The Usefulness of Current International Air Transport Statistics

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ABSTRACT

International air transport is the fastest growing segment of transport. It performs a major function in the globalization process and is a significant feature of the late 20th century. Public policy regarding international air transport has undergone a sea change in recent years as markets liberalized and airlines privatized. New management techniques, partly stimulated by enhanced information technology systems, have resulted in significant changes on the air services supply side. Aircraft and air traffic control systems have improved. These developments pose new challenges for those responsible for overall policy and for those supplying air transport services. Successfully confronting these issues requires a solid and relevant statistical database. This paper sets out to explore the data that are available, highlights their strengths and limitations, and indicates areas where improved statistics may be beneficial.

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INTRODUCTION

Trade in international air transport services is extensive and growing.[1] This trade has an importance in its own right, in terms of balance of payments considerations for example, but air transport also acts as a lubricant for trade in a wide range of other goods and services. It has been instrumental in stimulating many of the globalization trends that have been seen over the past 30 years. It is also a sector that has been, and continues to be, the subject of considerable governmental interventions and one that requires sophisticated management to perform efficiently. Performance indicators are thus of major importance both for public policy formulation and for monitoring internal efficiency.

The late 20th century has also seen a general appreciation of the need for changing how international aviation is controlled.[2] The institutional structure developed in the mid-1940s allowed considerable progress to be realized in international air transport markets during the four decades following World War II, but since then technology has progressed, the demands of air transport users have both changed and expanded, and new markets have emerged (OECD 1997).

Quantitative information is important to this sector. Where tight economic regulation continues, information is needed in the international horse-trading that is an integral part of the bilateral system of air traffic agreements pertaining to such regulations. Where there are efforts to reform, and especially to liberalize the regulatory structure, statistics are needed for both private and government sector use.

Airlines, airport authorities, and suppliers of aircraft and other material inputs require quantitative information to make effective management decisions and to permit longer term planning. Labor unions require data to effectively negotiate with employers. Governments need to monitor the state of the industry to enforce general regulations over such things as anti-trust behavior and to be in a position to conduct international negotiations. Increasingly more data is being demanded on the wider, social implications of air transport as matters of safety and environmental damage attract public attention. Finally, researchers require reliable and consistent data on international air transportation to perform basic analytical as well as policy-relevant research.

This paper focuses on the current availability of international air transport statistics. It looks at the uses made of the available sources and highlights the strengths and weaknesses of current data.[3] To this end, the paper initially provides context by setting out some of the important recent trends in international air transport. It then moves on to look at the main uses made of statistics, both by those concerned with international air transport policy and by those working in the sector or making use of its services.[4] An appendix to the paper critiques the available statistical sources, given the types of current and likely future demands placed on them.

TRENDS IN INTERNATIONAL AIR TRANSPORT

Two forces have helped shape the air transport industry: developments in markets for air transport services and institutional reform. Globalization and internationalization have been major industrial trends of the late 20th century. Part of this pattern is reflected in the significant trade growth that has taken place. Real export growth in the industrialized countries that make up the Organization for Economic Cooperation and Development (OECD) grew at over 7% per year from 1964 to 1992. Comparatively, first world production was

[1] Air transport is a network industry, and, from a technical perspective, it is somewhat artificial to separate international air transport from domestic air services; not only do they often use the same infrastructure and equipment, but the route networks are themselves interlinked. From many policy points of view and considering institutional structures, domestic services are normally treated differently from international ones.

[2] For instance, on the European side of the Atlantic there was the Comité de Sages for Air Transport (1994); on the U.S. side, the U.S. National Commission To Ensure a Strong Competitive Airline Industry (1993).

[3] The paper is not concerned with the more general attributes of good statistical series, data collection, and presentation, but focuses entirely on the issues peculiar to international air transport.

[4] To provide realistic boundaries, the focus of the paper is almost exclusively on the airline sector, and little attention is paid to the aircraft manufacturers' needs.

up by 9%, exports by 12%, and cross-border lending by 23%. Equally, there has been a significant rise in foreign ownership of assets that are now estimated to total about $1.7 trillion (U.N. Conference on Trade and Development 1994).

Whether these trends are passing fads or genuine long-term adjustments to the way production and trade is conducted is premature to judge. Preliminary indications are, however, that despite short-term problems with some Asian and South American economies, the observed trends are more than transient.

All this has taken place while the institutional structure of air transport services has seen significant developments (Kasper 1988). U.S. economic deregulation of its domestic air freight markets in 1977 and its passenger markets in 1978, combined with subsequent commitments to an "Open Skies" approach to international aviation in 1979, changed the way U.S. policy in this area is conducted. It has also, through both demonstration and direct knock-on effects, affected the ways in which other air transport markets are now regulated (Button 1990; OECD 1993, 1997).

The intra-European market is moving rapidly toward a situation found within the United States. Many European countries unilaterally liberalized their domestic markets, while the European Union (EU) since 1988 has moved, through a succession of "Packages," to a position that has left air transport largely free from economic regulation since mid-1997.[5] There are also indications that the European Union is slowly developing a single external approach to international aviation with the European Commission acquiring rights, albeit limited, to conduct negotiations on some "doing-business" aspects of international agreements.

Outside of Europe and North America, the majority of national markets in South America have been liberalized with a variety of privatization programs. In the Pacific region, the Australian and New Zealand domestic markets have also been deregulated. Additionally, the creation of the World Trade Organization (WTO) brought into play, albeit in an extremely small role,[6] a new and geographically wider policymaking institution to supplement those already in existence, such as the International Civil Aviation Organization (ICAO) and the International Air Transport Association (IATA) (Katz 1995). Aviation issues are also on the agenda of new regional groupings such as the Asian-Pacific Economic Council.

This combination of market trends and institutional reforms, combined with rising incomes and increased leisure time, have contributed to the steady growth of demand in aviation markets. Additionally, technological advances have allowed aircraft efficiency to rise and air traffic control systems to handle greater volumes of traffic, thus exerting positive effects on the cost side of the international air transport equation. The airlines themselves, partly as a response to these developments, have adopted more aggressive marketing strategies with the introduction of frequent flier programs, yield management, and code-sharing alliances (Gellman Research Associates 1994; USGAO 1995c).

As a result, air passenger traffic since 1960 has grown worldwide at an average yearly rate of 9% with freight and mail traffic growing by some 11% and 7%, respectively. In 1995, for example, some 1.3 billion passengers were carried by the world's airlines (Boeing Commercial Airline Group Annual a). Civil aviation has become a major service industry, contributing to both domestic and international transport systems. It facilitates wider business communications and is a key component in the growth of tourism, which is now one of the world's major employment sectors (World Travel and Tourism Council 1993).

In addition to passenger transport, aviation is an important form of freight transport, with some estimates suggesting it carries over 30% of world trade by value and is forecasted to rise, with some short-term volatility, 400% by 2015 (Boeing Commercial Airplane Group Annual a).

[5] For details of the various "Packages" of reforms, see Button et al. (1998); Vincent and Stasinopoulos (1990); Stasinopoulos (1992, 1993).

[6] A number of countries, especially the United States, have tended to oppose the multilateralism implied in air transport agreements like the General Agreement on Tariffs and Trade (GATT) and have preferred to use their bargaining power within the bilateral structure.

