LEARNING BY (NOT) DYING ON THE 8,000M PEAKS IN THE HIMALAYA AND KARAKORAM

Learning by doing is regarded as a fundamental driver of economic growth in the endogenous growth literature. Yet studies of learning by doing have examined industries for very brief periods only, and they generally use aggregate data to infer learning that may be occurring at a micro level. This study examines the history of an "industry"—Himalayan mountaineering on the peaks over 8,000m in height—over an entire century. As we are able to identify individuals taking part in climbing expeditions, we can test whether learning by doing takes place at the individual, "firm", or industry level. We find evidence that observed increases in successful ascent rates and concomitant decreases in death, frostbite and altitude sickness rates are in part due to learning by doing at the industry level, as an increase in the cumulative experience of prior expeditions reduces the chances that a later expedition will suffer an adverse outcome, and in part due to increases in the human capital of the climbers, as an increase in climbers' prior experience increases the probability of an expedition ascent.

1. INTRODUCTION

In 1895 the British climber Albert Mummery, perhaps the finest mountaineer of his time, and five others made the first serious attempt to climb a mountain exceeding 8,000 meters in height. The mountain they chose to climb was Nanga Parbat (8,126m), in present-day Pakistan. It is one of only fourteen mountains in the world whose peaks rise above 8,000m, all of which lie in the Himalaya or Karakoram mountains of India, Nepal, Pakistan, and Tibet. Mummery failed to reach the summit of Nanga Parbat and, unfortunately, died in the course of his attempt. More than thirty unsuccessful expeditions to various 8,000m peaks followed, resulting in over fifty deaths, before a French team led by Maurice Herzog reached the summit of the Nepali peak Annapurna (8,091m) in 1950. Herzog and summit partner Louis Lachenal suffered severe frostbite—Herzog would lose all of his fingers and toes—and survived only because their teammates and Sherpas[1] successfully evacuated them from the mountain.

By the 1990s, however, over a hundred expeditions *per year* would attempt to climb these mountains. Over half of these expeditions would place at least one team member on the summit, while less than one in seven expeditions would suffer a death or a case of frostbite or altitude sickness. Indeed, even novices

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[1] The Sherpas are Nepalese of Tibetan descent living in the Khumbu valley near Mt. Everest. They are often hired by mountaineering expeditions to be high-altitude porters, carrying loads and sometimes taking a more active role in the climb. Other cultural groups that have a history of serving as high-altitude porters include the Balti and Hunzi, regional groups in Pakistan. In what follows, we refer to people working in these roles as "Sherpas," but the cultural heritage of the people doing these tasks may be quite diverse.

willing to pay enough money to hire professional guides would climb the 8,000m peaks. Along with their Sherpas, these professional guides would supply camps, fix ropes, and carry extra oxygen bottles for the client. The trends in the number of expeditions, ascents, deaths, and frostbite and altitude sickness cases per year, shown in Figure 1 for the period since the Second World War, are unmistakable. Figure 2 shows that these trends are also apparent in the percentage of expeditions that make an ascent or suffer death, frostbite, or altitude sickness. Why have the rates of ascent, death, frostbite, and altitude sickness improved so dramatically? Is it due to better technology, learning by doing, human capital, or better organizational design? Or is it simply luck? The answers to these questions are important not just because of what they say about why mountaineering expeditions have become more successful but because these questions are fundamental to understanding economic growth. In particular, Lucas (1988, 1993) argues that learning by doing can explain differences in economic growth rates among countries. Reviewing Rapping's (1965) Liberty Ships data, which found learning effects on the order of a 10 to 30 percent reduction in manhours per ship for each doubling of prior output, Lucas concludes,

> "There is also considerable ambiguity about what this evidence means. Is it the individual worker who is doing the learning? The managers? The organization as a whole? Are the skills being learned specific to the production process on which the learning takes place, or more general? Does learning accrue solely to the individual worker, manager, or organization that does the producing, or is some of it readily appropriable by outside observers?" (1993, p. 262).

This paper uses data from all known expeditions to peaks over 8,000m in the period 1895-1994, plus all expeditions to Mt. Everest (also known as Chomolungma in Tibet and Sagarmatha in Nepal, 8,848m) for the period 1995-98, to examine the variation in the rates of these four outcomes. We find evidence of learning by doing spillovers, in that an increase in the number of prior expeditions by all countries to the 8,000m peaks reduces the rates of death and frostbite in current expeditions. We also find evidence of learning by doing spillovers within countries, in that an increase in the number of prior expeditions by the particular nations represented on the current expedition reduces the incidence of altitude sickness. Thus, at least some knowledge is appropriable by outside observers. However, an increase in the cumulative prior expeditions does not change the probability of an ascent. Rather, we find strong evidence that the increase in the rate of successful ascents is due in part to increases in the human capital of the climbers on the expedition, as gained through their own experience in climbing the 8,000m peaks. Thus, at least some knowledge is appropriable by those doing the learning.

Other technological improvements also explain part of the improvement in mountaineering outcomes. We find that advances in clothing and climbing gear have played a role in reducing deaths and increasing the ascent rate. However, the most interesting effects are with the use of bottled oxygen. While we find that bottled oxygen use decreases the occurrence of frostbite, we also find that it increases the chances of an expedition death and, in our basic probit analysis, reduces the odds of an ascent. These counterintuitive results could indicate a "lulling effect" due to a complacent reliance on technology (e.g., Viscusi 1984, Peltzman 1975). However, we also find evidence of a selection bias in the use of bottled oxygen (e.g., Heckman 1976): less skilled climbers are more likely to use bottled oxygen. After correcting for this bias, we find that bottled oxygen use has a weakly positive effect on ascent rates. Nevertheless, those who use bottled oxygen still have higher death rates, due perhaps to complacency or to an increase in the exposure to risk because of the greater logistical demands that bottled oxygen places on an expedition.

In addition, as climbing in the Himalayas has grown more popular, there have been two developments which have caused concern among climbers. One commonly vilified aspect of modern Himalayan climbing is the increase in the number of guided expeditions, which, it has been argued (e.g., Krakauer 1997), are made up of inexperienced climbers that are unprepared for the true risks of high-altitude climbing. However, we find that the average experience level of climbers on guided expeditions is actually higher, not lower, than that of other expeditions. Moreover, guided expeditions are more likely to achieve an ascent, and they do not display higher odds of death, frostbite, or altitude sickness. Secondly, the large number of parties on some routes is thought to have been a contributing cause of several high-profile accidents, such as the one that took place on Everest in 1996. However, we find evidence that such congestion has increased ascent rates and has not increased death, frostbite, or altitude sickness rates.

Finally, our research suggests that publicly funded expeditions may have fared well relative to privately funded expeditions, a result that is in contrast to the history of arctic exploration as reported by Karpoff (2001). Large "national" expeditions, which consist of climbers from a single country and, we argue, may be indicative of public funding, are more likely to be successful in making an ascent. Unlike Karpoff, we find no widespread evidence that these expeditions are likely to suffer adverse outcomes beyond higher frostbite rates.

The next section of the paper reviews the pertinent literature and discusses the hypotheses tested in this paper. Section 3 describes some of the general trends in Himalayan mountaineering from 1895 to 1998. Section 4 describes the data and performs univariate tests of some hypotheses, and Section 5 discusses the results of the econometric investigation. Section 6 concludes.

2. PREVIOUS LITERATURE AND STRUCTURE OF THE PRESENT STUDY

This paper ties into two strands of previous literature. The first is concerned with the potential existence of learning that may improve the performance of an activity or the likelihood of the achievement of an objective; the second uses historical information on expeditions to examine possible reasons that particular achievements occurred or poor outcomes were avoided on those expeditions.

The performance objectives we focus on that may reveal the existence of learning are the accomplishment of an ascent and avoidance of the deaths, frostbite, and altitude sickness that may be suffered in the pursuit of an ascent. In the literature, learning to improve performance has been shown to occur through "learning by doing" by individuals,[2] through "internal spillovers" of learning among individuals within a firm or across units of an organization,[3] and through "external spillovers" of learning from one firm to another within an industry.[4] In the present study, we can think of professional and

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[2] The existence of learning by doing by individuals has a long history in the literature. Yelle (1979) provides a review of literature concerning the learning curve, which was developed as a model of the phenomenon that experience in the performance of a task tends to reduce the labor hours required to do the task. Argote (1993) reviews evidence on whether an organizational learning curve merely reflects the aggregate learning of the individuals in the organization.

[3] "Organizational learning" within a firm is said to take place not just because individuals become better at their tasks but because technological development and improvements in the coordination of the production process also occur (Argote and Epple, 1990). Sources of learning within a firm may include (Epple *et al*. 1991) improvements in worker skills and knowledge as well as non-worker-specific sources such as the standardization of procedures; improvements in scheduling, the flow of materials, equipment, and coordination; and the specialization of labor. Organizational learning has been documented in a number of studies. Knowledge transfers within the organization were found by Epple et al. (1996) in a transfer from a single shift of a manufacturing plant to a second shift, by Darr et al. (1995) between pizza stores owned by the same franchisee (and less so between stores owned by different franchises operating within the same company), by Joskow and Rose (1985) within architect-engineering firms and utilities building coal-burning power plants, by Zimmerman (1982) within firms building nuclear power plants, and by Irwin and Klenow (1994) between shipyards owned by the same firm.

[4] Argote and Epple (1990) suggest that transfer of knowledge across firms can occur by, for example, the movement of personnel, communication, participation in meetings and conferences, training, improved supplies, and modifications in technology. Thornton and Thompson (2001) found evidence of spillovers of knowledge across shipyards that were not owned by

amateur climbers as forming a climbing "industry" that began well over a century ago and includes climbers from many countries.[5] A reasonable analogue to a "firm" in this industry is a national mountaineering club, examples of which exist in all major countries and which are the basis for the formation of many expedition teams.

Mountaineering expeditions can perhaps best be thought of as projects. A climbing expedition is formed for a single purpose: to climb a particular route in a particular style. The expedition has a project team structure: typically there is a leader who is ultimately responsible for climbing decisions, climbers, and paid porters, including both unskilled porters such as those who transport expedition gear to the base of the mountain and skilled porters like the Sherpas who climb with the (unpaid)[6] climbers. In other industries, individuals within a firm may form a team to work together on a new product introduction, a consulting job, or a creative endeavor such as a film. However, once the project is completed, they will move on to new projects, perhaps forming teams with workers from other units or freelancers. Similarly, expedition parties typically form within countries or clubs but fill in members outside the club and from other countries as needed and as opportunity arises.[7] Few mountaineering teams repeat exactly, so the climbing knowledge accrued by one team does not carry over intact to other expeditions. Whether and in what way this knowledge might be passed to a newly formed expedition team can be examined using such variables as the number of prior expeditions to 8,000m peaks by the leader(s), Sherpas, and other team members, and the cumulative number of prior expeditions of a country or the climbing industry as a whole. Note that the previous experience and the investments in human capital that have been made by the climbers involved in a particular expedition can be readily determined in this study as, in contrast to previous studies, we can identify *who* is doing the learning.

Improvements in success rates could be due to technological improvements rather than learning

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the same firm, although this was not as strong as the within-firm spillover effect. Irwin and Klenow (1994) and Zimmerman (1982) also found external spillovers; however, Joskow and Rose (1985) did not.

[5] Most examples in the literature examine industries for only a short time — the Liberty Ships program of the Second World War lasted only during the war (e.g., Rapping 1965, Thompson 2001, or Thornton and Thompson 2001), and this is also a feature of many information spillover models such as the franchise pizza case considered by Darr *et al*. (1995) and the addition of a second working shift case considered by Epple *et al*. (1996). In this paper, in contrast, we follow an "industry" for the first full century of its existence.

[6] The leader often retains exclusive rights to publish reports or photographs from the expedition.

[7] For example, on the 1970 British expedition that first climbed the South Face of Annapurna, American Tom Frost was invited in part because he "had developed new equipment and techniques" climbing big walls in Yosemite (Bonington, 2001, p. 13).

(Thompson 2001). Charles Evans, British leader of the 1955 first ascent of Kangchenjunga (8,586m), stated that "in part [we were successful] because we have learned about life at higher altitudes from our predecessors; in part it is because each expedition to a particular peak discovers more about the way to climb it; but in the main it is because of [bottled] oxygen" (Evans, 1956, pp. 58-9).[8] Bottled oxygen support played a part in the majority of the first ascents and was used on all of the first ascents of peaks over 8,200m.[9] After the Second World War nylon ropes became available which, unlike the hemp ropes used in early expeditions for which the motto was "the leader must not fall," would stretch to absorb some of the shock in a plunge. Other technologies that were introduced include twelve-point crampons and technical ice axes, which allowed climbers to climb steep and even vertical or overhanging ice; chocks and spring-loaded cams, which allowed climbers to set removable protection in rock; and plastic boots, which remained dry and provided better insulation than leather boots (Parsons and Rose 2003).[10]

The second strand of related literature, which could be called expedition-based research, is represented by a series of papers (Eguskitza and Huey 2000, Huey and Eguskitza 2000, 2001, and Huey, Eguskitza, and Dillon 2001) that focus on the use of bottled oxygen in Himalayan mountaineering and by the analysis by Karpoff (2001) of 92 Arctic expeditions from 1818 to 1909.

Huey and Eguskitza (2000) and Eguskitza and Huey (2000) examined the relationship between deaths on descent and the use of bottled oxygen on K2 (8,611m) and Mt. Everest, using data on climbers who successfully made the ascent in 1978-99. They find that expeditions that did not use bottled oxygen had significantly higher death rates on descent from the summit than those who did. In the present study we include data from all expeditions, not just those that reach the summit, and our data is for all 8,000m

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[8] Bottled oxygen was first used by the 1922 British Everest expedition, as advocated by George Finch, who had done studies of performance in a decompression chamber (Parsons and Rose 2003, p. 185). Its use was controversial (in part because it cost £400, about 10% of the cost of both the 1921 and 1922 expeditions), but the fact that Finch and Geoffrey Bruce were able to climb 150m higher and 30% faster than Mallory without bottled oxygen, plus the perceived benefit bottled oxygen provided in reducing frostbite, convinced the British to again use bottled oxygen on the 1924 Everest expedition (*id*, p. 190).

[9] Among the first ascents, both the 1950 French Annapurna expedition and the 1953 German Nanga Parbat expedition had bottled oxygen with them, but chose not to use it. The 1956 Austrian Gasherbrum II expedition lost its bottled oxygen in an avalanche and the 1960 International Dhaulagiri expedition reached the mountain only to find that the oxygen canisters were empty. Only the 1957 German-Austrian Broad Peak expedition did not plan to use bottled oxygen.

[10] The adoption of most technological improvements was relatively uncontroversial—only the French continued climbing up mountains walking backwards (using the *pied á plat*, or "flat-footed" technique) or cutting steps on 10-point crampons for a decade after the advent of the 12-point crampons (the 10-point crampons did not have points sticking out towards the front of the foot that enabled one to climb facing the mountain).

peaks, not just K2 and Everest. Thus, we attempt to capture the cost of carrying extra weight up the mountain as well as the benefits bottled oxygen yields. In addition, following Huey and Eguskitza, who note that "the survival impact of supplemental oxygen may be greater than suggested because mountaineers not using supplemental oxygen are probably relatively more experienced, and therefore might be expected to have lower death rates" (2000, p. 181)[11], we explicitly model the selection bias in bottled oxygen use.

Karpoff (2001) focuses mainly on the comparison of the performance of privately and publicly funded expeditions, but Karpoff's study is similar to this one in that it identifies determinants of the success of expeditions in terms of various outcomes, including the number of deaths, the number of ships lost, scurvy status, and whether a major or lesser accomplishment was claimed by an expedition. Karpoff finds that privately funded expeditions were more successful on all outcome measures.

In the present study, we were not able to identify the source of funding for most of the expeditions, but it is clear that many expeditions were publicly funded. The Nazi party in Germany funded the Nanga Parbat expeditions of the 1930s. The Chinese Everest expeditions in 1960, 1966, and 1975 and the 1964 first ascent of Shisha Pangma (8,027m) were certainly publicly funded, as were all but one or two of the Eastern bloc expeditions prior to 1989. However, even large "national" expeditions such as the 1921, 1922, and 1924 British expeditions to Everest were funded in large part by private donations.[12] Similarly, the $400,000 cost of the 1963 American Everest expedition was covered in part by a contribution of $114,000 by the National Geographic Society, although it also received contributions of equipment from the National Aeronautics and Space Administration (NASA) (Unsworth, pp. 365-6). Large national expeditions also differ from large international expeditions in an important way, as evidenced by the difficulties faced by Norman Dyhrenfurth in organizing the 1970 International Everest expedition.

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[11] Well-prepared climbers may choose not to use bottled oxygen because it goes against their ethic of climbing a mountain "by fair means." The "by fair means" argument seems to have first been made in the 1930s by British climbers Eric Shipton and H. William Tilman (Unsworth 2000, p. 211), although George Finch was possibly left off the 1924 British Everest expedition because of his advocacy of bottled oxygen use (Parsons and Rose 2003, p. 191). See Lowenstein (1999) for a lively discussion of the various motivations of mountaineers such as "self-signaling," "mastery," and "meaning".

[12] For example, of the £3,000-4,000 raised for the 1921 and 1922 expeditions, over £3,000 was raised by private subscription from members of the Alpine Club. King George V contributed £100 and the Prince of Wales contributed £50. In addition, contracts for exclusive press coverage were written with *The Times* and other newspapers (Unsworth, p. 33).

