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A Comparison of Aviation Safety In Canada and the United States

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ABSTRACT

The United States broke from a long-standing airline regulatory tradition in 1978 with passage of the Airline Deregulation Act that removed, over a period of several years, almost all economic regulation. Although all safety regulation was left intact in the U.S., economic deregulation was accompanied from the beginning by concerns about potential safety degradation. Recently, less restrictive economic regulation has extended beyond the U.S. to several other countries including, in 1988, Canada. As in the U.S., relaxing economic regulation has heightened concerns about safety.

This paper examines variation in safety rates among segments of the Canadian aviation industry and compares the Canadian experience with similar segments of the U.S. industry. The comparison provides insight into air safety in both countries, points to areas for potential safety improvement, and provides a baseline for a future assessment of changes in Canadian air safety.

Two trends emerge from the analysis. The first is that in both the Canadian and U.S. industries, as one moves from general aviation to charter service to commuter service to scheduled jet service, the proportion of accidents caused by pilot error drops consistently. A second trend is that a consistently higher proportion of accidents in the Canadian industry are initiated by pilot error. The notable and significant exception is in the other commercial/general aviation sector where pilot error plays the same dominant role in Canada as in the U.S.

INTRODUCTION

During the last decade, the commercial airline industry has seen rapid fundamental change in its economic operating environment which has heightened concern about airline safety. In the industry's early years, passenger airline service was considered an infant industry requiring protection from competition in order to grow. As the industry developed, many countries regarded it as inherently monopolistic and needing economic regulation in the tradition of a public utility. Some countries still regard their national airlines as needing protection from competition from other airlines in international markets. Throughout the industry's development, an additional part of the rationale for restricting or regulating competition rested on safety arguments. The prevailing wisdom held that only large and profitable carriers operating in a stable environment could provide adequate safety. Unrestrained competition, it was feared, could lead to cost-cutting in maintenance and shortcuts in crew training that might unintentionally compromise safety.

The United States broke from this regulatory tradition in 1978 with passage of the Airline Deregulation Act that removed, over a period of several years, almost all economic regulation. Although all safety regulation was left intact in the U.S., economic deregulation was accompanied from the beginning by concerns about potential safety degradation. To date, deregulation has not been accompanied by an increase in the rates of airline accidents or passenger fatalities, but the issue continues to cause concern.

Recently, less restrictive economic regulation has extended beyond the U.S. to several other countries including, in 1988, Canada. As in the U.S., relaxing economic regulation has heightened concerns about safety. It is too soon to assess the impact of these economic regulatory changes on Canadian air safety. However, state of Canadian air safety prior to regulatory reforms can be examined and compared to that in the U.S. The United States provides a useful point of comparison for assessing aviation safety in Canada. Both countries offer similar flight environments in terms of airports and airways, equipment, and mix of flight lengths. Both the Canadian and U.S. airline industries contain a similar mix of carriers with widely differing characteristics ranging from large jet-equipped carriers operating the latest wide-body aircraft to charter operators using very small single-engine planes.

This paper examines variation in safety rates among segments of the Canadian aviation industry and compares the Canadian experience with similar segments of the U.S. industry. The comparison provides insight

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into air safety in both countries, points to areas for potential safety improvement, and provides a baseline for a future assessment of changes in Canadian air safety. By disaggregating the industries in both countries into subsets of similar operating characteristics, differences in safety performance associated with these operating characteristics can be both controlled and highlighted. The analysis begins by selecting appropriate segments of the U.S. and Canadian industries and comparing the safety performance in these segments. Then the distribution of accident causes in each segment of the Canadian and U.S. industries is analyzed and compared.

THE CANADIAN AIRLINE INDUSTRY

From the early days of Canadian aviation, Air Canada has been the premier Canadian airline. In a manner similar to treatment of U.S. trunk airlines under Civil Aeronautics Board regulation, any carrier wishing to compete with Air Canada had to establish "public convenience and necessity" in order to obtain a license. Air Canada's primacy slowly declined beginning with the start of trans-Canada air services by Canadian Pacific Airlines in the late 1950s and continuing in the mid-1960s with recognition of this company as a flag carrier. Also in the 1960s regional carriers were allowed to compete with Air Canada on selected routes in a manner that paralleled U.S. local service airlines gaining permission to compete on selected routes with trunk airlines. Despite such inroads, however, the ability of carriers to compete with Air Canada was strictly limited. "Regional" carriers were confined to specific sectors of the country and CP Air's transcontinental services were subject to capacity controls and other restrictions. The Canadian system consisted of four "tiers" of carriers: Air Canada with an overwhelming market share and many monopoly routes; CP Air with international services and a limited domestic network, and the Regionals, serving primarily the North with a few selective high density Southern routes, and below these carriers, small independent commuter operators.