The growth trend has not been even but has exhibited geographical variation. For the period 1982 to 1992, ICAO data show that traffic grew by 11.4% on European-Asian/Pacific routes, but only by 5.0% in mid-Atlantic markets. The European-African traffic hardly grew at all. Airlines have seen a steady growth in their traffic within Europe since 1992. Overall traffic increased by 8.1% in 1994, the biggest annual rise in 15 years, except for a 9.1% increase in 1992 following the drop in traffic recorded in 1991. This trend continued in 1995, with growth reaching 6.1%. This fairly sustained growth in traffic, coupled with a more moderate increase in capacity, is reflected in an improved load factor for all the national carriers which, like productivity improvements, brought many of the airlines back into profitability.

Cargo traffic also exhibits important geographical variations, with the greatest growth in the mid-1990s coming in the Intra-Asian market (20.4% in 1994 and 15% in 1995) and a much more steady expansion in more mature markets such as the European-North American market (5.3% in 1995).

After running a deficit for several years, many airlines managed to get back into the black in 1995. Net profits for the 12 main EU airlines were in the region of US$800 million, against a net overall loss on the same scale in 1994. However, only British Airways, Finnair, and KLM achieved universally favorable results over the entire period from 1990 to 1994. Globally, British Airways, Singapore International Airlines, and Northwest Airlines were the most profitable in 1995, with net incomes of $740 million, $622 million (up to $624 million in 1996), and $506 million ($536 million in 1996), respectively. Some carriers such as Air France (–$581 million) and Canadian Airlines International (–$143 million) continued to report losses in 1995. All major Asian carriers achieved a positive net income in 1995.[7] The financial situation of carriers has tightened more recently, with profit levels declining as Asian markets have been in recession and competition heightened in markets like the North Atlantic.

In line with other sectors, aviation has experienced a significant move toward globalization and internationalization. Indeed, it is the stated objective of British Airways that it intends to become a "global carrier." In pursuit of wider market coverage and in an effort to enhance their own internal efficiency, other airlines have followed a similar course. The most recent development, and perhaps the most controversial, is the formation of various airline alliances.[8]

WHAT DO WE NEED FROM INTERNATIONAL AIR TRANSPORT STATISTICS?

There is no single user of air transport data. Rather, international air transport statistics are collected and analyzed for a variety of purposes. Such statistics are important to various public and private sector groups in their decisionmaking processes. The needs of each group, however, often differ. The use made of data can also vary within a group, according to the issues at hand. Over time these issues can also take on new dimensions. In consequence, compromise is inevitable in the way data is collected and summarized.

The aim here is to look at the current and potential future needs for these statistics. The needs are, therefore, the context for overall medium-term developments in air transport markets, public policy priorities, and commercial requirements. The needs of the public and private sectors inevitably overlap in many instances, requiring similar data.[9]

Policy Analysis

In recent years, there have been significant changes in the institutions governing international air trans-

[7] How much of the net revenue is attributable to international operations is difficult to assess in most cases because of joint operations with domestic services. For example, in 1995, 98.1% of British Airways revenue ton-kilometers was international as was 91.1% of Air France's and 100% of Singapore International Airlines, but only 30.7% of Delta Air Lines', 20% of Continental's, and 7.4% of U.S. Air's were international.

[8] Some indication of the growth in airline alliances can be found in the annual surveys conducted by *Airline Business.* The most recent survey indicates some 502 alliances globally, up 38% from 1997. The data, while indicative use a fairly broad definition of alliances. One thing that they highlight is the volatility of the arrangements that exist.

[9] One area of considerable public concern that is not touched on here is security. Almost by definition, there is limited knowledge of exactly what data are available to the security agencies and to what extent they are exchanged at an international level.

port. International air transport has traditionally been heavily regulated in terms of the fares and cargo rates that could be levied, the level of service that could be offered, and the airlines that could operate. Further, many carriers outside of the United States are state-owned. The situation that emerged from the Chicago Convention of 1944 was that each country retains rights over its own air space, and countries have tended to use this to negotiate bilateral air service agreements with other states. These agreements have varied over time in their detail but generally cover the capacity supplied, specify the permitted carriers, control fares and entry points, and pool revenues. Within this framework, IATA acted as a clearinghouse for information, with fares, capacity, and other features of the market very closely monitored. Data were relatively simple to collect because many key parameters were effectively determined by fiat within the framework of an international cartel.

More recently, many of the bilateral air service agreements have been liberalized. Since 1979, the U.S. government has pursued an Open Skies policy with respect to many of its bilateral negotiations in an effort to remove the more binding restrictions.[10] Within Europe, the Third Package of aviation reforms has led to a multilateral structure in the European Union (Stasinopoulos 1993).

Much of the debate over international liberalization has been conducted in the abstract, with logical argument being deployed in support of regulatory reform.[11] Statistical information has supplemented these theoretical and political arguments, with evidence drawn from a range of studies showing the benefits of freer aviation markets. The post-1978 developments in the U.S. domestic market have formed the bedrock for much of this work, but early lessons were also learned from analyzing some of the liberal bilateral arrangements. Examples include Barrett (1990) and the U.K. Civil Aviation Authority's (1993) work on the European markets. This latter work has provided retrospective assessments of the implications of change and, in doing so, had important demonstration effects for further reform. In general, however, the number of studies of this kind looking strictly at international air transport have been relatively small in number.

Recently, the increased internationalization of airline services has created the need for more current analysis and a longer term need for different types of statistics. As a prerequisite, there are important initial issues of definition. To take two examples of the latter, there is considerable commercial interest, together with accompanying public and legal debate, about the desirability of certain types of airline alliances.[12] Debates of this nature require good data if ultimately they are to prove constructive, but a major problem is that there is no accepted definition of what exactly constitutes an alliance. This has led to the emergence of different sets of statistics.[13] Somewhat linked with this, reforms are resulting in the restructuring of airline service networks, but this leads to major problems in defining what constitutes an air service; simple point-to-point data, for example, provide only a partial picture because most trips involve transit through a hub airport.[14] This definition problem also brings to the fore the important

[10] This was a logical extension of the deregulation of domestic U.S. cargo markets in 1977 and U.S. domestic passenger markets in 1978.

[11] The new attitude toward economic regulation is reflected in the criteria by which regulated markets are now assessed. Regulation, aside from purely protective measures, has traditionally been viewed as containing monopoly power while permitting economies of scale to be enjoyed. The new emphasis focuses on minimizing X-inefficiency and maximizing dynamic efficiency. The result is that the institutional structure shifts to a greater focus on cost minimization and innovation. Inevitably this requires different models and data. Some examples follow: *allocative efficiency* requires first- or second-best pricing of the final product; *scale efficiency* requires possible limitation on sub-optimal entry to industry; *technical efficiency or X-efficiency* require cost minimization by the incumbent firms; and *product choice and dynamic efficiency* require innovation by incumbents.

[12] The majority of airline alliances that have attracted the most public interest have involved one or more European carriers joining with a large U.S. airline. Alliances are certainly not unique to air transport, nor to transport in general, but are one of the most rapidly growing forms of this business practice.

[13] As an illustration, one can compare the number of alliances recorded in recent reports in the *Economist, Airline Business,* and *Avmark Aviation Economist.*

[14] This definitional question is important in assessing the degree of competition between carriers when there is a need to delineate the markets being served, e.g., anti-trust immunity matters surrounding alliance approvals.

interface between domestic and international air transport. From a transport perspective, travelers and shippers are concerned about origin to destination characteristics, but the data generally available to policymakers are divided between the local and the trunk elements of a passenger or cargo movement.