Unsworth writes that "because there was no national prestige involved, there was no single national institution prepared to underwrite the expedition" (p. 404). Indeed, NASA refused to help as it had for the 1963 American expedition, also led by Dyhrenfurth. Because of the inherent advantages national expeditions have for fundraising, in this study we include a dummy variable, "big national," which is set to one for teams of ten or more individuals all from the same country. This variable misses some expeditions that were national in character, such as the British 1953 Everest expedition, which included New Zealanders Edmund Hillary and Ed Lowe, but it allows us to test whether organizations with better access to funding are more likely to be successful.

We also examine how expedition size, which has ranged from one (solo) up to several hundred, affects the outcomes, being careful to separate the effects of numbers of climbers and numbers of paid Sherpas.[13] A large expedition has lots of resources available if trouble hits, but it is also exposed to risk for a longer time since it must move much more equipment to high camps. The number of parties on the same route at the same time may also affect success rates; with congestion there are more resources available to help in the event of a rescue, but it is also possible there will be a lack of coordination that could result in the formation of a dangerous bottleneck on the route.[14] There is a further question as to whether guided expeditions, on which possibly less-experienced clients pay for the service of being guided to the top of a mountain, create more risk.[15] Lastly, we were able to obtain daily weather forecasts for the Himalayas for the period December 1978 to February 1994.[16] Since for many expeditions we know the day of the summit attempt, we can examine the impact of the weather conditions by regressing the expedition outcome on the conditions for that day, assuming that each expedition *a priori* chooses the

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[13] The 1960 Chinese Expedition to Everest had over 400 members. A joint Japanese-Chinese expedition to Everest in 1988 had over 150 members, and expeditions by the Italians, Indians, and British have consisted of more than 50 team members. At the other end of the spectrum, there have been more than 60 solo climbs.

[14] Given the combined effects of cold and altitude, the queue at the bottom of the "Hillary Step" (a vertical section of rock and ice near the summit on Mt. Everest's normal South Col route through which only one climber at a time may pass) may have contributed to the large number of deaths in 1996, as may have the "bottleneck," a narrow couloir below the summit on the Abruzzi Ridge route of K2, in the 1986 disaster which claimed 13 lives.

[15] Hiring a guide differs from the usual practice of hiring Sherpas in that the guide is the leader and is responsible for climbing decisions, rather than being subordinate to the client.

[16] The data are from the European Centre for Medium-Range Weather Forecasts and include daily temperature and wind speed data for 2.5° grids (approximately 175 miles by 175 miles). Thus we have separate weather forecasts for Kangchenjunga, for the Everest group (Everest, Lhotse, Makalu, Cho Oyu, and Shisha Pangma), for western Nepal (Annapurna, Dhaulagiri, and Manaslu), the K2 group (K2, Broad Peak, Gasherbrum II, and Hidden Peak), and for Nanga Parbat. Temperature and wind speed were identified by Huey, Eguskitza, and Dillon (2001) as factors affecting success on Himalayan climbing expeditions.

best possible day for its summit attempt.[17]

3. A BRIEF HISTORY OF MOUNTAINEERING ON THE 8,000M PEAKS

In the period between Albert Mummery's death and the Second World War, the British focused mainly on Everest, the Germans on Nanga Parbat, and the Americans on K2. The lone French expedition explored Hidden Peak (also known as Gasherbrum I, 8,068m). The British made it above 8,500m three times on Everest (in 1924, when George Mallory and Sandy Irvine lost their lives, and again in 1933 and 1938), and American Fritz Weissner turned back about two hundred meters from the summit of K2 in 1939 because his Sherpa companion, Pasang Lama, refused to go any further and was unable to descend by himself (Houston and Bates 1954, 41-2). The Germans suffered terrible losses in their four attempts on Nanga Parbat, with 10 men dying in 1934 and another 16 in 1937.

These expeditions varied considerably in their composition and style. The large expeditions of the British to Everest and the Germans to Nanga Parbat involved a dozen or more climbers and as many high altitude Sherpas following a strict regimen of establishing camps in a pyramid structure so that each camp was able to supply the next. In contrast, the light British expeditions led by H. William Tilman and Eric Shipton in the 1930s included fewer than ten men in total. These teams rejected bottled oxygen and climbed as did mountaineers in the Alps, advancing quickly up with few, if any, fixed camps along the way and bivouacs as became necessary.

Following the Second World War, the unwritten claims of the British, Germans, and Americans on "their" mountains—Everest, Nanga Parbat, and K2, respectively—began to weaken. The French, led by Herzog, were the first after the war to obtain permission from the government of Nepal to climb an 8,000m peak, either Dhaulagiri (8,167m) or Annapurna.[18] Finding Dhaulagiri to be too difficult, they succeeded on Annapurna without the use of bottled oxygen. A British expedition in 1951 that was led by Shipton and included Hillary explored the area between Everest and Cho Oyu (8,201m) and discovered

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[17] This is complicated by some expeditions making several summit attempts—in which case we use the last attempt day—and by deaths, frostbite, or altitude sickness occurring at times other than the summit day. We exclude expeditions that do not report dates with this precision.

[18] Canadian born Earl Denman made an illegal attempt to climb Everest in 1947, and Danish climber Klaus Larsen made another illegal attempt to climb Everest in 1950. The Chinese invaded Tibet in October 1950 and banned western climbers from Tibet until 1980 (Sale and Cleare 2000, p. 50).

the South Col route that was to become the route for the first ascent of Everest. However, the British were nearly beaten to the summit of Mt. Everest by the Swiss, who in 1952 led both spring and autumn expeditions to Everest and, using the South Col route, made it to almost 8,600m, a new altitude record. The following spring the British finally succeeded on Everest when Hillary and Sherpa Tenzing Norgay reached the summit. A few days later the Germans finally climbed Nanga Parbat, after four previous expeditions that had resulted in twenty-six deaths. Hermann Buhl, climbing solo from the highest camp without bottled oxygen, though taking stimulant pills, reached the summit just before dark, spent the night standing on a ledge too small to sit upon, and returned to camp the next day with frostbite injuries. Several ascents were then completed in quick succession. After an American failure on K2 in 1952 (that was made remarkable by Pete Schoening's boot-axe belay saving seven climbers from falling to their deaths), the Italians succeeded in climbing it in 1954, the same year an Austrian team succeeded on Cho Oyu. In 1955 the British and French used large-scale expeditions to successfully climb Kangchenjunga and Makalu (8,463m), respectively. In 1956, an impressive Swiss expedition succeeded in both the second ascent of Everest and the first ascent of nearby Lhotse (8,498m), and a Japanese expedition made the first ascent of Manaslu (8,163m). The remaining Pakistani peaks then began to fall. The Austrians succeeded on Gasherbrum II (8,035m) in 1956 and Broad Peak (8,047m) in 1957, in an expedition that included Hermann Buhl and Kurt Diemberger among those making the first ascent. In 1958 an American team climbed Hidden Peak on a permit left for them by an Italian team who preferred to climb the smaller but more difficult Gasherbrum IV (7,900m). Dhaulagiri, which had been attempted seven times in the 1950s, was climbed in 1960 by Diemberger and an international expedition, making Diemberger the second non-Sherpa climber after Buhl to have made the first ascent of two 8,000m peaks. Lastly, Shisha Pangma, which was closed to Western climbers until 1980 (as were all Tibetan peaks), was climbed by the Chinese with a large expedition that placed 11 climbers on the summit in 1964.

With the exception of the 1957 Broad Peak first ascent, each of the 8,000m peaks fell to large expeditions placing fixed camps, using Sherpas, and for the most part using bottled oxygen.[19] The

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[19] The Broad Peak expedition had only four members, although they still placed fixed camps.

controversial replacement of Shipton by Colonel John Hunt as leader of the 1953 British Everest expedition was clearly a repudiation of the go-light "alpine" style of amateur explorers like Shipton. The fixed-camp or "expedition" style, as it came to be called, was also the preferred method during the second major phase in Himalayan climbing, which arguably began in 1956 with the Swiss Everest-Lhotse expedition. Expeditions in this phase typically upped the ante by trying not just for any ascent but one on a difficult route or in a difficult manner. Thus the 1963 American Everest expedition attempted simultaneously to climb Everest by two different routes, the "normal" South Col route plus the difficult and unclimbed West Ridge route. On the latter route, Tom Hornbein and Willi Unsoeld made the first ascent and, by descending the South Col route, they also achieved the first traverse of the mountain. This phase in Himalayan mountaineering was in full bloom by 1970, when two teams of climbers attempted new and difficult routes: British climbers led by Christian Bonington attempted the south face of Annapurna, and a German-Italian team led by Karl-Maria Herrligkoffer attempted the Rupal Face of Nanga Parbat. These were no longer attempts to climb the mountain by the easiest means possible but were full frontal assaults on 4,000m and 5,000m faces, respectively, involving much technical rock and ice climbing at high altitude. When British climbers Don Whillans and Dougal Haston reached the summit of Annapurna and Tyrolean-Italians Reinhold and Gunther Messner attained the summit of Nanga Parbat,[20] mountaineers around the world realized that climbs at a difficult technical standard were possible on the 8,000m peaks, and the new challenge was laid down. The number of routes climbed jumped from the fourteen "normal" first ascent routes to almost sixty routes during this period, with all of the 8,000m peaks except Shisha Pangma — still closed to Western climbers — seeing attempts on new routes.

The third phase in Himalayan mountaineering was the revival of the alpine style attempt which, discredited by the successes of the large expeditions, had been forgotten until a series of climbs in the late 1970s involving Reinhold Messner. Messner and Austrian Peter Habeler made a successful alpine style

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[20] Unfortunately, Gunther Messner suffered from altitude sickness on the ascent and was unable to return by the difficult Rupal Face route they had just climbed (they had no rope), so the brothers descended the Diamir Face; Gunther Messner died somewhere on the descent. Reinhold Messner thus accomplished the first traverse of the mountain, as well as its first ascent by the Rupal Face.

climb (employing no bottled oxygen, Sherpa support, or fixed ropes) of Hidden Peak in 1975. In the spring of 1978, Messner and Habeler climbed Everest without bottled oxygen, though as part of an expedition that used bottled oxygen. Three months later, Messner made the first completely solo climb of Nanga Parbat, climbing a new route on the Diamir face without bottled oxygen and without supporting climbers or camps. In 1980, Messner made the first solo ascent of Everest (again without bottled oxygen, fixed camps, or supporting climbers), and in 1984, Messner and fellow Tyrolean Hans Kammerlander completed a traverse of Hidden Peak and Gasherbrum II in seven days without bottled oxygen or support. While Bonington's 1970 Annapurna expedition and Herrligkoffer's 1970 Nanga Parbat expedition had shown that technically difficult climbs were possible at high altitude, Messner's climbs showed that small, unsupported, inexpensive expeditions could be successful, inspiring hundreds of other climbers to make attempts on the 8,000m peaks. The alpine style also carried prestige in that it was an attempt by "fair means," as, according to Messner, a climber's use of bottled oxygen turned Everest into a 6,400m peak (Messner, 1999, p. 73).[21]

The fourth, and most controversial, phase in Himalayan mountaineering was the advent of guided climbs, characterized by two highly publicized cases. The first of these was the successful completion in 1985 of the ascents of the highest peaks on each continent – the "Seven Summits" – by neophyte climber and Texas real-estate developer Dick Bass. The second was the 1996 disaster on Everest in which guides and clients on two expeditions on the South Col route were caught in a sudden and fierce storm. New Zealand guide Rob Hall and American guide Scott Fischer, leaders of their respective expeditions, plus several clients and assistant guides—a total of eight climbers—died on the mountain, and Texas surgeon Beck Weathers, who was twice left for dead, suffered horrific frostbite damage to his face, hands, and feet.[22] The incident was recorded in Jon Krakauer's *Into Thin Air* (1997), the first of numerous books on

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[21] Houston (1998, p. 199) found that the oxygen carried in the blood by acclimatized climbers at 8,000m averages about 32% of what it is at sea level, and at the summit of Everest (8,848m) it is 25% of what it is at sea level. "Breathing bottled oxygen increases the percentage, and thus the partial pressure, of inhaled oxygen, in effect 'taking the climber down' a few thousand feet" (*id* at 220). Houston estimates that a climber using bottled oxygen on the summit of Everest is breathing the equivalent of oxygen at 6,700m above sea level (*id* at 221).

[22] Hall had led successful guided expeditions on Everest in each year from 1992-1995 (Krakauer 1997, pp. 34-5). Though Fischer had acted as a guide on only one previous expedition (to Broad Peak in 1995) and was not the lead guide, Hall felt pressure from Fischer, because "he's based in America [and] eighty to ninety percent of the potential market for guided expeditions is in the

the 1996 disaster and an indictment of the concept of guided expeditions.

4. THE DATA AND UNIVARIATE TESTS OF HYPOTHESES

The data consist of 1766 expeditions to the fourteen 8,000m peaks and their subsidiary peaks over 8,000m during the period 1895-1994, plus 143 expeditions to Mt. Everest over the period 1995-98.[23] The data were collected using the *Himalayan Index*,[24] expedition reports from the *American Alpine Journal*, the *Alpine Journal*, and additional supplemental sources. The primary source for information was the *American Alpine Journal*, which contains expedition reports ranging from very detailed multiple-page articles to a single sentence written by members of the expedition or by journalists such as Elizabeth Hawley and Michael Cheney. These reports can include the team size, names of climbers including those who successfully reached the summit, the highest elevation that was attained if the expedition was unsuccessful, the number or names of Sherpas, and incidences of frostbite, altitude sickness,[25] or death. Ascents were cross-checked with an appendix in Sale and Cleare (2000). Information on ascents and deaths is quite good, but other information is often less accurate.[26] The data end in 1994 for all peaks except Everest because of an editorial policy change at the *American Alpine Journal* that excluded reports of expeditions on "normal" routes,[27] which comprise the bulk of expeditions. The Everest data from 1995

United States" (Krakauer 1997, pp 61-7).

[23] Inclusion of the subsidiary peaks is not controversial for mountains such as Kangchenjunga, with four subsidiary peaks all over 8,400m, or Lhotse, with Lhotse Shar (or East Peak 8,398m), which are viewed as distinct summits. However, Shisha Pangma's central summit (8,008m) and Broad Peak's foresummit (8,030m) are bumps on the ridge an hour away from the main summit. When climbers claim an ascent of a subsidiary peak, or if they in error claim an ascent of the main summit, we code this as an ascent, albeit of a subsidiary peak. Thus of the 307 ascents claimed on Shisha Pangma, only 149 are of the main summit. The south summit of Everest (8,500m) is an exception, as no mountaineer to our knowledge has claimed reaching the south summit as an ascent. The other subsidiary summits over 8,000m include the east summit of Annapurna (8,010m), the middle summit of Annapurna (8,051m), the south summit of Nanga Parbat (8,042m), the west summit of Kangchenjunga (also known as Yalung Kang, 8,505m), the south summit of Kangchenjunga (8,476m), the central summit of Kangchenjunga (8,482m), and the central summit of Broad Peak (8,015m).

[24] The *Himalayan Index* is an electronic database maintained by the Alpine Club (U.K.) and made available to us by Mike Westmacott. It lists an expedition's route, climbers, date, elevation attained, and citations for where further information may be obtained. Unfortunately, the index is designed as a source for climbers, so it contains only the first few expeditions on a route. Nevertheless, the *Himalayan Index* was very useful in that it contained basic information for many expeditions and the names of the climbers on those expeditions.

[25] Altitude sickness includes acute mountain sickness (AMS), high altitude pulmonary edema (HAPE) and high altitude cerebral edema (HACE) (Houston 1998).

[26] There are, however, several disputed ascents, including Lydia Bradey's 1988 ascent of Mt. Everest (which probably occurred) and Tomo Cesen's ascent of the south face of Lhotse in 1990 (which probably did not).

[27] Future reports are limited (AAJ, 1996, 146-147) to the recording of only the "*significant climbing activity* of the year" [italics theirs], meaning a climb which breaks "new or unusual ground." Since the majority of climbs on all mountains follow previous ascent routes, we include only Everest—for which we had complete information—after 1994. Everest is also of interest because it is Everest, the highest and best known of the 8,000m peaks.

forward come from an appendix in Unsworth (2000). We felt that it was important to include these data if we were to discuss the effects of guided expeditions, partly because the well-known 1996 Everest disaster occurred during this period.

Table 1 provides background information on the expeditions to the 8,000m peaks in five periods of exploration, in total through 1994, and on all Everest climbs from 1995 through 1998.[28] Interest in climbing these mountains has increased dramatically over the years from less than one expedition per year before 1950 to well over 100 attempts annually by 1990. The number of new routes attempted and routes first ascended roughly doubled from period to period until the 1990s, then dropped to about a quarter of the 1980s rate.[29] The average experience of expedition leaders and climbing team members has been increasing. Sherpas' experience rose through the 1970s, but appears to have been declining since; however, after the 1980s our information on both the number and names of Sherpas becomes much poorer.[30] Bottled oxygen usage dipped slightly in the 1980s but has been rising since.[31] The normal route is the first-ascent route, except on Mt. Everest, where we also include the North Col route (first ascended by the Chinese in 1960), which has been attempted by 170 expeditions, and on Nanga Parbat, where we also include the Diamir Face route (first climbed by the Germans in 1962), which has been attempted by 71 expeditions. The proportion of expeditions on the normal route declined in the 1970s but has risen ever since. Guided expeditions account for only 2.7% of total expeditions but accounted for 14% of Everest expeditions in the period 1995-98. Teams appear to be becoming more international over time. The size of climbing expeditions reached its peak in the 1970s, with the number of Sherpas per expedition in decline until the 1980s but rising in the 1990s. Winter attempts have become more numerous through to

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[28] The periods roughly correspond to the pre-war exploration phase, the 1950-69 first ascents phase, the 1970s difficult routes phase, the 1980s "by fair means" phase, and the 1990s guided expedition phase. Everest expeditions for 1995-98 are reported separately.