Canadian air service has experienced a gradual liberalization since the mid-1960s as the Regionals were granted official status and CP Air was allowed to expand its domestic capacity and was recognized as a flag carrier in specific geographical areas. The Ministry of Transport became increasingly liberal on route awards and permitting competing carriers in some city-pairs. Restrictions on CP Air were sharply reduced in 1979. Finally, the National Transportation Act took effect in 1988 and removed entry controls on service in Southern Canada. As in the post-deregulation U.S., a "fit willing and able" test is applied for market entry and carriers meeting the test can enter new markets without long and complicated hearings subject to challenge by incumbents and prospective competitors.

Unlike the U.S. experience, Canada has not experienced an initial growth in the number of new jet carriers. While the number of operators has grown, most of the entrants are relatively small companies. Indeed, the number of large independent inter-city operators has fallen steeply through consolidation, as most regional carriers have been absorbed either into the Canadian Airlines International group along with CP Air, Pacific Western, and Wardair or into the Air Canada group.

This restructuring of the Canadian industry has shared many of the characteristics of the U.S. experience. In both nations, large jet carriers have developed comprehensive feed networks operated by affiliated commuter and regional carriers. These airlines, using smaller aircraft, provide traffic feed to and from communities too small to support large jet service. These smaller carriers are integrated with the jet carriers through code sharing, marketing agreements, and joint scheduling strategies. As in the U.S., computer reservations system development has also played an important role.

While there are the similarities, there are also important differences. The Canadian system has not developed as extensive hub and spoke systems as are now prevalent in the U.S. Canadian cities are arrayed in a more linear configuration so that no prospective hub can draw substantial traffic feed from all directions. Even along the major east-west axis of Canada, population densities are not uniform and the huge expanse of northern Ontario generates almost no traffic. So while there is some hub activity, it is on a much more modest scale. In the U.S., the commuter operators tend to be tied to specific hubs with routes radiating from the primary hub to complement those of the parent. In Canada, however, commuters operate some hub-and-spoke services but may also fly trunk routes in competition with their parents. These airlines also tend to schedule flights on secondary routes that overfly connecting hubs.

SELECTING COMPARABLE INDUSTRY SEGMENTS

Table 1 presents selected characteristics of those Canadian carriers used in the analysis. Level 1 carriers are most comparable to scheduled jet carriers operating under Part 121 in the U.S. The Level 1 carriers in this table and the next are Air Canada, Canadian, Easter Provincial, Nordair, Pacific Western, Quebecair, and Wardair. Within Level 1

TABLE 1

Characteristics of Canadian Carriers Used in the Comparison

1983 - 1988

	Level 1 Carriers	Level 2 Carriers	Level 3 Carriers
Average Passengers per Flight	63	13	10
Average Minutes per Flight	102	48	76
Total Enplanements (million)	148.1	15.6	1.9
Total Aircraft Departures (millions)	2.358	1.211	0.249
Total Flight Hours (millions)	3.966	0.9781	0.316
Carriers in 1983	7	8	2
Carriers in 1987	6	9	4
1987 Enplanements per Carrier	4,293,641	336,229	157,519

Source: Derived from data supplied by Statistics Canada

there is considerable variation. The largest Level 1 carrier, Air Canada, is roughly comparable in passenger volume to Northwest Airlines prior to its merger with Republic or to Southwest Airlines. The other Level 1 carriers are substantially smaller than Air Canada and correspond in passenger volume to small U.S. jet carriers such as Air California (prior to its merger) or New York Air or to the very largest U.S. commuter carriers such as Air Wisconsin which operates both small jets and larger turboprops under Part 121 regulations.

Level 2 carriers are most comparable to U.S. commuters ranked in size between about 10th and 30th. Level 2 carriers included in tables 1 and 2 are Air BC, Air Ontario, Austin, Bradley Air, Nationair, NorCan Air, Northwest Territories, Time Air, Trans-Provincial, and Worldways. Again, these carriers vary in size within Level 2, but most carriers fall within this range. A carrier with the average enplanements for Level 2 would rank among the largest 20 U.S. commuters.