The traditional data on physical features of the international airline activities, such as route-miles served, are important for some aspects of the new policy environment; however, they are generally inadequate for the negotiations that take place leading to reform. Negotiations usually focus on the comparative advantage of each nation's airlines rather than with physical parameters. Yet, it is this type of commercial data that is generally lacking, and the adoption of yield management practices makes it difficult to collect.

Freer market conditions, once they are attained, inevitably bring with them concerns about the performance of markets and the conduct of the airlines within them. In the air transport context these take two forms. At one extreme, there is concern that network industries are inherently unstable and, in economic terms, lack a "core."[15] Undersupply is the result. At the other extreme is the fear that given the economies of scale, scope, density, and market presence that are seen as features of the sector, there will be a long-term oligopolization of the sector; again undersupply results. Linked to the latter is a concern that opportunities for new market entry will be further restricted by incumbent airlines pursuing predatory practices.[16]

While tackling these problems may involve individual case studies, background statistics are important as benchmarks against which to assess behavior. This raises questions regarding such things as industrial rates of return in different market types, degrees of rate and service variability, differences in service quality, and comparative cost structures.

The need for more and better data is also likely to be stimulated further in the future by recent broader trends in trade policy. The gradual development of international liberalization of trade in services under the administration of the WTO has to date had minimal effects on the air transport sector, but as the role of WTO expands, the likelihood is that better quantitative information will be sought by those developing policy.[17] It will also become increasingly germane as multilateral policing and monitoring of the regime demand standardization of information.

Forecasting Demand

Often linked to public policy analysis and formation but also extending beyond it is the role of statistical information in predicting demand for international air transport. As a sector, international aviation will continue expanding into the foreseeable future, although at different rates in various geographic submarkets. A number of international agencies, aircraft manufacturers, and airlines regularly produce forecasts of aviation traffic, mainly related to scheduled services (e.g., Airbus Industry Annual; Boeing Commercial Airplane Group Annual b, ICAO Annual a; Daimler-Benz Aerospace 1995; Douglas Aircraft Co. Annual).

While forecasting remains more of an art than a science, it seems likely, taking an overview of these forecasts, that passenger traffic will grow at a rate between 5% and 7% into the foreseeable future, much of it in the Asian-Pacific region (up to 9% a year). Forecasts also show slower growth in the more mature U.S. and European air transport markets.

The nature of the long-term growth trend in air transport is less important than the details about individual markets and fluctuations in medium-term traffic levels. The evidence to date is that many forecasts are not particularly accurate in this

[15] The lack of a core means that because of the features of the market (e.g., decreasing costs) there is no stable equilibrium. If all potential suppliers are aware of this, then none will enter the market because they appreciate that their position is unsustainable. For a technical discussion of these issues see Button and Nijkamp (1998). There may be links between the creation of dominant market actors and concerns over an empty core, because one mechanism for private companies, such as airlines, to internalize the instability problem is to form a cartel or to seek monopoly power.

[16] This has parallels with traditional trade issues like dumping.

[17] The annex to the General Agreement on Trade in Services (GATS) dealing with aviation covers no firm rights and is limited to three doing business issues: aircraft repair and maintenance services, the selling and marketing of air transport services, and computer reservation systems.

TABLE 1 ICAO Seven-Year Forecast and Actual Flights on the North Atlantic (thousands)

	Base-year forecasts															
	1984	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
1980	127.6	130.2	132.7													
1981	125.7	128.0	130.4	133.0												
1982	125.8	128.1	131.4	131.6	132.0											
1983	127.8	129.1	131.7	131.7	133.6	135.3										
1984	*132.7*	138.3	139.8	142.8	147.9	152.0	153.6									
1985		*140.8*	143.5	144.2	148.5	151.5	156.0	159.5								
1986			*141.4*	149.8	151.9	154.8	159.0	164.0	168.9							
1987				*158.5*	177.2	187.3	195.3	203.4	209.8	215.4						
1988					*175.7*	187.6	197.3	204.5	212.9	221.6	229.1					
1989						*192.0*	205.4	216.4	225.6	235.6	244.4	253.6				
1990							*206.1*	205.0	213.9	224.4	236.7	249.3	263.6			
1991								*213.0*	220.3	233.5	247.0	258.1	268.1	277.6		
1992									*228.2*	238.0	252.2	263.3	278.9	294.3	312.5	
1993										*242.8*	252.8	264.5	277.2	291.2	305.2	320.1

Note: Actual figures in italics.

latter respect[18] (see table 1). These medium-term forecasts are, however, particularly important in many managerial decisions, such as the ordering of new aircraft.

A problem with demand forecasting is that it traditionally has relied on extrapolations of patterns discerned in time series econometric analysis of past events and relationships. Establishing the nature of past and existing relationships between a range of variables and air travel demand is far from easy even with reliable data, but forecasting the future path of independent variables is generally more problematic. Assuming current and past relations will remain constant over the forecast period is also difficult.[19]

More recently airlines such as British Airways and manufacturers such as Boeing have been using various forms of scenario analysis in an attempt to develop strategies to confront uncertain futures (British Airway 1995). These involve less traditional statistical inputs but more qualitative material, and also require a range of forecasts of possible trends in those factors that influence the demand for air services and the costs of providing them.

Cost and Productivity Analysis

Costs of airline services are relevant for policymakers and airlines. The airlines have a commercial interest in having a finger on the pulse of their cost flows, especially as operations are increasingly market driven. Governments require cost data to assess not only legal matters regarding general industrial policy but also for such things as the way taxation policy is applied to the sector. There have been considerable advances in recent years in the ways in which airline costs and their efficiency can be measured.

The conventional accounting procedures and basic econometric models (e.g., using Leontief- or Cobb-Douglas-based functions) deployed until the late 1980s have been supplemented by more rigorous techniques as the understanding of the subtleties of cost functions has advanced, as methods of estimation have developed, and as relevant computer software has become available (e.g., Caves et al. 1987).

On the theoretical side, traditional neoclassical ideas of economies of scale have been supplemented by notions of economies of scope, density, networks, and experience.[20] On the demand side, ideas of economies of market presence have come to the fore in terms of influencing the optimal scale

[18] European Civil Aviation Administration (1994) offers a general discussion of air transport forecasting issues.

[19] Efforts at supplementing these procedures with Delphi and similar techniques do not resolve the problems and can, in some instances, worsen them.

[20] Economies of scale reflect declining costs of production as an airline's output increases; economies of scope are present when one airline can produce two or more services more cheaply than if these services were produced by separate airlines; economies of traffic density occur when the average unit cost of production declines as the amount of traffic increases between any given set of points served; economies of network size exist when the average cost of production declines as the number of city points served by an airline's network increases; economies of experience reflect falling costs with total sales in a market over time.

of activities and largely underlie the development of frequent flier programs and code-sharing alliances. Econometric models accommodate these features and allow parameter estimation through the use of flexible form models. The transcendental-logarithmic (trans-log) function is, for instance, now widely deployed because of its flexibility, although assigning input prices on items such as capital still poses serious problems.[21]

The recognition that inappropriately regulated market structures can lead to intervention failures, with associated high levels of X-inefficiency because carriers are not forced to produce on their lowest cost curves, has led to the adoption both of refined econometric procedures (e.g., the stochastic frontier approach) and programming techniques (particularly, data envelopment analysis) in empirical analysis. While technical disputes continue concerning the validity and usefulness of the alternatives, with institutional change, many of the assumptions of the more traditional ways of treating carrier cost functions are often no longer relevant.