[29] In part, this could be because our data end for most mountains after 1994; however, in the 1995-98 period Everest saw no new routes attempted and only one first ascent of a route (in 1996 by a Russian expedition).

[30] The experience level of the climbers or Sherpas who go unnamed in an expedition report is assumed to be the same as the average experience of those who are named. When there are no named climbers or Sherpas, all are assumed to have no experience. We have no way of testing this assumption, since we have no method for modeling who is and is not named.

[31] Bottled oxygen is coded as a one whenever *all* members of the expedition use bottled oxygen on the ascent attempt. Oxygen use was not reported for over 1200 of the expeditions in our sample. However, as a climb that does not use bottled oxygen is highly regarded by climbers, we assume that if bottled oxygen use was not reported, then the expedition used bottled oxygen. An exception to this was if the reported expedition style was solo, alpine or reconnaissance. In those cases we assume that the expedition did not use oxygen when it is not reported.

the 1980s. Although the total number of routes has increased over time (albeit at a decreasing rate), the congestion on routes has risen as well: by the late 1990s there were more than ten teams on the same route on Everest in the same season of each year. The proportion of expeditions attaining an ascent has risen over time and death, frostbite, and altitude sickness incidences have declined, although not monotonically. A nonparametric Kruskal-Wallis rank test of the null hypothesis that the rank order statistics are randomly distributed across periods indicates that, with few exceptions, the trends evident in the data are statistically significant.

Table 2 displays the data through 1994 by mountain. Expedition characteristics vary greatly across mountains. Everest is climbed the most, almost twice as often as any other mountain. Almost all the climbs on Broad Peak follow the normal route, compared with 20% on Annapurna and Hidden Peak. Guided expeditions account for over 8% of the climbs on Shisha Pangma and about 5% of the climbs on Gasherbrum II, Everest, and Hidden Peak but hardly any climbs elsewhere. Climbing on the nine 8,000m peaks in the Nepali Himalaya usually takes place in the pre-monsoon spring or the post-monsoon autumn, as the area is prone to the heavy snows of the summer monsoon; the Pakistani Karakoram is little affected by the monsoon, so climbs are typically made in the summer. Climbing teams on Everest are more than fifty percent larger than the average in both climbers and Sherpas, while Gasherbrum II sees almost twice as many expeditions with female climbers as the other mountains. Congestion is lowest on Kangchenjunga and highest on Cho Oyu and Broad Peak, which are usually climbed by their normal routes. Between 29% and 66% of expeditions produce a successful ascent, and between 6% and 26% result in a death.

Table 3 contains summary statistics organized by country of origin. International expeditions are included in the statistics for each of the countries represented on the team and also in an “International” row. The United States generates the most expeditions, followed by Japan, Spain—which did not appear in the data until the 1970s but by the early 1990s was organizing more expeditions than any other country—and France. The British and Germans together account for over 70% of the expeditions before the Second World War but fewer than 20% of expeditions by the 1980s. The Koreans, Japanese, and

Spanish are the most likely to climb in purely national expeditions.

Again, there is much variation among the expeditions when grouped by countries. Great Britain and the United States have the lowest ascent rates (around 40%), while climbers from the former Soviet Union have the highest (77%). Death rates are highest among the Indian (50%) and Chinese/Tibetan (34%) expeditions. Frostbite is also high among expeditions featuring Indian climbers. For whatever reason, no Korean expedition has ever reported a case of altitude sickness, but nearly 20% of Canadian expeditions have done so. Chinese expeditions climb on normal routes almost exclusively, but climbers from the former Yugoslavia do so only about 40% of the time. Bottled oxygen usage is highest among the Koreans, Indians, and other Eastern European countries and lowest among Polish climbers. Chinese and Indian expeditions are by far the largest expeditions in both numbers of climbers and numbers of Sherpas. Korean, Chinese, and Spanish expedition leaders had the least experience, while the Koreans, Chinese, and Indians had the least experienced climbing teams.[32] The Polish had the most experienced leaders and climbers.

Table 4 displays expedition outcomes by various expedition characteristics. The Kruskal-Wallis tests indicate that there are significant differences in outcomes when expeditions are grouped by each of the variables listed. As industry and country experience have risen, death, frostbite, and altitude sickness rates have declined and ascent rates have increased. More experienced leaders, climbers, and Sherpas have higher ascent rates but also show evidence of higher death, frostbite, and altitude sickness rates. Expeditions using bottled oxygen actually have a lower ascent rate. Unlike Huey and Eguskitza (2000), we do not find that bottled oxygen use reduces death rates, although it does decrease rates of frostbite and altitude sickness.[33] Expeditions on the normal routes have higher ascent rates and lower death and frostbite rates. Interestingly, guided expeditions have higher ascent rates but are otherwise unremarkable.

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[32] This result could be due in part to the difficulty in translating names to English. We spent a couple of days sorting by first and last names to find spelling and other errors. We learned from this exercise that "Sepp" is short for Josep in German and other such facts. This was also a problem for Sherpa names, for which various spellings exist.

[33] When we restrict our attention to those expeditions that made the ascent on K2 and Everest, we find that the number of deaths per expedition is 0.51 for those that did not use bottled oxygen versus 0.33 for those that used bottled oxygen. When we restrict ourselves to those who made the ascent on all mountains, the deaths per expedition for those who did not use bottled oxygen is 0.20 but 0.24 for those who did. Neither difference is statistically significant by a Kruskal-Wallis rank test. This is not an exact comparison with Huey and Eguskitza, since we are including all deaths, not just deaths that occur on descent from the summit.

Larger expeditions have higher ascent rates but also higher death, frostbite, and altitude sickness rates. The three technological advances tend to correlate with higher ascent rates and lower death and frostbite rates.

5. ECONOMETRIC RESULTS

The expedition statistics given in Table 4 suggest several possible reasons for the increase in ascent rates and decline in death, frostbite and altitude sickness rates. In order to estimate the effects of different factors on the expedition outcomes while simultaneously controlling for other effects, we turn to a multivariate analysis of the data. For this analysis we drop 167 of the 1,909 expeditions because there is no information about the size of the climbing team. In 596 of the 1,742 remaining expeditions we do not know if any Sherpas are employed, and in these cases we arbitrarily set the number of Sherpas at zero. We return to this issue later in the paper.

A. Probit Estimation of the Expedition Outcome Equations.

We begin by analyzing the four expedition outcomes using a simple probit model, where all explanatory variables are assumed—perhaps erroneously—to be exogenous. Table 5 contains the results from estimating the probability that an expedition makes an ascent or experiences a death, frostbite, or altitude sickness. Each outcome equation is estimated with three specifications. Model 1 includes all the expedition characteristics from Table 4 except the three technology variables, plus country and mountain effects. Model 2 adds the three technology variables, and model 3 replaces these variables with wind speed and temperature variables. The country and mountain effects are not reported, but are generally consistent with the differences reported in Tables 2 and 3.

Perhaps the most interesting result concerns the effect of using bottled oxygen. Expeditions that use bottled oxygen are less likely to make an ascent and more likely to suffer a death. The only positive effect of bottled oxygen use found is a reduction in frostbite rates. These results are roughly consistent with the univariate test results in Table 4 and suggest that the cost of carrying bottled oxygen outweighs the benefit.

Expeditions that climb the normal route on a mountain are more likely to make an ascent and are not statistically different from other expeditions in terms of death, frostbite, and altitude sickness outcomes. Guided expeditions are also more likely to make an ascent and are no more likely to suffer an adverse outcome. Expeditions that have more climbers or Sherpas, or are big national expeditions are more likely to make an ascent, although death or frostbite is more likely in big national expeditions. Expeditions with female members are more likely to make an ascent. Expeditions in the autumn are less likely to be successful and are more likely to suffer frostbite and perhaps death. Winter expeditions are less likely to be successful, but are no more likely to suffer more death, frostbite, or altitude sickness.

Expeditions that occur after a greater number of prior expeditions have taken place display a lower likelihood of death, frostbite, and altitude sickness, but no difference in ascent rates. Thus we find evidence that expeditions learn from the experiences of others, at least with regard to how to avoid negative outcomes. Interestingly, the cumulative experience of the nations represented on the expedition does not appear to be the channel of learning. Indeed, in model 3 of the ascent equation, this variable is negative and statistically significant. From Table 1 we saw that recent expeditions face higher levels of congestion, but congestion has a positive effect on the probability that an expedition makes an ascent.[34]

The human capital variables, which measure the average number of prior expeditions to any 8,000m peak by the leader, climbers, and Sherpas, respectively, have a statistically positive effect on ascents but do not affect either deaths or frostbite. There is also evidence (at the 10% significance level) that more experienced climbers are more susceptible to altitude sickness.

Among the technology variables, the introduction of the technical ice axe increases ascent rates, and nylon ropes reduce the death rate. Each of these effects is plausible, since technical ice axes were designed to allow climbers to climb steeper ice than before, and nylon ropes were designed to hold a fall better than hemp ropes. However, plastic boots, which made it easier to keep one's feet warm, do not

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[34] If the congestion, cumulative prior expeditions, or prior national expeditions variable is included without the other two variables, it is positive and significant or zero in the ascent equations and negative and significant in the deaths, frostbite and altitude sickness equations. Thus it is possible with a different specification to reverse the sign on both cumulative prior expeditions and prior national expeditions in the ascent equations. The signs on these two variables in the ascent equations may be due to multicollinearity, as prior national expeditions are highly correlated with cumulative prior expeditions ($r = 0.58$) and with congestion ($r = 0.61$). Each of these results holds for the bivariate probit models reported in Tables 6 and B2 as well.

appear to affect frostbite rates. One problem with the technology variables is that they suffer from multicollinearity, since the simple correlations between these variables range from 0.36 to 0.95. Thus, at the bottom of Table 5, we also report a Wald test on the joint significance of the technology variables. This test reveals that the technology variables are jointly significant in the ascent equation ($p < 0.01$) and the deaths equation ($p < 0.1$), but not in the frostbite or altitude sickness equations. Thus we conclude that technology has had a positive effect on ascents and perhaps has reduced deaths but has had no effect on the incidence of frostbite or altitude sickness.

We find that low wind speed and high temperatures make an ascent more likely. Expeditions that see higher temperatures also suffer less frostbite but higher incidences of altitude sickness, possibly because climbers attempt to take advantage of good weather even though they are not properly acclimatized.

The overall significance levels in the ascent equations are the highest, as measured by the value of the likelihood function, the pseudo R^2, or the log-likelihood ratio tests. However, with the exception of model 3 in the frostbite equation, each of the regressions is statistically significant at the 1% confidence level. The variation explained ranges from ten to twelve percent in the deaths and frostbite equations to thirteen to fifteen percent in the altitude sickness equations and nineteen to twenty-four percent in the ascent equations.

An obvious objection to these models concerns the bottled oxygen results. It seems odd that expeditions would choose a technology that reduces frostbite but also reduces the odds of an ascent and increases the likelihood of death. Indeed, Messner’s statement concerning bottled oxygen reported above suggests that climbers themselves understand that the reason to use oxygen is to increase the odds of an ascent. Furthermore, we find evidence to support Huey and Eguskitza’s (2000) hypothesis that more competent or experienced climbers choose not to use bottled oxygen, while less competent or experienced climbers choose to use it. Expeditions not using bottled oxygen have more experienced leaders (3.22 vs. 1.81 previous 8,000m peaks expeditions; Kruskal-Wallis test statistic 53.47, $p < 0.01$), more experienced climbers (0.71 vs. 0.43 previous 8,000m peaks expeditions; Kruskal-Wallis test statistic 19.79, $p < 0.01$), and less experienced Sherpas (0.36 vs. 0.74 previous 8,000m peaks expeditions; Kruskal-Wallis test statistic 8.72, $p < 0.05$). Thus the results in Table 5 could be biased due to the selectivity problem with bottled oxygen choice.

B. Bivariate Probit Estimation of the Expedition Outcome and Bottled Oyxgen Treatment Equations.

To determine if selection bias has affected the results given in Table 5, we model the bottled oxygen choice as a treatment effect. While the estimation of treatment effects is well known in economics (e.g., Heckman 1976, Maddala 1983), these models are usually estimated with an outcome that is a *continuous* variable, such as the estimates of the income differences between college graduates and non-college graduates. Here, our outcomes are *discrete*. Formally, the model may be written as[35]

$$y_{it}^* = \boldsymbol{\alpha_i x}_t + \beta_i c_t + u_{it} \tag{1}$$

$$c_t^* = \boldsymbol{\gamma x}_t + \boldsymbol{\delta z_t} + v_t, \tag{2}$$

where y_{it}^* is a latent variable of the potential outcome i = ascent, death, frostbite, or altitude sickness, for observation $t = 1,\ldots,T$; $\boldsymbol{x_t}$ is the vector of exogenous variables other than the treatment choice variable c_t, where $c_t = 1$ if the latent variable c_t^* is positive, and zero otherwise; $\boldsymbol{z_t}$ is a vector of instrumental variables used to identify the treatment equation; and $\boldsymbol{\alpha_i}$, β_i, γ, and δ are parameters to be estimated. We observe $y_{it} = 1$ when $y_{it}^* > 0$ and $y_{it} = 0$ otherwise, and $c_t = 1$ when $c_t^* > 0$ and $c_t = 0$ otherwise. The errors u_{it} and v_t are normally distributed with zero mean, unit variance, and covariance $\text{Cov}(u_{it},v_t) = \rho_i$.

When the outcomes in such a model are latent variables, two-step procedures result in inconsistent estimators (Wooldridge 2002, p. 478). Greene (1998) shows that one can directly estimate (1) and (2) by bivariate probit ignoring the endogeneity of c_t in equation (1), as the likelihood function for (1) and (2) is exactly the same as the likelihood of the bivariate probit with no endogenous right-hand-side regressors. Knapp and Seaks (1998) show that a test of the endogeneity of c_t in this model is the test that $\rho_i = 0$.

With this estimation procedure in hand, we need only an instrumental variable $\boldsymbol{z_t}$. The instrument must be correlated with the bottled oxygen choice but uncorrelated with the ascent, deaths, frostbite, or

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[35] Vectors are bolded; scalars are not.

altitude sickness residual. An instrument we found to be correlated with the treatment choice in most specifications was the variable "leader prior bottled oxygen free," which takes the value of one when the leader has been on an expedition previously on which at least one member did not use bottled oxygen, and zero otherwise. However, in the deaths equations this variable correlated only weakly with the treatment choice, so we also included a variable "team climbed on an expedition experiencing death," which is set to one if any team member has been on an expedition previously on which someone died, and zero otherwise. As with our other experience variables, these are set to zero if the leader or team members are first-time climbers on the 8,000m peaks. Slightly more than a third (34.9%) of leaders had previously been on an expedition in which some team member did not use bottled oxygen, and 26.9% of expeditions had at least one team member who had previously been on an expedition experiencing a death. We can test the correlation between $\boldsymbol{z}_t$ and c_t in (2) by testing $\delta = 0$. (We discuss an indirect test of the second requirement of an instrument—that $\boldsymbol{z}_t$ be uncorrelated with u_{it}—after presenting the estimation results.)

Tables 6 and 7 report the results of the bivariate probit estimation of (1) and (2), respectively.[36] After controlling for the endogeneity of bottled oxygen choice, the coefficient on bottled oxygen in the outcome equations in Table 6 indicates that bottled oxygen affects neither the probability that an expedition makes an ascent nor the probability that an expedition suffers frostbite, in contrast to the probit results in Table 5. However, bottled oxygen still has a positive effect on deaths; indeed the coefficients have increased both in magnitude and significance. Thus, the benefits that bottled oxygen conveys still appear to be outweighed by the cost.

The effects of most of the remaining explanatory variables are similar to those in the simple probit models. However, large national expeditions and those in the autumn no longer display significantly higher rates of death, while the number of Sherpas in an expedition now has a negative effect on the death rate. The number of cumulative expeditions may have a negative effect on ascents. However, the effect of cumulative expeditions is now strongly negative for deaths, frostbite, and altitude sickness. The result in

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[36] In model 3 of the deaths equation, we found that with the full set of variables the estimated value of ρ was -1, which would result in a *t*-statistic on bottled oxygen in the deaths equation to 20. With a smaller set of variables, the model behaved more closely to models 1 and 2. Thus we omitted all country dummies that were not significant in either model 1 or model 2 of either the deaths or bottled oxygen equations. It is this restricted model we report in Tables 6 and 7.

the model 3 specification that prior national expeditions reduce ascent rates is still present, and we also continue to find that expeditions with more experienced climbers suffer higher incidences of altitude sickness. One difference between the bivariate and probit models is that we find that leader's experience is now highly significant and positive in the ascent equations, although we also find in model 3 that the leader's and climbers' experience may increase death rates.

There are also very few changes in the mountain and country effects between the probit and bivariate probit models; most notable is that several countries no longer show significantly higher death rates, leaving only the former Soviet Union, Czechoslovakia, China/Tibet, India, and possibly Latin America with higher death rates. Kangchenjunga has a higher ascent rate in the bivariate specification.

Table 7 reports the results from the estimation of the bottled oxygen treatment choice equation (2), estimated for each of the 12 specifications corresponding to Table 6. The instrumental variable "leader prior bottled oxygen free" is negative and statistically significant in each of the ascent, frostbite, and altitude sickness equations but is not significantly different from zero in any of the deaths equations. The instrumental variable "team climbed on an expedition experiencing death" is negative and significant in each of the deaths equation specifications. The instrumental variables are jointly significant in all specifications of the four outcome equations, with F-statistics ranging from 3.3 to 11.7.[37]

Expeditions that climb the normal route, are guided, or have large numbers of climbers or Sherpas are more likely to use bottled oxygen. However, large national expeditions are actually less likely to use bottled oxygen, probably because some of their members choose to not use bottled oxygen on the ascent.[38] Expeditions with female team members are also less likely to use bottled oxygen. More experienced leaders and climbers also tend to be less likely to use bottled oxygen, although we find weaker evidence that teams with more experienced Sherpas tend to be more likely to use bottled oxygen; perhaps these Sherpas tend to be hired by less-experienced teams.