A carrier the size of the average Level 3 carrier would rank about 30th among U.S. commuters. However, there is considerable variation within Level 3; two of the carriers for which data are available would rank near the top 20 U.S. carriers and two others would rank out of the top 50. Level 3 carriers examined are Air Atlantic, Air Nova, Soundair, and Voyageur.

In addition to Level 1, 2, and 3 carriers, there are other important segments of the Canadian industry. Canadian "specific point" service is most comparable to U.S. commuter service, particularly as offered by some of the smaller commuter carriers. Canadian charter and contract service is most comparable to U.S. Part 135 non-scheduled service. Other commercial services in Canada find their closest counterpart in some segments of general aviation (Part 91) in the U.S., particularly with U.S. fixed-base operators.

COMPARING SAFETY PERFORMANCE

Table 2 compares Canadian carriers with U.S. counterparts using three measures of safety performance: accidents (both fatal and

TABLE 2

**Comparing Canadian and U.S. Safety Performance
Canadian and U.S. Carriers**

	Level 1 Carriers	U.S. Jet Carriers	Level 2 Carriers	U.S. Top 20 Commuters	Level 3 Carriers	U.S. 21-50 Commuters	U.S.51+ Commuters
Accidents per 100,000 Departures	.74	.24	1.51	NA	3.62	NA	NA
Fatalities per 1,000,000 Enplanements	.16	.30	.48	.67	2.09	1.21	4.08
Serious Injuries per 1,000,000 Enplanements	.08	.03	.24	.21	0.0	.48	3.00

NA-Not Available

Source: Canadian figures derived from data provided by Canadian Air Safety Board and Statistics Canada and cover the period 1983 to 1988. U.S. Figures derived from data provided by Federal Aviation Administration and National Transportation Safety Board and cover the period 1979 to 1985.

non-fatal) per 100,000 aircraft departures, fatalities per 1,000,000 enplanements, and serious injuries per 1,000,000 enplanements. The first two columns of the table compare Canadian Level 1 carriers with U.S. jet carriers. The Canadian carriers appear worse using two of the measures and better using the third. Accidents are rare events in commercial aviation in both the U.S. and Canada and fatal accidents are even more rare. Between 1983 and 1988, only one fatal accident occurred among Canadian Level 1 carriers, an in-flight fire on an Air Canada DC-9 in which 23 people were killed. That accident, like many in aviation, could easily have killed everyone on board resulting in a much higher fatality rate or, conversely, had the fire started during a different portion of the flight, might have resulted in no fatalities.

In another incident that same year, an Air Canada B-767 ran out of fuel in western Canada, but, through pilot flying skill and considerable good fortune, was able to land with only minor damage and without any fatalities. That accident could have easily have produced many fatalities. The point of these examples is that fatality rates, as well as accident rates, can vary substantially from year to year because of the unique circumstances surrounding each accident. While recognizing persistent differences in safety performance is critical for improving air safety, care must be taken not to draw too strong a conclusion from small differences, particularly when the data are reflect relatively short periods of time.

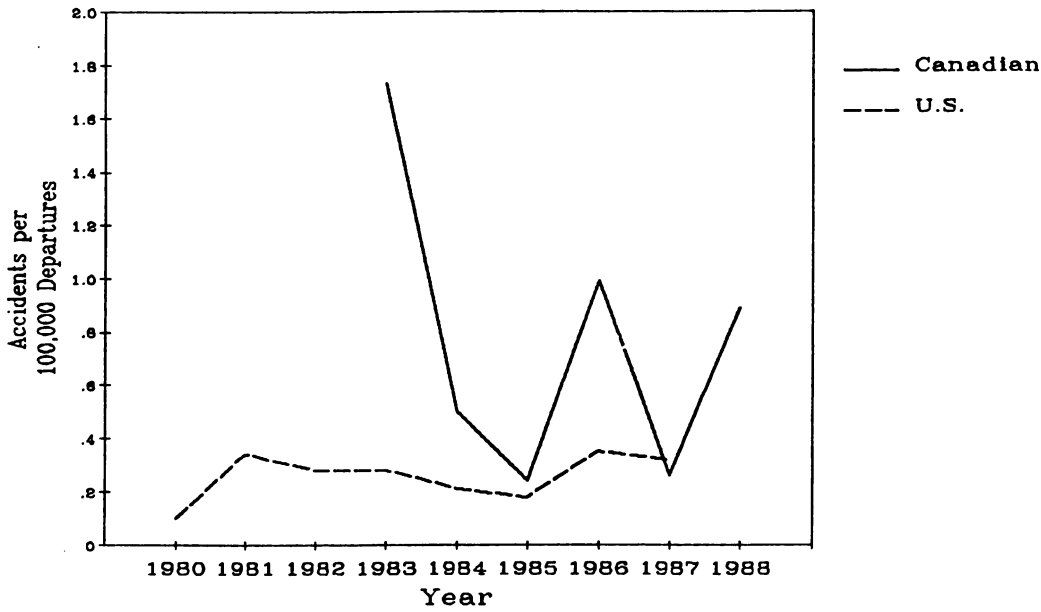
For the level 1 Canadian and U.S. jet carriers, the rate of accidents per 100,000 departures may be the most useful of the three measures. The number of fatalities or injuries in an accident can often be a matter of chance, including how many passengers boarded that particular flight. Thus, there can be considerable year-to-year variation in fatality and injury rates. The accident rate, however, shows considerably less variation and may well provide a better measure of safety, particularly when comparisons are made over short periods of time.