Overall, these developments have implications for the type of data needed to carry out detailed cost and productivity analysis and pose particular problems in policy assessment because much of the data requirement, for example, that regarding yields, has commercial value associated with it. While this is an issue for analysis of any domestic system, it is even more of a problem when international comparisons are being attempted.

Infrastructure

Modern international air transport relies on an extensive infrastructure. This includes not only airports and the navigation and air traffic control systems but extends to the infrastructure required to get passengers and cargoes to and from air terminals. There is also the communications infrastructure necessary to coordinate the activities of customers of airline services and suppliers of services to airlines.[22] Much of this infrastructure is used by both domestic and international airlines, with airports serving as interchange points in the larger air transport network.

The infrastructure data requirements relate to ongoing activities for immediate management and operational planning (e.g., slot, gate, and parking space allocations) and longer term concerns about capacity planning and investments. The latter, given the time it takes to gain acceptance for capacity expansion, can require 30- to 40-year forecasts.[23] In many instances at major international hub airports, the banking pattern of flight arrivals and departures (i.e., flights converging and then departing within narrow timeframes), coupled with the need to integrate domestic and international connections, involves considerable interchange of information between airlines and airport authorities on the local scheduling committee.

In many markets with a large international presence, the available infrastructure is increasingly reaching its technical capacity.[24] While some of the problems lie in the poor management of much of the infrastructure (e.g., X-inefficiencies associated with public ownership and noneconomic pricing), there remain very real capacity issues. Expansion of capacity is, however, difficult because of concern over adverse environmental impacts.[25] In most industrialized countries, investment in more physical capacity requires extensive public inquiry pro-

[21] The standard approach is to estimate the -log cost (or production) function in combination with share equations using Zellner's seemingly unrelated least squares procedures. This increases degrees of freedom and means the estimates are invariate to the share equation omitted and converge to yield maximum likelihood estimates. Oum and Yu (1995) offer an example of this approach.

[22] The research on the role of computer reservation systems and passenger air transport is fairly extensive, but that on the cargo side is more limited (Button and Owens 1999).

[23] These need to be relatively accurate for engineering design purposes, but since costs and benefits are discounted in cost-benefit assessments, they can be less accurate over the longer period. Good short-term data is also required for slot allocation purposes. At present, allocations are usually done administratively (e.g., Castles 1997).

[24] A report published by IATA (1990), for instance, concluded that without further enhancements, capacity of 16 European airports would be severely limited by the turn of the century, with Madrid, Frankfurt, Heathrow, Gatwick, Barcelona and Milan (Linate) the most severely affected. Even if potential measures help to increase capacity, without new runways put into place, 13 airports would still remain constrained by 2010.

[25] It is no accident that perhaps one of the most comprehensive and expensive cost-benefit studies conducted was on the location of a new "Third London Airport." The recommendations of the inquiry team were rejected (Commission on the Third London Airport 1971).

cedures to be conducted. These inquiries are costly and take considerable time to complete.[26]

Safety

Air travel is, by most objective criteria, the safest way to travel. Nevertheless, there are accidents. Between 1987 and 1996, there were 205 commercial jet aircraft losses in the world, 41 by U.S. operators (Boeing Commercial Airline Group Annual a). Over 65% of these were during takeoff or landing. Over the same period, there were 142 fatal accidents involving jet aircraft, of which 108 involved passenger airlines and killed 6,156 people. Globally, data on smaller commercial aircraft accidents are less complete. Aircraft accidents often attract considerable media attention and public concern because of the large numbers of individuals that can be involved in any incident.[27]

The current rate of accidents involving all U.S. carriers has remained fairly constant since the mid-1970s at about 0.05 fatalities per 100,000 departures or 0.0008 per million aircraft-miles. Non-U.S. carriers as a group have slightly worse statistics. The actual number of incidents varies quite considerably year by year because of the unevenness of the fatality incident rate. The problem is that while on a purely mileage-related basis, air transport seems safe, the predicted growth in the sector means the absolute number of incidents will rise unless safety per se is improved. Improving safety, or indeed even convincing the public of the generally good safety record of international air transport, requires a solid statistical foundation.

In practice, aviation safety data are often incomplete, inconsistent, or have serious gaps. This is in part because countries collect data and define terms differently. The U.S. National Transportation Safety Board, for instance, uses a very broad definition of an accident: any incident that involves, for example, a broken bone is classified as an accident. Other countries use tighter definitions. Equally, there are differences in the way air misses are defined and reported.

Efforts have begun to improve the ways in which these safety data are collected across countries. The 33 European Civil Aviation Conference states have followed the U.S. Federal Aviation Administration (FAA) in establishing a system called "Safety of Foreign Aircraft" to collect data on incidents with foreign aircraft. It is intended that the incident database will provide enough evidence to approach the responsible state authority on the operational and technical qualities of its carriers' operations. The practical problem is how to collect these data.[28]

Safety policy involves making tradeoffs. Accidents have a variety of immediate financial costs to aircraft loss and damage, and there are also quantifiable financial costs of preventive policies, though statistics on these are less easily obtained. The costs of lost life and injuries pose more of a challenge. There are techniques available to put monetary values on these derived from both revealed preference and stated preference methodologies that are used in benefit-cost analysis, but they are not free of criticism.

Environmental Issues

Aviation activities impinge on the environment. There is a longstanding concern about aircraft noise nuisance[29] and the local implications of accessing airports by land. Recently, however, the focus has changed to atmospheric pollution around airports and from flights themselves. The change in focus is linked to increased concerns over the emissions of greenhouse gases and the potential damage to the ozone layer, but also reflects the increased marginal utility that societies enjoying

[26] The process is not speeded up by the need in virtually all cases for the decision to be based on entirely new sets of studies. The evidence to date is that there seems to be little capacity to deploy value transfer procedures in this area (Johnson and Button 1997).

[27] Technically, this would seem to imply the need for Bayesian statistical analysis, but Guassian modeling still demonstrates the technical literature. There is some evidence, though, that safety considerations can affect the viability of air carriers (Button 1997).

[28] At present, the United States does not make extensive use of the standard recording devices on aircraft except when a major incident occurs, in contrast to many other countries (e.g., the United Kingdom). In 1998, FAA began seeking ways to make better use of this data to gain insights on situations where incidents have been averted and on the general way crews perform their duties so that a more proactive approach to safety may be developed. The main issues concern an unwillingness of labor to have incidents highlighted.

[29] Nelson (1979) offers some early analysis of these issues.

rising material living standards place on environmental conservation and the well-being of future generations.

Exact calculations are difficult, both because there are gaps in the scientific understanding that we have of the damage done by aircraft emissions and because data on the physical emissions themselves are limited. At the global level, British Airways (1994) estimated that commercial aviation produces some 500 metric tons of carbon dioxide emissions per year and thus contributes 1.25% to 1.5% of the greenhouse gas emissions.[30] The ozone layer may also be affected by nitrogen oxide emissions in the middle atmosphere, and at lower levels it may contribute at the margin to acid rain. Concern has also been expressed about the implications of ice crystals from engine exhausts in the stratosphere. Good data are required to monitor the use of aviation fuel by various types of aircraft in differing operating conditions to provide a more exact estimate of the environmental implications of air transport.

