogous to that of other network-based infrastructure industries, such as those providing for the distribution of electricity, natural gas or water. These industries generate social and economic benefits in the form of "network externalities" that are not fully captured by the revenues of the industry. For example, improving radar coverage of en route and terminal airspace is likely to generate a surplus to airspace users, in terms of flight opportunities, and lower operating costs, that is greater than the amount reflected in ATM charges.

ATM Investment and Productivity

Table 3 presents several indicators that characterise ATM from an investment and productivity viewpoint. Productivity is assessed in this paper using two indicators: the ratio between revenue and staff employed and the ratio between value added and staff employed.

Significant differences can be observed in investment and productivity between the US, Europe and Canada. Investment as percent of value added in 2002 was around 30% in the US and Europe whereas in Canada and the 4 countries of Central and South America it was closer to 20%.

Expenditures for R&D in the US and Europe appear to be roughly the same. However, the US figure in Table 3 shows only the FAA's R&D budget. Additional ATM-related R&D funding is made available through NASA, the Center for Advanced Aviation System Development (CAASD) and several university-based Centers of Excellence. The exact size of this additional funding could not be ascertained for this paper, but the total amount involved was of a magnitude comparable to the $195 million in the FAA's budget.

Productivity indicators suggest that value added and revenue per employee in the US (respectively $121,000 and $180,000) were significantly greater than in Europe ($87,000 and $118,000) or in Canada

Table 3 - ATM Investment and Productivity in 2002

Region	Capital Investment (M USD)	R&D (M USD)	Investment as % of Value Added	Staff Cost per Employee ('000 USD)	Annual Investment as % of Staff Cost	Value Added per Employee ('000 USD)	Revenue per Employee ('000 USD)
Europe	1138[a]	198[b]	27%	64	37%	87	118
US[c]	1358[d]	195[e]	33%	95	41%	121	180
Canada[f]	76	n/a	17%	62	24%	86	115
North-America and Europe	2572	218	28%	76	39%	105	143
Mexico, Brasil[g], Peru and Ecuador	79	n/a	18%	n/a	26%	n/a	n/a

Notes: a) Source: [17]; b) Source: [9]; c) fiscal year to 30 September 2002; d) Source: [18]; e) Source: [10]; f) fiscal year to 31 August 2002; g) 2001 values

($86,000 and $115,000). This difference can be at least partly attributed to differences in the staff cost per employee ($94,000 in the US, $64,000 in Europe and $62,000 in Canada) that in turn may reflect differences in purchasing power at the respective countries.

It is interesting to compare some of the indicators in Table 3 with what can be observed in other sectors. For example, European ATM staff costs per employee is high, i.e., comparable to that at the "Top 600," in terms of value added, European companies – see [16]. These 600 companies span a range of sectors as varied as insurance, aerospace and pharmaceuticals. This confirms the view of ATM as a sector where jobs have high skill content.

The average investment intensity of ATM, as measured by annual investment as a percent of staff cost (37% for Europe in 2002, as shown in Table 3) is lower than what has been reported for the same set of 600 companies in sectors like IT hardware, but greater than in sectors such as engineering or chemicals. Productivity in terms of value added per employee is of the same order of magnitude as in aerospace and automotive industries, but lower than in electricity, telecommunications or pharmaceuticals.

Finally, in terms of revenue per employee, ATM productivity is almost identical to the average turnover per person employed in the EU-25 countries in the transport, storage and communication sectors in 2001 – $118,000 vs. $119,000 per employee respectively [19]. However, this is only a rough comparison because the two sets of countries (EU-25 vs. the 31 countries covered by EUROCONTROL's Cost Effectiveness reports) overlap significantly, but certainly are not identical.

Conclusions

This paper has provided some initial insights into the economic value of ATM in its various dimensions: its contribution to gross domestic product and to employment and associated productivity and level of investment. Direct, indirect and induced impacts of ATM, on the basis of multipliers obtained from earlier work and of an analysis of publicly available data. The multipliers used suggest that for each $1 generated by ATM, a total of $2.6 are generated in the economy.

The total impact of ATM (including direct, indirect and induced effects) on North American and European GDP in 2002 was estimated to be of the order of $22 billion; with total direct, indirect and induced employment at approximately 230,000 jobs. In these two regions, ATM capital investment amounted to approximately 20% ($2.6 billion) of revenue in 2002. Considering only direct values, worldwide ATM revenues were estimated to be in the range of $15-20 billion in 2002.

Comparisons with other European data, confirm the view of ATM as a sector in which jobs have high skill content. Productivity appears to be comparable to that in other technologically advanced sectors of the economy.

One of our principal observations concerned the unavailability and/or unreliability of the data necessary to assess the economic contribution of ATM worldwide. As pointed out earlier, only 35 countries out of 188 provided ATM financial data to ICAO in 2002 – and these data are often incomplete. Moreover, even in the case of countries with advanced ATM systems, major gaps in the data exist and the interpretation of the available data is made difficult by lack of precision in data definitions. For example, we received strikingly contradictory information from various sources on the size of R&D expenditures for ATM in the United States, because different organizations and reports include diverse items under this category. It is hoped that the ongoing restructuring of the FAA's organization and management will rectify such problems, which have been documented extensively elsewhere [20].

The findings of this study should be treated as preliminary, in view of data limitations and the diverse characteristics of the countries and regions examined. There is ample room for refinement or correction of our results. It is hoped that this paper will stimulate further research in this important area.

The paper also noted that the economic value of ATM is not limited to the impacts estimated in Sections 3 and 4. ATM occupies a critical role in the aviation value chain as an "enabler" of air transport operations and therefore generates externalities that are not fully captured in its revenues and value added estimates. Future research should focus on a better understanding of this aspect, as well.

Key Words

Economic analysis, economic contribution, productivity, value added, employment.

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