Focusing on accident rates, Canadian Level 1 safety performance appears appreciably worse than that of U.S. jet carriers. Not only is the average accident rate higher, but as Figure 1 shows, the rates in each year are consistently higher as well. The U.S. rate is based on far more departures and shows far less year-to-year variation. The Canadian rate shows more variation but is still higher than the U.S. rate for all but one of the years shown.

The second pair of columns in table 2 compare the safety performances of Canadian Level 2 carriers and the largest twenty U.S. commuter airlines. For U.S. commuters, reliable aircraft departure data are not available, so only fatality and injury rates can be calculated and compared. As can be seen in the table, the Canadian carriers have lower fatality rates while the U.S. carriers have slightly lower serious injury rates. The safety performances of these two segments appear quite close.

FIGURE 1

Canadian and U.S. Jet Carrier Accident Rates
1983 - 1988



The Level 2 fatality rate is three times the Level 1 rate and the U.S. large commuter rate is over twice the U.S. jet carrier rate. In the U.S., the move from commuter service to jet carrier service is accompanied by first, pilots with more experience who meet stricter licensing standards; second, aircraft with more sophistication, more redundancy, and better backup systems; and third, flights which operate into airports with longer runways and better landing aids. A similar pattern seems to prevail in the Canadian industry.

The final three columns of Table 2 compare the safety performance of the Canadian Level 3 carriers with that of medium size U.S. commuters, those ranked 21 through 50, and U.S. commuters smaller than the largest 50. As can be seen in these columns, both Canadian Level 3 carriers and small U.S. commuters are substantially less safe than larger carriers. The Canadian Level 3 performance is intermediate between the two U.S. commuter segments. This portion of the Canadian industry is made up both of carriers similar to medium U.S. commuters and of carriers similar to small U.S. commuters.

CAUSES OF AVIATION ACCIDENTS

Examining and comparing overall safety rates can help identify segments of the industry where safety performance is worse than elsewhere and help assess whether safety is improving or worsening over time. Overall rates, however, provide little understanding about why some segments operate more safely than others and provide little guidance about where to focus efforts to improve safety. Insight into the source of safety differences can be gained by classifying accidents according to their cause and comparing the distribution of causes across segments of the industry and between Canada and the U.S.

The assignment of cause is based on examining individual accident reports from the Canadian Air Safety Board (CASB) and from the National Transportation Safety Board (NTSB). The most difficult problem is how to assign cause for those many accidents with multiple contributing factors. There are three principal approaches. Consider the example where an aircraft engine fails during takeoff and the pilot then makes a mistake

and fails to take the proper action to land the plane safely. Both engine failure and pilot error caused the accident in the sense that had there been no engine failure or had the pilot responded properly, there would have been no accident. The approach used in this analysis is to select as the cause the factor which initiated the sequence of events that culminated in the accident, in this case the engine failure. An alternative approach would be to select as the cause the last point at which the accident could have been prevented, in this case the failure of the pilot to take the proper steps. Still another approach is to consider both as "the" cause.

How do these approaches differ? One clear difference from the example is that pilot error will show up as a cause much more often in the second two approaches, whereas equipment failure will show up more in the first approach. To be sure, there are many accidents initiated by equipment failure that a pilot should have been able to prevent through flying skills. The approach used in this analysis focuses on identifying what lead to these situations. By focusing on what started the accident, the pilot errors identified in this approach can be thought of as "unforced" pilot error. Alternatively, focusing on the last point at which the accident could have been prevented mixes unforced pilot errors for some accidents with errors of failure to respond properly to equipment malfunction or other emergencies. The third alternative of counting all causes makes interpretation of the distribution of causes difficult since some accidents contribute more causes to the distribution than others and, indeed, some accidents may contribute multiple types of pilot error.