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[37] Stock, Wright, and Yogo (2002) suggest that one faces the problem of "weak instruments" when the F-statistic is less than 10. However, if the instruments were truly weak ($\delta=0$), then the bivariate probit estimates for bottled oxygen should be similar to the probit estimates. We find this is not the case for either the ascent or deaths equations, where bottled oxygen appears to be endogenous.

[38] There were 34 expeditions in our data that reported that some individuals used bottled oxygen while others did not. Of these, 20 (59%) were big national expeditions. When we redefined bottled oxygen use to include those 34 expeditions and re-ran the bivariate probit estimation, big national expeditions were no longer statistically significant in the bottled oxygen equation.

The plastic boots variable is negative and significant in each specification where included, which suggests that climbers have substituted between bottled oxygen and this technology. The wind speed and temperature variables are also insignificant, which is expected, since expeditions choose whether or not to use bottled oxygen well before they know the conditions on the day of their ascent.

The results of the Knapp and Seaks' (1998) Hausman test of the correlation between the bottled oxygen treatment errors and the outcome equation errors are given at the bottom of Table 6. The null hypothesis that $\rho_i = 0$ is rejected in models 1 and 2 of the ascents equation and in all specifications of the deaths equation, hence in these cases the errors in the treatment equation are correlated with the errors in the outcome equation. These results suggest that the negative effect of bottled oxygen on ascent rates in Table 5 is due to selection bias, as we now find that bottled oxygen has either no effect or a weakly positive effect on ascent rates. In the frostbite and altitude sickness models, however, the Hausman test of exogeneity is rejected only in model 1(and then at the 10% level); the evidence for a selection bias in these cases is weak.

C. Testing for the Exogeneity of the Instrumental Variables.

In Table 7 we found evidence that the instrumental variables "leader prior bottled oxygen free" and "team climbed on an expedition experiencing death" were individually or jointly correlated with the treatment choice of bottled oxygen. However, for these instruments to be valid, they must also be uncorrelated with the residuals from the outcome equations. We re-estimate the simple probit models using the instruments as additional explanatory variables. As Evans and Schwab note, "this is not a formal test since if the correct specification is a bivariate probit then single equation models are misspecified, but it does offer a clear sense of the patterns in the data" (1995, p. 965). Table 8 contains the results for the "leader prior bottled oxygen free" and "team climbed on an expedition experiencing death" variables. In none of the specifications are the instrumental variables correlated with the outcome, indicating that expeditions whose leaders and team members had these experiences on a prior expedition are no different in their outcomes than expeditions whose leaders and teams did not have these experiences.

D. Extensions.

Besides choosing whether to use bottled oxygen, expeditions make other discrete choices which might be endogenous. The normal route is typically the easiest route on the mountain; climbers may choose a route other than the normal route because it is more prestigious or is less traveled. Since female climbers comprise less than five percent of climbers in our data, a female ascent is highly regarded, making inclusion of female team members a reasonable choice to garner expedition prestige.[39] Finally, guided expeditions may be comprised of climbers who are not able to climb these mountains under their own direction.

In Appendix A we report evidence that expeditions differ systematically by these selection choices in terms of the experience of the leaders, climbers and Sherpas. We also report the results of tests to determine whether these regressors can be considered to be exogenous. The tests are based on the system of equations (1) and (2), expanded to allow as potential treatments the variables of whether to climb the normal route, to climb as a guided expedition, or to climb with female climbers. The equations are estimated using a linear probability model as suggested by Angrist (2000). We find that the assumption of exogeneity is valid for each of these possible treatments, providing further support to our bivariate probit specification.

In choosing our sample, we included data from 596 expeditions where we had no information on how many Sherpas were employed, if any. We assumed that for these expeditions the number of Sherpas was zero, since this was the case in almost 70% of the expeditions for which we had precise data on the number of Sherpas. However, an error here could bias our estimators. In Appendix B we report evidence that the 596 expeditions where we imputed the number of Sherpas differ from the remaining 1,146 observations. To see how sensitive our results were to this assumption, we re-estimated the bivariate probit model excluding these 596 observations. The main results of the paper are unchanged by restricting the sample in this fashion.

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[39] Indeed, neither Lhotse nor Kangchenjunga had seen a female ascent by 1994.

6. DISCUSSION OF THE RESULTS

This paper has examined possible explanations for the observed increase in ascent rates and concurrent decrease in death, frostbite, and altitude sickness rates of expeditions to the 8,000m peaks of the Himalaya and Karakoram. The bivariate estimation of the ascent and deaths outcome equations with the bottled oxygen treatment choice equation is the appropriate specification, as the choice of bottled oxygen usage was found to be correlated with the ascent and death outcomes. A simple probit estimation is used for the frostbite and altitude sickness outcomes.

Our results are broadly indicative of external learning spillovers (Lucas 1988, 1993). An increase in cumulative prior expeditions to the 8,000m peaks, the number of which acts as a proxy for the industry-wide knowledge gained from those experiences (Argote 1993), unambiguously reduces the odds of death and frostbite, although it does not appear to improve the probability of an ascent.[40] Internal learning spillovers within countries are less evident: prior expeditions by climbers from the same nation may decrease the odds of altitude sickness but also may decrease the odds of ascent. Darr et al. (1995) found that the frequency with which three knowledge transfer mechanisms occurred, that of regular communication, personal acquaintances, and meetings, were significantly higher among franchise stores that had common ownership compared to differently owned stores. These mechanisms would clearly arise more frequently among climbers sharing a common language. If we consider countries such as Switzerland, Italy, or Canada where more than one language is spoken, an alternative explanation for the mixed results is that learning may be disseminated among climbers who speak the same language rather than carry the same flag.

Some country-specific results support other aspects of learning by doing mentioned in the literature. For example, there is evidence that late entry to the climbing industry allows countries to start with a stronger set of skills (Argote et al. 1990). For the eight countries climbing in the pre-Second World War era, the overall ascent rate given in Table 3 is never higher than 51.6%, and only Italy, Switzerland, and

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[40] This effect may be stronger than we have indicated, as the correlation coefficient between "cumulative prior expeditions" and "congestion" is 0.60, which makes it difficult to disentangle the effects of each variable. When the "cumulative prior expeditions" variable is included in the outcome equations without the "congestion" variable, it is positive and significant in some specifications for ascents.

Germany have success rates in excess of 50%. In contrast, among the eleven countries whose first expedition occurred between 1950 and 1970, the lowest ascent rate is 48.9% (for Australia/New Zealand), and more than half make an ascent over 55% of the time. Although these results might reflect different climbing objectives, they are echoed in the multivariate analysis which controls for mountain and route effects. With the exception of Switzerland, Japan, and possibly France, all of the countries with significantly higher ascent rates began climbing well after the Second World War. However, in parallel with Thompson's (2001) observation that in the Liberty Ships program some shipyards appear to have traded quality for quantity of output of ships, it may be that some countries have traded lives for an ascent. In particular, the former Soviet Union and Czechoslovakia, as well as the Latin American countries, may be guilty of this.[41]

We sought to determine whether other types of capital might help predict the learning results we observed, following Thompson (2001), who established that previously undocumented capital investments in the Liberty Ships program decreased the learning effects attributable to cumulative experience by about 50%. We find strong evidence that prior experience by individuals on an expedition contributes to a successful ascent: the human capital variables are positive and statistically significant throughout the ascent models. However, the human capital variables have little effect on the three adverse outcomes. It is interesting that industry-wide knowledge appears to reduce the risk of adverse outcomes, but it is the skills developed by individuals through their own experience on prior expeditions that improves the odds of a successful ascent.

A second type of capital that may explain some of the learning results is the assortment of technologies that became available over time. Nylon rope appears to have played a part in reducing deaths, while technical ice axes have improved ascent rates. Plastic boots may also have allowed climbers to substitute away from bottled oxygen. However, inclusion of these variables results in only small changes in the coefficients on the learning by doing and human capital variables, indicating that little of

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[41] On the other hand, China and India appear to be expending lives and getting no improvement in ascent rates in return. The 1966 Chinese Everest expedition, which resulted in 24 dead climbers, "were told that what they had to do to keep warm was to remember the teachings of Mao Tse Tung…they were climbing in Mao Tse Tung's name, which they must still be doing, as they were never seen again" (Guha, 1968, p. 211).

the improvement attributed to learning is instead due to investment in these technologies.[42] Since no successful expeditions to the 8,000m peaks occurred prior to the introduction of nylon ropes, twelve-point crampons, snap-link karabiners, or down parkas, it could also be argued that these technologies had an important impact on later success rates.

Expeditions that choose to use bottled oxygen are more likely, all else equal, to make the ascent (although this result is not robust) and to reduce their chances of frostbite, but they have also increased the likelihood of a death occurring on the expedition. Huey and Eguskitza (2000) found that the use of bottled oxygen increases the chance that a climber who has reached the summit will survive the descent, but they note that "a full assessment of supplemental oxygen use awaits incorporation of data on death rates during ascent, risk to porters ferrying oxygen canisters, actual causes of death, and weather conditions" (p. 181). Although we have not tried to distinguish between deaths due to objective hazards (i.e., bad luck) and those due to subjective hazards (poor decisions), our results suggest that bottled oxygen raises the exposure to risk, presumably due to the increased logistical demands of carrying and deploying bottled oxygen on the mountain.

Congestion, as measured by the number of other expeditions on the same route of the same mountain in the same season, has been rising over time. We find that sharing the route with other expeditions increases the odds of an ascent and has no effect on deaths, frostbite, or altitude sickness. This is a surprising result, as having many other teams on the same route in the same season means there will be many leaders competing in a decentralized environment. As an example, Krakauer (1997, pp. 126-7, 142) reports several problems between Rob Hall's 1996 guided Everest expedition and a South African expedition led by Ian Woodall concerning the coordination of the fixing of ropes and the timing of ascent.[43] Yet we find no systematic evidence that such disputes have an adverse effect on expedition

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[42] Except in the case of bottled oxygen, we simply assume that climbers are using the technology if it is available. There are certainly examples where this assumption is in error: Mallory and Irvine chose not to use down parkas on their 1924 British Everest expedition, even though George Finch had used one on the 1922 British Everest Expedition, of which Mallory was a member (Parsons & Rose 2003, p 187). But certainly after the Second World War, few climbers went without down parkas.

[43] Unsworth reports how the decentralized system often works on Everest: "Leaders would meet at the start of the season to agree who would fix the ropes and ladders—the [Khumbu] 'Icefall doctors'—with everyone contributing towards the cost, although this was sometimes a controversy, especially with East European expeditions who often had no money to spare for such luxury" (Unsworth, 2000 p. 533).

outcomes. One interpretation of this result is that the benefits of a better-traveled path to the summit outweigh the additional problems of coordination of teams.[44]

Guided expeditions have a higher chance of making an ascent and do not appear to have a higher probability of any adverse outcome. This may be because the average client on a guided expedition is actually more experienced in 8,000m peak climbing than the average climber on a non-guided expedition. Big national expeditions are more likely to make an ascent. However, big national expeditions also have a higher chance of suffering frostbite. If we interpret this as a public-versus-private funding result, then our findings are similar to Karpoff's (2001) regarding negative outcomes but not in terms of successful accomplishments. Indeed, big national expeditions accounted for only about 17% of all expeditions in our data, but they accounted for six of the fourteen first ascents (43%) and 47 of 130 first ascents by route (36%). Hence big national expeditions have a much more impressive showing in Himalayan climbing than in arctic expeditions. However, as mentioned above, the correlation between big national expeditions and public funding is less than perfect, so this result should be interpreted with caution.

APPENDIX A. TESTING FOR THE EXOGENEITY OF OTHER REGRESSORS

Table A1 provides indications of some possible problems in interpreting the results of Tables 6 and 7. Expeditions that climb the normal route have less experienced leaders and climbers, yet are more likely to make the ascent and less likely to experience death. While the leaders and Sherpas on guided expeditions are relatively more experienced, which one might expect, the climbers are also more experienced on average than climbers on non-guided expeditions. Expeditions with female climbers and guided expeditions each have higher experience levels as well as higher ascent rates. Thus each of these variables could be subject to selection bias.

When faced with a system of equations with endogenous latent right-hand-side variables, Angrist (2000, pp. 17-18) argues that consistent estimators can be achieved by estimating (1) and (2) by two-stage

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[44] If anything, we have understated the congestion results. Omitting the "cumulative prior expeditions" from the regressions causes the "congestion" variable to be negative and significant in the deaths, frostbite and altitude sickness equations.

least squares using a linear probability model. However, the real advantage of Angrist's suggestion is that we are also able to test for the endogeneity of other regressors—something that is not possible in the bivariate probit framework. Our approach is as follows: we first find a set of instrumental variables satisfying the overidentification tests, and then we use these additional instruments to test whether other regressors, in particular the choices of normal route, guided, and including female climbers, are also exogenous. The residuals in the first stage regression are of the form $v_t = 1 - \gamma\mathbf{x_t} - \delta\mathbf{z_t}$ when $c_t = 1$ and $v_t = -\gamma\mathbf{x_t} - \delta\mathbf{z_t}$ when $c_t = 0$. Thus the errors suffer from heteroskedasticity. To correct for this problem, we use generalized method of moments (GMM) estimation rather than two-stage least squares (e.g., Baum, Schaffer, and Stillman 2002).

The instruments we consider are all similar to the "leader prior bottled oxygen free" variable, which is also included. The variable "leader climbed with females" takes the value of one if the leader has ever been on an expedition in which some members were female and zero otherwise. This variable has a mean of 0.266 in the full sample, so slightly more than a quarter of leaders have previously been on an expedition with a female team member. The variable "leader climbed with a guided expedition," which is set to one if the leader has previously been on an expedition that was guided (in any capacity), has a sample mean of 0.056, almost twice the frequency of guided expeditions in the data.[45] The variable "leader made an ascent" indicates if the leader has made an ascent of any 8,000m peak (mean 0.322). Finally, the variable "leader has been on an expedition that experienced death" is self-explanatory (mean 0.273).

Given the overidentification of the GMM model estimating the linear probability model forms of (1) and (2), we can conduct an *F* test of whether the instruments are correlated with the treatment choice and a Hansen's *J* test of whether the overidentification restrictions that $E(\mathbf{z}_t u_{it}) = 0$ are satisfied. The *J* test is distributed as a χ^2 random variable with degrees of freedom equal to the number of overidentifying restrictions (Baum, Schaffer and Stillman 2002). If the null hypothesis is rejected, then the instruments are correlated with the outcome residuals. A simple test of the exogeneity of regressors is possible with

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[45] The variable "leader climbed a non-normal route" (mean 0.438) was found to be correlated with the errors in the ascent equation and so could not be used.

the C statistic (Baum, Shaffer, and Stillman, 2002, p. 18), calculated as $C = J_R - J_U$, where J_R is the J statistic from the restricted model (where the suspect regressors are treated as exogenous) and J_U the J statistic from the unrestricted model (where the suspect regressors are instrumented). This statistic is also distributed as a χ^2 random variable with degrees of freedom equal to the number of suspect regressors, which here is three (normal route, guided, and female climbers).

The estimation results for each of these three tests are presented in Table A2. In each case, the *F* statistic on the correlation between the instruments and the Bottled Oxygen regressor is significant at the 1% confidence level. Thus the null hypothesis that these instruments are uncorrelated with the variables being instrumented is rejected.[46] Secondly, by the Hansen's *J* test the instruments are also independent of the residuals from the outcome equations (the null hypothesis that they are independent cannot be rejected at the 10% level). Hence the instruments appear to be valid in that they are correlated with the variables for which they are instruments but not with the errors in the equation being instrumented. Finally, the *C* statistic exogeneity tests cannot reject the null hypothesis that the normal route, guided, and female variables are exogenous.

APPENDIX B. HOW IMPORTANT IS THE MISSING DATA PROBLEM?

Table B1 reports summary statistics for the experience levels of the leaders and climbers, the number of climbers, the bottled oxygen choice, and the expedition outcomes for the samples where the Sherpa information is known and unknown. Leader's and climbers' experience levels are higher, bottled oxygen usage is lower, and ascent, deaths, frostbite, and altitude sickness rates are higher for those cases where the Sherpa information is known.[47] We re-estimated the bivariate probit models using the sample excluding those 596 observations where we had assumed zero Sherpas. These results are reported in

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[46] Baum, Schaffer, and Stillman (2002, pp. 14-15) suggest that one should also compare the Shea partial R^2 measure with the normal partial R^2 measure. If the two are different, then only a subset of the instruments may be correlated with the treatments, so the unrestricted model may still be underidentified. However, we found the two partial R^2 measures to be identical, so this was not a problem with this set of instruments and potential endogenous variables.

[47] The mean year for the sample where Sherpas are unknown is 1988.75, while the mean year for the sample where Sherpas is known is 1983.57 (the Kruskal-Wallis test statistic is 245, $p < 0.01$). Thus more recent expeditions have poorer data on Sherpas.

Table B2. With the restricted sample, neither the frostbite nor the altitude sickness equations reject the null hypothesis that bottled oxygen is exogenous (i.e., that $\rho_i = 0$) in any specification. The result in Table 6 that climbers' experience increases the incidence of altitude sickness vanishes; however, Sherpas' experience now decreases the incidence of altitude sickness. We found similar results by including a dummy variable for those 596 observations with missing Sherpa data.