Large aircraft are noisy, and noise complaints are common around international airports. There are various methods of presenting the noise problem in a quantitative form using indices,[31] but in and of themselves are seldom useful for policy debates other than to show changes in the scale of the problem. For policy debates, efforts have been made to provide monetary valuations of the noise measure, based on either hedonic price methods or contingent valuation techniques (Feitelson et al. 1996). However, the consensus has not yet emerged as to a universally applicable figure.

WHAT DO WE KNOW?

There are a variety of statistics available on different aspects of international air transport. Many are simply repetitive and others derivative, but even allowing for this, there are a number of primary and secondary sources that can be used. The goal of this section is not to give a detailed breakdown and commentary on all sources of data relating to international air transport; even a summary description of U.S. air travel would be excessively lengthy. Rather, this highlights the main types of data sources.

Some of the more easily accessible published data series are detailed in the appendix at the end of this paper. In addition to published statistics, there are numerous academic and consultant studies that have collected primary data that may be useful for meta-analysis.[32] The competitive nature of the international air passenger and air cargo sectors, however, means that much of the consultants' material is often confined to the "grey literature."

For a large number of the national agencies, global international air transport statistics are a secondary concern, and most agencies tend to focus their attention on the markets served by their own carriers. International data sets from international organizations are selective and limited. They tend to reflect those areas of activity over which the agency has responsibility. Mainly because of resource constraints and a lack of legal authority, organizations such as ICAO and IATA usually and inevitably rely on airlines and national governments to feed data to them. These data come in at varying speeds, often making full sets of statistics dated by the time of publication. In addition, the data are reduced to the lowest common denominator for comparative analysis. Methods of collection can vary between countries, and data reliability is sometimes suspect.

Those directly responsible for providing air transport offer a range of data sources. The aircraft manufacturers provide technical details of fleets and, in some instances, develop particular data sets to address issues of interest to them. This is particularly true regarding the age of aircraft fleets, their geographical dispersion, the technical reliability of individual types of aircraft, and their safety records.

Airlines provide standardized financial accounts at a national level to meet auditing requirements, but since such requirements differ between countries, comparability is often lacking.[33] In many

[30] Over time, aircraft are becoming more fuel efficient, but this is more than offset by the increased amount of air traffic.
[31] Quinet (1990) offers some examples.
[32] Button et al. (1999) provides a general discussion of the usefulness of meta-analysis in examining microeconomic issues.
[33] There are differences in the type of ownership of carriers, and in the types of information they need to make available for auditing purposes. A state-owned carrier is generally subject to different legal accounting rules from an airline that is a publicly traded or a private company, even within the same country.

countries, in part because of domestic regulations, data relating to service characteristics such as delays are published. Further, the global agencies, such as ICAO, and regional bodies, such as the Association of European Airlines and the Cargo Airlines Association, provide readily accessible compilations of secondary data and also periodic specialized studies using data gathered from members.

Providers of air transport infrastructure are useful sources of network-related information. The air traffic control and navigation systems provide aircraft flow data,[34] while the airports collect and publish data on international passenger and cargo movements through them. The need for customs and immigration clearance at many airports provides supplementary sources of data. Periodically, social and economic impact studies are conducted at individual airports, often as part of a statutory assessment procedure related to expansion programs of one kind or another. Such case studies generate insights into a variety of key parameters that become the bases for subsequent value transfer exercises.

The academic literature provides a range of data sources, parameter estimates, and information useful in value transfer and comparative analysis exercise. While the more general transport journals such as the various *Transportation Research* series, *Transportation Research Record, Journal of Transport Economics and Policy, International Journal of Transport Economics, Transportation, Transport Policy,* and *Transportation Reviews* often carry international air transport-related material, other specialized academic journals such as the *Avmark Aviation Economist* and the *Journal of Air Transport Management,* supplemented by trade-based publications such as *Airline Business* and *Aviation Daily*, are more regular suppliers of data and statistical analysis of international air transport issues.[35]

[34] In some cases, this is collected mainly for long-term planning purposes, but some agencies, such as Eurocontrol, have a major revenue-collecting function, and data is collected for accounting purposes.

[35] One might also add to this list of academic journals the disciplined-based publications in areas such as economics, engineering, and physics that carry pertinent material for many forms of air transport study.

TABLE 2 A General Indication of the Adequacy of International Air Transport Data

	Type of data			
Need	**Physical**	**Economic**	**Social**	**Modeling**
Policy assessment	++	+	+	+
Forecasting demand	++	+*	–	+*
Infra-structure	+	+	+	+
Costing	+	+	–	++
Safety	+	–	–	–
Environment	–	…	…	–

*The weaknesses here concern data availability and modeling procedures suitable for medium-term forecasting.

Scale: The most adequacy is indicated by ++, while the least adequate data are shown with …

WHERE ARE THE GAPS AND WEAKNESSES?

No single set of statistics will ever meet everyone's needs. There will always be gaps in data and the collection of redundant series. Statistics collection involves inevitable compromise and prioritization. International air transport is a complicated sector that can make the collection and subsequent presentation of statistics difficult. While offering a summary of the strengths and weaknesses of what is available is inevitably going to be subjective, and not in small part influenced by personal interests and knowledge, table 2 provides a simplified, normative assessment of the situation. It offers an indication of where data are available to meet the main needs of users, and where there would seem to be important gaps or weaknesses. The aspects of data considered are what might be thought of as basic—physical data, economic data, and social data—but added to this is a "modeling" criterion reflecting the types of technical instruments that are available for each need.[36]

Policy Assessment

In addition to the international sources of data that exist, many countries collect and publish additional statistics for their own, essentially policymaking,

[36] There is no intent to imply that each type of data is of equal importance for all needs.

purposes. This has traditionally been true at the more macro level for negotiating bilateral air service agreement adjustments, and more recently when considering such matters as responding to the emergence of a new strategic airline alliance (Dresner and Windle 1996).

In some instances, however, there have been criticisms concerning the nature of this information and its usefulness. For example, the U.S. General Accounting Office (1995c) has in the past been critical of the amount of suitable economic data available for conducting international bilateral negotiations.[37]

The initial thrust of the Open Skies policy in 1979 and prior de facto initiatives in stimulating the introduction of more liberal bilateral agreements by the United States between 1976 and 1981 were estimated by Dresner and Tretheway (1992) to have generated as much as $325 million in savings in North Atlantic fares alone in 1981. More global analysis was limited by the lack of complete data from less developed countries. Even the routes that were included could only be assessed as either the full economy fare or the lowest minimum fare.

The problems are not that data do not exist but rather that what exists is of limited use in addressing the questions under review. Physical data on passenger flows and flights are available, but these are often only of partial use in addressing what are fundamentally economic questions. While intellectually, for example, there may exist an a priori case for freer trade in international air transport services, in practice, bilateral negotiations are concerned with the costs and benefits of adjusting existing regulatory structures and, as we see below, data here are often lacking.[38]

Much of the data is also too aggregate to address key issues. This point was recently made in a study of alliances: "Probably because of the difficulty in obtaining consistent route specific data and the difficulty of separating effects of alliances from other changes, we are aware of only four empirical studies which attempted to measure the effects of airline alliances on carriers and consumers" (Oum and Park 1997).