The analyses of the distribution of causes in Canadian accidents reported below are based on an examination of 792 individual domestic commercial service accidents of fixed wing aircraft between 1983 and 1988. For some of the accidents in 1988 and a few in 1987, the cause could not be assigned because the CASB had not finished its investigation of the accident. The analysis of the distribution of causes in U.S. accidents is based on a total of 10,517 domestic accidents – 1,271 in domestic Part 121 and Part 135 service occurring between 1979 and 1987 and 9,246 in general aviation between 1983 and 1986. Each accident was placed into one of nine major cause categories:

Equipment Failure
Seatbelt Not Fastened
Environment
Pilot Error
Air Traffic Control
Ground Crew Error
Other Aircraft
Company Procedures
Other

Equipment Failure

If the events that initiated the accident were precipitated by mechanical or electrical malfunction in the aircraft, the accident was considered as equipment failure even if there were other subsequent important factors. In some cases, such as improper installation of a part or failure of an inspection to detect cracks or corrosion, more meticulous maintenance might have prevented the accident. In other cases, such as premature failure of a component that did not show excessive wear, maintenance practices could not reasonably be blamed. It is often difficult to tell from the accident investigation and report whether inadequate maintenance was at fault so no attempt was made to draw this distinction. An example of an equipment failure accident occurred on March 22, 1984 when a Boeing 737-200 operated by Pacific Western Airlines suffered an engine failure and subsequent fire during the takeoff roll in Calgary. Fortunately, no one was killed, but one passenger sustained serious injuries and 25 passengers received minor injuries.

Seatbelt Not Fastened

In U.S. jet service, a surprisingly common source of passenger injury, but fortunately not death, is encountering turbulence when passengers do not have their seatbelts fastened despite an illuminated seatbelt sign in the cabin and passengers having been requested to fasten their seatbelts by the cockpit and cabin crew. Such injuries include broken ankles, broken legs (in one case both legs), head, and neck injuries. During the period investigated, there were no such incidents in Canadian service nor were there many such incidents in U.S. commuter service, air taxi service, or general aviation.

Environment

Environment refers to adverse weather conditions and also includes collisions with animals. Weather conditions include accidents resulting from wind shear, thunderstorm-related turbulence, emergency landings due to weather conditions, and severe winds encountered during takeoff, landing, or while on the ground. A pilot who received an incorrect weather briefing resulting in flight into hazardous weather conditions is also included in this category. However, if a pilot attempted a takeoff under weather conditions that led to a takeoff accident, the accident was considered pilot error. If an aircraft was unable to stop after landing on a slick paved or gravel runway, it was considered a weather accident, unless the pilot landed excessively

long or fast on the runway or the runway selected was too short for the performance characteristics of the aircraft, in which case it was considered pilot error. For accidents involving ski-equipped aircraft landing on snow or ice, the accident was considered weather if the pilot made reasonable precautions to insure the surface was suitable for operation. If a pilot attempted to land in poor weather when the airport was below minimums and an alternate airport was available, it was considered pilot error. The distinction between weather and pilot error involved subjectivity on occasion, but considerable effort was made to achieve consistency. An example of an accident classified as weather occurred on December 10, 1986 at Bagotville Airport in Quebec when a Cessna 421 in charter service encountered icing while on approach resulting in a stall and hard landing and a landing gear collapse. One passenger received minor injuries.

Animal strikes includes any collision with animals either in flight or on the ground as well as accidents due to evasive maneuvers while trying to avoid such collisions. On July 20, 1986 a Quebecair Boeing 737-200 ingested a bird in the left engine on takeoff resulting in a rejected takeoff and the aircraft running off the end of the runway. In the U.S., accidents from bird strikes are quite rare, while accidents from striking deer on the runway are more common, especially in general aviation.

Pilot Error

An accident was classified as pilot error in those cases where the error appeared undeniable and initiated the sequence of events leading to the accident. Examples include when a pilot attempted a landing without lowering the landing gear or taxied into a stationary object or ran out of fuel because of failure to refuel or to switch fuel tanks during flight. Pilot error could involve deficient flying skills such as stalling the aircraft on takeoff or landing. It could also involve errors in judgment such as taking off into adverse weather, continuing a Visual Flight Rules (VFR) flight into Instrument Flight Rules (IFR) conditions by a pilot not qualified for IFR, or flying into a canyon too small in which to turn around. Flying while impaired by alcohol or drugs is also considered pilot error, but this type of accident appears extremely rare in commercial service in both the U.S. and Canada.