TABLE 1: EXPEDITION SUMMARY STATISTICS BY PERIOD, 1895-1998.

		All 8,000m Peaks						*Everest*	*Kruskal-Wallis*
Variable	*Description*	*1895-1994*	*1895-1945*	*1946-1969*	*1970-1979*	*1980-1989*	*1990-1994*	*1995-1998*	$\chi^2(4)$
Expeditions	Number of expeditions to any 8,000m peak	1766	30	78	146	848	664	143	N.A.
New Routes	Number of new routes attempted	148	12	24	34	61	17	0	***37.54
First Ascents Rte	Number of routes first ascended	130	0	17	32	62	18	1	***18.93
Cumulative Prior Expeditions	Cumulative prior expeditions by any nation to any 8,000m peak	835	15	67	172	632	1367	1819	***1474
Prior National Expeditions	Cumulative prior expeditions by nations on expedition to any 8,000m peak	104	4	11	24	76	173	191	***715.6
Leader's Experience	Average number of prior expeditions to any 8,000m peak by leader(s)	2.19	0.45	1.16	0.95	2.18	2.56	2.80	***47.45
Climbers' Experience	Average number of prior expeditions to any 8,000m peak by climbers	0.51	0.16	0.16	0.16	0.61	0.54	0.36	***39.45
Sherpas' Experience	Average number of prior expeditions to any 8,000m peak by Sherpas	0.64	0.31	0.65	0.57	0.53	0.63	1.39	***25.90
Bottled Oxygen	Dummy variable, = 1 if all members of expedition use bottled oxygen, 0 otherwise	72	53	68	72	63	86	82	***65.72
Normal Route	Dummy variable, = 1 if expedition attempts the "normal route," 0 otherwise	62	57	68	45	57	72	94	***39.74
Guided	Dummy variable, = 1 if expedition is guided, 0 otherwise	3	0	0	0	3	4	14	0.92
Big National	Dummy variable, = 1 if same nationality & number of climbers > 10, 0 otherwise	17	23	33	45	17	11	3	***46.56
International	Dummy variable, = 1 if not all climbers of the same nationality, 0 otherwise	25	13	19	18	21	32	26	***15.76
Climbers	Average number of climbers (including leaders, but excluding Sherpas)	10	10	12	16	9	9	12	***91.42
Sherpas	Average number of high altitude porters	9	20	18	11	5	11	20	***367.1
Female (%)	Average percentage of female climbers	5	2	2	4	5	5	4	6.40
Spring	Dummy variable, = 1 if month is March, April, or May, 0 otherwise	30	45	53	49	26	29	72	***35.38
Summer	Dummy variable, = 1 if month is June, July, or August, 0 otherwise	25	23	17	21	28	27	3	***49.05
Autumn	Dummy variable, = 1 if month is September, October, or November, 0 otherwise	35	10	20	27	34	41	25	***21.32
Winter	Dummy variable, = 1 if month is December, January, or February, 0 otherwise	5	0	1	1	8	3	0	5.00
Nylon Rope	Dummy variable, = 1 if nylon ropes available (1945 forward) , 0 otherwise	0.98	0	1	1	1	1	1	N.A.
Technical Ice Axe	Dummy variable, = 1 if technical ice axes available (1968 forward), 0 otherwise	0.94	0	0.8	1	1	1	1	N.A.
Plastic Boots	Dummy variable, = 1 if plastic boots available (1978 forward), 0 otherwise	0.88	0	0	0.34	1	1	1	N.A.
Congestion	Number of other expeditions on the same route in the same season	2.4	0	0	0.1	1.6	4.4	10.2	***428.4
Wind Speed	In meters per second	3.32	N.A.	N.A.	2.68	3.26	3.42	N.A.	**7.00
Temperature	In degrees Celsius	2.28	N.A.	N.A.	4.41	2.04	2.55	N.A.	1.94
Ascent	Dummy variable, = 1 if any member of expedition makes an ascent, 0 otherwise	45	0	29	47	43	51	54	***34.29
Death	Dummy variable, = 1 if any member of expedition suffers death, 0 otherwise	16	42	29	32	17	10	14	***27.71
Frostbite	Dummy variable, = 1 if any member of expedition suffers frostbite, 0 otherwise	8	13	23	18	9	4	1	**12.61
Altitude Sickness	Dummy variable, = 1 if any member suffers altitude sickness, 0 otherwise	5	10	8	6	7	3	1	2.08
No. Ascents	Average number of climbers per expedition making ascent	1.81	0	1.09	1.88	1.56	2.08	2.73	***37.17
No. Deaths	Average number of climbers per expedition suffering death	0.29	1.90	0.85	0.66	0.25	0.15	0.20	***29.77
No. Frostbites	Average number of climbers per expedition suffering frostbite	0.12	0.13	0.33	0.29	0.12	0.07	0.01	**12.82
No. Alt. Sick.	Average number of climbers per expedition suffering altitude sickness	0.06	0.17	0.10	0.08	0.08	0.03	0.01	2.10

Notes:—Statistics include the full sample of 1,909 expeditions. Season dummies do not add to 100% because of missing season data. The wind speed and temperature Kruskal-Wallis tests have only two degrees of freedom.

TABLE 2: EXPEDITION SUMMARY STATISTICS BY MOUNTAIN, 1895-1994.

Mountain	*Annapurna*	*Broad Peak*	*Cho Oyu*	*Dhaulagiri*	*Everest*	*Gasherbrum II*	*Hidden Peak*	*K2*	*Kangchenjunga*	*Lhotse*	*Makalu*	*Manaslu*	*Nanga Parbat*	*Shisha Pangma*
Height (m)	8091	8047	8201	8167	8848	8035	8068	8611	8586	8516	8463	8163	8126	8027
Location	Nepal	Pakistan /Tibet	Nepal/ Tibet	Nepal	Nepal/ Tibet	Pakistan /Tibet	Pakistan /Tibet	Pakistan /Tibet	Nepal/ India	Nepal/ Tibet	Nepal/ Tibet	Nepal	Pakistan	Tibet
First Ascent	May 1950	June 1957	October 1954	May 1960	May 1953	July 1956	July 1958	July 1954	May 1955	May 1956	May 1955	May 1956	July 1953	May 1964
Nationalities	France	Germany Austria	Austria	Germany Austria Switz.	U.K. N.Z.	Austria	U.S.A.	Italy	U.K.	Switz.	France	Japan	Germany	China
Expeditions	105	115	185	128	348	108	63	102	86	76	112	97	142	99
Routes	18	7	8	13	16	6	10	12	15	8	8	7	9	11
FA Routes	12	6	8	10	15	6	10	10	15	5	8	6	6	8
Percent of Expeditions Choosing:														
Normal Rte.	22.9	87.8	77.8	68.8	64.9	90.7	20.6	49.0	40.7	67.1	44.6	67.0	50.0	81.8
Btl. Oxy.	69.5	76.5	73.0	74.2	76.4	72.2	69.8	61.8	65.1	67.1	63.4	73.2	75.4	77.8
Guided	1.0	3.5	2.7	0	4.9	5.6	4.8	1.0	0	0	0	2.1	1.4	8.1
Percent of Expeditions:														
International	15.2	27.0	31.9	24.2	27.1	18.5	15.8	35.3	22.1	17.1	25.9	21.6	18.3	31.3
Big National	17.1	5.2	6.5	18.0	24.2	9.2	11.1	19.6	25.6	21.1	14.2	20.6	13.4	11.1
Spring	28.6	5.2	36.8	35.2	52.1	5.6	7.9	2.9	54.7	46.1	39.3	39.2	9.9	39.4
Summer	2.9	87.0	3.2	0	4.1	88.0	84.1	90.2	4.7	1.3	0.0	1.0	69.7	1.0
Autumn	53.3	3.5	49.7	54.7	37.1	0.9	3.2	2.0	31.4	46.1	52.7	51.5	6.3	58.6
Winter	15.2	0	5.4	7.8	5.3	0	0	1.0	7.0	6.6	7.1	6.2	3.5	0.0
Mean Climbing Team Size:														
Climbers	8.37	7.82	8.32	8.18	14.25	8.03	7.60	9.28	11.58	7.95	7.21	8.43	8.05	9.96
Sherpas	5.80	5.12	10.40	9.03	14.44	6.70	6.47	4.28	11.06	5.42	6.43	8.65	3.68	10.63
Female (%)	4.0	5.2	5.1	4.5	4.5	8.8	4.6	5.8	4.7	2.7	4.5	3.0	5.3	5.2
Mean Experience (Prior Expeditions):														
Climbers	0.89	1.32	0.96	0.88	0.66	0.72	1.05	2.20	1.27	1.73	1.30	0.62	0.96	1.33
Sherpas	2.96	0.44	1.37	2.97	4.07	0.22	0.09	0.40	5.36	2.67	1.36	1.77	0.18	1.18
Leader	1.84	2.07	1.99	1.65	1.96	1.40	2.41	3.50	1.94	3.05	2.19	2.09	2.13	2.92
Congestion														
Congestion	0.42	5.22	5.58	2.14	4.59	4.84	0.67	1.69	0.22	0.39	0.80	0.54	2.37	2.86
Percent of Expeditions Experiencing:														
Ascent	33.3	45.2	63.8	42.2	42.8	65.7	47.6	34.3	57.0	40.8	29.5	36.1	38.0	65.7
Death	25.7	9.6	6.5	18.8	20.2	11.1	11.1	25.5	23.3	14.5	8.9	19.6	15.5	9.1
Frostbite	7.6	6.1	4.3	7.0	6.7	5.6	6.3	11.8	14.0	10.5	10.7	10.3	9.9	6.1
Alt. Sick.	3.8	0.9	3.2	6.3	5.3	11.1	1.6	8.8	7.0	1.3	6.3	1.0	9.2	3.0
Mean Members per Expedition Experiencing:														
Ascent	0.93	1.67	2.59	1.64	1.93	2.58	1.43	1.14	2.48	1.12	0.85	1.16	0.83	3.10
Death	0.45	0.09	0.09	0.34	0.46	0.14	0.17	0.34	0.45	0.21	0.10	0.48	0.40	0.13
Frostbite	0.14	0.08	0.07	0.12	0.14	0.08	0.06	0.13	0.20	0.22	0.13	0.21	0.13	0.07
Alt. Sick.	0.04	0.04	0.04	0.06	0.09	0.12	0.02	0.09	0.07	0.01	0.10	0.01	0.11	0.04

Notes:—Statistics are based on the sample of 1,766 expeditions recorded prior to 1995. Everest data for 1995-98 is contained in Table 1. The first ascent countries exclude Sherpas who were on the first ascent of Everest (Tenzing Norgay, India), Cho Oyu (Pasang Dawa Lama, India), Manaslu (Gyalzen Noru Sherpa, Nepal), and Dhaulagiri (Nawang Dorje Sherpa and Nima Dorje Sherpa, Nepal). Shisha Pangma's first ascent included four Tibetans (Doje, Mima Zaxi, Sodnam Doje, and Yungden). In addition, Sherpa Gyalzen Noru Sherpa (Nepal) made the ascent of Makalu with the first ascent expedition, but a day later than the first ascentionists.

TABLE 3: EXPEDITION SUMMARY STATISTICS BY COUNTRY, 1895-1998.

	Expeditions 1895-1998		*Percentage of All Expeditions in Period*							*Percent Experiencing*				*Percent Choosing*		*Number of*		*Prior Experience of*		
			All 8,000m Peaks						*Everest 1995-1998*											
	Total	*(%) Int'l*	*1895-1994*	*1895-1949*	*1950-1969*	*1970-1979*	*1980-1989*	*1990-1994*		*Ascent*	*Death*	*Frost-bite*	*Altitude Sickness*	*Normal Route*	*Bottled Oxygen*	*Climbers*	*Sherpas*	*Leader*	*Team*	*Sherpas*
Australia/New Zealand	92	68.5	4.8	–	6.5	1.4	3.3	6.8	8.4	48.9	15.2	12	5.4	76.1	72.8	8.72	8.31	3.08	0.7	0.89
Austria	146	67.1	7.6	–	10.4	17.8	8.3	5.3	4.9	54.8	16.4	13.7	3.4	72.6	71.9	10.05	7.4	2.73	0.76	0.52
Canada	57	59.6	3	3.2	–	–	3.3	3.8	2.1	43.9	17.5	10.5	19.3	66.7	71.9	9.95	5.8	2.26	0.69	0.85
China/Tibet	29	37.9	1.5	–	6.5	2.1	0.4	2	3.5	69	34.5	3.4	10.3	96.6	79.3	44.33	46.76	0.59	0.31	0.44
Czechoslovakia	56	67.9	2.9	–	1.3	2.1	3.5	3	1.4	58.9	23.2	5.4	8.9	37.5	60.7	12.09	5.63	2.89	0.96	0.47
France	212	35.4	11.1	3.2	7.8	8.9	13.6	10.5	4.9	43.9	14.2	6.1	3.8	62.7	62.3	7.74	7.02	2.92	0.52	0.49
Germany	194	64.9	10.2	32.3	19.5	15.8	8.4	10.1	5.6	50	18	10.3	3.6	66.5	73.7	10.14	9.01	3.38	0.63	0.45
Great Britain	182	57.7	9.5	41.9	16.9	8.9	7.5	9.2	12.6	39	18.1	9.3	6.6	61	64.8	9.88	10.35	3.35	0.79	0.65
India	24	33.3	1.3	–	5.2	2.1	0.6	1.2	2.8	54.2	50	20.8	8.3	66.7	91.7	19.9	31.87	1.75	0.33	1.26
Italy	190	51.6	10	3.2	1.3	8.2	10.6	11.9	4.9	51.6	11.6	5.8	4.7	60.5	68.9	8.95	8.63	4.1	0.89	0.4
Japan	239	9.2	12.5	3.2	10.4	21.2	13.7	10.1	11.2	49	18.8	4.2	2.9	58.2	78.2	12.21	12.11	1.45	0.27	1.06
Korea	91	2.2	4.8	–	–	3.4	4.1	6.6	4.9	44	22	3.3	0	68.1	95.6	11.72	14.72	0.51	0.13	1.3
Latin America	77	59.7	4	–	2.6	2.7	3.1	5.6	5.6	55.8	20.8	13	5.2	77.9	81.8	10.32	10.41	3.1	0.59	0.74
Netherlands	54	44.4	2.8	–	1.3	0.7	2.6	3.9	2.8	53.7	13	3.7	7.4	79.6	83.3	8.17	8.29	2.27	0.63	1.16
Pakistan/Nepal	28	60.7	1.5	–	1.3	1.4	1.3	2	0.7	57.1	25	14.3	3.6	82.1	75	14.8	6.7	2.52	0.74	1.23
Poland	132	68.9	6.9	–	2.6	9.6	8.4	5.9	4.2	59.1	22	13.6	6.1	46.2	57.6	9.71	5.18	5.5	1.81	0.55
Scandinavia	43	62.8	2.3	–	1.3	1.4	0.7	3.8	6.3	60.5	16.3	9.3	9.3	81.4	83.7	11.03	15.9	2.29	0.66	0.99
Soviet Union	51	49	2.8	–	2.6	–	0.8	5.1	7	77.4	24.5	5.7	7.5	58.5	79.2	14.26	10.78	2.44	0.55	0.97
Spain	218	18.3	11.4	–	–	6.2	10.8	16.1	7	43.6	12.4	6	5	75.7	84.9	7.51	8.53	1.24	0.46	0.63
Switzerland	176	58.5	9.2	16.1	16.9	4.8	10.6	8.3	4.2	51.1	17.6	6.8	7.4	70.5	72.2	9.59	7.78	4.09	0.84	0.37
United States	274	55.5	14.4	9.7	16.9	13	12.7	16	17.5	40.9	14.6	9.1	9.1	62.4	68.6	9.85	8.35	2.51	0.71	0.86
Yugoslavia	59	32.2	3.1	–	–	4.1	3.2	3.2	3.5	49.2	13.6	11.9	5.1	40.7	66.1	10.35	5.22	1.95	0.92	0.07
Other Eastern Europe	22	40.9	1.3	–	–	–	0.9	2	2.1	58.3	25	16.7	4.2	75	91.7	9.97	10.48	1.77	0.4	0.29
Other Countries	55	47.3	2.9	–	–	4.1	0.5	3.6	14.7	65.5	5.5	1.8	1.8	83.6	81.8	10.81	31.9	3.65	0.43	1.2
International	475	100	24.8	13.3	19.2	18.5	21.5	31.6	25.9	56.8	17.7	9.1	6.3	68.6	71.4	10.96	10.01	3.89	1.04	0.77

Notes:— There are 1,909 unique expeditions in the years 1895-1998. In the "Expeditions 1895-1998" columns, the "Total" column contains the number of expeditions that include at least one member from that country group, and the "(%) Int'l" column contains the percentage of expeditions in which a member from that country has teammates from one or more other countries. The sum of the country percentages of expeditions in any given period is greater than 100% because of international expeditions. The "Pakistan/Nepal" row excludes expeditions where nationals from those countries serve as high altitude porters or guides for other expeditions. The "international" row contains data for expeditions involving more than one nation.

TABLE 4: EXPEDITION OUTCOMES BY EXPEDITION CHARACTERISTIC.