Forecasting

Forecasting of both supply and demand is important for the effective longer term management of the international air transport system, but the time horizons differ for the various actors. Most major airlines have their own divisions responsible for making use of published statistics and for collecting and analyzing additional commercial material. The advent of computer reservation systems (CSRs) following the creation of Sabre by American Airlines provides for rapid feedback and response on an individual, specific services level. This information is the key to the successful dynamic price discrimination that now characterizes much of the sector. For short-term forecasts, because of this built-in, interactive data-collection/application element, CRSs tend to be efficient.[39]

Longer term planning by airlines and others requires more aggregate levels of information. One source is their own internal market surveys and another the publicly available forecasts of aggregate trends and predictions of change by market segments. Bringing these and other data together at the airline level is, however, not easy, as exemplified by the volatile cycles the sector experiences and the often overreaction of the airlines.

The evidence from the past is that airlines are often rather poor at forecasting the longer term demands that they are likely to encounter. The dramatic swings in profitability of the sector is a man-

[37] The USGAO (1995b) has also argued that the U.S. policy response to code-sharing has been hindered by "… such [things] as a lack of detailed data on foreign carriers' code-share traffic traveling to and from the United States" and again, "Data problems handicap DOT's efforts to place a value upon the access rights to the U.S. market that it relinquishes to foreign governments in exchange for improved access or code-sharing. (See also USGAO 1995a.)

[38] In very strict terms, trade is about comparative advantage rather than competitive advantage in a single sector and in this sense the types of negotiations that treat trade in air transport separately from trade in all goods and services is somewhat illogical.

[39] The issues here are rather ones of how much information the owner of a CRS should be allowed to keep confidential and the extent to which airlines should be permitted to use their own systems in a competitive air transport market. Good information on revenues and prices is required for public policy and infrastructure policy formulation, but also important is that for competition to be effective, air carriers require that they be allowed to exploit any comparative advantage that they may enjoy.

ifestation of airlines' responses to uncertainty. Little work has been completed looking at just why airlines have been so poor at predicting relatively short-term shifts in their markets and in making decisions about aircraft purchases.

The long-term aggregate market forecasts that the airlines and infrastructure providers use are relatively good at pinpointing broad trends, but much less reliable at foreseeing the turning points in medium-term cycles. The evidence available indicates that one of the difficulties is less the inadequacy of the statistics available within aviation and more the difficulties of predicting determining variables, such as income levels. In the U.S. domestic market, for instance, Morrison and Winston (1995) found that the high levels of excess capacity that existed in the market in 1990 to 1993 were largely due to airlines finding it difficult to predict the future levels of key economic indicators, such as income.[40]

Costing and Productivity

Cost analysis can involve looking at the cost function of either air services suppliers or users. The technical analysis of costing and productivity analysis of supply has advanced a long way in recent years. There is now a plethora of models that can be applied to the costing problem and a range of econometric and programming software available to conduct the empirical estimation. Often the issue is less one of finding a suitable modeling framework than that of selecting the most appropriate from those available.

Problems still remain, however, regarding the data to feed into the models. Some of these were touched on earlier in the discussion of policy. In particular, the greater the commercialization of international air transport as economic regulations are lessened and airlines are increasingly privatized means that cost data are less readily available.[41] Where these data are released it is often done so in very broad categories.

More specific weaknesses have emerged in some recent studies and take a variety of forms. First, outside of the United States few countries have the information required for detailed cost analyses. For example, in his work on international airline productivity using a total factor productivity model, Windle (1991), while having data on U.S. carriers' fuel inputs, had to impute fuel use for non-U.S. carriers.

In other cases, even when some data are available, there is the lack of consistent time series statistics. One example of the problem of point data is seen in the simulation study of European air transport networks conducted by Berechman and de Wit (1996). With only 1992 data on the distribution of business and nonbusiness class passengers, a time series for 1986 to 1992 had to be imputed. The aggregate nature of information on yield and the fact that it was available only for U.S. carriers on North Atlantic routes caused Maillebiau and Hanson (1995) to rely on a partial database in their log-linear estimation that they speculated would produce an error-in-variables bias leading to underestimation of fare elasticities.

The theoretical debates concerning the desirability of competitive international markets are founded on a set of assumptions that imply, for instance, that costs are divisible, demand is relatively elastic, and that suppliers do not all have identical U-shaped cost curves. Violation of such conditions can lead to an empty core and inadequate supply (instability conditions). Button (1996) was forced to rely on variety of proxy variables when seeking to establish whether market stability conditions existed for international air transport within the European Union.

The issue of capital, while conceptually quite straightforward, is always difficult to deal with in applied analysis. Setting aside physical problems such as capacity measurements, there are inevitable difficulties in putting a monetary value on a capital stock and the opportunity costs of using it in its

[40] This is certainly not a problem peculiar to international air transport. In the 1960s, the U.K. statistical authorities attempted to use a logistic curve extrapolation of car ownership to predict future national income trends on the pragmatic basis that, whatever the intellectual problems involved, this could produce more accurate forecasts. This was also prior to Friedman's famous judgments about the criteria upon which to evaluate economic models.

[41] It was not unknown for "creative accounting" to be practiced when government intervention was more widespread.

current activity. Historic costing has now largely been abandoned in analytical work, though official data often include it. Replacement costing, while having an appeal in many sectors, poses particular problems in air transport where technical change is rapid. These general issues are compounded at the international level when different countries pursue different accounting conventions regarding such things as depreciation.[42]

From the perspective of costs to air transport users, there are considerable gaps in our knowledge. Yield management often makes it difficult to conduct analysis beyond that of simply trying to explain average yield and its effects on demand. Even if this were not so, a full analysis of user costs would embrace assessment of the "generalized costs" of using air transport. Such a cost function would entail, in particular, the monetary equivalent of the overall time costs involved. While travel time valuations are available (e.g., they are used by FAA), they seldom reflect such important features as the unreliability of time taken for a trip or differentials for various components of a trip (e.g., travel to the airport, waiting time at the airport, changing planes, and flight time). The evidence available is that different types of air traveler's seek different time attributes from air services,[43] and this needs to be reflected in an appropriate abstract mode model.[44] Related to this is the need to look at trips using a definition that includes travel time to and from airports as part of the overall cost of trip making. There are gaps in the way that user costs are modeled and in the data that are available for estimation.

[42] The concept of depreciation in an expanding network industry is a complex one in itself. While there is a case in engineering terms and with respect to maintenance costs in assuming that links in a network depreciate with time or use, if the network is expanding, the external benefits from being a part of that larger network mean that a link may gain in value. Its economic value is appreciating, and it becomes a negative cost item.

[43] Leisure travelers put a premium on low fares, but business travelers put service quality (including frequency, duration of overall trip, etc.) as their prime concern. For details of the underlying theory of the money value of time, see Sharp (1981).

[44] For an account of the theory of abstract modes, see Quandt and Baumol (1983).

Infrastructure

Airports are diverse, engaging in multifaceted operations, and obtaining comparable data is not easy (Doganis 1992). At the very least, it is difficult to separate the implications of international air transport movements from those of domestic traffic. ICAO (Annual b) is the only agency that collects comparable financial data on airports, but separation of data by various traffic types is not comprehensive. The number of countries participating is also small, and the data provided are limited.[45] Even at the national level, because airports are generally under the authority of local governments or state agencies,[46] data on key economic indicators are often lacking.