Air Traffic Control

An accident was classified as air traffic control when normal action by a controller could have prevented the accident such as ATC failing maintain adequate separation in flight between a small aircraft and a large jet to avoid wake turbulence.

Ground Crew Error

Accidents attributed to ground crew error included such cases as a service truck colliding with a parked aircraft and a ground crew member walking into a spinning propeller while delivering a message to the pilot of an aircraft about to depart. Aircraft misfueling is another form of ground crew error.

Other Aircraft

Other aircraft includes collisions between two aircraft either in the air or on the ground.

Company Operations

Accidents classified as due to company operations are where the policies or procedures of the company operating the aircraft lead to an accident. This cause was not found in Canadian operations during the years examined but has been found on rare occasion in the U.S.

Other

No classification scheme can account for the entire array of circumstances leading to injury or equipment damage in aviation. Accidents not falling into one of the above categories are classified as other and include such causes as medical impairment from heart attacks, aircraft accidents during illegal drug transport, accidents by unlicensed pilots, and accidents where the cause is ambiguous or the aircraft was not recovered, or the accident investigation was not yet complete.

Table 3 provides a comparison of the distribution of accident causes for four segments of the Canadian commercial aviation industry with their counterparts in the U.S. The first two columns (on the left) show the distribution of accident causes for Canadian scheduled commercial service (Levels 1, 2, and

Comparison of the Distribution of Accident Causes

Canadian and U.S. Service

Table 3

	Canadian Sched. Comm. Service	U.S. Sched. Part 121 Service	Canadian Specific Point Service	U.S. Sched. Part 135 Service	Canadian Charter Service	U.S. Charter Service	Other Canadian Comm. Service	U.S. General Aviation	Alaska General Aviation
Equipment	12.5%	20.4%	37.0%	30.6%	23.3%	30.3%	17.1%	18.5%	9.5%
Seatbelt	0.0%	24.8%	0.0%	0.6%	0.0%	0.1%	0.0%	0.0%	0.0%
Environment	37.5%	15.9%	22.2%	19.4%	13.7%	18.5%	6.8%	8.1%	14.2%
Pilot Error	25.0%	10.6%	40.7%	20.6%	54.6%	39.3%	69.6%	64.2%	66.2%
ATC	0.0%	6.2%	0.0%	0.6%	0.0%	0.8%	0.2%	0.2%	0.5%
Ground Crew	12.5%	5.3%	0.0%	8.1%	1.6%	1.5%	0.0%	0.4%	0.0%
Other Aircraft	0.0%	2.7%	0.0%	3.8%	0.6%	1.6%	2.5%	2.5%	2.4%
Company	0.0%	0.9%	0.0%	0.6%	0.0%	0.7%	0.0%	0.0%	0.0%
Other	12.5%	13.3%	0.0%	5.6%	6.1%	7.2%	3.8%	6.0%	7.1%
	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Number of Accidents	8	113	27	160	313	998	444	8627	619

Note: For accidents with multiple causes, the cause assigned to the accident is the one which initiated the sequence of events that culminated in the accident.

Source: Data were provided by the Canadian Air Safety Board and the National Transportation Safety Board. The Canadian figures are based on the period 1983 through 1988. The U.S. Part 121 and Part 135 figures are based on the period 1979 through 1987. The U.S. General Aviation figures are based on the period 1983 through 1986.

3) and U.S. scheduled Part 121 service. The service provided in these two segments is similar, with perhaps a slightly greater portion of the Canadian scheduled commercial service provided in smaller turboprop aircraft. The U.S. scheduled Part 121 service also contains some service by turboprops operated by predominantly jet carriers as well as some provided by large commuters operating under Part 121. As can be seen in this table, equipment failure, environment, and pilot error are the most common cause of accidents.

There appear to be differences between the two distributions, but the Canadian distribution is based on only eight accidents, so care must be taken not to draw a premature conclusion. The largest apparent differences are that equipment failures and seatbelt not fastened are proportionately more important in the U.S. whereas environment and pilot error are proportionately more important in Canadian operations.

The share of accidents by cause in these two columns can be combined with the accident rates reported in Table 2 to calculate a set of accident rates by cause. Table 4 contains these accident rates for four major categories: Equipment, Environment, Pilot Error, and All Other. As can be seen, the equipment and all other rates are similar for Canada and the U.S., but the environment and pilot error rates appear markedly higher in Canada and explain virtually all of the difference in accident rates between the two countries.