		Number of Observations	*Expedition Outcomes (%)*			
			Ascent	*Deaths*	*Frostbite*	*Altitude Sickness*
Cumulative Prior Expeditions	≤ 900	978	42.6	20.7	11.8	7.4
	> 900	931	48.8	11.3	3.5	2.7
	Kruskal-Wallis $\chi^2(1)$		7.64	***30.85	***45.81	***22.35
Cumulative Prior National Expeditions	≤ 100	1095	42.7	19.2	10.4	6.3
	> 100	814	49.6	12.0	4.2	3.5
	Kruskal-Wallis $\chi^2(1)$		***8.93	***17.98	***24.21	***7.18
Leader's Prior Experience	= 0	853	39.9	16.8	8.1	4.4
	> 0	1056	50.2	15.6	7.5	5.6
	Kruskal-Wallis $\chi^2(1)$		***20.19	0.54	0.17	1.45
Climber's Prior Experience	= 0	971	32.2	13.1	6.1	3.1
	> 0	938	59.6	19.4	9.6	7.2
	Kruskal-Wallis $\chi^2(1)$		***143.8	***14.05	***8.20	***16.94
Sherpa's Prior Experience	= 0	1548	40.2	13.8	7.0	5.4
	> 0	361	68.9	26.3	11.1	4.1
	Kruskal-Wallis $\chi^2(1)$		***97.34	***33.65	***6.63	0.87
Bottled Oxygen	'No' = 0	518	49.0	14.5	12.0	6.9
	'Yes' = 1	1391	44.4	16.8	6.3	4.5
	Kruskal-Wallis $\chi^2(1)$		*3.22	1.52	***17.12	**4.81
Normal Route	'No' = 0	677	34.6	19.1	9.7	6.1
	'Yes' = 1	1232	51.8	14.6	6.7	4.6
	Kruskal-Wallis $\chi^2(1)$		***52.19	**6.35	**5.50	1.83
Guided Expedition	'No' = 0	1840	44.6	16.3	7.9	5.1
	'Yes' = 1	69	75.4	14.5	4.3	5.8
	Kruskal-Wallis $\chi^2(1)$		***25.40	0.15	1.18	0.06
Number of Climbers	≤ 6	992	39.4	9.5	5.7	4.0
	> 6	917	52.4	23.4	10.0	6.3
	Kruskal-Wallis $\chi^2(1)$		***32.62	***68.51	***12.16	**5.14
Number of Sherpas	= 0	1297	40.0	11.5	5.8	5.5
	> 0	612	57.7	26.1	12.1	4.4
	Kruskal-Wallis $\chi^2(1)$		***52.26	***65.79	***22.98	0.96
Big National Expedition	'No' = 0	1133	44.5	13.6	6.7	4.6
	'Yes' = 1	319	51.4	28.8	13.2	7.8
	Kruskal-Wallis $\chi^2(1)$		***5.07	***45.17	***15.28	**5.74
International Expedition	'No' = 0	1434	41.9	15.6	7.4	4.7
	'Yes' = 1	475	56.8	17.6	9.1	6.3
	Kruskal-Wallis $\chi^2(1)$		***31.74	1.04	1.36	1.81
Female (%)	= 0	1538	42.3	15.5	7.3	4.9
	> 0	371	59.6	19.1	9.7	6.2
	Kruskal-Wallis $\chi^2(1)$		***35.78	*2.954	2.30	1.07
Autumn	'No' = 0	1262	48.5	16.4	7.6	5.9
	'Yes' = 1	647	40.1	15.7	8.0	3.6
	Kruskal-Wallis $\chi^2(1)$		***11.89	0.12	0.07	**5.06
Winter	'No' = 0	1816	46.6	15.9	7.7	5.1
	'Yes' = 1	93	25.8	20.4	9.6	5.3
	Kruskal-Wallis $\chi^2(1)$		***15.50	1.29	0.47	0.12
Congestion	= 0	838	37.9	21.1	11.8	5.9
	> 0	1071	51.7	12.3	4.6	4.8
	Kruskal-Wallis $\chi^2(1)$		***35.95	***28.80	***33.34	2.12
Nylon Rope	'No' = 0	30	0	43.3	13.3	10.0
	'Yes' = 1	1879	46.4	15.7	7.7	5.0
	Kruskal-Wallis $\chi^2(1)$		***25.16	***16.57	1.29	1.48
Technical Ice Axe	'No' = 0	102	21.5	32.3	20.5	7.8
	'Yes' = 1	1807	47.0	15.2	7.0	4.9
	Kruskal-Wallis $\chi^2(1)$		***25.23	***20.74	***24.45	1.62
Plastic Boots	'No' = 0	205	32.1	32.1	19.0	7.3
	'Yes' = 1	1704	47.3	14.2	6.4	4.8
	Kruskal-Wallis $\chi^2(1)$		***16.81	***43.36	***40.15	2.24

Notes:—Statistics are for all 1,909 observations. The Kruskal-Wallis tests for the expedition outcomes take into account the ties. Results are significant at the 1% ("***"), 5% ("**"), and 10% ("*") level, respectively.

TABLE 5: PROBIT ESTIMATION OF OUTCOME EQUATIONS

Dependent Variable:	*Ascent*			*Deaths*			*Frostbite*			*Altitude Sickness*		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Cumulative Prior Expeditions	0.0001	-0.0000	0.0002	-0.0005***	-0.0004***	-0.0007***	-0.0006***	-0.0005**	-0.0005*	-0.0002	-0.0003	-0.0005
	(0.84)	(-0.17)	(0.98)	(-3.73)	(-2.82)	(-3.23)	(-3.18)	(-2.47)	(-1.88)	(-0.9)	(-1.3)	(-1.56)
Cumulative Prior National Expeditions	-0.0007	-0.0006	-0.0023**	0.0005	0.0005	0.0007	0.0006	0.0005	-0.0002	-0.0020*	-0.0019*	0.0005
	(-1.11)	(-0.97)	(-2.38)	(0.75)	(0.71)	(0.67)	(0.61)	(0.52)	(-0.12)	(-1.74)	(-1.66)	(0.35)
Leader's Experience	0.021*	0.021*	0.016	-0.002	-0.000	0.001	-0.002	-0.002	-0.013	0.002	0.002	-0.010
	(1.93)	(1.85)	(1.2)	(-0.18)	(-0.01)	(0.06)	(-0.12)	(-0.15)	(-0.71)	(0.11)	(0.11)	(-0.42)
Climbers' Experience	0.187***	0.181***	0.203***	-0.007	-0.001	0.014	-0.049	-0.041	-0.033	0.083	0.078	0.110*
	(5.28)	(5.07)	(4.29)	(-0.17)	(-0.03)	(0.28)	(-0.91)	(-0.77)	(-0.53)	(1.58)	(1.46)	(1.71)
Sherpas' Experience	0.125***	0.125***	0.064***	0.026	0.027	0.035	0.008	0.008	0.017	-0.032	-0.030	-0.020
	(6.26)	(6.23)	(2.89)	(1.4)	(1.45)	(1.6)	(0.29)	(0.26)	(0.54)	(-0.82)	(-0.79)	(-0.48)
Bottled Oxygen	-0.462***	-0.447***	-0.581***	0.164*	0.161*	0.236*	-0.260**	-0.269**	-0.180	-0.094	-0.085	-0.211
	(-5.51)	(-5.29)	(-5.47)	(1.74)	(1.7)	(1.96)	(-2.42)	(-2.5)	(-1.33)	(-0.74)	(-0.66)	(-1.36)
Normal Route	0.328***	0.366***	0.340***	-0.077	-0.085	-0.081	0.044	0.031	-0.008	-0.008	0.017	0.028
	(3.85)	(4.24)	(3.15)	(-0.82)	(-0.9)	(-0.68)	(0.39)	(0.27)	(-0.06)	(-0.06)	(0.13)	(0.17)
Guided	0.531**	0.507**	0.572*	-0.098	-0.086	-0.092	-0.070	-0.055	-0.441	0.450	0.437	0.376
	(2.49)	(2.37)	(1.95)	(-0.43)	(-0.37)	(-0.31)	(-0.22)	(-0.17)	(-0.95)	(1.46)	(1.41)	(1)
Number of Climbers	0.021***	0.018**	0.037***	0.004	0.005	0.004	-0.002	-0.002	-0.008	-0.000	-0.001	0.004
	(2.81)	(2.43)	(3.23)	(0.86)	(0.94)	(0.65)	(-0.33)	(-0.26)	(-0.65)	(-0.01)	(-0.21)	(0.4)
Number of Sherpas	0.010**	0.014***	0.094***	0.012**	0.010**	-0.011	0.004	0.003	-0.005	0.005	0.007	0.001
	(2.08)	(2.74)	(4.85)	(2.22)	(2)	(-0.73)	(0.76)	(0.54)	(-0.29)	(1.1)	(1.36)	(0.06)
Female Climbers	0.599**	0.546**	0.198	0.195	0.216	0.299	-0.117	-0.094	0.187	-0.163	-0.198	-0.123
	(2.38)	(2.16)	(0.64)	(0.71)	(0.79)	(0.89)	(-0.32)	(-0.26)	(0.46)	(-0.39)	(-0.47)	(-0.27)
Big National Expedition	0.257**	0.280**	-0.026	0.189	0.187	0.122	0.356**	0.337**	0.326	0.246	0.249	0.165
	(2.12)	(2.3)	(-0.15)	(1.64)	(1.6)	(0.81)	(2.48)	(2.32)	(1.56)	(1.52)	(1.51)	(0.74)
International Expedition	-0.126	-0.121	-0.195	-0.021	-0.019	-0.022	0.170	0.162	0.155	0.158	0.155	0.103
	(-0.95)	(-0.91)	(-1.13)	(-0.15)	(-0.13)	(-0.11)	(0.97)	(0.93)	(0.67)	(0.76)	(0.74)	(0.39)
Autumn	-0.234***	-0.252***	-0.244**	0.161	0.172*	0.099	0.261**	0.283**	0.318**	-0.065	-0.086	0.049
	(-2.73)	(-2.93)	(-2.27)	(1.63)	(1.73)	(0.79)	(2.16)	(2.31)	(2.12)	(-0.45)	(-0.59)	(0.28)
Winter	-0.713***	-0.760***	-0.089	0.119	0.149	-0.157	0.249	0.279	-0.463	-0.018	-0.044	0.609
	(-4)	(-4.22)	(-0.34)	(0.66)	(0.82)	(-0.56)	(1.12)	(1.24)	(-1.27)	(-0.06)	(-0.16)	(1.47)
Congestion	0.091***	0.090***	0.101***	0.016	0.013	0.001	-0.038	-0.037	-0.031	-0.012	-0.012	-0.023
	(6.29)	(6.22)	(5)	(1.02)	(0.86)	(0.03)	(-1.51)	(-1.51)	(-0.98)	(-0.49)	(-0.48)	(-0.71)
Nylon Rope		N.A.			-0.593*			0.418			-0.171	
					(-1.94)			(1.15)			(-0.39)	
Technical Ice Axe		0.639***			0.085			-0.157			0.311	
		(2.96)			(0.37)			(-0.64)			(0.88)	
Plastic Boots		0.057			-0.179			-0.170			0.095	
		(0.35)			(-1.07)			(-0.89)			(0.38)	
Wind Speed			-0.090***			-0.035			0.015			0.036
			(-2.95)			(-1.02)			(0.38)			(0.71)
Temperature			0.047***			-0.013			-0.036***			0.030*
			(4.03)			(-1.09)			(-2.67)			(1.66)

Table continued on next page.

TABLE 5: PROBIT ESTIMATION OF OUTCOME EQUATIONS (CONTINUED)

Dependent Variable:	*Ascent*			*Deaths*			*Frostbite*			*Altitude Sickness*		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Number of Observations	1742	1742	1228	1742	1742	1228	1742	1742	1228	1666	1666	1106
Log Likelihood function	-973.1	-965.5	-645.7	-721.3	-718.0	-470.2	-447.3	-445.8	-302.7	-321.1	-320.1	-235.2
Pseudo R^2	0.194	0.200	0.241	0.104	0.108	0.117	0.121	0.124	0.101	0.132	0.135	0.150
Likelihood Ratio Test	468.3***	483.4***	409.8***	167.3***	173.8***	124.5***	123.0***	125.9***	68.2*	97.8***	99.8***	83.2***
Degrees of Freedom	52	54	54	52	55	54	52	55	54	51	54	51
Test that Technology = 0, χ^2(d.f.)		14.420***			6.630*			2.940			1.900	
Degrees of Freedom		2			3			3			3	

Notes:—Asymptotic *t*-statistics in parentheses. "***" significant at 1% level; "**" significant at the 5% level, "*" significant at 10% level. Nylon Rope is excluded from the Ascent equations, as no ascents occurred before 1945. Korea is excluded from the altitude sickness equations because no Korean expedition reported altitude sickness. Lhotse and Other Countries are excluded from model 3 of the altitude sickness equations as they perfectly predict altitude sickness. Annapurna is the omitted mountain and United States is the omitted country. Mountain and country fixed effects are not reported.

TABLE 6: BIVARIATE PROBIT ESTIMATION OF OUTCOME EQUATIONS.

Dependent Variable:	*Ascent*			*Deaths*			*Frostbite*			*Altitude Sickness*		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Cumulative Prior Expeditions	-0.000	-0.000 *	0.000	-0.001 ***	-0.001 ***	-0.001 ***	-0.001 ***	-0.001 ***	-0.001 **	-0.0002 *	-0.001 **	-0.001 **
	(-0.68)	(-1.8)	(0.46)	(-5.23)	(-4.4)	(-5.35)	(-3.67)	(-2.84)	(-2.05)	(-1.93)	(-2.24)	(-1.97)
Cumulative Prior National Expeditions	-0.001	-0.001	-0.002 **	0.000	0.000	0.000	0.001	0.000	-0.000	-0.002	-0.002	0.001
	(-1.11)	(-0.96)	(-2.34)	(0.53)	(0.51)	(0.57)	(0.6)	(0.52)	(-0.04)	(-1.52)	(-1.45)	(0.75)
Leader’s Experience	0.036 ***	0.036 ***	0.020	0.020	0.021	0.024	0.013	0.010	-0.003	0.020	0.019	-0.007
	(3.08)	(3.11)	(1.3)	(1.44)	(1.55)	(1.63)	(0.71)	(0.55)	(-0.13)	(0.99)	(0.93)	(-0.28)
Climbers’ Experience	0.193 ***	0.184 ***	0.210 ***	0.022	0.023	0.073	-0.034	-0.031	-0.017	0.104 **	0.097 *	0.121 *
	(5.57)	(5.31)	(4.31)	(0.56)	(0.6)	(1.6)	(-0.63)	(-0.58)	(-0.26)	(2.03)	(1.85)	(1.85)
Sherpas’ Experience	0.113 ***	0.111 ***	0.061 ***	0.012	0.013	0.015	-0.002	-0.001	0.009	-0.047	-0.045	-0.035
	(5.56)	(5.49)	(2.69)	(0.65)	(0.72)	(0.67)	(-0.06)	(-0.02)	(0.28)	(-1.23)	(-1.19)	(-0.83)
Bottled Oxygen	0.342	0.419 *	-0.365	1.151 ***	1.138 ***	1.308 ***	0.409	0.289	0.324	0.546	0.526	-0.052
	(1.33)	(1.69)	(-0.83)	(4.76)	(4.8)	(4)	(0.91)	(0.66)	(0.55)	(1.41)	(1.32)	(-0.11)
Normal Route	0.235 ***	0.262 ***	0.328 ***	-0.157 *	-0.161 *	-0.116	-0.018	-0.018	-0.027	-0.067	-0.041	-0.031
	(2.61)	(2.87)	(2.95)	(-1.74)	(-1.77)	(-1.05)	(-0.15)	(-0.15)	(-0.19)	(-0.51)	(-0.3)	(-0.19)
Guided	0.452 **	0.418 **	0.551 *	-0.231	-0.225	-0.188	-0.157	-0.132	-0.507	0.346	0.335	0.311
	(2.14)	(1.98)	(1.86)	(-1.04)	(-1.01)	(-0.68)	(-0.5)	(-0.42)	(-1.1)	(1.11)	(1.07)	(0.82)
Number of Climbers	0.007	0.004	0.032 **	-0.004	-0.004	-0.009	-0.012	-0.009	-0.020	-0.004	-0.004	0.001
	(1)	(0.6)	(2.03)	(-0.93)	(-0.82)	(-0.97)	(-0.86)	(-0.69)	(-0.93)	(-0.58)	(-0.67)	(0.08)
Number of Sherpas	0.007	0.011 **	0.092 ***	0.007	0.007	-0.025	0.001	0.001	-0.011	0.003	0.005	-0.001
	(1.5)	(2.23)	(4.56)	(1.44)	(1.35)	(-1.63)	(0.27)	(0.24)	(-0.58)	(0.6)	(0.92)	(-0.06)
Female Climbers	0.662 ***	0.612 **	0.225	0.328	0.344	0.548 *	-0.009	-0.004	0.256	0.004	-0.034	-0.002
	(2.7)	(2.5)	(0.72)	(1.25)	(1.31)	(1.82)	(-0.03)	(-0.01)	(0.63)	(0.01)	(-0.08)	(0)
Big National Expedition	0.235 **	0.254 **	-0.006	0.052	0.061	0.051	0.311 **	0.299 *	0.359	0.105	0.122	0.106
	(2.07)	(2.24)	(-0.03)	(0.45)	(0.53)	(0.35)	(1.97)	(1.87)	(1.58)	(0.62)	(0.71)	(0.48)
International Expedition	-0.075	-0.068	-0.178	0.013	0.014	0.166	0.185	0.176	0.187	0.095	0.092	-0.033
	(-0.57)	(-0.52)	(-1.01)	(0.09)	(0.1)	(1.14)	(1.08)	(1.02)	(0.82)	(0.48)	(0.45)	(-0.13)
Autumn	-0.226 ***	-0.248 ***	-0.239 **	0.140	0.143	0.083	0.246 **	0.268 **	0.316 **	-0.075	-0.099	0.035
	(-2.7)	(-2.94)	(-2.22)	(1.49)	(1.51)	(0.74)	(2.05)	(2.2)	(2.14)	(-0.54)	(-0.7)	(0.2)
Winter	-0.626 ***	-0.672 ***	-0.079	0.181	0.193	-0.151	0.289	0.306	-0.429	-0.048	-0.088	0.519
	(-3.51)	(-3.77)	(-0.3)	(1.06)	(1.13)	(-0.59)	(1.33)	(1.39)	(-1.19)	(-0.18)	(-0.33)	(1.33)
Congestion	0.082 ***	0.081 ***	0.097 ***	0.006	0.005	-0.018	-0.043 *	-0.042 *	-0.042	-0.016	-0.015	-0.026
	(5.59)	(5.55)	(4.45)	(0.43)	(0.34)	(-0.77)	(-1.78)	(-1.71)	(-1.23)	(-0.66)	(-0.62)	(-0.8)
Nylon Rope		N.A.			-0.578 **			0.382			-0.217	
					(-1.97)			(1.06)			(-0.51)	
Technical Ice Axe		0.591 ***			0.076			-0.147			0.270	
		(2.8)			(0.35)			(-0.6)			(0.79)	
Plastic Boots		0.160			-0.041			-0.099			0.182	
		(1.01)			(-0.25)			(-0.5)			(0.74)	
Wind Speed			-0.089 ***			-0.027			0.015			0.034
			(-2.93)			(-0.85)			(0.38)			(0.7)
Temperature			0.047 ***			-0.013			-0.035 **			0.030 *
			(4.02)			(-1.25)			(-2.59)			(1.71)

Table continued on next page.