One of the practical problems with financial statistics is that airports provide a range of different services, but many of these (e.g., handling of baggage and freight, and aircraft maintenance) are treated as commercial activities separate from the airport itself. The difficulty is compounded because the degree to which these types of service are handled by individual airports differs widely. Airports themselves vary considerably in terms of government involvement and control, and with this come differences in the nature of data disclosed. Differing national accounting practices add to the problem of comparability. The latter is also a major problem when examining air traffic control systems.

There is also the practical problem of deciding what the financial data actually implies; the increasing trend toward privatization and corporatization in many countries means that profit trends may well reflect the degree of monopoly power rather than efficiency. Total factor productivity models (e.g., involving such techniques as nonparametric index number) are now available, offering more useful guidance to efficiency (Hooper and Hensher 1997).

[45] Within Europe, as early as 1984 the European Commission attempted to establish indicators that would provide a basis for inter-airport comparisons as well as international comparisons.

[46] A very small number of major international airports such as Heathrow in the United Kingdom are privately owned, and here conflicts arise regarding availability of data. Commercial considerations point toward a degree of confidentiality, but at the same time the monopoly power of airports such as Heathrow has led to regulation and with it the requirement of public accountability.

Furthermore, there are issues concerning air traffic control and navigation systems. Many systems throughout the world are outdated and considered technologically obsolete. Countries such as the United States are attempting to update their systems and to incorporate new ideas such "Free Flight" into the way air traffic is managed. Elsewhere, most notably the European Union, the effort is on standardizing what are presently a diverse collection of national systems. Overlapping this are new initiatives for stimulating greater efficiency in the management of systems, for example, the Canadian move to corporatizing their system and the United Kingdom's introduction of private financing. Efficient use of resources in this rapidly changing environment requires not only good physical data but also reliable models and carefully constructed financial data. The financial data are particularly important if economically based charging is to be more widely adopted, both from a strict accounting perspective and as insurance at the international level that there is no exploitation of systems.

Safety

Safety statistics at the aggregate level are extensive and available in long time series. There is a need for greater international consistency, especially regarding the developing nations and the former communist states of Europe, but even here the international agencies are making progress. Safety data are sparse; incidents are infrequent and, increasingly because of improved technology and regulatory controls, often unique. As a result, the emphasis tends to be increasingly on looking at conditions where a potential for a serious incident existed but was avoided. Data on air misses has a long pedigree, but at the international level there are problems in that definitions of air misses vary between countries, and reporting of incidents is not always consistent.[47] As noted above, there are also major national differences in the way that cockpit recorded data are collected and used, in part because of labor relations problems and because insensitive collection could lead to adverse feedback on cabin crew behavior. These microdata are important, however, since the cause of many accidents is not known (e.g., flying into terrain) or results of a series of actions may not be immediately clear from the currently available data.

Presentation and explanations of safety data pose serious problems. It is generally agreed by economists that from a cost-benefit point of view, air transport may be too safe, that is, resources devoted to airline safety would yield a higher social return in some other use. Media coverage of incidents is part of the explanation (accidents involve a spatial and temporal concentration of deaths and injuries that make for spectacular journalism),[48] as is a general lack of education on the nature of probabilities. How this problem could be resolved is uncertain, but public knowledge of transportation safety is, in general, inadequate.

Environment

Concern about the environmental damage associated with air transport, beyond issues of noise nuisance, is comparatively recent and growing (USGAO 1992). It is not surprising that there is still considerable uncertainty about the physical links involved, let alone the economic and social implications. The gaps in this area are, thus, considerable. Part of the problem lies in the need for more pure scientific analysis to ascertain how various pollutants associated with air transport adversely affect the environment. Before this issue is fully clarified, it is impossible to place viable monetary values on environmental effects.[49]

In many ways, broad criticisms of environmental data transcend any discussion of the air transport sector. Many of the issues are new, the impacts often long term, and the underlying relationships

[47] Domestically in the United States, there have been periodic changes in rules of reporting with, for example, immunity from liability being given when incidents were reported between 1968 and 1971 but removed after 1971. Rates of reported incidents were found to go down significantly after 1972 (McKenzie and Shughart 1988). There was a dramatic drop in the number of air misses recorded in the period immediately following President Reagan's dismissal of striking air traffic controllers in the early 1980s, possibly because the there were not enough controllers available to take reports.

[48] As a personal aside, I have often wondered what the situation would be if newspapers were legally forced to give the same number of column inches to a transport death irrespective of the mode involved.

[49] There are additional problems in that aviation fuel can be bought at various points on an aircraft's flight itinerary, and hence, the amount of fuel burned on any particular flight is difficult to ascertain.

not fully understood (Button 1993; Levinson et al. 1998). The issues often have more to do with a need for basic scientific research than with large-scale data collection. What is missing, however, is a systematic effort to bring together existing knowledge and to ensure that ongoing and future analyses present findings and data in ways that allow for viable synthesis. There are many ways in which quantitative information and empirical findings may be brought together, but for full efficiency common reporting procedures are generally required.[50]

CONCLUSIONS

Reliable statistics are important both for public policymaking in international air transport and for the commercial vitality of operators. The world in which air transport operates is, however, a rapidly changing one. There are major technological advances not only in aircraft but also in the information and control systems that control their use. Institutional adjustments mean that the role of government is now different from what it was 20 years ago, with market forces, privatization, and commercialism playing a much stronger part in the way the sector functions. This produces new challenges in terms of information requirements.

It is not only the airlines' component of the sector that is undergoing transformation. Airports are being privatized or are being required to operate in a more commercially oriented manner, and air traffic control is in some instances being put on a more accountable basis. Successful change requires reliable and germane data if ex ante policy decisions are to meet specified criteria and ex post operations are to be efficient. At the international level, greater transparency will inevitably be needed if liberalization is to continue and not be thwarted by concerns of market manipulations at the infrastructure level.

What is encouraging is that international air transport statistics are in many ways improving and becoming more consistent. The coming together of national groupings, such as the European Union, to develop consistent "internal" air transport policies has necessitated this in some cases. The major international agencies in air transport, such as IATA and ICAO, have new roles to play in this respect, as the traditional structure of the industry changes and as new markets, particularly in the Pacific rim area and in Eastern and Central Europe, grow, albeit at a rather stuttering pace. The emergence of more competitive markets and greater commercialism in the sector as a whole poses additional challenges but equally stimulate actors to participate more fully in internalizing their data needs.

[50] Button (1998) provides a critique of techniques for synthesis of data sets and empirical findings, and offers comment on the respective merits of traditional "literary reviews," meta-analysis, and subjective quantitative assessment methods.

ACKNOWLEDGMENTS

The author would like to acknowledge the considerable help rendered by two referees and by the editor in improving earlier drafts of this paper.

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APPENDIX

International air transport data are available from a number of national and international organizations and commercial undertakings. While not an exhaustive inventory of data sources, this listing represents most of the major sources of data and what they attempt to show.[51] They are divided by the national or international agency source. Much of the data summaries from U.S. sources are adapted from the *Directory of Transportation Data Sources, 1996,* produced by the Bureau of Transportation Statistics, U.S. Department of Transportation.

U.S. Department of Transportation, Bureau of Transportation Statistics

Name: *North American Transportation Statistics on Canadian, Mexican, and United States Transportation*
Frequency: Biennial
Summary: This source provides data on the size, scope, and use of the various transportation modes in the three nations. Most of the data pertain to land modes (rail, highway, etc.), but there are some aviation data.