Returning to Table 3, the next two columns compare Canadian specific point service with U.S. scheduled Part 135 service. The distributions in these segments are based on more accidents than the previous segments, reflecting both a large number of operations and somewhat poorer safety records. The service is somewhat different between Canadian specific point and U.S. commuters in that U.S. commuters may face greater schedule pressures. The mix of equipment and the flight environment is similar in the two segments. Carriers providing Canadian specific point service appear to use a somewhat higher proportion of piston-powered aircraft than their U.S. counterparts, but as the table indicates, the proportion of equipment failure is virtually identical. The principal difference is the higher proportion of pilot error in the Canadian segment than in the U.S. segment, a difference also seen the first two columns. If all scheduled domestic commercial service is considered together, by combining the two segments in both countries, the higher proportion of pilot error in the Canadian segments is statistically significant at the 99 percent level.

The next two columns in the table compare Canadian charter commercial service with U.S. charter service. These columns are based on even more accidents than the previous columns. Here also, the segments being compared are very similar. U.S. charter service includes some charters operated under Part 121 with jet equipment, but Part 121 charters account for only about 5 percent of U.S. charter accidents and their distribution of causes is similar to the Part 135 charter distribution. In these segments as in the previous ones, the most noticeable difference is a higher proportion of pilot error accidents in the Canadian segment than in the U.S. segment. Here again, the difference is significant at the 99 percent level.

The final three columns compare the distribution of accident causes for other Canadian commercial service with U.S. general aviation excluding Alaska and U.S. general aviation operations in Alaska. These distributions are based on the largest number of accidents of any of the tables and are very similar. Unlike the three segments of the aviation industry discussed above, here the proportion of pilot error is essentially the same in Canada and the U.S. including Alaska.

A RECURRING PATTERN

Figure 2 summarizes the proportion of pilot error in aviation accidents for Canadian and U.S. carriers in each of the four segments. One clear trend emerges in the figure – a consistently higher proportion of accidents in the Canadian industry are initiated by pilot error. The notable and significant exception is in the other commercial/general aviation sector where pilot error plays the same dominant role in Canada as in the U.S.

Consider the U.S. experience. Here, the drop in the proportion (and rate) of pilot error accidents as one moves from general aviation to charter to commuter to jet carrier mirrors the career progressions of many pilots, starting in general aviation where initial flight instruction and licensing takes place, and with more training and experience a commercial license is obtained, then moving to charter service, then to commuter service where an Air Transport Pilot (ATP) license is obtained, and finally to jet service. In addition to higher levels of experience, there is also a filtering process as a pilot moves from level to level with the better pilots selected by the carriers to move on to the next level. An alternate career path in the U.S. is to receive initial flight training and extensive experience in military service and move directly to scheduled commuters or jet service. The increase in training, experience, filtering out poor pilots, and increasingly strict licensing requirements of civilian-trained pilots coupled with the extensive flight experience of military trained pilots

TABLE 4

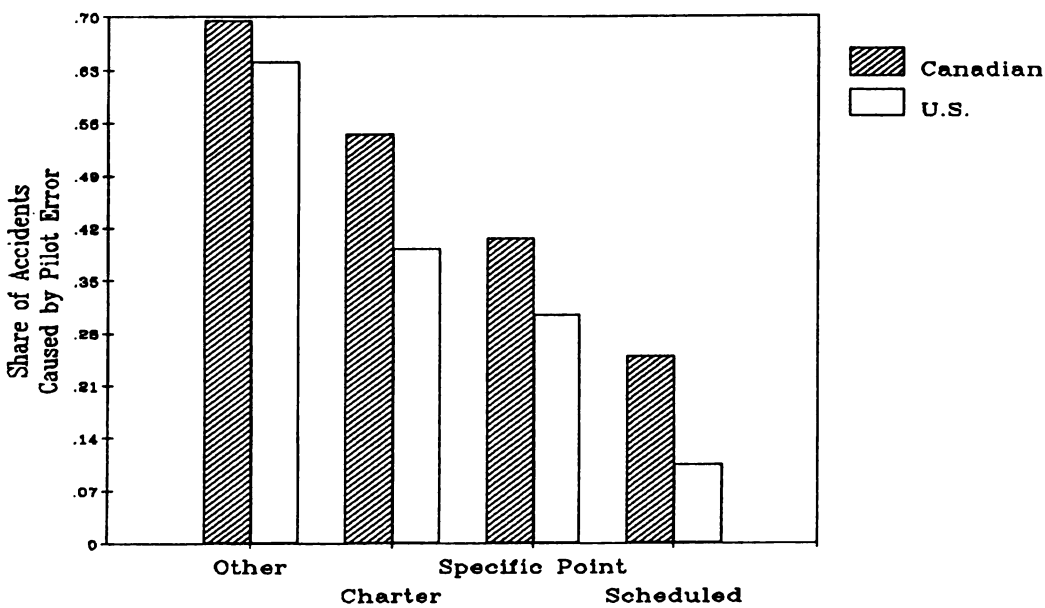
**Comparison of Accident Rates by Cause
Canadian Level 1 Carriers
and
U.S. Scheduled Jet Carriers
(Accidents per 100,000 Departures)**