TABLE 6: BIVARIATE PROBIT ESTIMATION OF OUTCOME EQUATIONS (CONTINUED).

Dependent Variable:	*Ascent*			*Deaths*			*Frostbite*			*Altitude Sickness*		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Number of Observations	1742	1742	1228	1742	1742	1228	1742	1742	1228	1742	1742	1228
Log Likelihood function	-1767.6	-1756.7	-1179.8	-1510.7	-1505.1	-1014.5	-1243.7	-1239.5	-836.5	-1127.6	-1123.7	-781.5
Wald Test, χ^2(d.f.)	792.6 ***	817.8 ***	583.4 ***	633.8 ***	640.0 ***	497.3 ***	461.1 ***	463.1 ***	360.5 ***	447.4 ***	450.4 ***	366.7 ***
Degrees of Freedom	104	108	108	105	111	79	104	110	108	102	108	102
ρ_i	-0.466	-0.501	-0.087	-0.575	-0.578	-0.778	-0.418	-0.350	-0.265	-0.428	-0.413	-0.112
LR Test that $\rho_i = 0$, $\chi^2(1)$	5.956 **	6.438 **	0.105	7.132 ***	7.606 ***	7.493 ***	2.986 *	2.288	0.731	2.825 *	2.526	0.158
Test that Technology = 0, χ^2(d.f.)		17.580 ***			4.480			1.680			2.600	
Degrees of Freedom		2			3			3			3	

Notes:—Asymptotic *t*-statistics in parentheses. Wald test values are for the whole bivariate probit model, including the bottled oxygen selection equation reported in Table 7. "***" significant at 1% level; "**" significant at the 5% level, "*" significant at 10% level. In model 3 of the deaths equation, countries that are insignificant in both the outcome and treatment equations for models 1 and 2 estimation were omitted (to force the estimate of ρ from –1). See the notes to Table 5 for the explanation of the other exclusion restrictions. Mountain and country effects are not reported.

TABLE 7: BIVARIATE PROBIT ESTIMATION OF BOTTLED OXYGEN TREATMENT EQUATIONS.

Dependent Variable:	*Ascent Covariate*			*Deaths Covariate*			*Frostbite Covariate*			*Altitude Sickness Covariate*		
Bottled Oxygen	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Cumulative Prior Expeditions	0.0009 ***	0.0010 ***	0.0012 ***	0.0009 ***	0.0010 ***	0.0011 ***	0.0009 ***	0.0010 ***	0.0012 ***	0.0009 ***	0.0010 ***	0.0013 ***
	(6.59)	(6.84)	(5.79)	(6.34)	(6.63)	(6.59)	(6.34)	(6.71)	(5.78)	(6.96)	(7.26)	(6.35)
Cumulative Prior National Expeditions	-0.0003	-0.0003	-0.0005	0.0000	0.0000	-0.0001	0.0000	-0.0000	-0.0005	-0.0002	-0.0003	-0.0008
	(-0.35)	(-0.43)	(-0.43)	(0.07)	(0.01)	(-0.17)	(0.01)	(-0.07)	(-0.42)	(-0.32)	(-0.36)	(-0.74)
Leader’s Experience	-0.044 ***	-0.045 ***	-0.042 **	-0.039 ***	-0.042 ***	-0.040 **	-0.042 ***	-0.044 ***	-0.041 **	-0.043 ***	-0.044 ***	-0.040 **
	(-3.23)	(-3.3)	(-2.47)	(-2.85)	(-3.02)	(-2.45)	(-3.12)	(-3.22)	(-2.44)	(-3.18)	(-3.26)	(-2.41)
Climbers’ Experience	-0.059 *	-0.053	-0.102 **	-0.033	-0.030	-0.069	-0.049	-0.043	-0.098 **	-0.054	-0.047	-0.103 **
	(-1.66)	(-1.49)	(-2.21)	(-0.92)	(-0.82)	(-1.51)	(-1.41)	(-1.21)	(-2.14)	(-1.55)	(-1.34)	(-2.24)
Sherpas’ Experience	0.027	0.027	0.055 *	0.034	0.035	0.053 *	0.025	0.026	0.053 *	0.035	0.036	0.066 **
	(1.14)	(1.12)	(1.81)	(1.47)	(1.51)	(1.89)	(1.1)	(1.14)	(1.78)	(1.52)	(1.54)	(2.17)
Normal Route	0.275 ***	0.278 ***	0.126	0.257 ***	0.265 ***	0.126	0.271 ***	0.274 ***	0.117	0.292 ***	0.296 ***	0.129
	(3.11)	(3.12)	(1.11)	(2.93)	(2.98)	(1.16)	(3.04)	(3.05)	(1.04)	(3.31)	(3.32)	(1.18)
Guided	0.505 *	0.519 **	0.606 *	0.405	0.415	0.491	0.492 *	0.502 *	0.612 *	0.428 *	0.444 *	0.619 *
	(1.95)	(1.99)	(1.72)	(1.58)	(1.61)	(1.45)	(1.89)	(1.92)	(1.75)	(1.67)	(1.72)	(1.76)
Number of Climbers	0.097 ***	0.097 ***	0.108 ***	0.099 ***	0.100 ***	0.114 ***	0.096 ***	0.098 ***	0.108 ***	0.098 ***	0.098 ***	0.105 ***
	(9.24)	(9.19)	(7.91)	(9.18)	(9.33)	(8.73)	(8.97)	(9.07)	(7.96)	(9.26)	(9.27)	(7.81)
Number of Sherpas	0.024 ***	0.024 ***	0.034 *	0.023 ***	0.019 **	0.044 **	0.024 ***	0.020 **	0.035 *	0.020 **	0.017 *	0.035 *
	(2.82)	(2.63)	(1.9)	(2.63)	(2.08)	(2.39)	(2.67)	(2.09)	(1.95)	(2.23)	(1.81)	(1.91)
Female	-0.420 *	-0.422 *	-0.503	-0.417 *	-0.420 *	-0.431	-0.446 *	-0.438 *	-0.520	-0.439 *	-0.439 *	-0.523 *
	(-1.67)	(-1.67)	(-1.58)	(-1.67)	(-1.68)	(-1.45)	(-1.75)	(-1.71)	(-1.62)	(-1.75)	(-1.74)	(-1.66)
Big National Expedition	-0.350 **	-0.386 **	-0.494 **	-0.305 **	-0.358 **	-0.531 ***	-0.358 **	-0.398 ***	-0.506 ***	-0.336 **	-0.377 **	-0.464 **
	(-2.35)	(-2.56)	(-2.56)	(-2)	(-2.34)	(-2.81)	(-2.39)	(-2.62)	(-2.62)	(-2.27)	(-2.51)	(-2.43)
International Expedition	-0.288 **	-0.296 **	-0.323 *	-0.296 **	-0.304 **	-0.097	-0.283 *	-0.286 *	-0.327 *	-0.185	-0.191	-0.208
	(-1.99)	(-2.04)	(-1.74)	(-2.06)	(-2.1)	(-0.65)	(-1.94)	(-1.95)	(-1.76)	(-1.29)	(-1.33)	(-1.15)
Autumn	0.116	0.140	-0.003	0.097	0.120	-0.007	0.093	0.119	-0.012	0.113	0.138	0.002
	(1.23)	(1.48)	(-0.02)	(1.04)	(1.27)	(-0.06)	(0.98)	(1.25)	(-0.1)	(1.2)	(1.46)	(0.02)
Winter	-0.131	-0.092	-0.160	-0.141	-0.107	-0.069	-0.167	-0.124	-0.191	-0.031	0.010	0.006
	(-0.76)	(-0.53)	(-0.6)	(-0.81)	(-0.61)	(-0.26)	(-0.97)	(-0.71)	(-0.71)	(-0.19)	(0.06)	(0.02)
Congestion	0.034 **	0.032 **	0.093 ***	0.034 **	0.032 **	0.088 ***	0.035 **	0.033 **	0.094 ***	0.030 *	0.028 *	0.089 ***
	(2.21)	(2.06)	(3.81)	(2.23)	(2.08)	(3.77)	(2.24)	(2.1)	(3.89)	(1.95)	(1.82)	(3.71)
Nylon Rope		N.A.			0.100			0.128			0.147	
					(0.31)			(0.41)			(0.47)	
Technical Ice Axe		0.114			0.109			0.030			0.070	
		(0.53)			(0.47)			(0.13)			(0.3)	
Plastic Boots		-0.341 **			-0.360 **			-0.348 **			-0.370 **	
		(-1.98)			(-2.07)			(-2)			(-2.14)	
Wind Speed			0.001			0.008			-0.001			-0.006
			(0.03)			(0.26)			(-0.02)			(-0.2)
Temperature			-0.003			0.000			-0.004			-0.001
			(-0.3)			(0.02)			(-0.33)			(-0.05)

Table continued on next page.

TABLE 7: BIVARIATE PROBIT ESTIMATION OF BOTTLED OXYGEN TREATMENT EQUATIONS (CONTINUED).

Dependent Variable:	*Ascent Covariate*			*Deaths Covariate*			*Frostbite Covariate*			*Altitude Sickness Covariate*		
Bottled Oxygen	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Leader Prior Bottled Oxygen Free	-0.209 **	-0.188 **	-0.221 *	-0.126	-0.100	-0.064	-0.226 **	-0.199 **	-0.228 *	-0.244 **	-0.220 **	-0.272 **
	(-2.2)	(-1.98)	(-1.82)	(-1.31)	(-1.03)	(-0.52)	(-2.33)	(-2.03)	(-1.9)	(-2.52)	(-2.24)	(-2.27)
Team Climbed on an Expedition Experiencing a Death	N.A.	N.A.	N.A.	-0.252 ***	-0.227 ***	-0.279 **	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
				(-2.96)	(-2.61)	(-2.59)						
Joint Test that Instruments = 0	4.830 **	3.920 **	3.310 *	11.730 ***	8.700 **	7.180 **	5.430 **	4.110 **	3.600 *	6.330 **	5.020 **	5.170 **
Degrees of Freedom	1	1	1	2	2	2	1	1	1	1	1	1

Notes:— The "Joint Test that Instruments = 0" is the likelihood ratio test of the null hypothesis that "Leader Prior Bottled Oxygen Free" (and "Team Climbed on an Expedition Experiencing a Death" in the deaths model) are (jointly) equal to zero in the Bottled Oxygen treatment equation. See the notes to Table 6. Mountain and country effects are not reported.

TABLE 8: EXOGENEITY OF “LEADER PRIOR BOTTLED OXYGEN FREE” AND “TEAM CLIMBED ON AN EXPEDITION EXPERIENCING DEATH” INSTRUMENTS.

Model		*(1)*		*(2)*		*(3)*	
Dependent Variable		Leader Prior Bottled Oxygen Free	Team Climbed on an Expedition Experiencing a Death	Leader Prior Bottled Oxygen Free	Team Climbed on an Expedition Experiencing a Death	Leader Prior Bottled Oxygen Free	Team Climbed on an Expedition Experiencing a Death
Ascent	Coefficient	0.020	N.A.	-0.010	N.A.	0.000	N.A.
		(0.01)		(-0.09)		(0.06)	
	Wald $\chi^2(1)$		0.020		0.010		0.000
Deaths	Coefficient	0.055	-0.128	0.080	-0.123	0.169	-0.184
		(0.52)	(-1.34)	(0.74)	(-1.27)	(1.28)	(-1.48)
	Wald $\chi^2(2)$		1.930		1.990		3.340
Frostbite	Coefficient	-0.049	N.A.	-0.037	N.A.	-0.010	N.A.
		(-0.38)		(-0.28)		(-0.07)	
	Wald $\chi^2(2)$		0.140		0.080		0.000
Altitude Sickness	Coefficient	0.067	N.A.	0.056	N.A.	-0.024	N.A.
		(0.44)		(0.37)		(-0.13)	
	Wald $\chi^2(2)$		0.200		0.140		0.020

Notes:—Estimation is by probit on the ascent, death, frostbite and altitude sickness outcomes, respectively. Other variables included in the regressions are the same as in Tables 5 and 6. The Wald test is of the joint significance of the coefficients. Asymptotic *t*-statistics in parentheses. “***” significant at 1% level; “**” significant at the 5% level, “*” significant at 10% level.

TABLE A1: EXPERIENCE DIFFERENCES BY EXPEDITION CHOICES.

		Number of Observations	Climbers’ Prior Experience		
			Leader	Team	Sherpas
Normal Route	‘No’ = 0	677	2.55	0.62	0.48
	‘Yes’ = 1	1232	2.00	0.44	0.72
	Kruskal-Wallis $\chi^2(1)$		*****10.08**	*****18.05**	1.80
Guided Expedition	‘No’ = 0	1840	2.10	0.50	0.59
	‘Yes’ = 1	69	2.79	0.59	1.76
	Kruskal-Wallis $\chi^2(1)$		*****41.75**	****5.87**	*****11.49**
Female (%)	= 0	1538	2.00	0.45	0.60
	> 0	371	2.97	0.73	0.76
	Kruskal-Wallis $\chi^2(1)$		*****30.49**	*****71.82**	2.63

Notes:—See the notes to Table 4.

TABLE A2: OVERIDENTIFYING AND EXOGENEITY TESTS FROM GENERAL METHOD OF MOMENTS ESTIMATION OF LINEAR PROBABILITY MODEL FOR ASCENT, DEATHS, FROSTBITE, AND ALTITUDE SICKNESS EQUATIONS.

Outcome Equation	*Null Hypothesis H_0:*	*Criterion*	*Statistic*	*Model Specification*		
				(1)	(2)	(3)
Ascent	Instruments are uncorrelated with Bottled Oxygen	Reject H_0	$F_{5,N}$ Statistic	5.22***	4.64***	3.05***
				(0.0001)	(0.0003)	(0.0097)
	Instruments are independent of errors	Accept H_0	*J* Statistic, $\chi^2(4)$	0.748	0.772	4.180
				(0.94)	(0.94)	(0.38)
	Exogeneity of Normal Route, Guided, & Female	Accept H_0	*C* Statistic, $\chi^2(3)$	0.675	0.015	4.174
				(0.87)	(0.90)	(0.24)
Deaths	Instruments are uncorrelated with Bottled Oxygen	Reject H_0	$F_{5,N}$ Statistic	5.22***	4.64***	3.05***
				(0.0001)	(0.0003)	(0.0097)
	Instruments are independent of errors	Accept H_0	*J* Statistic, $\chi^2(4)$	2.598	3.155	4.015
				(0.62)	(0.53)	(0.40)
	Exogeneity of Normal Route, Guided, & Female	Accept H_0	*C* Statistic, $\chi^2(3)$	2.361	2.483	3.779
				(0.50)	(0.47)	(0.28)
Frostbite	Instruments are uncorrelated with Bottled Oxygen	Reject H_0	$F_{5,N}$ Statistic	5.22***	4.64***	3.05***
				(0.0001)	(0.0003)	(0.0097)
	Instruments are independent of errors	Accept H_0	*J* Statistic, $\chi^2(4)$	1.753	1.652	1.839
				(0.78)	(0.79)	(0.76)
	Exogeneity of Normal Route, Guided, & Female	Accept H_0	*C* Statistic, $\chi^2(3)$	1.175	1.049	0.814
				(0.75)	(0.78)	(0.84)
Altitude Sickness	Instruments are uncorrelated with Bottled Oxygen	Reject H_0	$F_{5,N}$ Statistic	5.61***	4.99***	3.38***
				(0.0000)	(0.0002)	(0.0049)
	Instruments are independent of errors	Accept H_0	*J* Statistic, $\chi^2(4)$	4.086	4.114	3.420
				(0.39)	(0.39)	(0.49)
	Exogeneity of Normal Route, Guided, & Female	Accept H_0	*C* Statistic, $\chi^2(3)$	4.051	4.114	1.707
				(0.25)	(0.24)	(0.63)

Notes:—*p*-values are given in parentheses. The criterion is the statistical outcome required for a properly specified model. Estimation is by the general method of moments of a linear probability model specification of the ascent, death, frostbite and altitude sickness outcomes, respectively, with the maintained hypothesis that bottled oxygen is endogenous. The instruments are "leader prior bottled oxygen free" (and "team climbed on an expedition experiencing a death" in the deaths equation), "leader climbed with females," "leader climbed with guided expedition," "leader climbed on an expedition experiencing a death," and "leader has made ascent." Other variables included in the regressions are the same as in Table 6. The number of observations is the same as in Table 6. "***" significant at 1% level; "**" significant at the 5% level, "*" significant at 10% level.