Name: *Combined T-9 and Service Segment (Data Bank 27T)*
Frequency: Monthly
Summary: This databank shows point-to-point international traffic data between the United States and the originating/terminating nation. It does not show final passenger destinations; such data would be covered by domestic sources. This data set was replaced by Form 41 Schedule T-100 in 1990.

Name: *Schedule P-12(a) Fuel Consumption by Type of Service and Entity*
Frequency: Monthly
Summary: This source reports fuel consumption by aircraft operations by geographic area and service type (scheduled vs. nonscheduled).

Name: *T-100 International Segments (Data Bank 28IM and 28IS)*
Frequency: Monthly
Summary: All relevant data are collected relating to particular nonstop international flights for U.S. air carriers. Data are embargoed for three years before release.

Name: *Origin and Destination Survey (Data Bank 1A)*
Frequency: Quarterly
Summary: This database is derived from a 10% survey of air carriers. It provides a full itinerary of the air travel for all large U.S. certificated air carriers. The data sample all travel, so not all are international in nature.

Name: *American Travel Survey*
Frequency: 5 years
Summary: This survey provides limited long-distance international travel data.

U.S. Customs Service

Name: *U.S. Exports of Domestic and Foreign Merchandise (EM-545)*
Frequency: Monthly
Summary: This database shows the weight, quantity, nation of destination, and assessed valuation of merchandise leaving the United States.

Name: *U.S. General Imports and Imports for Consumption (IM-145)*
Frequency: Monthly
Summary: This source contains data on the net quantity, valuation, and nation of origin for imports.

[51] The author is indebted to Kirk Johnson for his assistance in compiling the list of data sources. What this list makes no attempt to cover are series that normally appear in a more general data series (e.g., in National Income Accounts, Labor Statistics, etc.). Data from these sources are often used in meso-level comparative analyis.

U.S. Department of Commerce, International Trade Administration

Name: *Canadian Travel to the United States*
Frequency: Annual
Summary: This sample details tourism from Canada to the United States (by individual state). Data include visitor nights, mode of transport, purpose, spending patterns, lodging, and seasonality.

Name: *Historical Arrivals Database*
Frequency: Annual
Summary: The data show annual arrivals from over 100 nations and regions.

Name: *In-Flight Survey of International Air Travelers; Overseas Visitors to the U.S.; U.S. Travelers to Overseas Countries*
Frequency: Annual
Summary: These data sets provide information on travel and spending patterns both to and from the United States. The data include places visited, demographics, means of booking, and duration stayed. The data summarize other sources.

Name: *International Air Passenger Database*
Frequency: Monthly (with both quarterly and annual summaries)
Summary: This data set shows international flight characteristics such as arrival/departure, class of aircraft, date of flight, flight number, and total number of U.S. nationals and foreigners.

Name: *Outlook for International Travel to and from the United States*
Frequency: Annual
Summary: This data set forecasts international travel to and from the United States, taking into account economic and political factors (e.g., recession, war, fluctuating currencies).

United Nations, International Civil Aviation Organization (ICAO)

Name: *Civil Aviation Statistics of the World*
Frequency: Annual
Summary: Provides summary data for a variety of air transportation sources, such as arrival/departure information, scheduled services, and the like.

Name: *The World of Civil Aviation*
Frequency: Annual
Summary: This publication provides an accounting of the major developments and trends in the international air transport arena over the past couple years and forecasts some of the potential trends in the short-term future on both a global and regional basis. It also discusses economic influences, policy issues, and the role of air carriers and airports in current and future industry trends.

Name: *Accident/Incident Reporting (ADREP)*
Frequency: Annual
Summary: This source reports annual statistics of accidents and incidents occurring within the ICAO reporting area.

Name: *Surveys of International Air Transport Fares and Rates*
Frequency: Annual
Summary: This source discusses the differences in international airfares. A separate publication exists to discuss regional differences in rates and costs.

Name: *Outlook for Air Transport to the Year 2005*
Frequency: Annual
Summary: This report forecasts broad trends in air transportation on a variety of topics into the middle of the next decade.

Name: *Digests of Statistics*
Frequency: Annual
Summary: This is a set of reports that discusses air travel demands, financial data for the industry, origin and destination statistics, and the like.

International Air Transportation Association (IATA)

Name: *North Atlantic Report*
Frequency: Annual
Summary: The database shows information on changes in traffic for individual airlines and the total route market.

Name: *Monthly International Statistics*
Frequency: Monthly
Summary: This shows traffic and capacity results from 85 major, scheduled airlines in the survey. The reporting delay is only about four weeks for these data.

Name: *World Air Transport Statistics*
Frequency: Annual
Summary: This annual report shows 10-year trends in traffic, capacity, finance, and fleet for IATA's member airlines, of which there are currently 85.

Name: *ASIA/PACIFIC Air Transport Forecast (1980–2010)*
Frequency: Annual
Summary: This publication forecasts travel demand between the Asian-Pacific and the rest of the world, assessing various traffic areas. It analyzes passenger traffic volumes and past growth, and discusses current hub activities and congestion.

Name: *European Air Transport Forecast (1980–2010)*
Frequency: Annual
Summary: This report forecasts air travel demand for European markets, much like the previous Asia-Pacific report, and includes statistics, albeit limited, on air travel in the former Soviet Union states.

Name: *North America Air Transport Forecast (1980–2010)*
Frequency: Annual
Summary: This publication forecasts air travel demand for the United States, Canada, and Mexico.

Name: *Passenger Forecast (1996–2000)*
Frequency: Annual
Summary: This report gives an aggregated view of the world's major airlines to forecast passenger demand for 66 countries. The report also disaggregates trends to 17 different world regions. Although not comprehensive, the statistics cover approximately 86% of the world's total international air traffic demand.

Australian Department of Transport

Name: *AVSTATS—International Scheduled Air Transport*
Frequency: Monthly and annually
Summary: This data set includes figures on revenue passenger, freight, and mail data, airline market shares, seat utilization, and the like for operations to and from Australia. The publication contains trend analysis from the previous year for comparison.

Airports Council International

Name: *Worldwide Airport Traffic Report*
Frequency: Annual
Summary: The data show passenger, freight, mail, and aircraft takeoffs/landings for major world airports.

European Union

Name: *New Cronos*
Frequency: Annual
Summary: Contains data on international passenger characteristics, origin/destination by country (especially within the E.U. member states) with aggregation for world regions (e.g., South America and the Indian Subcontinent). Also, arrival/departure data are available from major airports within E.U. member states.

Air Transport Association

Name: *ATA/Gallup Air Travel Survey*
Frequency: Annual
Summary: These data summarize a Gallup poll on American air travel for those 18 and older. It shows percentages of both domestic and international flights.

Name: *Passenger and Cargo Traffic History*
Frequency: Annual
Summary: This report shows aggregated figures on revenue passenger-miles and cargo capacity for U.S. carriers flying internationally.

Name: *Passenger Load Factor History*
Frequency: Annual
Summary: This source shows load percentages for U.S. carriers flying internationally.

Name: *Monthly Passenger Traffic Statistics*
Frequency: Monthly
Summary: These data include revenue passengers, load factors, enplanements, etc. for the international operations of U.S. carriers.

Name: *Monthly Cargo Traffic Statistics*
Frequency: Monthly
Summary: These data include international freight and mail delivery for U.S. carriers.

Reed Travel Group

Name: *Official Airlines Guide (OAG)*
Frequency: Monthly
Summary: The OAG is a set of publications that describe the flights available for all major airlines on both a domestic and international basis, including information on fares.