	Canadian	U.S.
Equipment	0.09	0.05
Environment	0.28	0.04
Pilot Error	0.185	0.03
Other	0.185	0.12
Total	0.74	0.24

Source: Derived from data contained in Tables 2 and 3.

FIGURE 2

The Role of Pilot Error In Aviation Accidents



Derived from CASB and NTSB data.

who move quickly into jet service appears to produce a steadily declining proportion of pilot error as a cause of accidents.

As the figure illustrates, there is a similar drop in the proportion of pilot error in Canadian service, but the differences between successive segments are less and the levels of pilot error remain consistently higher than the U.S. for all but the entry level segment. This consistent pattern of difference raises a series of questions warranting further research.

Part of the difference may be that Canadian pilots face more difficult flying challenges than their U.S. counterparts. A greater proportion of Canadian commercial operations appear to be conducted on ski-equipped or float-equipped aircraft or to airports without paved runways than in the U.S. These operations may be more difficult with a resulting increase in pilot error accidents. However, even if this is the case, such effects should be confined largely to the charter segments of the industry and they don't explain the differences in the share of pilot error in scheduled or perhaps even specific point service.

Another hypothesis is that military-trained pilots may make up a smaller portion of the pilot force in Canada than in the U.S. and that the military training process with its accompanying filtering produces better pilots than the civilian training process. This hypothesis, however would seem to have little bearing outside the scheduled jet service segment. If true, this hypothesis has disturbing implications for Canadian and U.S. airline service alike. In the U.S. the clear trend is that civilian-trained pilots are making up a growing proportion of beginning jet carrier pilots. Does this suggest that an increase in pilot error accidents can be expected in the future? If so, does it also suggest that civilian pilot training procedures will have to be improved in both the U.S. and Canada?

Another hypothesis is that operating procedures and regulations might be different in Canada than in the U.S. Perhaps, Canadian practices allow pilots to operate with less of a margin of safety than U.S. practice. Under such circumstances, a pilot in the U.S. might have a better opportunity to recover from a small mistake without it resulting in an accident. Similarly, while the mix of aircraft types are similar in comparable industry segments of the two countries, there may be systematic differences in the way in which the aircraft are equipped that put greater demands on Canadian pilots than their U.S. counterparts.

Another hypothesis is that pilot progression from one segment of the industry to the next is quicker or has less filtering in Canada than in the U.S. This hypothesis also has disturbing implications for both the U.S. and Canada. Concern has been raised in the U.S. that the recent heavy demand for jet carrier pilots has resulted in pilots being pulled from commuters to jet carriers more rapidly and with less experience than previously. In turn, commuters are forced to pull pilots from Part 135 charter carriers with less experience than previously. Table 5 lends support to this concern. The table compares the proportion of pilot error for the 1979 to 1985 period with than in 1986 and 1987. As the table indicates, the proportion of pilot error is higher in the later period in all three segments of the U.S. industry. Indeed, in 1986 and 1987, the gap between pilot error share in scheduled and charter Part 135 operations had narrowed considerably.

None of these hypotheses or other possible explanations have yet been examined in detail. More work is clearly needed to explore why the proportion and rate of pilot error accidents has been higher throughout most of the Canadian aviation industry than found in comparable segments in the U.S. Similarly, more work is needed to determine why the proportion of pilot error seems to be rising throughout the U.S. industry.

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ENDNOTE

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TABLE 5

**Proportion of U.S. Accidents from Pilot Error
1979-85 versus 1986-87**

	1979-85	1986-87
Part 121 Scheduled Domestic	9.3%	13.2%
Part 135 Scheduled Domestic	28.0%	42.9%
Part 135 Charter Domestic	36.1%	45.9%

Source: Data were provided by the National Transportation Safety Board.