TABLE B1: DIFFERENCES BETWEEN FULL AND RESTRICTED SAMPLE.

Variable	*Sherpas Known (N=1,146)*	*Sherpas Unknown (N = 596)*	*Kruskal-Wallis Rank Test $\chi^2(1)$*
Leader's Experience	2.40	1.88	***10.229
Climbers' Experience	0.65	0.29	***42.186
Number of Climbers	9.18	7.79	0.157
Bottled Oxygen (%)	61.1	91.4	***176.344
Ascent (%)	51.5	36.8	***7.190
Deaths (%)	20.5	9.6	***22.568
Frostbite (%)	10.1	3.1	***23.719
Altitude Sickness (%)	6.4	3.1	***5.032

Notes:—The bottled oxygen, ascent, deaths, frostbite, and altitude sickness Kruskal-Wallis tests take into account the large number of rank ties.

TABLE B2: BIVARIATE PROBIT ESTIMATES OF OUTCOME EQUATIONS ON RESTRICTED SAMPLE.

Dependent Variable	*Ascent*			*Deaths*			*Frostbite*			*Altitude Sickness*		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Cumulative Prior Expeditions	0.0002	0.0001	0.0002	-0.0006 ***	-0.0005 **	-0.0007 ***	-0.0004 *	-0.0003	-0.0003	-0.0004	-0.0005	-0.0004
	(1.31)	(0.42)	(0.85)	(-3.4)	(-2.52)	(-3.53)	(-1.71)	(-1.06)	(-0.86)	(-1.24)	(-1.52)	(-1.06)
Cumulative Prior National Expeditions	-0.0013	-0.0013	-0.0026 **	0.0001	0.0000	0.0003	0.0002	0.0002	-0.0013	-0.0009	-0.0008	0.0012
	(-1.46)	(-1.47)	(-2.03)	(0.1)	(0.02)	(0.27)	(0.18)	(0.18)	(-0.78)	(-0.61)	(-0.55)	(0.62)
Leader’s Experience	0.037 **	0.038 **	0.031 *	0.001	0.004	0.008	0.007	0.006	0.009	-0.003	-0.005	-0.034
	(2.34)	(2.51)	(1.74)	(0.07)	(0.2)	(0.48)	(0.31)	(0.25)	(0.4)	(-0.11)	(-0.18)	(-1.17)
Climbers’ Experience	0.141 ***	0.136 ***	0.198 ***	0.002	0.004	0.090 *	-0.096	-0.085	-0.038	0.076	0.077	0.091
	(3.39)	(3.28)	(3.37)	(0.05)	(0.09)	(1.76)	(-1.46)	(-1.3)	(-0.52)	(1.22)	(1.21)	(1.14)
Sherpas’ Experience	0.078 ***	0.075 ***	0.046 *	-0.016	-0.015	-0.029	-0.024	-0.024	-0.034	-0.081 *	-0.077 *	-0.050
	(3.37)	(3.28)	(1.7)	(-0.73)	(-0.71)	(-1.18)	(-0.69)	(-0.7)	(-0.91)	(-1.72)	(-1.66)	(-1.03)
Bottled Oxygen	0.259	0.424	-0.108	1.145 ***	1.119 ***	1.626 ***	0.033	-0.069	0.967	0.041	0.042	-0.492
	(0.8)	(1.43)	(-0.22)	(4.23)	(4.1)	(6.06)	(0.05)	(-0.12)	(1.59)	(0.08)	(0.08)	(-0.93)
Normal Route	0.274 **	0.280 **	0.279 **	-0.165	-0.185 *	-0.165	0.009	0.000	-0.146	-0.182	-0.153	-0.068
	(2.56)	(2.59)	(2.1)	(-1.58)	(-1.74)	(-1.39)	(0.07)	(0)	(-0.96)	(-1.13)	(-0.94)	(-0.35)
Guided	0.583 **	0.559 *	0.621	0.047	0.056	-0.055	-0.247	-0.242	-6.260	0.641 *	0.643 *	0.537
	(1.97)	(1.91)	(1.55)	(0.17)	(0.2)	(-0.17)	(-0.59)	(-0.57)	(0)	(1.69)	(1.69)	(1.15)
Number of Climbers	0.007	0.003	0.014	-0.004	-0.003	-0.017	0.001	0.004	-0.034	-0.003	-0.004	0.002
	(0.86)	(0.49)	(0.77)	(-0.93)	(-0.74)	(-1.43)	(0.06)	(0.24)	(-1.33)	(-0.43)	(-0.63)	(0.21)
Number of Sherpas	0.007	0.010 *	0.074 ***	0.008	0.006	-0.043 ***	0.012	0.009	-0.033	0.004	0.005	0.000
	(1.37)	(1.83)	(3.35)	(1.47)	(1.21)	(-2.65)	(1.21)	(0.87)	(-1.59)	(0.71)	(0.97)	(0)
Female Climbers	0.226	0.212	-0.127	0.177	0.190	0.458	-0.080	-0.066	0.237	-0.129	-0.153	-0.144
	(0.84)	(0.8)	(-0.38)	(0.64)	(0.68)	(1.51)	(-0.21)	(-0.17)	(0.58)	(-0.28)	(-0.33)	(-0.29)
Big National Expedition	0.353 **	0.364 **	0.284	-0.044	-0.033	-0.019	0.228	0.209	0.382	0.254	0.251	0.225
	(2.48)	(2.57)	(1.38)	(-0.32)	(-0.24)	(-0.11)	(1.22)	(1.12)	(1.51)	(1.21)	(1.19)	(0.89)
International Expedition	-0.096	-0.073	-0.252	0.015	0.021	0.077	0.095	0.060	0.151	0.125	0.117	-0.017
	(-0.56)	(-0.43)	(-1.13)	(0.09)	(0.12)	(0.45)	(0.43)	(0.27)	(0.56)	(0.5)	(0.46)	(-0.05)
Autumn	-0.196 *	-0.209 *	-0.252 *	0.263 **	0.278 **	0.237 *	0.296 **	0.313 **	0.314 **	-0.104	-0.125	-0.025
	(-1.81)	(-1.93)	(-1.83)	(2.33)	(2.44)	(1.87)	(2.13)	(2.24)	(2.01)	(-0.6)	(-0.71)	(-0.12)
Winter	-0.619 ***	-0.646 ***	0.001	0.196	0.225	-0.157	0.365	0.393 *	-0.133	-0.021	-0.043	0.568
	(-3.18)	(-3.31)	(0)	(1.03)	(1.18)	(-0.55)	(1.57)	(1.67)	(-0.36)	(-0.07)	(-0.15)	(1.31)
Congestion	0.116 ***	0.111 ***	0.131 ***	0.014	0.013	-0.018	-0.041	-0.038	-0.035	0.013	0.014	-0.013
	(5.09)	(4.92)	(4.16)	(0.75)	(0.65)	(-0.69)	(-1.29)	(-1.22)	(-0.89)	(0.41)	(0.42)	(-0.31)
Nylon Rope					-0.647 *			0.399			0.087	
					(-1.95)			(1)			(0.17)	
Technical Ice Ax		0.403 *			-0.008			-0.245			0.342	
		(1.7)			(-0.03)			(-0.88)			(0.85)	
Plastic Boots		0.180			-0.126			-0.228			0.030	
		(1)			(-0.69)			(-1.04)			(0.11)	
Wind Speed			-0.100 ***			-0.018			0.035			0.046
			(-2.6)			(-0.49)			(0.81)			(0.79)
Temperature			0.052 ***			-0.012			-0.022			0.033 *
			(3.77)			(-1.03)			(-1.47)			(1.67)

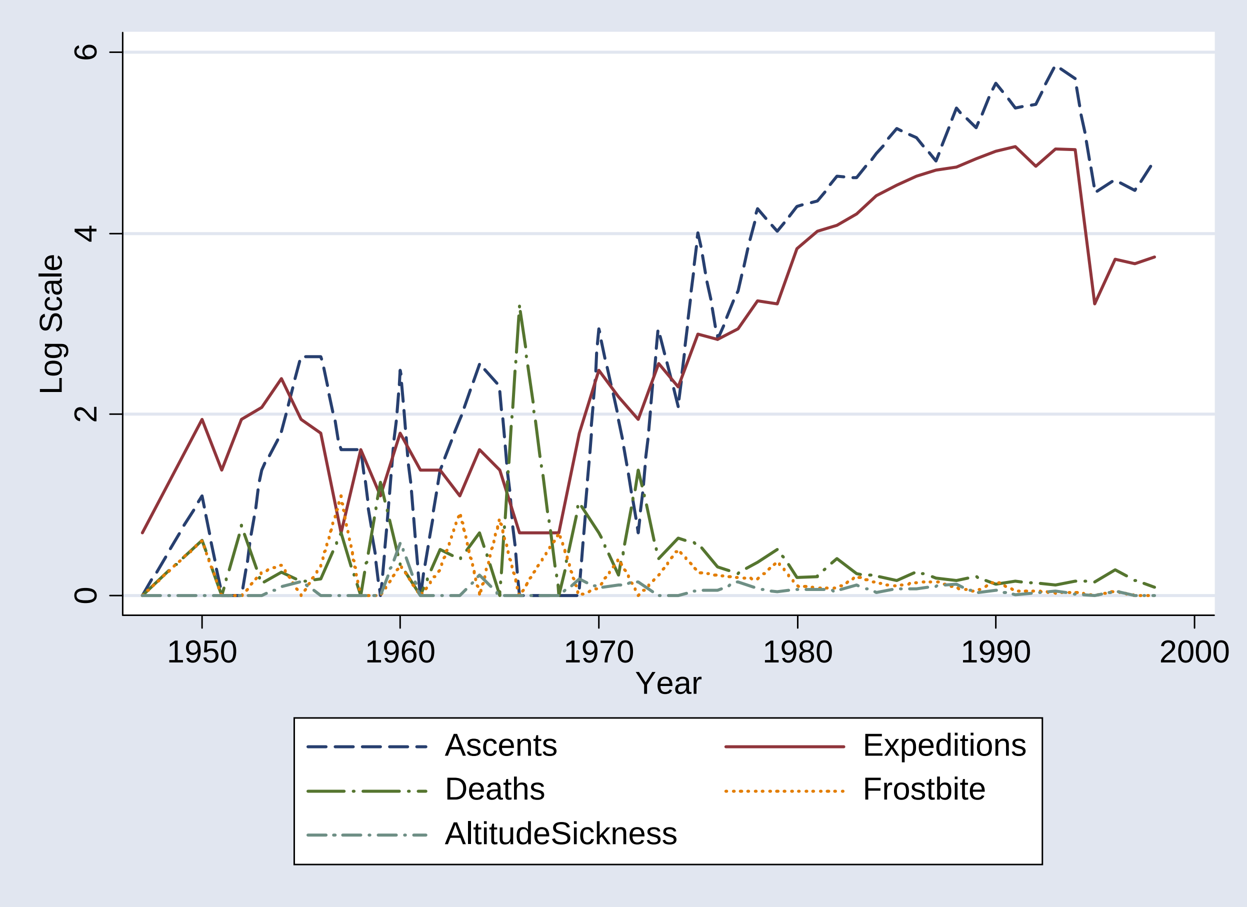
Table Continued on next page.

TABLE B2: BIVARIATE PROBIT ESTIMATES OF OUTCOME EQUATIONS ON RESTRICTED SAMPLE (CONTINUED).

Dependent Variable	*Ascent*			*Deaths*			*Frostbite*			*Altitude Sickness*		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Number of Observations	1146	1146	822	1146	1146	822	1146	1146	822	1146	1146	822
Log Likelihood Function	-1194.6	-1189.2	-821.7	-1090.6	-1085.9	-748.1	-928.7	-925.8	-636.7	-820.7	-818.5	-580.9
Wald Test, χ^2(d.f.)	552.7 ***	582.0 ***	411.2 ***	478.0 ***	482.8 ***	454.1 ***	337.2 ***	341.7 ***	290.8 ***	318.1 ***	320.7 ***	267.1 ***
Degrees of Freedom	104	108	108	105	111	79	104	110	108	102	108	102
ρ_i	-0.389	-0.485	-0.285	-0.590	-0.573	-0.854	-0.164	-0.105	-0.642	-0.102	-0.103	0.171
LR Test that $\rho_i = 0$, $\chi^2(1)$	2.999 *	4.706 **	0.740	7.680 ***	7.159 ***	9.622 ***	0.213	0.095	0.896	0.109	0.110	0.293
Joint Test Instruments = 0, χ^2(df)	3.500 *	3.170 *	1.040	7.150 **	5.910 *	2.350	3.860 **	3.290 *	1.190	5.010 **	4.400 **	2.060
Degrees of Freedom	1	1	1	2	2	2	1	1	1	1	1	1

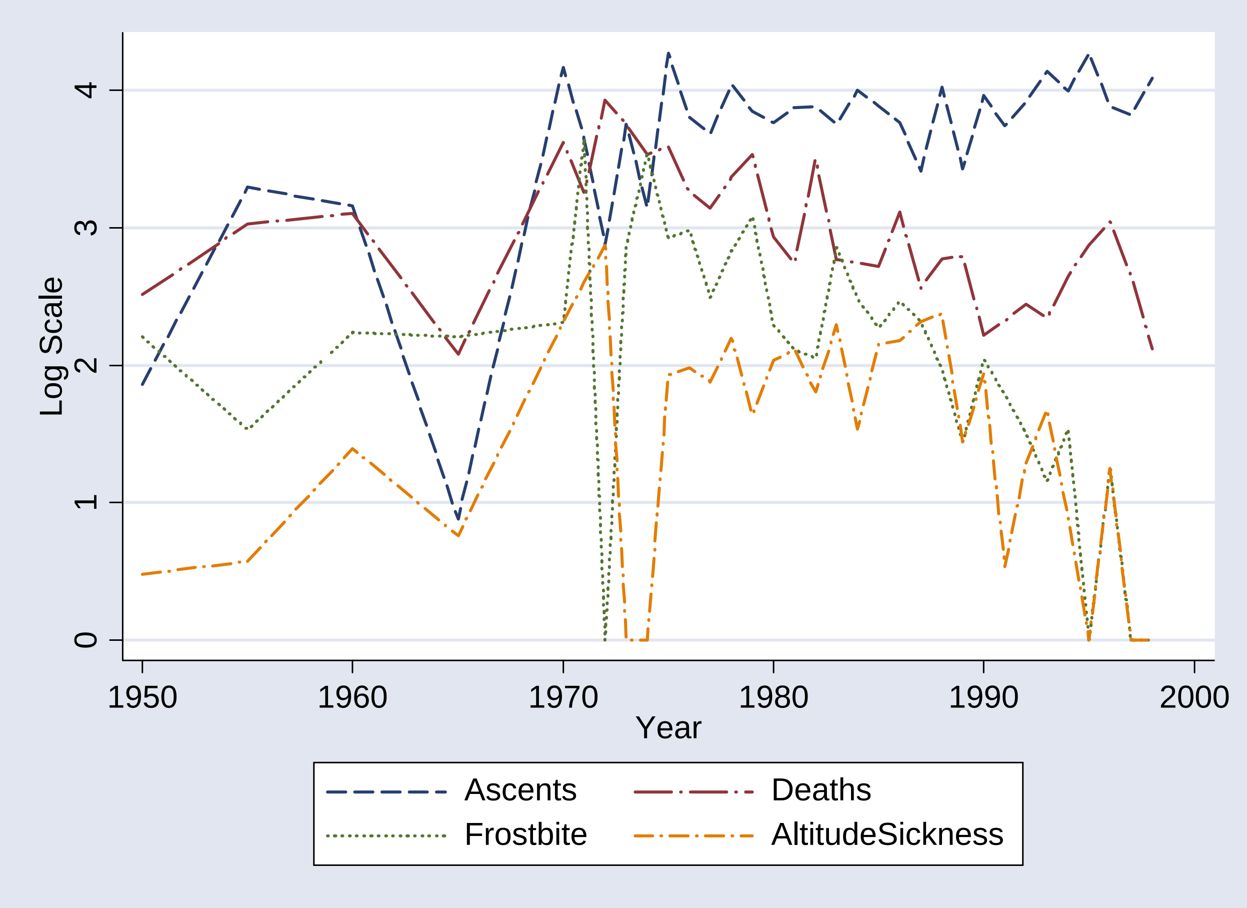
Notes:—See the notes to Tables 6 and 7.

FIGURE 1: NUMBER OF EXPEDITIONS, ASCENTS, DEATHS, FROSTBITE AND ALTITUDE SICKNESS CASES ON THE 8,000M PEAKS, 1945-1998.



Notes:—The figure depicts the log of one plus the number of expeditions and the number of climbers who make an ascent or suffer death, frostbite, or altitude sickness on any expedition to the 8,000m peaks between 1945 and 1998. Data for 1995-1998 is for Mt. Everest only.

FIGURE 2: PERCENTAGE OF EXPEDITIONS EXPERIENCING AN ASCENT, DEATH, FROSTBITE, AND ALTITUDE SICKNESS ON THE 8,000M PEAKS, 1945-1998.



Notes:—The figure depicts the log of one plus the percentage of expeditions experiencing an ascent, death, frostbite, or altitude sickness on the 8,000m peaks between 1945 and 1998. Data before 1970 is the five year average for the periods 1950-54, 1955-59, 1960-64, and 1965-69. Data for 1995-98 is for Mt. Everest only.

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